Adaptive Watershed Management to
Conserve Near-Shore Coral Reefs in San Andres, Colombia
Final Report, October 2006 - March 2008

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Introduction

An agreement for the project "Adaptive Watershed Management to Conserve Near-Shore Coral Reefs in San Andres" was signed by NOAA's International Coral Reef Grant Program and CORALINA in October 2006. The project's general objective was to conserve and recover coral reef ecosystems in San Andres' Seaflower Marine Protected Area (MPA) by implementing adaptive, participatory watershed management. To realize this objective, the project focused on improving monitoring; controlling sedimentation and pollution to the marine environment from poor practices in agriculture, construction, and waste disposal; and building capacity in scientists, managers, stakeholders, and neighborhoods, with support from US experts.

An Integrated Groundwater Management Plan (IGM), primarily for the watersheds, and Water Quality Action Plan (WQA), primarily for the coastal waters, were in place when the project began. A major component of the project was to evaluate and revise these plans with stakeholder participation and led by a US water quality expert. The project was carried out within the framework of the Cartagena Convention and Protocol Concerning Pollution from Land Based Sources and Activities (LBS) and the context of Colombian law and policy.

The project was executed from October 06 through March 08. All activities were completed, although not in accord with the original time table, which was adjusted to better suit US experts' schedules. This contributed to delays in meeting interim benchmarks. The budget was adhered to and additional matching funds were raised during project execution. Major outcomes included: 1) Science-based fresh and marine water quality monitoring improved for ground and coastal waters and staff trained in new methods; 2) Revised IGM and WQA with new, adaptive management actions underway for construction sites, agriculture, and neighborhoods that will continue to reduce land-based pollution, improve fresh and marine water quality, and conserve coral reefs and associated ecosystems; and 3) Stakeholders and villagers empowered to take part in watershed management, with participation strengthened at the neighborhood level, and public awareness increased of the community's role in and responsibility for watershed and coral conservation.

Substantial progress was made during the visits of the US-based experts. The first visit was from water quality expert Dr. Clifford W. Randall. This visit took place from November 19 - 24, 2007. Dr. Randall's visit was followed by that of MPA experts Dr. Cheri Recchia and Dr. Billy Causey from November 30 - December 3, 2007. During these visits, a number of activities were carried out that not only achieved project objectives but also added value to the project, as the experts all contributed much more than expected. Most significantly, the IGM and WQA were evaluated and revised, led by Dr. Randall with the support and input of stakeholders and CORALINA technical staff, and a host of new management measures are now being implemented.

Local capacity was built, with the project team and other CORALINA staff trained by the experts. The private sector (especially water concessionaires), farmers, and other government institutions were targeted by

education and training. Farmers were trained in new methods of farming and pasture management that reduce agricultural pollution and runoff from the rural areas (South End and Cove Valley Watershed), improving water quality and coral conservation. They were also educated in efficient ways to store and use water in the dry season, reducing stress on the watershed and improving freshwater management. Water concessionaires and others in the private sector are now involved in monitoring. Volunteer inspectors in the watershed are helping with monitoring, surveillance, and enforcement. Training programs and workshops were carried out jointly with other institutions to promote partnerships and achieve project objectives. Outreach and education programs targeted schools and the general community to improve awareness of the importance of watershed and coral conservation and the links between land-based activities and a healthy marine environment.

This Final Project Report (FPR) summarizes the project's objectives, activities carried out during the project, and results including present status. The FPR includes conclusions and lessons learned, a table summarizing outputs, and the project timeline, which has been updated to show when activities were actually carried out and completed. All project activities are summarized below by Work Program. Note that work programs are tightly linked; many activities fit into and contribute to outcomes in more than one work program.

Objectives

The general objective of the project was to conserve and recover coral reef ecosystems by implementing adaptive participatory coastal and watershed management. This objective was reached by completing a number of activities -- many of which are on-going and will continue indefinitely -- including transferring information and technology from US experts and implementing best management practices that successfully combine local knowledge with US expertise.

The project took a logic model approach, achieving this general objective by carrying out activities in three program areas, each with its own specific objective. The work programs focused on improving monitoring, building local capacity, and controlling sedimentation and pollution to the marine environment from poor practices in agriculture, construction, and waste disposal (strengthening adaptive management). The specific objectives and outcomes achieved during the project for these program areas were:

Work Program 1.
Water quality monitoring improved. Fresh and marine water quality monitoring programs were evaluated by US experts and strengthened through collaboration between US experts, CORALINA, and stakeholders. Staff and stakeholders were trained in monitoring methods.

Work Program 2.
New adaptive management actions underway (best practices). The Integrated Groundwater Management Plan (IGM) and Water Quality Action Plan (WQA) were assessed by US experts and local stakeholders (participatory, community-based assessment). This resulted in some revisions, with new procedures implemented. CORALINA managers and scientists were trained in new methods by US experts, as were key stakeholders.

Work Program 3.
Capacity and empowerment built. US expertise was transferred to CORALINA staff and stakeholders through collaboration and technical training. The general public was educated in special programs of outreach and education. Stakeholders took part in training led by the project team and also by visiting experts. Farmers, coastal and watershed residents, and key actors from the private and public sectors were empowered through this training to sustain new management strategies and technical alternatives.

Activities and results

Activities were carried out in the three work programs to realize the specific objectives and achieve outcomes, which in turn resulted in achievement of the general objective. The work programs are summarized below as: 1) Monitoring, 2) Management, and 3) Capacity building and empowerment. The US experts supported all three work programs.

Work Program 1, Monitoring

Monitoring water quality in the watershed, coastal zone, and nearshore waters has been Standard Operating Procedure for CORALINA since 1996. However, monitoring had not been revised to address the needs posed by the establishment of the Seaflower MPA in 2005. Therefore, activities of Work Program 1 included assessing existing data collection and analysis methods and implementing new techniques to strengthen the scientific base of monitoring programs and ensure usefulness of monitoring for management. All activities were successfully completed, although the time frame was delayed because expert visits took place later than originally planned. In point of fact, the delay allowed the project team to carry out a great deal of work to be better prepared for the visits, which ended up facilitating the efficiency and effectiveness of the expert visits. Therefore, even though the visits occurred later, given the higher level of on-site preparation and the exceptionally high level of expertise provided by the US experts, many recommended changes were implemented immediately while others were incorporated into monitoring well before the end of the project.

1.1 Complete an expert assessment of methods of data collection, including site selection, and analysis.

To prepare for the visit of the US experts, CORALINA completed a number of activities. These included strengthening the laboratory, compiling and analyzing existing data, and doing a preliminary evaluation of coastal water sampling. This work was done both internally and in collaboration with other institutions.

First, much effort was expended to strengthen the lab. In 2005, CORALINA's lab was awarded ISO 17025 certification to test for basic water quality parameters. To advance project objectives, lab scientists and technicians, the project team, and staff of the groundwater management project worked together on expanding the certification to include international standards in field water sampling. This work was evaluated in Oct 07 by IDEAM, the national certifying agency. The evaluation was positive so the scope of the international certification is likely to be expanded by the end of 2008, which will contribute to long-term sustainability of project outcomes.

Concurrently, an in-depth internal evaluation and analysis were carried out using groundwater monitoring datasets from 1999 to 2007. Management of information was improved, and the analysis provided longitudinal data about the status of groundwater that could be reviewed during the expert visit. Incidentally, the analysis showed a slight improvement in groundwater quality since 1999. This result will be further discussed in this FPR in the summary of Work Program 2, Management.

Finally, all methods of water quality sampling and analysis being used when the project began and prior to the expert evaluation were examined in a preliminary evaluation, which was incorporated into the national coastal and marine pollution program. This work was done in collaboration with the national marine research institute, INVEMAR.

US expert Dr. Clifford W. Randall, Professor Emeritus at Virginia Tech University and Chair of the Virginia State Water Control Board's Watershed Monitoring Subcommittee, corresponded with the project team and visited San Andres in November 2007. While on site, Dr. Randall led a participatory assessment of existing monitoring protocols and methods with CORALINA staff, observed staff in the field and laboratory, and recommended new US-based methods appropriate for San Andres and CORALINA. Expert recommendations to improve water quality monitoring methods are attached (see Appendix 1).

The evaluation of data collection protocols and methods focused on the capacity of personnel and training needs, site selection, timing, field methods, testing parameters, lab analysis, data management, data analysis, and public dissemination. All inland, coastal, and nearshore water quality testing sites for fresh and saltwater were included in the analysis.

CORALINA now monitors freshwater wells used by: 1) hotels (monthly), 2) aqueduct / municipal water supply (every 15 days), and 3) commercial extraction (weekly). CORALINA also produced two studies to improve conservation and use of groundwater resources. These are: 1) An analysis of datasets and the general database for monitoring the quality, level (quantity), and concession of wells in San Andres, and 2) Protocols for monitoring wells with concessions in San Andres.

In addition to assessing methods of data collection for monitoring water quality and quantity and recommending actions to improve effectiveness, Dr. Randall also recommended mapping areas of active and threatened erosion in the Cove Valley Watershed and South End. Cove Valley is the island's major watershed and a core zone in the Seaflower Biosphere Reserve. Mapping will allow protective measures to be implemented that would improve watershed conservation and reduce sediment runoff into coastal waters. The expert emphasized that reducing erosion is not only essential to protect fragile coral reefs but will also protect soil and increase the amount of rainwater that percolates into the perched aquifer.

In their visit (November-December 2007), MPA experts Dr. Cheri Recchia (Director, Marine Protected Area Monitoring Enterprise, State of California) and Dr. Billy Causey (Regional Director, Southeast Atlantic, Gulf of Mexico and Caribbean Region, National Marine Sanctuary Program, NOAA), worked with the project team and MPA managers and scientists to review methods currently being used to monitor effectiveness of the Seaflower MPA. The experts made clear that the priority for MPA monitoring should be gathering information to support evaluation of: 1) the biological effects of conservation zones, and 2) the socioeconomic effects of zoning on the primary stakeholders.

