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IMPACT AND AMELIORATION OF SEDIMENT AND AGRO-CHEMICAL POLLUTION IN CARIBBEAN COASTAL WATERS

Environmental Monitoring Options

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MRAG

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Authors:

MRAG Ltd, 47 Princes Gate, London SW7 2QA
Nicole Esteban
Chris Mees
Stephanie Seddon-Brown

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EXECUTIVE SUMMARY

Environmental monitoring is an essential tool in development management planning. It is the collection of information relating to selected *indicators* of the condition (*quality*) of the environment (e.g. presence or absence of chemicals, presence or absence of certain living species). Comparisons are made against :

- *baseline* information of local environmental quality, compared to a *reference* condition, that may be from another, but environmentally similar, water-body; and,
- Government set *standards* (e.g. for water quality),

against which the impact of external factors (such as pollution arising from agro-chemical run-off) and the success of present and future management actions can be assessed over time.

In the context of agrochemical pollution in water arising from land based activities, *watershed management* is important and is being increasingly adopted throughout the Caribbean. Watershed management is an integrated approach to management of the whole watershed, and the various activities that take place within it on land and water, rather than a focus on managing individual components of the watershed. Environmental monitoring can be a component of watershed management.

For monitoring to be effective, a *monitoring plan* should be developed. The plan should contain the goals and objectives of the monitoring programme, the procedures for carrying out the monitoring, data collection, data analysis and the programme evaluation. Scientifically reliable assessment techniques, quality controls, and valid sampling protocols to ensure that results are repeatable, consistent, and compatible with other data collection efforts are essential.

Monitoring is based on selected *indicators* of the quality of the environment. There are different costs associated with the *assessment* of different indicators (e.g. detection of pesticides is expensive), and certain monitoring techniques are more costly than others (e.g. rapid assessment methods have been developed that require a minimum resource commitment but can produce useful information on the condition of the environment). Monitoring agencies need to work with potential polluters (e.g. importers of agro-chemicals, owners of large farms) to assess the chief pollutant threats (e.g a particular pesticide), the vulnerability of different locations to pollutant threats (GIS can be a useful tool here), and to monitor the environment. The choice of indicator and assessment method must then be set in the context of the resources available; the use of the watershed (e.g. drinking water sources need particular attention); the management objectives for the watershed; any local considerations and watershed characteristics.

With respect to setting national *standards*, in Caribbean countries where resources are limited derivation of unique standards (e.g. for water quality) may not be practical and so these need to be based on widely accepted standards elsewhere. However, it may not be appropriate to base such standards on those in temperate countries or those with significantly different environmental conditions. Sharing of experience throughout the Caribbean is thus important and will enable the development of Caribbean specific standards over time. Similarly, sharing of information will be useful in establishing appropriate *reference conditions* for least disturbed locations.

To conclude: Environmental monitoring is an essential tool in development management planning. An *environmental monitoring plan* must be developed, and in relation to potential agro-chemical pollution this should be placed in the context of watershed management. Factors to consider in designing such a plan include:

- Goals and objectives of the monitoring programme
- Capacity and resources available (human and financial) to deliver adequate results in a specified timeframe
- Watershed characteristics, and use of the water-bodies to be monitored
- Assessment of pollutant threats
- Assessment of the vulnerability of a location or water-body to pollutant threats
- Adoption of scientifically robust and replicable techniques
- Selection of appropriate indicators to achieve monitoring objectives
- Sampling station specifics (i.e. where to sample along the watershed)
- Seasonality (i.e. when to sample)
- Definition of locally relevant reference conditions.
- Definition of locally relevant standards (e.g. of water quality)

ACRONYMS

BMP	Best Management Practice
CEHI	Caribbean Environmental Health Institute
CEP	Caribbean Environment Programme
CGPC	Coordinating Group of Pesticide Control Boards in the Caribbean
DFID	Department for International Development, UK
GIS	Geographic Information Systems
IADB	Inter-American Development Bank
IWCAM	Integrating Watershed and Coastal Areas Management
LWI	Land Water Interface
MAFF	Ministry of Agriculture, Forestry and Fisheries (St Lucia)
MRAG	Marine Resources Assessment Group Ltd (UK)
NEPA	National Environment and Planning Agency, Jamaica
NRCA	Natural Resources Conservation Authority, Jamaica
NRCS	National Resource Conservation Service, US
NRMU	Natural Resource Management Unit
OECS	Organisation of Eastern Caribbean States
PCA	Pesticides Control Authority (Jamaica)
PCB	Pesticides Control Board (St Lucia)
PSD	Pharmaceutical Services Division, Jamaica
RADA	Rural Agricultural Development Authority (Jamaica)
RBP	Rapid Bioassessment Protocols
RSAT	Rapid Stream Assessment Technique
R2R	Ridge to Reef Project, UAID (Jamaica)
SCA	Stream Corridor Assessment
SLASPA	St Lucia Air and Sea Ports Authority
STATIN	Statistical Institute of Jamaica
SVAP	Stream Visual Assessment Protocol
UNEP CAR/RCU	United Nations Environment Programme Caribbean Regional Coordinating Unit
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency
UWI	University of the West Indies
WASCO	Water and Sewage Commission, St Lucia
WIBDECO	Windward Islands Banana Development and Exporting Company Ltd.
WRA	Water Resources Authority, Jamaica

