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ENVIRONMENTAL HEALTH IMPACT ASSESSMENT OF IRRIGATED AGRICULTURAL DEVELOPMENT PROJECTS

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GUIDELINES AND RECOMMENDATIONS: FINAL REPORT

Prepared for the

WORLD HEALTH ORGANISATION
REGIONAL OFFICE FOR EUROPE

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ENVIRONMENTAL HEALTH IMPACT ASSESSMENT OF IRRIGATED AGRICULTURAL DEVELOPMENT PROJECTS

Prepared by

Environmental Resources Limited,
London

for the

World Health Organisation,
Regional Office for Europe

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1. INTRODUCTION

1.1 Background to the Report

In recent years, there have been a number of notable cases of adverse changes in patterns of water-borne disease resulting from development of water-related projects. In Annex 1 we describe briefly a number of case-histories of such developments. In few instances were the possible health impacts examined before the development took place, or taken into account in decisions on the development. The possibility of building mitigating measures into the proposals was thus lost.

In recognition of these problems, the World Health Organisation Regional Office for Europe has been requested to give guidance on how the environmental health impacts of irrigated agricultural development projects may be assessed, in order that health problems may be minimised. Environmental Resources Ltd. has been requested to assist WHO Regional Office for Europe by preparing the guidelines on Environmental Health Impact Assessment contained in this report.

1.2 Environmental Health Problems Associated with Irrigated Agricultural Development Projects

1.2.1 Disease Related Environmental Health Impacts

In any water-related development project there are a number of stages or activities, each of which may have effects upon the aquatic environment, and thus on water-related disease:

- water must be introduced to the development from somewhere;
- usually the water must be stored, with construction of a dam and/or reservoir;
- there must be a spillway for excess water;
- there must be a network of canals of gradually decreasing size, which may be continually or periodically inundated to transfer water to agricultural areas;
- usually there must also be a series of drains to remove excess water from fields.

A variety of environmental health hazards is associated with the hydrological changes involved in each of these stages.

In addition to these hydrological changes in the environment, irrigated agricultural developments may also involve movements of people; both away from areas where dams and reservoirs are to be built, and into the area, as part of the construction workforce and as incoming fishermen and farmers in newly-created reservoirs and irrigated areas. This movement of people has related health hazards, both through introduction of new diseases into an area, and through increased transmission of existing disease amongst immigrants who have no immunity.

Table 1.2(a) (see end of chapter) lists diseases which are related to water in some way, and briefly describes their methods of transmission. Water related diseases are generally classified into four main types:

- o water borne diseases - diseases spread through water supplies by ingestion (usually by a faecal-oral route);
- o water based diseases - diseases spread through an aquatic invertebrate animal;
- o water related diseases - diseases spread by insects that depend on water;
- o and water-washed diseases - disease that result from inadequate provision and use of water for personal hygiene.

Water borne diseases are caused by highly infective organisms, only a small number of which are needed to cause disease. The diseases are transmitted by contamination of water supplies by faeces from a human carrier of the infective organism. The two classic examples of waterborne disease are typhoid and cholera. In addition, diarrhoea and dysentery may be caused by waterborne organisms, including protozoa (for example giardiasis), amoebae (such as Entamoeba histolytica) and enterobacteria, (especially the Shigella genus).

Water based diseases are infections by worms, including flukes and trematodes. Most depend on aquatic crustacean hosts (called intermediate or secondary hosts) for their transmission. Faeces from infected humans contain worm eggs, which enter the secondary crustacean hosts through contamination of water. Parasite larvae emerging from the snails are able to bore through human skin, and thus are transmitted to humans by direct skin contact with water. The most important water based disease, schistosomiasis, is dependent on Bulinid snails as the main secondary host. Another water based disease, guinea-worm infection, is transmitted by ingestion of water containing the microscopic crustacean secondary host of the disease (Cyclops spp.). The disease organism leaves the secondary host once it is inside the primary host, the human body.

Water related diseases are transmitted by insect vectors that breed in or around water. Mosquitoes, tsetse flies (Glossina species) and Simulium species are the most important vectors of water-related diseases; they carry a wide range of infections including malaria, sleeping sickness, onchocerciasis and viral diseases. The diseases are transmitted when the insect bites on infected human host followed by an uninfected human.

Continued.

In contrast to the other types of water related disease, the transmission of **water washed** disease is reduced, not aided, by water. This group includes diseases where the level of infection may be reduced by provision of more abundant or more accessible water supplies. The diseases are transmitted from one person to another when personal hygiene is poor due to lack of adequate water supplies. The most important water washed diseases are diarrhoeas transmitted by a faecal-oral route; others include skin ulcers, scabies, skin fungus infections and trachoma.

All of the disease types described above may be associated with irrigated agricultural development; it is generally held that improved water supplies associated with reservoirs lead to reductions in water borne and water washed infections, but may lead to increases in the other types of water related disease.

1.2.2 Other Environmental Health Impacts

In addition to effects related to infective disease, water resource developments can also have other environmental health impacts. For example surface water may be contaminated by chemical substances either intentionally added to water (e.g. to control pests) or resulting from run-off or upstream pollution. This may result in toxic effects in humans using the water for drinking, cooking or washing.

Another well-known effect of irrigation developments which can have an impact upon health is the increase in salt levels of ground and surface water downstream of a development. This may affect the quality of water subsequently abstracted for drinking and other uses. Control of excess salt levels within an irrigated agricultural area is generally achieved by applying water in excess of that required by crops. This process encourages leaching of soluble salts (chlorides, sulphates and carbonates) from the root zone into the ground water flow, and hence into the downstream surface water flow (the irrigation return flow). Irrigation return flow always contains more salts than the original water supplied for irrigation and thus degrades the quality of the downstream water system to which it is returned. If the water is reused several times for irrigation, salt-levels will increase with each use.

High levels of salts in drinking water may make the water unpalatable and unsuitable for drinking use, leading to a range of direct and indirect health impacts through shortage of suitable drinking water. Toxic chemical effects may also occur more indirectly, for example Genu Valgum is a disease of bone deformation related to copper deficiency. The deficiency arises through a sequence of effects:

- a water resource development raises the water table, this causes increased alkalinity in soil;
- in more alkaline soils certain plants increase their uptake of molybdenum and when eaten by man this causes increased excretion of copper.
- the resulting deficiency of copper then leads to bone deformation.

Health effects may also occur through psychological disturbances resulting from changing lifestyles, through accidents at work, from dangerous plants and animals and from criminal injuries caused by community stress in construction areas. In general, these risks to health are small compared with the risks of infective disease. We therefore concentrate in this report on the problems of infective disease.

1.2.3 The Need for Environmental Health Impact Assessment

As the area of irrigated land and the number of major water related developments have increased, their potential for adverse environmental health effects has been magnified. The current area of irrigated agricultural land is over 90 million hectares in the developing countries alone, and is increasing rapidly.

The potential for environmental adverse health effects from water related developments has been illustrated by the experience of numerous major projects. In Annex 1 a number of case histories of such projects are briefly described. Table 1.2(b) summarises the effects described in these case histories.

It is thus apparent that irrigated agricultural developments, which are often specifically designed to improve human health and welfare, may have effects which achieve the opposite of their desired aim. As the case histories illustrate, such effects have only rarely been investigated and mitigating measures proposed, before a project is undertaken. In order to prevent such unfortunate side-effects in future development projects, it is essential that potential impacts of projects are examined at an early stage in project design.

1.3 EIA, HIA and Environmental Health Impact Assessment

In this report we concentrate on prediction of the impact of water-related projects, particularly irrigated agricultural developments, upon health.

The process of predicting effects of developments has been most widely used and developed in recent years in relation to the impacts of developments on the environment in general **Environmental Impact Assessment** - (EIA). A wide range of methodologies for carrying out EIA have been developed, and many guidelines produced. Examples of these guidelines and methodologies are given in Annex 2). Many different issues may be considered in EIA; these include both impacts on the physical

Table 1.2(b)

SUMMARY OF HEALTH EFFECT OF MAJOR WATER RELATED DEVELOPMENTS (SEE ANNEX 1)

Date of Completion	Project	Health Effects	Prevalence Pre-project	Post-project	Timescale
1933	Tennessee Valley River Project USA	Increase in Malaria			
1958	Kariba Hydro-electric Power Scheme Zimbabwe	Increase in Schistosomiasis. Sporadic increases in Trypanosomiasis	Low	70% (in children)	in 10 years
1960	Gezira-Managil Irrigation Scheme Sudan	Increase in Schistosomiasis. Short term increases in Malaria	5%	80%	in 29 years
1963	Ord River Dam, Northern Australia	Potential increase in Arboviruses			
1965	Soe Dam Ghana	Increase in Onchocerciasis			
1966	Volta Dam Ghana	Increase in Schistosomiasis	3%	70%	in 2 years
1968	Sugar Estate Irrigation Tanzania	Increase in Schistosomiasis	Low	85% (in fieldworkers)	in 1 year
1969	Kainji Dam Nigeria	Increase in Schistosomiasis	Low	30% 70%	in 1 year in 3 years
1969	Aswan High Dam Egypt/Sudan	Increase in Schistosomiasis	10%	c 100%	
1970	Ubolratana Dam Complex Thailand	Increase in Intenstinal Parasitic Infections: - Helminths - Protozoa. Increase in Opisthorchiasis		 52-80% 9-20% 27-70%	
1970	Kisuma Rice Irrigation Scheme Kenya	Increase in Malaria. Increase in Arbovirus infections (e.g. Onyongyong Fever)			
1970	Nagarjunasagar Dam India	Introduction and increase in Genu Valgum (bone disease)			
1974	Guayama, Guajataca and Lajas Valley Water Development Schemes Puerto Rico	Increase in Schistosomiasis			
1974	Lesotho Water Supply Improvements Southern Africa	No effects on the prevalence of faecal-oral or skin diseases			
1974	El Bir and Foum Gleita Reservoir Schemes Mauritania	Potential increase in Schistosomiasis			
1975	Tana River Basin, Kano Plains, Yala Swamp and Taveta Irrigation Schemes Kenya	Potential increase in Schistosomiasis			
1978	Malumfashi Agricultural Development Project, Nigeria	Increase in Schistosomiasis	Low	65% (males 15-20 years)	in 1 year
1978	Srinagarind (Chao Nen) Dam Thailand	Increase in Malaria	16%	25%	in 5 years
1979	Gambia Estuary Barrage Gambia	Potential increase in Schistosomiasis, Malaria, Filariasis and Enteric diseases Possible introduction in Trypanosomiasis			
1980	St. Lucia Water Supply Improvements St. Lucia, Caribbean	Reduction in Schistosomiasis	Infections reduced: 78% by chemotherapy 55% by molluscicides 50% from improved water supplies		

environment (air and water quality, landscape, ecology, soils) and uses of that environment (for agriculture, forestry etc.), and impacts on the human and social environment (health, economic welfare, social systems etc.). Assessment of potential health impacts may thus form part of the wider project impact assessment of an EIA.

In general, however, EIA's have tended to give little emphasis to health impacts; they have concentrated instead on prediction of nuisance impacts and impacts on ecology and natural resources. This volume therefore emphasises the particular problems encountered in predicting effects on health.

In contrast to EIA, **Health Impact Assessment (HIA)** aims to predict the direct effects of a development upon human health, in terms of increase morbidity or mortality. There are two main reasons why such an approach is difficult to apply in practice. Firstly, it is almost impossible, given the uncertainty of prediction, to derive precise figures for changes in morbidity or mortality arising from a development. Many different factors, both related and unrelated to the development, will play a part in determining future morbidity and mortality levels - so that any precise figures produced will be subject to a high level of uncertainty. Secondly, given this level of uncertainty, such figures are likely to be highly controversial, and political sensitivity may prevent their publication outside of confidential internal documents.

In response to the lack of emphasis of conventional EIA on health issues and the problems inherent in HIA, the concept of **Environmental Health Impact Assessment (EHIA)** has been developed. This approach aims to predict and assess the impacts of a development on environmental parameters which have a strong significance for health that is, environmental health factors. These include, for example, increases in levels of malaria-carrying mosquito populations, increased contact between man and parasitic schistosomes etc. By predicting future changes in environmental health factors, it is possible to indicate the potential changes in health which may be caused by a development. These indications may then be used by local health experts, in conjunction with other considerations, to assess future changes in morbidity and mortality.

1.4 The Layout and Content of the Report

This report provides outline guidance, based on past experience, on how environmental health impact assessment may be carried out. The report is organised in 4 main chapters, with additional background information provided in the form of annexes to the report.

EHIA involves four basic stages:

- **identifying** potential impacts;
- **predicting** the magnitude of impacts;
- proposing **mitigating measures**;
- **organisation and presentation** of information for the decision maker.

The aim of the report is to provide guidelines on how to carry out each of these stages.

In Chapter 2 we give guidance on **identification of impacts** on the environment, Chapter 3 focusses on **prediction,** and in particular on **prediction of environmental health impacts,** Chapter 4 focusses on **mitigation of health impacts,** whilst Chapter 5 discusses the **organisation and presentation** of information for the decision maker, that is, the individual or agency who must take this information into account in deciding whether the development should proceed.

The guidance developed in these chapters is based on an examination of numerous guidelines on EIA and on experience of application of the procedures and approaches recommended therein. A review of these guidelines is presented in Annex 2.

It may also be noted that an additional and important stage of EHIA is the monitoring of effects which actually occur after implementation, and a comparison of these with the effects predicted. This will form a basis for subsequent refinement of mitigation measures and of improvement in our ability to predict for future developments.

Table 1.2(a)

NOTES ON SOME WATER-RELATED INFECTIONS

Disease 1	Pathogen 2	Vector and Transmission 3	Water Association 4	Severity 5	Chronicity 6	Notes 7
			(a) Bacteria			
Bacillary dysentery	Shigella spp	Transmitted by faecal-oral route	Water-washed or waterborne	+++		
Bacterial enteritis	Salmonella spp Other bacteria	Transmitted by faecal-oral route Man → man or animal → man	Water-washed or waterborne	++		
Cholera	Vibrio cholerae	Transmitted by faecal-oral route	Water-washed or waterborne	+++		Not established in Australia, New Zealand, Pacific Islands, or the Americas
Leprosy	Mycobacterium leprae	Skin to skin contact	Water-washed	++	++	Epidemiology still uncertain - 10,000 new cases reported annually in Americas
Tularaemia	Brucella tularensis	Focus of infection is among rodents. Transmitted to man by ingesting water contaminated by rodent faeces or corpses, or by eating infected rodents or by bites from ticks, flies or mosquitoes. Also common in rabbits	Waterborne and sometimes spread by water-breeding mosquitoes	++		Mainly in North America, Europe, USSR and Japan
Typhoid, paratyphoid	Salmonella spp	Transmitted by faecal-oral route	Water-washed or waterborne	+++		
			(b) Viral			
Dengue	Dengue virus	Transmitted by the mosquito Aedes aegypti	Aedes aegypti breeds in water	+++		
Yellow fever	Yellow fever virus	Transmitted by mosquitoes, Aedes spp, Haemagogus spp Man → mosquito → man or monkey → mosquito → man	Mosquitoes breed in water	+++		Not reported from Asia or Australia
Other arboviral diseases	Arboviruses causing various haemorrhagic and encephalitic diseases	Transmitted by mosquitoes of many species from many birds and animals to man or, in some cases (eg. o'nyong nyong) from man to man	Mosquitoes breed in water	+++		
Infectious hepatitis	Hepatitis virus	Virus transmitted by faecal-oral route	Water-washed or waterborne	++	+	Epidemiology in doubt
			(c) Protozoal			
Amoebiasis or Amoebic dysentery	Entamoeba histolytica	Cysts transmitted by faecal-oral route. Found in rats, monkeys, dogs and pigs but infection is mainly man → man	Water-washed and possibly waterborne. Cysts can live in salt water for 12 days. Killed by heating to 50°C for 5 min.	++	++	Does not occur epidemically
Balantidiasis	Balantidium coli	Cysts transmitted by faecal-oral route. Found in rats, monkeys and pigs. Often pig → man	Water-washed and waterborne	+ Often no symptoms apparent		Epidemics reported in Brazil and Georgia, USSR
Giardiasis	Giardi intestinalis	Cysts transmitted by faecal-oral route	Water-washed and waterborne	+	+	Epidemic from water supply reported in Colorado
Malaria	Plasmodium spp	Anopheles mosquito. Man → mosquito → man. Occasionally in Africa, chimpanzee → mosquito → man	Anopheles breed in water	+++	+++	363,000,000 people living in malarious areas that do not yet have a control program. 464,000,000 are protected by some measures

Continued.

Table 1.2(a) (Continued)

NOTES ON SOME WATER-RELATED INFECTIONS

Disease 1	Pathogen 2	Vector and Transmission 3	Water Association 4	Severity 5	Chronicity 6	Notes 7
Trypanoso-miasis	Gambian sleeping sick-ness due to T. gambiense	Glossina spp., the riverine tsetse fly. Man -- fly -- man or also in Congo, domestic pig -- fly -- man	Flies live and bite near water	+++	+	In West and Central Africa
	Rhodesian sleeping sick-ness due to T rhodesiense	Glossina spp., the game tsetse fly. Game -- fly -- man. In Kenya has become adapted to riverine tsetse fly	If spread by game tsetse fly, has no water association. If spread by riverine tsetse fly, see preceding association	+++	+	In East Africa
(d) Helminths						
Ascariasis	Nematode Ascaris lumbricoides	Ova transmitted by faecal-oral route. Ascaris suum may be transmitted from pigs to man	Water-washed and possibly water-borne	+	+	
Clonorchiasis	Trematode Clonorchis sinensis	Parasite of bite duct of man, dog, cat and other animals. Man -- aquatic snail -- fish -- man. Man infected by eating infected fish. Man infected by eating infected crab or crayfish	Parasite depends on two aquatic hosts to complete its life cycle	++	++	19,000,000 people infected in China, Japan, Indochina, Taiwan and Korea. Promoted by raw fish eating and fish culture in ponds
Diphyllo-bothriasis	Cestode Diphyllo-bothrium latum	Man -- aquatic crustacean -- fish -- man. Man infected by eating infected fish	Parasite depends on two aquatic hosts to complete its life cycle	Often no symptoms apparent		Common in many parts of Europe. Also found in North America, USSR, Japan, Australia and parts of Africa and South America
Fasciolopsia-sis	Trematode Fasciolopsis buski	Pig -- aquatic snail -- water plant -- pig. Man infected by eating contamin-ated water plant	Parasite depends on an aquatic snail and an aquatic plant to complete life cycle	+	+	10,000,000 people infected in Southeast Asia and China
Filariases	Infection by certain nematodes (filariae)	Transmission from man to man by many different mos-quitoes and flies	Spread by water-breeding mos-quitoes and flies	+++	++	Filariasis occurs in some form throughout the tropics. 200,000,000 infected by the filaria Wuchereria bancrofti and Brugia malayi. Urban varieties transmitted by Culex fatigans are increasing due to poor sanitation in growing tropical cities providing more breeding sites
Guinea worm	Nematode Dracunculus medinensis	Cyclops spp are intermediate hosts. Man -- cyclops -- man. Reinfection of humans is oral	Cyclops lives in water. Cyclops killed by heat or adding potash, perchloron, or barbel fish to infected waters	++	++	Particularly common in parts of West Africa
Onchocerciasis (River blind-ness)	Nematode Onchocerca volvulus	Simulium spp the black fly. Man -- fly -- man	Simulium breed in water	++	++	Mainly found in West and Central Africa and Central America - 10% of the 10,000,000 inhabitants of the Volta River basin are infected and 7% are "economically blind"
Paragoni-miasis	Trematode paragonimus spp	Pig (or other animal) -- aquatic snail -- crab or crayfish -- pig	Parasite depends on two aquatic hosts to complete life cycle	+	+	East Asia and West Africa

Continued.

Table 1.2(a) (Continued)
NOTES ON SOME WATER-RELATED INFECTIONS

Disease 1	Pathogen 2	Vector and Transmission 3	Water Association 4	Severity 5	Chronicity 6	Notes 7
Schistosomiasis	Trematode Schistosoma spp	Aquatic snails are intermediate hosts. Schistosome eggs are passed in urine or faeces. Snails become infected and later humans are infected through the skin	Infection depends on skin contact with polluted water. Snails die above 39°C and are eaten by ducks and other snails. Snails killed by molluscicides	++	++	Perhaps 200,000,000 infected
			(e) Spirochaetes			
Leptospirosis	Leptospira spp	Focus in wild and domestic animals. Leptospires shed in animal urine and infect man through skin, nose, mouth or eyes	Leptospires can survive well in nature in warm conditions and neutral pH. Water-washed or waterborne	++		
Louse-borne fever	Borrelia spp	Transmitted by the louse Pediculus humanus. Man — louse — man	Cleanliness of body and clothing prevents infestation. Therefore a water-washed disease	+++		
Yaws	Treponema pertenue	Skin to skin contact	Water-washed	++	++	
			(f) Fungal			
Tinea or ringworm	Trichophyton concentricum	Skin to skin contact	Water-washed	+		Very common in Australasia and Pacific
			(g) Miscellaneous			
Conjunctivitis Trachoma	Infection of the conjunctiva	Common in conditions of poor hygiene, sanitation and nutrition	Water-washed	++	++	1/6 of world's population suffer from Trachoma
Gastroenteritis (Diarrhoeal disease)	Enteric infection by bacterial or viral agent	Common in conditions of poor hygiene, sanitation and nutrition. Probably faecal-oral transmission	Water-washed	+++		A major cause of death among children in tropics. Poorly understood
Scabies	Bacterial infection of burrow in skin caused by mite	Mite is Sarcoptes scabiei. Mite infestations can pass. Man — man or animal — man	Water-washed	+	+	
Skin sepsis and ulcer	Infection of minor skin trauma by bacteria or spirochaetes, or both	Found in conditions of poor hygiene and poor nutrition in tropics	Water-washed	+	+	

Notes: Severity = degree of infection
Chronicity = length of infection
+ = mild
++ = medium
+++ = severe

Source: Feachem, R.G.; "Infectious Disease Related to Water Supply and Excreta Disposal Facilities". Ambio 6(1), pp. 55–58, 1977.

2. IDENTIFICATION OF POTENTIAL IMPACTS

2.1 Introduction

The first step in EIA, and in environmental health impact assessment, is to identify the possible effects of the proposed development.

Identifying all the possible impacts arising from a development requires a systematic consideration of the way in which the development interacts with the environment to cause environmental change.

2.2 Steps in Identification of Effects

The first step is to identify all the different components involved in the proposed development which may interact with the surrounding environment. In water resource and agricultural irrigation development these components might include some or all of the activities identified in Table 2.2(a).

Table 2.2(a)

A CHECKLIST OF POSSIBLE COMPONENTS OF WATER RESOURCE DEVELOPMENT AND IRRIGATION PROJECTS

Construction Activity e.g.	- temporary access routes and accomodation; - introduction and re-emigration of immigrant workforce; - clearance of vegetation; - noise and dust.
Diversion of existing water courses.	
Tunnelling.	
Construction of dams.	
Inundation of land to create reservoirs.	
Operation of spillways.	
Operation of hydro-electric power generation.	
Construction and operation of irrigation and drainage channels.	
Irrigation of land.	
Changes in agricultural practices e.g.	- crops; - methods of cultivation; - intensity of cultivation.
Introduction or expansion of fisheries.	
Relocation of communities.	
Provision of water supply, effluent and waste disposal facilities in new and relocated communities and in temporary communities during construction.	
Provision of infrastructure for permanent and temporary communities including:	- roads, jetties and other transport facilities; - social services; - utilities.
Water resource management measures including:	- level control; - distribution of irrigation supplies.
Maintenance measures including:	- pest control; - channel clearance.
Measures for health protection:	- of construction workers; - of residents.

The second step must then be:

o to identify potential impacts resulting from each component of the development.

This requires an examination of the proposed development in relation to the present ecological, physical, and human environment:

o What are the conditions in the present environment?

o Are there any features in or uses of the present environment which may be particularly susceptible to change?

A checklist of possible health impacts of water resource developments and irrigation projects is given in Table 2.2(b). It is presented in the form of a series of issue questions.

In Table 2.2(c) the environmental changes which may give rise to water associated disease impacts are listed.

Table 2.2(c)

CAUSES OF HEALTH EFFECTS RELATED TO INFECTIVE DISEASE IN WATER RESOURCE DEVELOPMENTS

Causes	Effects
Change in habitats for water borne disease organisms → change in prevalence of disease organism Change in human exposure to water containing disease organisms	→ Change in incidence of "water borne" diseases
Change in habitats for aquatic disease vectors → change in prevalence of disease vectors and organisms Change in human exposure to water containing disease organisms	→ Change in incidence of "water based" diseases
Change in habitat for insect vectors → change in prevalence of disease transmitters Change in human exposure to insect vectors	→ Change in incidence of "water related" diseases
Change in availability of water and/or personal hygiene facilities and/or change in personal hygiene practices	→ Change in incidence of "water washed" diseases
Immigration of infected work force. Immigration and subsequent emigration of previously uninfected workforce Relocation of communities Settlement of newcomers	→ Change in incidence of all diseases

Table 2.2(b)

A CHECKLIST FOR POTENTIAL HEALTH IMPACTS OF WATER RESOURCE DEVELOPMENTS AND IRRIGATION PROJECTS

A. DIRECT IMPACTS ON PEOPLE IN THE PROJECT AREA:

- Will new diseases or new strains of the disease be introduced by immigrations of construction workers or new settlers? Will these affect new settlers or residents or both?
- Will relocated communities be exposed to diseases to which they have little or no immunity?
- Will new settlers be exposed to locally endemic diseases to which they have little or no immunity?
- Will food, waste or water cycles aggravate sanitation and disease problems?
- Will housing and sanitary facilities become overburdened, misused or not used at all, leading to conditions conducive to increases in water washed diseases and spread of communicable diseases by the faecal-oral route?
- Will soil and water be contaminated by excreta, facilitating spread of communicable disease?
- Will introduction of migrant workers cause increases in venereal disease among workers and subsequently residents.
- Will new settlers and relocated communities be exposed to physical, social and cultural changes leading to psychological strains and traumas? These may include changes in lifestyles and employment.
- Will changes in food supplies lead to possibilities of malnutrition, nutritional deficiencies or toxic effects? *These effects may occur because of:*
  - introduction of Western-style convencience foods;
  - changes in staple foods - possibly using unfamiliar toxic plants as substitutes for usual foods;
  - contamination of soil or agricultural water supplies with toxic substances;
  - reduced productivity of soils caused by hydrological changes (waterlogging, etc.), mineralisation or pollution of ground and surface waters;
  - reduced productivity of fisheries caused by hydrological changes or water pollution;
  - change in availability of trace metals in soils caused by hydrological changes (lowering or raising of water table etc.).
- Will effluents and emissions, or substances released intentionally into the environment (e.g. pesticides) pollute air or water or soil presenting a threat to human health?
- Will irrigation of fields increase opportunities for human contact with water borne, water based and water related disease?
- Will traffic in the area, and therefore road accidents, increase as a result of the development?
- Will new industries and similar activities attracted to the area by growth, result in pollution of air, soil or water or noise, with subsequent impacts on human health?

B. INDIRECT IMPACTS THROUGH EFFECTS ON DISEASE VECTORS:

- Will new vectors be introduced into the area from upstream as a result of hydrological changes?
- Will new vectors be introduced into the area on vehicles, animals, transplanted plants, soil, etc.?
- Will existing vectors be infected or reinfected by contact with infected humans coming into the area?
- Will the prevalence and distribution of existing infected vectors be changed by changes in the availability of suitable habitats for breeding and survival? These changes may result from hydrological changes (water velocities, temperature, depth, standing water, etc.), morphological changes (bank slopes, cover, etc.), climate changes (rainfall, humidity) and biological changes (vegetation, predators, etc.). They may affect presently infected or uninfected areas.

C. DIRECT IMPACTS ON WORKERS:

- Will migrant workers be exposed to locally endemic diseases to which they have little or no immunity?
- Will migrant workers be exposed to psychological strains and traumas from changes in living and working conditions?
- Will workers be exposed to physical threats to their safety (injuries, deaths) or chemical and physical hazards to health (toxic substances, noise, vibration, radiation, high pressures, etc.)?
- Will workmen be particularly exposed to contact with water and thus with water associated disease during their work?
- Will workmen be exposed to dangerous animals during their work (snakes, scorpions, etc.)?
- Will adequate supplies of food be provided to prevent malnutrition and minimise spread of disease (e.g. by use of itinerant food vendors)?