Both Dr. Recchia and Dr. Causey felt that CORALINA's MPA monitoring methods, protocols, and indicators were adequate at present but were more concerned about management and analysis of the information gathered. They emphasized that it is always possible to do more monitoring, no matter how much is already being done. But if resources are limited, it can be more effective to do less monitoring focused on the most important questions, allowing adequate time and resources for proper storage, analysis, and presentation of essential information.

In this regard, the US-based experts stressed that the most important need now is improved information management to ensure that datasets are accessible and information is organized systematically. They also questioned whether monitoring information is being analyzed adequately, so it can be used to inform management decisions. They stressed that technical and financial resources should be allocated specifically for this purpose. In summary, the MPA experts recommended that data be properly managed and analyzed, so that results can inform adaptive management and also can be regularly and systematically communicated to stakeholders (feedback). CORALINA needs to establish new systems of information management to achieve this. This advice will be incorporated into the monitoring component

of CORALINA's new GEF-IDB project, the purpose of which is to strengthen implementation of the Seaflower MPA (this project is now in the planning phase).

Protocols developed by CORALINA to look at the impacts of saline intrusion into the aquifer from sea-level rise related to global climate change were also examined. Dr. Randall helped CORALINA develop a system of modeling that can be used to study salinity of San Andres' aquifers. Results obtained will help identify interconnectivity and saline intrusion into the aquifers. These activities were carried out in collaboration with the Integrated National Adaptation Project (INAP), Colombia's national climate change project in which CORALINA is a partner, and are being continued in that project. INAP is funded by GEF, with the World Bank and Conservation International as implementing agencies.

1.2 Train CORALINA scientists and managers in new and revised monitoring methods and put these changes into practice.

To advance project objectives and prepare for the US expert visit, CORALINA staff were trained in implementation of the new international standards prior to Dr. Randall's arrival. This training took place on the mainland and was multiplied to other CORALINA scientists and technicians. Especially significant for the project, the training focused on specific methods to test for pesticides and heavy metals, both being essential to ensure watershed and coral health.

Experts trained CORALINA staff in how to implement all the agreed-upon new methods of monitoring and analysis, working with them in the field and lab to ensure that new practices were not only operational but also were feasible on site. First, both field (2 sessions) and in-house training (an intensive 2-day session) were led by Dr. Randall. Two priority areas -- Old Point Regional Mangrove Park and Cove Valley Watershed --were chosen as pilot sites in which to test the revised water quality sampling methods. Recommendations provided by the expert (see Appendix 1) were implemented at these sites.

To supplement staff training, training was also conducted with CORALINA's honorary inspectors during Dr. Randall's visit. The visiting US expert trained the members of this important volunteer program in methods of water conservation and erosion control (2 field workshops). The inspectors were also trained in sustainable agriculture techniques that will help farmers control pollution of the soil and water table. Employing a "training of trainers" approach, the idea is that the volunteer inspectors will multiply the training, sharing information and teaching regional farmers and other stakeholders. This will greatly increase the number of people who can be trained and will expand efforts to reduce land-based threats.

During the visit of, Dr. Recchia and Dr. Causey, these experts worked with the MPA team, project team, and other managers and scientists on the implementation of MPA performance indicators and methods of effective monitoring. Following the evaluation and revisions of monitoring methods with immediate expert support permitted new protocols to be introduced and tested for applicability to the local setting well before the project ended.

1.3 Involve stakeholders in monitoring.

A number of actions were carried out to complete this activity, and again results were achieved that go far beyond the original scope of the project. Not only were volunteers from civil society successfully involved in monitoring by the project's end, but institutional and private sector stakeholders were also incorporated into the freshwater monitoring network.

To ensure that an effective and manageable stakeholder network (early warning system) was set up to protect the Cove Valley watershed from threats, as called for in the project, it was decided to work

through the existing honorary inspectors program. Major reasons underlying this decision were that these volunteers already were organized, trained in environmental issues and practices, and deeply committed to working with CORALINA to improve conservation. Therefore, it was decided to involve these volunteers more heavily in surveillance than they had been before the project and also to use them as trainers, as explained above. In this way, training was more effectively multiplied to farmers, householders, and other stakeholders, which will reduce threats to the watershed. Multiplication of information is continuing after project conclusion, supporting CORALINA staff in the field and promoting long-term project sustainability.

Volunteer inspectors received training in this project that also allows them to take on the role of spotting and reporting threats to the watershed. In addition to the training mentioned above, to ensure that they can effectively play a stronger role in management, inspectors were trained in methods of surveillance and enforcement. The project targeted a special group of volunteers that was established in 2005. This group is composed entirely of members of the native or "raizal" community and about 80 % of these volunteers live in the Cove Valley Watershed. They are equipped with handheld radios and have direct communication to CORALINA's "Green Line" and enforcement team. This facilitates rapid institutional response to infractions or threats observed in the watershed.

A decision was also made to involve other public institutions in monitoring. The most significant institution involved in freshwater management is the municipal water authority. This entity was trained in environmental monitoring so that their personnel could collaborate with CORALINA technicians and scientists. The water authority now supports with monitoring of the 17 wells in Cove Valley Watershed that are integrated into the municipal groundwater extraction network. This authority also helps monitor four wells in Lox Bight on the northwest side of the island. These wells are part of the concession for the desalination plant, which is managed by a private water company. The collaboration with the municipal water authority contributes substantially to monitoring and also strengthens project outcomes.

Stakeholders from the private sector were also trained and are now working with freshwater monitoring. First, personnel of the largest company that bottles, sells, and distributes potable water were trained. This enterprise now supports CORALINA in monitoring the well in its concession, located in North End. The training was conducted by Dr. Randall and the CORALINA project team. Then Dr. Randall and the team met with and trained employees of a private company that has a concession in the rural area, which is also now supporting monitoring of its well. Finally, employees of a large hotel with its own well in North End were trained and are monitoring that well.

An especially innovative stakeholder-based monitoring program was designed and introduced, also with the collaboration of the private sector. This is on-going spot monitoring with owners of water trucks that extract and distribute water from many of the island's wells. Every week, six trucks from the 23 currently authorized to transport water are randomly selected for water quality sampling. The vehicles' owners are all involved in this monitoring process.

Finally, CORALINA's laboratory developed a program to train students at the local branch of the national technical institute (SENA) in monitoring and analysis of water samples. This is a wonderful opportunity for San Andres' youth, given that CORALINA is the only institution in the archipelago with scientists and a water quality testing facility certified for international standards.

1.4 Develop appropriate ways to give information (monitoring results and their significance) back to the communities.

The community's awareness - especially that of key stakeholders - of the links between watershed

management, coral conservation, and impacts from human activities was improved through the dissemination of information about monitoring programs and their results. A number of meeting were held throughout the course of the project to ensure that the community was continuously informed about watershed and MPA management, along with the specific progress of this project and monitoring activities. Meetings targeted key stakeholders including the tourist sector (restaurants and hotels), the private sector (water trucks and concessionaires), and institutions (the municipal water authority and others concerned with fisheries, agriculture, environmental health, etc.).

Informational bulletins (3) were distributed throughout the project and distribution is continuing – one report for owners or concessionaires of commercial wells and two reports for CORALINA staff, especially technicians, scientists, and managers. The former, a bulletin on monitoring and condition of commercial groundwater wells, is now delivered quarterly to each owner (72 owners and concessionaires) to keep these stakeholders informed about the results of monitoring and the current condition of their wells. Information on the volume of water extracted and data on physical, chemical, and microbiological parameters are included.

For internal use, two in-house bulletins about coastal zone monitoring are produced on a monthly basis. These reports – "Intensive Monitoring of the Coastal Zone" and "Systematic Monitoring of the Coastal Zone" -- provide current information on coastal and marine water quality. Besides keeping staff apprised of the results of monitoring and condition of coastal waters, information presented in these bulletins is disseminated by CORALINA staff to the public at meetings, workshops, via the media, during campaigns, and simply by word of mouth.

In addition to the bulletin for the owners and concessionaires of the commercial wells that supply much of the freshwater, a booklet produced with the groundwater project educates stakeholders about the Integrated Groundwater Management Plan (IGM) and includes information on monitoring. Information is disseminated not only to all well owners but also to the owners of hotels and major tourist facilities because the tourist sector is the largest consumer of freshwater extracted from commercial wells.

A new development during the course of the project was that the Ministry of Social Welfare (formerly the Ministry of Health) passed Resolution 1575 in 2007, which established higher water quality standards for the country. Given the relevance and importance of this norm to the project, a communication strategy to inform the community about the resolution was implemented. An information campaign targeted the general public, using a variety of means such as radio announcements, letters to civil society organizations and public institutions, and meetings with interest groups, schools, etc.

Work Program 2, Management

The main purpose of this work program was to complete a participatory evaluation of the Integrated Groundwater Management Plan (IGM) and Water Quality Action Plan (WQA) -- involving both primary stakeholders and US experts -- and to implement new management practices. Priorities were to identify and agree on appropriate technologies to eliminate or reduce practices in the watershed and coastal zone that negatively impact coral health, especially related to land-based pollution and sedimentation. Again, the timeline was adjusted to allow for the later visits of the US experts. All activities were completed except design of new performance indicators, which were not needed now. Existing indicators were reviewed and considered acceptable. New indicators do not need to be put in place until new analyses are implemented. Additional outputs were again achieved beyond those originally forecast. Some activities were finite, ending during the project, such as the assessment, while others are continuing. Long-term actions initiated in this

work program are now led by appropriate CORALINA staff, especially the groundwater and MPA management teams, and by the stakeholders themselves.

2.1 Complete expert and participatory assessments of the IGM and WQA.

The IGM and WQA were assessed by experts and stakeholders (participatory assessment) and revised in accord with changes agreed upon by experts, CORALINA, and stakeholders. When the project began, the IGM, as originally approved in 2000, was being implemented by the groundwater management team in cooperation with the community. The original WQA (2003) was being implemented partially, but not fully, mostly as part of MPA management.