BACKGROUND

Introduction

This report contributes to a three-year research project *Impact and amelioration of sediment and agro-chemical*[1] *pollution in Caribbean coastal waters* which is funded by DFID's NRSP LWI programme (R7668). It follows on from an earlier LWI project *Review of the impacts of pollution by sediments and agro-chemicals of tropical coastal waters with reference to the Caribbean region* (R7111). The present project is managed by two organisations: the University of York, responsible for the sedimentation aspects of the project; and MRAG Ltd, responsible for agro-chemical components of the project, and was conducted in collaboration with project partners in Jamaica (University of the West Indies: Centre for Marine Sciences, Department of Chemistry, Natural Products Institute, and Caribbean Agricultural Research Institute; and, Caribbean Coastal Area Management Foundation) and St Lucia (MAFF: Department of Fisheries and Department of Agriculture; and, Caribbean Environmental Health Institute). Agro-chemical related activities were undertaken in St Lucia and Jamaica. The project commenced in June 2000 and ends in July 2003, with the publication of guidelines for best management practices for agro-chemical management.

Humans have been impacting the environment for centuries and altering the ecosystem's natural cycles, including producing pollutants that find their way to the streams, rivers, lakes and oceans. The coastal seas and oceans are especially vulnerable because they are often so close to the pollutant source, which is especially the case in the Wider Caribbean region where islands are very small in size. This means that pollutants do not have to travel a long way before they are found in coastal ecosystems and therefore may be found in high concentrations in coastal waters. In order to detect anthropogenic changes and impacts, it is therefore crucial to consistently monitor and collect baseline data. This type of information is then used to monitor the impacts and the fate of the various substances, such as agro-chemicals, on the environment.

Objectives

The present document aims to provide a review of some of the various environmental monitoring methods for agro-chemical pollution in the Caribbean. The report does not represent a comprehensive review of environmental monitoring options. Neither does it aim to prescribe or recommend particular options. Rather, it sets out to indicate the range of options available and provides references to sources of information available in the literature and on the web. Decisions on which options are relevant need to be placed in the context of available human and financial resources, and in the context of the perceived threat. This report also describes some existing monitoring occurring in Jamaica and St Lucia from consultation with relevant institutions[2] (see also Boodram, 2002; Edwards, 2001; Lewis and Esteban, 2002). It includes: An introduction to environmental monitoring; different methods for assessing various environmental indicators; water quality monitoring; watershed management; and, pollution studies.

[1] For the purpose of the current project, the term agro-chemical includes pesticides and fertilisers used in agriculture.

[2] Jamaica: PCA, RADA, PSD, WRA; St Lucia: PCB, MAFF, SLASPA,CEHI, Customs & Excise, OECS, SWMA, STATIN, WIBDECO, Bureau of Standards, SCIC, WASCO, Water Authority.

1 ENVIRONMENTAL MONITORING

1.1 Introduction

Monitoring the environment provides evidence of its quality or the impact of certain external factors that may be affecting it. Environmental monitoring is the collection of information relating to selected indicators of the condition of the environment at a certain point in time. Comparisons are made against baseline information over time. Such monitoring is useful to determine the impacts of particular actions (e.g. pollution arising from agriculture or development) and whether, for example, the predicted benefits of a treatment or management plan to address those impacts is successful. Results can suggest improvements to any management strategy (to reduce negative impacts) and can help define management of similar activities that may be proposed in the future.

For monitoring to be effective, a monitoring plan should be developed. The plan should contain the goals and objectives of the monitoring programme, the procedures for carrying out the monitoring, data collection, data analysis and the programme evaluation.[3] There are various monitoring programmes or projects that are currently underway in the Caribbean. One example is the CARICOMP programme on coral reef monitoring and another example is The Nature Conservancy programmes which have several tailored monitoring programmes for organic pollution (e.g. sugar, bauxite, sand mining).

There are many different types of environmental monitoring and some of these will be described in this report with emphasis on water quality monitoring and pollution studies. In the context of agrochemical pollution a number of factors need to be considered in designing a monitoring programme. Those examined in this report include:

- Management at the level of the Watershed
- Choosing relevant indicators for monitoring, and related sampling station specifics (i.e. where to sample along the watershed and when)
- Assessment methods (in the watershed, for water quality)
- Determination of the potential pollutant threat

1.2 Environmental Indicators

Environmental indicators are measurable features that can provide useful evidence of environmental and ecosystem quality or reliable evidence of trends in quality. They are selected parameters and indices which can be used to characterize overall conditions in the receiving water and provide benchmarks for assessing the success of watershed management efforts. It is therefore useful to use these indicators when monitoring certain aspects of the environment.