D. IMPACT ON HEALTH SERVICES:

- Will health and other social services be overburdened with consequent effects on health of residents and workers?

Source: various publications including

World Bank; "Environmental, Health and Human Ecologic Considerations in Economic Development Projects". World Bank: Sources: Various publications including Washington, 1974. (New edition in press).

2.3 Key Points in Identification of Impacts

In identifying potential impacts the following points should be remembered:

- Effects can be beneficial as well as adverse.

- Effects are not restricted to the immediate interaction between an activity and the environment; these primary effects may themselves be the cause of secondary and higher order effects.

- Effects may be reversible or irreversible, repairable or irreparable.

- Effects can occur over the short and the long term, they may be temporary or continuous, and they may increase or decrease with time.

- Effects can be local, regional, national or global in scale.

- Accidental effects should be included; an activity may give rise to effects from unusual, unexpected or emergency situations; natural events in the surrounding environment (floods, etc.) may also cause the activity to lead to exceptional effects.

- An activity may stimulate other developments which may have effects on the environment and health; these indirect effects must also be considered as consequences of the proposed activity.

- An activity may establish a precedent for further development which may ultimately result in a much greater effect on the environment and health.

- There will be changes in the environment and health even if the proposed activity is not implemented; these should be taken into account in the assessment to provide a "moving baseline" for comparison.

3. PREDICTION OF IMPACTS ON ENVIRONMENTAL HEALTH

3.1 Introduction

3.1.1 Aims of Prediction

The second step in EHIA is to predict the magnitude of the impacts identified.

The aim of prediction is to provide information about the nature and extent of impacts resulting from a development project to describe how different environmental health factors will change as a result of implementation.

This information on the magnitude of effects will be used to compare the proposed development against the alternative of taking no action and against other alternative development proposals to see which will have the least impact. Prediction also enables the efficacy of different mitigating measures to be compared.

3.1.2 The Process of Prediction

The process of prediction in EHIA is often gradual. At first very simple approximate predictions are made to find out whether effects are likely to be important. Later, more comprehensive predictions may be needed to give fuller information on important effects and to enable a proper definition of appropriate mitigating measures.

In order to predict impacts it will be necessary:

- o to describe the present state of the physical, biological and human environment, using available data or by surveys and monitoring;
- o and to predict how the physical, biological and human environment will change,and how these changes will affect environmental health factors.

This information may then be used by local experts:

- o to predict future incidence of disease in man (HIA).

In Table 3.1(a) we indicate the steps in prediction of changes in incidence of water borne, water based and water related disease.

Table 3.1(a)

STEPS IN PREDICTING HEALTH EFFECTS RELATED TO DISEASE IN WATER RESOURCE DEVELOPMENTS

1. Obtaining baseline information (Baseline) Survey	Description of present state of the environment (Step 1, see 3.2)	Description of present state of human health and exposure to disease
2. Predicting future changes (EHIA)	Prediction of how the environment will change following the development (Steps 2A & 2B See 3.3)	Prediction of how human exposure to disease will change following the development (Step 3, see 3.4
3. Predicting future incidence of disease (HIA)	Prediction of change in number of cases of disease, and change in individual risk of disease, following the development	

The variables used to describe the state of the environment and to measure the impact will depend on the nature of the impact in question. They may be qualitative or quantitative variables describing the ultimate impact (e.g. incidence of human infection), or describing intermediate changes in environmental health factors leading to the effect (e.g. area of vector habitat, population of vectors, level of human contact with infected water).

3.1.3 Methods of Prediction

Certain environmental changes can be modelled using formal methods such as mathematical or physical simulation, and experimental techniques in the laboratory and the field. But formal prediction of health impacts is often difficult because of our lack of understanding and the large degree of uncertainty attached to attempts to simulate processes of transmission of disease. Only through use of expert judgement based on detailed information about the existing disease levels in the project area, existing social conditions and experience from similar projects elsewhere, can some indication of likely changes in disease incidence be given.

Guidance on the methods that are available for each of the stages in prediction identified in Table 3.1(a) is given in the following sections.

3.2 Step 1: Obtaining Baseline Information

3.2.1 Baseline Information Required

Baseline information relevant to environmental health has two components:

- o information on the existing environment; and
- o information on existing human health and exposure to disease.

Baseline information on the existing environment is needed to identify the important physical, biological and environmental factors determining disease levels in an area. This may include information on:

- o transmission pathways for existing disease problems;
- o specific vector species (of mosquito, snail, bird etc.) responsible for the transmission of diseases;
- o data on vector and disease organism habitats, for example preferred breeding and feeding sites, limiting factors, e.g. existence of a dry season, water level fluctuations;
- o vector and disease organism life-cycles, breeding periods, periods of maximum disease transmission

Information is also needed to identify the pathways by which people are exposed to disease, for example:

- o the size, location and characteristics of the existing human population, particularly the degree of contact with water, sanitation arrangements, and eating habits;
- o current health problems; prevalent diseases and immunities in the local population and in migrant and incoming settlers, levels of infection, degree of resistance of the population, any fluctuations in disease with seasonality etc.

Table 3.2(a) gives a checklist of baseline information on the environment and human health which may be relevant to prediction of health effects.

Table 3.2(a)

CHECKLIST OF POTENTIALLY RELEVANT INFORMATION ON THE ENVIRONMENT AND HUMAN HEALTH

1.	Review existing information on the environment and human health and related subjects	
	(a)	Epidemiology: morbidity and mortality rates, geographical distribution, vector ecology.
	(b)	Health and medical services: facilities, staff, special projects and programmes: degree of development, capacity and coverage.
	(c)	Human population and its characteristics: agricultural, migrant, nomadic, etc.; population growth, importance of migratory movement, displacement within the project area.
	(d)	Cattle: numbers and economic importance, prevalent diseases.
	(e)	Community and housing patterns: locations, design, construction materials.
	(f)	Water supply, excreta and waste disposal facilities.
	(g)	Climatic patterns: temperature, rainfall, humidity, wind, etc.
	(h)	Water: surface water and groundwater, quality, pollution, abundance and seasonal variation, floods and droughts, seasonal variation in temperature.
	(i)	Soil: physical and chemical characteristics, including permeability, stability, salt content, etc.
	(j)	Natural and cultivated aquatic and land vegetation: domestic and wild animals.
	(k)	Economy: national and local, sources and levels of income.
	(l)	Topographical maps: contour lines, roads, villages, etc., of the region and the watershed, design plans of proposed project, etc.
2.	Carry out surveys to check existing information or fill in gaps in knowledge: requires assessment and collection of basic data by specialists	
	(a)	Detailed epidemiology of major existing diseases and biology and ecology of principal vectors.
	(b)	Health and medical services, disease and vector control programmes and activities, evaluation of effectiveness and resources.
	(c)	Human and cattle movement: migratory currents, their origin and paths.
	(d)	Sanitation: actual and potential sources of water supply, investigation of groundwater sources, actual and potential sources and routes of pollution, practices involving water contact, and methods of excreta disposal, cattle watering and manure disposal.
	(e)	Existing and proposed agricultural crops and practices: irrigation methods, suitable crops, rotation in cultivation and irrigation, use of pesticides and fertilizers, their kind and amount.
	(f)	Local economy: present status and prospects for future development.
	(g)	Sociocultural patterns: present level and possible disturbance produced by the project.
	(h)	Engineering and operational reconnaissance and mapping for ecological, hydrological and geological or soil studies.
	(i)	Contact with agencies operating in the project area, their type of activities and possibility of assistance and coordination.

In order to provide accurate information for prediction of environmental health impacts, it is necessary for information obtained about the environment to be site-specific. Information obtained in one area cannot be assumed to apply equally to a different, although superficially similar, area.

> For example, fluctuation of water levels has been found to discourage breeding of **Anopheles quadrimaculatus**, and thus outbreaks of malaria, in the Tennessee Valley, USA. However, the species of anopheles which is the main vector of malaria in the Volta area, **A. gambiae** is favoured by fluctuations in water levels as it prefers to breed in shallow sunlit puddles. Similarly, different species of Bulinid snails have different habitat requirement, so that it is particularly important to know which species is the main secondary host for schistosomiasis within a particular geographical area.

A checklist of points to consider in obtaining baseline information is given in Figure 3.2(b)

Table 3.2(b)

CHECKLIST OF QUESTIONS ON OBTAINING BASELINE INFORMATION

- o What are the major health problems current in the population, what is the level of infection and degree of resistance?
- o What are the environmental transmission pathways for existing diseases?
- o What habitats are important for breeding and feeding of disease organisms and vectors?
- o What are the life-cycles of important disease organisms and vectors?
- o What are the numbers, locations and characteristics of existing populations?
- o What existing information is available on local environmental and social conditions?
- o What time-period and geographical coverage are necessary for a survey of existing conditions to encompass important temporal and spatial variations?

3.2.2 Methods of obtaining Baseline Information

The first stage in obtaining baseline information is to establish what information on the existing environment may already be available: from local or national government statistics on population and health, or from previous environmental and ecological studies of the area.

In many cases it will be necessary to collect entirely new information on an area. This may require:

- o detailed fieldwork to establish which species of vector are present in the area;
- o vector population sampling to establish which particular species are the main transmitters of disease;
- o field observation over a period of time, to establish the life-cycle, habitats and limiting factors for the vector species identified;
- o surveys of existing health problems, which may include medical examination of a sample of the local population over a period of time to establish levels of infection, resistance to disease and disease variations with time. (The sample of population examined should cover a range of ages, occupations and locations within the area);
- o detailed observation of current social habits, in particular detailed examination of sanitation, and of human contacts with water to establish current transmission routes.

A comprehensive survey programme for an area may require input from a range of specialists, including medical specialists, environmental health specialists, ecologists and biologists, over a period of time sufficient to encompass seasonal variations in habitats and life-cycles.

A survey programme must be designed specifically for each different location, taking account of local conditions and amount of information already available.

3.3 Step 2: Predicting Future Changes in Environmental Health Factors

3.3.1 Information Required on Future Changes in the Environment

Surveys of the existing environment, as described in 3.2, provide information about the environmental health factors which are important in disease transmission. The next step in the prediction process is to ascertain how the environmental health factors identified as important will change following implementation of a proposed development.

This consists of two stages:

Step 2A: Predicting changes to environment and habitat factors favouring disease transmission

Step 2B: Predicting effects of changes in these factors on disease vectors

In order to do this the following information may be required, on:

- the nature of the completed irrigated agriculture development, for example the configuration of the channels, spillways, storage ponds etc, steepness of banks, materials to be used for construction;
- the construction phase of the project can also be important, for example construction of access roads, temporary accommodation for construction workers;
- operation of the system: frequency of inundation, maintenance of water levels, use of chemicals, etc.

3.3.2 Step 2A: Predicting Changes to Environmental and Habitat Factors

The first stage is to see how the development will cause changes to physical habitats for disease vectors and organisms, for example:

- effects of the irrigation system upon hydrology, levels and velocity of water flow, rates of seepage from the system, amounts, location and seasonality of standing water (including temporary puddles), existence of wave action;
- effects of the irrigation system on water quality and water temperature;
- whether currently vegetated areas be flooded, and if so whether vegetation will be submerged or cleared prior to flooding;
- availability of water supplies and/or personal hygiene facilities within the scheme;

- whether human waste will be disposed of into the water;
- effects of irrigation system structure, hydrology and water quality on amounts and types of vegetation both within and surrounding the water channels;
- effects of irrigation system maintenance (e.g. weeding, clearing) on aquatic vegetation and channel bank vegetation.

Table 3.3(a) gives examples of changes to environmental and habitat factors which may have important environmental health effects.

Table 3.3(a)

ENVIRONMENTAL FACTORS FAVOURING INCREASED DISEASE TRANSMISSION

Vector	Disease	Environmental and Habitat Habitat Factors Favouring Increased Disease Transmission
Simulium sp.	Onchocerciasis	Fast-flowing, well aerated streams (flow speed 0.7-1.2 m/s)
Bulinid and other aquatic snails	Schistosomiasis	Slow flowing water, increased aquatic vegetation, existence of shallow banks around water bodies
Anopheles sp.	Malaria and arboviruses	Varies greatly with species, but in general favoured by increased vegetation at water body margins, continuous inundation of fields of irrigated crops, overgrown irrigation channels
Culex sp.	Filariasis and arboviruses	Existence of faecal polluted waters in vicinity of human settlements
Mansonia sp.	Filariasis	Presence of roots and leaves of aquatic plants to provide anchorage

3.3.3 Methods of Predicting Changes to Environment and Habitat Factors

Basic information on the nature of irrigated agricultural developments, such as channel configuration, construction materials, bank steepness etc is generally included in plans for the proposed developments. Such plans should also include data on the operation of the proposed system - water levels and velocity, presence of standing water and any proposals for water supply and sanitation.

Accurate information on system failures, for example water leaks and seepage, may be less readily available, but it may be possible to infer likely failure rates from experience with similar projects elsewhere. (This information can be of great significance in predicting likely effects on the environment, as seepage can lead to the formation of large areas of standing, stagnant water which may act as breeding grounds for disease vectors).

To predict effects of developments on hydrology. A number of formal mathematical methods are available - some have been used in environmental impact assessment. However, the majority of these methods are designed to predict effects of developments on existing water bodies. Predicting effects in new water bodies created by an irrigated agricultural development is more difficult. Some methods are available which may be appropriate for application to particular irrigated agricultural developments.

Formal mathematical methods may also be used to predict effects on water quality. Again, the majority of methods have been designed to predict the effects of new discharges or runoff into an existing water body, and are thus inappropriate to predict effects on water quality in a new irrigation system. However data have been developed which allow the potential organic pollutant load generated by a certain level of population to be calculated. This information can be used to assess effects on water quality due to disposal of human wastes in the irrigation system.

Mathmatical methods may also be available for predicting increased salt levels in downstream flows.

In each case the advice of experts in hydrology and water quality should be sought to apply prediction methods and to interpret their results.

3.3.4 Step 2B: Predicting Effects of Changes in Environment and Habitat Factors on Disease Levels

Information on changes in environment and habitat factors is in turn used to predict effects upon disease vectors and organisms, for example:

- effects of irrigation system structure and hydrology on disease organisms and vector habitats, e.g. feeding and breeding sites; these can be affected, for example, by steepness of channel banks, level or flow of water, presence of standing water, frequency of inundation of fields etc.;
- effects of changes in vegetation on disease vector feeding and breeding sites (for example, number of shaded areas, amount of food available);
- effects of changes in disease vector and organism habitats on organism and vector populations distribution and longevity etc.

Table 3.3(b) give examples of ways in which changes to habitats may affect particular disease vectors and organisms.

Table 3.3(b)

CHANGES TO THE ENVIRONMENT WHICH MAY AFFECT MOSQUITO VECTORS OF DISEASE

Change in environment/habitat	Effect
- Simplification of the environment	Allows one species of mosquito to become dominant
- Increased surface water - Rise in water table - Changes in water flow	More breeding sites available May also affect species composition as different water conditions are preferred by different species
- Microclimatic changes to give cooler and wetter climate	Allows for increased longevity of mosquitos, increasing the probability of biting humans more than once and thus transferring disease
- Changes in human settment	May provide additional breeding sites; may allow for increased biting of humans by mosquitos

Source: Surtees, G.; "Effects of Irrigation on Mosquito Populations and Mosquito-Borne Diseases in Man, with Particular Reference to Rice Field Extension". In Environmental Studies, Vol. 1, p. 35-42, 1970.

3.3.5 Methods of predicting effects on disease levels

Predicting how changes in the environment will affect disease vectors and organism life cycles is a complex procedure which requires a thorough understanding of the specific vector and environment concerned. It is often not possible to apply information gained with one species of, say, mosquito or aquatic snail to another, or to extrapolate from one environment to another.

The current state of ecological knowledge is generally inadequate for the development of broadly-applicable methods for predicting effects of environmental changes upon particular species with any accuracy. Instead it is usually necessary to make an expert judgement in each particular circumstance, based on as full information as possible about the particular environment and species concerned.

Table 3.3(c) gives an overall check list of points to consider predicting future changes to the environment and man.

Table 3.3(c)

CHECKLIST FOR PREDICTING FUTURE CHANGES TO THE ENVIRONMENT AND MAN

- o What is the nature of the proposed development, what are the different components which make up the development?
- o How will the development be constructed? What temporary structures and movements of people will be required?
- o How will the development be operated? What are the plans for maintenance etc.?
- o How will the development affect local hydrology? What will be the flow velocities, will there be standing water etc.?
- o Will water supply and sewerage systems be incorporated in the development? Will wastes be disposed of into the water?
- o How will the development affect local water quality?
- o How will changes in water quality and hydrology affect aquatic and non-aquatic vegetation?
- o Will planned maintenance affect aquatic and non-aquatic vegetation?
- o Will changes in water quality and hydrology affect disease organism and vector habitats?
- o Will changes in vegetation affect disease organism and vector habitats?
- o Will changes in disease organism and vector habitats affect organism and vector populations, distribution and longevity etc.?
- o Will water within the system have uses other than irrigation, e.g. for drinking, fishing, washing, etc.?
- o Where will human settlements be located in relation to the development?
- o What will be the level of human bodily contact with water?
- o What personal hygiene and eating habits are likely to occur after the development, how will wastes be disposed of, are eating habits likely to be related to disease?
- o Will there be immigration to the area? What are the likely social habits and health status of migrants?

3.4 Step 3: Predicting changes in Human Exposure to Disease

3.4.1 Information required about Changes in Human Exposure

Detailed information is needed on future human activities to assess the extent to which contact between disease vectors and people will occur, thus indicating the importance of disease factors identified.

Human activities may be affected in many ways by irrigated agricultural developments. In addition to changing the lifestyles of people already within the development area - for example by introducing water supplies, or giving opportunities for new forms of agriculture - developments may lead to immigration of new populations to the area.

Such populations may migrate to the development area either during construction - construction workers, their families, and others associated with them - or to take advantage of the new opportunities for agriculture, and perhaps fishing, afforded by the development.

This influx of people may lead to the introduction of diseases not otherwise endemic in the area, and may also be associated with increases in numbers of animals such as dogs and rats which can act as a reservoir for disease. The new population may be less immune to existing disease than the local population, leading to an increase in disease incidence. In addition, the stress of social disruption created by large-scale immigration may lead to a general increase in ill-health.

Information will thus be needed concerning future social patterns and lifestyles to determine the likely human proximity to areas forming habitats for disease vectors and organisms:

- human use of water following the development; whether water within the irrigation system will be used for washing, drinking, fisheries etc.;
- location of human settlements; whether these will be close to water bodies, spillways and in general to vector and disease organism breeding and feeding areas;
- levels of bodily contact with water; for example through washing in water and water based recreation, through labour in inundated fields, through maintenance of the irrigation system;
- human personal hygiene and eating habits; how will wastes be disposed of, future hygiene practices, eating habits related to disease (for example eating raw fish or plants which may be infected by parasites;
- immigration to the area; how many migrants will settle and when, information on social habits and health status of potential migrants.

3.4.2 Methods of Predicting Changes in Human Exposure to Disease

Prediction of opportunities for human contact with disease is highly complex, not only because of the need for detailed information on social attitudes and lifestyles, but also because it is likely that the development itself may change these attitudes and lifestyles; for example:

- development of a reservoir may allow fishing to become important in an area. Increased agriculture may attract an entirely new population of farmers to the area, with quite different social preferences;
- an increase in the numbers of people within an area may in itself force changes in lifestyle;
- the existence of reservoirs and water channels may encourage water based recreation where none existed before.

The number of variables to be considered is very high, and accurate prediction is consequently difficult.

Information about current social preferences and lifestyles within the development area may be obtained from previous research surveys of the area. Some information may already be available from Government social surveys or censuses.

Plans for the development may contain indications of expected or planned targets for migration to the area, though of course these targets may be exceeded or may not be achieved. Experience of other development projects within the region may give some indication of the social changes which may follow major developments.

However it must be remembered that such experience should only be extrapolated from one region to another with great caution. Prediction must take the form of expert judgement based on as full information as possible about the planned development and current social preferences.

3.5 Step 4: Predicting Future Incidence of Disease (HIA)

3.5.1 Information on Future Disease Incidence

Health Impact Assessment (HIA) involves prediction of future levels of disease. Information needed about future incidence of disease may include:

- information on the level of incidence of a disease;
- information on the risk of a particular individual contracting a disease.

Changes in disease levels are related to changes in the prevalence of disease organisms or vectors due to environmental changes, and changes in human exposure to disease through social changes and population movements. However disease levels within a particular area will be affected by a wide range of other factors unrelated to the project, which may also change over time.

3.5.2 Methods of Predicting Future Incidence of Disease

Formal methods are not readily available for predicting future incidence of disease. Instead expert judgement is needed to relate information on future changes in the environment and on human exposure to disease to future disease incidence.

This process may be aided by examination of experience with water-related development projects elsewhere, although again extrapolation to different areas and projects must be treated with caution.

Mathematical models of disease patterns do exist for certain water related diseases, notably malaria and schistosomiasis. Most models so far developed are, however, only applicable to existing endemic diseases within a given environment. They cannot account for changes to the environment which will be caused by a development. The relationships used in such models could, in theory, also be used to develop models which could account for environmental change.

One model has been used in relation to water development projects in Dezful, Iran*. The model produced was very simple, and its accuracy in prediction has not been fully assessed as yet. The model is based on regression analysis of data on disease from one particular location only and is highly site-specific. It would require considerable testing and recalibration before it could be usefully applied to different environments and different developments.

In general, assessment of the direct health impacts of a development must be a matter of judgement on the broadest available evidence by experts with experience of local health factors and disease incidence.

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*Rosenfield, P.L. and others. "Development and verification of a schistosomiasis transmission model" in American Journal of Tropical Hygiene 26 (3), pp 505-516, 1977.

4. MITIGATING MEASURES

4.1 Introduction

In previous sections of the report we have described the types of health effects which may be associated with irrigated agricultural developments, and how such health effects may be predicted. Once the impacts of a development have been predicted the question remains of what should be done to mitigate these potential effects.

Even when all development alternatives have potentially serious environment health effects,the overall benefits to be obtained from the development may outweigh the adverse effects. In that case the introduction of mitigation measures to minimise adverse effects will be essential to ensure the success of the project.

4.2 Choice of Mitigating Measures

In Table 2.2(a) we indicated the various factors which may determine the effects of water related developments upon health, particularly relating to infective diseases. Adverse effects on health may be reduced by measures designed to influence these factors (mitigating measures). The choice of mitigating measures will depend upon:

- the exact nature of the project concerned; mitigation measures may be specific to certain types of development;
- the stage of development of the project; certain mitigation measures are only feasible at particular stages, for example in construction or during operation;
- local climate and physical conditions (e.g. hydrology, topography);
- the types of disease organisms and vectors which have been identified as important in causing health effects;
- the aims of the project; mitigation measures must allow the aims of the project to be achieved within the required time-period;
- local social, cultural and political factors; these may greatly affect the feasibility of certain types of mitigation measures.

4.3 Types of Mitigating Measures Available

Environmental mitigation measures have been classified by the WHO Expert Committee on Vector Biology and Control into three major groups:

- o environmental modification; that is large scale alterations to the form of the environment, such as clearance of land before a project commences, drainage and dewatering of areas around a project;
- o environmental manipulation; smaller scale control of the environment during the operational phase using physical, chemical and biological methods;
- o modification or manipulation of human behaviour or habitats to reduce man-vector-pathogen contact.

Table 4.3(a) indicates the mitigating measures available within each of these three groups for control of vector-borne disease.

Table 4.3(a)

TYPES OF MITIGATION MEASURES AVAILABLE FOR CONTROL OF VECTOR-BORNE DISEASES

Vector or intermediate host	Diseases transmitted	Environmental modification						Environmental manipulation						Modification or manipulation of human habitation or behaviour				
		Drainage (all types)	Total earth filling	Deepening and filling	Land grading	Velocity alteration	Impoundment	Clearing and burning of terrestrial vegetation	Shading or exposure to sunlight	Water level fluctuation	Sluicing for flushing	Aquatic vegetation control	Salinity regulation	Water supply and sewerage	Screening and bednets	Refuse collection and disposal	Land use restriction	Improved housing
Anopheles mosquitos	Malaria	++	++	++	++	+	−	+	+	+	+	+	++	+	+	+	+	+
Aquatic snails	Schistosomiasis	+	+	++	+	+	−	−	−	+	+	+	+	++	−	−	+	−
Culex and *Aedes* mosquitos	Filariasis; viral and other diseases	++	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+	+
Blackflies	Onchocerciasis	−	−	−	−	+	++[a]	−	−	−	+	−	−	+	−	−	+	−
Houseflies	Infantile diarrhoea	−	−	−	−	−	−	−	−	−	−	−	−	++	+	++	−	+
Tsetse flies	African trypanosomiasis	−	−	−	−	−	−	++	−	−	−	−	−	−	−	−	+	−
Triatomid bugs	Chagas' disease	−	−	−	−	−	−	+	−	−	−	−	−	−	+	−	−	++
Rat fleas	Plague	−	−	−	−	−	−	−	−	−	−	−	−	−	−	++	−	++
Cyclops	Dracontiasis	−	−	−	−	−	−	−	−	−	−	−	−	++	−	−	−	−

Key:

− = Little or no directly demonstrated value, or not applicable.
\+ = Partially effective (some species).
++ = Primarily effective (most species).
[a] Small dams = adverse effect; large dams = good effect.

Source: World Health Organisation; "Environmental Management for Vector Control: 3rd Report of the WHO Expert Committee". Geneva: WHO, 1980. WHO Technical Report Series No. 649.

Table 4.3(b) outlines the mitigation measures used in the case histories, and the degree of success which they achieved in reducing adverse effects on health. All three types of mitigation measures have been used in practice.

The different types of mitigating measures are described in more detail in the following paragraphs, listing the factors which may affect their success or failure and the stage of the project at which they should be used. Section 4.7 reviews the factors to be considered in choice of mitigation measures.

Table 4.1(b)

MITIGATION MEASURES USED IN THE CASE HISTORIES

Project	Adverse Effect	Mitigation Measure	Success of Mitigation
Aswan High Dam	Increase in schistosomiasis	None	-
Kainji Dam	Increase in malaria. Some increase in onchoceriasis in certain areas.	Control programme with spraying of DDT	Some reduction but problems with resistance to DDT. Initially reduced, but rapid re-infestation by vector.
	Increase in schistosomiasis	None	-
Gezira Irrigation Scheme	Increase in schistosomiasis	Use of molluscicides on vector	Some success, but problems with choice of molluscicides and method of application
Srinagarind Dam	Increase in malaria	None	-
Gorgol River Irrigation	Increase in schistosomiasis	None	-
Ord River Dam	Threat of increased arbovirus disease	None	-
Malumfashi Agricultural Development	Increase in schistosomiasis	None	-
Ubolratana Dam	Intestinal parasites. High level of opisthorchiasis. Arbovirus infection (meningitis)	Health education programme concerning eating habits and sanitation	Results from small number of villages where applied indicate success
Volta Dam	Increase in schistosomiasis.	Herbicides for vegetation control to discourage schistosomiasis vectors.	Some success in removing vector habitat, but cleared shoreline lead to increased human bodily contact with water and threat of increased disease
	Increase in malaria.	None	
	Threat of increased yellow fever transmission	None	
Gambia Estuary	Increases in malaria, filariasis, schisto-somiasis, enteric infection were predicted	Elimination of snail schistosomiasis vectors by allowing saline water intrusion and tidal fluctuations in water levels was suggested	Project not proceeded with, partly due to predicted adverse effects
Soe Dam	Increase in onchocerciasis	Removal of vector larvae by stiff brushes. Spraying with DDT. Measures to reduce water flow conditions favourable to vector	All methods achieved some success, but not total eradication
Tanganyika Sugar Estate	Increase in schistosomiasis	Mixture of molluscicides application and chemotherapy	Infection reduced by 50%
Nagarjunsagar Dam	Genu valgum due to alterations in dietary trace elements	Alterations to diet suggested but not implemented	-
Guayama, Guajataca and Lajas Water Project	Increase in schistosomiasis	Drainage of waterlogged areas. Use of predator snail for biological control	Drainage efficient in eliminating snails. Biological control cheaper and more successful than chemical
St. Lucia Water Supply	High levels of schistosomiasis	Mixture of chemotherapy, molluscicides and prevention of human water contact	Chemotherapy most successful, reducing infection by 78%. Molluscicides reduced infection by 55%. Prevention of contact reduced infection by 50%.
Lesotho Water Supply	Diarrhoea, gastro-enteric and skin diseases	Construction of improved clean water supplies	Little effect on diseases, water was deduced to be of minor importance in transmission
Kariba Dam	Introduction of schistosomiasis and trypanasomiasis	Snail control programme	No data
Kisumu Irrigation	Increase in arboviruses, malaria. Threat of schisto-somiasis	Mitigation of schistosomiasis by programme of molluscicide use linked to project	No increase in schistosomiasis occurred

4.4 Environmental Modification Measures

4.4.1 What Measures are Available?

Environmental modification measures are defined as permanent physical transformations of the environment designed to prevent or eliminate disease effects on human health. They involve large-scale alterations to the environment of the project area, designed to make the environment less favourable for organisms and vectors causing disease. Environmental modification measures include:

- modification of water body and water course forms to reduce suitable habitats for disease organisms and vectors, for example steepening channel banks to discourage vegetation growth and encouraging high water velocity;
- drainage and de-watering of potentially waterlogged areas, to reduce potential disease organism and vector habitats;
- reduction of seepage from water bodies through improved lining, again reducing potential habitats suitable for disease organisms and vectors;
- clearance of vegetation from areas prior to construction, for example clearance of vegetation from areas which are to be flooded to form reservoirs;
- planting of vegetation less favourable to known disease vectors and organisms, or favourable to competing or predator species.

