PROJECT WATER (GRAHAMSTOWN): A CASE STUDY OF THE DEVELOPMENT OF AN ENVIRONMENTAL EDUCATION PROJECT

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ALICE NICOLA ASHWELL

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ABSTRACT

Environmental education is an approach to education which emphasises the interrelatedness of people and their human and non-human environments and seeks to encourage environmental awareness, concern and action.

This case study documents the implementation and development of Project WATER, Grahamstown, a practical environmental education project dealing with catchment conservation and water quality monitoring. The Grahamstown project is one of a number of local water quality monitoring initiatives affiliated to GREEN (the Global Rivers Environmental Education Network). Participants in the project included student teachers from the Department of Education at Rhodes University and pupils and teachers from three farm schools in the district and four high schools in the town. Project WATER, Grahamstown developed as an Action Research and Community Problem-Solving project.

The study focuses on fragmentalist and holistic approaches to education, people's responses to Project WATER and the choice of action research as the research method.

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CHAPTER ONE: INTRODUCTION

1.1 ENVIRONMENTAL EDUCATION AND THE CURRENT CRISIS:

> Whenever society faces large problems, there is a tendency to think that either their roots or their solutions lie at least partly in the education system.
>
> (Brennan 1991:279)

Humanity is facing an environmental and social crisis of unprecedented proportions. Large-scale exploitation of natural ecosystems and human societies by powerful political and economic interests has resulted in species extinctions, impoverishment and displacement of human communities, pollution of air, water and soil, a rise in the incidence of certain pollution-related illnesses, and burgeoning consumerism and wastefulness. Unlike past generations, in the face of global overpopulation, people can no longer counter the effects of overexploitation and overcrowding by moving to less populated areas (Bowers & Flinders, 1990). It is time to face rather than try to escape our problems.

Many authors (Bowers & Flinders, 1990; Capra, 1983; Engel, 1990; Kurth-Schai, 1992; Merchant, 1983; Orr, 1992; Sterling, 1990) maintain that this environmental and social crisis results from "the worldview that has developed out of ... seventeenth century Galilean-Cartesian-Baconian-Newtonian science" (Orr, 1992:iv). Aspects of this dominant worldview, which Orr associates with modernism, include reductionism, dualism and a mechanistic worldview. Reductionism refers to a concern to study, in an objective manner (Bowers & Flinders, 1990), component parts of systems rather than interrelationships and wholes (Capra, 1983). Related to this, a mechanistic view of complex systems such as the Earth reduces them to mechanical rather than organic systems which can be controlled and manipulated through understanding their component parts (Merchant, 1983; Sterling, 1990). Dualism is the tendency to view aspects of life as independent pairs of factors which are seen as oppositional, exclusive and unequal in value, such as humanity and nature, mind and body, student and teacher, reason and emotion (Kurth-Schai, 1992). Such views contribute to a

sense of alienation of individuals from their human and non-human environments. This possibly accounts for the apparent lack of concern with which people exploit and degrade the very systems upon which their lives depend. Bowers and Flinders (1990:120), in commenting on the inadequacy of a reductionist worldview to address present-day environmental challenges, warn that "... the permanent loss of topsoil, contamination and depletion of water resources and altered atmospheric conditions - because of cultural assumptions and practices that seemed progressive in the seventeenth century - may not be survivable over the long term".

Orr (1992) feels that the ecological crisis represents, in large measure, a failure of education to provide society with an alternative and more sustainable worldview. Gough (1989:233) notes that schools not only reflect but also perpetuate the dominant worldview described above:

> Holistic emphases are conspicuous by their absence in conventional schools, which reinforce an atomistic world view through virtually every aspect of their design, construction and modes of operation.

Despite the existence of alternative models of holistic (Greig, Pike & Selby, 1987 & 1989), active and experiential teaching and learning (Brady, 1985; Criticos, 1989; Dewey, 1956; Warner Weil & Mc Gill, 1989), reductionist approaches predominate in most schools. Obvious examples include the separation of knowledge into unintegrated subject disciplines, the division of pupils according to age and 'ability' and the progressive specialization of pupils in certain subject areas (Bowers & Flinders, 1990; Gough, 1989; Greig, Pike & Selby, 1989). The dominant worldview is also reflected in the objectification of knowledge, which has had a profound effect on the practice of schooling. Knowledge, in Cartesian terms, is seen as objective and 'value-free', built up of facts which can be proven empirically (Capra, 1983; Merchant, 1983). Knowledge taught at schools may be seen as a commodity, with teachers and texts as purveyors and pupils as consumers of that commodity. Most of this knowledge originates in the 'storehouses' of existing social knowledge, rather than from direct perceptions by students of their environments (Gough, 1989). Individual pupils

compete for knowledge which teachers are encouraged to transmit as efficiently as possible, success in the competition being rewarded by grades and promotion.

In my opinion, a commodity view of knowledge does not encourage critical questioning of that knowledge or of the structures responsible for its transmission. It does, however, provide many opportunities for control of the learner through, for example, prescriptive syllabi, authoritarian discipline structures and the power of the examination system as a tool for promotion or withholding advancement. Values promoted in such a system include individualism, competitiveness and willing acceptance of 'expert' information, authority and hierarchical structures. Pepper (1987) warns that a sense of fatalism may result if one views certain prevailing states of affairs as being 'natural', and therefore acceptable and inevitable.

In South Africa, the reductionist tendencies of the dominant paradigm are expressed in the educational policies of the Nationalist government. 'Apartheid education' has become something of a caricature of separationist values. Blacks have been separated from Whites, English-speakers from Afrikaners and educational provision for different racial groups has been notoriously unequal (Hartshorne, 1992a). Christian National Education has presented state ideology in the form of unquestionable, 'natural' facts (Ashley, 1989) and authoritarian structures have ensured the maintenance of hierarchical separations between seniors and juniors, and teachers and pupils.

In contrast to these approaches, a view of knowledge as being socially constructed (Berger & Luckman, 1967), rather than objective and absolute, provides a foundation for very different forms of educational organisation and practice. If the knowledge, insights and experience of all participants in the teaching / learning situation are acknowledged, and if participants are involved in a shared process of constructing meaning (Wildermeersch, 1989), autocratic and bureaucratic approaches to education can give way to active democratic processes of negotiation, group decision-making and cooperation. Knowledge which grows out of active social processes in which an interplay of reason and intuition are possible, can become more personal, relevant and valuable to the learner.

Greig, Pike and Selby (1989) call the Cartesian-Newtonian worldview a Fragmentalist worldview and contrast it with what they describe as an Holistic worldview (Appendix 1). They advocate an alternative educational system based on holistic values as a means of addressing social, environmental and educational problems. Their approach emphasises connectedness rather than separateness, non-hierarchical structures, participation and consensual democracy, a liberationist, empowering mindset and reverence towards the environment. This description has much in common with what Bowers and Flinders (1990) call an Ecological approach to education and what Gough (1989) refers to as an Ecopolitical paradigm for education. All these schemes represent attempts to develop an educational approach which promotes holistic values, which may help to counter the dominant worldview which has been blamed for the current social and environmental crises.

A variety of educational movements, reflecting aspects of an holistic worldview, have arisen in the last twenty years in response to the environmental and social crises and inadequate educational systems outlined above. Environmental education, as a response to the environmental crisis, seeks to teach people how to live more sustainably on the Earth (Bakshi & Naveh, 1978; *Connect*, 1978; Irwin, 1991; IUCN/UNEP/WWF, 1991; Martin & Wheeler, 1975). Peace education, human rights education and education for democracy have developed in response to other aspects of the global crisis (Greig, Pike & Selby, 1987).

South Africa is currently experiencing rapid social change and the demand from many quarters (Christie, 1991; Hartshorne, 1992a; Kallaway, 1987) is for society and education to become more democratic. In order to clarify a much misunderstood term, Carr (1991) distinguishes between the 'moral' and 'market' models of democracy. He suggests that the dominant market model is based on dualistic principles of an active political elite and a passive citizenry whose only concern is that their individual liberties are preserved. A moral democracy, on the other hand, depends on the participation of a knowledgable and informed citizenry in the affairs of society. In that it emphasises non-hierarchical, egalitarian structures, cooperation, participation and an empowering mindset (Appendix 1), the moral model of democracy is consistent with the holistic worldview described above. Educational projects and institutions, by providing opportunities for more holistic education, could help students to develop the skills and attitudes required to participate in a moral democracy in

South Africa. Without these skills, the likelihood is that citizens will become coopted by a market democracy in which social and environmental decision-making will remain the responsibility of a political elite.

Some environmental educationists have been investigating ways to respond to the call for more relevant, responsive education, at the same time as seeking ways to address environmental problems. Robottom (1987a) has suggested guidelines for the development of environmental education which include the need for it to be enquiry-based, participatory and practice-based, critical, community-based and collaborative. These same values are implicit within the Action Research and Community Problem-Solving approach described by Wals, Beringer and Stapp (1990), which was used to inform the development of Project WATER in Grahamstown (Section 1.2). As the term environment becomes understood more holistically as encompassing the social, political and economic as well as the biophysical environment (O'Donoghue & Mc Naught, 1989), citizen involvement in addressing community socio-environmental problems becomes a relevant and necessary approach for environmental education.

1.2 THE GREEN PROJECT:

Because water is such an important environmental issue throughout the world, a number of environmental education initiatives have been established internationally which concentrate on water quality monitoring, such as WATCH (United Kingdom), the East African Environmental Education Network (EAEEN) and the Global Rivers Environmental Education Network (GREEN). The GREEN project has grown from a local initiative of the University of Michigan, Ann Arbor, to monitor pollution of the Rouge River, into a worldwide network of water monitoring groups which includes Project WATER in South Africa.

The GREEN project at Michigan is run according to an approach known as Action Research and Community Problem Solving (Mitchell & Stapp, 1991; Wals, Beringer & Stapp, 1990). This approach endeavours to bridge gaps between natural and social sciences, learning and doing, and the school and community, through involving students in identifying and

addressing local environmental problems. Students identify problems in their local environments which they wish to investigate, and address them using an action research approach which consists of successive cycles of planning, implementing and evaluating action. In the process of addressing an actual problem in their community, students learn skills of communication and problem-solving and develop a deeper understanding of the problem they have defined.

1.3 PROJECT WATER:

Project WATER (Water Awareness Through Educational Response) is a South African water monitoring project which makes use of a simple, low-cost water quality monitoring kit modeled on a much more expensive commercial kit distributed by GREEN (O'Donoghue, 1991a & b). The project developed as a result of collaboration between a number of participants from different organisations during 1991 and early 1992 (see Literature Review). Water availability and quality is a serious problem in South Africa (Coetzee & Cooper, 1991; Davies & Day, 1986; Huntley, Siegfried & Sunter, 1988), and providing a wide range of communities with the tools of water quality monitoring was seen to be an important goal of Project WATER. As the project developed and spread to various centres in the country, the national project became known as GREEN S.A., while some local projects retained the original name, Project WATER.

An outline of the kit and supporting materials is given in Appendix 2, while a full description of the project and procedures can be found in the field guide, *GREEN water quality monitoring in southern Africa* (O'Keeffe & Day, 1992). Briefly, the kit enables one to observe and test for the following:

(a) Catchment, river and health risk characteristics (Appendices 3a - c)
(b) Water life, including animals and plants associated with fresh water systems, some of which are pollution indicators (Appendices 4a & b)
(c) Coliform bacteria which indicate faecal contamination of water

(d) Nitrate and Phosphate content of the water indicating nutrient enrichment of the water which can cause eutrophication and ageing of aquatic systems

(e) Dissolved Oxygen and Biochemical Oxygen Demand, indicating the available oxygen in the water under normal conditions and the demand for oxygen by living organisms and chemical compounds, which may indicate pollution

(f) pH or the degree of acidity or alkalinity of the water

(g) Temperature and temperature differences between different parts of the river

(h) Turbidity or murkiness of the water, indicating the amount of suspended solid in the water, which usually relates to the degree of erosion in the catchment

(i) Total solids, which gives a measure of the total amount of dissolved and suspended solid material in the water.

Results of these tests and observations can be used to determine an index of water quality for each sampling site (Appendix 5). Participants are encouraged to keep ongoing records of water quality with a view to identifying sources of catchment mismanagement and taking action to address such problems.

1.4 BACKGROUND TO THE CONTEXT OF THE RESEARCH:

In this section, I outline the factors influencing my choice of Project WATER as a research topic and the way in which the focus of the research changed during the early part of the year. The development of Project WATER / GREEN S.A. started gaining momentum in 1991. At that time, I was concerned about the accessibility, immediate relevance and effectiveness of much of the environmental education work with which I was involved. The one-day excursions to natural areas which I organised not only excluded many people who could not afford the experience, but also tended to create the impression that the environment was in some way removed from the daily lives of the visitors and therefore not really their responsibility. Project WATER appealed to me because it enabled ongoing active involvement in a meaningful environmental project which integrated community- and environmental health issues. By providing the tools to investigate an environmental issue

directly affecting their lives, Project WATER had the potential to make environmental education relevant to economically disadvantaged rural and urban people.

When the opportunity arose for one year's full-time study in Grahamstown, I chose to investigate, using an action research approach, Project WATER as a tool for environmental health education in settlements obtaining their drinking water directly from rivers (Ashwell, 1991). However, because of the seasonality of rivers and the severity of the drought in the eastern Cape, I found that very few rural or urban communities made direct use of rivers for their domestic water supplies. The Grahamstown municipal health department, rural teachers and farmers I consulted considered diseases related to water supply and sanitation to be of low priority, compared to problems of malnutrition and diseases related to overcrowding, such as tuberculosis. People who have grown up drinking unpurified water generally have high levels of resistance to sicknesses such as gastroenteritis. Because this disease is not notifiable, no reliable records of its occurrence were available (Theron, 1992, pers. comm.). A community health focus was felt to be more appropriate in rural areas of the Ciskei (Manona, 1992, pers. comm.). However, the time constraints of completing a half-thesis made a rural community health project untenable. Limitations included the time required to establish working relationships (Van Vlaenderen, 1992, pers. comm.), language difficulties and limited funding restricting the distances that could be travelled.

I therefore decided rather to work within the school community of Grahamstown. As one of the most important educational centres in the country, Grahamstown offered much scope for the initiation of such a project. My initial plan was to conduct an evaluation of Project WATER as an environmental education resource in schools (Ashwell 1992a). However, it soon became clear to me that, because I was responsible for initiating the project in Grahamstown, an evaluation of the resource would to a large degree be an evaluation of myself. Seeing this as problematic, I decided instead to describe the process of project development as a case study informed by action research (Section 1.5). I was particularly interested to note the response of teachers and students to a project which had the potential to encourage holistic approaches to environmental education (Section 1.1).

1.5 THE RESEARCH FOCUS:

The focus of the research was to describe the process of development of Project WATER in Grahamstown in the light of the 'current crisis' outlined in Section 1.1. It was my intention:

* to examine whether the development of Project WATER in Grahamstown revealed evidence of fragmentalist and holistic views of education and the environment,
* to explore ways in which Project WATER provided opportunities for holistic educational practice, and
* to investigate how people responded to opportunities for involvement in Project WATER.

1.6 AN OUTLINE OF THE CHAPTERS:

In the Literature Review (Chapter Two), the historical development of Project WATER is described in the context of general developments in approaches to environmental education in South Africa.

Chapter Three describes the methods employed to investigate the development of Project WATER in Grahamstown. The experiences are described and discussed in three case reports (Chapter Four), dealing with project development at the university, in urban and in rural schools. Comments on the process of local redevelopment of the kit and materials are found in Chapter Five.

Issues emerging from the case study are discussed in Chapters Six (Discussion) and Seven (Conclusions and Recommendations). In Chapter Eight the research process is evaluated and a number of recommendations made.

CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION:

In this review, I trace the development of Project WATER / GREEN S.A. and associated water-related environmental education resources in South Africa, and show how these developments reflect changes in approaches to environmental education in South Africa in recent years. It has been difficult to find literature documenting particularly the early stages of project development. I have, therefore, depended on discussions with environmental educationists and on general environmental education and curriculum literature to substantiate claims made about different approaches to educational resource development which appear to be reflected in the development of the GREEN Project.

2.2 APPROACHES TO ENVIRONMENTAL EDUCATION IN SOUTH AFRICA:

Many environmental education initiatives in South Africa have their roots in outdoor education and conservation education (Irwin, 1991). A survey of articles in the *Southern African Journal of Environmental Education* (1984 - 1990) and the *Environmental Education Bulletin* (1989 - 1991) reveals that, before the Environmental Education Association of Southern Africa (EEASA) Conference of 1990, a landmark conference in environmental education in South Africa (Irwin, 1992, pers. comm.), most environmental education initiatives were aimed at trying to raise environmental awareness in order to conserve nature. There was no shortage of commitment to environmental education, but many initiatives appeared to be based on 'accepted wisdom' rather than critically reflective practice informed by appropriate theory. Some of the articles published in early editions of the Journal reflected the assumption that, if students learned more about ecological interrelationships, their awareness of the need for conservation would be enhanced and they would be more likely to behave appropriately (Marker, 1984; Mills, 1987; Zaloumis, 1987). More recently, this 'common-sense' approach to environmental education as a stimulus for behaviour change

has been questioned. Volk, Hungerford and Tomera (1984:17) state that "It appears that ... environmental educators continue to hold the belief that citizenship action can be brought about through a focus on environmental knowledge and awareness, although a growing body of research ... indicates otherwise". O'Donoghue (1990a:82) argues that "behavioural research has failed to reveal a causal relationship between attitude change and behaviour modification". Rather, there is a growing belief among certain environmental educationists that reconstructive change is brought about by social processes involving dialogue and negotiation within particular contexts (Wildermeersch, 1989).

Some environmental educationists have been challenged by these insights to question the assumptions underpinning their practices. Furthermore, demands of a changing political and social order in South Africa have required that environmental educationists broaden their definition of environment to include social, political and economic aspects as well as the biophysical (O'Donoghue & Mc Naught, 1989). This move away from a narrow definition of environment as the biophysical surroundings to a broader, holistic view is a specific example of what Capra (1983) refers to as paradigm shift away from a "narrow, fragmented approach" (p. 95) to one that recognises the "essential interrelatedness and interdependence of all phenomena - physical, biological, psychological, social and cultural" (p. 285).

2.3 WATER-RELATED EDUCATIONAL RESOURCE DEVELOPMENT:

Changes in approach to environmental education can be traced in the development of water-related educational resources in South Africa. Because the availability of water is a very important environmental issue in this country, it has long been a focus for environmental education initiatives. River Day, proclaimed by the Chief Directorate of Nature and Environmental Conservation, has been celebrated in the Western Cape since 1989 and recently the Department of Water Affairs and Forestry declared National Water Week to provide an opportunity for groups to focus their attention on the importance and conservation of fresh water (Department of Water Affairs and Forestry, 1992). Universities, water authorities and environmental groups have published informative and promotional books, posters and pamphlets and organised catchment hikes and field trips to raise the level of

awareness and knowledge about fresh water ecosystems and environmental problems affecting them (Camp, O'Donoghue & Schreuder, 1992; Chief Directorate of Nature & Environmental Conservation, 1990; Davies & Day, 1986; River Day Committee, 1992).

At the Umgeni Valley Project in Howick, Wildlife Society of Southern Africa education officers have for many years made use of a succession of water study booklets based on an original workbook combining reference material and worksheets compiled by one of the staff (Greig, 1977). These booklets have been used during fresh water ecosystem studies to help education officers and students identify the organisms found during water studies and to learn about their ecology.

Originally, the water study booklet was "very structured and needed to be intensely facilitated by the education officer" (Wright, 1992, pers. comm.). Modifications to the booklet over the years have changed its role to a reference booklet that can be used by groups as a flexible research tool (Taylor, 1992, pers. comm.). The worksheets were removed from the booklet, the reference section expanded and an identification and reference page illustrating all the organisms dealt with in the booklet was included to make it easy for students to find information (Umgeni Valley Project, ca. 1982 & ca. 1988). The cost of producing booklets decreased because of the advent of photocopying and later off-set litho printing, making more copies of booklets available for the students (Umgeni Valley Project, ca. 1990). These changes have enabled students to become less dependent on the education officer and more responsible for researching the ecosystem together (Wright, 1992, pers. comm.). A Wildlife Clubs booklet which concentrated on biological monitoring of pollution in streams was produced by the National Office of the Wildlife Society (Everett, 1980). However, this information was not included in the above-mentioned water study booklets produced at the Umgeni Valley Project.

Initially, these water study booklets were devised and adapted to serve the needs of education officers running conservation education courses at the Umgeni Valley Nature Reserve. During the course of the Action Ecology Project (an environmental education resource development project run by O'Donoghue of the Natal Parks Board), a farm school teacher made use of the water study booklet in an attempt to encourage field work in his school

(Camp, O'Donoghue & Schreuder, 1992; O'Donoghue, 1990a). This occurred at a stage when reaction was growing among certain educationists to the Research, Develop, Disseminate, Adopt (RDDA) (O'Donoghue & Taylor, 1988; Popkewitz, 1984; Robottom, 1987a & b) or 'develop and sell' (Moodie, 1987) approach to resource material development and distribution. O'Donoghue was investigating participant-centred resource development as an alternative approach. As a result of using the water study booklet with his students, the teacher suggested modifications to the contents which O'Donoghue incorporated into a new edition (Umgeni Valley Project, 1991).

The booklet was then printed and distributed through the newly developed SHARE-NET resources network based at the Umgeni Valley Project (Taylor & O'Donoghue, 1990). The resource became, as it were, 'public domain'. It was no longer simply a resource belonging the nature reserve but, through the combined effects of participatory development and a distribution network, the booklet was available to a wider audience. As a SHARE-NET resource, this inexpensive, easy-to-use booklet was made available copyright-free and on computer disk for rewriting locally (SHARE-NET, 1992). SHARE-NET itself developed as a result of a need expressed by environmental educationists for a resources network which could support education projects and assist with the production of resource materials (Umgeni Valley Project, 1988). Unlike database networks which provide information about available resources, SHARE-NET is a support service, facilitating the production of educational materials and communication between people involved in environmental education.

The development of participatory approaches to resource production paralleled significant changes in South African society in general and approaches to environmental education in particular. The release of political prisoners such as Dr Nelson Mandela, leader of the African National Congress, and the unbanning of liberation organisations in February 1990 increased the earnestness of calls for a participatory democracy in South Africa. At the 1990 EEASA conference in Jonkershoek, Cape, it became evident that there was a growing appreciation among many environmental educationists of the need to consider political, social and economic, as well as biophysical, aspects of the environment (Kahn, 1990; Low & Hoon, 1990; Naidoo, 1990). The emphasis on moving out of nature reserves and working with 'communities' was unprecedented in environmental education in South Africa

(*Environmental Education Bulletin*, 1990, Number 3). Articles in the *Southern African Journal of Environmental Education* reflected a growing political and social emphasis by environmental educationists (Kahn, 1989; Naidoo, Kruger & Brookes, 1990). Further evidence of a growing socio-political environmental lobby was the establishment of Earthlife Africa and the publication of *New Ground* by the Environmental and Development Agency. In mobilising environmental concern around issues such as the health effects of industrial pollution and the social effects of rural poverty, these groups and their publications made, in my experience, environmentalism more acceptable and relevant to socio-economic groups previously alienated by its predominantly white, middle-class, nature conservation image.

Against this background, the base of educational resources relating to water study started to expand to include materials which could be used for more than just an ecological study of a stream. On a trip to England, O'Donoghue came across a water quality slide which related pollution levels in streams to the types of organisms found living there. The slide was adapted for local conditions and produced with the help of a sponsor (Appendix 4b). This simple tool provided users with a rough indication of how safe river water was to drink, thereby relating river ecology to human needs.

A desire among environmental educationists to reach out to groups not previously engaged with led to an interest in the development of literacy materials based on an environmental theme. The literacy comic, *River of Our Dreams* (The Storyteller Group, 1991), was produced in cooperation with The Storyteller Group (O'Donoghue, 1990b). This group develops literacy materials in comic form by workshopping ideas with potential readers. *River of our Dreams* presents environmental education as a process leading to community action (The Storyteller Group, 1992). The comic deals with an environmental issue in a more action-centred way than many other educational materials produced locally by 'mainstream' environmental educationists.

Interest in the development of problem-solving approaches in environmental education was stimulated by a paper on an approach known as Action Research and Community Problem-Solving AR:CPS (Wals, Beringer & Stapp, 1990). One of the most successful projects making use of this approach was the Global Rivers Environmental Education Network

(GREEN) based at the School of Natural Resources, Michigan University, Ann Arbor (Mitchell & Stapp, 1991). A handbook produced by the Ann Arbor team described AR:CPS as:

> a problem-solving approach that stresses the utilisation of skills such as critical thinking, problem-solving and working in groups so that we may keep up with ... changes.
>
> (Bull *et al*, 1988:11)

On a visit to the United States, O'Donoghue met staff at GREEN Headquarters and purchased a water monitoring kit. The kit was too expensive for the majority of South African schools, but the idea had great promise as a means of enabling people to get involved in the investigation of a local environmental issue, having both community health and nature conservation relevance. O'Donoghue therefore embarked on a project to modify the kit and make it affordable for the majority of schools. In the process, much of the scientific apparatus was replaced by everyday items such as plastic syringes and Tupperware, resulting in the combined advantages of lowering the cost of the resource and 'demystifying' science (Head, 1985). The process of kit redevelopment and localisation to South African conditions was a cooperative one, involving staff of a private water board, Umgeni Water / Amanzi, fresh water ecologists, educationists and students (O'Donoghue, 1991a & b). Umgeni Water / Amanzi had been organising poster competitions and catchment hikes for school groups under the auspices of Project WATER to publicise the work of the water authority. The existence of a cheap, simple water testing kit added an exciting dimension to the field trips and technical and professional staff from Umgeni Water / Amanzi supported the development of the kit enthusiastically (Camp, 1991; Natal Witness reporter, 1991).