The Centre for Watershed Management has developed a useful website, the Stormwater Manager's Resource Centre which describes such indicators and includes useful information on stormwater management issues. The information below is taken from that source. Table 1 provides examples of 26 different types of environmental indicators. Profile sheets exist for each indicator on the website (http://www.stormwatercenter.net/). The profile sheets for each indicator include a

[3] UNEP, 1998

brief description of the indicator; a discussion on the usefulness of the particular indicator; a review of the advantages and disadvantages of the indicator; case studies; implementation costs (US dollars in 1995); and references.

Table 1-1 Potential watershed indicators[4]

	Environmental indicators
Water quality indicators	• Water quality pollutant constituent monitoring • Toxicity testing • Non-point source loadings • Exceedance frequencies of water quality standards • Sediment contamination • Human health criteria • Water quality indicators cost comparisons
Physical and hydrological indicators	• Stream widening/downcutting • Physical habitat quality • Impacted dry weather flows • Increased flooding frequency • Stream temperature monitoring • Physical and hydrological indicators cost comparisons
Biological indicators	• Fish assemblage analysis • Macro-invertebrate assemblage • Single species indicator • Composite indicators • Other biological indicators • Biological indicators cost comparisons
Social indicators	• Public attitude surveys • Industrial/commercial pollution prevention • Public involvement and monitoring • User perception • Social indicators cost comparisons
Programmatic indicators	• Number of illicit connections identified/corrected • Number of BMP's installed, inspected, and maintained • Permitting and compliance • Growth and development • Programmatic indicators cost comparisons
Site indicators	• BMP performance monitoring • Industrial site compliance monitoring

The choice of indicators for monitoring purposes should be based upon the management objectives for a watershed; any local considerations and watershed characteristics; and available resources. Different indicators will be used depending on the use of the watershed itself e.g. drinking water sources need particular attention; sites of special interest, e.g. for rare indigenous species, also need particular attention. Some examples of indicators and methods appropriate for differing watershed management categories are shown in Table 1-2.

[4] Source: http://www.stormwatercenter.net/ and adapted from Claytor, 1996.

Table 1-2 Indicators appropriate for different watershed management categories[5]

Watershed management category	Suggested indicators
Sensitive stream	• Single species bio-monitoring (e.g., crayfish) • Impervious cover measurements • Aquatic habitat and the stream geometry
Impacted stream	• Impervious cover measurements • Aquatic habitat and stream geometry • Biological indicators such as macro-invertebrate and fish populations
Non-supporting Stream	• Single species bio-monitoring • Selected chemical constituents such as metals, hydrocarbons, and other toxins • Trash and debris surveys • Public attitude surveys
Restorable stream	• Impervious cover measurements • Aquatic habitat and stream geometry • Biological indicators such as macro-invertebrate and fish populations • Trash and debris surveys • Public attitude surveys • Programmatic indicators
Urban lake	• Impervious cover measurements • Monitoring for selected chemical constituents, such as phosphorus • Water clarity or turbidity • Bacteria monitoring or beach closures • Programmatic indicators
Water supply reservoir	• Impervious cover measurement • Monitoring for selected chemical constituents such as bacteria and other pathogens • Water clarity or turbidity
Coastal or estuarine	• Biological indicators such as macro-invertebrate and fish populations • Monitoring for selected chemical constituents • Bacteria monitoring, shellfish beds, or beach closures
Aquifer protection	• Impervious cover measurement • Biological indicators such as amphibians, macro-invertebrates and fish • Selected chemical constituents such as metals, hydrocarbons, and trace metals

[5] Source: http://www.stormwatercenter.net

Regardless of the specific indicators selected, it is important to utilize scientifically reliable assessment techniques, quality controls, and valid sampling protocols to ensure that results are repeatable, consistent, and compatible with other data collection efforts.

The first step in using environmental indicators is to establish a baseline or current condition against which the success of future watershed management actions can be assessed. This baseline then needs to be compared to a reference condition. The reference condition is the best attainable condition for that indicator in a "least disturbed" location. For the reference condition to be appropriate it must be from an area with similar natural environmental conditions, such as within the same geological area, eco region, and of the same drainage area and/or stream order to reflect what the baseline condition would be in the absence of disturbance.

Some environmental indicators require that monitoring stations be established and field sampling conducted. Indicator monitoring may require several years of sampling to be able to establish trends and assess programme effectiveness. For those indicators that require field sampling, there are several key factors to consider when establishing long term field monitoring stations. Stations that are poorly chosen may provide no useful information, or require several years of additional data collection to provide the necessary information. Table 1-3 highlights some key factors to consider when locating field monitoring stations.