4.4.2 When and How Should Environmental Modification Measures be Used?

As environmental modification measures may involve major works, they are best applied at the early stages of project development, where they may be incorporated into project design. Certain measures such as reduction of water seepage are part of good engineering practice, which should be incorporated into all projects.

The scale of environmental modification measures may mean they are only feasible where major health impacts are anticipated. However, in preventing a problem arising, rather than curing effects once they have occurred, they may be highly effective in reducing adverse health effects.

4.5 Environmental Manipulation

4.5.1 What Measures are Available?

Environmental manipulation methods are defined as those which produce temporary conditions unfavourable to the transmission of disease. They are smaller-scale alterations to the environment, which are carried out during the operation rather than the construction of a project. Environmental manipulation may involve physical, chemical or biological measures:

- Physical mitigation measures have been widely used in relation to vector-borne diseases such as schistosomiasis, onchocerciasis and malaria control. Examples include scrubbing of vector breeding sites to remove larvae, drainage of areas which have become waterlogged and clearance of vegetation from water channels and banks. Control can also be exercised through regulation of water salinity, flushing of channels and water bodies through sluicing, and manipulation of water levels.

- Chemical mitigation measures have been used for the control of vectors of water-based and water-related diseases. They include spraying snail habitats with molluscicides to reduce schistosomiasis incidence, spraying mosquito breeding sites with DDT to reduce malaria, and adding insecticides to spillways to reduce Simulium populations and thus onchocerciasis levels. Whilst such measures have been used successfully, the potential health effects of chemical contamination of water should always be considered.

- In theory, biological mitigation measures are available for control of habitats favourable to disease organisms and vectors, through the introduction of competitor or parasitic species. For example, plant species which form a favourable habitat for disease vectors may be controlled by the introduction of a competitor species which will eventually exclude the unwanted plants. Predator species which eat secondary host Bulinid snails (Schistosomiasis) may be introduced to water bodies.

  There have been few applications of biological control, mostly on an experimental basis. Lack of knowledge about the long term effects of biological control methods prevents their more widespread application. However, research currently in progress suggests that they may in the future provide effective means of control without the safety hazards associated with use of chemicals.

4.5.2 When and How Should Environmental Manipulation Measures be Used?

Successful use of environmental manipulation measures depends on sound ecological knowledge of disease organisms and vectors. Such measures must be specifically designed for each particular development, organism and environment, but it may be possible to utilise knowledge gained elsewhere:

- Physical manipulation measures may be simple to introduce into water-related developments if they are anticipated in the early stages of development and incorporated into the operation of the project. However, there may be limits on their feasibility related to the size of the project. It will not normally be possible to produce regular fluctuations in the level of large reservoir, nor to ensure that a large number of irrigation channels remain free of weeds. Nevertheless, well designed physical measures may be highly effective in mitigating potential adverse health effects.

- The degree of success which can be achieved by chemical mitigation measures depends to a great extent on the degree to which chemical control can be efficiently tailored to the characteristics of the disease vector or organism concerned. As the aim of many water-related development projects is to provide a plentiful supply of relatively clean water, it is obviously not possible to add large amounts of toxic substances to water.

  In the case of onchocerciasis, chemical control of Simulium species is aided by the feeding efficiency of Simulium larvae: insecticides at very low concentrations are absorbed and accumulated by the larvae. In addition, if insecticides are added to a spillway, the turbulent mixing of the water will distribute the insecticide very thoroughly, and may allow for transport of insecticide, and thus control of Simulium species, for long distances downstream.

  Where vectors (e.g. Bulinid snail vectors of schistosomiasis) are clustered at limited sites in a development, control by spraying at those points can be highly effective. However, where the vectors are more widely distributed, chemical control is much less effective and requires far larger amounts of pesticide to be used. The same considerations apply to the use of chemical measures for control of mosquitos.

- Biological mitigation measures may in the future become important for long-term control of habitats which promote disease. At present expensive and time-consuming research is required for their development and this is likely to be justified only in exceptional circumstances.

4.6 Modification or Manipulation of Human Behaviour or Habitats

4.6.1 What Measures are Available?

Human-based mitigation measures aim to reduce adverse health effects through reduction of human exposure to disease, for example by:

- o reducing contact between humans and infected or otherwise harmful water through such measures as provision of alternative safe water supplies, location of settlements away from main water bodies, or reducing recreational and sanitary use of water bodies by fencing them or making them appear unattractive;

- o ensuring adequate supplies of water for washing etc. to assist in reduction of water-washed diseases;

- o reducing the possibilities for infection by water borne and water based diseases relying on access of human wastes to water for their transmission. Provisions for sewage treatment and disposal (excreta disposal) can prevent such access;

- o reducing the possibilities for transmission of water-related diseases by chemotherapy treatment of human carriers so that insect vectors are less likely to become infected when biting humans;

- o reducing unintentional creation of suitable habitats for disease organisms and vectors, for example by ensuring adequate refuse disposal, and controlling man-related animals (such as rats and dogs) which may be important as secondary disease hosts;

- o provision of adequate health care facilities and health monitoring for current residents and migrants.

4.6.2 When and How Should Human-Based Mitigation Measures be Used?

The majority of the adverse health effects of water-related developments are associated with poor hygienic conditions. The presence of disease vectors is only a hazard when they are able to come into contact with disease organisms in man - either through biting infected persons or through inadequate disposal of human wastes. By improving health and hygiene, major reductions in adverse health effects can be achieved. In addition, measures such as provision of safe water and excreta disposal may have beneficial effects on the health of the community as a whole.

However, the experience of the case-histories indicates that human-based mitigation measures must be applied with care. Often it is necessary to accompany the measures with a programme of health education to stress their relationship to health problems. In certain cases social customs may negate the effect of mitigation measures, for example when residents prefer to use streams for washing clothes, even when piped water supplies are available. In this case human exposure to disease continues, and the mitigating measure is unsuccessful.

Improved sanitation and water supply may be introduced most efficiently into the design stages of a water-related project. At this stage, too, mitigating measures designed to reduce recreational and other human-water contact may be best incorporated.

4.7 Factors to be Considered in Selection of Mitigation Measures

In Section 4.2 we indicated that a number of factors could influence the choice of mitigation measures. Some of these factors, the nature of the development and of the environment, are unique to each development. However, more general guidance can be given on the timing of mitigation measures during the different stages of a development. Table 4.7(a) lists a series of steps to be taken during the design, construction and operation phases of a development, with particular reference to infective diseases.

Prevailing institutional factors, as well as environmental factors, may influence the usefulness of mitigation measures, and should be taken into account. For example sophisticated mitigation measures using heavy and complex machinery, must be compatible with local maintenance and operating skills, supply of spare parts, etc. Other measures may require training programmes (for operators or local residents) or even legislative support (for example concerning location of residential areas). Such requirements must be balanced against availability of resources in choosing mitigation measures.

In Table 4.7(b) we include a checklist of questions which should be considered when selecting mitigation measures.

Table 4.7(a)

MITIGATION MEASURES TO BE CONSIDERED AT DIFFERENT STAGES OF A DEVELOPMENT

Design Phase

1. Establishment of design criteria to minimise health hazards and to achieve the objectives of the health programme.
2. Evaluation of preliminary project designs and alternatives.
3. Establishment of proposed practices of water-system management and their effects on vector habitats.
4. Preliminary design and options for canal lining, overpasses and other structures.
5. Final detailed design of works in the reservoir
   - (a) Shoreline modification and improvement
   - (b) Clearance and disposal of trees and brush, of man-made structures and fences
   - (c) Relocation of roads, villages, cemeteries, shrines, etc.
   - (d) Discharge structures sized for water-level regulation and downstream flushing.
6. Final detailed design of works in irrigation schemes
   - (a) Equalising reservoirs and night-storage ponds, when necessary
   - (b) Canals and drains
   - (c) Regulating structures, gates, sluices, etc. and distributing chambers
   - (d) On-farm water use
   - (e) Groundwater use and control
   - (f) Potential for incorporating domestic water supply.
7. Final detailed design of measures and works in communities
   - (a) Selection of sites for new communities distant from water sources
   - (b) Provision of safe, adequate and convenient water supply and sewage disposal systems
   - (c) Recreation: provision of safe ponds as alternatives to infected water bodies, sports grounds, etc.
   - (d) Other protective measures, such as house-screening, surface-water drainage, general sanitation and public laundry installations.
8. Provisions for maintenance activities and their financing.
9. Environmental management
   - (a) Regulating structures for measurement and control of water discharge and velocity
   - (b) Gates required for rapid drying and flushing of irrigation subsystems
   - (c) Adjustment of water salinity in coastal breeding-sites through the installation and operation of gates
   - (d) Water-level regulation in small reservoirs by means of automatic siphon spillways
   - (e) Safe crossings and bridges over canals and drains
   - (f) Lining of canals and drains, closed or subsurface conduits.
10. Enhancement and simplification of chemical and biological control
    - (a) Design of dispensers for chemical application attached to or incorporated into regulating structures, metal rakes and screens against snails
    - (b) Access roads and paths for surveillance and spraying, clear water lanes and landings for boats.
11. Health education of the public and development of community participation.

Construction Phase

1. Health protection of the construction labour force.
2. Special facilities for disease control and treatment at the construction site.
3. Adequate housing and sanitary facilities for construction workers and their families.
4. Surveillance of infections in imported manpower and local population.
5. Monitoring, vaccination, treatment of local population and elimination and control of endemic diseases, especially those with potential for intensification with project operation.
6. Environmental protection, erosion, spillage, air and water pollution, disposal of wastes, aesthetic alterations, etc.
7. Inspection to ensure that construction is carried out according to health designs.
8. Health education of the public and development of community participation.

Operations Phase

1. Allocation of funds, assignment of staff and implementation of disease control programmes.
2. Surveillance, screening and treatment of infected persons.
3. Establishment of practices and schedules for the control of mosquitos, snails, flies, weeds, etc.
4. Establishment of practices and schedules for water-level regulation.
5. Maintenance and modernisation of structures and other works.
6. Application of chemical and biological methods for vector and weed control.
7. Drainage of all water collections around the reservoir.
8. Prevention and correction of excessive seepage.
9. On-farm water management.
10. Operation, maintenance, improvement and development of water supply and sewage disposal systems, general sanitation.
11. Health education of the public and development of community participation.
12. Evaluation of vector and disease pattern changes, efficacy of control programmes, study and implementation of amendments or alterations to improve results.
13. Preparation of periodic and special reports for information purposes.

Source: World Health Organisation; "Environmental Management for Vector Control: 3rd Report of the WHO Expert Committee. Geneva: WHO, 1980. WHO Technical Report Series No. 649.

Table 4.7(b)

CHECKLIST OF QUESTIONS ON MITIGATION MEASURES

- o Can the design of water body or water course forms be modified to reduce habitats for disease organisms and vectors?
- o Can potentially waterlogged areas be drained or de-watered?
- o Can seepage from watercourses be reduced by improved lining?
- o Will prior clearance of vegetation aid water quality improvement?
- o Can selective vegetation planting minimise disease organism and vector habitats?
- o Can water levels be manipulated to control disease vectors?
- o Can water quality be controlled through flushing and salinity regulation to control disease vectors and organisms?
- o Can disease vectors be physically removed by flushing, scrubbing or drainage?
- o Can insecticides, molluscicides and bactericides be used to control disease organisms and vectors safely?
- o Can biological control be used to exclude disease vectors through competition and/or reduction of habitat availability?
- o Can disease levels be reduced through provision of safe water supplies for drinking and washing?
- o Can adequate excreta and refuse disposal facilities be provided, both during and after construction?
- o Can human/water contact be reduced through location of settlements, fencing of water bodies, etc.?
- o Can health education for current and future residents aid in reducing accidental creation of disease vector and organism habitats, and in general reducing transmission of disease?
- o Can medical screening and treatment by chemotherapy reduce the possibilities for disease transmission?
- o Will adequate health care monitoring and treatment facilities be available for current, future and temporary residents?

5. ORGANISATION AND PRESENTATION OF INFORMATION FOR THE DECISION MAKER

5.1 Introduction

5.1.1 An EHIA forms one input into a decision making process in which a choice is made between:

- o implementing the project as proposed;
- o designing measures into the proposals to prevent or minimise undesirable effects (mitigating measures);
- o choosing an alternative development to achieve the same basic objectives with less impact on the environment;
- o or abandoning the project altogether.

In practice the choice between alternatives is usually less clear cut, the ultimate development may be a compromise between a number of options. In many circumstances there are no alternatives except to proceed (with or without mitigation) or to abandon the project.

5.1.2 The aim of EHIA is to provide the decision maker with the best possible information on the environmental health effects of alternative courses of action - including the alternative of "no action" - and on the possibilities for mitigation. The decision maker will then weigh the beneficial and adverse effects of the available alternatives against each other and against the other costs and benefits of development, in taking his final decision on whether to allow the project to proceed and in what form.

5.1.3 A number of guidelines and methodologies have been developed to advise on this stage in the context of a general Environmental impact Assessment (EIA). We review these in Annex 2, as they may equally be used to present the results of an EHIA. A number of conclusions and recommendations are drawn about the most effective way of communicating the results of EHIA to the decision maker.

The recommended approach requries the team:

- o to present information about all the impacts of alternative courses of action;
- o to identify those impacts which are crucial to the decision;
- o to illustrate how the decision might be affected by different judgements about the relative importance of impacts.

This is therefore a process of organising and presenting the results of the assessment in a way which is most useful to the decision maker.

The recommended approach does not aim to identify "the preferred alternative", but to enable the decision maker to make the best informed decision taking into account all the relevant issues.

5.2 Presentation of Information on Impacts of Alternatives

Information on the impacts associated with alternatives can be most effectively presented in a matrix format. A simple form covering health and other environmental effects is shown in Table 5.2(a).

Table 5.2(a)
A MATRIX OF IMPACTS VS. ALTERNATIVES

Impacts	Alternatives			
	I	II	III	Comments
Water Pollution				
Air Pollution				
Ecological Effects				
Health Effects				
Effects on Landscape				
Effects on Culture and History				
Social Effects				
Etc.				

The purpose of this matrix is to provide a summary of all the information obtained in identifying and predicting impacts.

The alternatives forming the horizontal axis may relate among other things to:

- o different development approaches, e.g. one large reservoir versus several smaller reservoirs;
- o different timing for stages in the development;
- o different development locations;
- o different processes and working methods;
- o different methods of mitigation;

and should always include the alternative of "no action".

The impact categories forming the vertical axis, will include all the potential effects identified in the first stage of the assessment.

The information presented within this first matrix will be the results of the prediction stage.

In presenting this information several key points should be remembered:

- o the matrix should include as much real information as possible about the nature, size and significance of effects;
- o cross-references should be given to the text of the report for further information about the effects and the methods used to predict them. Where experts are asked to advise on prediction of impacts they should be identified and their conclusions explained and justified. Where predictive models or other methods are used, the methods should be described and their likely reliability assessed;
- o information on effects should be presented in a way which is understandable to the non-expert reader. Technical matters should as far as possible be translated into everyday terms;
- o where there is uncertainty or no information this should be clearly indicated;

A checklist of the items that should be covered in the matrix is given in Table 5.2(b).

Table 5.2(b)

A CHECKLIST FOR INFORMATION ON EFFECTS

The Nature and Extent of Effects

- o Magnitude
- o Frequency and duration - short or long term, continuous or intermittent, increasing or decreasing with time, accidental or hazardous
- o Geographical extent - local, regional, national, global
- o The groups and interests in the community who are affected (including economic interests, minority groups, recreation, conservation, etc.)
- o The reversibility or irreversibility of the effects. Can the effects be mitigated?
- o Whether the effect involves committment of non-renewable resources
- o Whether the effect involves establishing a precedent for future activities which cumulatively may have a much greater effect in the long term

Significance

- o The importance or uniqueness of the affected environment or the people or interests affected
- o The controversiality of the effect
- o Whether the effect violates any legal standards or policy objectives for environmental protection (e.g. air quality standards, "no deterioration" objectives, etc.)
- o Whether the effect threatens endangered or protected species or habitats, or protected sites (historic, cultural, archaeological, scientific)

If there are many different alternatives and impact categories to be presented in the matrix it may be useful at this stage to further summarise the information. This can be done by ranking, scoring or rating (see Table 5.2(c)) but ranking and scoring are not recommended for use at this stage for the reasons given in the table.

Table 5.2(c)

RANKING, SCORING AND RATING

Ranking

In ranking the alternatives are ordered in terms of preference with regard to each Effect Category, as shown below:

RANKING OF ALTERNATIVES			
Impacts	Alternatives		
	I	II	III
A	1st	2nd	3rd
B	1st	2nd	3rd
C	2nd	1st	3rd
D	2nd	3rd	1st

As a means of summarising information ranking presents one major problem, that is:

- loss of information.

Ranking provides no information about the absolute or relative importance of impacts. The reader has no information about how good or bad the preferred alternative is or about the differences between the first, second and third alternatives. An initial reading of the example above might suggest that Alternative I is best overall; but if all three alternatives have major adverse effects in categories A and B and I is only slightly less bad than II and III, whilst alternative II is much better than I or II in category C, this might lead to II being identified as the preferred alternative.

This conclusion cannot be reached on the basis of the information provided by ranking.

The use of ranking is not therefore recommended.

Scoring

In scoring a numerical scale is set up for each Impact Category (e.g. 1-10, 1-100, ...). Alternatives are then scored according to their relative or absolute impact in each category. An example is shown below:

SCORING OF ALTERNATIVES				
Impacts	Alternatives			
	I	II	III	Scale
A	0	4	5	0-10
B	1	2	3	0-5
C	8	5	10	0-10
D	17	20	11	0-100

Scoring systems can be used to arrive at the "preferred alternative" by weighting the scores for each Impact Category and adding the weighted scores to give a total for each alternative.

There are four basic problems inherent in this approach:

- like ranking, scoring results in loss of information for the decision maker who is provided with information about the relative effects of alternatives but not about their absolute effects. The decision maker needs real information about the magnitude and significance of effects in order to make judgements about the environmental and other costs and benefits of the proposed activity;

- scoring systems need accurate and detailed information about the effects of alternatives. Often this is not available in EIA because of lack of resources and/or knowledge. Any uncertainties or assumptions involved in providing the data necessary to define scores will be disguised in apparently precise numbers;

- the outcome of scoring and weighting is very dependent on the definition of Impact Categories. If, for example, several different categories were defined for health effects, this might lead to a greater emphasis on health in the final result than if only one health category was defined. This problem of Impact Category definition applies in all attempts to summarise EIA findings, but particularly in approaches involving numerical analysis;

- the selection of appropriate weights to represent the combination of interests in the affected community can be very difficult, particularly as it can involve political judgements about the importance of different interests. If the EIA study team or any other selected group of people are used to define weights, their conclusions and therefore the "preferred alternative" will depend on their particular attitudes and interests.

The use of scoring, and in particular of scoring and weighting to define the "preferred alternative", is therefore not recommended.

Rating

In rating the alternatives are also placed on a scale for each effect category but the scale is verbal (nominal) rather than numerical. A simple example of a verbal scale is: HIGH, MEDIUM, LOW, as shown in the example below:

VERBAL RATING OF ALTERNATIVES				
Impacts	Alternatives			
	I	II	III	Comments
A	NONE	MED.	MED.	
B	V. LOW?	LOW	MED.	
C	HIGH	MED?	V.HIGH	
D	LOW	LOW	V.LOW	

To help the reader interpret the summary results:

- the alternative with the lowest impact in each category is shaded;
- areas of uncertainty are highlighted (?);
- and very severe impacts are highlighted (▭).

Continued.

Table 5.2(c) (Continued)

RANKING, SCOPING AND RATING

A more complex rating system is shown below:

RATING ASSIGNMENT SYSTEM FOR EVALUATION MATRIX	
+5	Major long term, extensive benefit (highest possible rating)
+4	Major benefit, but characterised as either short term or of limited extent
+3	Significant benefit; either long term covering a limited area, or short term covering an extensive area
+2	Minor benefit, but of a long term or extensive nature
+1	Minor benefit over a limited area
0	No impact
-1	Minor adverse effects over a limited area
-2	Minor adverse effects, but of a long term or extensive nature
-3	Significant adverse effects; either long term covering a limited area, or short term covering an extensive area
-4	Major adverse effects but characterised as either short term or of limited extent
-5	Major long term, extensive adverse effects (lowest possible rating)

In this example numbers are used for convenience, to indicate the different levels of impact. It might be more reasonable to use symbols such as o, e, e, •, •:

o firstly because they avoid the temptation to add up numbers to give a total for each alternative;

o and secondly because they give a more immediate visual representation.

Experience with the use of these verbal rating approaches, particularly using symbols, suggests that they are an effective mechanism for communication. They provide a basic level of information which can be readily appreciated and which leads the reader to ask the right sort of questions about the trade-offs that need to be made between impacts and alternatives.

The use of verbal rating for, where necessary, summarising effect vs. alternative information is therefore recommended.

5.3 Identifying Crucial Issues

The next stage in organisation and presentation of information involves identifying the key issues which will affect the decision.

A "key issues" matrix can be developed which excludes certain alternatives and impact categories from further consideration:

- o firstly any alternatives where impacts fail to meet environmental standards or where the alternatives are considered to be unacceptable for some other reason may be excluded;

- o secondly, any impact categories where the difference between alternatives is not relevant to the decision, may be excluded; for example if none of the alternatives have any significant effect in one impact category, this category may be excluded.

In the examples shown in Table 5.2(c) it might be possible to exclude Alternative III because of its severe impact in Category C, and to exclude Impact Category D because all alternatives have low or very low impact (see Table 5.2(d)).

Table 5.2(d)

THE KEY ISSUES MATRIX

Effects	Alternatives		Comments
	I	II	
A Health	NO IMPACT	MED.	....
B Air Quality	V. LOW	LOW	....
C Ecology	HIGH	MOD.	I disturbs a unique wetland ecosystem II destroys a forest system found widely throughout the region

The reasons for excluding alternatives or impact categories must be clearly explained.

This process will result in a simplified matrix showing the principal trade-off that the decision maker must make, for example between the impact of Alternative I on ecology and the impact of Alternative II on health.

5.4 Illustrating the Implications of Different Trade-Offs

Finally it may be helpful for the decision maker, to show how his decision would be affected by different judgements on the importance of impacts.

For example, at a very simple level:

- o "if impact on ecology (C) is considered to be of overriding importance then Alternative II would be preferred, while if impact on health (A) is of overriding importance then Alternative I would be preferred".

In this way the decision maker is shown how his own judgements will affect his final decision.

At this stage it may also be possible to introduce the other factors affecting the decision, such as cost and technical feasibility.

Usually at this stage the analysis is reduced to a small number of key alternatives and impacts. The important trade-offs can be clearly explained in the text of the report. However in cases where there are still several alternatives and impacts to be considered the trade-offs may not be so clear. In these circumstances it may be justifiable to use scoring and weighting systems to illustrate the implications of different judgements.

This can be done by setting up the analysis with different sets of weighting factors so as to show how different priorities would give rise to different outcomes. This approach should, however, be used with care; in particular tests should be carried out to show how sensitive the outcome is to small changes in weighting. Also the reader should recognise that none of the weighting scenarios developed may actually reflect his real preferences and should therefore treat the results with the necessary caution.

6. REQUIREMENTS AND RECOMMENDATIONS FOR FURTHER WORK

6.1 Requirements for further development of EHIA

In Chapter 1 adverse environmental health impacts which may result from irrigated agricultural developments were described. In the following chapters the ways in which such impacts can be predicted and mitigated were examined giving guidance based on past experience in EHIA and EIA.

It is clear from these chapters that EHIA remains a relatively undeveloped subject. Whilst a number of studies have examined effects which have occurred following water-related developments, few attempts have been made to predict such effects before they occur. Our state of knowledge about transmission of disease, and the ways in which environmental factors affect transmission, is still inadequate for accurate prediction. Whilst a number of research programmes are underway on the subject of disease transmission, few have considered the problem of prediction.

In order to improve the development of EHIA, therefore, a range of further work is required. Recommendations for such work are outlined below.

6.2 Recommendations for further work on EHIA

A range of further work may be carried out to improve the accuracy and efficiency of Environmental Health Impact Assessment. This might include:

- Preparation of further guidance on steps in prediction of environmental health effects:

  - Step 1: Obtaining data on the baseline situation. Development of detailed guidance on identification and measurement of environmental health factors important for EHIA.

  - Step 2A: Predicting changes to environment and habitat factors. Improved and detailed guidance on methods available for predicting how environmental factors will change following implementation of a development.

  - Step 2B: Predicting effects of environment and habitat factors on disease levels. Development of guidance on predicting changes in vector and organism life-cycles.

  - Step 3: Predicting changes in human exposure. Development of guidance on how human exposure may change due to practical, behavioural and immigration factors following implementation of a development.

- Development of detailed guidance on how information on effects on environmental health factors may best be presented to decision-makers, and to local medical experts carrying out HIA.

- Detailed evaluation of the success and failures of attempts to mitigate adverse potential health effects. This would include development of guidance on selection of appropriate mitigation measures.

In summary, whilst methodologies and guidance for EIA have been developed extensively by many different organisations, guidance on EHIA is sparse. Development of more detailed guidance on prediction, information presentation and choice of mitigation measures may assist in the wider application of EHIA, and avoidance of the unacceptable effects which poorly-planned irrigated agricultural developments have sometimes caused in the past.

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ANNEX 1

Case Histories of Water Resource and Agricultural Irrigation Development Projects and Water Related Infection

NAME OF PROJECT	:	Nagarjunasagar Dam
TYPE OF PROJECT	:	Irrigation
LOCATION	:	State of Andhra Pradesh, Southern India
DATE	:	1970
EFFECTS	:	Genu valgum, a crippling bone disease associated with skeletal fluorosis, developed in young people, especially males. 75% of cases were in the age group 10-20 years.
CAUSE OF EFFECTS	:	Water seepage from the dam raised the sub-soil water level, in turn increasing the soil alkalinity and providing suitable conditions for increased uptake of molybdenum by sorghum. Increased dietary intake of molybdenum increased the excretion rate of copper. This copper deficiency, coupled with skeletal fluorosis which was endemic in the area, resulted in genu valgum.
MITIGATION MEASURES:		No measures have been taken
SUCCESS OF MITIGATION MEASURES:		No information is available
RECOMMENDATIONS	:	o Provision of drinking water from the same canals which irrigate the land to reduce fluorosis, since canal water contains less fluoride than the village well water. o Nutritional rehabilitation programmes based on complementary diets of rice and wheat as these crops do not take up molybdenum to the same extent as sorghum. Both these crops are grown and consumed by the more affluent members of the area amongst whom the incidence of genu valgum is low.
REFERENCES	:	Agarwl, A.K.; "Crippling Cost of India's Big Dam", New Scientist, p. 260-261, 30 January 1975.