The kit and support materials were produced in draft form and developed through pilot implementation processes (*GREEN S.A. Newsflash*, 1992a & b). In this way, a number of participant groups from various parts of the country were able to contribute further innovations and improvements to materials and methods. The project initiators made a concerted attempt to avoid centralised control of the water project by encouraging regional initiatives to 'make the project their own'. The Stellenbosch Water Analysis Project (SWAP)

developed its own logo, redesigned the kit using available materials and translated the booklets into Afrikaans (De Lange & Schreuder, 1992) and Xhosa. As local projects started to develop their own titles and logos, O'Donoghue changed the name of the national project to GREEN S.A., linking South African projects to the international network, yet encouraging local initiatives to develop their own identities. He hoped that the decision to "give the tools of environmental interpretation away" (Uzzell, 1989:9) would stimulate reconstructive change in communities through participation in problem identification and solving at a local level (O'Keeffe & Day, 1992).

Because water is a very important environmental issue in the country, a number of other water-related environmental education resources have been produced. Two resources which have been developed through participatory approaches have been *Enviro Facts* information brochures on water and a poster dealing with the water cycle. In the case of the *Enviro Facts*, the choice of topics, format, content and points for debate have arisen through consultation, workshopping and correspondence between the editor and educationists, scientists and members of the general public (Gowar, 1991). Urban Foundation Primary Science Project (Western Cape) teachers and Directorate of Nature and Environmental Conservation staff held workshops to design a poster on the water cycle. A two year project developed out of the teachers' need for a resource that would clearly explain processes involved in the water cycle (Barrett, 1992). This rationale for poster development contrasts with that of the Department of Environment Affairs which produces attractive posters to advertise the various commemorative days on the conservation calender, believing that they form a focus for the promotional activities organised by other environmental groups (Van Rensburg, 1992, pers. comm.).

These and other resources developed in various centres might, in the past, have been used in isolation from one another. However, initiatives such as EEASA and SHARE-NET encourage the sharing of resources by environmental educators, making a wide selection of 'tools' available for teaching, learning and action (SHARE-NET, 1992).

2.4 CONCLUDING SUMMARY:

In this summary, I reiterate some of the changes in approach to environmental education which have occurred in recent years and which have been reflected in the development of the water project. I contend that some of these changes reflect holistic or ecological approaches to education which have arisen in response to the perceived inadequacy of reductionist approaches (Chapter One). These changes have by no means been universal and it is likely that many environmental educationists continue to subscribe to a purely biophysical view of the environment and prefer to teach 'in' and 'about', rather than 'for' the environment (Robottom, 1987b), using predominantly transmissive techniques.

A reaction to reductionist approaches has led to the demand for more holistic, ecological and democratic approaches in society. Capra (1983) refers to this reaction to reductionism as a global 'paradigm shift'. This reaction can be seen in the desire for a more holistic understanding of the term environment and in the need for environmental education to acknowledge human as well as plant and animal communities, in urban and rural areas as well as in nature reserves. The importance of more democratic processes of social meaning-making (Wildermeersch, 1989) is reflected in participatory approaches to resource development and in the types of resources being produced, many of which are well suited to groupwork. The SHARE-NET handbooks have taken the spotlight off the teacher or group leader as owner and purveyor of knowledge and have provided opportunities for groups to interpret the environment together. Opportunities for group problem-solving and decision-making are provided through AR:CPS approaches to environmental education. Project WATER is an example of a project that can be approached in this way.

Grundy (1987) reflects on approaches to curriculum development in the light of Habermas's three knowledge-constitutive or epistemological paradigms. These approaches are evident in the previous discussion. For example, attempts to change peoples' behaviour through raising their awareness reflects a Technical (empirical-analytical) approach. Action-centred cooperative learning is more compatible with a Practical (historical-hermeneutic) approach. Some environmental educationists consider environmental education to be an emancipatory and empowering approach (Critical paradigm) (Naidoo, Kruger and Brookes, 1990), but this

approach is currently not widespread in South Africa. Project WATER, through an AR:CPS approach does, however, provide an opportunity for education to become more socially critical as groups get involved in long-term projects to address local environmental issues.

CHAPTER THREE: METHODOLOGY

3.1 A NOTE ON THE STYLE OF REPORTING:

Although not common practice, this thesis has been written in the first person. As participant observer in a series of case studies, I was directly involved in the processes of project initiation, development and evaluation and in reflecting on these processes. Constant references to 'the researcher' would have been cumbersome and conveyed a notion of objectivity which is inappropriate to interpretive research (Mc Neill, 1990; Reason & Rowan, 1981).

3.2 RESEARCH APPROACH:

> Case studies are 'a step to action' - they begin in a world of action and contribute to it. Their insights may be directly interpreted and put to use ...
>
> (Cohen & Manion, 1989:150)

Researching the development of Project WATER in Grahamstown required me to record in detail the process of project development. It also required continuous reflection on the process in order to understand it better and to try to make improvements to the project. Through the process of project development, my understanding of environmental education developed and it became apparent that an objectives-based evaluation was inadequate to provide a framework for the research. I therefore chose to undertake a case study informed by action research which permitted modifications to research design as situations changed and my own understanding developed (Section 1.4).

The research approach was qualitative and naturalistic (Cohen & Manion, 1989) consisting of multiple case studies (Bromley, 1986; Yin, 1984) detailing aspects of the development of

Project WATER in Grahamstown. A naturalistic case study approach was chosen because it allows for in-depth discussion of complex situations and is appropriate where the researcher takes the part of participant observer (Cohen & Manion, 1989) and is involved in an innovative process which s/he wishes to describe "in depth, in detail, in context, and holistically" (Patton, 1987:19). The approach was interpretive rather than analytical, and was consistent with a Hermeneutic-Interpretive, rather than an Empirical-Analytical epistemology (Habermas, in Grundy, 1987). The research was thus descriptive rather than predictive and, for this reason, general recommendations arising from the research should be seen as suggestions for critical consideration by the reader.

Internal validity of the research findings depended to a large extent on the integrity of the researcher and other participants. Where feasible, draft copies of the research were submitted to participants and colleagues for validation by "member checking" (Miles & Huberman, 1984:242). Triangulation, or the use of a number of methods to gain understanding of a situation (Mc Kernan, 1991; Patton, 1987), was also used.

Action research was chosen because it is a collaborative, participatory, self-evaluative approach to research (Cohen & Manion, 1989) which encourages observation and reflection in order to improve one's practice and understanding (Grundy & Kemmis, 1984). It is thus appropriate when researching the implementation and development of an educational project in which a number of participants are involved. Rather than considering Project WATER participants to be subjects of the research, they were asked to collaborate as co-researchers in developing and evaluating the project.

Action research is a useful method for educationists wishing to improve their practice, through observation of and reflection on the effects of interventions. It allows for flexibility of research approach which is particularly important when investigating a new and unfamiliar situation in which preconceptions and initial plans are regularly challenged (Cohen & Manion, 1989; Hustler, Cassidy & Cuff, 1986; Mc Kernan, 1991). However, the degree to which an action research approach could be followed in this study was limited by three factors which will be elaborated on in Chapter 8 (Evaluation). Briefly, these factors were

lack of teacher involvement, lack of continuity and 'quality time' with the groups, and the time constraints of a half-thesis.

In the case of Project WATER (Grahamstown), action research as an approach to educational research was strongly linked to Action Research and Community Problem-Solving (AR:CPS) as an approach to project work in schools (Mitchell & Stapp, 1991; Wals, Beringer & Stapp, 1990) (Section 1.2). The process of researching the development of Project WATER in Grahamstown was essentially a process of AR:CPS, with the problem being water quality and the community involved in the process of problem-solving being myself and the pupils, students, teachers and other members of the Grahamstown community involved in Project WATER. Throughout, the processes of research and development of Project WATER were integrated and informed each other. As will be seen in the case reports (Chapter 4), early development of Project WATER in Grahamstown did not resemble a true community project. Pupils were initially more interested in using the Project WATER kit to help them carry out a school science project, than to investigate and address a water pollution problem in the community. However, as various groups investigated aspects of water quality in Grahamstown, problem areas were identified and opportunities arose for cooperative community problem-solving. At the time of writing opportunities existed for the continued development of an AR:CPS project in Grahamstown based on water quality monitoring (Section 6.8).

3.3 RESEARCH METHODS:

The process of project development was investigated and described using the following methods:

3.3.1 Case study based on three case reports:

In recording the development of Project WATER in Grahamstown, a detailed research diary was used to record events, observations, personal thoughts and reflections. This, together with other written records such as interim reports and correspondence,

provided the 'story' which formed the basis of the case studies (Hustler, Cassidy & Cuff, 1986; Elliott, 1991; Mc Kernan, 1991; Patton, 1987). Demonstrations and training sessions were recorded using audio tape, field observation checklists, photographs, reflective self-evaluation and discussions with or written evaluations from participants (Elliott, 1991; Mc Kernan, 1991). This information was used to make improvements to training procedures and materials.

Discussions and interviews with groups or individuals were recorded by audio tape or, in cases where participants felt uncomfortable being tape recorded, by hand. Because of the exploratory nature of the research, interviews were either open-ended or semi-structured (Mc Kernan, 1991). Workshop or group discussions were guided by outlines such as a SWOT analysis schedule (Appendix 6) or 'Definitional Aims' schedule (Appendix 7) designed during the study. Letters, student projects and press articles were also consulted when investigating the outcomes of the project.

3.3.2 Local redevelopment of the Project WATER kit and materials:

Before the Project WATER kit could be used confidently by groups wishing to embark on water-related community action projects, the tests and written materials had to be assessed locally. This was done both by myself during demonstration and training sessions and by participants as they experimented with the kit. Feedback was obtained by means of individual and group discussions, questionnaires and workshop sessions. Personal observations were recorded in the research diary. Local experts in fresh water research and microbiology were consulted to obtain their suggestions regarding the water life observations (O'Keeffe, 1992, pers. comm.) and coliform bacteria test (Kirby & Pogrund, 1992, pers. comm.).

3.4 EVALUATION OF THE RESEARCH APPROACH:

The choice of research approach is evaluated in Chapter Eight. Comments are made as to its strengths and limitations with a view to informing other researchers considering using a similar approach.

CHAPTER FOUR: THE RESEARCH PROCESS: DESCRIPTION AND INTERPRETATION
PART I: THE CASE REPORTS

4.1 INTRODUCTION:

At the beginning of the first school term of 1992, the national coordinator of GREEN S.A. ran a workshop in Grahamstown to promote Project WATER / GREEN S.A.. I invited teachers from urban and rural schools in Grahamstown and staff from various departments at Rhodes University to attend the workshop with a view to stimulating an interest in the project. However, although a number of university staff attended, only two school teachers came to the workshop. This experience indicated to me that combined workshops might not be the best approach. I therefore decided to try working with schools on a more individual basis.

Having spoken to at least one teacher from each school, either in person or by telephone, I sent a letter and questionnaire (Appendix 8) in which I outlined the project and offered to visit the school to demonstrate the kit. After further follow-up, eight groups agreed to participate. The groups are listed below and the development of the project in each group is described in the case reports.

Case 1: Student teachers, Rhodes University

* Bachelor of Primary Education (B.Prim.Ed.) III
* Higher Diploma of Education (H.D.E.)

Case 2: Town Schools

* Graeme College
* St Andrews College / Diocesan School for Girls (DSG)
* Mary Waters Secondary

Case 3: Farm Schools

* Brighton
* Begelly
* Farmerfield

Before describing the cases, a few comments about the development of the research approach are necessary. I initially wished to evaluate Project WATER as an environmental education resource in schools but an evaluation focus proved to be problematic. Firstly, as mentioned in Section 1.4, I became concerned that an evaluation of the project was essentially an evaluation of myself because I was responsible for the initiation of the project locally. I wanted to avoid problems of evaluation bias resulting from my close involvement with the project. Secondly, I found that an evaluation focus limited my view of Project WATER. I started to see the project as an object (the kit) to be evaluated and for a time lost sight of the project as an educational process (Section 3.2).

In attempting to evaluate 'the kit', I looked for ways in which to 'measure' the effect of the kit on participants and the environment. This deterministic approach to research was consistent with my past experience of natural science research. However, the more I experienced of the project, the more I realised that relationships between awareness, knowledge and behaviour are highly complex and not simply causal. An empirical / analytical approach to research seemed inadequate in this context and the associated 'pre-test' and 'post-test' techniques I had initially designed started to appear rather trivial. At the same time, my experience of and appreciation for qualitative and participatory research approaches developed. A desire to evaluate how the water project fulfilled stated objectives of environmental education and how it 'changed' participants gave way to a desire to describe the process of project development and reflect on outcomes emerging from the experience.

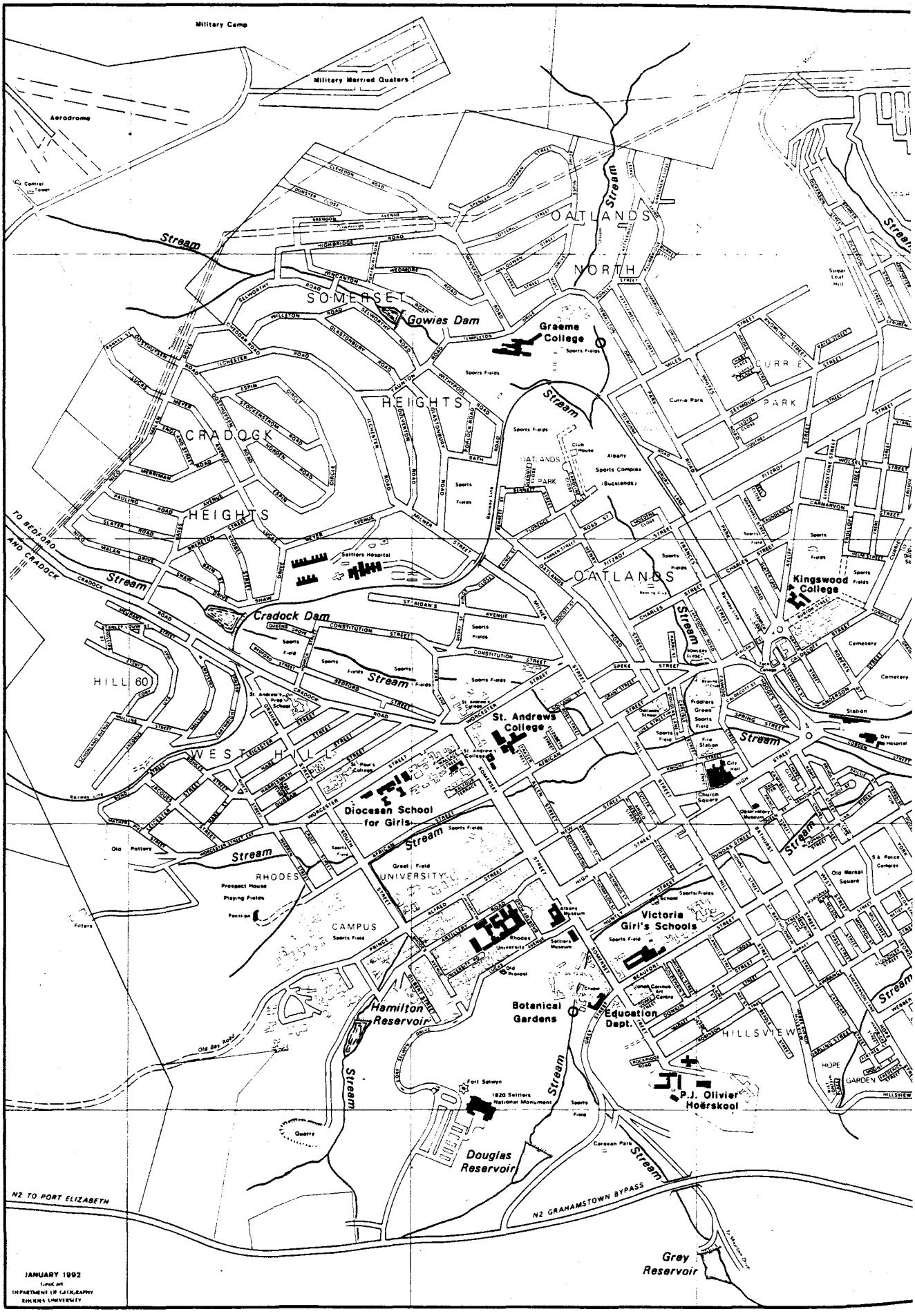
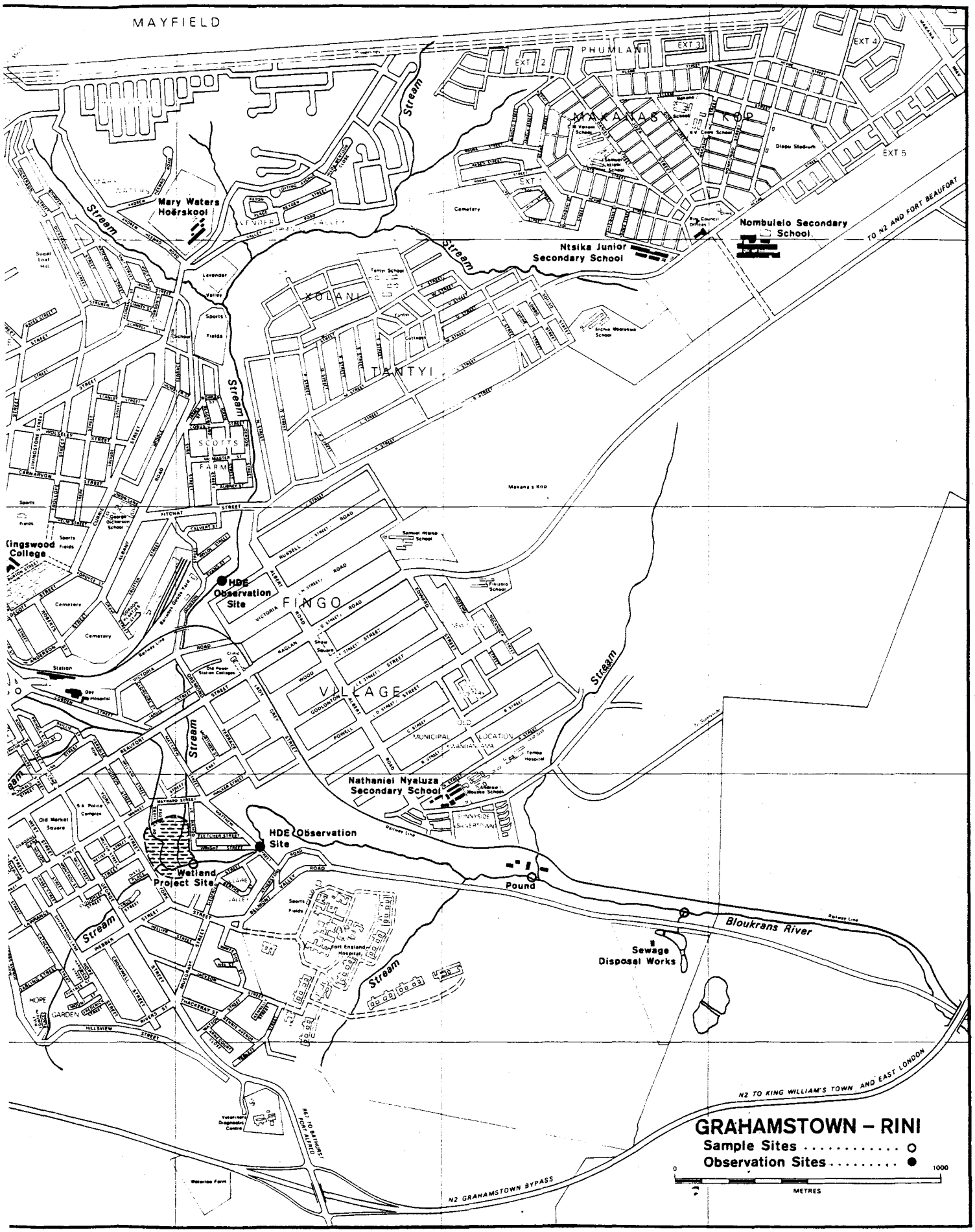


FIGURE 2: Map of Grahamstown showi



town showing schools, streams and sampling sites

FIGURE 2: **Map of Grahamstown showing schools, streams and sampling sites**

LEGEND:

B.Prim. Ed. III students:

Sample sites:

1. Municipal Pound
2. Sewage Treatment Works outflow
3. See Figure 3: Railway bridge site

H.D.E. students:

Observation sites:

1. Municipal Pound
2. Matthew Street
3. Evans Street

Sampling site:

See Figure 3: Railway bridge site

Mary Waters Secondary pupils:

Sampling sites:

1. Municipal Pound
2. See Figure 3: Railway bridge site

Observation sites:

1. Evans Street
2. Matthew Street

◄ FOLD OUT

FIGURE 3: **Map of the Grahamstown district showing farm schools, rivers and sampling sites**

LEGEND:

Begelly Farm School:

Sampling sites:

1. Berg Stream at picnic site
2. Kariega River on farm

Brighton Farm School:

Sampling sites:

1. Kowie River near school
2. Kariega River near school

Farmerfield School:

Assegaai River near school

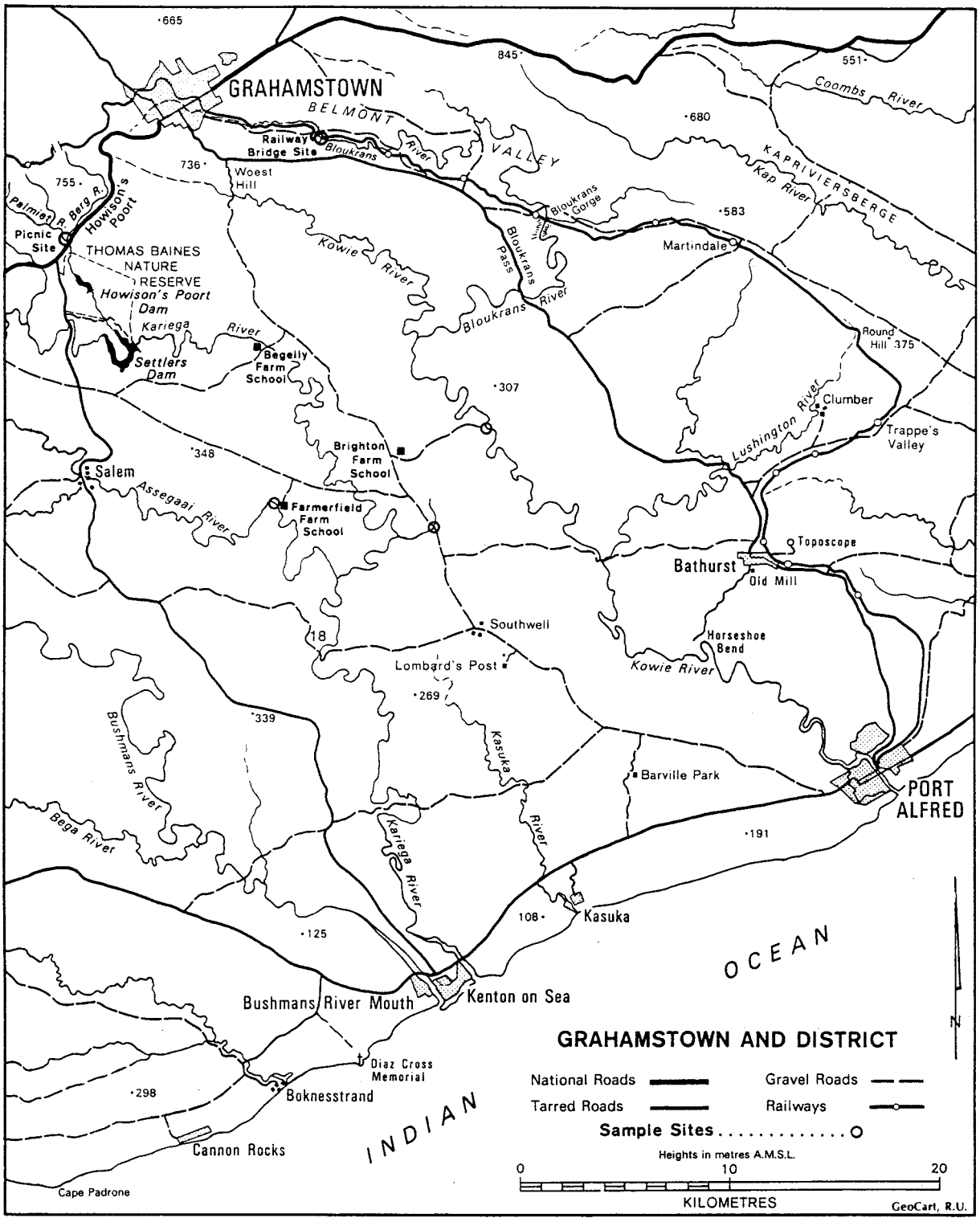


FIGURE 3: Map of Grahamstown district showing farm schools, rivers and sampling sites

4.2 CASE 1: RHODES UNIVERSITY STUDENT TEACHERS:

4.2.1 Bachelor of Primary Education (B.Prim.Ed.) III Students:

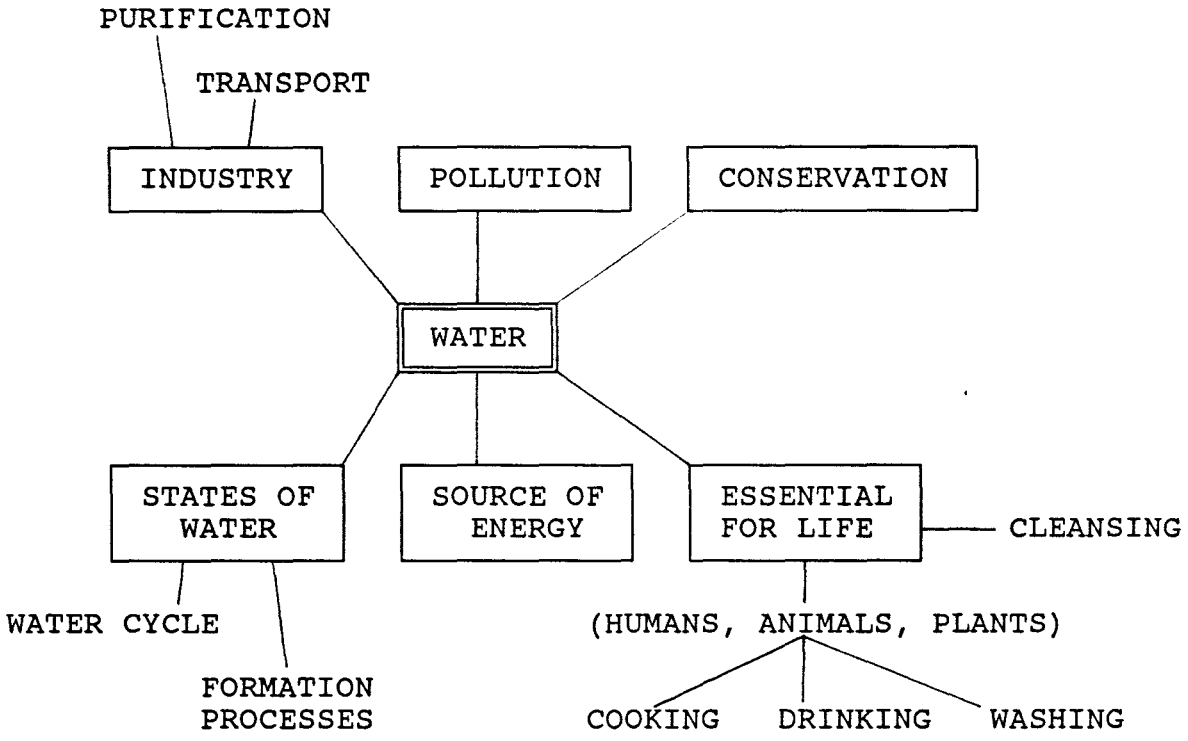
My first opportunity to work with a group on Project WATER occurred when a lecturer in the Department of Education at Rhodes University invited me to demonstrate the project to her class of B.Prim.Ed. III students. She felt it would be relevant as they were at the time dealing with 'Water' as a theme in their Primary Science Method course. This provided me with an opportunity to pilot test fieldwork procedures and develop research tools.