Table 1-3 Key factors to look at when locating indicator monitoring stations[6]

Location consideration	Notes
Station should be representative of sub-watershed characteristics	Consider available resources (funds and staff) to determine the number of stations per sub-watershed. Remember that the assessment of management measures will depend on results of monitoring and sub-watershed classification will depend on conditions of resource.
Stations should be located downstream of proposed future activities	In order to assess the implementation of land use management techniques, BMPs or other sub-watershed protection measures, monitoring stations must be carefully located in order to compare before and after conditions.
Stations should be located based on statistical randomness criteria (where appropriate)	When using the monitoring data to compare multiple sub-watersheds, the location of stations should be consistent across the spectrum of sub-watersheds being analysed. Two commonly used techniques are to locate stations at the confluence of second order streams or just upstream of road crossings.
Stations should be relatively easy to access	Some stations will need to be revisited tens to hundreds of times. Managers need to consider ease of access and time in locating stations.

[6] Source: http://www.stormwatercenter.net

Location consideration	Notes
Stations not likely to be compromised by vandals or storm damage	Stations that involve installing expensive or sophisticated monitoring equipment should be located in a "secure" area and consideration should be given to what will happen to equipment during a major storm. Equipment may need to be housed in a durable monitoring "house" or have remote sensors or samplers to collect data.

1.3 Different methods for assessing environmental indicators: Rapid Assessment Methods

Indicator monitoring often involves complex data collection and analysis techniques that can require substantial investments of time and resources. Local communities often lack the resources and expertise to undertake these complex tasks, yet need accurate information on watershed and stream conditions. Rapid assessment methods have been developed that are scientifically reliable and replicable yet are methods that can be undertaken with a minimum resource commitment while producing timely, useable information. The Storm Water Centre website provides details on various rapid assessment methods, briefly, these methods include:

- Impervious cover model. Impervious cover can be defined as any surface in the urban landscape that cannot effectively absorb or infiltrate rainfall. As the percentage of impervious cover increases with increased urbanisation in the vicinity of a watershed, stream quality tends to diminish. This classification system allows a community to predict the current and future stream quality based on the assessment of impervious cover.

- Simple method. This model allows stormwater runoff pollutant loads to be calculated with a minimum need for data collection. Pollutant loads for chemical constituents are estimated as a product of total annual runoff and pollutant concentrations.

- Rapid stream assessment technique (RSAT). The assessment method allows rapid assessment of stream conditions and restoration needs. The methodology is available as a downloadable file[7].

- Rapid bioassessment protocols. The Rapid Bioassessment Protocols (RBP) are a series of methodologies developed by the U.S. Environmental Protection Agency (USEPA) for assessing water quality, habitat, and biology in streams and rivers and can be found on their website. [8]

- Stream visual assessment protocol. The USDA Natural Resource Conservation Service (NRCS) developed the Stream Visual Assessment Protocol (SVAP) as a basic assessment technique that does not require

[7] http://www.stormwatercenter.net/monitoring and assessment/rsat/smrc rsat.pdf
[8] www.epa.gov/owow/monitoring/rbp/

extensive biological expertise or training[9]. This assessment is intended to be conducted in cooperation with landowners as an educational/outreach tool.

[9] www.wcc.nrcs.usda.gov/water/quality/frame/wqam/

2 WATER QUALITY MONITORING

2.1 Jamaica

Water quality is often tested to provide information on the overall condition of a watershed. There are standardised sets of water quality parameters that are used for different water sources to control watershed activities (agriculture, industrial, sewage, etc).

The Water Resources Authority (WRA) is the hydrological agency of the Ministry of Water and Housing and has a mandate to monitor water resources for Jamaica. Amongst their many duties the WRA monitor the water quality of ground and surface water and assess hydrological basins in terms of their availability and quality.[10]

In order to maintain control of the quality of Jamaica's water resources, the WRA is empowered by the Water Resources Act (1995) to declare Water Quality Control Areas. To date, no such declaration has been made but national ambient water quality standards have been developed for freshwater in Jamaica (see Table 2-1) as well as for trade and sewage effluent. There are however, no standards set for marine conditions.

Table 2-1 Jamaican National Ambient Water Quality Standard – Freshwater

Parameter	Measured as	Standard Range	Unit
Calcium	(Ca)	40.00-101.0	mg/L
Chloride	(Cl^-)	5.00- 20.0	mg/L
Magnesium	(Mg^{2+})	3.60- 27.0	mg/L
Nitrate	(NO_3^-)	0.10- 7.5	mg/L
Phosphate	(PO_4^{3-})	0.01 - 0.8	mg/L
pH	(-)	7.00- 8.4	-
Potassium	(K^+)	0.74- 5.0	mg/L
Silica	($Si0_4$ or Si_2^+)	5.00- 39.0	mg/L
Sodium	(Na^+)	4.50- 12.0	mg/L
Sulphate	(SO_4^{2-})	3.00- 10.0	mg/L
Hardness	($CaCO_3$)	127.00-381.0	mg/L (as $CaC0_3$
Biochemical Oxygen Demand		0.80- 1.7	mg/L
Conductivity		150.00-600	ΦS/cm
Total Dissolved Solids		120.00-300	mg/L

Source: WRA[11]

The WRA (Jamaica) is assisting with the drafting of national standards for ambient, potable, irrigation and recreational water quality. Together with the National Environment and Planning Agency (NEPA)[12], and other government and research organizations, national standards are also being developed for:

[10] Esteban, 2001
[11] Source: www.nepa.gov.jm/standards/
[12] NEPA was previously called the Natural Resources Conservation Authority (NRCA).