NAME OF PROJECT : St. Lucia Water Supply

TYPE OF PROJECT : Introduction of household water supply to reduce schistosomiasis prevalence

LOCATION : Caribbean Island of St. Lucia

DATE : 1966 to 1980

EFFECTS : Schistosomiasis was endemic, with half of the 100,000 population exposed to Schistosoma mansoni infection.

CAUSE OF EFFECTS :

- Exposure to cercaria-infested water resulted from the following activities:
  - carrying water from river to household;
  - washing clothes;
  - bathing;
  - swimming;
  - fording rivers.
- The degree of body exposure and duration of exposure were the major determinants.
- The biological cycle of Schistosoma mansoni coincided with that of the village communities. Cercarial density peaked during the middle of the day as did the intensity of human activities, notably washing.

MITIGATION MEASURES: Three approaches were tried:

- chemotherapy;
- molluscicides;
- prevention of human-water contact by provision of domestic water supply.

SUCCESS OF MITIGATION MEASURES:

- In terms of per capita costs, chemotherapy was the most economic and most effective method, reducing new infections by 78%. This compared with a reduction of 55% following the use of molluscicides and 50% from improved water supplies.
- Medicine was only effective in areas where infection was rampant and had little impact where infection rates were low.
- Widespread snail extermination proved expensive and although a great majority of snails were destroyed it only required a few survivors to reproduce and rapidly repopulate an area.

- The provision of domestic water supplies, laundries and swimming pools proved most costly. For these measures to be successful the social habitats of river washing and bathing would have had to be changed. Strong health education programmes were deemed essential to motivate people to use the new facilities.

- The benefits from an overall improvement in community health resulting from improved water supplies may, however, have justified the additional cost of such a programme.

RECOMMENDATIONS : None made

REFERENCES :

Dalton, P.R.; "A Socio-ecological Approach to the Control of Schistosoma mansoni in St. Lucia", Bull. Wrld. Hlth. Org. 54, p. 587-595, 1976.

Unrau, G.O.; "Water Supply and Schistosomiasis in St. Lucia", Prog. Wat. Tech. 11(1/2), pp. 181-190, 1978.

NAME OF PROJECT : Kainji Dam

TYPE OF PROJECT : Hydro-electric power, irrigation, fishing and navigation

LOCATION : River Niger, Nigeria

DATE : 1964 to 1968

EFFECTS :

- o Increased prevalence of urinary schistosomiasis (Schistosoma haematobium) but only at localised foci around the shoreline where infection rates increased from 30% in 1970 to 70% in 1972. Only around 5-10% of the shoreline supported the vector snail (Bulinus globosus).
- o Elimination of Simulium damnosum, vector of onchocerciasis, both around the lake and for 10 miles downstream of the dam.

CAUSE OF EFFECTS :

- o Sharply sloping banks and wave action prevented water weed growth which would have encouraged vector snail establishment.
- o Schistosomiasis only occured in limited areas:
  - where there was intensive human activity, e.g. ferry jettys;
  - on the eastern shoreline where the banks were relatively flat and so supported vegetation, which provides shade and humidity for aestivating vector snails.
- o High water turbidity did not favour snail establishment.
- o Onchocerciasis was reduced because of:
  - reduced water flow upstream of the dam destroyed Simulium damnosum breeding sites;
  - periodic changes in lake level due to seasonal flooding provided an unfavourable environment for Simulium damnosum as well as for the snail vector of schistosomiasis, Bulinus globosus;
  - frequent adjustments of spillway release to match the varying lake level caused river level variations downstream of the dam, preventing Simulium damnosum breeding for 10 miles downstream.

MITIGATION MEASURES: During construction phase:

- implementation of an onchocerciasis and malaria control programme to protect the dam labour force;
- Simulium damnosum breeding sites treated with 0.33ppm to 2ppm DDT for 30 minutes each 10 days.

SUCCESS OF MITIGATION MEASURES: During construction phase:

- Simulium damnosum easily was reduced in treated areas. Rapid reappearance and recolonisation of breeding sites however, indicated that neither larvae nor adults were completely eliminated. (Re-infestation may have occured from untreated areas some distance from the lake);
- Simulium damnosum eggs and pupae were not susceptible to DDT;
- effect on malaria incidence hard to assess. The disease continued to be highly prevalent, probably due to mosquitoes developing resistance to DDT.

RECOMMENDATIONS :

- o Molluscicides should be used at focal points where schistosomiasis was prevalent.
- o Health education to prevent establishment of schistosomiasis.
- o Prevention of weed growth on eastern shoreline which may result in swampy conditions suitable for the vector snail.

REFERENCES :

Imevbore, A.M.A.; "The Kainji Dam and Health", in Man-made Lakes and Human Health, Stanley, N.F. and Alpers, M.P. (Eds.), Academic Press, London, 1975.

Waddy, B.B.; "Research into the Health Problems of Man-made Lakes, with Special Reference to Africa", Trans. R. Soc. Trop. Med. Hyg. 69(1), 39-50, 1975.

NAME OF PROJECT : Lesotho Water Supply

TYPE OF PROJECT : Village water supply improvements

LOCATION : South Africa

DATE : 1974

EFFECTS : The population suffered high morbidity and mortality especially in under-five year olds, due to diarrhoea and gastro-enteric diseases. These diseases and infectious skin diseases were the main types of reported water related diseases.

CAUSE OF EFFECTS :

- o Poor personal and domestic hygiene and inadequate sanitation.
- o Poor nutritional status.

MITIGATION MEASURES: Construction of improved water supplies.

SUCCESS OF MITIGATION MEASURES:

- o The improved water supply raised water quality, but did not affect the quantity used nor the pattern of domestic and personal hygiene.
- o Faecal-oral diseases, namely diarrhoeas and typhoid, had a similar prevalence in villages with and without piped water. Piped water supplies, in altering only water quality, influenced transmission by waterborne mechanisms. The failure of piped water to influence faecal-oral diseases indicate that they are not primarily waterborne in Lesotho.
- o The improvement scheme also failed to affect the prevalence of skin and eye diseases.

RECOMMENDATIONS : The following recommendations were made to be incorporated into future water supply improvement schemes to achieve significant reductions in water related diseases.

- personal body washing and clothes washing facilities should be constructed to improve personal hygiene;
- major change in disposal of excreta; (under 10% of households had latrines);
- health education programme to improve domestic and personal hygiene. Programme to be directed at specific unhygienic practices;

- health education programme to improve food hygiene plus an investigation into key areas of food contamination;

- improvement in rural health services to record and treat water-related diseases more effectively.

REFERENCES : Feachem, R. et al; "Water Health and Development: An Interdisciplinary Evaluation", London, Tri-Med Books, 1978.

NAME OF PROJECT : Kariba Hydro-electric Scheme

TYPE OF PROJECT : Hydro-electric power

LOCATION : Zambezi River, Zimbabwe

DATE : Completed 1958, Filled 1963

EFFECTS :

- Infestation of inlets and backwaters of the lake by vector snails heavily infected with schistosomiasis, though the main stream of the Zambezi had been relatively free of schistosomiasis prior to dam construction.

  Schistosoma haematobium had increased by 70% in children 10 years after completion.

- Sporadic cases of trypanosomiasis in areas away from the lake, previously free of the disease.

CAUSE OF EFFECTS :

- Snail populations encouraged by:
  - reduced water flow;
  - shoreline growth of weeds such as Salvinia auriculata.

- Raising of water level pushed back tsetse fly into areas further from the lake. However as the vegetation in these areas did not provide the double canopy of shade which the tsetse fly prefers, this invasion was short lived.

- Within the immediate surroundings of the lake trypanosomiasis declined due to the inundation of the tsetse fly habitat.

MITIGATION MEASURES: An extensive snail control programme was implemented.

SUCCESS OF MITIGATION MEASURES: No information available

RECOMMENDATIONS : None made

REFERENCES :

Webster, M.H.; "Medical Aspects of the Kariba Hydro-electric Scheme", in Stanley, N.F. and Alpers, M.P. (Eds.) Man-made Lakes and Human Health, Academic Press, London, 1975.

NAME OF PROJECT : The Guayama, Guajataca and Lajas Valley Water Development Projects

TYPE OF PROJECT : Joint hydro-electric and irrigation schemes

LOCATION : Puerto Rico

DATE : 1974

EFFECTS :

- o Effects on schistosomiasis transmission varied widely between schemes.
- o The irrigated southern coastal plain near Guayama became a major endemic zone for schistosomiasis 15 years after construction in 1974.
- o In contrast, the more recent Guajataca system and Lajas Valley project have experienced no problems with schistosomiasis.

CAUSE OF EFFECTS : The differences in schistosomiasis transmission between different schemes indicates that transmission was encouraged by:

- waterlogged and swampy land, present on the southern coast. This provided a suitable habitat for the growth of snail vector populations. The more recent schemes were located on sandy porous soil;
- slow water flow, as found in swampy areas, also encouraged snail population growth. The Lajas Canal was unsuitable for the establishment of snails due to the high water velocity;
- poorly designed irrigation systems. The Guajataca system had more efficient water control devices than the poorly designed southern coast system, and had fewer night storage ponds.

MITIGATION MEASURES:

- o Drainage of waterlogged areas.
- o Use of the predator snail <u>Morisa cornuarietis</u> for biological control.
- o A snail control programme was initiated in the Lajas Valley when the irrigation system began operating.

SUCCESS OF MITIGATION MEASURES:

- o Drainage was efficient in eliminating snails.

- Biological control was found to be cheaper than using chemicals.
- The Lajas control programme, by starting at the same time as the irrigation operation, prevented any transmission.

RECOMMENDATIONS : None made

REFERENCES : Jobin, W.R.; "Tropical Disease Bilharzia and Irrigation Systems in Puerto Rico", J. Irrig. Drainage Division, ASCE, P. 307-322, September 1978.

NAME OF PROJECT : El Bir and Foum Gleita Reservoir Schemes

TYPE OF PROJECT : Dam construction for rice irrigation (Proposed)

LOCATION : Gorgal River in Fourth Region of Mauritania, West Africa

DATE : Initial proposal made in 1974

EFFECTS : It was predicted that there would be an increase in the incidence of schistosomiasis especially in young males (infection rates already ranged from 14 - 78% in 10 year old school children). Prevalence rates were already highest in M'Bout, the closest town to the proposed reservoir.

CAUSE OF EFFECTS

- Although schistosomiasis was endemic in the area, transmission was limited by the dry season. A perennial irrigation system would remove this limiting factor allowing survival of vector snails through the dry season.
- Snails were encountered in or near existing rice fields but not in the main rivers, suggesting that the proposed areas for irrigation were likely to become snail habitats.

No quantitative estimation of the future rates of schistosomiasis was attempted.

MITIGATION MEASURES: No mitigation measures were suggested. No information available on implementation of the dam proposal.

SUCCESS OF MITIGATION MEASURES: No information available

RECOMMENDATIONS : None made

REFERENCES :

Jobin, W.R., Negroñ-Aponte, H., and Michelson, E.H.; "Schistosomiasis in the Gorgol Valley of Mauritania", Am. J. Trop. Med. Hyg. 25(4), p. 587-574, 1976.

NAME OF PROJECT : Tana River Basin, Kano Plains, Yala Swamp and Taveta Irrigation Schemes

TYPE OF PROJECT : Irrigation

LOCATION : Kenya

DATE : Proposed 1975

EFFECTS : It was predicted that expansion of the four irrigation systems by a total of 17,000 ha would significantly increase the prevalence of schistosomiasis in these areas.

CAUSE OF EFFECTS : Schistosomiasis was already endemic in Kenya and snail breeding was intense around the existing irrigation schemes:

Tana River Basin

- Schistosoma haematobium - up to 100% infection
- Schistosoma mansoni - up to 22% infection in children at key focal points

Kano Plains

- Schistosoma haematobium - around 4% infection
- Schistosoma mansoni - up to 62% infection

Yala Swamp

- Schistosoma haematobium - 6.5% infection
- Schistosoma mansoni - 17% infection

Taveta

Both Schistosoma haematobium and Schistosoma mansoni were transmitted through the year

The high prevalence of schistosomiasis resulted from the provision of perennial water supplies to each scheme, and continual man-water/contact through agricultural practices.

Extension of these systems would provide a larger breeding habitat for the snail vectors (namely Bulinus pfeiffi, Bulinus globosus and Bulinus sudanica) and so increase schistosomiasis infection rates.

MITIGATION MEASURES: No information available. Scheme currently still under development.

SUCCESS OF MITIGATION MEASURES: No information available

RECOMMENDATIONS :

- o Incorporation of public health surveys into preliminary investigations concerning irrigation development. Data, then to be used to determine feasibility of the project and to provide information to estimate the public health requirements.

- o Immediate measures should be taken to prevent establishment of snails.

  Application of molluscicides (e.g. N-tritylmorpholine) before and during construction and at key focal points where man/water contact is high.

- o Studies on the application of health education to the local population.

- o Improvement of sanitation and overall housing facilities.

- o Location of new villages away from irrigation channels and drains.

- o Provision of chlorinated water to villages.

- o Continual medical examination and treatment of the communities for schistosomiasis.

REFERENCES :

Choudhry, A.W.; "Potential Effects of Irrigation on the Spread of Bilharziasis in Kenya", East African Medical Journal, 52(3), pp. 120-126, 1975.

NAME OF PROJECT : Malumfashi Agricultural Development Project

TYPE OF PROJECT : Irrigated agricultural development with up to 50 small earth dams

LOCATION : Malumfashi, Kaduna State, Nigeria

DATE : 1977 to 1978

EFFECTS : Increased incidence and transmission rate of schistosomiasis, especially _Schistosoma haemotobium_.

CAUSE OF EFFECTS :

- o Significant changes in the proportions of different snail species present in low-earth dam lakes to give dominance by _Bulinus globosus_, previously limited as water sources dried up during dry season. _Bulinus globosus_ is the major secondary host of _Schistosoma haemotobium_.

- o Increased human water contact activities (fishing, bathing, swimming and playing), predominantly amongst males, who account for 77% of environmental egg contamination and 83% of infected population.

MITIGATION MEASURES: None noted

SUCCESS OF MITIGATION MEASURES: No information available

RECOMMENDATIONS : None made directly, but warning given that with the construction of more small dams planned, and with potential increases in human/ water contact through development of fish farming possible, schistosomiasis is likely to remain at a high level in the absence of control measures.

REFERENCES :

Bradley, A.K. and other; "Malumfashi Endemic Diseases Research Project I", _Annals of Tropical Medicine and Parasitology_, Vol. 71, pp. 443-449, 1977.

Tayo, M.A. and others; "Malumfashi Endemic Diseases Research Project IV", _Annals of Tropical Medicine and Parasitology_, Vol. 72, No. 5, pp. 483-486, 1978

Tayo, M.A. and others; "Malumfashi Endemic Diseases Research Project XI", _Annals of Tropical Medicine and Parasitology_, Vol. 74, No. 3, pp. 347-353, 1980.

NAME OF PROJECT	:	Gambia Estuary Barrage
TYPE OF PROJECT	:	Irrigation and water conservation
LOCATION	:	Gambia
DATE	:	1979 - pilot study of barrage (construction has not yet taken place)

EFFECTS (PREDICTED):

- o Extension of risk of malaria upstream.
- o Increase in malaria transmission and deaths especially in young age groups (62% of working population likely to be affected by increase in malaria).
- o Increase in filariasis.
- o Invasion of schistosomiasis-transmitting snails into area and their establishment with rapid population growth.
- o Increase in schistosomiasis infection rates.
- o Increase in enteric infection.
- o Increase in social diseases.
- o Possible introduction of trypanosomiasis.
- o Increase in bird transmitted viruses.

CAUSE OF EFFECTS :

- o Permanent change of water regime upstream of barrage from alternating fresh and brackish to a permanently freshwater environment will allow colonisation by Anopheles gambiae, a freshwater breeding mosquito.
- o Expansion of irrigated agriculture will provide further mosquito breeding grounds.
- o Young age groups are less immune to malaria resulting in higher mortality rates.
- o 'Ponding' of the river behind the barrage will encourage local vegetation growth which in turn may provide a habitat for mosquitoes such as Mansonia africanus and Mansonia uniformis, vectors of filariasis.
- o Elimination of salinity and tidal fluctuations from the estuary will enable snail vectors to invade irrigation channels from surrounding areas, resulting in an increase in the incidence of schistosomiasis.

- o Reduction in river flow rate will allow these snails to migrate further upstream increasing the area at risk to schistosomiasis.

- o Double cropping of rice paddies causing the soil to remain moist for most of the year will allow worm eggs, if deposited in faeces, to develop and become infectious. This could increase transmission of worms such as ascaris, hookworms and whipworms, causes of enteric diseases.

- o Increase in population around barrage due to workers and their families may assist in the spread of social diseases to neighbouring towns.

- o Poor food preparation and handling resulting from the failure to cope with the population increase will assist in the development of enteric infections.

- o Human trypanosomiasis can be passed from man to man. Immigrant populations may introduce this disease.

- o The lake may attract virus carrying bird species.

MITIGATION MEASURES: Elimination of snail vectors by allowing saline water to flow into the lake resulting in a tidal rise and fall of water levels.

SUCCESS OF MITIGATION MEASURES: No data available: barrage not yet constructed

RECOMMENDATIONS :

- o Collection of data on the impact of the barrage construction activities in relation to the prevalence of disease, levels of health facilities and services.

- o Collection of data on the incidence of vector borne diseases prior to barrage construction.

- o Monitoring and surveillance of vector movements.

- o Setting-up disease vector control unit consisting of a multi-disciplinary team of experts from engineers to entomologists.

- o Vector control measures:

  - insecticides on mosquito breeding sites,

- irrigation channel design (e.g. flow, water level fluctuations, bank linings, cross-sectional shape) to prevent snail establishment.

- o Provision of safe and adequate domestic water supply.
- o Chemotherapy where the population is cooperative.
- o Education in hygiene, personal and communal.
- o Adequate planning for sanitation schemes.
- o Provision of health centres.

REFERENCES : "The Gambia Estuary Barrage Study - Stage II", The Gambia River Basin Development Organisation, (Unpublished), 1979.

NAME OF PROJECT : Srinagarind (Chao Nen) Dam

TYPE OF PROJECT : Reservoir with associated agricultural development

LOCATION : Quae Yai River, Kanchanaburi Province, West Thailand

DATE : 1978

EFFECTS :

- o Following dam construction an increase in malaria prevalence in the population from 16% in 1972 to 25% in 1977 was recorded.
- o Waterborne parasitic diseases, such as schistosomiasis, did not appear to have increased.

CAUSE OF EFFECTS : Construction of the dam resulted in major changes in habitats, particularly with the clearance of forests for crop cultivation. This favoured the mosquito species most implicated in malaria transmission in the area (Anopheles minimus), leading to this species becoming dominant in the area.

MITIGATION MEASURES: No measures noted

SUCCESS OF MITIGATION MEASURES: No information available

RECOMMENDATIONS :

- o Malaria control measures were recommended considering the possibility of intensification and spread of malaria to less immune migrant populations.
- o Although waterborne parasitic diseases such as schistosomiasis and filariasis did not appear to be a threat to public health, it was recommended that surveillance should continue for waterborne parasites and their immediate hosts.

REFERENCES :

Bunnag, T., Sornmani, S., Pinithpongse, S. and Harinasuta, C.; "Surveillance of Waterborne Parasitic Infections and Studies on the Impact of Ecological Changes on Vector Mosquitoes of Malaria after Dam Construction", Southeast Asian J. Trop. Med. Pub. Hlth. 10(4), p. 656-660, 1979.

NAME OF PROJECT : Tanganyika Planting Co. Sugar Estate

TYPE OF PROJECT : Irrigation scheme

LOCATION : Northern Tanzania

DATE : 1968

EFFECTS : Invasion of the irrigation network by snails, in particular Biomphalaria pfeifferi (host of Schistosoma Mansoni). Prevalence of schistosomiasis rose to 85% in field workers on the estate.

CAUSE OF EFFECTS : The provision of perennial slow flowing irrigation water allowed the invasion and establishment of the vector snail.

MITIGATION MEASURES: Implementation of a three year programme of control using molluscicides and chemotherapy.

- Two molluscicides used:
  - N-tritylmorpholine, dripped into headwaters of the irrigation system at the rate of 0.025 mg of active ingredient per litre for 5 days every 7 weeks for 3 years;
  - Niclosamide, sprayed on drainage ditches and standing water every 10-12 weeks after snails had been detected by routine sampling.
- A mass diagnosis and treatment campaign was then carried out to find and treat existing infections.

SUCCESS OF MITIGATION MEASURES:

- The molluscicides were successful in reducing transmission and, with medical treatment, prevalence of infection was reduced by about 50%.
- It was estimated that, on this estate, the costs of future snail control measures would be covered by savings derived from a reduction in the number of drug treatments required. Savings derived from increases in productivity would be an extra advantage as would the overall improvement in community health.

RECOMMENDATIONS : It was concluded that snail control on this sugar estate was a feasible and worthwhile undertaking.

REFERENCES : Fenwick, A.; "The Costs and a Cost-Benefit Analysis of an S. Mansoni Control Programme on an Irrigated Sugar Estate in Northern Tanzania", Bull. Wld. Hlth. Org. 47, p. 573-578, 1972.

NAME OF PROJECT : Tennessee Valley River Project

TYPE OF PROJECT : Dam construction for flood control, hydroelectric power and navigation (around 20 dams)

LOCATION : Tennessee, USA

DATE : 1933 to present

EFFECTS : Large increase in anopheline mosquito production, and a consequent increase in the incidence of malaria

CAUSE OF EFFECTS : The impounding of large areas of water significantly extended the areas suitable for mosquito reproduction

MITIGATION MEASURES: The Tennessee Valley Authority was established in order to implement an integrated pest management programme, which can be divided into two general categories:

A. Pre-impoundment measures: to identify and possibly eliminate problem areas prior to impoundment.

These measures included pre-impoundment surveys prior to and during construction in order to identify problem areas and insect vectors. Consequently it was possible to make a number of environmental modifications to resolve these problems:

i. Reservoir basin cleaning, to remove trees that would have penetrated the water surface and so possibly provide sites for mosquito production;

ii. Shoreline modifications, to prevent aquatic vegetation growth and to eliminate depressions that would hold water during reservoir drawdown, both of which would normally favour mosquito production.

iii. Drainage ditch construction to connect depressions to the main reservoir. Mosquito control would then be facilitated by water level fluctuations which occur in the reservoir.

iv. Dyking and dewatering of the extensively vegetated shallow water areas to eliminate mosquito breeding.

B. Post-impoundment measures which included environmental modifications and manipulations of zones with potentially high man-mosquito contact.

a. Environmental Modifications:

i. Dewatering required the continuous use of pumps and flood gates to sufficiently vary the water level in the shallow zones for effective mosquito control.

ii. Shoreline modifications were made also after impounding.

iii. Periodical drainage maintenance was required to remove silt and vegetation and so ensure proper functioning.

iv. Habitat modification through the planting of water tolerant tree species such as the baldcypress tree (Taxodium distichum) were made in an attempt to create an environment unsuitable for mosquito breeding.

b. Environmental Manipulation:

i. Water level management involved weekly fluctuations of one foot in some reservoirs whilst a gradual water level recession was practiced in others during the mosquito breeding period.

ii. Vegetation control measures included:

- water level manipulation,
- herbicidal control,
- mechanical control of shoreline growth (mowing),
- biological control (use of herbivorous fish).

iii. Tillage of grassy depressions and river flood plains to control floodwater mosquitoes.

Insecticides were used in specified critical areas to reduce man/mosquito contact only as a supplemental control measure when the environmental management measures did not produce the desired level of control.

SUCCESS OF MITIGATION MEASURES:

- Dewatering could not be operated cost-effectively in several zones and so allowed heavy mosquito reproduction. Fortunately at that time, these areas were not closely associated with human activity.

- Shoreline modifications successfully prevented mosquito breeding along the shore and proved as cost-effective as the use of larvicides.

- Tree planting on the shoreline successfully controlled the mosquito numbers by:

  - shading, which eliminated most of the shoreline vegetation required by mosquitos for breeding;

  - accelerating the rate of dehydration of flood plain depressions during summer months, thereby reducing the mosquito breeding potential in these transient pools;

  - changing the mosquito fauna from a species complex which rapidly disperses from the breeding area to one which remains closely associated with the wooded habitat.

- water level management was the most effective single mitigating measure although to be optimally effective it required support from the other methods mentioned.

- Tillage was effective in controlling mosquitoes by burying ova to a depth sufficient to prevent larvae emerging.

RECOMMENDATIONS : None made

REFERENCES :

Tennessee Valley Authority and United States Public Health Service: "Malaria Control on Impounded Waters", US Government Printing Office, Washington D.C., 1947.

Breeland, S.G. and Pickard, E., 1964: "Cultural Attempts at Control of Floodwater Mosquitoes in Small Plots in the Tennessee Valley Region of North Alabama", TVA Division of Health and Safety, Quarterly Progress Report, 1964.

Cooney, C.J. and Bates, A.L.: "Environmental Management Measures for Vector Control", Office of Natural Resources, Tennessee Valley Authority, T. USA, 1982.

NAME OF PROJECT : Ubolratana Dam Complex

TYPE OF PROJECT : Hydroelectric power, irrigation, flood control, fishing and recreation

LOCATION : Nam Pong District of Khon Kaen Province in Northeast Thailand

DATE : 1964-1966 (Ubolratana) and 1964-1970 (Nong Wai Dam - Diversion)

EFFECTS :

- o High prevalence of intestinal parasitic infections in both the indigenous population and new settlers: 52-80% infected with helminths, 9-20% infected with protozoa.
- o Prevalence of opisthorchiasis high (27-70%). About 6-7% of fish collected from water beds were infected with opisthorchiasis metacercariae.
- o Some evidence of leptospirosis in man and rodents.
- o Many cases of eosinophilic meningitis admitted to provincial hospital from the Dam region.
- o No evidence of human schistosomiasis.
- o No evidence of increase in malaria.

CAUSE OF EFFECTS :

- o Increases in the number of animal reservoirs, intermediate hosts and infective agents of endemic diseases. Local fish harbour opisthorchiasis and the local custom of raw fish eating allows this to spread to man. Also increase in numbers of snail hosts of parasites which also attack man.
- o Meningitis was increased by increased presence of rats in new development, which harbour the infective agent *Angiostrongylus cantonensis*, and increased numbers of the snail vectors, *Pila* sp.

MITIGATION MEASURES:

- o Health education programmes in villages to discourage eating of raw fish, and encourage sanitation measures.
- o Malaria Eradication Project of Thailand has been active in the area. (No details available).

SUCCESS OF MITIGATION MEASURES:

- o Results from a small number of villages indicated great reductions in parasitic diseases following construction and use of hygienic latrines.
- o Low level of malaria indicated success of Malaria Eradication Project.

RECOMMENDATIONS :

- o Further health education to improve eating habits and general nutrition.
- o Further research into variations in eating patterns is required.

REFERENCES :

Harinasuta, C.; "Ubolratana Dam Complex, Thailand", in Stanley, N.F. and Alpers, M.P. (Eds.), Man-made Lakes and Human Health, Academic Press, London, 1975.

NAME OF PROJECT : Kisumu Rice Irrigation Schemes

TYPE OF PROJECT : Irrigated agricultural development

LOCATION : Kisumu, Kenya

DATE : Pilot schemes in operation from 1970

EFFECTS :

- o Increased incidence of certain arbovirus infections, particularly onyongnyong fever, which is endemic. This is part of a general change in the pattern of arboviruses to which man is exposed due to change in mosquito species composition.
- o Increased incidence also of malarial parasites and increased infant mortality.
- o No evidence of schistosomiasis increase.

CAUSE OF EFFECTS :

- o Six ecological consequences of irrigation were identified as affecting mosquito populations:
  - simplification of the environment;
  - increased surface water;
  - higher water table;
  - changes in water flow;
  - climatic changes towards wetter and cooler conditions;
  - human population changes.
- o Simplification of the habitat reduced the total number of animal species:
  - irrigation favoured ground-pool species such as Anopheles gambiae and Culex;
  - Anopheles gambiae is most prevalent in young rice plants and would be further favoured by change to two rice crops per year.
- o Higher humidity in the atmosphere above rice fields also favoured mosquito survival and increased longevity, thus increasing the chances of an individual surviving to bite more than once and transmit disease from one vertebrate host to another.