The B.Prim.Ed. class was a group of five students in their third year of study who were accustomed to working as a group on projects. They had had experience of an environmental approach to teaching in their previous year of study. Despite the fact that most of the tests in the Project WATER kit are beyond the scope of current Primary Science syllabi, this group made use of the whole kit and provided valuable feedback about the project and its possible application at the primary school level.

My involvement with the B.Prim.Ed. class lasted approximately six weeks. The lecturer provided ample time for the project and took part actively in the field work and discussions. At the first session I attended, the class illustrated the scope of water as a topic in the Standard Two to Four Cape Education Department Science syllabi using concept maps. This provided some interesting insights. For instance, although it is easier, because of fewer timetable constraints and less subject specialisation by teachers, to offer integrated studies at primary than at high school level, this syllabus, as reflected in their concept map, tends to separate scientific knowledge from other aspects of a study of water. There were no direct references, for example, to the relationship between water and health, the importance of water in determining where people live, water as a habitat or the aesthetic qualities of water. A scientific approach to the study of water was seen to be factual, utilitarian and socially neutral. In their concept map the class did not show links between topics, such as industry, pollution and water being essential for life, suggesting either

a limited understanding of the use of concept maps or of the interrelationships between the topics selected (See Figure 1).

Figure 1: Water as a topic in Primary School Science. Concept Map constructed by B. Prim. Ed. III class.



The B.Prim.Ed. students attended a demonstration, two field trips and two follow-up sessions in which results of their field work were discussed and the project evaluated. They were asked to evaluate the project in terms of its general application and the extent to which they felt it could be used at the primary school level. They were also asked to evaluate practical aspects of the training procedure. Many of these students' comments resulted in redevelopments to materials and training approaches, some of which are recorded in Chapter 5. Some of the more pertinent observations and comments are recorded in this section.

Pre-field work instruction of the B.Prim.Ed. group consisted of a demonstration only, which proved to be inadequate. The students were unsure of themselves on the first field trip and took so long to carry out the tests that another field trip was necessary in order to investigate the two other intended sampling sites on the Bloukrans River (See Figures 2 & 3). The first site was a particularly badly polluted part of the stream near the municipal pound (Figure 4) and students were reluctant to start the investigations. The lecturer encouraged them to participate by starting to search for invertebrates on the rocks, but the presence of litter, foam and slime in the water detracted from their enjoyment of the exercise.

Practice and more pleasant surroundings enhanced the group's efficiency on the second field trip and the third site (Figure 5) was tested in half the time they had taken at the first site. The water at this last site was noticeably cleaner than at the other two sites. Trees lined the stream which flowed over rocks and water life was plentiful. Enjoyment of the activity increased markedly from the first site to the third, reflected in 'faces' the students chose to describe their feelings about each site (Appendix 9). For instance, at the first sample site, the faces chosen reflected that the students had felt hot, puzzled, cautious and disgusted. At the third site, they were relieved, satisfied and concentrating. One felt paranoid, but admitted that this was related to her fear of crabs, not to the state of the river. The fifth student, obviously enjoying himself, had felt mischievous. They explained that these differences were related to their increased confidence with the tests, their own organisation of the group into a 'team' with well defined tasks and the improvement in the appearance of the river the further downstream they sampled.

After the field trips, the B.Prim.Ed. students attended discussion sessions during which we interpreted the results and evaluated the experience. Some students admitted that they had not understood the implications of results obtained in the field until being able to discuss them together in class. They considered the process of interpreting data in a group an essential and integral part of the project. It promoted a questioning approach and enabled the students to make sense of their results and to begin to see relationships between results of different tests. In an Action Research

FIGURE 4: Pupils from Mary Waters Secondary School searching for water organisms in the Bloukrans Stream near the Municipal Pound

FIGURE 5: Rhodes University H.D.E. students monitoring water quality in the Bloukrans Stream at the railway bridge site

and Community Problem-Solving approach to environmental education, such stages of 'reflection' and 'dialogue' are necessary to enrich and inform action.

The B.Prim.Ed. class carried out a comparative study of three sites along the Bloukrans Stream. I have noticed that studies of a number of contrasting sites are more effective than studies of a single site in developing a 'feel' for 'good' and 'bad' results. By comparing results from sites with visibly different levels of pollution, the B.Prim.Ed. group developed that 'feel' and an understanding of the interrelationships between the various factors investigated, such as phosphate levels, coliform bacteria and water life.

The process of analyzing results entails conversion of actual measurements into 'Q-values' (Water Quality Index ratings) which can be summed to provide an overall water quality rating for each sample site (Appendix 5). Although this is meant to help participants to get an idea of the water quality significance of each reading, the B.Prim.Ed. students (and students from a local school, Section 4.3.8) disliked this part of this exercise. They saw more value in looking for relationships between various physical, chemical and biological factors than in calculating overall Water Quality Indices and comparing these. They experienced this as a troublesome exercise which introduced unnecessary complications without providing any deeper insights. In fact, they felt that reducing observations to an overall numerical rating tended to emphasise reaching an end point or 'answer' rather than promoting an understanding of interrelationships between factors. Comments from students suggested to me that this response may have been aggravated by their reluctance to work with graphs and figures. Indeed, some students at St Andrews College enjoyed working out overall Q-values and saw this part of the exercise as an opportunity to try to develop a computer programme which would convert raw data automatically into overall Q-values (Section 4.3.4).

The B.Prim.Ed. class was surprised to find that levels of faecal coliform bacteria, nitrates and oxygen indicated that water in the stream leaving the town (upstream of the municipal sewage works) was far more polluted with sewage than water in the

outflow channel leaving the sewage works (Figure 2). They had expected the municipal sewage works to be a source of pollution. Instead, they discovered that it actually contributed to the dilution of existing high pollution levels in the Bloukrans River. This ability to test an hypothesis or challenge a preconception by means of direct investigation was something that participants from all groups (farm schools, town schools and university) referred to in commenting on the strengths of the project.

In the evaluation session, the B.Prim.Ed. class suggested that, from their experience, primary school pupils would find the water life investigations more meaningful and enjoyable than the other tests. They were, however, concerned about the safety of young children and stressed that they should not be allowed to investigate polluted streams. Adult helpers, such as parents, should be involved in field trips to ensure adequate supervision. There was some disagreement as to whether primary school pupils would understand the coliform test. In the case of primary scholars from the farm schools (Section 4.4), I used a simple, animated approach to describe the process of bacterial reproduction which appeared to satisfy the pupils. Primary pupils from these schools also managed to carry out the coliform test quite satisfactorily.

The B.Prim.Ed. students suggested that the physical and chemical tests could be demonstrated to primary scholars by the teacher if the opportunities arose naturally in class as a result of pupil curiosity. Some students in this and other groups experienced confusion and frustration because they felt that instruction in the use of the kit had been too rushed. This class suggested that, if the project was to be done at school, tests should be taught gradually and preferably in the context of related sections of work in the curriculum. This would make the project more meaningful and avoid the problem of overloading the students with too many new concepts at once. Bardwell (1992:7) cautions that "the negative response to a learning situation in which one feels barraged by information, coerced, or bored can extend to the subject itself". In the case where the 'subject' is environmental issues and where one is keen to encourage environmental concern and action, one would particularly like to avoid situations such as this.

It was interesting to observe, even within this small B.Prim.Ed. group, the different levels of experience the students brought to the exercise and the different stages at which they experienced 'cognitive dissonance' (when new information no longer fits with existing patterns in the learner's understanding) and 'closure' (when new information is satisfactorily incorporated into the learner's mental map) (Bardwell, 1992). The project satisfied student curiosity at a number of different levels. Both those satisfied with 'seeing' ("... for me, seeing was enough") and those who felt they "must know and understand" felt that the project had provided opportunities for 'meaningful learning' (Gowin, 1981).

Part of the final evaluation session with the B.Prim.Ed. class was a discussion to investigate the extent to which they thought their involvement in the water project had resulted in the attainment of various objectives of environmental education, such as appropriate attitudinal and behavioural changes. At that stage of the research, I still saw the research as an evaluation of Project WATER rather than as a descriptive case study. The methodology used at that stage was predominantly objectives-based.

To focus discussion I designed and made use of a summary of objectives derived from various definitions of environmental education (Irwin, 1989). I called this schedule the 'Definitional Aims of Environmental Education' and used it to investigate the depth to which involvement in the project had affected this group (Appendix 7). The hierarchical arrangement of objectives was not meant to suggest any form of causal relationship between the different levels. Rather, I arranged the objectives according to the ease or difficulty with which I felt they could be attained in practice, with enhanced awareness being attained most easily, and the development of commitment, values and a code of behaviour the most difficult to influence.

The group reported that the project had enhanced their **awareness** of pollution and the diversity of river life, and their **knowledge** and **understanding** of the effects of people on water quality in the upper reaches of the Bloukrans River. They had developed **skills** of group cooperation, critical evaluation and water quality monitoring through measurement, observation and interpretation of results. However, as we

worked further through the list of objectives, the effects became less obvious. They felt that **motivation** to get involved with the project depended on the existing concern and interest of the individual and external influences, such as class projects organised by the teacher. The group did not feel that involvement in the project would necessarily bring about changes in environmental **concern**, **motivation** or **commitment** of participants.

I sensed a change in the attitude of the group as we moved from discussing the effects they had actually experienced (for instance, knowledge and skills) to considering the need for environmental education to encourage active participation in addressing environmental problems. The group became more defensive and apathetic and started to blame the problem of water quality on socioeconomic and political structures in society which they felt they were powerless to address. There was little sense that citizens could or should attempt to address these problems, nor evidence that the group had insight into how this could be done. I was unable to pursue this issue further with the B.Prim.Ed. class because of time constraints but experienced similar responses from the H.D.E. students (Section 4.2.2) and students from some of the schools. It should be borne in mind that, particularly in the case of the student teachers, time available for the project was limited and my brief was to teach them how to use the Project WATER kit, not to involve them in an ongoing water monitoring project. From the outset, therefore, the students did not see their involvement in the project as involving community action. This may have limited their expectations of the project.

4.2.2 Higher Diploma of Education (H.D.E.) Students:

As a result of suggestions made by the B.Prim.Ed. class, the H.D.E. class was given a training session in the laboratory during which students had an opportunity to carry out most of the tests in small groups (Figure 6). Despite being encouraged to get as much 'hands-on' experience as possible in the laboratory, they did not make use of all the sets of equipment available. Some students treated the session as a game,

FIGURE 6: Rhodes University H.D.E. students at a laboratory training session practising the test for dissolved oxygen

FIGURE 7: Teacher and pupil from Mary Waters Secondary School recording observations at a badly polluted site on the Bloukrans Stream

squirting one another with the syringes. I was interested to investigate what I perceived to be negative responses to the project, as I felt that understanding people's reluctance to get involved or take the project seriously would help me to improve my practice through a greater sensitivity to the needs and interests of the students with whom I worked.

After the session, I asked two students whom I knew and trusted to speak candidly, to reflect on possible reasons for some students' lack of application. The first student listed three reasons: they had not been consulted about the project, some felt that it was an imposition on their normal routine at a time when they were under considerable pressure of work, and they did not see the relevance of the project. The other student said despondently that this behaviour was typical of the general attitude of many of her class-mates who were not interested in doing more than the minimum required of them by the course.

The H.D.E. group consisted of thirteen students from three different subject method groups (Biology, Geography and Physical Science). Although water is an important topic in high school Biology, Geography and Science, it appeared that the lecturers had not emphasised the relevance of the water study to their H.D.E. students. Furthermore, it was evident from discussions that this class had had no experience of environmental education as an approach in their teacher education programme. When asked, during my first contact with the class, to explain what they understood by environmental education, most gave rather vague definitions such as "teaching that takes place outdoors" (student quote). After the field trip, almost half of the students reported that they had seen the exercise as "fun" and "a break from the classroom" (student quotes) but unimportant to their studies. In general, the group appeared less interested in the project than the B.Prim.Ed. class had been, despite the greater relevance of many of the water quality tests to high school Biology, Geography and Science pupils.

Only two class periods and one 'free' afternoon were available for the project with the H.D.E. class. One method lecturer did not attend any of the sessions and the

lecturer responsible for the combined group participated in a very limited way in the fieldwork and not at all in class discussions. This teacher justified her lack of involvement by saying that she did not want to dominate the students. Based on my observations of class behaviour, however, I believe it transmitted the message that the exercise was unimportant. Field work was limited to one afternoon session, allowing for detailed testing at only one site in the Belmont Valley and a series of observations at sites upstream to look for possible sources of pollution. More than half the class left early that afternoon, leaving only four students and one lecturer to observe the last site.

At the sampling site (Figure 5), two of the groups applied themselves diligently and carried out the tests successfully. One group, whose members had not applied themselves during the laboratory session, made a number of technical mistakes with the coliform test which they should have practised in class. The last group spent most of the time at the stream trying to make a long-handled fishing net out of a piece of bamboo and the sieve they had been given to catch water organisms.

At one of the observation sites where the stream was particularly badly polluted with litter and sewage (Figure 7), I asked the group to offer some responses to what they saw. One student commented by saying, "This is a long-term educational problem. There's nothing I can do about it". To me this comment by a student teacher reflected a narrow view of the role of the teacher and a tendency to consider school education as something separate from and unrelated to the life of the surrounding community.

The feedback session with the H.D.E. group was relatively unproductive in terms of discussion and evaluation. I curtailed the discussion of results because some of the students had not carried out certain tests and there was a general feeling that the class was not interested in the process of analyzing their results. I decided to explore this apparent lack of interest and asked whether people should get involved in addressing environmental problems in their communities and, if so, why so few people seem to do so. This was the only question of the session that elicited relatively lively

discussion. Reasons the students gave for why people tended not to address community problems included that they were stopped by bureaucracy, that they felt disempowered because they were disenfranchised and therefore not part of the decision-making process, or that they were "unconcerned about the beauty of nature because they [were] poor or homeless" (student quote). Even those who could vote and had their basic needs satisfied felt that there was no culture of democracy in the country and therefore people were not used to their actions making a difference. People tended to wait for someone else to 'sort the problems out', even though some students admitted that there was much that citizens could do to address community problems.

4.2.3 General comments:

The overwhelming response to the problem of water pollution expressed by these two groups of student teachers was one of disgust at the state of the streams they had visited and despair because of the scale and complexity of the problem. On the one hand, students recognised the futility of treating symptoms, but on the other hand, they felt powerless to address the underlying causes: "What's the point of cleaning the river up? It will just get like that again by next week!" (H.D.E. student).

The B.Prim.Ed. class felt concerned about the problem and most said that they would be willing to help if someone gave them something to do. However, when asked, not one student was prepared to initiate action. One student stressed that involvement in environmental action depends on one's particular interests in life. Comments from these and other groups (Section 4.3) suggested two factors which may influence the extent to which an action project such as this will be adopted and developed: the existence of a 'culture of involvement' in society and the participation of environmentally concerned individuals.

From my dealings with the student teachers it appeared that, although individuals may be concerned, in most cases they do not understand the basic principles of community

problem-solving. I investigated this problem further by interviewing educators in Grahamstown (Ashwell, 1992b). There was general agreement that pupils at school are seldom given the opportunity to get involved in identifying and addressing community problems. Furthermore, most pupils are not expected to play a significant role in decision-making within the school system, and "do not often see themselves as being able to make a difference" (respondent quote). In addition to societal factors stressed by the student teachers, these respondents suggested features of the school system in South Africa which inhibited the possible development of community problem-solving approaches at schools.

Involvement in community action is considered an important aspect of environmental education (Robottom, 1987a & b). Schools should, in terms of an holistic approach to education, provide an opportunity for pupils to become involved in community-oriented projects. However, neither group of student teachers introduced to Project WATER was convinced that they or their future pupils could take action to address the water pollution problem based on data obtained through water quality monitoring. If by the time student teachers complete their teacher education courses, they have not had an opportunity to be involved in community problem-solving approaches themselves, I would submit that it is unlikely that many of them will see the value of or risk getting involved in such a project with their pupils. The implications of this for environmental education will be discussed in Chapters Six and Seven.

4.3 CASE 2: HIGH SCHOOLS IN GRAHAMSTOWN:

4.3.1 Initial responses:

Of the eight high schools and eight primary schools contacted in Grahamstown, the following responses were obtained (See Table 1).

Table 1: Responses from schools to notification about Project WATER

SCHOOL	INITIAL RESPONSE	FINAL RESPONSE
Primary schools (Town)	no responses	not followed up
DSG	will think about it for next year	one pupil project
Graeme College	requested a demonstration	12 project participants; involved in wetland project
Kingswood High	one teacher attended workshop	no response
Mary Waters Sec.	requested a demonstration	Wildlife Club project; wetland project
Nathaniel Nyaluza	no response	wetland project
Nombulelo	no response	no response
Ntsika	no response	wetland project
P.J. Olivier	requested a demonstration	wetland project
St Andrews College	negative response (later positive)	four pupil projects; wetland project
Victoria Girls High	no response	no response

If schools did not respond positively to my written invitations and follow-up visits or telephone calls, they were not pursued further at the stage of initial implementation. One reason for this was that I was concerned about the fact that I would only be in Grahamstown for one year and felt that, if the project was to be sustainable in the long term, it would be better to work with groups which were genuinely interested

in the project. Throughout the process of project development I was concerned that the project did not become too dependent on me and looked for a possible local coordinator to take over the project once I left (Section 4.3.8).

Despite discussions with teachers about ways in which Project WATER could be used within the context of the syllabus, none of the high schools used it in the classroom situation. Teachers initially seemed unwilling to get involved in the project themselves but some encouraged pupil involvement through school Biology or Environmental Club projects. Neither of these activities affected an examinable or teacher-dependent part of the curriculum, although project marks did contribute towards the year mark.

4.3.2 Hoërskool P.J. Olivier:

I had an opportunity to demonstrate Project WATER to a group of Standard Eight Biology pupils who had just completed a chapter on pollution in the Ecology section of the syllabus. Members of the class appeared keen to participate in the demonstration by doing some of the tests themselves. They showed interest in the practical demonstration of some of the effects of pollution which they had recently studied in theory.

The teacher, however, declined my offer to take the Biology class to investigate a local stream, saying that the group of 40 pupils was too big and that it would not be possible to organise transport. He did not encourage the pupils to make use of the kit to do project work. I noticed later in the year that only one pupil from the school submitted a project to the Schools' Science Expo. When I suggested that the kit be used extramurally by an Environmental Club at the school, the teacher replied that these clubs only existed in private schools. The school did, in fact, have a *Landsdiensklub* (Land Service Club) and later in the year this club decided to get involved in a community project which developed from the water project (Section 4.3.8).

4.3.3 Graeme College:

The response from Graeme College to my letter was very positive. Although the teacher who liaised with me could not make time to be involved directly in the project, the pupils were informed about it and some expressed an interest in using the kit in their class Biology projects.

Graeme College has a history of involvement in science and environmental projects. They have for a number of years looked after an area of natural bush next to the school, have been involved in cutting hiking trails and clearing alien water weeds and are regular participants in the Schools' Science Expo. Projects form a very important part of the curriculum and the school is considering an interdisciplinary programme for 1993. Arrangements can be made if pupils wish to do an interdisciplinary project dealing with, for instance, Geography and Biology, for marks from one project to be credited to both subjects (De Villiers, 1992, pers. comm.).

I demonstrated the kit to a group of about thirty Standard Eight and Nine pupils. The teacher believed that using the water kit would present the pupils with a greater challenge than doing a non-experimental project. To encourage pupils to get involved, he offered extra marks to those who submitted projects in which they had taken an experimental approach. Interested pupils and the Biology teacher later attended a practical session at a stream on the school property where they were encouraged to try out some of the tests. Only one school period was available and limited equipment meant that not all the pupils managed to try out the tests. Feedback from this group and the B.Prim.Ed III class (Section 4.2.1) caused me to change initial training sessions to a laboratory session in which small groups of participants had access to their own sets of equipment and could all practise in relatively comfortable surroundings with fewer distractions than outdoors.

As part of the process of planning their projects, the Biology teacher required his pupils to present project proposals to the class in which they outlined their project plans and methodologies. Most of the pupils using the kit wanted to test water

quality in various parts of the Grahamstown catchment of the Bloukrans River (Figure 2). These pupils chose to investigate a problem such as pollution related to some other factor, such as land use in the catchment, implications for recreation or the occurrence of indigenous fish (see below).

Projects proposed by Graeme College pupils:
(* = projects completed and submitted)

Standard Nine:

(a) Effect of the sewage works outflow on pollution in the Bloukrans River

(b) Effects of water pollution on indigenous fish in the Bloukrans River

(c) * Coliform bacteria levels in rivers and dams used for recreation (title changed)

Standard Eight:

(a) * Comparing water pollution in pristine and settled parts of a river

(b) * Comparing pollution levels at different sites along one river

(c) Looking at the effect of an alien water weed on a river

(d) * Using an alien water weed as a hydroponics growth medium

(Note: A .monograph providing detailed accounts of a selection of these and other water projects is planned for publication in 1993.)

The pupils, as participants in the early stages of the development of Project WATER, were in a position to contribute valuable evaluative comment to help improve draft editions of project materials and instructions, particularly as some of the materials did not apply directly to conditions in Grahamstown (Chapter 5). I therefore asked the pupils to see themselves as co-researchers with me in the evaluation and ongoing development of Project WATER in Grahamstown and asked them to consider their experience of the project critically with a view to making improvements and recommendations.

Because I realised that initial training in the use of the kit during demonstrations had been inadequate, I offered to assist the pupils individually as they got involved in their own research. I offered to accompany them on their first field trip in case they encountered problems with the methodology. However, of the twelve pupils, only one made use of my offer from the outset. Later, two other groups also requested help when they encountered problems. It was these three groups that eventually produced meaningful projects. Those who did not make use of my offer of help either dropped the project altogether or made use of the resource in a very superficial manner (Section 4.3.7).