To prepare for the expert assessment, the project and groundwater management teams completed a preliminary participatory assessment of the IGM and WQA with stakeholders. During this consultative process -- which involved meetings with key stakeholders from civil society, the private sector, and institutions -- the community identified issues to be discussed with the experts. The positive results of the project analysis of watershed monitoring 1999-2007, as mentioned in Work Program 1, seem to indicate that actions initiated to date have had a quantifiable, beneficial effect on water quality. This positive trend, although small, encouraged stakeholders and the project team and was taken into account in the IGM assessment.

When Dr. Randall arrived, the project team brought him up to date on the process and what was known. He did a thorough review of both plans and led intensive meetings with the project team and stakeholders, spearheading a complete revision, recommending alternative technologies new to the island, and reaching agreement on specific actions that would be introduced to improve the plans' effectiveness (see Appendix 2).

Following the assessments and revisions, some of the changes made to the IGM and WQA were implemented immediately. Others were implemented prior to project completion. Still others require more extensive funding, training, and allocation of resources, and thus require more time before they can be implemented.

2.2 Design performance indicators.

To improve monitoring and its usefulness to management, CORALINA's indicators for coastal and groundwater quality and for MPA effectiveness were reviewed. Ideally, indicators will strengthen adaptive management by setting criteria against which effectiveness can be better measured, helping to address Dr. Recchia's and Dr. Causey's concerns about the management, accessibility, and application of monitoring information.

When the project began biological and socioeconomic indicators were in place for the Seaflower MPA. The MPA experts found the indicators adequate generally but made the following recommendations:

- Train stakeholders in protocols and techniques for monitoring specific indicators to increase community participation and volunteer contributions.
- Identify beach indicators for MPA effectiveness and do more regular beach monitoring.
- Develop and implement indicators for invasive marine species.
- Develop and implement indicators for diseases that affect the health of significant coastal and marine species including corals.

Indicators for coastal and groundwater quality were put in place in 2006 (CORALINA Resolution 532). These indicators are directly linked with objectives and also have quantifiable standards against which to measure change. These meet and exceed national standards since they also meet international standards. Dr. Randall recommended that new parameters be added to the water quality analysis, especially organic nitrogen (TKN) and chemical oxygen demand (COD). When these analyses are added, new indicators must also be put in place for them. Indicators should also be developed for sediments and to measure change at areas of special concern and "hot spots", if new parameters are required (see Appendix 1).

2.3 Identify and map sources of land-based pollution.

Prior to the expert visits, CORALINA's maps of land-based pollution sites were updated. Point-source pollution sites were identified and visited in the field, precisely located with GPS, and the information was entered into the Geographic Information System (GIS). All the maps are available at CORALINA's planning department in the GIS section.

Dr. Randall reviewed old and new maps during his visit, using past and present datasets. He recommended ways to improve existing maps. He also recommended producing additional maps that could be used to reduce threats from pollution, especially to the Cove Valley Watershed (inland) and the San Luis aquifer (coastal). Suggestions included mapping areas of special concern and contamination "hot spots" and using maps to track and plot monitoring results (see Appendix 1). Maps are being produced in accord with his recommendations. Several maps, including a new map that shows sources of pollution in the Cove Valley, are attached (see Appendix 3).

2.4 Reduce land-based pollution.

Based on the assessments, monitoring results, and updated maps, problem sites were identified. Four sites that were sources of different types of land-based pollution were selected as pilot sites. A specific, appropriate project was designed that targeted each source of pollution. New practices, that were low-tech, low-maintenance methods appropriate for the local environment and technical capacity, were introduced. The project team carried out the pilots in collaboration with other CORALINA projects and/or the support of other institutions. These projects all improved management and also included monitoring (Work Program 1) and capacity building and empowerment (Work Program 3). The alternative, problem addressed, location, and a brief description are given below for each pilot project:

- Pilot Project 1. Neighborhood wastewater treatment system, Problem – household sewage, Location - Sally Taylor (Linvale). In 2006-07 a communal septic treatment system for domestic waste water was constructed and became operational. Since this was an expensive, labor-intensive pilot that will hopefully prove to be a replicable model that reduces pollution to the watershed and coastal waters, the project team supported other CORALINA teams in this work. Nineteen residences were connected to the system, which benefits about 70 people. Prior to the introduction of the pilot system, all of these homes were discharging wastewater and sewage directly into the soil. The municipal sewage plan for the island, as it now exists, does not include a sewage system or any wastewater management alternative for the island's elevated or rural areas. Sally Taylor section is both. Runoff washes directly into Cove Valley, so it was a perfect location for this pilot. Regular monitoring has been done since 2007 and will continue, providing information needed to evaluate the effectiveness of the wastewater treatment alternative.

- Pilot Project 2. Coastal clean-ups and gully maintenance, Problem – runoff into coastal waters, Location - Cove Seaside. Cove Seaside is the gully drainage area for the Cove Valley Watershed. Bad practices such as direct dumping of solid waste, poor management of household wastes, and

unsustainable methods of agriculture and land clearing result in pollution and sedimentation in the gully, coastline, and nearshore waters. Led by the project team and other CORALINA staff, the volunteer inspectors and community of Cove Seaside joined with the Office of Civil Defense, departmental government, and three schools to carry out coastal and gully cleanups. The first was part of the International Coastal Clean-Up in Sep 07, with another in Feb 08. The community is attempting to maintain a clean coast, having become very conscious of problems that result from garbage and sedimentation in the gully and coastal waters and, presumably as a result of the project and capacity building, have become pro-active in seeking solutions to protect their environment.

- Pilot Project 3. Low-tech erosion abatement structures, Problem – soil erosion, Location - Cove Valley Watershed. Areas of severe erosion were identified in Cove Valley Watershed. Simple structures were engineered to shore up eroded slopes and control further erosion. CORALINA worked with the community to design, construct, and install the structures. Found waste materials – old tires and natural waste such as trees, limbs, and cane trash – were put together and used as building materials to reduce soil erosion. Regular monitoring to evaluate the effectiveness, longevity, and any unanticipated impacts of these simple structures began during the project and is continuing.

- Pilot Project 4 – Hog farm waste management beds, Problem – waste from animal husbandry, Location - Cove Valley. There are a number of pig framers in the Cove Valley. To solve some of the problems of soil pollution and bad odors that result from poor management practices, submerged waste management beds were designed using simple artisanal methods. This alternative was introduced at 10 hog farms to test how effectively it controlled pollution from animal waste and reduced odor. The farmers were trained in construction and use of this low-tech method, which is in use at all 10 sites. Additional funds were raised to carry out this pilot, adding to the project's co-funding and outputs.

The project team also worked on another new, important pollution control mechanism, which again added to project outputs. New standards for septic tank construction – a very important tool to reduce impacts on the aquifer and coastal waters -- were developed in collaboration with other CORALINA projects and public institutions. A guide was produced to make the new standards available. The Health Department, Secretary of Education, and CORALINA are now working together to disseminate the standards to the public.

Finally, CORALINA, as the environmental authority for the archipelago, demanded that all institutions with jurisdiction over solid and liquid waste disposal identify and implement long-term actions to solve the many problems associated with inadequate waste management on the island. CORALINA staff are working with and supporting all relevant offices in seeking and carrying out solutions.

2.5 Develop policies and practices to reduce pollution and sedimentation from construction sites in the watershed and coastal zone.

A series of meetings was held with the Secretary of Planning to talk about introducing policies and enacting regulations to prohibit, control, and improve environmental management of coastal development, especially close to fragile ecosystems (mangroves, beaches, and corals). The idea was to reduce threats to water quality and mitigate risks, particularly those associated with climate change impacts such as flooding, loss of terrestrial area from sea level rise, and storm events. Although the local government was willing to meet and discuss these issues, it was impossible to incorporate CORALINA's recommendations into local planning policies before the project ended because the timing coincided with a gubernatorial election and total transition in departmental and municipal administrations.

The new administration took over in Jan 08. CORALINA immediately approached the new governor, secretaries, council members, department heads, and others about working together to incorporate best management practices into local planning and construction. Whenever there is a change in administration, delays occur -- not just because of the attention paid to political campaigns prior to the election but also because the newly elected and appointed officials often know little about the environment or about new and on-going conservation initiatives and must be educated after they take office.

On the other hand, the project timing was fortunate in that the new administration is responsible for reviewing the Territorial Ordering Plan for the San Andres Department Archipelago (POT) in 2008, as part of the national review process. The project team supported CORALINA's planning department in reviewing this document at the request of the new Secretary of Planning. The purpose of the assessment, as called for by Decree 325 that deals with environmental organization of the territory, was to ensure that the POT is in accord with environmental management policies, plans, and laws that are already in place.

Furthermore, the new administration is also working on a new development plan for the islands. CORALINA is currently reviewing the draft plan and will be recommending specific policies and practices that should be incorporated to reduce and mitigate pollution, erosion, and other threats to the watershed and marine environment posed by construction sites. This should help ensure long-term sustainability of project outcomes. Before the project ended, the team met with local architects and engineers to ask their views and guarantee that they would have input to the recommendations.

Meanwhile, CORALINA strengthened its surveillance of new construction sites and put stricter requirements into place as part of the EIA process for new and large constructions. These requirements were enforced in major construction projects including the new hospital, sports stadium, and rebuilding of public roads. Indeed, CORALINA temporarily closed down the municipal road construction project and fined the company the maximum allowable amount when it failed to comply with standards, demanding that the contractor utilize construction practices that were less harmful to the environment. The work was producing excessive dust and sediments that were polluting the watershed and coastal zone and also endangering the health of the community. CORALINA followed up on the new requirements by enacting a regulation to include these standards in housing projects.

2.6 Work with farmers in the watershed, including those that raise cattle and hogs.

Extensive work was carried out with farmers in the Cove Valley Watershed, as well as in South End. First, to ensure that this activity was successfully carried out, CORALINA updated its inventory of farmers. Twenty-six farms were visited in the project, 17 in the Cove Valley and 9 in San Luis and South End. Information was gathered on farming practices, crops, animals, issues facing the farmers, etc. and sustainable agriculture practices and new technologies were shared with them.