- The quality of liquid industrial waste and sewage discharged into ponds, rivers, and coastal waters.
- The minimum quality of the natural surface and underground water resources.

The WRA and NEPA are presently setting up a national water quality and sediment loading (streams) monitoring programme. The WRA have produced an atlas on water quality in draft form which has collated information from all agencies (including pesticides, nutrients, chemicals, industrial pollution and saline intrusion).

2.2 St Lucia

In St Lucia, the Water and Sewage Commission is responsible for the management of water resources. St Lucia does not have standardised water quality parameters neither for marine nor freshwater and the laboratories usually compare their results against widely accepted levels and the US Environmental Protection Agency (USEPA) standards.[13]

[13] For more information on EPA water standards see: http://www.epa.gov/ebtpages/watewaterqstandards.html

3 WATERSHED MANAGEMENT

Watershed management is an integrated approach to management of a particular system (i.e. the whole watershed, and the various activities that take place within it on land and water), rather than focussing on managing individual components of the watershed. Environmental monitoring can be a component of watershed management. The need for management of watersheds is increasingly recognised and has already been taken up in St Lucia and Jamaica.

3.1 Jamaica

A Watershed Monitoring Programme is to be developed for use primarily by NEPA in Jamaica. This programme will provide information which will enable NEPA to: develop and set up a national watershed programme; identify issues and problems in the watersheds; make sound decisions; carry out appropriate actions and track progress.

Case study: Water Resources Authority (WRA)

Technical input to water erosion control, the identification of critical watersheds, and training programmes are provided by the Water Resources Authority (WRA). They have also contributed to the standardization of Jamaica's watershed management units and documentation on maps.

A method of prioritising watersheds for rehabilitation has been developed, in collaboration with the National Environment and Planning Agency (NEPA) and other government and research organizations. The method is based on: watershed characteristics such as slope, soil, and plant cover, land use and rainfall; the potential damage to property and infrastructure; and the quantity, quality, and use of water resources in the area. The Hope River, Rio Cobre, Great River, Yallahs River, and Rio Minho watersheds were selected for initial rehabilitation under an Inter-American Development Bank (IADB) funded project.

The Jamaican Government recognizes the importance of watershed management research. Given the resource constraints, research activities will focus on more applied research. This will include determining erosion rates; identifying the most appropriate erosion control measures; studying farmers' and other land users' acceptance of conservation treatments or methods; and identifying incentive needs and effectiveness. Joint research initiatives will also be undertaken with other organizations and institutions.[14]

Case Study: From Ridge to Reef (R2R)

The Ridge to Reef (R2R) project is funded by the United States Agency for International Development (USAID) and is a five year programme which focuses on achieving upland watershed management results with subsequent downstream improvements along the LWI in Jamaica. It addresses watershed degradation by improving and sustaining management of natural resources in targeted areas. The project is targeting the Great River and Rio Grande watersheds and has as its main objectives to: improve the skills and capacity for sustainable natural resource management, the promotion of eco-friendly watershed usage, including improved farming practices and finally the increased public awareness of the strong links between the various activities in the upper part of the watersheds and the LWI.

3.2 St Lucia

There are a number of initiatives in St Lucia, including those in the ‘St George’s Declaration of Principles for Environmental Sustainability in the OECS’ to which St Lucia has made a formal commitment. The Declaration covers watershed management and protection as well as a number of other areas. The main focus of the Declaration is the integration of the basic sustainable development principles of integrating social, economic and environmental considerations into the national development policies, plans and programmes.

Case Study: Watershed management in St Lucia and St Vincent and the Grenadines

The project is sponsored by the Organisation of Eastern Caribbean States (OECS) and by the USAID and is supported by many community based organisations. Their approach is increasingly common for co-management of natural resources. There are two pilot sites with watersheds in St Lucia and St Vincent and the Grenadines. These watersheds have suffered from various problems such as banana cultivation including agro-chemical use, run-off, soil erosion, animal grazing, and discharge of effluent from local communities. A core committee was formed with local representatives (farmers and key stakeholders) and national representatives (Forestry Dept. and scientists) to target the existing problems in these watersheds. After two years, strong partnerships were formed between the Forestry Dept. and the local communities, and the programme gave rise to modified practices as well as an increased awareness of the water quality.