I observed that the Standard Eights and Nines responded to the water project very differently. It is worth mentioning that, being an outsider and in no way prejudiced against either group, I treated both groups identically. In fact, most meetings were with both classes together and I was not conscious of which pupil was from which class. Therefore I do not feel that my involvement was an important factor affecting the different responses observed.

The Standard Eight project proposal presentations were of a consistently higher standard than the Standard Nines (as I observed and in terms of marks obtained). None of the five Standard Nine pupils made use of my offer to assist them with the tests whereas five of the seven Standard Eight pupils did. With regard to pupils not completing their water projects, one pair of Standard Eights dropped out because of ill-health of one partner which prevented them doing their field work in time. Only

one of the Standard Nines handed in a water project and it was obvious from his report that he had not understood the tests. Most of his report consisted of sections of text copied verbatim from the water monitoring handbook. The Standard Nine class was seen by one of the teachers I interviewed to be uninterested in school work. He interpreted their limited involvement in the water project as consistent with their general approach to school.

Most of the pupils procrastinated before starting their field work. This meant that, when they encountered problems, there was little time to repeat the tests and this led to pupils dropping the project. Another disadvantage of this procrastination was that, until the pupils actually embarked on their projects, the suggestions I gave them regarding technique and record keeping meant very little. Fruitful dialogue between myself and the pupils did not take place before they were personally involved in the project, encountering problems and questions which needed to be resolved.

Towards the end of term when projects were due, those pupils who were still involved with the project became more keen to discuss practical difficulties they had encountered and the interpretation of their results. At these meetings I chose to play 'devil's advocate', helping pupils to highlight areas of uncertainty and to clarify their thoughts. This was an important stage in the pupils' research as it helped them to see how the results of different tests related to one another and to build up a meaningful picture of water quality.

The flexibility of the kit as a tool for scientific research was demonstrated particularly well by one Graeme College pupil who used only four tests from the kit (the phosphate, nitrate, pH and oxygen tests) to monitor the effect of the presence of an alien Nitrogen-fixing water weed, *Azolla filiculoides*, on the growth of plants in hydroponics media. Involvement in this project was stimulated by a concern for an endangered fish species which lives in a pool on the Bloukrans River which is covered by this weed. The pupil hoped that, if a commercial use could be found for the weed, it would be harvested from places like the Bloukrans Pool and no longer present a problem to the natural environment. Interestingly, this pupil perceived that

he was using the kit in a way other than that for which it had been designed. However, to my mind it was just this selective and creative use of the resource that demonstrated its flexibility and the importance of the user in expanding its potential.

4.3.4 St Andrews College / Diocesan School for Girls (DSG):

St Andrews College and DSG are private schools in Grahamstown which cooperate to offer co-educational classes for their senior pupils. Not realising this, I sent two separate letters inviting participation in the project. The experience with these schools indicated to me the importance of meeting with teachers personally when trying to encourage involvement in a project.

The teacher in charge of Biology at St Andrews / DSG sent a message declining my written and telephonic invitations. Soon after that, a teacher from DSG visited me in person to return their questionnaire and decline the invitation, saying that they had already "planned their programme for the year and would be visiting the coast again" and that they "might consider the project next year". After discussing the potential of the project with this teacher and stressing that pupils could make use of it individually to enhance project work, I was given the chance to demonstrate the project to the combined Standard Eight Biology classes from St Andrews College and DSG.

Initially, the extent of my involvement with St Andrews / DSG was considerably less than with Graeme College. By the time I was invited to address the pupils, it was very nearly school holidays. The initial demonstration was followed by a laboratory training session for interested pupils. Just before the pupils went home on holiday, during which time they were meant to complete their projects, a meeting was held to discuss their questions and suggest useful hints. Three of the five participants managed to complete their projects with no further assistance from me. This suggested that the written instructions were clear and that the tests were simple to

execute. The variety of project topics was interesting, illustrating once again the flexibility of the water testing kit.

Projects done by St Andrews / DSG pupils:

(a) A survey of water quality in the Grahamstown catchment of the Bloukrans River

(b) Is tap water the best drinking water? A study of the quality of water at different stages in the process of purification

(c) A comparison of water quality in Eastern Cape dams

(d) Setting up the perfect fish tank ecosystem

(e) *Spirogyra* as a pollution indicator.

One of the St Andrews College pupils had decided to make use of the Project WATER kit after attending the workshop run by the national coordinator in January, planning to submit his project to the Schools' Science Expo. This pupil made use of many available resources, including the Project WATER kit, pool chlorine and soil test kits, computer technology, technical and professional support from the school laboratory technician and Rhodes University scientists, and school and university libraries. The thoroughness of both this pupil and the pupil from Graeme College who used the kit to study hydroponics, was reflected in their attention to accurate scientific technique, their questioning attitude towards their results and their attention to effective presentation.

In accompanying the St Andrews pupil on his first sampling trip, the importance of the project as a catalyst for questions was highlighted (compare Section 4.4.4).

Trying to interpret unexpected readings at a number of sites provided scope for forming and testing hypotheses and for real experimentation. At school, what are called 'experiments' are often simply 'demonstrations' of techniques in which the outcome is known in advance and there is no speculation about the interpretation of results. Project WATER provided pupils with an opportunity to investigate situations in which the outcome was unknown and to look for ways of interpreting unexpected results. This gave pupils a much more realistic understanding of research than was generally experienced at school.

This pupil was interested in computers and subjected his results to statistical tests to look for correlations between results of different tests. He also decided to write a program to automatically convert raw data into water quality indices. Far from considering the mathematical aspects of the project to be a problem (compare Section 4.2.1), this pupil found them to be part of the attraction of the project.

Through my involvement with St Andrews College pupils and with the Wildlife Society (Section 4.3.8), I met Wayne Joubert, a newly appointed Biology teacher at St Andrews. Joubert recognised the environmental education potential of Project WATER and agreed to take over coordination of the project from 1993. St Andrews is well placed to act as the local support centre for this project. The school has a laboratory technician and a well equipped laboratory for the preparation of solutions. It also has desk-top publishing facilities which could be used for local redevelopment of materials and electronic mail facilities for computer conferencing.

4.3.5 The Schools' Science Expo:

Most pupils at Graeme College, St Andrews College and DSG who chose to get involved with Project WATER did so with a view to presenting their projects at the annual Schools' Science Expo held at Rhodes University (Figures 8 & 9). This was a valuable opportunity for local teachers and pupils to see the potential of Project WATER as a stimulus for varied and interesting project work. Seven projects

Posters exhibited at the Schools Science Expo, Rhodes University, June 1992

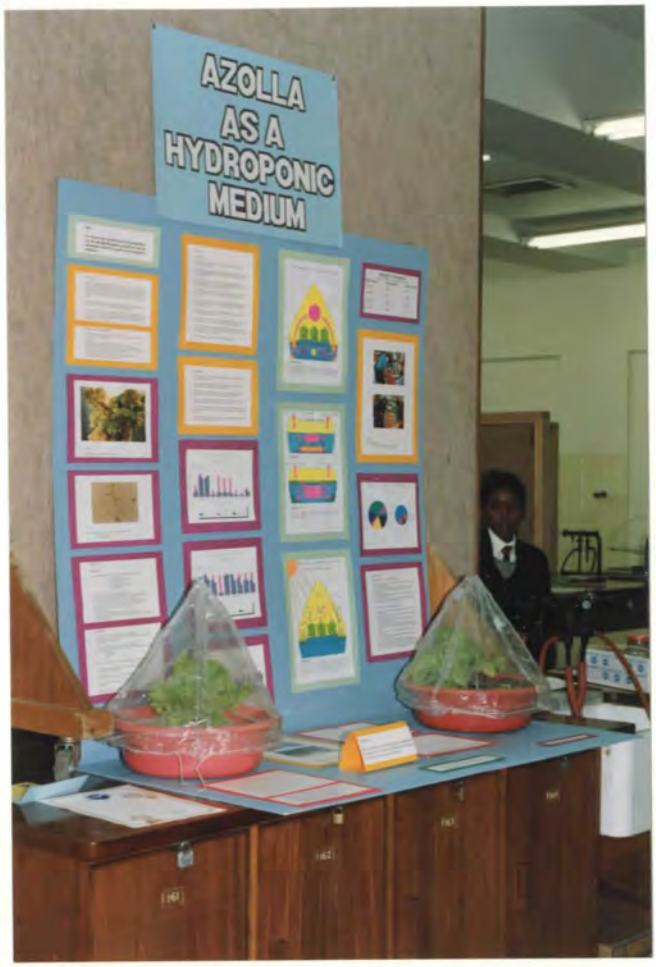


FIGURE 8: *Azolla* as a hydroponic medium: G.Cambray, Graeme College

FIGURE 9: An assessment of water quality in the Grahamstown catchment area of the Bloukrans River: B. Irwin, St Andrews College

making use of the kit were submitted. All these projects were awarded medals, two being gold medals. The two gold medallists both went on to win gold medals at the national competition held later in the year in Bloemfontein. At the national competition, the pupil who had used an alien water weed as a hydroponics medium was selected to represent South Africa at the international finals in Amarillo, Texas in 1993. A parent of one of these pupils told me that she felt the availability of simple tests provided by the Project WATER kit had encouraged her son to undertake a more sophisticated experimental project than he might otherwise have done.

Two Project WATER workshops were run during the Expo. Most of the pupils who attended were from Grahamstown schools which had not been involved in the project. I felt that this indicated pupil interest at these schools despite the lack of response from their teachers.

4.3.6 The evaluation seminar:

A seminar was arranged for the first night of the Expo at which pupils could present their projects, discuss their experiences and evaluate the project as a whole. The seminar was reported in the press by one of the pupils who attended (Appendix 10). The seminar consisted of short project presentations followed by a workshop in which groups undertook a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis of the project (Appendix 6), evaluating the kit, materials and their experiences. This method was chosen because it provided a balance of structure and flexibility for the discussion, ensuring that the topic was explored broadly. Two adults attending the seminar were asked to take notes and the feedback was shared at the end of the session.

Extremely useful insights were gained through this exercise, with pupils participating enthusiastically and contributing openly. Comments are summarised in Appendix 11 and some of the main points are discussed below. It was noteworthy that the pupils had accepted their role as evaluators and were prepared to offer honest and critical

comment and to suggest improvements to the project as a whole. One of the teachers suggested that this was because pupils had, from the outset, been encouraged to evaluate the project critically and had felt free to offer their opinions as these were welcomed and taken seriously.

(a) Educational benefits:

The pupils felt that the project offered numerous educational benefits, not least that it provided the tools to enable them to undertake experimental work of their own design. The pupils recognised a wide range of possible applications of the project both within and beyond the school setting and appreciated the possibilities of communicating with other groups involved in the project nationally and internationally. In discussing how to promote the project at schools, some of the pupils felt that the project should not become "part of the syllabus" because it might then become "institutionalised and routine" (their comment) and lose much of its impact.

(b) Teacher involvement:

It is interesting that the project started to make its mark on the school community of Grahamstown through the involvement of pupils rather than teachers. Despite this, however, one of the strongest criticisms which emerged from the SWOT analysis and later discussions with pupils was their dissatisfaction with the lack of teacher involvement. Although pupils were capable of carrying out the project on their own, they recognised the importance of teacher support to the ongoing success of the project in schools. Pupils generally felt strongly about the issue of teacher support. One saw teachers as resistant to change and new ideas and, from his perspective, considered them to be the "biggest problem" inhibiting innovation at schools.

I had assumed that the pupils were autonomous enough to manage the project without the support of a teacher. However, this proved not always to be the case. Without teacher support, there was little infrastructure to support the pupils' project work at school. In the case of Graeme College, chemicals could have been made up and sterilization facilities established at the school but instead I had to provide these

services which introduced difficulties and delays. Had a teacher been directly involved in the project, laboratory space and equipment could have been provided and pupils could have been supervised in the preparation of their own chemicals and apparatus. This would have made the project less dependent on me and enhanced the pupils' autonomy. This did in fact happen at St Andrews College where the school bought all the chemicals, made up the solutions and provided pupils with incubation facilities. Pupils from that school were far less dependent on me than pupils at Graeme College.

I was interested to investigate factors influencing local acceptance of the project and decided to interview teachers to investigate reasons for their unresponsiveness. Most stated that it would have been better for me to have visited the schools in person initially rather than writing and telephoning. This did not always result in acceptance of the project (for example, Hoërskool P.J. Olivier) but a visit was more difficult to ignore than a letter and allowed the teachers to explore alternative methods of implementing the project in their schools. The enthusiasm of the project coordinator was also an important factor which was lost without personal contact (compare the DSG case). An initial visit could help teachers to feel that they would be able to depend on the coordinator for ongoing support (De Lange, 1992, pers. comm.).

In some cases, the senior teacher made a decision not to become involved, without consulting other staff. Visiting the school could overcome this problem, particularly if the introductory visit consisted of a meeting with as many staff as possible, such as during a staff meeting. It is a well-known problem that letters addressed to schools do not always get into the hands of the staff member who would be most interested in responding to them.

One respondent stated that some teachers might be threatened by a researcher, particularly a scientist, visiting their classes. He said that pupils might compare the teacher with the researcher, causing the teacher to be "exposed" (his term) as ignorant. A Project WATER field worker I consulted had experienced this problem with teachers who had resisted her visits because they had felt threatened by her

(Thabede, 1992, pers. comm.). Similarly, one of the pupil participants mentioned that he had observed resistance from teachers at his school to 'interference' by visiting University researchers. He referred to this as the 'town and gown' syndrome.

Teachers also stated that they could not afford the time to get involved in something they perceived to be peripheral to their immediate needs. Timing was seen to be a crucial factor influencing the successful introduction of such a project. By the time I invited teachers to get involved in the project at the beginning of the year, most had already planned their work for the year and could not see a place for the project. However, having seen the way in which the project developed during the year, a number of teachers I consulted indicated that they would be interested in getting involved in the project the following year.

(c) Project publicity:

Another concern voiced by some pupils during the SWOT analysis and other interviews was that the project had not had enough publicity. They felt that unless it developed a 'higher profile', its future development would be limited. Some felt that more publicity from the project coordinator should have preceded project implementation. One of the pupils present at the SWOT analysis disagreed with this view, however, stating that "Interest [in the project] must be generated by the people who've used it".

A representative from the Grahamstown Municipal Health Department also felt that the project would not "sell" (his term) until the kit was packaged more attractively. He also felt people would not trust results obtained using an inexpensive kit and for this reason suggested that the selling price be increased.

The above comments suggested to me that the development of a project 'image' which would confer status on participants was an important consideration for some. This reflected a 'marketing' approach to project development which contrasts strongly with the low-cost, participatory approach taken by the initiators of Project WATER.

4.3.7 Responses from less involved pupils:

Evaluative comment obtained at the Schools' Science Expo Seminar reflected the feelings of pupils who had completed their projects and who had shown most interest in the project. I felt it was important to interview pupils who had not attended the seminar in order to investigate the feelings of the less interested pupils.

A common observation was that these pupils had chosen to use the Project WATER kit because they "had to do a project, did not know what to do and the water project looked interesting" (pupil quote). It provided an opportunity to carry out experiments and the adventurous nature of field work appealed to some. They saw the project as a "one-off thing", not as a project that would continue after they had submitted their reports to their teachers. They felt that doing the tests on a regular basis would become "boring" and were rather incredulous that I might expect "teenagers to run around doing things like this in their spare time!" (pupil quotes). When asked, unlike the pupil who had studied *Azolla* as a hydroponics medium, none of these pupils admitted to having been motivated to make use of the project out of a sense of concern for the environment.

Some pupils who did not complete their water projects reported that they had "thought it would be easy" and had simply "lost interest" when it had become obvious that the project demanded some commitment. They had been deterred by practical problems such as limited time and difficulties with transport and techniques, despite my regular visits and offers of help. This was quite understandable given the nature of their initial motivation. These pupils felt that the project would work better as a compulsory class project. They wanted field work time to be provided, transport arranged and tests to be divided between groups to reduce the boredom they experienced while repeating measurements.

These pupils remarked that people would have to be personally interested in water quality monitoring and have a particular goal in order to sustain involvement in a project such as this. One pupil thought that involvement might be enhanced if the

individual lived close to a stream or river and was personally concerned about it. Bardwell (1992:7) observes that "It is not surprising that citizens are more *actively* concerned about issues close to home that affect their lives directly...". Without this personal interest, the pupils believed that ongoing involvement in water quality monitoring projects would have to be externally motivated by, for example, a teacher.

4.3.8 Wildlife Society & Community Involvement:

Early in the year, I was asked to join the Education Subcommittee of the Grahamstown Centre of the Wildlife Society. Involvement with a local environmental group played an important role in the development of community support for Project WATER, providing a link between myself, the schools and environmentally concerned members of the Grahamstown community.

The Wildlife Society runs an annual environmental project competition for schools in Grahamstown. The committee wished to promote the competition once again but were concerned that the projects done should be relevant and useful to the Grahamstown community. One of the lecturers in the Education Department had emphasised to me the value of integrating community needs and school project work (Van Harmelen, 1992, pers. comm.) and I shared this insight with the committee. The committee organised a discussion meeting with representatives of the Grahamstown Municipal Health and Parks Departments, the Albany Museum and the University-based Institute for Water Research, to discuss project topics that could be suggested to schools (Wildlife Society, Grahamstown, 1992a). My earlier concern that water quality monitoring might not have been of genuine interest to the community proved to be unfounded. I discovered that a number of people were already concerned and had wanted to do something about the problem of water quality for some time (for example the Institute for Water Research, Rhodes Geography Department and private individuals). Project WATER had provided tools to assess water quality easily and cheaply.

Pupils from Graeme College and St Andrews College involved in Project WATER were invited to present their research findings and suggestions to a second meeting of this group (Wildlife Society, Grahamstown, 1992b). They pointed out serious faecal contamination of the Botanic Gardens Stream, originating from a sewer which often overflowed. They also drew attention to pollution of certain streams in the town caused by runoff from the township. Many homes in the township obtained water from stand-pipes in the streets and sewage disposal was by means of night-soil buckets. Disposal of domestic waste water via the stormwater drains and inadequate servicing of night-soil buckets led to very high levels of phosphates and faecal coliform bacteria in the runoff from the township. Although many people in the town were unaware of the serious pollution problem in these streams, some residents were affected by the foul smell, and use of the streams was limited by the pollution.

The pupils' findings provided concerned members of this group with specific information to justify resubmitting a proposal to the Municipality to establish wetlands or reedbeds in the Bloukrans Stream downstream of the township, in an attempt to address the water pollution problem. It was decided to establish the reedbeds on a piece of degraded municipal land which had been used in the past to dump builders' rubble and other refuse (Figure 2). It was suggested that the whole piece of land be upgraded into a community park to serve the needs of people who live, work and catch public transport nearby (Appendix 12).

Realising that support for the project was growing, I contacted local high schools again to find out whether they were interested in participating in the project. Interest was stimulated by local success stories, such as the way in which pupils involved with Project WATER had excelled at the Schools' Science Expo and the fact that the Municipality was prepared to support the wetland project. A meeting was held at which a teacher from a school in East London shared how his pupils had become involved in an environmental project which had resulted in improvements to living conditions in a nearby squatter camp. A committee was elected to coordinate activities and to ensure that the project was incorporated in plans for school club activities and project work the following year. It was very encouraging to see that

three schools, Nathaniel Nyaluza, Ntsika and P.J. Olivier, which had not previously been involved in the project, attended the meeting and pledged their support (Project WATER, Grahamstown, 1992). At an initial site meeting, representatives from six high schools and one primary school in Grahamstown carried out an initial survey and litter clean-up of the proposed wetland area.

The Curator of Fresh Water Fish in the Ichthyology Department at the Albany Museum offered to house all school projects dealing with water quality at the museum in order to provide pupils with a data base and ideas for projects. Pupils who know that their projects will be referred to by others may be encouraged to see the value of their work and to produce more thorough and careful research. In the above-mentioned ways, involvement in Project WATER helped to bridge the gap between school and community in Grahamstown. In turn, community involvement provided momentum for the continued development of Project WATER in Grahamstown.

4.3.9 Mary Waters Secondary School:

The Mary Waters Wildlife Club originated as a hiking club which developed a nature conservation focus. The teacher who had previously been in charge had attempted to delegate responsibility for the club to two first year teachers. Neither of these teachers had a biological or scientific background, nor experience running a club. By March when I visited the school, there had been no club activities.

My involvement with this group consisted of an introductory talk on Project WATER, a practical laboratory session, a field trip and follow-up sessions to discuss results and evaluate the project. I had hoped that the teachers would take a more active role in the project but, because they felt unskilled in science they requested me to run the programme.

The introductory and laboratory sessions were well attended (approximately thirty pupils), but unfortunately the weather on the day of the field trip was extremely inclement and only thirteen pupils arrived. We followed a stream near the school until it entered the Belmont Valley, stopping at various points to look at features of the catchment, observe the quality of the water and consider possible sources of pollution of the stream (Observation Schedule: Appendix 13). The group tested two sites in the Belmont Valley (Figures 2 - 5 & 10) and visited the sewage treatment works.

The first report-back session was attended by many of the pupils who had not been on the field trip. It was a very awkward session as these pupils were restless because they could not follow what was going on. I felt that their presence inhibited pupils who had attended the field trip from sharing their results.

After this session, pupil interest in the project declined. Teachers and pupils attributed this to the fact that many of the pupils had not attended the field trip and therefore did not consider the follow-up activities relevant. Some pupils had joined the club because they saw it as a hiking club. The teacher in charge reckoned that these pupils were not interested in the scientific investigations which followed the field trip. A third problem was that after the field trip, other school activities such as interhouse sports and examinations took precedence and interfered with meetings to discuss possible further development of the project.

Two of the teachers felt that a further obstacle limiting pupil participation in the project was my lack of fluency in Afrikaans, the language spoken by the pupils. The language problem was addressed to some degree using group work which enabled the pupils to discuss and debate issues without being inhibited by not knowing whether I would understand them. However, spontaneous discussion between the pupils and myself was limited.

Early discussions with the teacher in charge of the club had led me to expect that the pupils would be keen to communicate their findings or get involved in an action

FIGURE 10: Teacher and pupils from Mary Waters Secondary School testing the Bloukrans Stream at the municipal pound for dissolved oxygen

FIGURE 11: Teacher from Farmerfield School helping pupils to identify water organisms

project to address the water pollution problem. It was, however, extremely difficult to get pupils together after the initial feedback meeting. After a number of poorly attended meetings, I started to feel that the pupils were not interested in carrying the project further.

I investigated reasons for the apparent apathy of the club towards involvement in projects with the teacher who had originally been in charge of the club. He suggested that an underlying reason could be related to the state of political disenfranchisement and sense of alienation from the land which Black people have experienced in South Africa for many years. As the teacher said: "It is hard for us to realise that we have a stake in the country ... we Black people don't identify with the country because it is not yet our country". He reported that the club had experienced two instances of the municipality being unwilling to assist them with environmental projects at the school. This had made them feel that their requests were unimportant and had left members of the club despondent and less willing to get involved with projects in future.

Another problem, he felt, related to teacher-pupil relationships, particularly in informal situations such as club excursions. Since the schools unrest in the mid-1980's this teacher had observed attempts at schools to "close the gap between teachers and pupils" (his comment). However, this had resulted in a growing lack of respect towards teachers, especially in informal situations such as weekend excursions where some teachers felt they would be unable to control their pupils. This sense of insecurity on behalf of the teachers mitigated against their involvement in extramural activities.

The pupils enjoyed physically demanding activities such as hikes and a number of them still saw the club as a hiking club rather than a wildlife club. The teacher felt that the ideal club leader would be an environmentally concerned teacher whose physical abilities the pupils respected. He saw the need for a role model providing what Hartshorne (1992b) has referred to as 'authentic authority' to encourage environmental concern among members of the club.

As in the case of the university students (Section 4.2), these pupils also lacked experience and skills of community problem-solving and, for reasons mentioned above, may not have seen community problem-solving as their responsibility. In this kind of situation, I believe it is unlikely that involvement in practical environmental monitoring projects such as Project WATER will automatically result in community action without the guidance of a teacher or group leader.

4.3.10 General comments:

The initial development of Project WATER in Grahamstown high schools occurred in an extramural context. Teachers either allowed or encouraged pupils to make use of the project to assist them in their own project work or made use of it as a club activity. In all cases, however, teachers were only peripherally involved. This was not seen to be ideal because, on the one hand, pupils were not supported in the carrying out of their projects and, on the other hand, teachers were not learning to make use of the resource themselves and exploring its potential for their own situations. Furthermore, where projects were carried out by individuals or pairs of pupils and not made part of classroom activities, opportunities for the development of ongoing community problem-solving projects by classes were limited.

In spite of this, a number of teachers who observed the way in which their pupils made use of the project started to see its potential for use within the classroom situation. At St Andrews College, aspects such as further redevelopment of the kit, localisation of the written resources and development of a computer network were mentioned as possible projects for the coming year (Chapter 5). Joubert hoped to involve subject disciplines such as technical design, computer studies and biology in the ongoing development of the project. Graeme College was considering a long-term interdisciplinary project involving the ongoing monitoring of the Kowie River. Pupils who had had experience of the project could, according to a teacher, become instructors responsible for teaching both teachers and other pupils how to use the kit.