Besides on-site training, a number of meetings were held with farmers. Alternatives to enhance production, increase water supply, strengthen soil, and promote sustainability were looked at, including methods to reduce negative impacts from raising cattle and hogs. Farmers were trained in sustainable technologies such as using manure and natural fertilizers, composting, biological controls and natural pesticides, crop rotation, cover cropping, and other techniques of farm and pasture management that would improve water quality and coral conservation by reducing deforestation, agricultural pollution, erosion, and runoff.

Farmers were also taught efficient ways to store and use water in the dry season, reducing over-extraction, minimizing stress on the watershed, and improving freshwater management. Dr. Randall

introduced methods to capture and store rainwater that are used by farmers in the US. He also showed farmers how to make natural fertilizer ("compost soup"). Natural methods to destroy agricultural pests and prevent crop disease were also shared.

The project team worked with animal farmers in the watershed to implement practices to reduce sedimentation and soil compaction from grazing. Nutrient loading, pollution, and disease risks are associated with animal waste washing into gullies and the sea. Besides the pilot project for hog farmers summarized above (Pilot Project 4), farmers tried new practices to control animal waste and erosion including stabling cattle, pastoral-forestry, and selective land clearing. A study of cattle-raising on the island was completed, providing valuable information for the project team that was also used for awareness and education campaigns (see Work Program 3).

In addition to training and putting alternative, more sustainable farming techniques into practice, CORALINA also strengthened law enforcement in rural areas. To reduce agricultural burning, poor land clearing practices, and deforestation, surveillance was increased in farming communities in the evening and on weekends.

Work Program 3, Capacity Building and Empowerment

CORALINA is firmly committed to the use of education as one of management's most powerful tools. Considering that an educated, aware, and empowered work force and civil society are essential for long-term effectiveness of Work Programs 1 and 2, the project team devoted much time and effort to building capacity and empowering stakeholders to continue implementing actions begun in the project. All activities in Work Program 3 were completed, with priorities being to facilitate long-term stakeholder participation in adaptive management, empower neighborhoods to conserve their environments and natural resources, and create awareness of the links between land-based practices, water quality, and the condition of the watershed and coral reefs. Many capacity building and training activities are summarized earlier in the FPR (Work Programs 1 and 2, Pilot Projects 1-4), so this section describes only educational activities not mentioned elsewhere in this report.

3.1 Train key stakeholders.

As discussed in prior sections of the FPR, key stakeholders -- including farmers, livestock raisers, owners of wells and water concessionaires, volunteer inspectors, developers, planning and water authorities, and other private and public institutions -- were trained during the project to ensure effective implementation of new best practices and compliance with requirements long after project completion. Workshops, meeting, and site visits were realized throughout the project including during the expert visits in November and December 2007.

Before the expert visits, the project team did 11 field training workshops with farmers, working together to develop and start implementing methods of sustainable agriculture to reduce soil pollution and sedimentation. Farms that raise animals (cattle or hogs) were visited in the Cove Valley Watershed and San Luis section to discuss and put into practice alternatives to use or dispose of animal manure. Implementing such alternatives both improves production and reduces pollution. During Dr. Randall's visit, two on-site field workshops were held with farmers - - one in Cove Valley and the other in Bowie Bay on the south end coast.

The project team also worked with public institutions including SENA (continuing education), INCODER (fisheries), ICA (farming), and the Secretary of Agriculture and Fisheries. These institutions

were trained in management practices and educated about project objectives, so that they could continue to apply and multiply this training in their work with other institutions and the general community.

3.2 Educate neighborhoods.

In addition to activities mentioned in Work Programs 1 and 2 and in neighborhood pilot projects (Pilot Projects 2 and 3), the project team, CORALINA staff, and Dr. Randall visited neighborhoods to carry out education and training.

To build close relationships with the community from the outset of the project, the team visited neighborhoods in the Cove Valley Watershed and along the coast in San Luis. Theses visits paved the way for the implementation of new practices that would be developed in the project. The team shared information about the importance of the watershed and coastal and marine ecosystems and also about the IGM and WQA. CORALINA has been carrying out extensive education and outreach in neighborhoods for over 10 years, and the project team and visiting experts observed that the community has become very aware of the significance of these areas and their ecosystems. Nowadays islanders are generally interested in maintaining the health of the watershed and coast, not only for the sake of residents and wildlife but also for tourists.

As an on-going activity, CORALINA staff and the project team visited with neighborhood groups, as well as farmers, to educate villagers about reducing land-based pollution from poor disposal of solid, liquid, and oily wastes. To build awareness about sustainable watershed management at the end of the dry season (April-May), the project team did a house-to-house campaign with other CORALINA staff. Information was disseminated about agricultural burning, land clearing, and deforestation and tree management because the subsistence / small-scale farming season traditionally begins at this time.

Furthermore, the project team supported the groundwater management project in its on-going work with villagers to educate them about freshwater conservation and control over-extraction from neighborhood and residential wells, especially in the Cove Valley Watershed. The team also supported CORALINA in its pilot program of rainwater harvesting, which is an adaptation measure in the national climate change project INAP.

3.3 Carry out outreach program.

The outreach program to disseminate information about the project, create island-wide awareness, and educate the general public to support project objectives is continuous, but in terms of project outputs, it was completed.

In addition to activities already mentioned in the PCR, 10 schools were visited with an average of 35 students attending talks at the first set of five schools and 42 students at the second set of five schools. Most schools and neighborhoods took part in the International Coastal Clean-Up in September 07 and again in the local clean-up the following February. To support the work being done in one of the priority sites, Cove Seaside, the school there has “adopted” the Cove mangroves. CORALINA staff trained the students in mangrove ecology and care. The children are now working with the neighborhood to ensure that the mangroves remain healthy and to alert CORALINA if problems are observed.

A media campaign was implemented throughout the project and is also continuing. Announcements, interviews, and bulletins that spread knowledge about the project’s activities and objectives were presented on local radio and television. Special messages and tips about watershed and marine conservation directed at the entire island community were a regular feature on CORALINA’s local

television program, *Seaflower Magazine*, and also were broadcast on local radio shows. Information about the project and these topics is also available on CORALINA's webpage. The webpage, which is mainly in Spanish, is currently being translated into English. The environmental education group is presently evaluating the effectiveness of some of CORALINA's education programs, including the webpage, media campaigns, and some of those carried out in the project.

A variety of educational materials were distributed at meetings, workshops, and in the house-to-house visits. These are summarized in Table 1.

Table 1. Educational materials distributed

Booklet or brochure	*Copies distributed*
8 Ways to Protect Coral Reefs in our Seaflower Biosphere Reserve	120
Burning that Generate major fire	100
MPA Mangroves	97
Ordering and Management of Cove Valley	84
Use of Rain Water in our Seaflower Biosphere Reserve	45
Welcome to the Seaflower MPA	83
What is happening to the Sea in our Seaflower Biosphere Reserve?	53

Outputs and time table

The project outputs, as proposed in the project document, are presented below in Table 2. Since outputs were mentioned earlier in association with activities, a summary table is provided here. Additional and expanded outputs achieved in the project, which went beyond the original proposal, are not all listed here since the purpose of the table is simply to illustrate that all activities were completed and that the original outputs were achieved. Some additional outputs, such as the four pilot projects to reduce land-based pollution from key sources, have been added to the table. Outputs are summarized by work program, activity, product, and status when the project ended.

Table 2. Outputs

WP		Activity	Output	
			Product	Status
1	*Monitoring*	Outcome 1: Water quality monitoring improved		
		1.1 Assess monitoring programs	Assessment report	Revised monitoring underway
		1.2 Train staff	Workshops and field work	Staff implementing new methods
		1.3 Set up stakeholder network	Volunteer training	Volunteers working in the watershed
		1.3 Develop feedback mechanisms	Bulletins (3)	Regular distribution to stakeholders
2	*Adaptive management*	Outcome 2: Adaptive management actions underway		
		2.1 Assess and revise IGM and WQA (participatory & expert)	IGM assessment	Revisions incorporated
			WQA assessment	Revisions incorporated
		2.2 Design performance indicators	Present indicators reviewed	Indicators adequate for now (new indicators required when new analyses are implemented)

		2.3 Identify sites and sources of land-based pollution	Updated and new maps	Sites visited and information consolidated
		2.4 Reduce land-based pollution	Priority sites and problems identified	Pilot projects (4) on-going
			Consultations with stakeholders	Pilot projects (4) on-going
			Actions agreed on and implemented	Pilot projects (4) on-going
		2.5 Improve construction site management	Meetings with stakeholders and government	On-going with new administration
			Permit requirements designed	CORALINA regulation enacted On-going with new administration
		2.6 Improve farming practices	Farms visited (26)	New practices on-going
			Expert workshops/site visits (2)	Completed
			Actions agreed on and underway	New practices on-going, led by farmers themselves
3	*Capacity building*	Outcome 3: Community capacity and empowerment built		
		3.1 Train key stakeholders	Workshops and meetings	All capacity building activities were completed during the project Working with key stakeholders, neighborhoods, schools, and outreach and media are continuing
		3.2 Work with neighborhoods	Community meetings and house-to-house campaigns	
		3.3 Carry out outreach program	Schools visited (10)	
			Educational materials distributed (about 600 copies)	
			Media campaigns on TV and radio	

The final project time table is presented in Table 3. As explained, timing of the expert visits was changed. This meant that some activities were delayed and some interim benchmarks were not achieved on schedule. However, by the end of the project all activities were completed. Indeed, restructuring the timeline, although unanticipated, probably strengthened the project, as discussed in the following section.