MITIGATION MEASURES: From outset of the scheme irrigation water was treated with molluscicide 'Frescon' to control schistosomiasis snail-hosts.

SUCCESS OF MITIGATION MEASURES: Very few Bulinus or Biomphalaria snails found in irrigation area. No increase in schistosomiasis recorded.

RECOMMENDATIONS :

- Further research required into effects of changing plant distribution and abundance on mosquito species composition.
- Prior study of effects before changes to environment are made.
- Study of effects of agricultural practice on mosquito numbers.
- Good land management and irrigation control to reduce mosquito increases.
- Study of effects on other vertebrate hosts of human parasites.
- Study of human factors (housing, sanitation) affecting mosquito populations.

(These recommendations were taken up and a large-scale health study, the Kisumu Study, was instituted).

REFERENCES :

Surtees, G.; "Effects of Irrigation on Mosquito Populations and Mosquito-Borne Diseases in Man, with Particular Reference to Rice Field Extension", in Environmental Studies, Vol. 1, pp. 35-42, 1970.

Simpson, D.I.H.; "The Kisumu Study", in Stanley, N.F. and Alpers, M.P., Man-made Lakes and Human Health, London, Academic Press, 1975.

NAME OF PROJECT	:	Blue Nile Irrigation Projects Gezira-Managil and Rahad Scheme
TYPE OF PROJECT	:	Water conservation and irrigation
LOCATION	:	Sudan
DATE	:	Gezira-Managil begun 1925 completed 1960 Rahad begun around 1975 completed 1982
EFFECTS	:	Increased infection rates of Schistosoma mansoni from 5% of population in 1944 up to 80% in 1973. Schistosomiasis currently affects around 50% of the population. During initial stages of the development, between 1925 and 1935 there was a major increase in malaria.
CAUSE OF EFFECTS	:	o Provision of slow flowing water in irrigation channels favouring the vector snail. o Increase in human water contact due to the irrigation scheme. o Increase in population in irrigated areas. o Early build-up of malaria due to influx of farmers from infected areas.
MITIGATION MEASURES:		Establishment of Blue Nile Health Project. The control programme, run by the National Coordination Board, included the following integrated control measures: - extensive community education; - chemotherapy for schistosomiasis control; - medical treatment of diarrhoeal diseases; - malaria treatment based on laboratory diagnosis; - use of chemical, biological and environmental methods for mosquito and snail control (£1 million per year spent on molluscicides); - extensive improvements in domestic water supply to reduce man/water contact; - construction of pit latrines; - community action on drainage and sanitation.
SUCCESS OF MITIGATION MEASURES:		o Reduction in locally acquired schistosomiasis infections, and prevalance of infection imported from other endemic areas reduced by 50% within the new Rahad zone. No evidence of locally acquired infections in a study of 3000 school children. Following use of molluscicides no infected snails were found in this zone during 1981.

- Schistosomiasis still endemic in Gezira-Managil zone.

- Within all zones the use of anti-malaria insecticides (within houses) and larvicide, and presumptive treatment with chloroquinone maintained malaria transmission at a low level.

  Prevalence of the parasite in children ranged between 0.4% to 1.4%.

  Widespread resistance of the mosquito Anopheles arabiensis to malathion required a new insecticide - fenitrothian.

RECOMMENDATIONS :

- Full implementation of the Blue Nile Health Project with continuous monitoring of its success.

- Replacement of chemical control with alternative vector control measures such as environmental and biological control of snails and mosquitoes, improvement in basic health services, permanent modification of agriculture and domestic water use and changes in human behaviour.

REFERENCES :

Amin, M.A.; "Schistosomiasis in the Sudan", in Arid Land Irrigation in Developing Countries, Worthington, E.B. (Ed.), Pergamon Press, Oxford, 1978.

Panel of Experts on Environmental Management for Vector Control (PEEM), Report on the Second Meeting, Nairobi, 14-20 September 1982, WHO, Geneva, 1982.

NAME OF PROJECT : Soe Dam

TYPE OF PROJECT : Reservoir

LOCATION : Upper Region of Ghana

DATE : 1965

EFFECTS : Increase in prevalence of onchocerciasis. Prior to construction the nearest breeding place for the vector Simulium damnosum had been 14 miles to the South.

CAUSE OF EFFECTS :

- o Fast flowing water in the dam spillway (3.5 to 4.3 feet/sec) favoured Simulium breeding.
- o The concrete of the spillway provided a suitable support for the Simulium eggs.
- o Larvae were able to migrate to areas of higher water velocity when water flow decreased.
- o Non-submerged pupae hatched when the surrounding air was sufficiently humid.

MITIGATION MEASURES: The following methods were used:

- o Stiff brushes to remove Simulium damnosum larvae from the concrete face above the water line.
- o 5% DDT sprayed on the concrete against attached larvae.
- o 0.1 ppm DDT in form of an emulsion added to the water.
- o Variations in water flow.

SUCCESS OF MITIGATION MEASURES: All methods had some success (not specified)

RECOMMENDATIONS : None made

REFERENCES :

Burton, G.J. and McRae, T.M.; "Dam Spillway Breeding of Simulium damnosum Theobald in Northern Ghana", Ann. Trop. Med. Parasit., 59, p. 405-411, 1965.

Lewis, D.J.; "Some Recent Observations on African Simuliidae", Proc. 11th Int. Congr. Entomology, Vienna, 1960, 3, p. 131, 1962.

NAME OF PROJECT : Ord River Dam

TYPE OF PROJECT : Irrigation, power and tourism

LOCATION : East Kimberly, Northern Australia

DATE : Completed 1963

EFFECTS :

- Changes in bird-mosquito-arbovirus-man equilibria. So far, no major increase in human disease had occurred.
- Malaria and schistosomiasis are not currently found in the area, though species capable of acting as vectors are present.

CAUSE OF EFFECTS :

- Changes in the environment resulted in ecological and evolutionary changes in the prevalence of various arboviruses.
- Anopheles sp. capable of carrying malaria parasites was found to be present in the area.

MITIGATION MEASURES: No measures suggested

SUCCESS OF MITIGATION MEASURES: No information available

RECOMMENDATIONS :

- Continual surveillance of malaria and arbovirus situation.
- Identification of freshwater molluscs to determine whether they can act as intermediate hosts for schistosomiasis species.

REFERENCES :

Stanley, N.F.; "The Ord River Dam of Tropical Australia", in Man-made Lakes and Human Health, Stanley, N.F. and Alpers, M.P. (Eds.), Academic Press, London, 1975.

NAME OF PROJECT : Aswan High Dam/Lake Nasser

TYPE OF PROJECT : Hydro-electric power and irrigation, with additional fishing and recreation at Lake Nasser

LOCATION : Upper Egypt and northern Sudan

DATE : 1960 to 1969

EFFECTS :

- A 10-fold increase in urinary schistosomiasis Schistosoma haematobium giving an infection rate of 100% in some communities. Introduction of Schistosoma mansoni, intestinal schistosomiasis, and its increase to high levels of incidence.

- Increases in malaria currently limited by confinement of Anopheles gambiae to Southern Sudan. However, should the species be introduced, environmental conditions would favour its expansion.

CAUSE OF EFFECTS :

- Creation of conditions for transmission of waterborne diseases in a previously arid area, through water being constantly available. In agricultural areas irrigated by water from the dam, change from periodic to perennial irrigation greatly increased the prevalence of schistosomiasis.

- Increased human contact with water facilitated increased incidence of the disease.

MITIGATION MEASURES:

- Large scale snail control was estimated to be not economically feasible due to the extensive shoreline zone.

SUCCESS OF MITIGATION MEASURES: No data available

RECOMMENDATIONS : Careful and comprehensive planning involving multi-disciplinary studies on the natural environment and modifications brought about by the projects, as well as on the human aspect in relation to adaptability to new environment.

REFERENCES :

Brown, D. and Deom, J.D.; "Summary: Health Aspects of Man-made Lakes", in Ackerman and others (Ed.), Man-made Lakes: Their Problems and Environmental Effects. American Geographical Union, 1973.

Farid, M.A.; "The Aswan High Dam Development Project", Stanley, N.F. and Alpers, M.P. (Eds.), in Man-Made Lakes and Human Health, Academic Press, London, 1975.

NAME OF PROJECT : The Volta Dam

TYPE OF PROJECT : Hydro-electric power, fishing, navigation, irrigation

LOCATION : Ghana

DATE : Begun 1962, Lake Filled 1967

EFFECTS :

- Extension of mosquito breeding habitats (but malaria was already endemic).
- Significant increase in urinary schistosomiasis from 3% to 70% in surrounding villages. 2 million people had the disease.
- Reduction in the prevalence of onchocerciasis above the dam.
- Reduction in Trypanosomiasis.
- Creation of opportunities for the spread of yellow fever.

CAUSE OF EFFECTS :

- Provision of breeding sites for the most important malaria vector Anopheles gambiae due to the extensive shoreline (6400 km). This species has a wide range of breeding habitats including shallow waters which would exist in parts of the littoral zone and in isolated pools near the shore.
- Schistosomiasis, originally only sporadic, was encouraged by the environmental conditions created by the lake:
  - slow water flow, preferred by the vector snail;
  - establishment of aquatic plants which support the snails and their eggs. In particular the species Pista stratiotes, Salvinia nymphellula, Lemnna sp. and the submerged plant Ceratophyllum demersum were responsible for harbouring many snail species especially Bulinus truncatus rohlfsi host of Schistosoma haematobium resulting in an urinary schistosomiasis epidemic;
  - movement of large numbers of people to the lake, taking advantage of the productive fishing has greatly increased human-water contact;

- *Simulium damnosum* breeding sites flooded. Absence of moving water further prevented breeding;
- inundation of tsetse fly (trypanosomiasis vector) breeding areas initially reduced its population;
- the yellow fever mosquito *Aedes aegypti* breeds in discarded containers and pans. Although the lake itself would not create conditions favouring increased incidence, it was feared that the movement of people to the shore would encourage breeding.

MITIGATION MEASURES:

- o Herbicides used locally to control the weeds which supported the vector snails for schistosomiasis.
- o Widespread measures for snail control considered unfeasible due to the extent of the shoreline.
- o Prevalence of schistosomiasis was lower on the eastern shore due to the steep unprotected shoreline which discouraged weed growth with which the snails are associated.
- o Fluctuations in the water level to control the vector snail were considered unfeasible due to the size of the lake and also because this would provide habitats for *Anopheles gambiae*.

SUCCESS OF MITIGATION MEASURES: Herbicides succeeded in removing weeds from the immediate shoreline, encouraging the movement of people to these areas. However submerged weeds survived away from the shoreline and it was feared that the incidence of schistosomiasis would increase due to the higher human population density.

RECOMMENDATIONS :

- o Discourage human access to the lakeside by the provision of alternative and conveniently placed water supply systems in villages.
- o Health education programmes to complement the above measures.
- o Improved sanitation, preventing human wastes reaching the lake or its tributaries.
- o Routine medical surveys.

- Continual surveillance and assessment of ecological changes.
- Multi-disciplinary approach should be adopted to dam design.

REFERENCES :

Obeng, L.E.; "Health Problems of the Volta Lake Ecosystem", in Stanley, N.F. and Alpers, M.P. (Eds.), Man-made Lakes and Human Health, Academic Press, London, 1975.

Obeng, L.E.; "Should Dams be Built? The Volta Lake Example", Ambio 6(1), pp. 46-50, 1977.

Rosenfield, P.L.; "The Management of Schistosomiasis", Resources for the Future, Washington, 1979.

NAME OF PROJECT : Acheloos Water Development Scheme

TYPE OF PROJECT : Irrigation Scheme

LOCATION : Thessalian Plain, Greece

DATE : 1981

EFFECTS :

- o Increase in abundance of mosquitoes (though not carriers of malaria)
- o Possible immigration of foreign workers infected with malaria
- o The two factors above may result in an increase in malaria
- o Possible increase in arbo viruses, carried by mosquitoes and migrant birds (via mosquitoes to man)

CAUSE OF EFFECTS :

- o Although malaria has been eradicated, the chief vectors, A. superpictus and A. sacharovi, remain in large numbers. An increase in the mosquito population will be encouraged by the impounding of water, providing a suitable breeding habitat.
- o Workers from malarious countries will be attracted into the area by employment opportunities
- o Mosquitoes and migrant birds will be attracted to the water development area

MITIGATION MEASURES: Public authorities are aware of the possibility of re-establishment of malaria from imported cases. Careful malaria surveillance is carried out.

SUCCESS OF MITIGATION MEASURES : Although there are imported cases of malaria (many of which are unreported) no cases of indigenous malaria have arisen from these. So far control has been successful.

RECOMMENDATIONS : None made

REFERENCE Environmental Resources Ltd, 'Preliminary Environmental Impact Assessment of the multi-purpose Water Development Scheme in Thessalia /Acheloos', Report for WHO, April 1980.

NAME OF PROJECT	:	St. Paul River Development	
TYPE OF PROJECT	:	Hydroelectric Power Scheme	
LOCATION	:	Liberia	
DATE	:	1982	
EFFECTS	:	o	Increase in the incidence of malaria
		o	Possible increase in onchocerciasis
		o	Increase in the incidence of schistosomiasis, particularly *Schistosoma haematobium*
CAUSE OF EFFECTS	:	o	Malaria is already holoendemic in Liberia (ie a large proportion of the population harbour the parasite). The impounding of water would extend the mosquito breeding habitat favouring an increase in transmission of the disease.
		o	Onchocerciasis is already widespread in Liberia, particularly in the St. Paul area (50% of the population being carriers of the parasite). The provision of rapid waters associated with the spillways of hydroelectric developments would encourage breeding of the vector fly (*Simulium sp*).
		o	Extension of the habitat of the vector snail *Bulinius globosus*. At the moment, the distribution of the vector snails and consequently the transmission of the disease is limited.
MITIGATION MEASURES:			Active research and clinical programmes aimed at the prevention and cure of onchocerciasis.
SUCCESS OF MITIGATION MEASURES:			No data available
RECOMMENDATIONS	:		None made
REFERENCE	:	o	Liberia Electricity Co. 'St. Paul River Hydroelectric Development, Feasibility Study. Vol. IV ; Environmental and Socioeconomic Considerations'. Chas. T. Main International Inc., Liberia, Oct. 1982.

ANNEX 2

Review of EIA Guidelines and Methodologies

INTRODUCTION

In the following pages a number of published reports are reviewed, which aim to give guidance on procedures and methods for EIA.* We have noted where guidance is given on:

- o methods for identification of impacts using checklists, matrices and networks;
- o methods for prediction of the magnitude of impacts;
- o methods for assessing the significance of impacts using verbal rating scales, ranking and scoring. Where methods of scoring and weighting (or alternative approaches) for identification of the preferred alternatives are described these are noted.

Various examples illustrating guidance from these sources, are presented in the Attachments in this Annex.

Examination of the practical successes and failures of the various approaches described leads to a number of key conclusions and recommendations concerning EIA methods:

i. EIA comprises three main phases:

- o identification of impacts to be studied; this requires examination of alternatives and their interactions with the environment as it develops over time;
- o prediction of impacts: that is determining the nature and extent (or magnitude) of changes in the environment and in human and biological receptors affected by the proposed development alternatives;
- o organisation and presentation of the results of EIA in a form that is useful to the people who must make decisions about the proposals. This involves assessing the significance of impacts and presenting them in a form so that alternatives can be compared.

An additional stage, not usually addressed explicitly in guidelines and methodologies, in the selection of mitigating measures.

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* This review is abstracted from an in-depth study prepared by ERL and published in 1981 [Ref. 21]. Reference is also made to reviews by Clark [Ref. 22], Susskind [Ref. 23], Siu [Ref. 24], Dickert [Ref. 25], Canter [Ref. 26], Warner and Preston [Ref. 27], Bissett [Ref. 28], USACE [Ref. 29], Hobbs and Voelker [Ref. 30], Smith [Ref. 31], Lee and Wood [Ref. 32] and Jain [Ref. 33].

ii. Identification of impacts is a key to EIA; if the full range of possible impacts are not identified at the start of an EIA the detailed investigation may take the wrong direction and fail to address key issues until a late stage in project planning, if at all.

Checklists and matrices may provide useful guidance for identification of impacts but they should be used only as a starting point. The range of impacts associated with any development is always unique and it is impossible to be comprehensive in a checklist. They are provided as "aide-memoires" rather than registers of impacts, and should be used within the context of a broad-ranging examination of the specific proposal and the specific environment in which it will be developed.

iii. The definition of categories of impact in an EIA is also important. Different weights can be implicitly placed on particular impact categories according to the level of detail in which they are defined. For example, a single heading "impacts on health" may appear to give lesser weight to health as an issue of concern, than would be the case if a series of different types of health impacts were identified as separate categories.

The user should not be left with the impression that selection of impact categories was an arbitary procedure, nor that impacts were ignored because they could not be measured or quantified.

This problem should be explicitly recognised in defining impacts and reference to a variety of checklists in which impacts are specified at different levels of detail may help the EIA team to identify those categories most appropriate to their particular application.

iv. Prediction is a key stage in EIA, but in many circumstances objective, value-free prediction of the magnitude of impacts is not possible.

There are two reasons for this:

o firstly, the environment is a complex, dynamic system involving interactions that are difficult to determine and often poorly understood. As a result, prediction frequently requries an expert to make judgements about relationships within the system, about how these may change in the future and about the effect of the proposed activity. Experts may differ in their assessment of future impacts;

- o secondly, the changes that are of particular interest and relevance to the affected community and the decision maker may not be those that can be directly related to measureable or predictable changes: e.g. loss of attractive landscape cannot be measured objectively. In order to predict such impacts value judgements must be made.

In selecting methods for predicting effects and in presenting their results, these two points need to be recognised and their implications for the accuracy and reliability of predictions should be explained. The methods used, or the expert advice sought, to predict effects should be described so that the results can be evaluated and tested.

v. Guidelines and methodologies on organisation and presentation of the results of EIA focus on:

A. methods of presenting the results;

B. types of information that should be highlighted in the presentation;

C. methods of summarising the information.

vi. With regard to Point A, most guidelines advise the use of an **impacts versus alternatives matrix** approach for presenting the results of EIA. This enables the user to see in a concise format the advantages and disadvantages of the available alternatives. Certain guidelines emphasise the need for a "Comment" column to explain the matrix entries particularly where these are abbreviated.

vii. The guidelines also identify certain types of information which must be included in presenting the findings of EIA. In particular we may note the following:

- o the matrix should include real information about the magnitude of effects - their size, extent and duration;

- o the impacts on different groups and interests in the community should be identified and evaluated separately to show the extent of impact on each group. Where the final decision will require a trade-off between different impacts this should be made clear;

- o information should be presented on the different phases of the activity and on indirect, secondary and cumulative impacts;

- the extent of uncertainty associated with predictions should be explicitly stated. In particular where effects cannot be adequately described because of lack of understanding, information or resources, this should be explained;

- the information should be organised to highlight the most important impacts associated with each alternative;

- the methods used to predict impacts and the criteria used to assess their significance should be described so that their results can be checked and tested. Assumptions and judgements made in reaching the final results should be described and justified;

- where experts are used to predict impacts, they should be identified and the basis for their predictions should be explained.

viii. With regard to Point C, summarising the impacts of alternatives usually requires an implicit or explicit assessment of the significance (or importance) of different impacts, so that all the information can be converted onto a common scale. This is usually done by adopting a verbal rating or a numerical scoring system.

In the former all impacts are rated as "high, medium, low" or some equivalent scale, so that a "high" air pollution impact is equivalent to a "high" health impact in terms of their importance to the final decision.

In the latter, impacts are scored on numerical scales (0-10, 0-100, etc.) and multiplied by weights to convert them to a common scale of "impact units". These can then be summed to give a total impact score for each alternative. These approaches enable the EIA study team to identify the "preferred alternative".

Practical experience with scoring and weighting methods indicates a number of underlying problems:

- to use these methods in a comprehensive way requires very substantial amounts of accurate information and resources which are rarely available in practice;

- it is usually difficult for agreement to be reached on the appropriate values for impact weighting; the values arrived at will differ according to the attitudes and expertise of the individuals who select them;

- o when scoring and weighting methods are used the amount of information available to the decision maker is reduced; sufficient information may therefore not be available for him to balance the environmental advantages and disadvantages with each other and with other costs and benefits of the proposed development.

Scoring and weighting methods are not therefore recommended for use in EIA.

ix. Where verbal rating is used to summarise the **impacts vs. alternatives matrix**, the key issues can be highlighted:

- o by showing the preferred alternative in each impact category (e.g. by shading);
- o by flagging very severe impacts;
- o by showing where there is uncertainty about the prediction and assessment of impacts.

x. The criteria that are used to assess the significance of impacts should be identified. The various guidelines reviewed identify a range of different criteria for assessing significance:

- o which groups in the community and which interests are affected;
- o the uniqueness of the affected environment;
- o whether the effect is short or long term;
- o whether the effect is reversible or irreversible;
- o whether the effect involves commitment of non-renewable resources;
- o the controversiality of the effect;
- o uncertainty about the effect;
- o whether a precedent is established;
- o whether protected resources are threatened;
- o whether environmental standards and objectives are threatened.

The last two which related to compliance with legal standards and goals for environmental protection, establish absolute criteria for the acceptability or otherwise of alternatives. If an alternative does not meet legal requirements then it can be eliminated from the assessment or amended to reduce the adverse impact to acceptable levels.

ANALYSIS OF EIA GUIDELINES AND METHODOLOGIES

Title	Source	Date	Content
Environmental Management for Vector Control [Ref. 1]	3rd Report of WHO Expert Committee (Technical Report Series No. 649)	1980	This report is principally concerned with mitigation of health impacts caused by vector borne disease. The report gives guidance on identification of potential effects, including baseline study requirements and planning of control measures during design, construction and operation. A checklist of major steps for the prevention and control of vector borne disease is included and is reproduced in Attachment 1. No guidance is given on prediction of effects.
Guidelines for Assessing Industrial Environmental Impact and Environmental Criteria for the Siting of Industry [Ref. 2]	United Nations Environment Programme	1980	These guidelines were prepared by UNEP for countries planning to set up and undertake EIA. They advise on various tools for use in EIA including: checklists, matrices and flowcharts for identification of impacts (an example of an actions vs. environmental components matrix is given - see Attachment 2), baseline studies and preliminary assessment, criteria for assessment and summary matrices for presentation. The guidelines include a number of Screening Test Tables identifying potential impacts, information requirements and sources of information. These are reproduced in Attachment 3 and establish baseline information needs for prediction of effects. The guidelines are focussed on industrial development and therefore do not consider water associated health impacts specifically.
Environmental, Health and Human Ecologic Considerations in Economic Development Projects [Ref. 3]	World Bank	1974	This handbook was prepared by World Bank to provide guidance on detection, identification and measurement of environmental and related human ecological effects. Guidance is given in the form of checklists of questions about potential impacts of different types of development. Examples for agriculture and utilities (including dams) are given in Attachment 4. General guidance is given on public health impacts and on control of adverse health effects (see Attachment 5).
A Procedure for Evaluating Environmental Impact [Ref. 4]	US Geological Survey; Leopold et al	1971	This report describes a methodology for EIA. It provides an actions vs. environmental components matrix for identification of impacts and recommends use of this matrix for summary presentation. Each interaction within the matrix is scored for magnitude and importance on the basis of detailed investigations reported in the environmental impact statement. Actions and environmental components which are not important are deleted to give a reduced matrix. No guidance is given on methods of prediction. Scoring is based on expert evaluation.
A Framework for Identification and Control of Resource Degradation and Conflict in Multiple Use of the Coastal Zone [Ref. 5]	Sorensen, J. University of California (USA)	1971	This report was prepared for planning purposes. It gives guidance on: the use of networks for identification of environmental effects including higher order and indirect effects (see Attachment 6).
A Verbal Rating System for Environmental Impacts - Town of Jackson, Ohio [Ref. 6]	Environmental Impact Statement on Construction of a Wastewater Treatment Plant, Jackson, Ohio (USA)		As part of this EIA, the EIA team set up a verbal rating scale for use in a summary matrix. This is given in Attachment 7.
An Environmental Evaluation System for Water Resources Planning [Ref. 7]	Battelle Columbus Laboratories; Dee et al. (USA)	1973	This report describes a methodology for undertaking EIA. It provides: a checklist of environmental factors to be considered in identifying impacts (see Attachment 8), a list of variables for measuring environmental effects, a numerical scoring system for impacts (Environmental Quality Units EQU's) and a weighting and summation scheme (Environmental Impact Units EIU's) involving expert judgment, for identification of the preferred alternative. No specific guidance is given on prediction of impacts or on methods for weighting although paired comparison and Delphi techniques are suggested in various supporting references. In a later report (see next reference) the authors concluded that the use of weighting and summation to give composite scores was unsuitable for EIA.
Environmental Quality Assessment in Multi-Objective Planning [Ref. 8]	Battelle Columbus Laboratories; Duke et al. (USA)	1977	This report describes a methodology for undertaking EIA. It provides: a checklist of environmental factors and advice on use of matrices for identification of impacts, advice on variables for measuring impacts, qualitative criteria for assessment of significance based on a concept of 'environmental potential' and guidance on a sequence of summary formats for presentation of the EIA results which emphasise the method followed in the assessment.
Optimum Pathway Matrix Analysis and Approach to Environmental Decision Making [Ref. 9]	Institute of Ecology; Odum et al. (USA)	1971, 1975	This report describes a methodology for environmental decision making. It provides: a checklist of potential impacts, a procedure for scoring effects of alternatives (as ratios to the highest value (x/x_{max}) and weighting to give a total impact score for alternatives). Separate weights are applied for short term and long term impacts $(W = W_{st} + 10W_{lt})$. The methodology expressly provides for sensitivity analysis to test the reliability of results.
The Water Resources Assessment Methodology [Ref. 10]	US Army Corps of Engineers; Solomon et al	1977	This report describes a methodology for EIA of water resource developments. It provides a method for numerical scoring, weighting and summation for identification of the "preferred alternative". Particular attention is given to methods of obtaining weights by paired comparisons of alternatives. No guidance is given on identification or prediction of impacts.

ANALYSIS OF EIA GUIDELINES AND METHODOLOGIES (Continued)			
Title	Source	Date	Content
A Comprehensive Methodology for Assessing Environmental Impact [Ref. 11]	Sondheim, S.W.	1978	This report describes a methodology for EIA. The methodology incorporates a scheme for scoring and weighting to identify the "preferred alternatives". Impacts are scored by expert panels and weighted by representatives from interest groups. No guidance is given on identification or prediction of impacts.
The Numeric Weighting of Environmental Interactions [Ref. 12]	Lands Directorate, Environment Canada; Ross et al	1976	This report describes a methodology for EIA. A checklist of interactions between different components and the environment is set up by using a matrix of environmental components versus environmental components. Higher order interactions were identified by powering the matrix. Ways in which the proposed activity can affect these environmental interactions are identified and the potential interference is scored on a 4-point verbal scale (no noticeable disruption -- severe disruption). A ranking of alternatives is recommended but no guidance is given on methods for achieving this from the scores.
Environmental Impact Assessments by Use of Matrix Diagrams [Ref. 13]	Alabama Development Office; Hyde et al (USA)	1974	The report describes a methodology for EIA. It advises use of an impacts vs. alternatives matrix to summarise findings, and verbal rating of impacts with direct conversion to numerical scores (-3 = major adverse impact; +3 = major beneficial impact). The "preferred alternative" can be identified by summing scores. There is no explicit scoring and weighting. No guidance is given on prediction of impacts.
National Environmental Policy Act Implementing Procedures [Ref. 14]	US Bureau of Land Management, Dept. of the Interior	1980	The guidelines were prepared for BLM activities subject to EIA. They provide guidance on: identification of impacts using checklists and matrices, the types of alternatives to be examined, the selection of variables and methods for predicting impacts, verbal scales and criteria for assessing the significance of impacts and presentation of EIA results in summary matrices. The handbook provides a series of worksheets to be completed during an assessment.
Interim Guide for Environmental Assessment [Ref. 15]	US Dept. of Housing and Urban Development	1975	The guidelines were prepared for HUD activities subject to EIA. They provide guidance on: a checklist of environmental components and sub-components to be considered in identifying impacts, methods for predicting impacts including advice on necessary expertise and information, verbal scales and criteria for assessing the significance of impacts and a summary matrix format for presentation of EIA results. Extracts concerning the use of a checklist for identification of impacts, verbal scales and summary presentation are included in Attachment 9.
Federal Environmental Assessment Review Process Guidelines [Ref. 16]	Federal Environmental Assessment Review Office, Canada	1979	The guidelines were prepared for initial screening of projects subject to the federal procedure. They provide guidance on: identification of impacts using "actions vs. environmental effects" matrices and criteria for assessing the significance of impacts.
Methodological Guide for Assessment of Effluent Treatment Plants [Ref. 17]	Ministry of the Environment, Central Workshop, France	1979	The guidelines were prepared for EIA of sewage treatment and disposal activities. They provide guidance on: identification of impacts using a checklist of potential impacts, techniques and methods for investigation of impacts and advice on mitigating measures.
National Environmental Policy Act Process Rules [Ref. 18]	US Forest Service, Dept. of Agriculture	1980	The guidelines were prepared for USFS activities subject to EIA. They provide guidance on: identification of impacts using a checklist and criteria for assessment of significance. The list of criteria for assessment of significance is given in Attachment 10.
Assessment of Major Development Projects [Ref. 19]	PADC University of Aberdeen, for the UK Dept. of Environment	1980	The guidelines were prepared for ad hoc implementation of EIA. They provide guidance on: identification of impacts using checklists and matrices, checklists for prediction of impacts, methods for prediction of impacts, criteria for assessment of significance and use of summary matrix format for presentation of results.
A Comprehensive Framework for Appraisal of Trunk Roads [Ref. 20]	The Leitch Committee, UK Dept. of Transport	1979	The guidelines were prepared for the Dept. of Transport to advise on methods of appraising alternative highway proposals. They provide guidance on: issues to be considered in the assessment, variables for measurement of impacts and a summary matrix format for presentation of results. This includes provision for highlighting impacts on different interest groups and for a comment column noting further relevant information (see Attachment 11).