Teachers from both schools recognised the potential of this project to provide a focus for interdisciplinary study.

My encounters with high schools in Grahamstown during 1992 revealed limited involvement in community-based environmental project work. Project WATER provided some opportunities for this to occur. However, involvement in water quality monitoring did not automatically lead to the development of environmental action projects. This development appeared to be influenced by a number of factors including recognition by members of the group that the problem was important to them and the involvement of people who were genuinely interested in addressing the problem. Involvement in an environmental project such as Project WATER provided opportunities for pupils to develop the skills and confidence to identify and address an environmental problem within their communities. In time this may contribute to the development of a 'culture of involvement' in society.

4.4 CASE 3: FARM SCHOOLS IN THE GRAHAMSTOWN DISTRICT:

4.4.1 Introduction:

The community health applications of Project WATER are probably of more relevance in areas not supplied with treated, piped water than in areas which are. I was therefore eager to work with some rural schools in the Grahamstown area. Mr Cecil Nonqane, an education officer at the Albany Museum, introduced me to some farm schools in the district. This was a great advantage as, not only was he able to suggest schools likely to respond positively to the invitation, but being introduced by a respected member of the community facilitated my acceptance by the schools.

Of the five schools I was introduced to by Mr Nonqane, three responded positively. These schools were Begelly (26 Standard 3, 4 and 5 pupils), Brighton (19 Standard 5 pupils) and Farmerfield (97 Standard 5, 6 and 7 pupils) (Figure 3). All three schools were characterised by a principal who had been at the school for a number of years and who was genuinely concerned about the learning opportunities afforded to the pupils. This was evidenced by the fact that all three schools were regularly visited by education officers of the Molteno Project, an in-service literacy education project, Mr Thompson Gojela, a nature conservationist from the Algoa Regional Services Council, and Mr Nonqane himself. A spirit of concern was expressed by one of the teachers who, when discussing how the pupils would be involved in the water project, stated categorically that: "They must *do* the work. It's no good if they just watch, because they will go away and not be able to do anything when they leave school".

Teachers indicated that the immediate relevance to these communities of water quality enhanced their interest in the project. One principal was insistent that, once our initial studies of water life were completed, we moved on to investigating whether their water sources were contaminated with faecal bacteria. Another was very interested to see that the support materials of Project WATER included a design for a pit latrine. This made the project relate practically to her immediate needs.

On my first visit to the schools, I took with me the complete Project WATER kit. The response of the teachers was that, because most of the schools were primary schools, the physical and chemical tests would not be appropriate. They chose to investigate water organisms and, because of the relevance to the health of their pupils, bacterial contamination of the streams, dams and water tanks from which the schools get their water.

4.4.2 Language teaching focus:

Working in the farm schools challenged one of my assumptions about the level of English ability in rural Black schools. I knew that English was supposed to be the medium of instruction from Standard Three upwards (Education & Training Act No. 90 of 1979, Amended June 1991) and was unprepared for my observation that, because most of the pupils hear no English spoken on the farms, few can communicate confidently in English by Standard Five. This, coupled with my inability to speak Xhosa, severely limited the extent to which I could understand and interpret proceedings during the visits. However, the limitation of language also provided a great opportunity for the teachers to play an active role in the project as they acted as interpreters and were far more involved in the process of teaching than most of the teachers in the town schools (Figures 11 & 12) had been.

The project in the farm schools developed a strong language teaching focus. What I said in English was interpreted by the teacher, giving the pupils a chance to hear English interpreted. In some cases, teachers wrote lists of new vocabulary on the chalkboard as I spoke, with Xhosa translations to assist the children. During the field sessions, I provided the pupils with a simple reference booklet (Umgeni Valley Project, 1991) which enabled them to find out about the water organisms they found in the streams (Figures 13 & 14). I asked the pupils to report on the animals they had found to their classmates. Working in groups helped them to understand and make sense of the English information. In some cases, the pupils who could read English translated the information into Xhosa so that the younger children could

FIGURE 12: Teacher from Begelly Farm School helping pupils find out about water organisms

FIGURE 13: Pupils from Begelly Farm School looking for water organisms in the Berg Stream

FIGURE 14: Pupils from Farmerfield School using the water booklet to find out about organisms found in a stream near the school

FIGURE 15: Pupils at Farmerfield School working in groups to prepare a poster showing the organisms they found in a stream near the school

understand (Figures 15 & 16). In other cases, reports were given in English, providing practice in reading and reporting.

After the field work sessions, I gave pupils copies of *River of our dreams* (The Storyteller Group, 1991), a literacy comic which tells the story of a group of school children from Johannesburg who investigate life in a river using the same booklet as the farm school children had used. I pointed out in the comic that pupils at schools elsewhere in the country were involved in the same project as they were. They were very pleased to receive the comic and in one school spontaneously started reading aloud together when the comics were handed out. On a follow-up visit I asked whether the pupils had been using the comics. I found that the children had them in their bags and, from their appearance, they had obviously been well read.

4.4.3 The water study booklet:

As a result of pupils translating sections of the water booklet (Appendix 4a) into Xhosa, some teachers asked that the whole booklet be translated in order to be more accessible to a greater number of pupils. I asked two technicians at the Institute for Water Research to assist with the translation of technical terms and teachers said they were willing to assist with the general translation. I subsequently discovered that the booklet was being translated professionally by a publisher so local translation was not pursued.

I have since become aware of a debate as to the desirability of translating the water booklet into Xhosa. Bongie Thabede of Umgeni Water / Amanzi reported that people she had consulted in Natal preferred the booklet being in English as it provided pupils with more practice in reading English (Thabede, 1992, pers. comm). The experience of pupils translating the information for themselves was seen to be of greater educational value than having the resource in the vernacular. This is an issue that requires further research, particularly as certain environmental educationists become interested in literacy and second language teaching.

Second language teachers have for many years recognised the value of encouraging pupils to read about and discuss topics that genuinely interest them (Ellis, 1986). This provides pupils with a great deal of motivation to learn. In the farm schools the curiosity of pupils was stimulated by the experience of exploring streams and finding water organisms. This, and the fact that they were asked to teach the rest of the class about the organisms they had found, motivated them to read and discuss the information in the booklet on water life. Working in groups helped the pupils to work out the meanings of words, as they could draw on the experience of all the members of the group. It also enabled them to practise verbalising new words before having to speak to a large group. The above experience indicates that the booklet on water life and other *Hands-On* booklets have potential as teaching resources for language across the curriculum and second language teaching. Reading these booklets formed a natural part of an enjoyable field work experience.

4.4.4 A stimulus for question-posing:

After the field work session at Farmerfield school, I asked groups of pupils to raise any questions that might have emerged from their experience at the river. The questions were very interesting and penetrating, revealing a real desire to understand and not simply to accept what was told them. Questions included, for example: "What does the method of breathing [of water organisms] tell us about the quality of the water?", "What kills animals in the water?", "Why do bacteria live in dirty water?", "How can some animals live in water that is harmful to us?", "Why did we find mayfly nymphs even though the water was dirty?" and "Why does the mayfly adult live only a day while its nymph lives for a whole year?" (pupil questions).

The pupils also commented on some of the things they had found interesting about the project. For instance, they were interested to have learned that finding many different animals living in fresh water indicated that it was clean, having thought that the presence of animals in the water would make it dirty. In a letter written to me at the end of the project, pupils from Brighton school stated that it was important to

them to have learned that boiling dirty water could make it safe to drink. A Farmerfield pupil stated that he was more interested in studying water since having seen the different animals that live in it.

At the farm schools, I often observed classes answering teachers' questions in unison and interpreted this to mean that pupils were taught in a rote fashion which did not encourage questioning. This interpretation was challenged in discussion with a colleague who suggested that answering questions in unison was a way of maintaining the cohesiveness of the group. It certainly appeared from the sorts of questions the pupils asked about stream life that their sense of enquiry was by no means impaired. A strong sense of group cohesiveness was noticed in the manner in which pupils were consulted by their teachers when decisions had to be made, the way in which teachers constantly asked whether the group was together in understanding what was happening (Siyavana? = Are we together?) and the way in which pupil worked naturally and productively in groups.

4.4.5 Use of the Water Cycle poster:

During introductory sessions with the farm school pupils, I felt it was important to make sure that they understood the concept of the river as a whole system, from its source to its mouth. Being the children of farm labourers, it was unlikely that the pupils would have travelled widely and therefore it was possible that they might never have been to the sea or seen the ways in which rivers were used and polluted in urban areas. I therefore made use of a poster produced by the Urban Foundation and Cape Nature Conservation which illustrated the water cycle, including the various stages of a river and some of the sources of pollution which contaminate it (Chapter Two).

When the teacher asked the pupils to name things which polluted water, they mentioned things they were familiar with, such as litter, soap and livestock. Chemicals, oil and even sewage were not immediately identified. Nutrient runoff from agricultural lands, although something that happened in their own areas, was not

mentioned because it was not visible. The poster helped to illustrate that people living upstream of the pupils could pollute the water they used. The way in which they used the stream could, in turn, affect people living downstream. It also helped to illustrate water supply and sanitation in towns, and industrial uses and pollution of water, issues most of the children were unaware of.

4.4.6 Action resulting from field work:

Brighton and Farmerfield pupils investigated streams on or near the farms where their schools were situated. Begelly, however, chose to have an excursion to a mountain stream because the river on their farm was stagnant and very muddy. We therefore visited the Berg River, a mountain stream supplying Settler's Dam which provides Grahamstown with water (Figure 3).

The pupils found numerous organisms and, using the water quality slide (Appendix 3b), concluded that the water was clean and suitable for drinking. However, they also noticed that people who had been picnicking at the stream had left a lot of litter. When asked about the possible effects of this visible form of pollution, the pupils were concerned that it might make the water dirty and kill some of the animals. I asked whether we could do anything about this problem and they suggested tidying up the litter and putting it in the bin provided. The pupils enthusiastically cleaned up the stream area (Figures 17 & 18) and, without being asked, one group started picking up litter along the road verge. Within a very short space of time, they had filled all the containers we could find.

Having taken photographs of the outing, I discussed with the teachers and pupils the possibility of publicising what they had done in the local newspaper. On returning to school, one group of pupils planned an article for the local newspaper (Appendix 14) and another group wrote a letter to the municipality, asking that the litter they had collected be removed. In order to enable the pupils to plan their writing without being inhibited by language, I suggested that they write in Xhosa and that their

FIGURE 16: Begelly Farm School pupils working together to translate information about water organisms into Xhosa

FIGURE 17: Begelly Farm School pupils collecting litter from the Berg Stream

teachers help them to translate their letter and article into English. In this way, action to address a problem in the environment developed out of a school field trip and pupils practised skills of writing articles and official letters in the context of an actual experience.

4.4.7 The coliform test:

I was concerned that pupils who had never seen a microscope might not understand the idea of microscopic organisms such as bacteria. I therefore tried to think of simple ways of explaining the presence of coliform bacteria in sewage-contaminated water and the way in which the coliform test worked. The coliform test was usually done after the pupils had searched for water organisms in the stream. I compared catching bacteria by filtering water through a micropore filter to catching water organisms with a sieve, as they had done. I described the concept of bacterial reproduction by binary fission in simple terms in order to show how incubating the filter on a growth medium produced visible colonies which one could count (Appendix 15).

Pupils used the coliform test to test water quality in water tanks, rivers and dams near the schools. Water in many of the rivers and dams was obviously too dirty to drink. The drought had dried up many of the streams, leaving only muddy, stagnant pools which, like the dams, were visited by livestock.

In order to see whether various types of water treatment could kill bacteria and make water suitable for drinking or washing purposes, a series of coliform tests was done. The pupils tested river or dam water before and after various treatment methods (sand filtration, boiling, treatment with Dettol and Milton) (Figure 19). Boiling and treatment with antiseptics killed all the bacteria, resulting in no colonies growing on the filters. Untreated and filtered water, however, was found to contain numerous bacteria. Pupil interest in this aspect of the project was reflected in their enthusiasm to participate in and see the outcome of the tests. The group at Brighton school

FIGURE 18: Teachers and pupils from Begelly Farm School and a nature conservation officer with the litter collected from the Berg Stream

FIGURE 19: Teacher and pupil from Begelly Farm School testing water from the stream on the farm for coliform bacteria

admitted that they were trying to implement in their homes what they had learned from these experiments. With regard to the issue of purifying their drinking water, the pupils wrote: " We are trying to remember ... although sometimes we forget because we are not used to boiling water" (from pupil letter).

4.4.8 Possible future developments:

Despite emphasising that approaches such as the coliform test and field work with the water booklets are methods that the schools could use in future, I do not know whether these approaches will continue once I have left. In order to provide teachers with the opportunity to continue with the project if they wish, I introduced them to the teacher who will be coordinating Project WATER in future. Mr Nonqane of the Albany Museum would also be in a position to support further developments, having been involved in the project from the beginning in Grahamstown. Throughout the project, teachers and pupils were directly involved in doing the field work and experiments themselves. They therefore have had the opportunity to develop skills which they can use later if they wish.

4.4.9 General comments:

I recognised two factors which contributed to the positive response to Project WATER which I experienced in the farm schools. These were firstly its relevance to community health and secondly its potential to enrich the educational situation. Unlike in urban areas where people have access to treated, piped water, the health of rural people is directly affected by the quality of water in their tanks, rivers and dams. This problem is exacerbated during periods of drought when diminishing water sources are in greater demand and pollution becomes more concentrated. Teachers saw the relevance of this project to their daily lives and were keen for their pupils to become involved.

Mr Nonqane introduced me to schools which he knew were responsive to project work. I found the teachers very willing to make time for projects that would provide enriching educational experiences for their pupils. Their flexibility provided opportunities for project lessons and field trips to become truly interdisciplinary in nature, an important aspect of environmental education (*Connect*, 1978). Lessons regularly combined language, science, biology and geography. Pupils were occasionally required to do simple mathematics, such as when diluting antiseptics and when calculating bacterial concentrations in water. The teachers did not appear to be concerned with where the project fitted into the syllabus. The exercises were accepted because of their immediate relevance. The project also lent itself to many different educational approaches, such as observation, experimentation, group work and reporting. Pupils stated that the topic interested them because it was relevant to their everyday lives and most of the work was done in their immediate environment.

The flexibility of teachers in the farm schools was not encountered in town schools I visited. It may be unfair to compare these situations as another significant difference between the schools was that the farm schools were on the whole primary schools and the town schools were all high schools. The teachers in the town schools were more constrained by time, the syllabus and subject divisions. This sense of knowledge compartmentalisation is a tendency which environmental education seeks to overcome (*Connect*, 1978). In my experience with the farm schools, Project WATER provided a focus which helped to make education more interdisciplinary, responsive and relevant.

CHAPTER FIVE: THE RESEARCH PROCESS: DESCRIPTION AND INTERPRETATION
PART II: LOCAL REDEVELOPMENT OF PROJECT WATER

5.1 INTRODUCTION:

One of the guiding principles of the development of Project WATER is to make the 'tools' of water quality monitoring affordable and available to as many people as possible (O'Donoghue, 1991b). Participants are encouraged to make use of cheap, easily obtainable equipment and materials and to adapt the kit in innovative ways as they see fit. As the project has spread from Natal where it originated to other parts of the country, certain local modifications to materials have been necessary. Project participants are encouraged to 'make the project their own' and to redevelop it locally. In some cases, this sense of local identity has extended to the development of new project titles and logos, such as SWAP (the Stellenbosch Water Analysis Project).

In this section, certain aspects of the process of local redevelopment of Project WATER in Grahamstown are recorded and discussed, including:

* Redevelopment of the kit and materials for local conditions
* General modifications to the project
* Issues emerging from the redevelopment process.

Most of the observations, modifications and suggestions were communicated to other GREEN project coordinators in the country during the period of the research. As a result, many of the procedural modifications have been incorporated into later editions of the materials (O'Keeffe & Day, 1992) and some of the issues have been raised in national and international newsletters (*GREEN S.A. Newsflash* 1992a & b; Schreuder, Ashwell & O'Donoghue, 1992).

Therefore, only a few examples will be mentioned here to illustrate points about the local redevelopment of the resource.

5.2 REDEVELOPMENT FOR LOCAL CONDITIONS:

One of the resources forming part of the Project WATER kit is a simple booklet on water life (Umgeni Valley Project, 1991; Appendix 4a) which enables participants to identify and find out about fresh water plants and animals. This booklet was produced in Natal and participants trying to identify organisms in local streams soon discovered that some common invertebrates such as blackfly larvae (Family Simulidae) were not represented. St Andrews College, which will become the support centre for Project WATER in Grahamstown, has desk-top publishing facilities which may be used to support the revision of the materials for eastern Cape conditions.

Of greater concern were discrepancies with the water quality slide which is used to predict water pollution levels (Appendix 4b). This is a simple resource which correlates the presence of certain 'indicator' organisms with levels of pollution in the stream or river. On the water quality slide, the mayfly nymph is an indicator of very clean water. In the eastern Cape, however, certain mayfly nymphs (Family Baetidae) are remarkably tolerant of low oxygen levels and occur commonly in highly polluted water. This discrepancy caused considerable confusion among project participants who could not reconcile low water quality ratings obtained using the other tests with the presence of this animal. For example, a pupil found a large number of these particular mayfly nymphs living in the Botanic Gardens Stream in which there had recently been a sewage spill (Figure 2). It was particularly worrying that people might use the water quality slide uncritically, not confirm their results using other tests, and consequently drink dangerously polluted water.

Participants recommended that the slide be modified for local conditions. O'Keeffe of the Institute for Water Research at Rhodes University was consulted and made certain suggestions regarding more representative pollution indicator organisms for the area. The water slide can be modified by pasting diagrams of these organisms onto the slide over

existing but incorrect pictures (O'Donoghue, 1992, pers. comm.). This type of problem could be addressed by the coordinator of the project. However, there may be more educational value in local participants using the opportunity provided by this problem to construct their own water quality slide based on expert advice and their own test results and observations of river life.

5.3 GENERAL PROJECT MODIFICATIONS:

A number of suggestions for general changes to materials and procedures resulted from discussions with participants and local scientists and through my own experimentation with the kit (see also Appendix 11).

In the early days of the project, the national coordinator had wanted to encourage people to develop their own kits rather than buying them ready-made. In practice I found that, until pupils had had experience working with a kit, they did not have the confidence to develop their own. Not being particularly practically inclined, I personally preferred to buy a ready-made kit than to go to the trouble of constructing one myself, finding it time-consuming to collect all the necessary equipment. I found that participants generally preferred to buy an initial kit and supplement and modify the apparatus as they developed a sense of familiarity with the project.

The coliform test was refined after discussions with microbiologists at Rhodes University. The need to investigate this test more closely resulted from a problem I encountered at one of the farm schools. The pupils had wanted to test the quality of water in the school water tank. I had run out of equipment and therefore had to collect a water sample and test it once I returned to work, rather than in the field as I would normally have done. The water was collected in a plastic bottle which the children cleaned with water from the tank.

The test results indicated unexpectedly high levels of bacterial contamination (47 000 total coliform colonies / 100 ml). I surmised that the bottle in which the water sample had been collected might have been dirty but also felt it was necessary to run a quality control check

on the coliform test itself. I ran a test with 5 ml 'sterile' water supplied with the kit. 14 total coliform colonies developed (280 / 100 ml), not enough to account for the levels of contamination of the water tank sample but enough to raise concern about the sterility of the apparatus and the reliability of the procedure.

The Head of Department, Professor Ralph Kirby, and the Chief Technician, Ms Moira Pogrund, in the Department of Microbiology were consulted and suggested a number of ways to avoid possible contamination. They also suggested a method of sterilising plastic apparatus without the use of heat and made their facilities freely available to me for the duration of the project. These modifications have been recorded elsewhere (*GREEN S.A. Newsflash* 1992b).

On my next visit to the school, I showed the results to the group but stated that I was not convinced that the results were reliable because the container might have been contaminated. Despite making these misgivings clear to the group, the pupils responded with shock and anger towards the farmer who managed the school. This farmer was disliked because he was very unsupportive of the school. In comparison to the other farm schools I had visited, the school building, teachers' accommodation and grounds were badly maintained, and the farmer was unwilling to assist the school with transport to functions, for example. In discussions I had with him, he spoke in racist terms about his labourers and the pupils. The pupils and teachers felt that the apparently poor state of their drinking water reflected his lack of concern and they identified the issue of contaminated drinking water as something they could confront him about.

The second test, performed with sterile equipment and in duplicate on water drawn directly from the water tank, revealed an average of only 80 total coliform per 100 ml. The situation was defused but the experience highlighted a very important issue in low-cost water quality monitoring. As more people are able to monitor the quality of their water sources, conflict situations such as almost occurred at the farm school may develop. O'Donoghue (*GREEN S.A. Newsflash* 1992b) warns that too much emphasis on accuracy can spoil the enjoyment of water testing. However, action based on unreliable results can quickly discredit a

potentially worthwhile project. I believe that it is imperative that a sense of responsibility develops hand-in-hand with a sense of empowerment.

Another example of general redevelopment of the project was the production of alternative catchment observation checklists. In the original materials, two checklists were provided to help participants make relevant observations of catchment and river quality to complement the chemical, physical and biological tests (Appendices 3a & b). Student teachers, school pupils and a Wildlife Society environmental education officer were asked to assess these checklists during field trips.

The responses were that the checklists were "rather dull, particularly for young children" (student quote), and difficult to complete in the field as they required too much writing. Certain comments suggested that the checklists presupposed unrealistically sophisticated knowledge about streams. For instance, most participants felt that their experience of different streams was inadequate to enable them to rank stream quality in terms of an overall percentage rating. Some had problems interpreting terms used in the catchment observation checklist. For instance, the Wildlife Society environmental education officer thought that 'settlement patterns' referred to aspects of geology, or "the way in which the rocks have settled" (her quote). In a recent edition of the Project WATER instruction booklet (O'Keeffe & Day, 1992) explanatory notes have been included to simplify the use of one of the checklists (Appendix 3a).

The B.Prim.Ed. students dismissed a suggestion by the education officer that a 1 to 5 ranking system for each category of observations be provided to facilitate the calculation of an overall percentage catchment quality rating. They felt that a certain amount of qualitative appreciation of the system would be lost by reducing observations to a numerical rating. They preferred to combine the river and catchment observations into a single checklist as they saw these to be integrally related.

In order to address some of the problems mentioned above, I designed an alternative observation schedule and field tested it with student teachers and school pupils (Appendix 13). Providing options under each observation category reduced misunderstandings and

facilitated recording without reducing observations to numerical rankings. Space for notes was provided so that these options did not become restrictive. A sheet of expressive faces (Appendix 9) was provided with each schedule in order to enable participants to identify and record their emotional responses to the area under study.

Because Project WATER has been used extensively in rural areas where untreated drinking water and poor sanitation present a serious health risk, the GREEN national coordinator suggested that a health risks checklist be designed highlighting unsanitary practices that could contaminate water sources. In order for this checklist to be useful to illiterate people, a pupil from Graeme College suggested that it be produced pictorially rather than in words. Precedent for this exists in South America where health workers from the Del Agua project (Lloyd & Helmer, 1991) provide rural settlements with sanitation assessments in the form of a drawing of the water source with sanitary risks circled. I therefore designed a health risks checklist and submitted it to other project coordinators for comment. This has been developed and included in the most recent edition of the GREEN Field Guide (O'Keeffe & Day, 1992) (Appendix 3c).

5.4 ISSUES EMERGING FROM THE REDEVELOPMENT PROCESS:

A number of issues emerged through the process of cooperative redevelopment of the Project WATER kit and materials in Grahamstown. Some of these have been described above and others are mentioned elsewhere in the text. By way of summary, key issues are reiterated below:

5.4.1 A cooperative redevelopment approach was advantageous because it involved a range of participants and helped to enhance local 'ownership' of the project. Aspects of the project requiring revision for local conditions provided participants with relevant topics for further research.

5.4.2 As participants worked with the low-cost kit, they developed the confidence to supplement, modify and redevelop it. The fact that the kit used everyday items

like plastic syringes in innovative ways helped some participants to feel inclined to modify the equipment themselves.

5.4.3 Encouraging participants to evaluate printed materials critically helped to point out ambiguous or stylistically problematic sections so that more appropriate materials could be produced.

5.4.4 Project WATER has the potential to involve and empower members of a community in addressing a local environmental problem. Careless or irresponsible use of the tests can, however, produce unreliable results which may discredit the project or lead to conflict situations.

Local redevelopment of resources is a relatively new approach in environmental education. The above observations suggest that the approach has social and educational value. It is a definite departure from the Research, Develop, Disseminate, Adopt model of resource- and curriculum development which has been criticised for its ineffectiveness in causing meaningful educational change (Naidoo, Kruger & Brookes, 1990; O'Donoghue, 1990a; Popkewitz, 1984). Involving users of a resource in its local redevelopment enhances their understanding of the resource and issues relating to its development. Involving a range of participants in the process helps to establish a local network providing both expertise and community support for the project.

CHAPTER SIX: DISCUSSION

6.1 INTRODUCTION:

As outlined in Chapter One, some authors believe that present environmental and social problems can be blamed on a dominant fragmentalist (reductionist, mechanistic) worldview in society. They believe that education systems to a large extent reflect and reproduce this world view by emphasising divisions between subject disciplines and classes and promoting individualism and competitiveness within authoritarian or bureaucratic systems. They feel that reductionist approaches, because they have led to many of the problems of the modern world, are inadequate to address social and environmental ills, and call for alternative holistic approaches to education.