Table 3. Revised time table

Activity		Year / Month																	
		2006			2007												2008		
		O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
1	1.1 Assess monitoring programs														X	X	X		
	1.2 Train staff														X	X			
	1.3 Set up/ implement volunteer network		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	1.4 Develop feedback mechanisms								X	X	X				X	X			
2	2.1 Revise/ implement IGM	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	2.2 Design performance indicators													X	X	X	X		
	2.3 Identify sites and sources of land-based pollution												X	X	X				
	2.4 Reduce land-based pollution	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	2.5 Improve construction site management					X	X	X	X	X	X	X	X	X	X	X	X	X	X
	2.6 Improve farming practices							X	X	X	X	X	X	X	X	X	X	X	X
3	3.1 Train key stakeholders		X						X						X	X			
	3.2 Work with neighborhoods									X	X	X	X	X	X	X	X	X	X
	3.3 Carry out outreach program		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Conclusions and lessons learned

All project activities, outputs, and indicators were completed in the timeframe (18 months) and within the NOAA-International Coral Reef Program grant approved budget. Realizing all activities and outputs resulted in the achievement of the specific objectives and the project's general objective to conserve and recover coral reef ecosystems in the Seaflower MPA by implementing adaptive participatory coastal and watershed management. However, there were problems finishing activities on schedule according to the original project timeline. Initially this created challenges for the project team, who were at first unsure how to proceed. But, in the long run, restructuring the timeline actually was seen to have strengthened the project. First, it gave the project team more time to work with the community and with key stakeholders prior to the expert visits. Second, the team members were also better prepared themselves for the visits, having already completed preliminary assessments with the stakeholders, worked on pilot projects, met with farmers, etc. There is no doubt that such actions contributed to the achievement of additional outputs and stronger outcomes.

The support of the visiting experts was of unimaginable value. The three experts donated substantial time and technical assistance, especially Dr. Randall to whom the project team and community owe special thanks. The experts are all extremely knowledgeable in their respective fields and were consistently helpful. Their willingness, even eagerness, to share US technologies and expertise with staff and local stakeholders was exceptional and very beneficial. Their support not only produced the best possible project outcomes, but also strengthened CORALINA as an institution and developed substantial capacity in San Andres' civil society.

The collaborative approach taken in the project was also a strength. Most activities were carried out by the project team working jointly with other CORALINA staff, public institutions, and stakeholders from civil society and the private sector. Such an approach not only produced better results but also promoted local empowerment, compliance, and the high level of stakeholder involvement. Activities in this project were also linked with complementary CORALINA projects on groundwater management, climate change, MPA management, laboratory and GIS functions, and surveillance and enforcement; further enhancing project results and advanced CORALINA's institutional goals, functions, and mandate.

Reducing land-base pollution through pilot projects -- each of which tackled a different major problem in a different location -- was an extremely successful approach that added substantially value to project outcomes. Each of the pilots is an accessible demonstration project that can be easily replicated. Moreover, the community is integrally involved and has taken on "ownership" of each pilot, which is likely to result in their ability to assist with replication, train other stakeholders, and identify and share lessons learned.

Continuing with best practices that emerged from the project and implementing expert recommendations that have not yet been put into practice will be particularly important in several new CORALINA initiatives. Two of these in particular are, first, the new GEF-IDB project to protect marine biodiversity by improving MPA management and, second, the national green market project that will be underpinned by alternatives that promote sustainable agriculture. Of course, the on-going work in the Cove Valley Watershed, a critical site and core zone in the Seaflower Biosphere Reserve, will continue to benefit from the project outcomes.

Most importantly, most activities carried out in the project launched programs that will continue long after project completion. For example, involved institutions are meeting now to discuss how reduce and mitigate threats from coastal construction. Farmers and water concessionaires are carrying out new methods. Neighborhoods and schools are assuming responsibility for maintaining ecosystems. Volunteer inspectors are implementing new programs. Achievements like these illustrate that the project has succeeded -- awareness of the negative impacts of land-based activities on the watershed and marine ecosystems has grown, volunteers are playing an active role in surveillance and enforcement, farmers are changing to sustainable practices, and stakeholders are monitoring water quality side-by-side with the authorities.

Appendix 1
Summary of Recommendations
of the Water Quality Management and Monitoring Expert, Dr. Clifford W. Randall

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Part I. Expert Recommendations for the Water Quality Action Plan (WQA)

Recommendations

The basic principle for implementing the Water Quality Action Plan should be to prioritize actions based on an analysis of the data resulting from monitoring. There is a need to link land-based activities first to coastal water quality and then to condition of nearshore coral reefs (land-based activity → coastal water quality → coral reef condition).

To more effectively achieve this:
- Develop an integrated database using a comprehensive monitoring program.
- Analyze data to identify "hot spots"; i.e., areas of greatest water quality concern.
- Prioritize 'hot spots' according to probable impact on coral reefs.
- Prioritize actions based on analyzed data; e.g., chronic vs. acute situations, long-term vs. short-term actions, emergency vs. preventive actions, etc.
- Implement remediation and preventive actions; first defining methods and then implementing action.

Methods

To improve methodology and achieve the above recommendations, do the following:

- Develop a comprehensive map of areas of coral growth decline, with % decrease since 1979 and other survey years.

- Develop geographical maps of areas of water quality concerns using monitoring data results. Plot data on comprehensive maps. For this, maps are needed of the entire island and its coastal waters, as well as enlarged maps of specific areas. On large area maps show:
    a) Coral areas
    b) Submerged aquatic vegetation areas
    c) Coastal silt accumulation areas
    d) Contaminated sediment areas

- Identify and monitor Specific Water Areas of Concern. As a minimum, these should include:
    a) Hooker Bay – expand sampling to include DO and temperature profiles of water column. Collect water samples at surface, mid-depth if total depth > 2 meters, and bottom. Construct isopleths and isoconcentration lines of contaminants for sampling stations and the entire bay.
    b) Cove Bay - Same
    c) Port and Commercial Fishing Area(s) – Same
    d) End of Sewage Outfall Area – Same
    e) Septic Tank Disposal Area – Same

- Identify and map Land Areas of Concern, including:
    a) Cove Watershed - show 17 wells. Plot water surface elevation at wells. Collect data of groundwater elevation between wells to show cones of influence of the wells. Use both vertical and horizontal graphs to show current cones of influence. Produce maps and graphs for end of dry season and end of wet season. Plot nitrate data on map, also ammonia, salinity, total and fecal coliforms, and enterococci data.
    b) North End (city) – Same. Also show major commercial wells and their cones of influence. Show aquifers that supply artesian wells, if known. If unknown, use tracer studies to determine artesian sources.
    c) South End (flat land agricultural areas) - Same

Part II. Expert Review, Evaluation, and Recommendations for Sampling and Analysis Programs

Monitoring of coastal waters

To improve effectiveness of monitoring of coastal water quality, the expert emphasized the principle that: Coastal and estuarine water quality is primarily determined by the condition of the sediments for depths up to 10 meters.

Keeping this principle in mind, the expert made the following comments and recommendations:

- Comment - Sampling is too infrequent.
  Recommendation – Change frequency to 4X per year.

- Comment - Currently samples are taken only at surface.
  Recommendation - Samples are also needed from bottom of water column and mid-depth if the total depth is > 2 meters, for physical and chemical parameters. Always take DO and temperature at mid-depth, as well as at bottom.

- Comment - Surface sample is sufficient for microbiological samples but need to add parameters.
  Recommendation - Include determination of both algae and dinoflagellate counts with identification of major types, in addition to total & fecal coliforms and enterococci.

- Comment - BOD_5 is not a very meaningful test for coastal waters. At low concentrations, the test is neither accurate nor precise.
  Recommendation - Need COD or TOC analysis instead. If COD is selected, use only potassium dichromate procedure with appropriate chemical additions for likely interferences.

- Comment - Need annual assessment of sediments.
  Recommendation – Annual assessment of sediments to include depth, sediment oxygen demand (SOD), and contents of total phosphorus, ammonium, organic nitrogen, specific hydrocarbons of potential concern such as herbicides, pesticides, PCBs, etc. (begin with mass spectrophotometer analysis), plus the following metals: iron ($Fe^{2+ \& 3+}$), aluminum, zinc, copper, lead, mercury, cadmium, tin, and total, tri- and hexavalent chromium.

Analysis of coastal waters data

To improve analysis of the data from coastal waters, the expert recommended the following:

- Use maps to show data variation and change, and quantify changes with time.

- Plot isoconcentration lines on maps of areas of greatest concern (e.g., Hooker Bay) for all parameters measured. Perform for both surface and bottom of water column. Repeat for other selected areas. Link areas where reasonable.
  a) Plot isopleths of changes in DO, temperature, PO_4-P, NO_3-N & NH_4-N with depth and time.
  b) Plot microbiological data, i.e. total & fecal coliforms, enterococci, algae, and dinoflagellates:
  c) Plot sediment data, i.e. SOD, depth, etc.

Monitoring of ground water

To improve monitoring of groundwater, the expert made the following recommendations:

- Define the island's aquifers
    a) Perched aquifer of Cove Valley
    b) Lower aquifer of Cove Valley (if one exists)
    c) Artesian aquifer(s) from the Cove Valley to other island areas
    d) Unconfined aquifer(s) on South End
    e) Unconfined aquifer(s) on North End

- Continue utilization of island maps
    a) Illustrate relative contamination of groundwater
    b) Highlight "hot spots" of contamination

- Use the map plot of the 17 aqueduct wells of the Cove Valley
    a) Show groundwater levels and well cones-of-influence
    b) Plot chemical parameters on map for each well
    c) Draw isoconcentration lines that link all 17 wells
    d) Add other known wells in the area to the extent that data are available

Upgrade of Water Quality Analysis Laboratory

The expert commented that the laboratory is well managed and well maintained. Analytical techniques used are very rigorously performed, with reliable results. However, versatility of the laboratory is lacking because only very basic physical, chemical and microbiological analysis can be performed in the laboratory because of equipment limitations. Currently, the laboratory does not perform a number of analyses that should be added.

The expert recommended that the following analyses would be useful for monitoring water quality in the coastal waters and in the island's underground and surface waters:

1. Organic Nitrogen - Total Kjeldahl Nitrogen (TKN) test (Requires a minor investment for the labor intensive TKN test. Needs a significant investment for purchase of Total Nitrogen analyzer).

2. Chemical Oxygen Demand (COD) – Considerably more accurate for low concentrations than BOD_5. Perform according to Standard Methods (Requires a minor investment).

3. Total Organic Carbon (TOC) – Best measure of low concentrations of organic matter in environmental waters (Measurements require a moderately expensive instrument).

4. Toxic Metals Analysis – Best instrument for this purpose would be an Atomic Absorption Instrument (Requires expensive investment).