ATTACHMENT 1: CHECKLIST OF MAJOR STEPS FOR THE PREVENTION AND CONTROL OF VECTOR BORNE DISEASES AT EACH PHASE OF WATER RESOURCES DEVELOPMENT PROJECTS

Planning phase

(1) Review of existing information on health and related subjects

- (*a*) Epidemiology: morbidity and mortality rates, geographical distribution, vector ecology.
- (*b*) Health and medical services: facilities, staff, special projects and programmes; degree of development, capacity and coverage.
- (*c*) Human population and its characteristics: agricultural, migrant, nomadic, etc.; population growth, importance of migratory movement, displacement within the project area.
- (*d*) Cattle: numbers and economic importance, prevalent diseases.
- (*e*) Community and housing patterns: location, design, construction materials.
- (*f*) Water supply, excreta and wastes disposal facilities.
- (*g*) Climatic patterns: temperature, rainfall, humidity, wind, etc.
- (*h*) Water: surface water and groundwater, quality, pollution, abundance and seasonal variation, floods and droughts, seasonal variation in temperature.
- (*i*) Soil: physical and chemical characteristics, including permeability, stability, salt content, etc.
- (*j*) Natural and cultivated aquatic and land vegetation; domestic and wild animals.
- (*k*) Economy: national and local, sources and levels of income.
- (*l*) Topographical maps: contour lines, roads, villages, etc., of the region and the watershed, design plans of proposed project, etc.

(2) Surveys: To check existing information or fill in gaps in knowledge; assessment and collection of basic data by specialists

- (*a*) Detailed epidemiology of major existing diseases and biology and ecology of principal vectors.
- (*b*) Health and medical services, disease and vector control programmes and activities, evaluation of effectiveness and resources.
- (*c*) Human and cattle movement: migratory currents, their origin and paths.
- (*d*) Sanitation: actual and potential sources of water supply, investigation of groundwater sources, actual and potential sources and routes of pollution, practices involving water contact, and methods of excreta disposal, cattle watering and manure disposal.
- (*e*) Existing and proposed agricultural crops and practices: irrigation methods, suitable crops, rotation in cultivation and irrigation, use of pesticides and fertilizers, their kind and amount.
- (*f*) Local economy: present status and prospects for future development.
- (*g*) Sociocultural patterns: present level and possible disturbance produced by the project.
- (*h*) Engineering and operational reconnaissance and mapping for ecological, hydrological, and geological or soil studies.
- (*i*) Contact with agencies operating in the project area, their type of activities and possibility of assistance and coordination.

(3) Decision-making for the prevention and control of diseases

- (*a*) Review of project proposals and preliminary designs and options.
- (*b*) Identification of existing health problems.
- (*c*) Prediction of possible future problems and of their health effects.
- (*d*) Determination of the importance and extent of actual and potential health problems to establish an order of priority in prevention and control operations.
- (*e*) Feasibility studies of control measures, including cost-effectiveness and cost-benefit analyses.
- (*f*) Selection of village sites and types of water supply and excreta disposal installations.
- (*g*) Selection of methods of vector and disease control and estimates of manpower and organizational requirements.
- (*h*) Organization of field trials and pilot projects.
- (*i*) Settlement of displaced and immigrant population and estimates for the provision of water supply, sanitation and other health facilities.

Design phase

(1) Establishment of design criteria to minimize health hazards and to achieve the objectives of the health programme.

(2) Evaluation of preliminary project designs and alternatives.

(3) Establishment of proposed practices of water-system management and their effects on vector habitats.

(4) Preliminary design and options for canal lining overpasses and other health structures.

(5) Final detailed design of works in the reservoir

- (*a*) Shoreline modification and improvement.
- (*b*) Clearance and disposal of trees and brush, of man-made structures and fences.
- (*c*) Relocation of roads, villages, cemeteries, shrines, etc.
- (*d*) Discharge structures sized for water-level regulation and downstream flushing.

(6) Final detailed design of works in irrigation schemes

- (*a*) Equalizing reservoirs and night-storage ponds, when necessary.
- (*b*) Canals and drains.
- (*c*) Regulating structures, gates, sluices, etc., and distributing chambers.
- (*d*) On-farm water use.
- (*e*) Groundwater use and control.
- (*f*) Potential for incorporating domestic water supply.

(7) Final detailed design of measures and works in communities

- (*a*) Selection of sites for new communities distant from water sources.
- (*b*) Provision of safe, adequate and convenient water supply and sewage disposal systems.
- (*c*) Recreation: provision of safe ponds as alternative to infected water bodies, sports grounds, etc.
- (d) Other protective measures, such as house-screening, surface-water drainage, general sanitation, and public laundry installations.

(8) Provisions for maintenance activities and their financing.

(9) Environmental management

- (*a*) Regulating structures for measurement and control of water discharge and velocity.
- (*b*) Gates required for rapid drying and flushing of irrigation subsystems.
- (*c*) Adjustment of water salinity in coastal breeding-sites through the installation and operation of gates.
- (*d*) Water-level regulation in small reservoirs by means of automatic siphon spillways.
- (*e*) Safe crossings and bridges over canals and drains.
- (*f*) Lining of canals and drains, closed or subsurface conduits.

(10) Enhancement and simplification of chemical and biological control

- (*a*) Design of dispensers for chemical application attached to or incorporated into regulating structures, metal rakes and screens against snails.
- (*b*) Access roads and paths for surveillance and spraying, clear water lanes and landings for boats.

(11) Health education of the public and development of community participation.

(12) Health facilities: dispensaries and hospitals.

Construction phase

(1) Health protection of the construction labour force.

(2) Special facilities for disease control and treatment at the construction site.

(3) Adequate housing and sanitary facilities for construction workers and their families.

(4) Surveillance of infections in imported manpower and local population.

(5) Monitoring, vaccination, treatment of local population and elimination and control of endemic diseases, especially those with potential for intensification with project operation.

(6) Environmental protection, erosion, spillage, air and water pollution, disposal of wastes, aesthetic alterations, etc.

(7) Inspection to ensure that construction is carried out according to health designs.

(8) Health education of the public and development of community participation.

Operations phase

(1) Allocation of funds, assignment of staff and implementation of disease control programmes.

(2) Surveillance, screening and treatment of infected persons.

(3) Establishment of rule curves and schedules for the control of mosquitos, snails, flies, weeds, etc.

(4) Establishment of practices and schedules for water-level regulation.

(5) Maintenance and modernization of structures and other works.

(6) Application of chemical and biological methods for vector and weed control.

(7) Drainage of all water collections around the reservoir.

(8) Prevention and correction of excessive seepage.

(9) On-farm water management.

(10) Operation, maintenance, improvement and development of water supply and sewage disposal systems, general sanitation.

(11) Health education of the public and development of community participation.

(12) Evaluation of vector and disease pattern changes, efficacy of control programmes, study and implementation of amendments or alterations to improve results.

(13) Preparation of periodic and special reports for information purposes.

Source: World Health Organisation. Environmental Management for Vector Control: 3rd Report of the WHO Expert Committee. Geneva: WHO, 1980, WHO Technical Report Series No. 649.

ATTACHMENT 2 AND 3: SCREENING TEST AND BASELINE SUMMARY TABLES FOR ENVIRONMENTAL IMPACTS OF INDUSTRIAL DEVELOPMENTS

SCREENING TEST TABLES

A4.1.1	Climate and Air Quality
A4.1.2	Water
A4.1.3	Geology
A4.1.4	Soils
A4.1.5	Ecology
A4.1.6	Environmentally Sensitive Areas
A4.1.7	Land Use and Land Capability
A4.1.8	Noise and Vibration
A4.1.9	Visual Quality

Each of the 9 screening test tables gives examples of:

- the SUBELEMENTS of each environmental element.
- the POTENTIAL IMPACT(S) for each subelement - questions designed to indicate the most important potential environmental problem associated with the subelement.
- REQUIRED INFORMATION - types of data and knowledge required to undertake an assessment of the probable severity or importance of the impact(s) for that subelement.
- the SOURCE OF INFORMATION - organisations and/or materials (maps, reports, etc.) from which relevant data or information may be sought.

BASELINE SUMMARY TABLES

A4.2.1	Climate and Air Quality
A4.2.2	Water
A4.2.3	Geology
A4.2.4	Soils
A4.2.5	Ecology
A4.2.6	Environmentally Sensitive Areas
A4.2.7	Land Use and Land Capability
A4.2.8	Noise and Vibration
A4.2.9	Visual Quality

Each of the 9 baseline summary tables gives examples of:

- the SUBELEMENTS of each environmental element.
- the OBJECTIVES - basic reasons for including the subelement in an environmental assessment.
- the REQUIRED INFORMATION/SPECIALIST(S) - types of data required to undertake an environmental assessment and the type(s) of specialist(s) or expert(s) recommended for more in-depth analyses.
- the METHODOLOGY - process or technique by which input information is translated into environmental assessment information.
- the FINDINGS/MEASUREMENTS - information providing a basis upon which to address the problems raised by the screening tests.

SCREENING TEST TABLE

A4.1.1 CLIMATE AND AIR QUALITY

Subelement	Potential Impact(s)	Required Information	Sources of Information
Wind: directions and speed	Will the project (structure and area) modify the local wind behaviour, e.g. channelling of wind, obstruction, etc? Will the project be placed in a "high risk" area?	Wind speeds and directions, including unusual conditions - tornadoes, etc. Height of structures.	Meteorological records; existing residents in area. Developer.
Precipitation/ humidity	Will the project have an impact upon the local precipitation/ humidity pattern? Will the project be sited in a "high risk" area?	Precipitation/humidity data including unusual conditions - flash floods, etc.	Meteorological records; existing residents in area.
Temperature	Will the project have an impact upon the local temperature pattern?	Temperature data, including extremes.	Meteorological records.
Air quality	Will the project generate and disperse atmospheric pollutants? Will the project generate any intense odours?	Estimate of atmospheric pollutant emissions from point sources (stacks, etc. area sources (parking zones) and line sources (transportation); estimate of total emissions burden; fugitive emissions from bulk loading and handling facilities; estimate of undesirable or persistent odours.	Air pollution expert

BASELINE SUMMARY TABLE

A4.2.1 CLIMATE AND AIR QUALITY

Subelement	Objectives	Required Information/ Specialist(s)	Methodology	Findings/ Measurements
Wind: directions and speeds	Protection of life and structures/ materials	Wind rose: historical wind direction and speed; unusual conditions - hurricanes, tornadoes, high winds; sea breeze conditions. Meteorologist	Location of site: estimate risk potential; measurement of micro-climate.	Risk of occurrence, frequency and magnitude; nature and character of micro-climate.
Precipitation/ humidity	Protection of life/human health	Precipitation/ humidity data; unusual conditions - flash floods, very high rainfall, hail, fog, snow. Meteorologist	Location of site: estimate risk potential; measurement of micro-climate.	Risk of unusual conditions; nature and character of micro-climate.
Temperature	Protection of life/human health	Temperature data: unusual conditions - extremes in temperature: heat dome(s), frequency and extent of temperature inversions: valley downwash conditions; ventilation potential. Meteorologist	Location of site: estimate risk potential; measurement of micro-climate.	Risk of unusual conditions: nature and character of micro-climate.
Air Quality	Protection of human health; protection of wildlife, amenity and materials.	Ambient air quality, including existing air pollutant loading - particulates and gases - from present and predicted sources in the area. Air pollution expert.	Location of site: monitoring and measurement of ambient air quality: trends in air quality: scentometer and odormeter.	Concentration of air pollutants (in ppm or $\mu g/m^3$) on site and in area: type and intensity of odour.

SCREENING TEST TABLE

A4.1.2 WATER

Subelement	Potential Impact(s)	Required Information	Sources of Information
Hydrological balance	Will the project alter the hydrological balance?	Extent of project; source of water - ground or other. Importance of groundwater in maintaining area rivers, streams, lakes, ponds, wells, flora and fauna.	Developer Hydrologist/ hydrogeologist
Groundwater regime	Will the project affect the groundwater regime, e.g. in terms of quality, quantity, depth/gradient of water table and direction of flow? Will alterations to water table depth alter structural qualities of soil? Will dewatering methods be necessary to undertake excavations?	Extent of project; source of water supply; waste disposal practices; proposed surface cover. Ground conditions - permeability, percolation, water table, location of recharge area, slope proximity to streams or other waterbodies.	Developer Geological maps/ survey; local well-drillers; soils engineer. -
Drainage/channel pattern	Will the project impede the natural drainage pattern and/or induce alteration of channel form?	Existence, nature and pattern of drainage; soil characteristics.	Site visit; geological maps.
Sedimentation	Will the project induce a major sediment influx into area water bodies?	Location of construction and cleaning activities. Erosion potential of site soils. Direction of runoff flow, & slope on site. Erosion and sediment control plan for site.	Developer Soils surveyor Site visit; topographical map Developer
Flooding	Will there be risk to life and materials due to flooding?	Extent of project; 100-year flood plain.	Developer Geological survey
Water quality	Does potable water supply meet established standards - WHO, etc? Will receiving waters meet established standards? Will waters be adequately accommodated and treated? Will groundwater suffer contamination by surface seepage, intrusion of saline or polluted water?	Whether existing water quality meets standards for intended usage; capacity of waste treatment plant/sewerage system to accommodate project wastes. Water disposal plan; source of water. Location of groundwater recharge.	Health/waste disposal authorities Developer Hydrologist/ hydrogeologist
Surface waters	Will the project impair existing surface waters through filling, dredging, water extraction or discharge; waste discharge or other detrimental practices? Will recreation or aesthetic values be endangered? Will the project affect dry weather flow characteristics?	Location of project; location of construction and clearing activities. Source of water supply and site of waste disposal; dams/obstructions; flow characteristics over an extended period. Ecological characteristics; recreation uses.	Developer Civil engineer/ hydrologist Aquatic biologist - area survey

BASELINE SUMMARY TABLE

A4.2.2 WATER

Subelement	Objectives	Required Information/ Specialist(s)	Methodology	Findings/ Measurements
Hydrological balance	Protection of plant and animal life; protection of water supply for domestic and industrial needs.	Inflow of groundwater - infiltration from precipitation and surface water bodies; underflow; leakage through confining layers, etc. Outflow of groundwater - seepage into surface water bodies: underflow; water withdrawal, etc. Construction and surface covering; groundwater extraction. Hydrologist/ hydrogeologist.	Determination of hydrological balance	Alteration of hydrological balance
Groundwater regime	Protection of groundwater supply for industrial needs: human health and safety: protection of plant and animal life.	Nature of waterbearing strata; aquifer presence and source - type of recharge and flow: water table; evaporation loss. Project activities - water demand. foundations, waste disposal practices. Hydrologist/ hydrogeologist/ geotechnical engineer/engineering geologist/chemist	Field and laboratory testing: aquifer pump tests: analysis of alteration of flow direction by pumping or construction; piezometric mapping or radioactive/ chemical tracing.	Water quality: permeability; percolation: details of aquifers; impact on groundwater quality, recharge, flow direction, etc.
Drainage/ channel pattern	Protection of plant and animal life; human safety; Protection of land.	Project activities in headwater and/or catchment areas; construction on or near channel: soil erosion potential: map of drainage pattern. Hydrologist.	Estimate increase in impervious covering; predict effects on channel patterns and profile via estimated sediment yield in the channel.	Modification of runoff pattern; changes in channel pattern, profile and gradient.
Sedimentation	Protection of human health and plant and animal life: drainage basin protection.	Soil erosion potential: drainage basin maps: % slope and distance to waterway: precipitation intensity: duration of construction: soil protection. Soil surveyor	Minimum buffer strip equation: universal soil loss equation.	Width of buffer strip: sediment yield (tonnes/ hectare/year).
Flooding	Human safety: protection of plant and animal life and structures /materials.	Location of site and flood plain(s): nature and extent of construction activities - bridges, water front development, floodway excavation and control measures: leeves, flood walls; increase in impervious surfaces; obstruction of drainageway, etc. Hydrologist/civil engineer.	Locate development site in regional flood plain map, pilot study of construction effect on flood characteristics: hydraulic and hydrologic analysis: ecological survey.	Flood risk: increased runoff and resulting flood levels.

A4.2.2 Cont'd

Subelement	Objectives	Required Information/ Specialist(s)	Methodology	Findings/ Measurements
Water quality	Protection of human health and aquatic life	Existing water quality; possible sources of pollution: runoff, leakage from waste treatment system, surface seepage of pollutants, intrusion of saline or polluted water; capacity of treatment system. Water quality analyst; aquatic biologist; water pollution control engineer; sanitary and civil engineers.	Laboratory analyses or field measurement of water quality; pollution indices.	Potential for degradation of water quality; safety of potable water.
Surface waters	Protection of: plant and animal life; water supply for domestic and industrial needs; natural water purification systems; groundwater recharge and discharge; and, recreation and aesthetic values.	Location of surface waters - streams, rivers, ponds, lakes, etc; surface water volume, flow rates, frequency and duration of seasonal variations; 7-day, 10-year low flow; water uses; ecological characteristics; recreation and aesthetic "uses". Hydrologist/ecologist	Measure proximity of site to surface waters; field measurement of volume, rate and direction of water movement; categories of water usage; ecological assessment - see ECOLOGY.	Potential modification of volume, rate and direction of water movement; impact on ecological character; degree and type of water usage.

SCREENING TEST TABLE

A4.1.3 GEOLOGY

Subelement	Potential Impact(s)	Required Information	Source of Information
Unique/special features	Will features be affected by project activities?	Geological features of educational, scientific, aesthetic and human interest at or adjacent to site; landmarks.	Government geological survey; aerial survey/ remote sensing; educational/ scientific institution.
Tectonic/seismic activity and volcanic activity	Is there risk of damage or loss resulting from tectonic/seismic activity and/or volcanic activity?	Location of project in relation to tectonic/ seismic features (e.g. faults), rock masses (e.g. valleys) and volcanic eruption.	Seismicity studies; geological maps.
Mineral resources	Are there mineral resources of potential value close to the project?	Location of mineral sources and current economic significance; presence of mine, quarry or other extractive activity.	Geological maps/ survey. Mining records; mineral resource map.
Physical/ chemical weathering	Will there be an increase in rock decomposition/degradation as a result of the project?	Existing or exposed rock susceptible to phenomenon at or adjacent to site; water pollution risk.	Geological maps/ survey; environmental scientist; mining records; developer.
Landslide	Are there potential dangers related to slope failures or falling rock?	Site location; existing geological/seismic data; existing and proposed slopes on site; existing instability; faulted, jointed or fractured rock.	Developer (site plan); Geological and topographical maps; site visit; seismicity study.
Subsidence	Is there risk of major ground subsidence associated with the project?	History of subsidence in vicinity of project; subsurface mining activities - past and present; natural subsidence features.	Geological survey; mining records/ companies; insurance companies.

BASELINE SUMMARY TABLE

A4.2.3 GEOLOGY

Subelement	Objectives	Required information/ Specialist(s)	Methodology	Findings/ Measurements
Unique/special features	Preservation of educational, scientific and aesthetic interest	Stratigraphy, landforms. Geologist/engineering geologist	Geological survey/ mapping.	Designation of unique/special features
Tectonic/ seismic activity and volcanic activity	Human Safety; avoidance of structural/ material damage.	Location of site in relation to seismic features/ known seismic events and volcanic eruptions Engineering/ geologist/ seismologist	Seismicity study/ statistical analysis of seismic data and volcanic eruption potential	Seismic risk in terms of risk zone index or frequency and intensity
Mineral resources	Protection of resources in potential future conflict with project construction and operation.	Location of type and quantity of deposits. Geologist/ mineralogist	Mineral survey/ mapping; proximity to infrastructure	Type, quantity and economics of removal of mineral resource.
Physical chemical weathering	Protection of human health and safety and the natural environment; prevention of structual/ material damage; protection of water quality.	Rock/soil classification; degree of weathering; exposure due to natural or constructional processes. Geologist/ geotechnical engineer	Qualify/quantify degree of increased weathering; analysis (field and laboratory) of ground conditions and receiving water quality; climatic factors.	Degradation/ decomposition rate; changes in soil/ rock macro- and micro-structure; receiving water pH value, heavy metal content, swelling/ shrinkage potential.
Landslide	Human safety, protection of the natural environment; avoidance of material/ structural damage.	Ground conditons; engineering properties of soil or rock; groundwater regime; slope gradient and length; loads; landslide history; ground acceleration spectra. Geotechnical engineer. engineering geologist.	Site investigation; long- and short-term stability analysis; aerial photography; seismicity study.	Factor of safety; rockfall risk; suitable slope configurations.
Subsidence	Human safety, protection of the natural environment; avoidance of material/ structural damage.	Ground conditons; existing subsidence; proposed mining depth and extent. Geotechnical/mining engineer; engineering guologist	Geophysical survey; study of existing subsidence; aerial photography.	Subsidence potential and magnitude

SCREENING TEST TABLE

A4.1.4 SOIL

Subelement	Potential Impact(s)	Required Information	Source of Information
Erosion (wind and water)	Will there be a substantial loss of soil due to construction or operational practices?	Extent of site preparation - roadways or other linear features; slope angles; receiving waters. Ground conditions; wind patterns.	Developer - site plan Site investigation
Slope stability	Will there be a risk of losses due to instability?	Site location; existing geological data; estimate of ground conditions; existing instability.	Site investigation; developer (site plan); geological maps
Liquefaction	Will project cause or be exposed to liquefaction of soils in slopes or foundations?	Project location; general seismic data; evidence of liquefaction; machinery producing vibrations.	Developer; site investigation
Bearing capacity	Will there be risk to life or structures because of sudden failure?	Loading: dead or live load ratio; ground conditions; strength properties of soil/rock; groundwater	Developer Preliminary site investigation
Settlement/ heave	Is there risk of damage to structure or services?	As bearing capacity plus settlement/heave parameters.	Developer - Preliminary site investigation Architect/engineer
Earthworks	Will there be an alteration to existing conditions, e.g. water regime or topography, or the need for landscaping?	Extent of earthworks; location and transport of fill/excavated material; disposal of unsuitable materials.	Developer; preliminary site investigation; land survey; haul routes.
Soil structure	Will the project modify the properties of impacted soils?	Site location, soils characteristics data.	Developer; soil survey.

BASELINE SUMMARY TABLE

A4.2.4 SOILS

Subelement	Objectives	Required Information/ Specialist(s)	Methodology	Findings/ Measurements
Erosion	Protection of surface water quality; protection of the natural environment; avoidance of structural/ material damage.	Soil/rock classification; degree of weathering; topography; strength of erosion agencies.	Site investigation (full scope); climatic survey; estimate of potential soil losses.	Soil loss of unit sediment yield.
Slope stability	Human safety; protection of the natural environment; avoidance of material/ structural damage.	Ground conditions; engineering properties of soil or rock; groundwater regime; soil or rock macrostructure; slope gradient and length; loading. Geotechnical engineer; engineering geologist	Site investigation; stability analysis (long and short term). Aerial photography. Seismicity study.	Factor of safety. suitable slope configurations
Liquefaction	Human safety; protection of the natural environment; avoidance of material/ structural damage.	Ground conditions; engineering properties of soil; relative density; cone penetration resistance; groundwater regime. Seismic data. Geotechnical engineer; engineering geologist	Site investigation; liquefaction analysis.	Liquefaction potential
Bearing capacity	Human safety; avoidance of material and structural damage.	Ground conditions; strength properties of soil or rock; groundwater regime; seismic design data. Geotechnical engineer/ engineering geologist	Site investigation; desk study; field and laboratory work. Design.	Total and differential settlements
Settlement/ heave	Material and structural damage; protection of the natural environment.	Ground conditions; consolidation and swelling properties and 'elastic' parameters for soil or rock; ground water regime; climatic factors; loadings. Geotechnical engineer	Site investigation; desk study; field and laboratory work. Design.	Total and differential settlements
Earthworks	Human safety; avoidance of material and structural damage.	Ground conditions; engineering properties of soil; groundwater regime; loadings; slope gradient and length; location of suitable fill material. Geotechnical engineer.	Site investigation; field and laboratory work; Aerial photography; investigation of borrow pits.	Environmental impact of cuttings, embankments, and borrow pits.
Soil structure	Protection of plant and animal life; protection of land and water quality.	Physical and chemical characteristics of soil, soil profile	Site investigation; field and laboratory studies.	Potential for modification of soil properties

SCREENING TEST TABLE

A4.1.5 ECOLOGY

Subelement	Potential Impact(s)	Required Information	Source of Information
Species checklists	Are there rare/endangered species which require protection? Are there species which are particularly susceptible to human activities? Would the loss of certain plant species deny food or habitat to wildlife species?	Species checklists - unusual, rare or endangered species; species providing food and cover for wildlife.	Government departments: conservation, wildlife, forestry; university departments: conservation, wildlife, forestry, botany, zoology; natural history groups.
Plant communities	Are there any unusual populations/communities that may be of scientific value? Are there natural populations/communities that are particularly susceptible to human activities?	Identification of populations/communities: distribution and character; inter-relationships and interactions.	As above
Diversity (species & spatial)	Does the diversity (species & spatial) of any community render it susceptible to human activities?	Extent of project Number and relative frequency of species in area spatial inventory.	Developer Ecologist
Productivity	Will project activities impair natural productivity?	Extent of project Productivity of land on site and surrounding area	Developer Ecologist/ agronomist
Biogeochemical/ nutrient cycling	Will project activities disrupt nutrient materials flow, e.g. selective concentration/dilution of substances?	Extent of project; Disturbance of natural communities; soils type and erodability; slope and topography; drainage patterns; annual precipitation.	Developer Soils surveyor/ ecologist/ hydrologist

BASELINE SUMMARY TABLE

A4.2.5 ECOLOGY

Subelement	Objectives	Required Information/ Specialist(s)	Methodology	Findings/ Measurements
Species checklists	Preservation of educational, scientific, aesthetic value	Project location; regional characteristics of plants and animals. Botanist/zoologist; wildlife/conservation ecologist.	Field inventory of species	Species composition: unusual, rare or endangered species; pest/ nuisance species; key species.
Plant communities	Preservation of natural communities/ natural resources and recreation and aesthetic value.	Project location; regional characteristics of populations and communities. Ecologist	Field inventory of populations/ communities; boundary delineations - aerial photography.	Faunal/floral maps; unusual rare or endangered communities.
Diversity (species and spatial)	Preservation of ecological system functioning	Project location; plant growth - and life-forms; vertical structure and horizontal patterns of plants; species diversity. Ecologist	Species diversity indices; importance-value distributions; spatial diversity inventory.	Species diversity indices of communities; importance value curves to plot the relative importance of species.
Productivity	Preservation of ecological system functioning	Project location; productivity of area natural communities; ecological carrying capacity. Ecologist	Primary and secondary productivity measurement; carrying capacity measurements	Productivity levels and carrying capacities of different communities
Biogeochemical/ nutrient cycling	Preservation of ecological system functioning	Project location; amount of disturbed surface; soils type and erodibility; precipitation; slope and topography; surface drainage pattern; nutrient levels. Ecologist/soil surveyor/hydrologist	Monitoring of nutrients in soils and drainage channels, lakes, etc; soil loss rates	Potential impact on nutrient levels and nutrient budgets

SCREENING TEST TABLE

A4.1.6 ENVIRONMENTALLY SENSITIVE AREAS

Subelement	Potential Impact(s)	Required Information	Source of Information
Prime agricultural land	Will the project be located on or near prime agricultural land?	Location of project Land use & land capability classification on and near site Future agricultural needs	Developer Soils survey; site visit.
Forestry land	Will the project be located on or near forestry land?	Location of project Location of forests on and near site Future forestry needs	Developer Topographical maps; site visit
Wetlands/ estuarine and coastal zones	Will the project impair existing wetlands/ coastal zones/shorelines through filling, dredging, waste discharges or other detrimental practices? Impact on recreation?	Location of project Location of wetlands/ coastal zones/shorelines on or near site. Water quality from construction/plant runoff Waste disposal plans; dams or obstructions downstream from project. Beach erosion from dock, pier or breakwater construction	Developer Topographical maps; site visit Civil engineer Developer Sedimentologist/ hydrologist
Landfills, solid/toxic waste disposal sites	Will the project perturb abandoned, existing or planned landfills, solid/ toxic waste disposal sites?	Location of abandoned, active or planned landfill, solid/toxic waste disposal sites	Topographical maps; site visit; developer.