Education described as holistic (Grieg, Pike & Selby, 1989), ecological (Bowers & Flinders, 1990) or ecopolitical (Gough, 1989) encourages interdisciplinary studies dealing with topics relevant to the needs of students and the wider community and promotes skills of critical thinking, problem-solving and action, and participation in cooperative, democratic processes (Appendix 1). This description of holistic education has much in common with that of environmental education as outlined in the Tbilisi Declaration (*Connect*, 1978) (Appendix 16). At a time when society is faced with serious environmental and social challenges, I believe these approaches to education are necessary to counter the effects of the fragmentalist practices common in many educational institutions.

In this section I refer to examples from the three case reports which, I feel, reflect both fragmentalist and holistic approaches to education. I also consider ways in which Project WATER encouraged holistic educational practice and contemplate possible future developments of the project in Grahamstown.

Because I worked with pupils extramurally or visited the schools irregularly to present demonstrations or lessons, I did not observe many lessons given by the teachers or

experience many aspects of school administration. I formed an impression of the schools through interviews and informal discussions with pupils, teachers, parents and other members of the Grahamstown community, and observations made during school and class visits.

6.2 HOLISTIC APPROACHES OBSERVED:

I observed some examples of what I consider to be holistic, democratic approaches to education in the groups with which I worked. At Graeme College, the teacher, although he did not feel he could allocate class time for involvement in Project WATER, consulted his colleagues and pupils to find out whether they were interested in getting involved with the project. In the farm schools and at Mary Waters Secondary, I noticed that teachers consulted their pupils when decisions had to be made which affected the classes. For example, at Mary Waters, the teacher in charge of the wildlife club made sure that the pupils were involved in the planning of details of the field trip.

I felt the use of the term '*Siyavana*?' (Are we together?) rather than '*Niyaqonda*?' (Do you understand?) by the farm school teachers reflected concern for group consensus. The choice of the prefix signifying 'we' (si-) rather than 'you' (ni-) suggested that the teacher identified him/herself as part of the group and not separate from the pupils. Indeed, the farm school teachers participated actively in the project and learned with their pupils. This also occurred in the case of the B.Prim.Ed. group where the active participation of the lecturer seemed to play an important role in encouraging student participation in field work and discussion.

The farm school teachers recognised the relevance of the water project to the everyday lives of their pupils who were directly dependent on untreated water sources. They were generous in their provision of class time and did not seem to be concerned about whether the project related to the syllabus directly or not. It was relatively easy to negotiate class time for project work in the farm schools because there were few teachers and time tables were simple. A simple system provided greater flexibility for interdisciplinary study and responsiveness to developing interests than did the complicated time tables encountered in the town schools.

Graeme College appeared to have the strongest tradition of environmental projects benefitting the community (Section 4.2.3). Teachers and pupils from this school mentioned that they invited other schools to work with them on environmental projects, encouraging cooperation rather than competition between schools. There was also evidence of teachers making allowances for and promoting interdisciplinary approaches in the curriculum.

6.3 FRAGMENTALIST APPROACHES OBSERVED:

Initial responses from schools to Project WATER were varied. Unlike the case of Graeme College, many teachers who received the invitation ignored it and did not consult other staff members or pupils to find out whether they would be interested in getting involved in the project. In the hierarchical system of the school, it appeared to be acceptable for teachers to make decisions on behalf of pupils without consulting them and, likewise, for senior teachers to make decisions on behalf of their junior colleagues.

Most high school teachers I spoke to did not see the need to get involved in Project WATER with their classes. They were concerned about covering the syllabus and preparing pupils for examinations and did not see the project helping them to achieve these objectives. Extremely busy school programmes and structured time tables allowed little flexibility to involve whole classes in project work. At best, teachers encouraged pupils to get involved extramurally, in which case the project did not interfere with classroom teaching but enabled pupils to pursue an individual interest.

This general reaction seemed to imply, firstly, that few teachers recognised a need for environmental or holistic education. Had they done so, it is likely that they would have recognised the potential of Project WATER and responded more positively. As it was, Project WATER seemed to be perceived as just another project competing for space in a rich and demanding school programme. Secondly, the demanding and inflexible nature of the school programme mitigated against teachers embarking on the project unless they were particularly committed to the idea of environmental or holistic education. If they were not,

it was unlikely that they would persevere in overcoming the obstacles commonly mentioned, such as time and syllabus constraints.

It is not surprising that teachers find difficulty in incorporating interdisciplinary projects such as Project WATER into the curriculum. Most schools are organised along fragmentalist lines, with knowledge being divided into separate subject disciplines, and links seldom being made to other disciplines. For instance, consider the concept map constructed by the B.Prim.Ed. students to illustrate 'Water' as a topic in Standard Three and Four Science (Section 4.2.1, Figure 1). The students did not make links between the factors they had chosen to show how they were related, nor did they mention 'non-science' aspects of a study of water. At high school, increased subject specialisation and complicated time tables make it difficult for teachers to embark on interdisciplinary projects with their pupils. Pupils consulted during the evaluation seminar (Section 4.3.6) recognised that work done at school was usually predefined and felt that teachers were resistant to change. They saw the project becoming institutionalised and routine if it became incorporated into the syllabus and suggested that it remain part of the extramural programme for this reason.

As local coordinator of Project WATER in Grahamstown, my perception of Project WATER and decisions I made influenced the way in which the project developed locally. I wanted to see Project WATER develop in Grahamstown but found teachers reluctant to get involved. Therefore, when teachers from Graeme College indicated that pupils wanted to make use of the kit in their Biology projects, I suggested this approach to other high schools. Few of these pupils were concerned about water quality but needed to complete a project and saw the water kit as a means to this end. The kit proved to be a very flexible resource in the hands of pupils who used it to undertake a wide variety of projects and to form and test hypotheses. However, with the emphasis on science projects during this phase of project development, I did find myself starting to view Project WATER as a kit to enhance science project work rather than as a tool to encourage active participation in addressing an environmental problem.

In schools, the emphasis is usually on competition between individuals rather than on group cooperation. Evidence for this can be seen in the layout of many classrooms, the

predominant systems of evaluation and the tendency to rank pupils according to achievement. Whereas Project WATER is well suited to ongoing cooperative work by groups of pupils, in the high schools the kit was mainly used by individuals or pairs of pupils to complete school Biology projects. In general, these pupils were not interested in continuing their investigations after submitting their projects. Some pupils stated that they saw the water kit as a resource that would give them a competitive advantage in the Schools' Science Expo competition. This view of Project WATER reflects the approach of the present school system which encourages pupils to work towards goals such as passing examinations, after which no further interest in that particular aspect of the subject is expected of them.

I found little evidence of community-based environmental project work being done in schools. Where pupils were involved in addressing environmental or social problems, this was done extramurally and on a voluntary basis. Only two schools attended the annual Wildlife Society environmental projects competition for Grahamstown high schools and only one of these had been involved in ongoing environmental projects serving the Grahamstown community. This separation of the interests of the school from the needs of the wider community was most dramatically illustrated in the attitude of the H.D.E. student who considered water pollution in Grahamstown streams to be a "long-term educational problem" and therefore not his responsibility (Section 4.2.2). Robottom (1987a) believes that environmental education should be community-based, involving students in a process of active collaboration to address real community problems, effectively narrowing the gap between school and community. Project WATER provides tools to enable teachers and pupils to investigate and address local water-related environmental problems. However, if teachers do not recognise environmental education as their role and if potential project participants do not see community action as their concern, Project WATER may become no more than a resource stimulating interesting school science projects and enhancing pupils' achievements in project competitions.

It was my experience during the course of the research that many teachers perceived environmental education in general and Project WATER in particular as something extra to be added to an already overloaded curriculum. De Lange (1992, pers. comm.) believes that teachers need to take a new look at curriculum content and to "drop some of the baggage"

(her quote) that prevents them pursuing holistic approaches. Environmental education should not be added to the curriculum as another subject, complete with syllabus and examinations, or as an optional extramural activity; nor should it be seen to be the responsibility of only the Biology and Geography teachers at the school. Rather, I believe environmental education should be an approach to the curriculum which seeks to question and provide alternatives to the dominant fragmentalist approaches of educational institutions. These alternatives should include the development of relevant, integrated syllabi, participatory, experiential and critical teaching and learning approaches, democratic teacher-pupil relationships and closer school-community links.

6.4 THE PROBLEM OF ALIENATION:

In different contexts throughout the case study, I detected evidence of what I have called alienation, or a sense of separateness of individuals from their human and non-human environments. Alienation can be related to a non-ecological or fragmentalist world view. People who do not perceive that they are in some way related to or dependant on the natural environment or other people, may be unconcerned about the effects of their actions upon them. A sense of alienation may therefore be at the root of much environmental degradation and social injustice.

I felt that a sense of alienation was reflected in the comment from three teachers in the town that water quality monitoring would not interest pupils who could simply open a tap and get clean water. The inference was that, if people did not perceive an environmental problem to affect them directly, they could simply ignore it. This revealed an inadequate understanding of and concern for ecological systems. In integrated environmental and social systems, it is not appropriate to see problems as finite and having limited effects. For instance, despite being supplied with treated piped water and water-borne sewage, residents of certain parts of Grahamstown were affected by water pollution in that they had to contend with foul smells from polluted water in streams draining the township where water supply and sanitation were less adequate.

A number of project participants considered government policies to be a major cause of a sense of political alienation. In particular, the H.D.E. students and a teacher from Mary Waters Secondary held aspects of the political system in South Africa responsible for their lack of involvement in addressing community problems. They recognised the lack of a culture of democracy in the country and explained that many South Africans had been alienated from the land by forced removals and resettlement policies, and from the process of political decision-making through disenfranchisement. This had resulted in a sense of apathy as many people no longer saw community problem-solving as their responsibility, but expected the authorities to solve problems for them. At a local level, officials from the Grahamstown Municipality, by not responding to requests for help with tree-planting and paper recycling projects, had effectively alienated members of the Mary Waters Wildlife Club from further involvement in environmental projects. Pupils and teachers felt that their efforts and concerns were unimportant in the eyes of the Municipality, and were less inclined after these encounters to take action to improve their local environment.

An interesting issue which emerged as Project WATER developed in Grahamstown was the issue of publicity and marketing. Some participants and associates were concerned that the kit needed to be marketed more aggressively. They were concerned that people would not feel good about being associated with a cheap product, even though it produced quite adequate results. Marketing approaches require the development of a product image that confers status on users. In the case of the water project, the kit was more than just a product. It was part of an enabling process and the kit was designed to cost as little as possible so that it would be available to the greatest possible number of users. To have raised the price in order to encourage interest, as was suggested by a municipal representative, would have made it more difficult for some groups to be able to obtain their own kit, emphasising the alienation of economically disadvantaged groups from the choices available to the rich. I also felt that the intrinsic value of the resource would be reduced to an arbitrarily assigned extrinsic value (its cost).

Those people who wanted to improve the image of the kit did not recognise another important advantage of the simplicity and everyday nature of the apparatus. Participants saw that it was possible to do accurate scientific investigations without expensive, specially

designed equipment. They were more inclined to modify certain parts of the kit because the apparatus was not custom made and had been developed by people adapting everyday items in innovative ways. Many people experience a sense of alienation from science, feeling that it is the pursuit of an elite few working with complicated apparatus in laboratories. Head (1985:37) states that "one common complaint is that science has lost its appeal as an innovative adventurous activity". He feels that people tend to see science as a body of knowledge to be overcome, rather than an approach which students can use to help them address problems and issues they have identified. Resources such as Project WATER, by making the tools of scientific investigation more widely available, can help to demystify science and transform it "into a more participatory, needs-oriented social enterprise" (Engel, 1990:14).

A sense of alienation is a powerful factor inhibiting constructive community action. In South Africa the government has for many years deliberately tried to distance people from participating in the affairs of the country, and has resisted the principles of a moral democracy (Section 1.1). Under these circumstances, encouraging community action to address environmental and social problems may prove very challenging. However, resources and approaches such as Project WATER and AR:CPS provide the tools to enable communities to investigate and address not only local issues but also the sense of alienation which has mitigated against past involvement in local environmental action.

6.5 POTENTIAL OF PROJECT WATER TO STIMULATE HOLISTIC EDUCATION:

Despite some participants not recognising the potential of Project WATER to stimulate community action, my experiences with pupils and students in Grahamstown suggested that Project WATER provided educational opportunities which may be described as holistic. The actual water quality investigations enabled participants to develop an understanding of the complex interactions between components of a stream ecosystem. By comparing results of stream observations and tests, participants saw that abiotic (physical and chemical) conditions in a stream influenced the numbers and types of organisms living there. Various types of

pollution affected conditions in the stream and could be monitored using the test kit. Participants were encouraged to discover the sources of pollution in different streams and through this some became more aware of the interrelationships between political, social, economic and biophysical aspects of the environment. For instance, the existence of extremely high levels of faecal coliform bacteria in streams running off Rini township was found to be a result of the bucket system of sewage disposal. Use of the bucket system continued because levels of poverty in the township meant that the Rini Municipality could not afford more sophisticated alternatives. The very existence of the township was in turn a result of the policies of apartheid. Because streams and rivers flow through and therefore link different parts of a town or region, they are valuable systems to illustrate how the activities of people in one area can affect the lives of people elsewhere.

Project WATER provided an opportunity for practical interdisciplinary study. Participants gained a greater knowledge and understanding of biological, physical, chemical and geographical aspects of local streams. Investigations were practical, providing participants with opportunities to develop a number of skills. Participants were able to investigate a 'real' problem in their environment and the experience of trying to explain unexpected results encouraged speculation, discussion and the development of problem-solving skills. In the farm schools, the project was a valuable opportunity to develop second language skills. In most cases, teachers translated what I said into Xhosa, giving pupils a chance to hear English translated. Pupils were required to read about the organisms they had found in an English reference booklet and to discuss their findings and present them to the rest of the class.

Through active, practical involvement in water quality monitoring, participants were exposed to issues in their local environment and some expressed emotional responses to their observations and measurements (Section 4.2.1). The experience of learning incorporated not only the acquisition of new knowledge and skills, but also personal responses related to the participants' values and expectations. This integration of the rational and emotional is considered an important aspect of holistic education (Grieg, Pike & Selby, 1989). Apart from providing an educational opportunity in which different subjects and the cognitive, affective and psychomotor aspects of learning were naturally integrated, Project WATER also

promoted links between school and community. The wetland project provided an opportunity for different schools to interact non-competitively.

Project WATER provided many opportunities for cooperative, participatory learning. The project, being new to both teachers and pupils, provided an opportunity in which both could learn together, diminishing the tendency for pupils to see the teacher as an authority and helping them to see learning as a cooperative process (Sections 4.2.1 & 4.4). The process of group discussion or dialogue was very important as a means of making sense of the results of tests and observations. Instead of simply being told by a teacher about conditions in local streams, pupils and students interpreted their own results and experienced posing and solving problems and hypotheses. In a situation such as this, the teacher can play the role of a mediator of experience, guiding the discovery processes of pupils through questions that encourage reflection and discussion.

Project WATER, by enabling participants to address a local environmental issue, provided opportunities for skills to be learned in context, giving them immediate relevance. Knowledge was applied practically and led to a deeper understanding of the complexity of environmental and social issues. At the time of writing, a project to establish wetlands to address an aspect of the water pollution problem in Grahamstown had recently been initiated. Involvement in an ongoing project such as this could encourage participants to develop a sense of commitment and responsibility towards the local environment and community and lead to further opportunities for the development of understanding, concern and cooperative action.

6.6 COMMUNITY PROBLEM-SOLVING AND THE FUTURE OF PROJECT WATER IN GRAHAMSTOWN

I had expected, at the stage of initial project implementation in Grahamstown, that once Project WATER participants got involved in measuring water quality and discovered that streams were polluted, they would become concerned and want to do something about the problem. Working with pupils and student teachers revealed, however, that first-hand

investigation of an environmental problem, although it did raise awareness, did not automatically result in participants deciding to take remedial action. Not being used to addressing community problems, pupils appeared to lack both the skills of problem-solving and the recognition that their involvement could make a difference.

My experience of the development of Project WATER suggested certain factors that seemed to encourage community action once pupils had identified a particular water quality problem. Firstly, when the high school pupils saw that representatives of organisations such as the University, Municipality and Museum were concerned about the problem they had identified and willing to help them address it, some were encouraged to get involved in a remedial project. Secondly, ongoing dialogue with people concerned about environmental action was important. Pupils who did not immediately see that their involvement could make a difference were encouraged by stories of other groups which had made a difference in their communities. Dialogue between myself, representatives of community organisations and pupils helped pupils to see the relevance and importance of their investigations. Dialogue also provided pupils with opportunities to discuss possible problem-solving strategies with people who could help them address particular aspects of the water quality problem.

There are various schools of thought about environmental problem-solving (Ashwell, 1992c). Some people feel that it is important for people to have practice addressing theoretical problems before attempting to address real community problems. Robottom (in press) disagrees, feeling that there is no conclusive evidence that problem-solving skills are transferable or that roleplaying increases one's ability to tackle an actual problem. Wals, Beringer and Stapp (1990) suggest that an action research approach to community problem-solving enables people to develop a deeper understanding of a problem through the process of addressing it. Skills are developed as they are required and strategies are modified as reflection on progress suggests that to be necessary. Opportunities for pupils and students to get involved in addressing an actual community problem are important in terms of developing the concern, competence and imagery (Bardwell, 1992) required to instil confidence to tackle other unique community problems.

The development of a potentially long-term environmental project in Grahamstown occurred gradually during 1992, encouraged by the involvement of concerned individuals, the availability of tools to investigate water quality and the recognition that the project was important to the community. With the involvement of Joubert as project coordinator, the interschool committee and representatives of community organisations, it appears likely that this project will develop further in the coming year.

It was my experience that not many teachers in Grahamstown high schools were interested in participating in the water project at the beginning of the year. They did not appear to know how to incorporate a potentially interdisciplinary, community action-oriented project into their year plan. However, as the project developed locally, a number of teachers recognised its educational potential and some suggested that they would get involved in the project in the coming year through, for example, interdisciplinary project work.

If environmental education is seen as an holistic, integrated, empowering approach to education rather than as yet another subject, attempts to impose environmental approaches on teachers and pupils may not be successful in the long term. Unless teachers recognise the importance of holistic educational approaches, incorporation of such a project into the syllabus might, as one of the pupils from Graeme College observed, result in it becoming institutionalised and routine. However, if such a project develops through a process of sustained dialogue and reflection between teachers, pupils and members of the wider community, there may be a greater chance that fragmentalist views and practices will be recognised, challenged and replaced by holistic, democratic and empowering approaches. Project WATER provides the tools and methods to enable people to participate actively in investigating and addressing water-related problems in their communities. These situations in turn provide opportunities for the development of sustained dialogue and reflection.

CHAPTER SEVEN: CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS:

The environmental crisis has brought into question accepted wisdom about the desirability of uncontrolled technological progress and development. Negative consequences of development have included large-scale destruction of natural areas, rapid depletion of the earth's resources and serious pollution of land, air and water. Development has often led to a widening of the gap between rich and poor, with minority groups and poor communities suffering many of the adverse effects of development, and the rich enjoying most of the benefits. Faced with the consequences of the actions of a powerful minority, many citizens resign themselves to being unable to cause significant change in society.

People are considered less likely to exhibit exploitative, destructive behaviour towards the environment and society if they recognise their connectedness to and dependence on the human and non-human environment. Therefore, certain educationists believe that, in order to address the environmental crisis, education should encourage the development of views described as holistic or ecological (Appendix 1). An holistic approach to education can be recognised in environmental education projects, such as Project WATER, which promote interdisciplinary approaches, an understanding of the interconnectedness of people, their human and non-human environments, and environmental concern and action. Because holistic values are seldom embodied within school curricula, it is often difficult to promote environmental education programmes at schools.

The response from teachers in Grahamstown to Project WATER suggested that some did not value an environmental approach to education as they were not able to find time for the project within the curriculum. I believe that the present school system, which is designed along fragmentalist lines (Appendix 1), presents teachers who do not recognise the value of holistic educational approaches with an obstacle to participation in environmental education

projects. In Section 7.2.2, I suggest ways in which environmental educationists and teacher educators might provide opportunities for teachers and student teachers to experience and debate the value of environmental education approaches.

In Grahamstown, use of the Project WATER kit provided a clearer picture of water quality in the streams, dams and watercourses tested. Despite prevalent notions about the importance of raising environmental awareness in order to promote action, however, this knowledge did not automatically lead to participants taking action to address the problem of water pollution in Grahamstown. Pupils generally had to be encouraged to take action based on their findings. However, once ideas for action had been suggested, pupils were often keen to respond by, for instance, collecting litter, publicising their findings and making representation to the Municipality.

Towards the end of the year, a community environmental project developed out of high school pupil involvement in water quality monitoring. Certain factors appeared to contribute to the development of this community project. Project WATER provided the means to investigate water quality and provided evidence of the seriousness of the water pollution problem. Members of the Grahamstown Centre of the Wildlife Society had been concerned about pollution of the Bloukrans Stream but had not been able to approach the Municipality with actual data The pupils who had participated in Project WATER provided water quality data which confirmed that the Bloukrans Stream was seriously polluted with sewage and phosphate runoff from the township. The Wildlife Society used this information in a discussion with representatives from the Grahamstown Municipality to support a proposal for the construction of wetlands to treat the water pollution problem. Pupils were encouraged by the interest shown by representatives of the Municipality, Wildlife Society, Rhodes University and Albany Museum to get involved in the wetland project. Their interest indicated that the project was worthwhile and that the pupils could depend on the community to support their efforts.

Although it is too early to comment on the development of the wetland project, an environmental project which involves both school and community has potential to provide participants with numerous opportunities for the development of skills of decision-making,

problem-solving and communication. I believe that it is essential that people develop such skills in order to be able to participate actively and effectively in the affairs of their communities. Educational projects that encourage participation in community action projects may help to develop a 'culture of involvement' in society and to counter the fragmentalism and apathy that have been blamed for the current environmental crisis.

7.2 RECOMMENDATIONS:

In this section, I list suggestions to educationists wishing to embark on community-oriented environmental projects with groups, based on my experiences with Project WATER in Grahamstown. I also make some general recommendations regarding community projects as an approach to environmental education. These recommendations are based on my experience of a single case study in Grahamstown. They are therefore by no means seen as definitive, but rather are offered as points for discussion with educationists.

7.2.1 Environmental action projects:

(a) Get to know the people with whom you want to work before attempting to involve them in the project. If you are new to an area, find somebody who can introduce you to groups and individuals who will be interested in working with you (Section 4.4.1). Encourage people with a genuine interest in and concern for the project to share responsibility for the project (Section 4.3.4).

(b) Try to make contact with community groups which can offer support (Section 4.3.8).

(c) If you plan to work with teachers, make sure that you inform them of the project in time for them to consider incorporating it into their year plan (Section 4.3.6b).

(d) Start with what the group and the wider community consider to be their needs (Sections 4.3.3 & 4.3.8). Preferably encourage the group to define a problem it would like to address. If you are trying to promote a particular project such as Project WATER, make links between what the group feels it needs and what the project can offer.

(e) Discuss the rationale for and the value of the project with the group. Make sure that they see the value of their involvement in the project and do not feel that they have been forced to participate (Section 4.2.2).

(f) Share ownership of the project with the group by negotiating the direction the project should take. As the competence of the group develops, encourage members to take over more and more of your responsibilities. Work towards 'giving the project away' (Section 4.3.8).

(g) If possible, meet regularly with the group (Section 8.4) and encourage the development of skills gradually as the need arises. Try not to teach skills out of context or to overload the participants by teaching them too much too quickly (Section 4.2.1).

(h) Try to provide adequate time for an action project to develop. If too little time is allocated and the problem is not addressed, the project may become marginalised as an environmental practical. . Participants may feel disempowered if problems are highlighted but not addressed (Section 4.2.3).

(i) Don't separate yourself from the learning process (Sections 4.2.1 & 4.4.2). Learn with and from the group, as much as you expect the group to learn from your knowledge and experience.

(j) Take an action research approach to project development. Plan, act and reflect with participants so that a deeper understanding of the problem

develops through involvement in addressing it. A reflective approach provides flexibility and responsiveness to complex, changing situations (Section 8.2).

(k) Encourage enthusiasm for the project and a vision of what is possible. Encourage people from within the project and representatives of other projects to share their experiences and successes (Section 4.3.8).

7.2.2 General recommendations:

(a) Teacher Education:

The formal school system does not specifically promote holistic and community problem-solving approaches to education. Teachers are unlikely to engage in these alternative approaches (interdisciplinary, issues-based, experiential, critical, community-based, participatory) unless they are seen to be of such educational significance that they justify the effort required to implement them. Teachers also need to know that they are competent to coordinate these approaches.

In order for prospective teachers to obtain experience of interdisciplinary, action-oriented approaches characteristic of environmental education, I suggest that student teachers be required to engage in a community project during their teacher education programme. My experience with student teachers indicated that, if they had not previously been introduced to environmental education as an approach, they did not immediately recognise its value. Time to clarify the concept 'environmental education' and to experience and reflect on environmental approaches appeared to be necessary.