5. Specific Organic Compound Analysis - Including known toxic organics (Requires gas chromatograph, an expensive instrument, with two or more detectors).
6. Cation and Anion Analysis for detection of some metals and some organic compounds – Accomplished by an ion chromatograph (Requires expensive instrument).

7. Analysis of unknown organic compounds of suspected toxicity – Mass Spectrophotometer interfaced with Gas Chromatograph (Requires an expensive instrument).

8. Auto-Analyzer - Automated analysis of large numbers of samples of COD, nitrogen forms, and phosphorus forms (Requires a significant investment in both funds and operator training).

The expert emphasized that Items 1 and 2 should be added as soon as possible.

Item 1, TKN test, detects all reduced forms of nitrogen; i.e., ammonium plus organic nitrogen. This test is essential for performing nitrogen mass balance analyses. It is also used to measure sediment contamination, and total loads of nitrogen being discharged by point sources and stormwater runoff. It can be added to lab capability primarily through glassware and chemical purchases. Analyze in accordance with Standard Methods.

Item 2, COD, will give a better estimate of organic contamination of the water than BOD_5 and can also be added primarily through glassware and chemical purchases. It is also useful for detecting and estimating discharges and spills from ships in coastal area, in a short period of time (two to four hours). It can be used along with oil and grease measurements for discharges and spills. Also used for sediment analysis.

Part III. Expert Discussion and Recommendations

In conclusion, Dr. Randall provided CORALINA with a comprehensive report that included discussion, his conclusions, and very useful final information and recommendations. These recommendations point the way to management measures and future projects that should be developed to ensure long-term sustainability of this project and improved coral conservation of San Andres' watersheds and nearshore coral reefs. This section of his report is quoted directly below (Dr, Clifford W. Randall, unpublished report to CORALINA, May 2008):

Protection of the coral reefs surrounding San Andres Island requires a very comprehensive program that reduces or prevents pollutants from several sources, e.g. terrestrial sources such as erosion, agricultural contaminants, dump leachates, urban runoff and wastewaters; marine activity sources such as fishing wastes, ballast discharges, dredging, boat & ship maintenance and repairs, etc.; and oil and fuel terminals. One of the most important sources is erosion. A massive amount of damage can occur in a very short time from erosion during storms and construction projects. This damage can be controlled only if erosion controls are already in place when the storm and construction projects begin. Information regarding the control of nonpoint pollution is available on the internet from the USEPA, under the heading of Polluted Runoff. Other sources of information are available on the internet from several states of the USA, plus from a few USA based non-profit organizations. Plans and regulations to prevent erosion from major construction projects need to be evaluated for completeness, and modified and established as soon as possible.

Because available water is in very short supply on San Andres plus the need to control erosion of land to the coastal waters, efforts to reduce and manage gullies that have formed in the ridges surrounding the elevated valley of the Island need to be implemented. Damming the existing major gullies so that runoff is retarded or prevented is recommended. This could help control further erosion and also increase the amounts of rainwater that percolates to the perched groundwater table. Constructing a dam at the Cove to form a freshwater reservoir is also recommended. This would assist in the control of erosion and simultaneously provide an additional water resource that could be utilized for drinking water. Water from the reservoir could be pumped to the existing water treatment plant for treatment and utilization. The existing treatment plant was designed to treat surface water, but is underused because the current supply is entirely groundwater, which is much simpler to treat to potable standards. Treatment of water from the Cove reservoir could be easily implemented utilizing the existing facility.

Currently, CORALINA is expending a considerable fraction of its financial and laboratory resources on the monitoring and administration of the commercial wells located in the Cove Valley and the north side of the Island, but the income from this effort is very small relative to the effort. Also, during recent years the utilization of private cisterns has been discouraged in spite of the inadequate supply of fresh water. It is recommended that a program to encourage utilization of cisterns be developed that includes disinfection of existing cisterns, design of individual filters for preliminary treatment of rooftop runoff water, and simple methods for chemical disinfection of water in cisterns. This would increase the amount of available fresh water on the Island and take some of the pressure off of the commercial wells, which the Island may be 'mining' at present, i.e. utilizing the water faster that it is being replaced.

Conversion of the solid waste dump to a sanitary landfill, which was just beginning at the start of my visit, will be a major improvement in waste management on the Island, and should provide needed management, i.e., reduction of leachate flow from the dump to both the groundwater and the coastal water. Efforts should be made to implement capture and utilization of methane gas from the landfill. The semi-annual collection and processing of household hazardous chemicals for appropriate disposal should be implemented and widely advertised to reduce the amount of such materials that would otherwise be sent to the landfill.

Efforts to educate farmers regarding application of manures and fertilizers, rotation of crops and methods of farming and field management to reduce agricultural pollution, including erosion, seem to be reasonably

comprehensive and successful. They should be continued and perhaps expanded through the use of monitored demonstration projects that show the erosion and pollution control reductions that can be accomplished through implementation.

It appears that efforts need to be made to more accurately define the magnitude of pollution from fishing activities, including seafood processing, and a plan is needed for the management of future dredging spoils.

The current disposal of untreated wastewaters through the short ocean outfall is not believed to be adequate because of the fresh sewage odors that prevail in the discharge area. A comprehensive survey of microbial, organic and nutrient pollution spreading from the discharge site is recommended to define the current situation. For the long term, it is recommended that methods of treating the high saline wastewater be investigated to see if relatively new methodologies can be used to treat the wastewater before discharge and improve current coastal water environmental conditions. In particular, it is recommended that fixed film treatment systems such as a moving bed biological reactor (MBBR) or a Sessil tower be investigated for this purpose and implemented as soon as a technically and financially feasible system is defined. Note that restoration of the freshwater supply to sustaining levels would sharply reduce the salinity of the sewage and make it much easier to treat using conventional methods of sewage treatment.

CORALINA should develop an emergency response plan for major spills of oil and other chemicals that could result from shipping activities, including shipwrecks.

Appendix 2
Summary of Participatory Evaluation Results to Strengthen the IGM and WQA

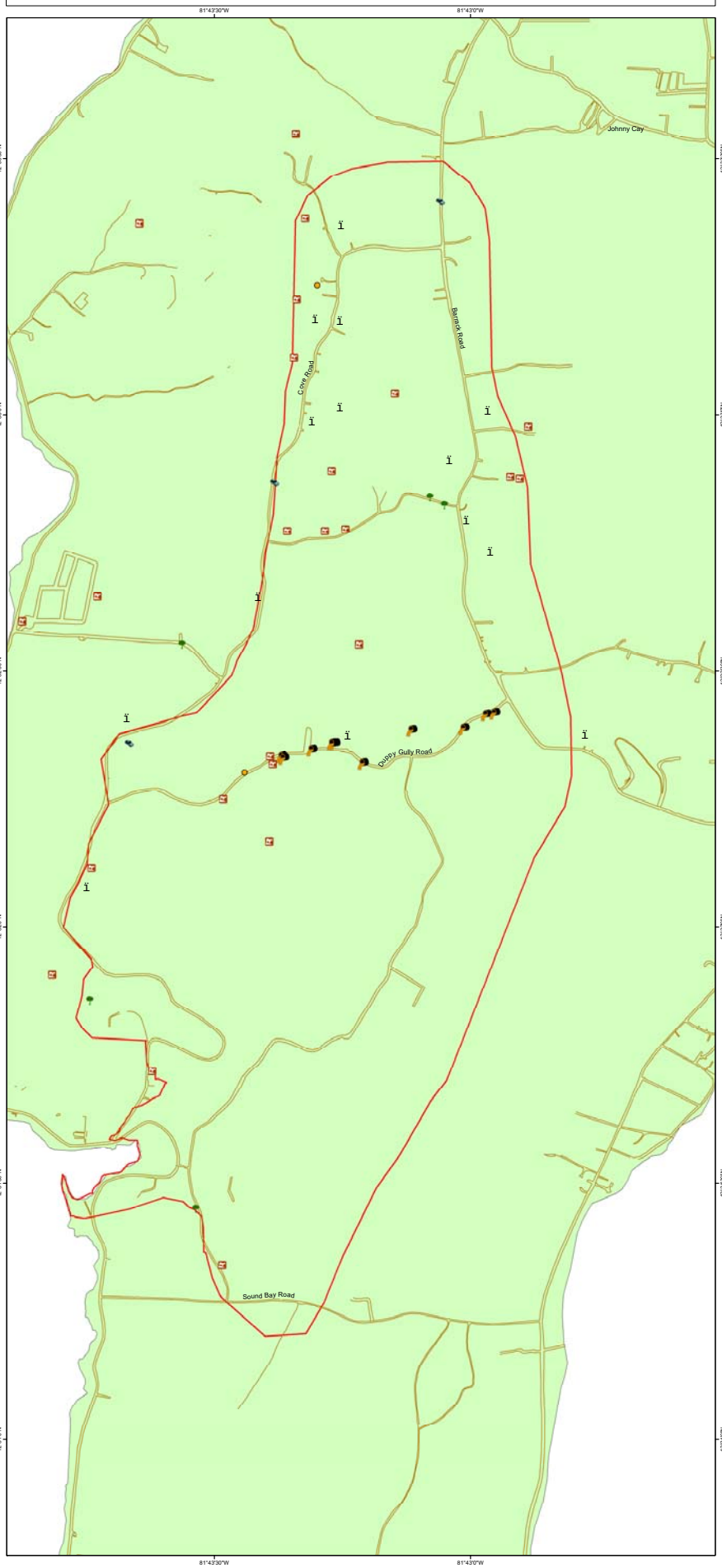
Integrated Groundwater Management Plan (IGM)

- Increase the capability and versatility of the laboratory to measure freshwater quality
- Identify terrestrial "hot spots" and design and implement appropriate actions for each spot, beginning with the top priority site, the Cove Valley Watershed
- Increase rainwater harvesting for agriculture, residences, and private sector enterprises.
- Encourage including cisterns in residential construction, with appropriate sanitary controls and disinfection practices in place
- Construct a dam and reservoir at the head of the Cove Valley to increase freshwater supply for household use (recommendation from Dr. Randall not yet agreed to by stakeholders)
- Construct wet and dry detention ponds at strategic locations in the Cove Valley to increase filtration into the aquifer
- Encourage the construction of farm ponds to support agriculture
- Control gully erosion throughout the island
- Improve erosion control in the Cove Valley
    a) Implement rigorous erosion controls for all construction projects, with the legal requirement that controls must be in place before breaking ground.
    b) Strengthen management and enforcement of tree felling and land clearing regulations.
    c) Eliminate all agricultural burning.