3.3 Regional Programmes

Regional initiatives include those programmes through the United Nations Environment Programme Caribbean Regional Coordinating Unit (UNEP CAR/RCU) and the OECS Natural Resource Management Unit. One of the major regional watershed initiatives is the GEF project: Integrating Watershed and Coastal Areas Management in Small Island Developing States of the Caribbean (IWCAM). This is a large project looking at all aspects of watershed management and brings together the Caribbean Governments that have limited resources but a common goal to pursue a path of sustainable development. It is co-executed by the Caribbean Environmental Health Institute (CEHI) and the UNEP CAR/RCU in Jamaica. CEHI are designated as the lead agency for freshwater resources management in the region and the UNEP CAR/RCU has been designated the lead for biodiversity and integrated coastal zone management. The full project will look to strengthen institutional capacity at the national and regional level; provide assistance to countries in understanding the links between problems in the freshwater and marine environments; assist countries in integrating their management of watersheds and coastal areas; and address national priorities within the regional context.[15] The demonstration projects for IWCAM have currently been submitted to GEF for review. It is important that any future actions and monitoring programmes in the region look to explore how they may be tied into this IWCAM programme to avoid duplication and ensure sustainability of these actions.

[15] For more information on this programme see : www.cehi.org.lc/water_resources/

4 POLLUTION STUDIES

The aim of pollution studies is to recognise or identify the potential polluters and work with them to monitor the environment. On an international level, the United Nations International Maritime Organization works in close cooperation with the petroleum and shipping industries to monitor the environment and work on joint programmes to ensure that governments and industry are more prepared for oil spills. They also cooperate to fund and support continuous research on the impacts of oil on certain marine communities. In Jamaica, the WRA has worked with the bauxite companies and the Petroleum Corporation of Jamaica (PCJ). Different methodologies of monitoring and evaluating point and non-point pollution sources are described in the sections below.

4.1 Pollution vulnerability mapping

An assessment of potential pollution problem areas is important for determining sites where development will have least impact on natural resources. Pollution vulnerability mapping is often based on Geographic Information Systems (GIS) and is a useful tool for planning and environment departments.

Groundwater vulnerability mapping is an example whereby the vulnerability of different aquifers to pollution is determined. In Jamaica, three provisional maps of groundwater vulnerability have been completed for Kingston, Montego Bay, and St. Elizabeth.[16] The following figure shows an example of the Kingston map:

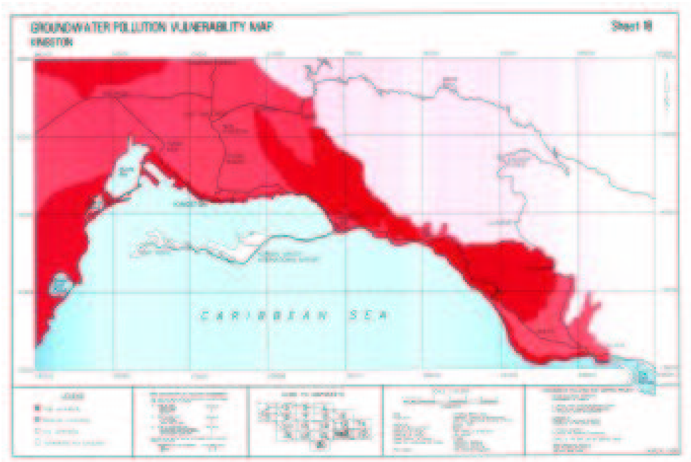

Figure 4-1 Groundwater Pollution Vulnerability Map of Kingston

4.2 Stream assessment

In addition to mapping analysis based on remote sensing tools, field assessments of on-the-ground conditions are invaluable in validation of remote imagery and the identification of restoration opportunities. While there are many stream assessment techniques (see field training by the Centre for Watershed Protection[17]) available for

[16] For more information see www.wra-ja.org/
[17] www.cwp.org/Community_Watersheds/stream_assessment.htm

watershed monitoring, the EPA method is frequently used, such as the Rapid Bioassessment Protocol (RBP) Habitat Assessment[18] to broadly distinguish between subwatersheds. In the US, the state of Maryland's new Stream Corridor Assessment (SCA) Survey is helping restoration practitioners to identify stream restoration priorities in Maryland watersheds. Over the last five years, the Water Restoration Division (WRD) of the Maryland Department of Natural Resources has been developing and refining the SCA Survey, a training and assessment tool that will provide assistance to local governments, watershed associations, and any other land management group interested in environmental restoration or management at the small watershed scale.[19]

4.3 Island-wide monitoring for agro-chemical pollution

The majority of past studies have focussed on particular pesticides (often those that are easy to analyse and those known to be persistent eg. dieldrin, endosulfan, DDT) in one location and there has not been an island wide system for monitoring. To monitor agro-chemical pollution island-wide, a range of pesticides are selected based on import and/or manufacture data, as appropriate. Priority pesticides are generally selected to reduce costs and then certain pesticides chosen (focusing on those that are also restricted for use in the environment e.g. atrazine in ground water and endosulfan) based on the available budget. The frequency of sampling is determined based on the potential of a sample site for contamination. Watersheds are selected for a variety of crop types, to include watersheds with low agricultural production as well as high production for comparison. Lastly, sites are selected downstream and upstream of agricultural fields; in the proximity to water abstraction sites; downstream and upstream of water treatment plants; and before a water-use centre sensitive to pesticide pollution (eg. aquaculture).