A4.1.7 LAND USE AND LAND CAPABILITY

Subelement	Potential Impact(s)	Required Information	Source of Information
Land use	Will the project conflict with existing or proposed land use?	Location of project Land use classification on and near site	Developer Topographical maps; site survey.
Land capability	Will the project degrade land capability types?	Location of project Land capability classification on and near site.	Developer Site visit; agronomist/ soil surveyor

BASELINE SUMMARY TABLE

A4.2.6 ENVIRONMENTALLY SENSITIVE AREAS

Subelement	Objectives	Required Information/ Specialist(s)	Methodology	Findings/ Measurements
Prime agricultural land	Maintenance of food production crops and livestock.	Location of agricultural lands; land use classification; productivity levels. Agronomist	Location of site in relation to land capabilities	Productivity levels of prime agricultural land
Forestry land (Silviculture)	Maintenance of lumber production	Location of forests; productivity levels. Forester	Location of site in relation to forests	Productivity levels of forestry land
Wetlands/ estuarine and coastal zones	Protection of: plant and animal life; natural water purification systems; groundwater recharge and discharge; and, recreation and aesthetic values.	Location of wetlands/ coastal zones/shorelines; characteristics of each. Ecologist/hydrologist	Measure proximity to wetlands/ coastal zones/ shorelines; determine direction of ground and surface water flow and their quality and quantity.	Nature and character of wetlands/ coastal zones/ shorelines
Landfills, solid/ toxic waste disposal sites	Protection of plant and animal life and water quality	Location of landfill; geology and hydrology of area encompassing landfills. Hydrologist/ hydrogeologist	Measure distance from site to landfill, etc. determine chemical composition of wastes; soil permeability, ground and surface water flow, quality and quantity.	Risk of gases, particulates, water and soil pollution; odour.

A4.2.7 LAND USE AND LAND CAPABILITY

Subelement	Objectives	Required Information/ Specialist(s)	Methodology	Findings/ Measurements
Land use	Assess potential conflict(s) with project construction and operation	Land use classification - existing and projected, residential, commercial, industrial, extractive, strip development, transportation, utilities, recreation, conservation, agricultural and undeveloped land, historical. Planner/geographer	Locate proposed development in relation to existing and/or projected land uses	Impact of site on existing and/or projected land use
Land capability	Assess relationship of project construction and operation to land capability types	Land capability classification. Agronomist/soil surveyor	Locate proposed development in relation to land capability types	Potential for adverse impact on land capability types

SCREENING TEST TABLE

A4.1.8 NOISE & VIBRATION

Subelement	Potential Impact(s)	Required Information	Source of Information
Internal noise	Will the internal noise levels present a potential risk to the hearing of workers? Will the safe operation of the project be affected?		Plant suppliers, developer, noise expert.
External noise	Will the project create noise levels which will cause annoyance, discomfort to nearby properties?	Estimates of the external noise levels due to transportation, construction, and operation at properties in the vicinity. Existence of noise sensitive land-users within one mile of the development (educational buildings, hospitals, recreational areas etc.)	Existing land maps, planning authority, site inspection. Plant suppliers. Developer, noise expert.
Vibration	Will the project cause damage to structures (natural and man-made) due to vibration?	Details of all permanent and temporary plant likely to cause vibration - pile drivers, large generators, reciprocating machines, blasting etc.	Developer, plant supplier, vibration expert.
	Will the vibration levels within the plant be such that there is a risk to employee safety.	Estimates of internal vibration levels and employee exposure.	Plant suppliers, developer, noise expert.

A4.1.9 VISUAL QUALITY

Subelement	Potential Impact(s)	Required Information	Source of Information
Visual content and coherence	Will the content of the scene perceived by the residents of the surrounding area be adversely affected by the project? Will the coherence of the surrounding area be impaired by the project?	Proposed development plans Description of views before and after project Extent to which the site has coherence	Developer Site visit Site visit Landscape architect

BASELINE SUMMARY TABLE

A4.2.8 NOISE & VIBRATION

Subelement	Objectives	Required Information/ Specialist(s)	Methodology	Findings/ Measurements
Internal Noise	To protect the hearing of employees and to ensure safe operation of the project.	Plant details and layout, structural details, noise levels produced by each item. Pattern of employee movement in working day. Noise expert.	Determine noise map within development/communication pattern, determine individual exposure.	Employee exposure to levels in excess of criterion in dB(A) Leq. Risk of hearing damage, risk of lack of communication.
External noise	Protection of human health/ lack of interference with conflicting land-users.	All existing and proposed development within one mile of site. Topographical details. Wind rose. Base noise levels in area. Transportation details. Plant and building details. Construction plant details. Noise expert	Monitor existing background noise. Calculate future noise levels from construction, operation and transportation.	Estimated noise levels at each noise sensitive area/property. Estimated excess over criteria. Accessibility for construction and operation.
Vibration	Protection of structures, human life.	Plant details and layout, structural details, vibration levels produced by each item. Pattern of employee movement in working day. Vibration expert/structural dynamicist.	Estimate vibration levels in structure and frequency content. Calculate natural frequencies of structure. Determine employee exposure.	Estimated vibration levels at employee work places and exposure. Risk of structural damage.

A4.2.9 VISUAL QUALITY

Subelement	Objectives	Required Information/ Specialist(s)	Methodology	Findings/ Measurements
Visual content and coherence	Sense of time and place; sense of harmony.	Project plans; building design; pictorial images; visual observations. Landscape architect	Photographic analysis of intrusion; descriptive evaluation.	Defined scales of visual intrusion; judgment of coherence.

Source: United Nations Environmental Programme. Guidelines for Assessing Industrial Impact and Environmental Criteria for the Siting of Industry, UNEP Industry and Environment Guidelines Series, Volume 1; Paris, 1980.

ATTACHMENT 4: CHECKLIST OF ENVIRONMENTAL CONSIDERATIONS FOR AGRICULTURE AND UTILITIES

I. AGRICULTURE

ENVIRONMENTAL CONSIDERATIONS

1. AGRICULTURAL DEVELOPMENT

A. Environment/Resource Linkages

☐ Is this a climax ecosystem (e.g., undisturbed tropical forest), or has it undergone earlier man-induced changes?

☐ If new water sources are to be tapped, what is known of their extent and replenishment?

☐ Will changes in population density and/or life style brought about by the project be likely to create environmental/health/social problems?

B. Project Design and Construction

☐ Will the necessary measures to protect environment and health be incorporated in the design and construction of the project?

☐ How will sheet erosion or gully erosion resulting from the removal of trees and other vegetational cover be controlled?

☐ If ponds, canals or other surface water bodies are involved, can a fishery be established?

☐ How will downstream water users be affected by the project, e.g., supply, pollution, pesticides, etc.?

☐ Will stored agricultural products be the target of insect and rodent pests? If so, what control measures will be taken?

☐ Will wildlife or fish populations and/or their migrations be affected? How will this be handled?

☐ Will pesticides and fertilizers be employed? If so, what steps will be taken to minimize their undesirable effects?

C. Operations

☐ How will the project be monitored to gauge its effects on the environment, human health and social welfare?

☐ Will extension sources be provided? Can they be used to detect and counteract any adverse effects, should they arise?

☐ Will those responsible for continuing management and supervision of the project (if applicable) be on the alert for environmental problems? Do they know where to seek advice and assistance?

D. Sociocultural Factors

☐ If the project involves settlement or relocation of peoples, has a plan for their removal and settlement been prepared and/or approved by, or benefited from review by, qualified social scientists?

☐ Will the peoples to be resettled be fully briefed and oriented to their new environmental setting and the changes to be expected, if any, in their life styles, living arrangements and occupation?

☐ Will the affected peoples need to acquire new skills and techniques for successful adaptation? Does the project plan provide for the necessary education and training?

☐ Will the project also provide for training in the techniques of erosion control, water management, forest and range management, etc.?

☐ Will indigenous, primitive peoples be affected? What provisions will be made to assure their future?

E. Health Impacts

☐ Will agricultural disease problems result from this project? If so, how will they be handled?

☐ If the project involves colonizing new areas, will the settlers receive medical examination and treatment to control the introduction of new diseases?

☐ Will the settlers be informed of the health hazards to be expected, and of methods of control?

☐ Will a system of health care delivery be included in the project?

F. Long-Term Considerations

☐ Does the project preempt any future resource options either by its presence or operation?

☐ Will the project so alter the environment as to preclude its future use for other activities, including other agricultural uses?

☐ Will waterlogging and/or soil salinity become a problem? Can the process of soil laterization be expected and, if so, what will be its consequences?

☐ If large areas of indigenous vegetational cover are to be removed (e.g., tropical forests), can mesoscale climatic changes be expected?

2. IRRIGATION SYSTEMS

A. Environmental/Resource Linkages

☐ What will be the ecological consequences of changes in land-use patterns and population distribution? Will future resource uses be preempted?

☐ Will undesirable population crowding occur as villages expand either to make way for or take advantage of the irrigated areas?

☐ What type of environmental planning is being done?

☐ Are major components of the ecosystem known? How will the project affect them?

☐ Will changes in population density upset ecological balances?

☐ What will be the impact of the project on the biota in the water system?

☐ Will the diversion of water to cultivated areas seriously degrade the capabilities of the original water system to support valuable biological species?

☐ Will important wildlife migration routes be permanently disrupted?

B. Design and Construction

☐ Has a consolidated construction plan for the development been prepared that takes into account ecological factors?

☐ Are road patterns, land excavations, fill sites, refuse disposal activities, etc., planned to minimize damage to the natural environment?

☐ What provisions have been made, if needed, for restoring borrow pits and other scarred sections of the construction area by filling, grading and reseeding to prevent erosion?

☐ Will precautions be taken to protect management and construction crews from introducing new diseases and/or redistributing endemic diseases?

C. Operations

☐ Will water diversions be screened to prevent the destruction of fish?

☐ What steps are being taken to preserve fish and wildlife resources in the area?

☐ Will runoff water contain residues, such as pesticides and fertilizers, that contaminate downstream waters?

☐ What are the sedimentation, salinity and erosion problems?

☐ How will waterlogging and salt accumulation be controlled? Will serious aquatic weed problems arise?

☐ How does the irrigation network interact with sources of drinking water?

☐ Will irrigation permit the cultivation of new crops to which exogenous pests might be attracted?

☐ What provision has been made for monitoring the effects of the development on the environment and on affected peoples?

D. Sociocultural Factors

☐ Will the introduction of water, new crops or population increases be detrimental to important social or cultural practices?

☐ Will the construction or operation of the system adversely affect other agricultural, economic or commercial practices in the area?

☐ Will construction of the system or new cultivation cause the relocation of people seeking new opportunities? If so, what steps will be taken to ensure orderly and productive resettlement?

E. Health Impacts

☐ To what extent will the project introduce new public health problems? Will health care services be included in the project?

☐ Will food, wastes or water cycles aggravate sanitation and disease problems? Has provision been made for adequate environmental sanitation?

☐ Will changes in water velocities, temperatures and depth result in a more favorable environment for insect pests and disease-bearing organisms?

☐ Will changes in water patterns introduce disease-bearing organisms into previously unaffected areas?

F. Long-Term Considerations

☐ What undesirable long-range changes in population or the environment may accompany the irrigation system development?

☐ Will further related development projects planned for the future introduce new possibilities for adverse environmental effects?

IV. UTILITIES

ENVIRONMENTAL CONSIDERATIONS

1. DAMS

A. Environmental/Resource Linkages

☐ Have alternatives to the dam been fully considered? Is the dam's presence and operation, including the impoundment, compatible with present or planned development of the region?

☐ Is it a multipurpose dam? If not, could it be made multipurpose through modification?

☐ Will important resources be lost or their use precluded because of the dam's presence or operation? Does the dam offer opportunities for enhancing the environment through planned modifications in design or operating regimes?

☐ Will new settlements and/or cultivation of reservoir slopes cause erosion and premature silting-up of the impoundment?

☐ Will alteration of the water regime (e.g., seasonal flooding, etc.) have important environmental or human ecological implications?

☐ Will aquatic weeds, and the introduction or exacerbation of diseases constitute formidable and costly problems?

☐ What is the nature and magnitude of the human resettlement problems? Are there adequate resources to carry it out in a manner minimally disruptive of the well-being of the affected peoples?

☐ Will new public health problems arise as a result of the project?

☐ Will important historic, religious, archaeological, or geological sites be inundated?

☐ Will the operation of the dam affect the interests of any nation(s) downstream, and has it (have they) been consulted?

B. Design and Construction

☐ Will the design allow for the movement of important migratory fish populations?

☐ Will the dam construction activities be carried out in a manner that will minimize erosion and other damage to the environment?

☐ Are road patterns, land excavations, fill sites, and refuse disposal activities consistent with good environmental protection practices?

☐ Will land in construction areas be restored by filling, grading, reseeding, and reforesting to prevent erosion and erase scars?

☐ Will trees and vegetation be removed from the impoundment area to minimize the introduction of aquatic weeds and to improve the habitat for an exploitable fishery?

☐ Will control of disease vectors be carried out during the construction period?

C. Operations

☐ Can the operating regime be made to benefit fish and wildlife resources wherever possible?

☐ How fast will siltation occur, and how can it best be handled?

☐ How will aquatic weeds be controlled?

☐ Will there be undesirable interactions between the altered surface water patterns and underground aquifers and their recharge?

☐ What physical and biological alterations can be expected to take place in downstream, estuarine and ultimate discharge areas?

☐ *Can changes in water salinity be expected, and how will this be handled?*

☐ Will new settlements and cultivated areas contribute sediment and pollutants to the impoundment, including fertilizer and pesticide runoff? How will this be controlled?

☐ Will land-use planning, zoning and other measures be employed to protect the watershed area from practices and activities detrimental to the project?

☐ Will important wildlife forms be salvaged and relocated?

D. Sociocultural Factors

☐ What will be the human ecological consequences of changes in land use and economic activities, population redistribution, influx of migrants, and changes in life styles and traditional living patterns?

☐ Have resettlement plans had the benefit of advice from social scientists and anthropologists? Are such plans in keeping with the sociocultural needs of the affected peoples? Will the new settlements have adequate provisions for sanitation, disease control and health care services?

☐ Will measures be taken to control squatting on riparian lands and undesirable crowding around the periphery?

☐ Will religious and historical sites and artifacts important to local peoples be salvaged and preserved?

E. Health Impacts

☐ What types of health problems will arise, and how will they be controlled?

☐ Will the work force, including families, be given a preemployment medical screening to prevent the introduction of new diseases? Will they receive periodic examinations to detect diseases and parasitism, and to receive clinical treatment? Will arrangements be made with local health authorities to control venereal disease and enforce environmental sanitation standards?

F. Long-Term Considerations

☐ Will contingency resources be available to cope with unforeseen or unexpected environmental and health problems?

☐ Will any provision be made for follow-up studies of the environmental and human ecological consequences of the project?

2. POWER PLANTS (FOSSIL-FUELED, NUCLEAR-FUELED AND HYDROELECTRIC)

A. Environmental/Resource Linkages

☐ What site selection criteria will be used?

☐ Will they include environmental considerations, such as effects on air and water quality, and the resulting impact on residents of the area, fish, wildlife, and vegetation?

☐ Will alternative sites and alternative orientation of the plant be considered in order to minimize adverse environmental impacts?

☐ Does the site correspond to other local or regional development and land-use plans?

☐ Have the environmental consequences of power transmission and fuel storage been considered in site selection?

B. Project Design and Construction

☐ Will the power-plant construction activities be carried out in a manner that will minimize damage to the natural environment?

☐ Is there a consolidated construction plan that takes into account spatial planning and ecological factors?

☐ Are road patterns, land excavations, fill sites, and refuse disposal activities consistent with good environmental protection practices?

☐ Will land in construction areas be restored by filling, grading and reseeding to prevent erosion?

☐ Will air pollution be a problem and, if so, how will it be controlled?

☐ How vulnerable is the power plant to surface subsidence, earthquakes, tornadoes, and other catastrophes?

☐ What is the extent and impact of the environmental degradation which could be expected in the event of such catastrophes?

☐ What steps are planned to avoid soil erosion and the silting of streams, as transmission facilities and access roads are constructed?

C. Operations

☐ What disposition will be made of solid and liquid residues (e.g., ashes, nuclear wastes)?

☐ How will fuel be stored?

☐ Are low-sulphur fuels available for fossil plants?

☐ Have alternative fuel schedules been developed?

☐ Does the disposal or storage method include adequate cassetting or neutralization to minimize the danger of soil or water pollution?

☐ What steps are planned to contain and reclaim ash dumps to avoid pollution of surface and groundwater by acid-laden runoff?

☐ If waste disposal into water bodies is planned, what will be the effects on aquatic life?

☐ To what degree will tidal action and currents dilute plant effluents?

☐ What provision will be made for controlling the release of radioactive waste material into water bodies?

☐ If additional units are constructed, what will the total load of radioactive waste materials be?

☐ Is the makeup of the plant's gaseous emissions known in terms of chemistry and volume?

☐ What downwind environmental effects can be anticipated with respect to humans, crops, forests, and wildlife?

☐ How can such effects be minimized?

☐ Will emission control equipment be installed? If so, is the level of control adequate?

☐ What impact will thermal effluents have on the receiving waters?

☐ What temperature increase can be anticipated, and how will this affect indigenous biota?

☐ Is there sufficient water motion in the receiving bodies to dissipate heat effectively?

☐ Has the use of cooling towers or ponds been sufficiently explored?

☐ What is the probability of producing undesirable fog conditions through the dissipation of waste heat?

☐ What impact will the impoundment for a hydroelectric plant have in terms of the destruction of agricultural and forest lands, and habitats for fish and wildlife?

☐ What measures are planned to mitigate the loss of natural habitats for fish and wildlife?

☐ To what degree will archaeological and scenic values be affected?

☐ How will the reservoir and downstream flow affect water quality parameters, such as temperature, dissolved oxygen, nutrients, nitrogen concentration, hydrogen sulfide, and color? (See also Environmental Considerations for dam construction, pages 37-38.)

D. Sociocultural Factors

☐ Will construction or operation of the plant adversely affect agricultural, economic or commercial practices in the area, such as farming or access ways in a reservoir impoundment area?

☐ Will plant construction cause displacement of peoples because of flooding, required rights-of-way or because of new opportunities?

☐ Will plant effluent adversely affect agriculture, aquaculture or related practices?

E. Health Impacts

☐ What new public health problems may arise from the project?

☐ Will changes in water velocities, temperatures and depth result in a more favorable environment for disease-bearing organisms?

☐ Will the changes in water patterns introduce disease-bearing organisms into previously unaffected areas?

☐ Will long-term exposure to gaseous emissions prove a significant health problem?

☐ Are contingency resources available to deal with unexpected problems of health maintenance or disease control? In the case of nuclear power plants, is there a contingency plan for dealing with emergency health problems and accidents in the event of an emergency?

F. Long-Term Considerations

☐ What provision has been made for industrial development associated with the power plant?

☐ What impact due to increased immigration will that activity have on the environment?

3. SEWERAGE AND SEWAGE TREATMENT

A. Environment/Resource Linkages

☐ Will site selection and choice of available technology include environmental considerations, such as effects on water quality and resulting impact on residents of the area, fish, wildlife, and vegetation?

☐ Will alternative sites and alternative orientations on the selected site be considered?

☐ Have potential recycling schemes to use water for irrigation or industrial cooling purposes, or sludge for fertilizer been considered in the project?

☐ Has the plant been designed to serve as a regional resource with thought given to expansion?

B. Project Design and Construction

☐ Will the project provide a system for domestic and industrial wastes separate from that for storm water? If separate systems are provided, what provision has been made for storm water drainage? If combined, what effects can be anticipated if the system overloads?

☐ Can the system be economically designed to accommodate or eliminate overloading problems, perhaps with storage or pumping, or by separating the sewage and storm water components?

☐ Will the sewer system create new health problems by transporting and concentrating wastes at new locations?

☐ What effects will the sewage system have on water supply sources?

☐ Is there a consolidated construction plan for the plant that takes into account urban plans as well as ecological factors?

☐ Are road patterns, land excavations, fill sites, refuse disposal, etc., planned to minimize damage to the natural environment?

☐ What provisions have been made for restoring scarred sections of the construction area by filling, grading and reseeding to prevent erosion?

C. Operations

☐ Will gases, odors, insects, and disease vectors be a problem?

☐ What types of waste treatment equipment (e.g., incinerators or digesters) are proposed that might cause air pollution problems?

☐ Are adequate air pollution controls provided?

☐ What type of sewage will the plant process — domestic, industrial, mixed? What percentage of the waste in each category will be processed, and how effective will the treatment be for each type?

☐ What type of toxic materials can be expected in raw sewage inputs, e.g., heavy metals, oils, hydrocarbons, other chemical compounds?

☐ Will the plant be designed to remove toxic materials?

☐ What sewage ordinances are provided to protect the system and personnel from explosives and other dangerous material?

☐ What provisions have been made for the effective monitoring of plant effluents?

☐ What are the present and projected uses of the waterways into which the project effluent will be discharged?

☐ Will the level of treatment provided be compatible with the present and projected uses of the receiving waters?

☐ Will sewage outfalls create additive or synergistic effects?

☐ What effect will the effluent have on the dissolved oxygen regimen of the receiving waters?

☐ What effects will the effluent have on the aquatic biota in the vicinity of the plant and downstream?

☐ Have seasonal variations in water flow and temperature and water levels been considered?

☐ Is thermal pollution of the waterway an associated problem?

☐ What provisions have been made for training professional, technical and operating manpower in the environmental aspects of the system operation?

☐ What types of maintenance will be required? Will funds be available?

☐ Is jurisdictional responsibility clearly established to ensure the operation of the system in a manner that will protect or enhance the environment?

D. Sociocultural Factors

☐ Has the site for the sewage treatment plant been selected to minimize impact on important cultural assets or on land use and economic activities of local residents?

E. Health Impacts

☐ How will waterborne diseases and vectors be controlled?

☐ What effect will the location of outfalls have on domestic and agricultural uses of the water courses?

☐ Will the effluent be satisfactorily disinfected?

☐ What provision has been made for the disposal of sludge in a manner that will not adversely affect public health and welfare, or the environment?

F. Long-Term Considerations

☐ Is the project designed so that future plant expansion can be accomplished in a manner consistent with the protection of the environment?

Source: World Bank. Environmental Health and Human Ecologic Considerations in Economic Development Projects. World Bank: Washington, 1974, updated 1983.

V. PUBLIC HEALTH[1]

"He who has health has hope, and he who has hope has everything."[2]

PART I — POTENTIAL ADVERSE EFFECTS UPON HUMAN HEALTH

A. Direct Health Impact upon People in the Project Area

Communicable disease. The coming of a major development project to an economically deprived area may have profound effects upon the health of the inhabitants. If there is an established community, however small, it is destined for explosive growth. The existing level of sanitation, while primitive, may have been reasonably adequate to meet the needs of a small population. But with the arrival of many people from other areas and a rapid increase in population density, two problems are virtually certain to arise.

First, the new arrivals introduce new diseases or new strains of the causative organisms of locally endemic diseases, to which both residents and newcomers may be susceptible. The highly mobile workmen who tend to follow new construction projects constitute a serious source of disease transmission. They arrive in large numbers, accompanied or soon followed by dependents. Camp accommodations are seldom ready to receive all of them. Indeed, the first arrivals are needed to construct the early shelters and sanitary facilities, while they live under highly adverse field conditions.

Second, existing housing and sanitary facilities in the area quickly become overburdened due to the simultaneous arrival of nonproject people, including more job applicants than can be employed, and many others who hope to profit from the work in some manner. This influx is likely to result in conditions that are particularly conducive to the spread of communicable disease.

As certain diseases spread rapidly among a susceptible group of individuals, the causative organism tends to become more virulent, and the illnesses more severe. Of particular importance are those gastrointestinal diseases spread by contaminated food and water, such as the common diarrheas, but also amoebic dysentery, typhoid and cholera. Viral hepatitis is spread in the same manner, and is a common hazard of the construction site and its fringe habitations.

The respiratory diseases, such as influenza and pneumonia, are generally less of a problem, although tuberculosis, transmitted by close contact, is a particular threat where crowding, inadequate sanitation and scarcity of food occur.

Other parasitic diseases are often introduced into project areas, especially in the tropics. These may spread rapidly, either due to the inadequate disposal of human excreta and garbage, or to the intervention of insect carriers of disease.

A special problem is an almost certain sharp increase in venereal disease, first among the migrant workmen and then the local population.

Housing and sanitary facilities. Change from an accustomed environment as a result of a new development project may adversely affect two different groups of people. The effects upon those moving into a construction area are the more obvious. In addition to the increased risk of communicable disease, marked psychological strains are readily observed. People who move to a construction site from the traditional life of a village for the first time may feel lost and confused when confronted with the strange life of the "labor block," with its new social patterns, its community showers, and its unfamiliar sanitary facilities. Unless they are carefully instructed in the use of such amenities and then closely monitored, difficulties arise. Foreign objects are discarded into toilets and drains, and sewer lines are soon clogged. These crises tend to discourage the further use of sanitary facilities, causing the camp environment to deteriorate rapidly to a septic state. Such stresses contribute to the psychological breakdown of certain individuals, adding to the aberrant behavior often observed on new projects. The problem is further aggravated by the almost certain overcrowding of whatever housing is provided.

Another group more seriously affected over the longer term are those local people who are displaced from their ancestral homes by the land requirements of the development project. In the case of a water resources project, such as a major dam or a new lake of broad extent, many thousands of homes including entire villages may be relocated. The adverse psychological impact of these migrations, involving the loss of ties to the land and the destruction of long established traditions, are not compensated for simply by building new towns for the displaced. The adverse health experience of these groups cannot be attributed solely to their increased exposure at the new village sites to those communicable diseases that are peculiar to a lakeside environment in the tropics (1). Change alone may have a harmful effect.

Where populations are relocated in new areas, there is a risk of exposure to diseases to which the people may have little immunity or for which no cure as yet exists. Certain insect vectors of disease are distributed according to rather sharp geographical patterns. For example, the black fly (Simulium) vector of onchocerciasis or "river blindness" breeds only in rapidly flowing streams. Wide areas traversed by such streams in sub-Sahara Africa have been depopulated in the past for fear of this insect. Sometimes this occurrence has been forgotten or is overlooked, and vacant areas are resettled. The new population will thus be exposed to a disease of which it is unaware, used as it is to living along major rivers of placid flow where the fly does not thrive.