The student teacher class could be divided into interdisciplinary groups and each group could be required to identify a community project to be addressed during the year. The project would need to be achievable within two or three terms and defining such a project would help students to get an idea of the scale of problem they might later address with their own pupils. For

example, each group could be assigned to a school or informal education project in the town and be required to spend one timetabled afternoon per week working with pupils on a community service project identified in collaboration with the pupils and teachers. Projects might include coordinating service club activities at schools, rehabilitating a derelict plot to provide a children's play park or establishing a tutoring programme to assist educationally disadvantaged pupils at the school.

The advantages of such a programme would include student teachers developing skills and confidence to enable them to institute similar programmes once they started teaching. It would also provide experience of working as an interdisciplinary team. Students would benefit from ongoing contact with schools and develop confidence in dealing with pupils which would help to prepare them for teaching practice. Involvement in a community-oriented project might help student teachers to develop an understanding of the importance of the school in its community as a vital unit of society in which constructive action for change can occur. If this project was approached as an action research project, it might develop students' skills of reflective self-evaluation, encourage them to critically reflect on the purpose of education and provide a stimulus for some to continue with action research in their own classrooms.

(b) Teacher In-Service Education and Training (INSET):

In order to provide in-service teachers with the opportunity to discuss holistic, community problem-solving approaches to environmental education, workshops could be run through teachers' centres by environmental educationists or teacher educators with experience in these approaches. Teachers from schools in which these alternative approaches were part of the curriculum could be invited to describe their programmes and experiences. Education policy-makers could be invited to these workshops to explore ways of introducing flexibility into subject syllabi and examination systems in order

to provide teachers with opportunities to pursue alternative approaches. Support networks could develop out of these workshops to provide teachers embarking on innovative projects with contacts to provide assistance and encouragement.

(c) Environmental educationists and formal education:

Having previously worked as an environmental educationist organising day-visits for school groups to natural areas, I found the experience of involvement in a longer term environmental education project very rewarding. The opportunity to work for an extended period with pupils and teachers provided insights into perceptions of environmental education in formal education, understandings of the obstacles to the approach and an appreciation of the value of community-oriented environmental action projects in schools.

I feel that environmental educationists working in non-formal educational settings are well placed to support teachers in formal education with ideas, expertise and encouragement to embark on environmental projects. In my experience in Grahamstown, the Wildlife Society Education Subcommittee was pivotal in bringing together school and community groups to define a project of mutual concern. The environmental education officer or committee can act as a catalyst, providing prospective teachers with the imagery required to inspire an action project, the knowledge to deepen their concern and the skills and tools to develop a sense of competence.

CHAPTER EIGHT: EVALUATION OF THE RESEARCH APPROACH

8.1 INTRODUCTION:

In this section I evaluate the research approach in terms of its strengths and weaknesses and make a number of recommendations based on my experiences. My initial choice of research methodology changed from an evaluation study to a descriptive case study informed by action research. I believe this was a sound decision which enabled me to develop a deeper understanding of Project WATER as an educational process rather than simply an educational resource.

8.2 POSITIVE FEATURES OF THE RESEARCH APPROACH:

I had initially planned to evaluate Project WATER according to a set of environmental education objectives which I defined before embarking on the study. This approach might have proved limiting in the long run, as I did not have a thorough understanding of the potential of the project at that time. The case study approach, on the other hand, required me to write and reflect on detailed descriptions of the process of project development. This helped me to deepen my understanding of the project and to become more aware of my assumptions about research and environmental education.

Evaluation forms part of each level (spiral) of action research (Mc Kernan, 1991). However, rather than simply measuring the worth of the project, as is the aim of some evaluation studies, evaluation done as part of action research contributes immediately to the practical improvement of the project (Grundy & Kemmis, 1984). I believe that an action research approach to evaluation proved to be more useful to the development of Project WATER in Grahamstown than an objectives-based evaluation would have been.

Action researchers acknowledge that one cannot understand a problem fully before investigating it (Wals, Beringer & Stapp, 1990). Therefore, one accepts, from an action research perspective, that it may sometimes be necessary to modify a research decision if, upon implementation and reflection, it appears unsound. In other forms of research such as surveys, once the pilot study has been completed, it is unusual for researchers to change their research strategies. Doing action research, I found that I discarded certain research tools during the project when I found that they were no longer consistent with my developing understanding of the research. However, it was the use of those tools and the reflection on their use that contributed to my developing understanding. I therefore did not consider the rejected approaches to be mistakes, but saw them rather as worthwhile stages in the development of the research project. I see this flexibility to respond to changing circumstances and new insights to be a strength of action research.

Action research is often seen as a participatory form of research in which all involved in the situation under investigation discuss and reflect on developments. It was an advantage to consider the pupils, students and teachers with whom I worked to be co-researchers rather than subjects of the research. The pupils developed a critical approach, providing very useful evaluation to improve the project. The willingness of participants to discuss and evaluate the project may have been related to their role as co-researchers, a less threatening position than that of research subjects. This cooperative, participatory approach to research was consistent with the holistic, democratic approach to education which I hoped to encourage through Project WATER.

Action research into the development of an environmental education project provided an opportunity to experience research as praxis, where theory and practice are integrated and inform each other (Grundy, 1987). In addition to providing an opportunity for me to reflect on the process of project development, action research also prompted me to reflect on the underlying assumptions motivating my decisions, making it a very personal approach to research.

8.3 DIFFICULTIES WITH THE RESEARCH APPROACH:

I experienced a few problems with action research as an approach in my particular situation. Firstly, **lack of teacher involvement** at some schools meant that dialogue concerning the educational potential of Project WATER was limited. Most students chose the project to help them do better science projects and were neither interested in the project as a 'tool for transforming education' nor were they in a position to influence school policy in the short term. Secondly, although Bassey (1986) believes that action research can be done quickly, this requires **continuity and "quality time"** (Hustler, Cassidy & Cuff, 1986:15) which were not available to me as an occasional visitor to the schools.

Action research consists of overlapping spirals of planning, acting, observing and reflecting (Grundy & Kemmis, 1984). Discoveries and insights made during one spiral of research inform and influence the next stage of the research. In this way, the problem is redefined and understanding develops through continued involvement in the project. The **time constraints of a half-thesis** limited the possible number of research spirals. Because I was working within the school system, this was particularly problematic as opportunities for further development of Project WATER were linked to syllabus and project work, both of which were bound to an annual cycle (Boltt, 1992, pers. comm.).

One of my goals during the year was to encourage as many schools as possible to become involved with Project WATER. This resulted in my attempting to record project development in eight groups. This contributed to the limited time available with each group and resulted in a more superficial treatment of certain issues than would have been possible had I dealt with fewer groups in more detail.

8.4 RECOMMENDATIONS REGARDING THE RESEARCH:

Based on the experience I have gained of an action research case study, I feel that it would have been wiser to have worked with fewer groups in more depth. It would have been an advantage to have been able to meet with the group(s) on a regular basis, such as once a

week, for at least six months. This would have enabled me to have developed a better relationship with the participants which would have facilitated more spontaneous dialogue and reflection. Working more closely with fewer participants might have enhanced their understanding of the purpose and nature of the research. Time and language constraints limited opportunities for dialogue and reflection with some participants, and this in turn limited the potential of Project WATER to develop from a school science or Wildlife Club project into a community action project. For these reasons, I feel that action research is an approach better suited to an 'insider' such as a teacher in a school than an 'outsider' with limited access to and understanding of a group.

Action research was not always a straightforward or 'comfortable' approach to research. Being unaccustomed to educational research, I sometimes wished for the security of a more formally structured and predictable research approach. However, in retrospect, I believe that the advantages of the approach for my particular research project, such as enhanced understanding and responsiveness to changing situations, justified my choice of action research as an approach to inform the case study.

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Two Worldviews: A Checklist of Some Key Features

The Fragmentationalist Worldview	The Holistic Worldview
An emphasis on separateness and disconnectedness. Wholes are made up of separate parts; the whole is no more, no less, than the sum of its parts. That parts interact does not qualitatively influence the whole. We are separate from other peoples and the global environment.	An emphasis on connectedness. Parts are only finally understandable if viewed in dynamic relationship with all other parts. The combined interaction of all the parts creates an organic whole which is greater than the sum of their individual effects. We are profoundly connected to other peoples and the global environment.
A preference for analysis and reduction (understanding things by reducing them to their separate parts).	A preference for synthesis, integration, the synoptic.
The observer is separate from what she observes; complete objectivity is achievable.	Observer and observed are intimately connected. What is observed, how it is observed and resulting interpretations are influenced by the observer's priorities, values and framework of thought. The observer is to some degree observing herself; she is neither 'outside', 'neutral' or 'objective'.
The rational and cerebral are separate from and superior to the emotional, the intuitive, the spiritual.	Our full potential is only realised through the dynamic and equal interplay of the rational and cerebral with the emotional, the intuitive and the spiritual.
Mind is separate from matter; the human mind is housed within but separate from the human body; mind and consciousness set humans apart from the rest of the planet.	Consciousness pervades everything.
Egocentrism/dividuality; identity has its source in self.	Individuality; identity arises out of a dialectic between self and whole. We achieve the highest level of individuality when we reflect the whole.
Outer-directedness; we look out on the world and seek to understand it. The focus is on change external to the person.	Outer- and inner-directedness; a 'journey outwards' to understand the world requires a reciprocal 'journey inwards' to understand self and self in the world. The focus is on personal growth and transformation as much as social/environmental change.
Patriarchal values; masculine behaviours and qualities prized; feminine behaviours and qualities devalued.	Post-patriarchal values; a tensile, yet creative, integration of masculine and feminine behaviours and qualities.
Emphasis on hierarchical, centralised, inegalitarian structures, competitive relationships and representative democracy; reliance/dependency upon authority and experts. A 'control' mindset.	Emphasis on non-hierarchical, decentralised, egalitarian structures and collegial/co-operative relationships, participative involvement and direct, consensual democracy. A liberationist, empowering mindset.
Anthropocentric; humankind seen as the principal actor on the planet; plant and animal species and inorganic matter accorded value only in terms of human priorities and needs.	Biocentric; humankind seen as but one element within the planet's system; plant and animal species and inorganic matter have their own intrinsic value.
Separateness from, domination and control over, nature; an exploitative ruthlessness towards the environment.	Oneness with nature; reverence towards the environment.

Source: Greig, Pike & Selby, 1989, pages 16 & 17

TOOLS FOR WATER QUALITY ACTION

HANDS-ON TOOLS

1. Water project guide
2. Water quality card
3. Water life field guide
4. Shell habitat charts
5. Envirofact information sheets

GREEN RESOURCE BOX

Project W.A.T.E.R.
Low cost test kits

BAG OR TUB

Community health kit or
School project bag

CATCHMENT ACTION TOOLS

1. Revegetation guide
2. VIP Latrines
3. Wetland effluent management
4. Recycling solid waste
5. Water purification and disease control

CATCHMENT CHECK LIST	WATER LIFE	COLIFORM BACTERIA	DISSOLVED OXYGEN	CHEMICAL BALANCE	PHYSICAL FACTORS
People's activities and catchment conservation	Common indicator species to assess water quality	Faecal or total coliform bacteria in fresh water	DO in fresh water BOD5 - Biochemical oxygen demand, 5 day	pH Nitrates Phosphates	Temperature Turbidity Total solids

APPENDIX 3a: CATCHMENT OBSERVATIONS

CATCHMENT OBSERVATIONS:

Name of catchment: . . . . . .

Observation point/s . . . . . .

Settlement patterns (Who lives there) . . . . . .

. . . . . .

Land use patterns (What they do) . . . . . .

. . . . . .

Landfill sites and effluent disposal (How they dispose of waste) . . . . .

. . . . . .

Riverbank vegetation and distance of human activities from the banks

. . . . . .

Habitat modification and destruction (How things have been changed)

. . . . . .

Wetland and ground water disturbance

. . . . . .

Any other observations . . . . . .

. . . . . .

Rating scale for assessing catchment conservation:

0%	25%	50%	75%	100%
Entire river severely modified and degraded				river vegetation intact and catchment well conserved

CATCHMENT CONSERVATION SCORE %

Source: O'Keeffe & Day, 1992, page 14

APPENDIX 3b: RIVER OBSERVATIONS

RIVER OBSERVATIONS:

Name of River . . . . . .

Observation point/s . . . . . .

Litter (Plastic, paper, cartons and cans) . . . . . .

. . . . . .

Sewage contamination and animal faeces (Cloudy grey or green slime)

. . . . . .

Waste water from household washing (Soap froth)

. . . . . .

Factory effluent (Oil, froth or sludge)

. . . . . .

Dead animals (Dogs, cats, birds, frogs etc)

. . . . . .

Soil erosion (Muddy water)

. . . . . .

Destruction of riverbank vegetation

. . . . . .

Any other observations . . . . . .

. . . . . .

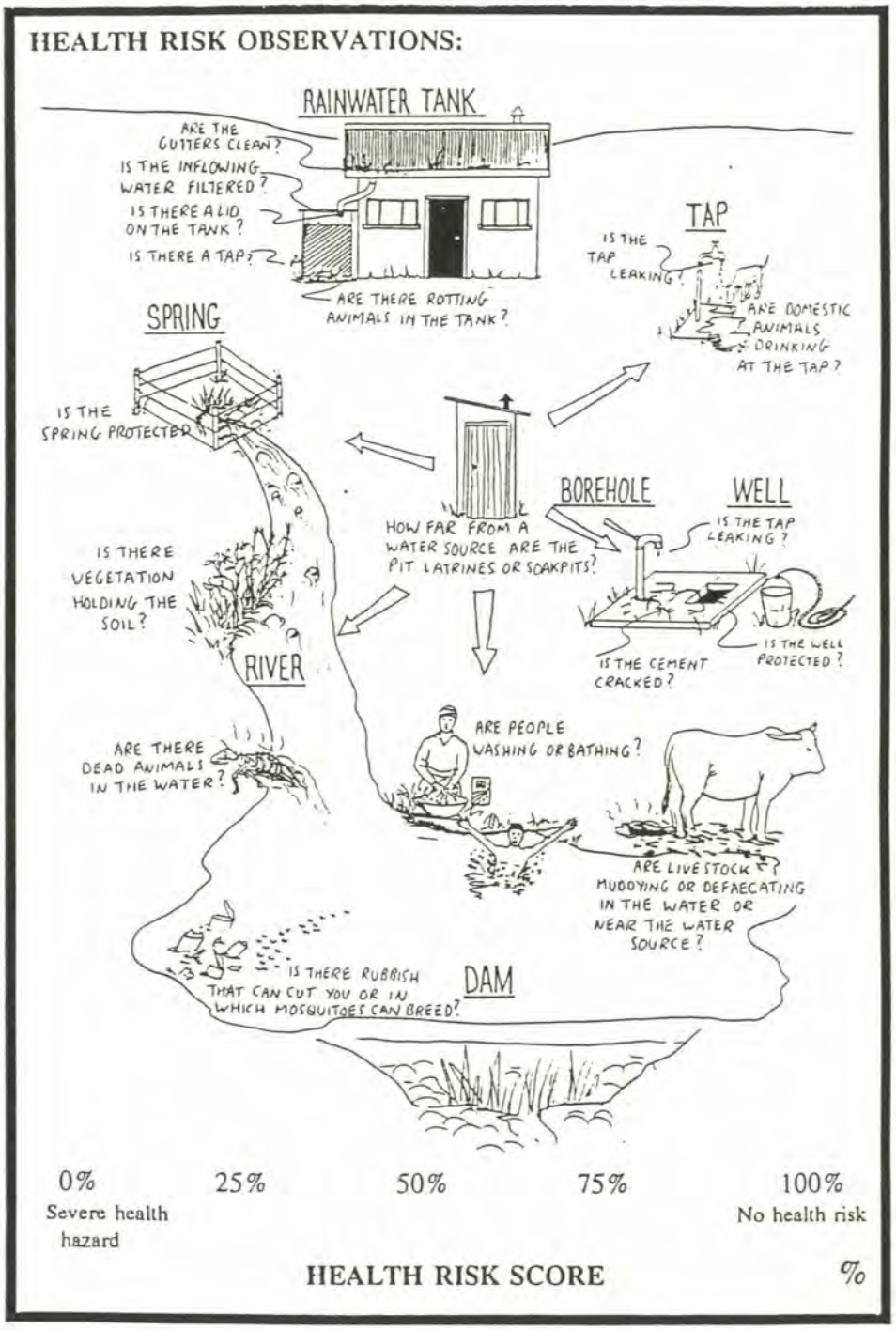
Rating scale for assessing river observations:

0%	25%	50%	75%	100%
Entire river severely contaminated				river clean and well conserved

RIVER QUALITY SCORE %

Source: O'Keeffe & Day, 1992, page 15

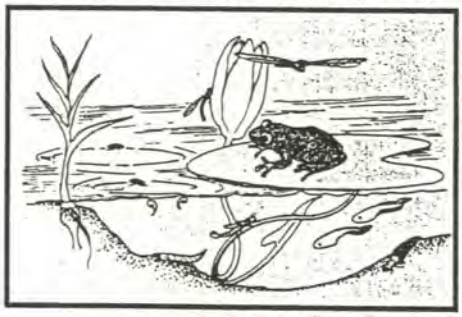
APPENDIX 3c: HEALTH RISKS OBSERVATIONS



Source: O'Keeffe & Day, 1992, page 16

APPENDIX 4a: COVER, CENTRE-SPREAD AND EXAMPLE OF A PAGE FROM THE WATER STUDY BOOKLET

HANDS-ON
STREAM AND POND LIFE



A FIELD GUIDE

Compiled by:
UMGENI VALLEY PROJECT
In co-operation with:
BHEKI NENE AND PSP SCHOOLS

Edited and expanded by:
NORA CHOVEAUX

Illustrations:
PAT SIMONS AND COLLEEN HUGHES

PHYLUM:ARTHROPODA Class: Insecta
Order: Odonata

DRAGONFLY

ADULT
size:

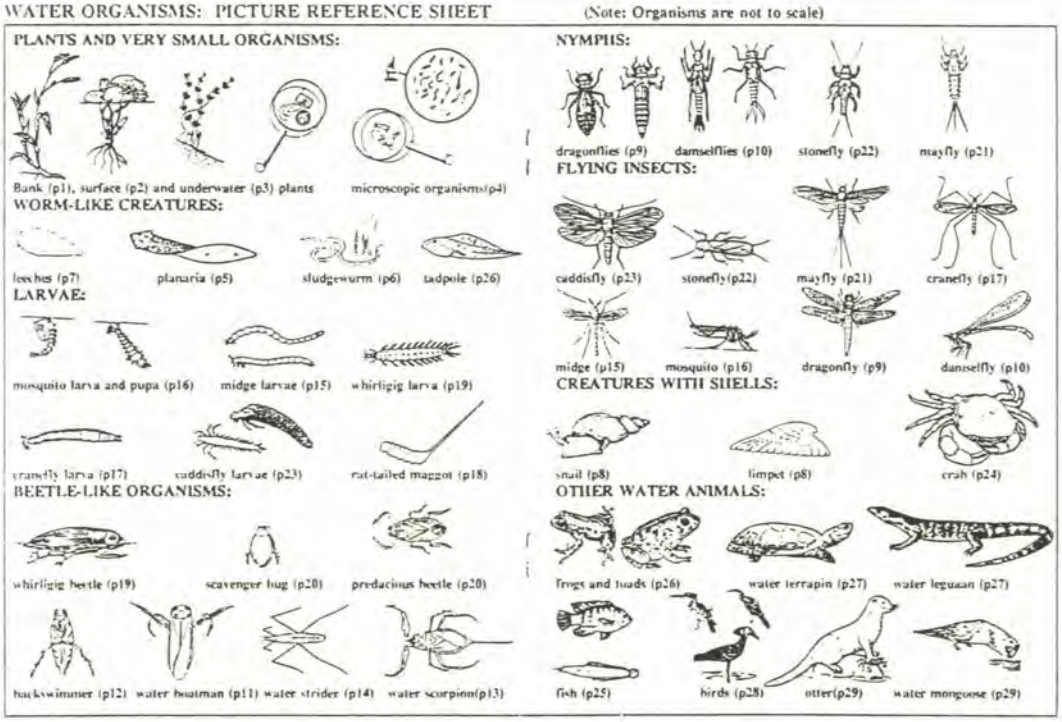
NYMPHS
size: up to 30 mm.

LIFE-CYCLE: adult -> egg -> nymph -> adult

FEATURES: The adults fly very fast. Nymphs develop in the water and crawl amongst weeds and stones. Folded underneath their jaw they have a modified lower lip or "mask." This is used to catch prey. Water is drawn in and out of the body through an opening at the rear end. This provides a supply of oxygen to the rectal gills, just inside the opening. The nymphs can live in fairly polluted water.
REPRODUCTION: The female lays her eggs in the stems of water plants or by skimming over the water to wash the eggs off her abdomen. The nymphs emerge after 3-4 weeks. After 11-15 moults, the nymph creeps out of the water, sheds its skin, and the adult emerges.
FEEDING: Nymphs eat water insects. Adults capture insects in flight.
DID YOU KNOW? In emergencies the nymph is able to expel water from it's rear end - propelling itself forward like a jet!.

9

WATER ORGANISMS: PICTURE REFERENCE SHEET (Note: Organisms are not to scale)

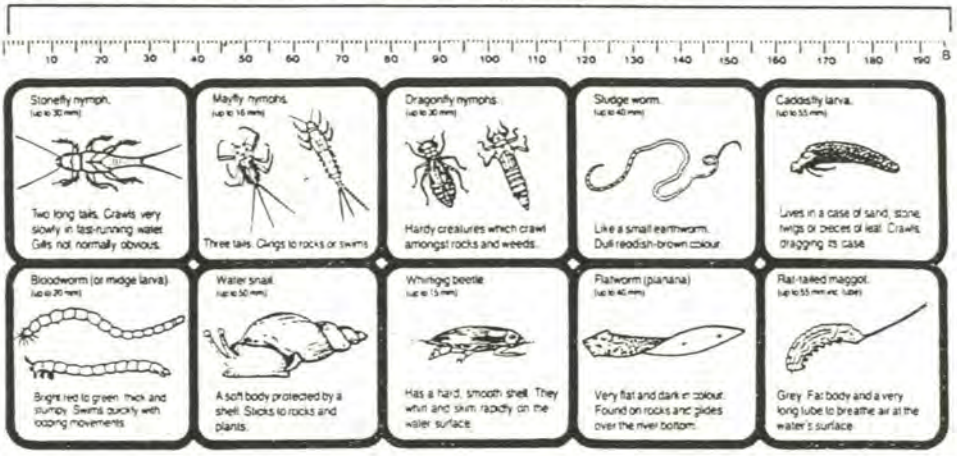


Source: Umgeni Valley Project, 1991

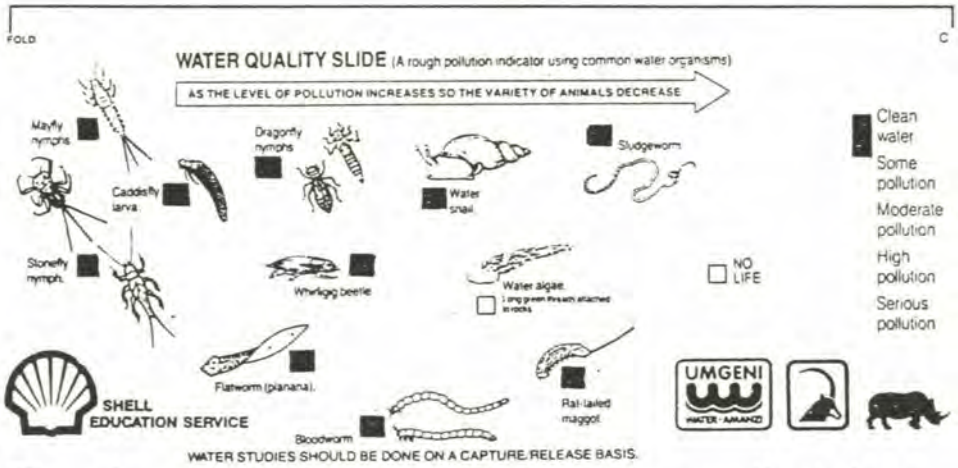
APPENDIX 4b: HOW TO USE THE WATER QUALITY SLIDE

MAKING UP THE WATER QUALITY CARD:

Fold the card to make a water quality slide.



It looks like this on one side. These are all common water organisms that live in clean or in polluted water.

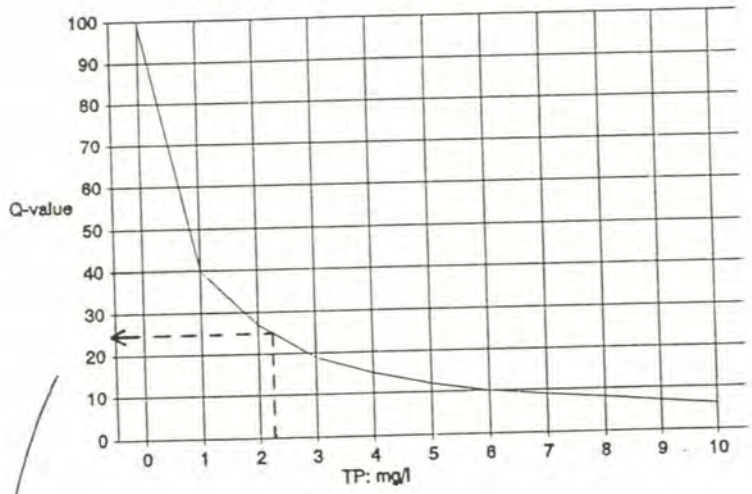


The other side should look like this. It has small windows and a sliding card. Slide the card to the right to discover animals and plants that are commonly found in clean and in polluted streams.