Water Quality Action Plan (WQA)

- Increase the capability and versatility of the laboratory to measure marine water quality
- Expand coastal and estuarine (mangrove forests) water quality data collection and analysis
- Identify "hot spots" in the coastal waters and design and implement appropriate actions for each spot, beginning with priority sites such as Hooker Bight (Old Point mangroves) and San Andres Bay
- Manage and reduce point-source pollution from wastewater outfalls and discharge sites
- Manage and reduce agricultural pollution (fertilizers, pesticides) and sedimentation
- Manage and reduce urban and village stormwater pollution and drainage (uncontrolled runoff)
- Implement modern conservation measures to reduce pollution and increase water filtration for all new constructions, such as requiring the use of porous pavers, infiltration areas, and swale drains
- Dam the mouths of gullies to reduce runoff and pollution into coastal waters and improve water filtration (recommendation from Dr. Randall not yet agreed to by stakeholders)
- Reduce erosion and sedimentation from agriculture, constructions, and other development
- Define the magnitude and impact of commercial fishing and fueling activities in coastal waters
- Develop a management plan for dredge spoils
- Manage ballast water discharges and the associated introduction of exotic marine species
- Develop an emergency action plan to reduce impacts and remediate the effects of marine spills, shipwrecks, and groundings

TENSORES DE CONTAMINACION EN LA CUENCA DEL COVE DE LA ISLA DE SAN ANDRES



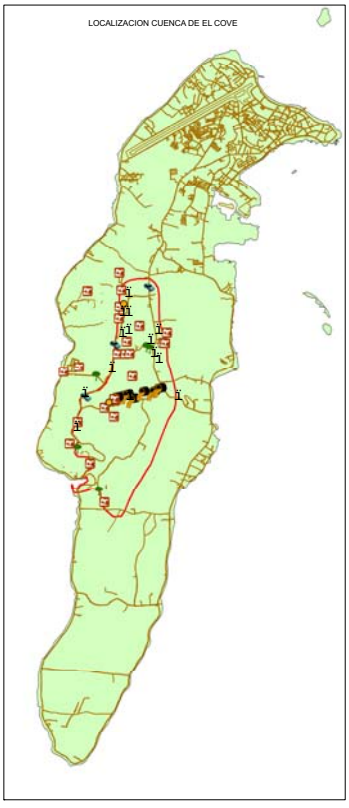
Corporación para el Desarrollo Sostenible del Archipiélago de San Andrés, Providencia y Santa Catalina

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

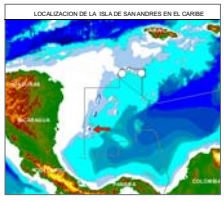
Leyenda

- Cementerios
- Talleres
- Galpones
- Ganaderia
- Botaderos
- Agricultores
- Red vial
- Límites cuenca
- Isla

LOCALIZACION CUENCA DE EL COVE



LOCALIZACION DE LA ISLA DE SAN ANDRES EN EL CARIBE



MAPA: TENSORES CONTAMINANTES CUENCA DEL COVE EN LA ISLA DE SAN ANDRES

ESCALA:	DATUM:	MAPA NO:
1:7.000	WGS84	

FUENTE:
PUNTOS REFERENCIADOS CON GPS - GRUPO CONTROL Y VIGILANCIA

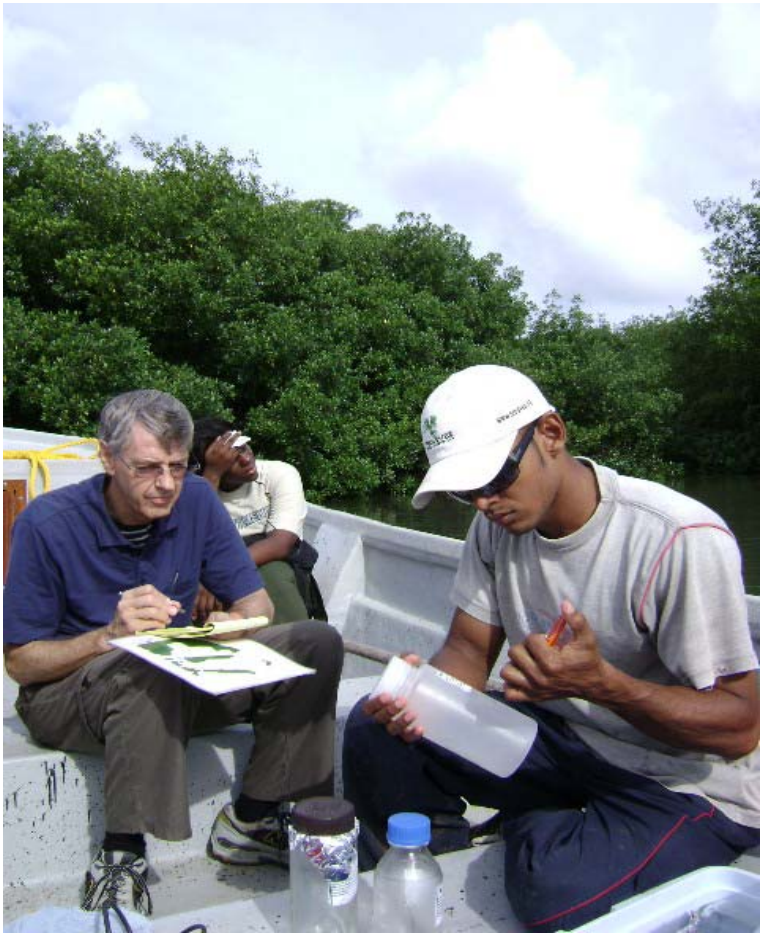
TECSIG:	FECHA DE ARREGLOS E IMPRESION:
A.Mitchell	Junio 18 de 2008

RUTA ARCHIVO:
C:/GIS/ARCHIVOS DE IMPRESION/SAN ANDRES/TENSORES CONTAMINANTES CUENCA COVE

PHOTO ROLL REGISTRATION

Work program 1.0 Monitoring

1.1 Complete an expert assessment of methods of data collection, including site selection, and analysis.



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1.2 Train CORALINA scientists and managers in new and revised monitoring methods and put these changes into practice.

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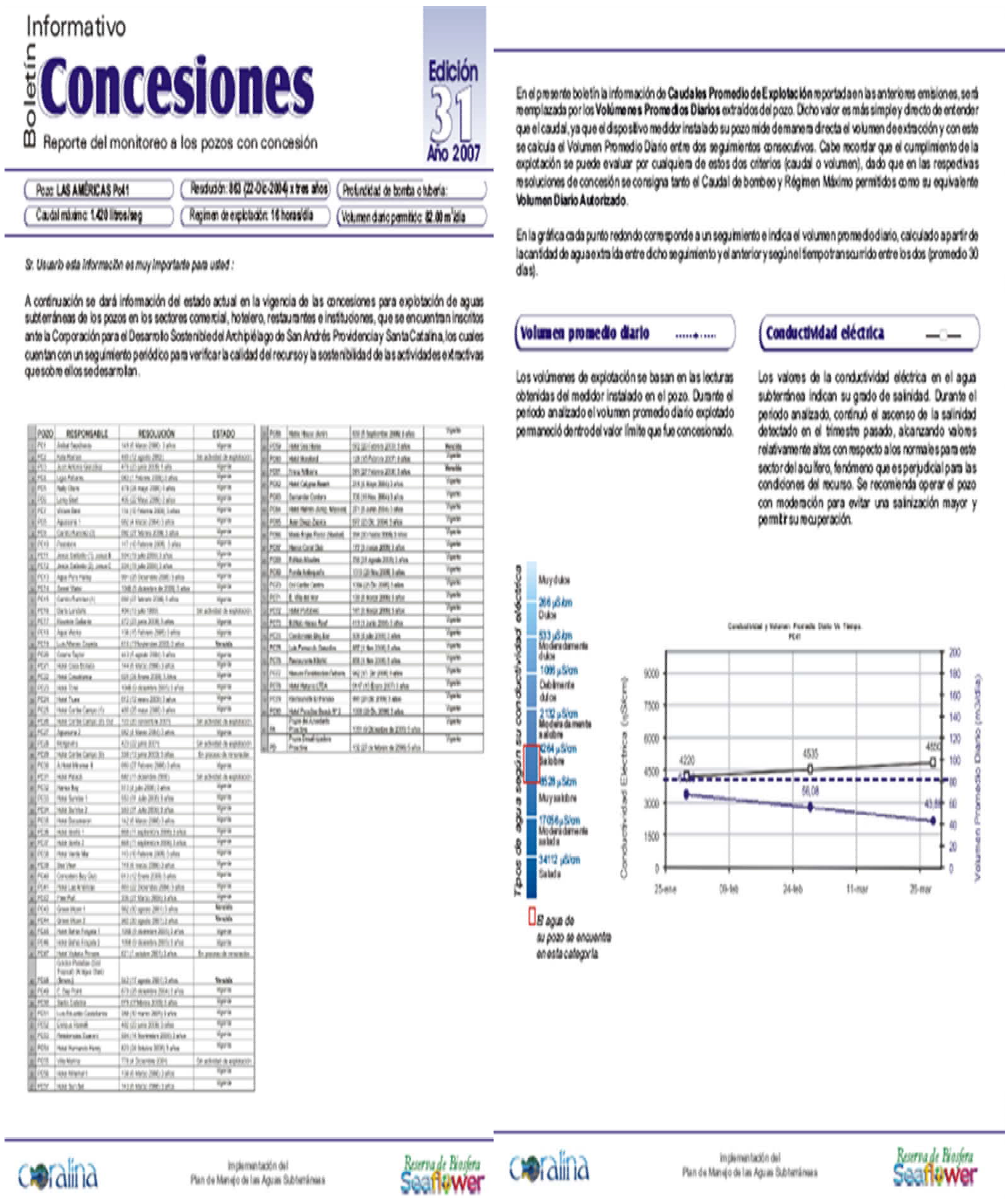
1.3 Involve stakeholders in monitoring