This methodology was used for the current study (see Lewis and Esteban 2002). A snapshot survey rather than an extended monitoring programme was conducted. It focussed on 3 watersheds in St Lucia and pesticides were prioritised according to their toxicity and/or quantity imported or used in the country. The factors that contributed to this decision included the high cost of chemical analyses, the desire to include as many chemicals as possible in the analysis, and for the study to be as comprehensive as possible.

4.4 Biotic and chemical monitoring integrated with GIS

Geographic Information Systems (GIS) are often used in pollution studies to overlay the land use data with water quality parameters. Biotic monitoring of benthic invertebrates in streams and rivers is a low cost means of monitoring river pollution. Chemical and microbiological monitoring at selected sites provides an additional means of assessing impacts of pollution. An example of a river monitoring programme and integrating the use of GIS is that set up by Lloyd and Thorpe (1997)[20] with CEHI in St Lucia. They used 52 macro-invertebrate groups and a monitoring network of 50 sample stations in 15 streams. Emphasis was on water supply, stream gauging and prawn farming and the highest priority was given to locations of water abstraction intakes. Stations were also chosen to reflect altitudinal

[18] www.epa.gov/owow/monitoring/rbp/
[19] Source: www.epa.gov/owow/info/NewsNotes/issue59/states59.html
[20] Lloyd, B. and Thorpe, T. (1997) The development and integration of biotic and chemical monitoring with land use assessment for tropical river resource management. ODA Environment Research Programme. Final report on project R5936.

variation in land use and activities in the lower, middle and upper catchments. A GIS using remote sensing data to define land use at present, as well as in the past 10 years was overlayed with the water quality data, to see where there may have been, or may be, a cause and effect of stress on the environment or ecosystem. In this case, GIS therefore allowed data to be viewed spatially allowing these cause and effect relationships to be more evident.

5 CONCLUSIONS

5.1 Conclusions

Environmental monitoring is an essential tool in development management planning. In the context of agrochemical pollution in water arising from land based activities, integrated watershed management is important and is being increasingly adopted throughout the Caribbean. Environmental monitoring can be a component of watershed management.

For monitoring to be effective, a monitoring plan should be developed. The plan should contain the goals and objectives of the monitoring programme, the procedures for carrying out the monitoring, data collection, data analysis and the programme evaluation. Scientifically reliable assessment techniques, quality controls, and valid sampling protocols to ensure that results are repeatable, consistent, and compatible with other data collection efforts are essential.

Monitoring is based on selected indicators of the quality of the environment. There are different costs associated with the assessment of different indicators (e.g. detection of pesticides is expensive), and certain monitoring techniques are more costly than others (e.g. rapid assessment methods have been developed that require a minimum resource commitment but can produce useful information on the condition of the environment).

For the Caribbean, feasible and practical monitoring options are required given the typically low resources available. For example, it is difficult to encourage wide scale long-term environmental monitoring programmes when these are often hampered by the unavailability of labs or equipment to do the analysis locally (and high cost) and therefore the high costs associated when foreign labs do the analysis. Such programmes are therefore often funded by specific donor or international agencies that give support for short or defined periods of time. This does not always allow for sustainability of these monitoring programmes. Local technical capacity may also need to be developed to meet the requirements of particular monitoring programmes.

Monitoring agencies need to work with potential polluters (e.g. importers of agro-chemicals, owners of large farms) to assess the chief pollutant threats (e.g a particular pesticide), the vulnerability of different locations to pollutant threats (GIS can be a useful tool here), and to monitor the environment. The choice of indicator and assessment method must then be set in the context of the resources available; the use of the watershed (e.g. drinking water sources need particular attention); the management objectives for the watershed; any local considerations and watershed characteristics.

With respect to setting national standards, in Caribbean countries where resources are limited derivation of unique standards (e.g. for water quality) may not be practical and so these need to be based on widely accepted standards elsewhere. However, it may not be appropriate to base such standards on those in temperate countries or those with significantly different environmental conditions. Sharing of experience throughout the Caribbean is thus important and will enable the development of Caribbean specific standards over time.