Source: Unpublished information sheet, SHARE-NET, Howick

APPENDIX 5: HOW TO OBTAIN WATER QUALITY INDEX RATINGS

Chart 6: Total Phosphates (TP)



Water Quality Index (WQI):

TEST	Results	Q - value	Weighting	TOTAL
Dissolved oxygen	% sat		0.17	
Total coliform	colonies/100ml		0.16	
pH	units		0.11	
B. O. D.	ml/l		0.11	
Temp. difference	°C		0.10	
Phosphates	2,3 mg/l	25	0.10	2,5
Nitrates	mg/l		0.10	
Turbidity	mm		0.08	
Total solids	mg/l		0.07	
OVERALL WATER QUALITY INDEX				

WATER QUALITY INDEX RANGES

90 - 100	Excellent
70 - 90	Good
50 - 70	Medium
25 - 50	Bad
0 - 25	Very bad

Source: O'Keeffe & Day, 1992, pages 38 & 48

APPENDIX 6: SWOT ANALYSIS SCHEDULE WITH QUESTIONS USED TO CLARIFY SECTIONS

STRENGTHS	WEAKNESSES
(Positive points about: * the kit * the project as a whole)	(Problems encountered with: * the kit * the materials * project organisation)
OPPORTUNITIES	**THREATS**
(Possibilities for development of: * the kit * the project at your school * the project in Grahamstown What should happen next?)	(What problems stand in the way of the project developing further: * at your school * in Grahamstown? How can we overcome these obstacles?)

APPENDIX 7: DEFINITIONAL AIMS OF ENVIRONMENTAL EDUCATION: DISCUSSION SCHEDULE

This schedule was designed to focus discussion during reflection on the Project WATER experience with the B.Prim.Ed. group (Section 4.1.1). The schedule was constructed by analysing a number of definitions of environmental education and extracting the objectives mentioned in them. These objectives were ranked according to the relative ease with which I imagined they would be achieved through an environmental education programme (simplest at the top and most difficult at the bottom).

ENVIRONMENTAL AWARENESS

KNOWLEDGE OF:

the total environment	**the ecological basis of life**	**problems and possible solutions**	**our role**

SKILLS

UNDERSTANDING OF:

the interrelatedness of people, their cultural and biophysical surroundings

ATTITUDES	**CONCERN**	**MOTIVATION**	**VALUE JUDGEMENTS**
DECISION-MAKING	**INITIATIVE**	**EMPOWERMENT**	**PARTICIPATION**

to change the environment for the better

COMMITMENT	**VALUES**	**CODE OF BEHAVIOUR**	**ENVIRONMENTAL ETHIC**

APPENDIX 8: INITIAL LETTER INVITING GRAHAMSTOWN SCHOOLS TO PARTICIPATE IN PROJECT WATER

Department of Education
RHODES UNIVERSITY
P.O. Box 94, Grahamstown, 6140 SOUTH AFRICA
Telegrams 'Rhodescol' Fax (0461) 2 5049 Telephone (0461) 2 2023 ext 383/384

30 January 1992

Dear Sir / Madam

PROJECT W.A.T.E.R. : IMPLEMENTATION IN THE GRAHAMSTOWN AREA

I am doing research in Environmental Education at Rhodes University this year and will be looking at the use by school groups of a low-cost water quality testing kit. The Project W.A.T.E.R. (Water Analysis Techniques for Environmental Research) kit enables one to test the biological, bacteriological, physical and chemical components of fresh water with a view to assessing its quality.

This kit was developed in collaboration with numerous schools and is designed with simplicity and low cost in mind. It is now being used in various parts of the country and redeveloped locally by project participants.

As an environmental education resource the kit facilitates cross-curricular teaching. Worksheets focus on the catchment system as a whole, promoting a concern for conservation of the water source. Skills developed in language, biology, geography, science and mathematics classes are used in carrying out the tests. Apparatus is constantly being assessed and students doing design and technical subjects can help to redevelop and produce apparatus for the kit.

Project W.A.T.E.R. can be applied in many contexts. The kit can be used for school projects (e.g. G.E.C. Expo), to encourage fieldwork, to monitor the quality of rivers with a view to conservation and as a primary health care resource for monitoring sewage contamination of drinking water supplies. Although the chemical tests are of most interest to high school pupils, the animal observations and bacteriological test have been used successfully with primary school groups.

A Project W.A.T.E.R. support centre is being established in the education department at Rhodes University to provide equipment and chemicals for groups to assemble and replenish their kits. A computer network is being established to enable project participants to communicate their findings.

If your school is interested in hearing more about Project W.A.T.E.R., I shall be happy to address or run a workshop for your staff. Because the data collection phase of my thesis has to be completed by the end of June, it would be necessary to train adult participants this term so that the project could be implemented with pupils during the second term.

Please would you or a staff member complete the attached questionnaire and return it to me by 21/02/92. For further information, please telephone me on 22023 x 393. I look forward to hearing from you.

With many thanks for your cooperation.

Yours sincerely

A Ashwell

Ms Ally Ashwell

PROJECT W.A.T.E.R.

SCHOOLS' QUESTIONNAIRE

NAME OF SCHOOL: _____

PRINCIPAL: _____

DATE COMPLETED: _____

1.0 INTEREST IN PROJECT W.A.T.E.R.
Delete whichever does not apply:

1.1 I am / am not interested in participating in Project W.A.T.E.R.

1.2 I do / do not wish to be kept informed about the project.

1.3 Teachers and classes interested in hearing more about Project W.A.T.E.R.

TEACHER	CLASS(ES)
_____	_____
_____	_____
_____	_____

2.0 INVOLVEMENT IN CROSS-CURRICULAR / ENVIRONMENTAL PROJECTS
Please give brief information about the following:

2.1 Recent (since 1990) cross-curricular education initiatives in the school:

_____

_____

2.2 Subjects currently including a fieldwork component (e.g. outdoor practicals, practical projects, excursions)

_____

_____

2.3 Recent environment-related activities undertaken by the school:

_____

_____

2.4 Recent involvement by the school in specifically water-related project work:

_____

_____

APPENDIX 9: EXPRESSIVE FACES USED TO REFLECT PARTICIPANTS' REACTIONS TO VARIOUS SITES ALONG THE BLOUKRANS RIVER

HOW DO YOU FEEL TODAY?

APPENDIX 10: ARTICLE IN GROCOTT'S MAIL: PROJECT WATER EVALUATION SEMINAR

Project W.A.T.E.R workshop

THE beginning of this year saw the launch of Project W.A.T.E.R in the Albany district.

Headed by Ms. Ally Ashwell of the Rhodes Department of Education this project brought the power of monitoring water quality within the reach of all Grahamstonian school pupils. The project's kit enables the use to easily evaluate the quality of water by a number of simple tests.

These include Coliform bacteria tests, Phosphate tests, Nitrate tests pH tests and dissolved oxygen tests.

At a recent seminar conducted by Ms A Ashwell, pupils who had used the kit for school projects evaluated it's potential. The results of the seminar were positve. The kit was found to be suitable for use in school projects, rural water monitoring, aquaculture, hydroponics and as a general indicator of water quality for use by the local municipality.

The kit costs a modest R35, which is the cost of one conventional Phosphate test run by the water authorities.

Another advantage of this kit is that it does not require a laboratory to operate it. Examples of this are the tests for the Nitrate and pH which merely entail dipping a stick in the water. The stick changes colour according to the quality of the water. The colour of the stick is then compared to colours on a chart (provided) which have values.

On the whole the kit was found to be adequate but one major disadvantage which Barry Irwin, of St Andrew's College, noted was that the kit did not contain a chlorine test. However Barry solved this problem by using a pool chlorine test. The apparatus for the test are easily acquired from most pool specialists.

Schools which have participated in the project so far are: DSG, Graeme College, Mary Waters, and St Andrews College.

Anybody who is interested in using this kit is welcome to contact Ms A Ashwell at the Education Department, Rhodes University.

Source: Grocott's Mail, 24 July 1992, page 2

Article by G. Cambray, Graeme College pupil

APPENDIX 11: RESULTS OF SWOT ANALYSIS OF PROJECT WATER WITH HIGH SCHOOL PUPILS AND TEACHERS

The following comments were obtained in workshop sessions with pupils and teachers from Graeme College, St Andrew's College and the Dioscesan School for Girls. They have been arranged according to the aspect of the project evaluated. All points made by participants have been recorded.

1.0 STRENGTHS:

1.1 The kit itself is relatively cheap, portable and easily mass produced. It is interesting, fun to use and attractive in its simplicity. It makes water testing available to many people.

1.2 On the whole, the techniques are simple to execute (especially the Nitrate and pH tests) and can produce fairly accurate and reproducible results. A wide range of tests is provided. Laboratory facilities are not essential.

1.3 The equipment can be used both indoors and outdoors. It can be reused a number of times if carefully washed.

1.4 The written instructions are clear and thorough, enabling participants to carry out the tests even without having had practical training. The booklets are well illustrated. The absence of copyright is an advantage.

1.5 It proved to be a valuable educational tool.

1.5.1 Being flexible in its application, it enabled pupils to carry out a variety of different projects and developed in some users a greater sense of environmental and social awareness.

1.5.2 It enabled pupils to undertake experimental projects they would otherwise not have considered because of the inaccessibility of techniques and materials.

1.5.3 It provided an opportunity for participants to develop skills of observation, manipulation of apparatus, group work and problem solving.

1.5.4 One teacher felt it was an advantage for pupils to experience the realities of research and experimentation in a situation where results were not always what one expected and had to be checked and explained.

1.6 The opportunity to investigate the interaction between abiotic and biotic components of an ecosystem helped to demonstrate the ecological basis of life. The project could be embarked on by teachers of a number of different subjects, enabling an interdisciplinary approach and team teaching.

2.0 WEAKNESSES:

2.1 In the field, the ice-cream container was found to be too small, but participants could easily provide another one for easier storage of equipment.

2.2 Apparatus & Chemicals

2.2.1 Plastic equipment has drawbacks. Some participants were suspicious of the reliability of the apparatus. Markings on the syringes were sometimes hard to read and eventually rubbed off. Unless equipment was washed immediately after use, chemical residues built up and made the syringes very tight. The phosphate coating in new syringes made them unsuitable for the phosphate test unless they were thoroughly pre-washed. A number of particpants chose instead to use test tubes for this test.

2.2.2 General instructions should suggest a list of extra equipment to take into the field on sampling trips. Suggestions were: a bucket, rubber gloves for sampling in polluted streams, fresh water for washing one's hands after doing the tests and wide-necked jars for collecting water samples for the BOD_5 test (the cooldrink bottle recommended in the instructions was found to be unsuitable as it was difficult to get the syringe into the bottle to withdraw a water sample without sucking in air).

2.2.3 Some of the chemicals are dangerous and, although this was stressed in the instructions and on the containers, this information cannot be overemphasised. Participants need to be warned about the proper storage and expected shelf life of chemicals as some, notably ascorbic acid, deteriorate over time.

2.2.4 It is unclear on the colour code for the Nitrate dip-sticks 'which way is up'. This should be clarified as it confused a number of participants.

2.3 Written materials

2.3.1 The water-quality slide was found to be inaccurate for Eastern Cape rivers and should be adapted using results obtained locally by participants.

2.3.2 The instructions on setting up the coliform apparatus omit to warn that the yellow protective sheet covering the micropore filter must be removed before filtering the water sample.

2.3.3 Some early drafts of the materials were poorly reproduced, or presented as separate pamphlets for each test. It would be better to have all instructions in one book.

2.3.4 Another record form, without Water Quality Index (WQI) graphs, is needed on which to record results obtained in the field. This form could provide space for results from a number of sampling sites. One of the local participants produced his own record form, and suggested that it would be better for participants to develop their own record forms to suit their particular purposes.

2.3.5 Although the water quality index graphs provided a useful frame of reference for evaluation of local water quality measurements, many pupils found the calculation of an overall water quality index unnecessary and felt that such an emphasis actually detracted from the interpretation and understanding of results. They saw greater value in discussing how the results of individual tests related to other tests at the same site and the same test at other sites. They felt that an overall numerical rating obscured the range and variety of individual test results.

2.3.6 The WQI graphs are too small. One of the participants in Grahamstown has plotted these graphs on Harvard Graphics and uses coordinates to calculate WQI values for his particular readings.

2.3.7 The printed materials deteriorate when used in the field or laboratory. Instruction sheets could be laminated to protect them or it could be suggested that photocopies of the originals be made for field use, retaining the original booklet(s) for reproduction.

2.4 Implementation

2.4.1 Initial training and supervision were in some cases felt to have been inadequate. A training video left at the school would be a useful source of reference.

2.4.2 Too few teachers were involved in the project.

2.4.3 Some participants felt the project should have had more publicity.

3.0 OPPORTUNITIES:

3.1 The kit is flexible. Tests can be added or omitted, according to the specific needs of each participant. It can be used in the context of various subjects at different age levels.

3.2 In addition to ways in which it has been used in Grahamstown, the kit has a wide range of possible applications, including projects related to human and environmental health, agricultural management and as a practical science and biology teaching resource in schools. In rural areas, it could be used by both schools and clinics. It is suitable for outdoor use and therefore can enable school field work.

3.3 The project should be promoted more widely in schools and to the general public by means of workshops, media articles and by participants reporting their findings.

3.4 Involvement in the project promotes environmental consciousness and understanding about water. It enhances learning by providing hands-on experiences and practice in working with chemicals.

3.5 Suggestions for further development in Grahamstown:

3.5.1 Create a data base to keep an ongoing record of test results. Decide on a method of mapping sites so that they can be recorded accurately.

3.5.2 Link up with other participating schools, either by e-mail or correspondence.

3.5.3 Promote use of Project WATER in the context of individual school projects and ongoing monitoring projects through Wildlife Clubs and class projects.

3.5.4 One teacher felt that Project WATER would provide an excellent focus for an interdisciplinary project planned by the school for the coming year. He suggested using project participants from this year to train both other pupils and teachers in the use of the kit next year. Water quality tests could be integrated into the curriculum and taught in science or biology classes, making use of a team-teaching approach.

3.5.5 Improve project publicity. At school this could be accomplished by displaying projects at a parents' evening.

4.0 THREATS:

4.1 One of the pupils felt that, in order for the project to become more widely adopted, its 'image' would have to be improved. He felt that its cheapness might reduce the project's appeal and believed more attention needed to be paid to marketing. However, 'image' would have to be balanced with cost to ensure the widest possible availability of the kit.

4.2 Uncertainty as to the reliability of results obtained with a low-cost kit was felt to limit the application of the project. Two pupils felt that, if they were using the kit to test drinking water, they would not trust test results even where duplicate readings were in close agreement. Student teachers also stated that they would be wary of basing community action on results obtained with the low-cost kit. However, neither group had a problem basing interpretations and conclusions of science projects on single, unrepeated results. User incompetance was also mentioned as a source of uncertainty but this could be overcome by experience.

To overcome the problem of participants not trusting the results obtained with the low-cost kit, a support centre could invest in a commercial water quality testing kit and validate results of local projects as requested.

4.3 Chemicals & Equipment

4.3.1 The availability of chemicals and the need to make up accurate solutions might limit the application of this project, especially in terms of rural or indigent groups. However, plans by the national coordinator of GREEN S.A. to dispense measured quantities of dry chemicals would help to overcome this problem. The organisation of local networks could provide support for poorly equipped groups.

4.3.2 Despite the fact that the initial kit is relatively inexpensive, the cost of chemicals and plastic equipment which needs to be replaced periodically can become limiting, particularly for individuals or poorer groups.

4.4 The materials need to be multilingual. This group was unaware that materials are available in Afrikaans through SWAP. However, instructions should also be translated into African languages. (Since this workshop, materials have been translated into Xhosa.) One pupil suggested that cartoon instructions could be provided to assist semi-literate users.

4.5 **Practical application**

4.5.1 Teachers may find it difficult to do such a project with large classes. One pupil suggested that the catchment observations and water life studies be done in the field and water samples be brought back to class for analysis, where small groups could do a limited number of tests each.

4.5.2 Boredom with the tests and lack of dedication are obstacles to ongoing monitoring projects in schools. Two pupils felt strongly that teenagers would not take up water testing as a hobby, seeing the project as a "one-off thing" (pupil quote). Pupils generally lost interest in a project once it had been handed in and marked. External motivation would be necessary to sustain the project, for example by integrating it into the year plan for a particular class.

4.5.3 It was generally agreed that the project would not be sustainable in schools without teacher support. Participants felt that lack of teacher involvement ("disinterest", "lack of motivation" - pupil quotes) was the single greatest threat to the promotion and development of the project in schools. Response to the project would depend very much on the individual school and on the way in which teachers viewed the syllabus.

4.5.4 Those teachers consulted felt that lack of time and lack of support from other staff mitigated against their involvement in the project but acknowledged that teacher support was vital for the ongoing success of the project in their school.

4.5.5 Some pupils and teachers also felt that peer pressure might inhibit the degree to which pupils got involved in the project. However, pupils consulted did not feel that peer pressure would inhibit them choosing to use the kit in the first place.

4.5.6 Pupils felt that the project should beware of losing its impact and momentum by becoming routine. They therefore felt that it should not just become "part of the syllabus" (pupil quote).

4.5.7 Some pupils felt that the project might be resisted for political reasons because it enabled communities to test their water sources and confront authorities with evidence of pollution. Resistance might also come from people who did not understand the tests or the relationship between illness and drinking polluted water, particularly if they themselves were used to drinking untreated water and had a high level of resistance to water-borne diseases.

APPENDIX 12: ARTICLE IN GROCOTT'S MAIL: PROPOSED CONSTRUCTION OF ARTIFICIAL WETLANDS

At a Project WATER meeting at the Andrean Club were (from left) Dr Dennis Hughes, Rhodes University hydrologist, Mr Raymond Theron, Chief Health Inspector, Garth Cambray, of Graeme College, and Mr Wayne Joubert, of St Andrew's College and the Grahamstown Centre of the Wildlife Society.

Wetland for Kowie ditch?

PROJECT Water, a low-cost water quality monitoring project, has been implemented in several urban and rural schools in the Grahamstown district this year.

The project forms part of an international initiative known as Green (The Global Rivers Environmental Education Network) which aims to involve citizens in the ongoing monitoring of river water quality with a view to addressing problems of environmental and community health.

Students from Graeme College and St Andrew's College who have been involved in monitoring the quality of water in the Grahamstown catchment of the Bloukrans River recently presented their findings, concerns and suggestions at a meeting organised by the Education Subcommittee of the Grahamstown Centre of the Wildlife Society.

The meeting was attended by representatives from the Municipal Health and Parks Departments, Rhodes University, Albany Museum and various environmental organisations.

Students were concerned about sewage contamination of the Botanical Gardens stream from a mains pipe which frequently leaks. People are warned to avoid contact with this water which has often been shown to have very high levels of faecal bacteria.

Students were also concerned about the high levels of faecal contamination and nutrient enrichment in the upper reaches of the Belmont Valley, particularly upstream of the sewage treatment works.

Members of the group will be meeting soon to consider the possibility of creating artificial wetlands on a piece of municipal land near Raglan Road which borders the stream.

Reeds are well known purifiers of streams as they serve to remove excess nutrients, oxygenate the water and trap silt. The reeds, in turn, can be harvested and used to make baskets or paper.

As Project Water gains momentum locally and nationally, it is hoped that more schools and interest groups will become involved and that concern for the quality of our water sources will grow.

Source: Grocott's Mail, 21 August 1992, page 2

Article written by A. Ashwell

APPENDIX 13: CATCHMENT HIKE: OBSERVATION SCHEDULE

NAME OF CATCHMENT: _____

SECTION: _____ to _____

DATE: _____ **TIME:** _____

OBSERVERS: _____

River structure: natural / cement bottom / fully canalised / dams / weirs

Notes: _____

Water flow: none / stagnant pools / slow / fast

River banks: cement / bare earth (eroding) / grass / trees / indiginous bush / alien bush

Notes: _____

Land-use along river: residential / commercial / industrial / waste disposal / mining / quarrying / agricultural / transportation / natural area

Notes: _____

_____

Human use of river: drinking / washing / recreation / irrigation / watering animals / open sewer / industry / transport

Notes: _____

Water appearance: clear & colourless / clear & dark / muddy / cloudy / oily / green slime

Notes: _____

Water pollution: litter / foam / oil / sludge / dye / mud / faeces or sewage / dead animals / smell

Notes: _____

_____

Possible health hazards: _____

_____

Feelings about the area:

APPENDIX 14: ARTICLE IN GROCOTT'S MAIL: BEGELLY FARM SCHOOL OUTING TO THE BERG RIVER

Mrs Winifred Fobe, principal of the Begelly farm school, is seen above helping Std 5 pupils translate sections of a water study booklet into Xhosa to teach younger scholars.

On the banks of the Berg River: Begelly farm school children seek living organisms in a pool.

• See story on Pg 7

Outdoor studies for farm scholars

• from Pg 5

AN excursion to the Berg River picnic spot in Howison's Poort by Begelly Farm school children, led by the principal, Mrs Winifred Fobe, served several purposes.

The youngsters studied water life, did bacterial tests to discover whether the water was clean enough for human consumption and incidentally cleaned up the litter from the river and surrounds.

They picked up pieces of wire, plastic containers, glass bottles and waste paper. Their wish now is that in future people who use the picnic spot will leave it clean availing themselves of the garbage bins provided for their rubbish.

This rubbish can get into the river, pollute the water and kill the animal life, they warn.

Seeking living organisms, they found many insects and other invertebrates including crab, back-swimmers, scavenger beetles, mayfly, stonefly and caddisfly nymphs. The bacterial test revealed that the water was clean enough for human consumption.

This reinforced the view that the water must be kept clean if it were to sustain water life and not endanger the health of animals or humans.

Source: Grocott's Mail, 19 June 1992, pages 5 & 7

Article written by teachers and pupils from Begelly Farm School

APPENDIX 15: BACTERIAL REPRODUCTION BY BINARY FISSION AND THE COLIFORM TEST

Having established that bacteria are extremely small (approximately 10 x 10 x 10 x smaller that one millimetre in length) and individually invisible to the naked eye, I described how they reproduce, relating this to the coliform test which enables one to estimate bacterial concentrations in water.

Bacteria do not reproduce like people or cows or birds. Instead of giving birth to young, bacteria eat, get bigger and, when they have reached their maximum size, split into two. Each small bacterium then eats, grows bigger and in turn, when it has reached full size, splits in two. I demonstrated this by clasping my hands together to represent one bacterium. As it 'grew', I slowly pulled my hands apart until, separating my hands into two clenched fists, the 'bacterium' split into two copies. I then clasped hands with a pupil and we repeated the sequence, showing that after two generations, there would be four bacteria. I usually repeated the sequence once more with two more pupils, resulting in eight bacteria after three generations. I then asked the class how many bacteria there would be in the next, and the next, and the next generation. They saw that each generation, the number of bacteria would double relative to the previous generation. I then told them that, given enough food and warm conditions, some bacteria reproduce every twenty minutes and asked them to work out how many generations there would be in one day. Having seen how rapidly the population increased in six generations, the pupils saw that after a day (approximately 72 generations), one original bacterium would have formed millions of copies.

I then related this to the coliform test. I explained that, when the micropore filter was placed in the petri dish with liquid food and kept warm, each bacterium trapped on the filter would develop so many offspring that eventually we would be able to see the groups of bacteria (colonies). Because most bacteria cannot move around on the filter, each colony would represent one original bacterium. Knowing how many millilitres of water had originally been filtered, the pupils could work out the concentration of bacteria in the original water sample in bacteria / 100 ml.

APPENDIX 16: GUIDING PRINCIPLES FOR EFFECTIVE ENVIRONMENTAL EDUCATION AS ADOPTED AT THE 1977 INTERGOVERNMENTAL CONFERENCE ON ENVIRONMENTAL EDUCATION HELD AT TBILISI, USSR

Environmental Education should:

* consider the environment in its totality - natural and built, technological and social (economic, political, cultural-historical, moral, aesthetic);

* be a continuous lifelong process, beginning at the pre-school level and continuing through all formal and nonformal stages;

* be interdisciplinary in its approach, drawing on the specific content of each discipline in making possible a holistic and balanced perspective;

* examine major environmental issues from local, national, regional and international points of view so that students receive insights into environmental conditions in other geographical areas;

* focus on current and potential environmental situations while taking into account the historical perspective;

* promote the value and necessity of local, national and international cooperation in the prevention and solution of environmental problems;

* explicitly consider environmental aspects in plans for development and growth;

* enable learners to have a role in planning their learning experiences and provide an opportunity for making decisions and accepting their consequences;

* relate environmental sensitivity, knowledge, problem-solving skills and values clarification to every age, but with special emphasis on environmental sensitivity to the learner's own community in early years;

* help learners discover the symptoms and real causes of environmental problems;

* emphasize the complexity of environmental problem-solving and thus the need to develop critical thinking and problem-solving skills;

* utilize diverse learning environments and a broad array of educational approaches to teaching/learning about and from the environment with due stress on practical activities and first-hand experience.