1.4 Develop appropriate ways to give information (monitoring results and their significance) back to the communities.

Bulletins distributed to owners of concessions wells



Informativo
Boletín **Concesiones**
Reporte del monitoreo a los pozos con concesión
Edición 31 Año 2007

Pozo: LAS AMÉRICAS Po41 | Resolución: 863 (22-Dic-2004) x tres años | Profundidad de bomba o tubería:
Caudal máximo: 1.420 litros/seg | Régimen de explotación: 16 horas/día | Volumen diario permitido: 82.00 m³/día

Sr. Usuario esta información es muy importante para usted :

A continuación se dará información del estado actual en la vigencia de las concesiones para explotación de aguas subterráneas de los pozos en los sectores comercial, hotelero, restaurantes e instituciones, que se encuentran inscritos ante la Corporación para el Desarrollo Sostenible del Archipiélago de San Andrés Providencia y Santa Catalina, los cuales cuentan con un seguimiento periódico para verificar la calidad del recurso y la sostenibilidad de las actividades extractivas que sobre ellos se desarrollan.

En el presente boletín la información de **Caudales Promedio de Explotación** reportada en las anteriores emisiones, será reemplazada por los **Volúmenes Promedios Diarios** extraídos del pozo. Dicho valor es más simple y directo de entender que el caudal, ya que el dispositivo medidor instalado su pozo mide de manera directa el volumen de extracción y con esto se calcula el Volumen Promedio Diario entre dos seguimientos consecutivos. Cabe recordar que el cumplimiento de la explotación se puede evaluar por cualquiera de estos dos criterios (caudal o volumen), dado que en las respectivas resoluciones de concesión se consigna tanto el Caudal de bombeo y Régimen Máximo permitidos como su equivalente **Volumen Diario Autorizado**.

En la gráfica cada punto redondo corresponde a un seguimiento e indica el volumen promedio diario, calculado a partir de la cantidad de agua extraída entre dicho seguimiento y el anterior y según el tiempo transcurrido entre los dos (promedio 30 días).

Volumen promedio diario

Los volúmenes de explotación se basan en las lecturas obtenidas del medidor instalado en el pozo. Durante el período analizado el volumen promedio diario explotado permaneció dentro del valor límite que fue concesionado.

Conductividad eléctrica

Los valores de la conductividad eléctrica en el agua subterránea indican su grado de salinidad. Durante el período analizado, continuó el ascenso de la salinidad detectado en el trimestre pasado, alcanzando valores relativamente altos con respecto a los normales para este sector del acuífero, fenómeno que es perjudicial para las condiciones del recurso. Se recomienda operar el pozo con moderación para evitar una salinización mayor y permitir su recuperación.

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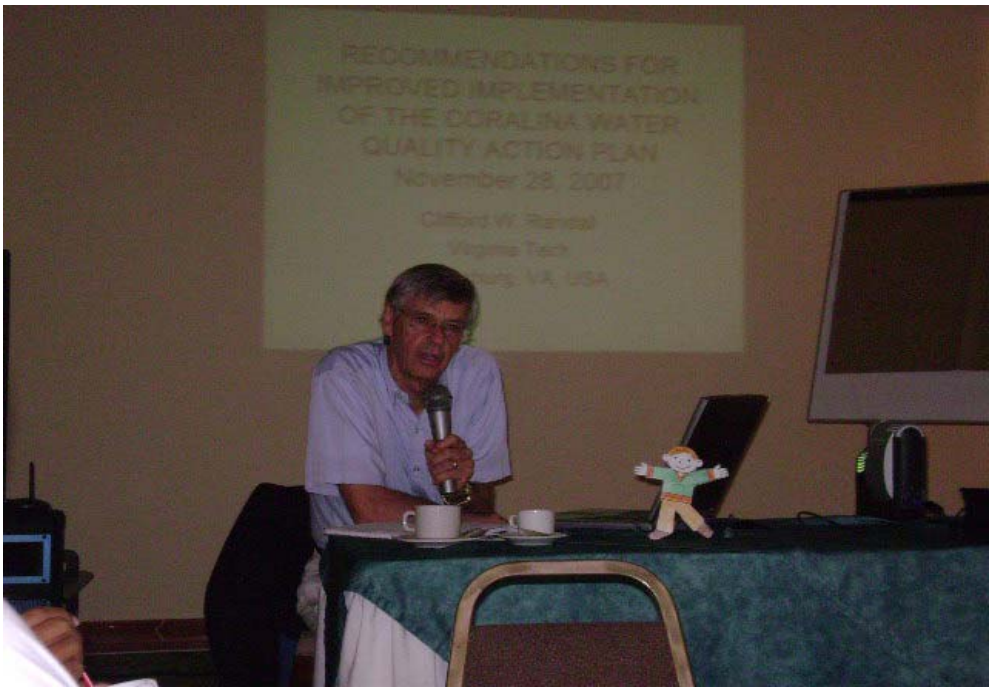
Work program 2.0 Management

2.1 Complete expert and participatory assessments of the IGM and WQA



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2.4 Reduce land-based pollution.

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2.5 Develop policies and practices to reduce pollution and sedimentation from construction sites in the watershed and coastal zone.

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2.6 Work with farmers in the watershed, including those that raise cattle and hogs

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Work program 3. Capacity building and empowerment.

3.1 Train key stakeholders.

3.2 Educate neighborhoods

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3.3 Carry out outreach program

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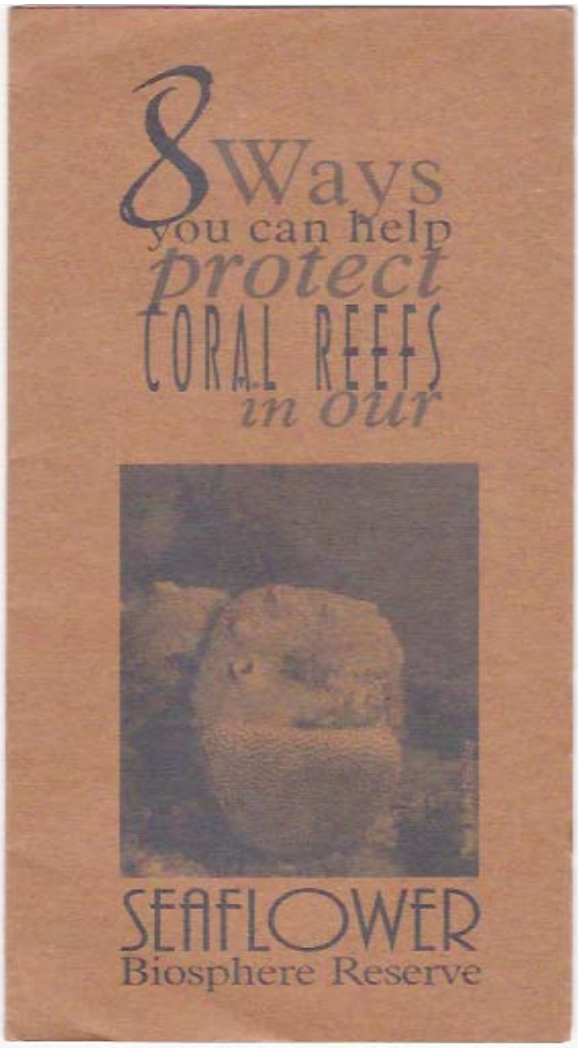
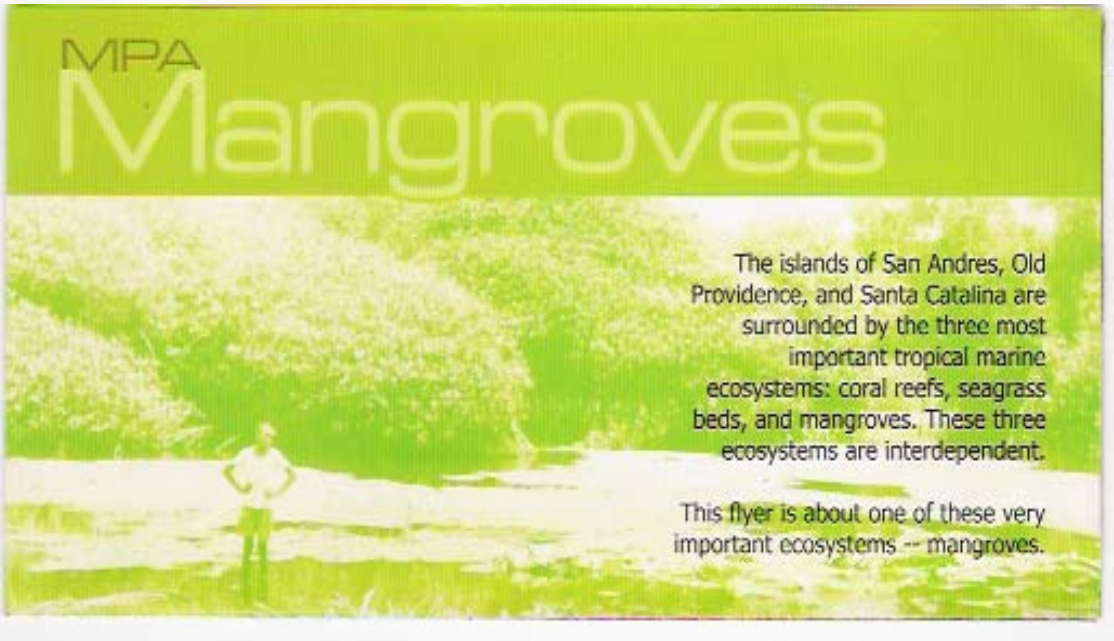
Educational materials distributed





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