In a similar vein, local studies based on locally relevant indicators must be shared, and those used to define a baseline and a reference condition. Successful monitoring programmes depend on factors such as availability of baseline data. For example in

St Lucia, some baseline macro invertebrate data is available through the Lloyd and Thorpe (1997) work and a macro invertebrate species identification manual was developed by CEHI. However, this type of baseline data may not always be available in all countries but comparisons may be drawn, and conclusions on appropriate reference conditions derived. Use of macro invertebrates as pollution indicators are often regarded as cheap and rapid assessment methods (biological indicators). However, there is a need for people to have the necessary expertise to identify the various species. This expertise may or may not be available in country and may not always be at a low cost. Capacity building may be required.

To conclude: Environmental monitoring is an essential tool in development management planning. An environmental monitoring plan must be developed, and in relation to potential agro-chemical pollution this should be placed in the context of watershed management. Factors to consider in designing such a plan include:

- Goals and objectives of the monitoring programme
- Capacity and resources available (human and financial) to deliver adequate results in a specified timeframe (Capacity building)
- Watershed characteristics, and use of the water-bodies to be monitored
- Assessment of pollutant threats
- Assessment of the vulnerability of a location or water-body to pollutant threats
- Adoption of scientifically robust and replicable techniques
- Selection of appropriate indicators to achieve monitoring objectives
- Sampling station specifics (i.e. where to sample along the watershed)
- Seasonality (i.e. when to sample)
- Definition of locally relevant standards (e.g. of water quality)
- Definition of locally relevant reference conditions or sites.

The reader is referred to the reference list for more detailed information on topics covered in this report.

5.2 Potential follow up actions

Given limited capacity and resources, effectively targeted research activities and long term monitoring programmes are essential. There is potential for action at both the national and regional level.

Nationally

- Investigate the expertise, financial resources and personnel in the Rural Agricultural Development Authority (RADA Jamaica), the Ministry of Agriculture, Forestry and Fisheries (MAFF in St Lucia), the Pesticide Control Board (St Lucia) and Pesticide Control Authority (Jamaica) and other relevant organisations, such as CEHI and the University of the West Indies (UWI), to see what is feasible in terms of further research and monitoring.
- Evaluation of existing monitoring capacity.
- Evaluation of agro-chemical pollutant threats in order to target any monitoring activity
- Compile available existing material on threatened watersheds, and identify gaps in knowledge requiring further study.
- Establish monitoring plans in the context of existing national protocols and those committed to regionally (e.g. St Georges Declaration), and appropriate to local capacity and resources.
- Develop local capacity for monitoring.

Regionally

- Evaluate the potential for locally shared reference conditions and sites relating to similar habitats throughout the Caribbean versus the need for locally specific conditions. Compile data on undisturbed and less disturbed watershed habitats to develop a regionally applicable set of reference conditions (Who: Commission via the Coordinating Group of Pesticide Control Boards in the Caribbean (CGPC) and with CEHI– National bodies to contribute to this process).
- Evaluate the potential for harmonisation of standards throughout the Caribbean. Jointly explore standards appropriate to the local environmental conditions, and establish national / regional standards. (Who: CGPC; CEHI)
- Compile all nationally available information (as above); analyses effectiveness of alternative approaches; share information to enhance local programmes. Regionally, it may be possible to pool resources for the Wider Caribbean countries, such that research and long term monitoring programmes could be funded through a regional agency or body like the CGPC. Research could be shared between the countries through a common regional database that is maintained by the CGPC Secretariat, UNEP Caribbean Environment Programme (CEP) or a dedicated team.
- Provide capacity building programmes to national partners (e.g. CEHI)

6 REFERENCE LIST AND USEFUL WEB SITES

Boodram, N. (2002) Fate of agro-chemicals in the land-water interface, with reference to St Lucia. Research Project DFID NRSP R7668. London: MRAG Ltd. www.mragltd.com (select land water interface; selected project examples and Report 4).

Caribbean Environmental Health Institute
http://www.cehi.org.lc/water_resources/

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Esteban, N. (2001) Report of a project visit to Jamaica and St Lucia. Impact and Amelioration of Sediment And Agro-Chemical Pollution On Caribbean Coastal Waters. Report for research project DFID NRSP R7668. December 2001. London: MRAG Ltd. www.mragltd.com (select land water interface; selected project examples and Trip Report 3).

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Lloyd, B. and Thorpe, T. (1997) The development and integration of biotic and chemical monitoring with land use assessment for tropical river resource management. ODA Environment Research Programme. Final report on project R5936.

National Environment and Planning Agency (NEPA) Jamaica:
http://www.nepa.gov.jm/standards/

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United Nations Environment Programme (UNEP) (1998) Best Management Practices for Agricultural Non-point Sources of Pollution. CEP Technical Report No. 41. UNEP Caribbean Environment Programme, Kingston.

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USDA Natural Resource Conservation Service (NRCS) water quality assessment web page: http://www.wcc.nrcs.usda.gov/water/quality/frame/wqam/

Water Resources Authority (WRA) Jamaica: www.wra-ja.org/