A similar risk exists if people are moved into an area where the tsetse fly is present or may become established, since it transmits sleeping sickness if it becomes infected with the parasite by biting sick persons.

Newcomers to an area are often highly susceptible to locally endemic diseases. If displaced persons become exposed to leishmaniasis or kala-azar, transmitted by the bite of the sandfly (Phlebotomus), the disease is likely to spread in epidemic proportions. This is a problem in countries, such as Sudan, Ethiopia and Somalia, where both the parasite and the insect vector flourish.

(For a detailed description of these and other diseases, see page 48ff.)

Dietary change. It is tempting to assume that the immediate economic benefits to workmen and to the community at the site of a development project will result in an improvement in the general nutritional status of the local population. This is not always the case. The introduction of Western-style convenience foods, such as prepared baby foods, may result in child malnutrition unless milk is available as well (2).

Even the introduction of high-protein food mixtures, such as a corn-soya-milk preparation, is not an unmixed blessing, since its use may aggravate the nausea and diarrhea that accompany some cases of malnutrition.

The distribution of unfortified dried skim milk, unless accompanied by the administration of vitamin A capsules, has been observed in northeast Brazil to aggravate the symptoms, such as eye defects, of vitamin A deficiency (3).

Finally, the introduction of whole milk or milk products into the diet of populations in Africa and in southeast Asia has been shown to cause distressing gastrointestinal symptoms, such as abdominal pain and diarrhea, in a significant number of persons. This condition, termed lactose intolerance, has an unusual racial distribution and tends to affect adults more than children. It is probably due to inherited enzyme deficiency (4).

Where rural peoples are removed from the area of rising impounded waters to new locations, there is a risk of their substituting certain unfamiliar but toxic plants for food items to which they have been accustomed. This hazard is commented upon by Waddy (5) in a review of experience with farmers who were displaced by the rising Zambesi river behind the Kariba dam. Where the staple diet is changed completely as a result of population movement, other difficulties may arise. In Thailand, for example, where people displaced by a rising lake were resettled in a new area, their staple diet was changed to milled rice. A reduced growth rate was subsequently reported in children aged one to three, and was attributed to relative malnutrition (6).

Effects upon groundwater. The most obvious adverse effects upon groundwater in the project area result from the contamination of streams or lakes with sewage. Existing communities near the project site, and especially those downstream, are at risk of having their traditional water source seriously affected by the discharge of project wastes. Besides the burden of excreta from an enlarged human and animal population, other sources of contamination are encountered — the runoff from laundries, maintenance shops, laboratories and health care facilities, for example. The risk of communicable disease such as viral hepatitis from contaminated water is a serious one.

The essential need for sewage collection and treatment is obvious and these facilities should be scheduled for installation at the earliest stage of preconstruction. Sewage treatment equipment should be of a type and capacity to insure against the discharge of chemically hazardous or aesthetically repugnant effluents into streams from which water is drawn by downstream neighbors who do not have water purification facilities.

Another hazard may result from the contamination of an underlying water table due to leaching out of even trace amounts of chemicals held in settling ponds or lagoons for stabilization or evaporation. This is a particular risk of chemical plants operating on some types of terrain. A disturbance in the pH reaction of an underground water table may affect all those who draw water from wells or springs over a large area near the project.

Changes in ecological balance. The human health effects of a disturbance in the ecological balance of a project area may be manifested by an adverse change in the nutritional state of the local population through the introduction of an actual toxic hazard.

This situation can occur on a water resources project if changes that affect aquatic life are produced in a stream, a lake or an inlet of the sea. Fish kill due to reduced oxygen content in impounded waters is an obvious problem (7). A less dramatic but more serious consequence is a long-term decline in fish spawning when deoxygenation persists. People who have depended upon fish as a major source of protein then come under risk of significant malnutrition.

A similar threat may occur from the thermal pollution of waste waters from power-plant operations, a condition that also adversely affects aquatic balance and reduces fish population (8).

Certain industrial processes give rise to toxic effluents released into the air in gaseous or particulate form. As a result, longer term health effects from air pollution may be encountered near industrial plants that emit fluoride into the atmosphere. Unless fluoride emissions are completely controlled, the operation of some phosphate fertilizer plants, steel mill open hearth shops, and aluminum

[1] Numbers in the text refer to the numbered references in the section corresponding to this chapter under VII — References

[2] Arabian Proverb

smelters may produce adverse effects on plant life. Where vegetation is utilized as livestock forage, the health of the animals is impaired, resulting in diminished milk yield, decreased weight gain and cachexia (11). Where such cattle are relied upon as a major source of protein, human nutrition is affected.

Changes in agriculture. An indirect effect upon the health of people living in a project area may occur where surface water irrigation projects with poor drainage cause a rise in the level of the water table of alluvial plains. The resultant waterlogging of agricultural areas and increase in the salinity of groundwater require changes in agricultural methods and in crops. This condition has been reported from the Indus Basin development in West Pakistan. The response of farmers in the irrigated districts of the Punjab has been to convert from wheat to rice cultivation (12). Where situations such as this occur in the tropics, farmers may become newly exposed to the risk of contracting schistosomiasis (bilharziasis or snail fever), since the snail host tends to propagate in irrigation systems, and the parasite is often introduced by carrier individuals. Other parasitic diseases, such as guinea worm, may also be introduced and spread under these circumstances, unless strict supervision of sources of drinking water is maintained.

Increased risk of road accidents. A sharp rise in the rate of serious injury from road accidents is such a constant factor related to development projects that it should be placed high on the list of risks to human health. Medical services on and near such projects regularly report that the care of traffic injuries is among their most critical problems (1, 13). An alarming increase in mortality rates due to the motor vehicle as a regular concomitant of economic development has been documented (14). It is often the neighbors of a development area, unaccustomed to paved roads and high-speed transport, who are struck down as they go about their own business on foot. Adequate provisions should be made to care for accident victims, and special consideration should be given to preventive measures, such as driver training, adequate road markings and traffic controls on access roads.

Risks to community health from certain industrial processes. Certain development projects involving industrial processes have the potential of adversely affecting the health of neighbors in other ways. There is a risk of accidental release of toxic gases from some chemical plants, petroleum refineries and shipping centers which may be the result of explosion, fire, malfunctioning equipment, or human error. A conspicuous example of the acute effects of this type of hazard occurred in the small town of Poza Rica, Mexico, where the accidental release of hydrogen sulfide from a sulfur recovery plant resulted in the death of 22 persons of some 320 who were afflicted (10).

Experience with beryllium indicates that, as a result of exposure to airborne contaminants (16), illness may occur among residents in the neighborhood of some industrial plants that process highly toxic substances. The potential hazards to community health arising out of the operation of nuclear power plants are well documented (8).

Special mention should be made of the probable role of emissions from industrial plants in contributing to the lethal effects of the major air pollution disasters that occurred in the Meuse Valley in 1930, at Donora, Pennsylvania, in 1948, and in London in 1952. Each of these episodes was characterized by the occurrence of a period of fog of several days' duration settling over an industrialized area, with a marked buildup in dirty air, caused by a combination of adverse weather conditions and severe air pollution. A significant increase in deaths due to respiratory disease occurred in both cities. Subsequent studies have confirmed that an abrupt rise in the concentrations of smoke and sulfur dioxide in ambient air is positively associated with excess mortality (15).

It seems clear that these disasters came about, due at least in part, to the siting of multiple industrial sources of sulfur dioxide emission in populated areas that are subject to significant weather abnormalities of the thermal inversion type.

The discharge of toxic wastes from industrial projects into lakes or streams poses another type of potential threat to human health. A dramatic example of the consequence of the entry of a toxic chemical, mercury, into the products of a food chain has been documented in Japan. Over 200 cases of mercury poisoning ("Minamata disease") resulted from the consumption of fish taken from an inlet contaminated by effluent from a chemical plant that processed vinylchloride (9).

Illnesses of a specific nature have been attributed to cadmium in Toyama City in Japan, where residents have been exposed to cadmium released from a mining complex into the water supply (17).

The adverse effects of noise upon a community have led to increasing pressures for ordinances controlling noise at the source, with particular emphasis upon construction projects, industrial processes, commercial trucking and airport operations. The neighbors of development schemes around the world are becoming intolerant of noise sources that result in loss of sleep, irritability, and decreased personal efficiency (18).

B. Direct Health Impact upon Workmen

Work accidents. The risk of work accidents is of major concern to the project planner. Aside from the monetary cost — arising out of the medical care of accidental injuries, disability payments, damage to facilities, and disruption of work schedules, there is the important human cost, and its impact on relations with labor and with the community. Construction work is among the most hazardous of occupations at best. Where large numbers of the work force have had no prior construction or industrial experience, the problem of job safety is even greater, especially during the early stages of the project. Safety measures and the provision of facilities and staff for the care of injuries are a necessity.

When the construction of facilities has been completed, the operational stage of the project may demand an even higher level of safety awareness and competence on the part of workmen. An adequately staffed safety unit, with provision for training and supervision of workmen in job safety, is essential.

Exposure to chemical and physical hazards. In addition to the risk of traumatic injury arising out of work accidents, the operational stage of many development projects is characterized by potential exposure of workmen to chemical hazards, such as toxic liquids, gases, dusts, fumes, mists and vapors — as air contaminants and as skin irritants. Construction jobs may also be accompanied by physical hazards, including those caused by vibration, extremes of temperature and pressure, electromagnetic and ionizing radiation, noise, and such special risks as caisson disease in the case of divers, for instance.

A detailed analysis of each type of industrial, mining or power project for inherent hygienic hazards to be anticipated will indicate the steps that should be taken for their measurement and control. An inventory of the industrial hygiene hazards encountered in one industrial process, aluminum smelting (the reduction of aluminum oxide to metallic aluminum) is outlined in Tables V.1 and V.2 (pages 54-59). A similar inventory may be prepared for each of the other steps in aluminum production from mining, through alumina refining, to reduction, to the final stages of rolling or forming the metal and to product distribution. The same methodology of assessment of health hazards may be applied to other types of development projects. A useful source book from which a list of health considerations on a given project may be initiated is the *Encyclopedia of Occupational Health and Safety* published by the International Labour Office (19). The more detailed treatment of health factors that will be required for most industrial processes dictates reference to a larger library of sources on industrial methods and on industrial hygiene practices (20, 21).

Exposure to local diseases. The introduction of a work force and its followers into a project area, especially in a previously undeveloped region, may result in the exposure of many nonimmune individuals to endemic diseases.

Malaria — The classic example was the catastrophic impact of malaria upon early efforts to construct a Panama Canal. Malaria remains probably the most serious single threat to health through the tropics and subtropics. The Anopheles mosquito is the carrier insect of this disease.

The newcomer to an area where malaria is highly endemic may be misled by the apparent robust health of most of the local people. The adults, however, are simply the relatively resistant survivors of a disease that regularly kills a large percentage of infants. The previously unexposed immigrant into such an area, which includes virtually all of Africa, most of Southeast Asia, and much of Latin America, is at grave risk of incurring malaria, some forms of which have a mortality rate of 10 percent in untreated cases. Military forces and construction crews throughout history, up to the present, have been inactivated by this disease. Recent experiences in Viet-Nam, and on construction projects in Africa (1), continue to demonstrate that even the availability of antimalarial drugs is not completely protective. Malaria is almost always underestimated as a cause of disability in the tropics — as to its very wide geographical distribution, the high risk of infection, and as to the severity of the disease in nonimmune subjects (23).

Onchocerciasis — Of next importance as a risk to the health of workmen imported into many tropical areas where a water resource project is planned, is onchocerciasis or river blindness. While not as frequent a cause of disability as malaria, it is often more feared because of its early manifestation of an intensely itching skin eruption and later on, the development of nodules seen or felt beneath the skin. Involvement of the eye leading to loss of vision is a dramatic and tragic complication that occurs chiefly among lifelong residents of a hyperendemic area.

Onchocerciasis is spread by the bite of several species of the black fly, especially Simulium damnosum in Africa, an aptly named bloodsucking pest that swarms in enormous numbers, inflicting painful and bleeding bites. Projects may be seriously interrupted by this biting scourge, and senior staff have threatened mass resignation when the rate of infection with onchocerciasis is observed to rise among the workmen. The black fly is virtually worldwide in distribution, but those species which are notable as vectors of onchocerciasis are encountered chiefly in East and West Africa, and in Guatemala.

Where the disease has been prevalent for a long time, infection rates of 99 percent in adult residents have been recorded. Under these circumstances, the number of infective flies in the Simulium population is high. Technically speaking, a single bite by an infective fly is sufficient to transmit the disease. Settlements in areas with rapidly flowing streams, as mentioned previously, have been abandoned all across sub-Sahara Africa due to the depredations of Simulium and the alarming disease it carries.

The large new dams of Africa have resulted in some new exposures to onchocerciasis. Simulium control may add appreciably to the overall cost of a dam in a fly breeding area, notably the Kainji on the Niger. Some other development projects — coffee plantations in Guatemala and timbering in Uganda — also have been afflicted by onchocerciasis (24). During the actual construction of a dam in a black fly area, as the velocity of the water flow in a river is temporarily increased by narrowing the channel or by a diversion around the main dam site, fly breeding may actually increase. On completion of the dam, breeding is usually arrested in the placid waters behind the barrier, but may continue in the downstream runoff.

Schistosomiasis — A third hazard to the workmen on some development projects in the tropics and in some temperate zone areas is schistosomiasis (bilharziasis, snail fever). The disease is contracted by wading or bathing in water in which the parasite has been released by certain species of snail. The parasite penetrates the intact skin of man, resulting in a chronic and progressive disease of either the urinary tract or the intestinal tract depending upon the particular schistosome. The resulting disease is markedly debilitating and exceedingly difficult to treat.

It is estimated that some 150 million people are victims of the three major forms of schistosomiasis. The distribution (see map on page 53) is concentrated mainly in sub-Sahara Africa, the Nile Valley, Iran and portions of the Middle East, Brazil, Venezuela, the Lesser Antilles and Puerto Rico, China, Japan, and the Philippines.

The culprit snails propagate chiefly in shallow, sluggish waters, such as ponds, borrow pits, irrigation canals, and along the banks of lakes. The risk of infection is not so great during the actual damming of major rivers as it is when the lake behind the dam has filled. But workmen engaged in surveying, clearing, excavating, and preparing a site may be exposed by wading or bathing in contaminated groundwater. A single exposure may be sufficient to contract the disease. Among people who have long been exposed, with infection rates often exceeding 90 percent of the population, a sign such as bloody urine occurs so commonly that it is regarded locally as a normal phenomenon. The principal risk of increased spread of the disease to inhabitants of an endemic area where a new lake is rising, or where irrigation has been introduced, is discussed more fully in the next section.

Some of the other vector-borne diseases to which workmen may be exposed on development projects:

Dengue (breakbone fever) — a viral disease transmitted by the Aedes aegypti mosquito — occurs in any warm, moist climate. It is characterized by fever and excruciating pain in the joints and behind the eyeballs. A more serious form causes internal bleeding.

Viral encephalitis — the most serious form of a disease caused by several different viruses, transmitted by mosquitoes — is worldwide in distribution. The relative risk of infection is determined by the presence of the disease locally in man or animal, and the extent of mosquito infestation. Sandfly fever is a related disorder caused by a virus which is transmitted by the sandfly.

African sleeping sickness (Gambian trypanosomiasis) — caused by the bite of the tsetse fly transmitting the parasite — is greatly feared throughout sub-Sahara Africa. A single tsetse inside a moving vehicle is a common cause of road accidents due to panic among the passengers and distraction of the driver.

Chagas disease (South American trypanosomiasis) — a parasitic disease confined to Latin America, chiefly in Brazil and Peru — is transmitted by the bite of the reduviid bug, found mainly in rural areas. The disease affects the internal organs, including the heart in some cases.

Leishmaniasis (espundia or kala-azar) — also a parasitic disease — is transmitted by several species of sandfly or phlebotomus. A Latin American form, primarily affecting the skin, occurs in epidemic proportions when work parties, including some infected persons, enter a forest to cut lumber. A visceral form of the disease occurs especially in East Africa, India and China.

Bancroftian filariasis (elephantiasis) — caused by a miscroscopic worm transmitted by a mosquito, principally Culex — occurs throughout the tropics.

In addition to the above-listed diseases which are mainly transmitted by insects, all development projects in the tropics carry a high risk of spreading a variety of intestinal parasites among newcomers. Meticulous attention to food sanitation is imperative. Viral hepatitis is also transmitted by contaminated food or water.

Completing the catalogue of risks to human health on development projects, especially construction jobs in the tropics, is exposure to venomous snakes, scorpions, large reptiles such as crocodiles, and dangerous fish.

Nutritional status of workmen. A widespread problem of human health in poorer areas is malnutrition, most commonly a lack of sufficient protein in the diet. The result is diminished physical stamina and increased susceptibilty to infection. On some development projects the health and productivity of workmen have been improved by providing low-cost meals or supplementary foods on the job. The best results have been attained when supplementary feeding is accompanied by instruction and persuasion on the value of a balanced diet. This also provides an opportunity to emphasize food sanitation, and to discourage the patronizing of itinerant food vendors who often are a source of food-borne intestinal disease.

C. Indirect Health Impact due to Effects upon Disease Vectors

Changes in the ecology of an area induced by a new development project may have a profound, if indirect, impact upon human health as a result of effects upon biologic vectors of disease, i.e., the introduction of new disease vectors, or the spread or intensified breeding of certain insects and aquatic species that provide a vehicle for the completion of the life cycle of some important parasites and viruses that afflict man. These vectors of disease, more common in the tropics, have been related most often to the construction of dams and other water resource developments (Table V 3, page 60). But any field project that brings man into an area where both the parasite and the vector thrive constitutes a risk.

Introduction of new disease vectors. The movement of populations induced by the establishment of a development project may introduce, or reintroduce, dangerous insects into an area previously free of them. The most conspicuous example is the spread of the tsetse fly in sub-Sahara Africa, from heavy breeding areas to less affected areas along roadways (28). Infective flies may travel great distances as "passengers" in conveyances, establishing new foci of sleeping sickness along the way. This accounts for the "sleeve" distribution of the disease in settlements along roads, tracks and communicating streams of Africa. Where the fly finds new breeding grounds and human reservoirs of infection are available, outbreaks of the disease occur. This is most likely to happen on agricultural or livestock development projects, since cattle also attract the tsetse. However, transmission of the disease is from man to man by the bite of an infected fly.

New disease vectors, such as certain mosquitoes, may also be introduced into a project area by aircraft, where insects may lurk in a passenger compartment or a baggage hold.

Finally, the possibility exists of bringing into a new area a snail vector of schistosomiasis on the underside of vehicles or on amphibian aircraft. Some aquatic snails, remarkably resistant to desiccation, have been shown to have been transported for considerable distances in mud adhering to the bills and feet of wading birds, to the bodies of water buffaloes, and to the roots of transplanted shrubs and trees. A single individual snail is capable of producing young, and can quickly colonize a new habitat (29).

New infection or reinfection of existing vectors. Vector-borne diseases of man become established in a population when three conditions prevail: (1) the vector is present; (2) human or animal cases are introduced, serving as a reservoir of the parasite; and (3) opportunities exist for exposure of previously uninfected individuals.

Control programs usually aim at all three factors: eradication of the vector; treatment of active cases in man (or destruction of an animal reservoir, such as rodents infected with the plague); and education in prevention, such as avoidance of waters infested with parasites. Major emphasis is usually on vector control and treatment. The effectiveness of this dual approach has been well demonstrated, notably in the eradication of malaria from southern Italy, from much of the Caribbean, from most of Venezuela, and from the southern United States.

Even when eradication of malaria has been achieved, strict vigilance is required to avoid reintroduction of the disease through reinfection of surviving mosquitoes by feeding upon humans who bring in new infections from uncontrolled areas. This is a risk on development projects if labor is imported from malarious areas. In fact, the high level of mobility of labor forces is a highly significant factor in the difficulty of controlling malaria throughout Africa (30).

Increased propagation and spread of existing vectors. The most serious impact upon human health arising from a development project, especially a water resources plan, comes from changes wrought on the environment that affect the habitat of disease vectors, such as mosquitoes, black fly and those aquatic snails that harbor schistosomiasis.

An increase in the mosquito population often occurs in the early stages of clearing and constructing a project site, as breeding occurs in many water foci, however small. These include ground puddles, vehicle ruts, and trash heaps containing discarded metal containers. Fortunately, mosquito abatement is relatively easy to achieve by strictly controlling water accumulations and by insecticidal spraying, so that mosquito-borne diseases, such as malaria, can be held in check.

Breeding of the black fly vector of onchocerciasis, Simulium damnosum, is generally arrested in the still waters of a lake rising behind a new dam, but very active breeding may occur around spillways or in the runoff stream below the dam where water velocity and turbulence provide a favorable habitat for the growth of larvae (31). It usually is desirable to treat the stream with insecticides to discourage black fly breeding near dams in infected areas (32).

The greatest risk is that of spreading schistosomiasis as a consequence of a water resource development in a previously endemic area, or in any area that may support the growth of an aquatic snail vector of the disease.

The snails that serve as intermediate hosts of schistosomiasis in Africa are of the genera Biomphalaria and Bulinus. In Asia, host snails are mainly of the Oncomelania genus which are amphibious. The principal host snail in the Americas is Australorbis (29).

The characteristics of snail habitats are described by Malek as follows:

> *"The snail intermediate hosts of schistosomiasis are adapted to a wide range of environmental conditions. They breed in many different sites, the essential conditions being the presence of water, relatively solid surfaces for egg deposition and some source of food. These conditions are met by a large variety of habitats: streams, irrigation canals, ponds, borrow-pits, flooded areas, lakes, water-cress fields and rice fields. Thus in general they inhabit shallow waters with organic content, moderate light penetration, little turbidity, a muddy substratum rich in organic matter, submergent or emergent aquatic vegetation and abundant micro-flora. The snails may be found in isolated habitats quite independent of major drainage systems because snails or their eggs are sometimes carried passively to such habitats which seem favorable. Accordingly, to determine their habitats systematic search for the snails must be conducted over a period of several seasons"* (33).

The resource developments most likely to favor increased propagation and spread of these snails are those which impound water behind dams to serve hydroelectric plants, irrigation systems or a fishing industry (3). The most conspicuous examples are those on the Nile, affecting Egypt and Sudan. The spread of schistosomiasis there has been quite marked, with rates of infection rising to 75 percent or more in exposed populations.

In Ghana, West Africa, as Lake Volta rose behind a major dam completed in 1964, an infective species of Bulinus snail was identified in the inundated area by 1966. The explosive growth of aquatic weeds favored massive reproduction of the snail. The parasite of schistosomiasis was present among people who had arrived from infested areas in the Volta delta, and infected the local snail population. Outbreaks of the disease were soon observed in new townships along the lake. The rate of infection increased steadily, and within two years nearly all the children in these settlements were affected (34).

The snails also thrive in irrigation canals and ditches supplied with water pumped from underground, and along the shores of natural lakes, such as those of East Africa and the crater lakes of Cameroon.

D. Impact upon Existing Health Services

The introduction of a major new project into a developing area is likely to create heavy demands for a variety of social services, including medical care for project personnel, their dependents, and the many additional people ordinarily attracted to a development site. In addition, public health measures such as monitoring the safety of water and food supplies, enforcement of sanitary regulations and the control of disease vectors must be considered.

All of these requirements are likely to overwhelm existing local resources, and governments may not be able to provide out-of-ordinary funds for the additional facilities and staff required to serve the expanded community. The following sequence of events may be expected:

- arrival of project personnel and dependents;
- establishment of new communities;
- expectations of health services;
- arrival of nonproject people;
- increase in disease and injuries;
- increase in health awareness among original residents;
- demand for medical care of international standard.

Increasingly, the project authority is expected to furnish health services, either directly or by arrangement with contractors (35). In fact, planning and financing of health care by the project authority is now required by many developing countries, a trend that is on the increase.

FIGURE V.1 World Distribution of Bilharziasis (after WHO-25)

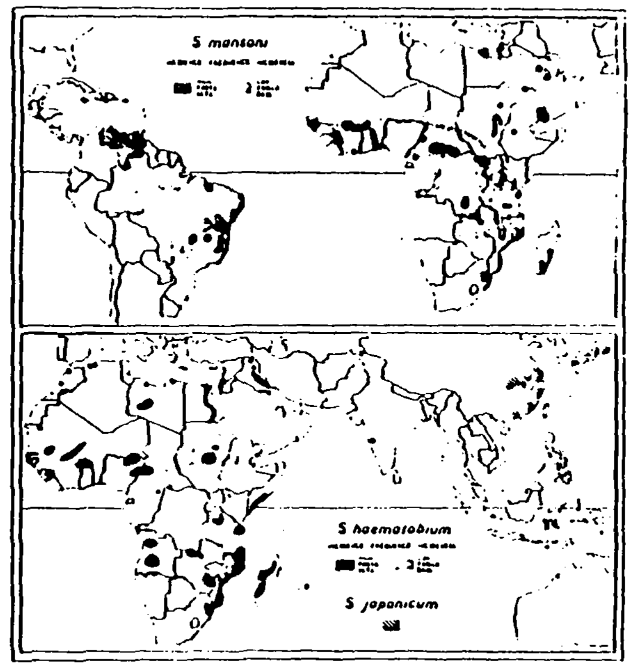


Table V.3 — Some Parasites of Man related to an Aquatic Environment

Adapted from Hughes & Hunter (26); after Thomas (27)

Parasites	Intermediate Host	Method of Infection	Diseases Most Commonly Transmitted
Nematoda:			
Onchocerca volvulus	Black fly (Simulium)	*Fly bite*	River blindness (onchocerciasis)
Wuchereira bancrofti	Several mosquitoes	Mosquito bite	Elephantiasis (filariasis)
Protozoa:			
Plasmodium spp.	Anopheles mosquito	Mosquito bite	Malaria
Trypanosoma gambiense	Tsetse fly (Glossina p.)	Tsetse bite	African sleeping sickness
Trematoda:			
Schistosoma haematobium	Aquatic snail (Bulinus)	Bathing or wading in infested water	Urinary schistosomiasis (bilharziasis)
Schistosoma mansoni	Aquatic snails (Biompholaria; Australorbis)	Infested water	Intestinal schistosomiasis
Schistosoma japonicum	Amphibious snail (Oncomelania)	Infested water	Visceral schistosomiasis
Viruses:			
Over 30 mosquito-borne viruses are associated with human infections	Several mosquitoes	Mosquito bite	Encephalitis; dengue

PART II — GUIDE TO PLANNING THE CONTROL OF ADVERSE HEALTH EFFECTS

The effectiveness of prevention and control of adverse effects on human health arising out of a development project depends largely upon sound advance planning. Specific authority and responsibility must be assigned among the official agencies and other organizations that are to be involved in the project and will have to deal with its impact upon the community. Perhaps most importantly — adequate funding of control measures to be taken must be made available.

A classic example of making a complete assessment of the health risks to be anticipated on a major project, with a detailed plan for prevention and control, is contained in the *Report of the Preparatory Commission for the Volta River Project in West Africa* (36). These observations and recommendations, prepared by the late Drs. Andrew Topping and George MacDonald of the London School of Hygiene and Tropical Medicine, constitute a model for the guidance of the planner who is responsible for considering human health factors on a development project.

This planning guide is presented here in outline form, with a check list of preventive measures to be considered in forestalling the occurrence of unnecessary risks to health on major projects.

A. Community Aspects: Human Factors

Housing
Sanitary facilities
Communicable disease control

Responsibility

Central Planning
Ministry of Health
Project Authority

Implementing entities

Local Government
Housing Agency
Health and Sanitation Agency
Project Authority
Contractors

Preventive measures

Adequate housing space
Control of number of occupants
Adequate sanitary provisions
Education in use of facilities
Sanitary inspections and enforcement
Early completion of safe water system
Monitoring water and food supplies
Tuberculosis control
Immunizations
Instruction in nutrition

B. Community Aspects: Environmental Factors
Effects on groundwater
Effects on ambient air
Effects on ecological balance
Changes in agriculture
Road accidents

Responsibility
Central Planning
Ministry of Health
Ministry of Resources
Environmental Protection Agency
Ministry of Agriculture

Implementing entities
Local Government
Water Authority
Fisheries Department
Highways Department
Project Authority
Contractors

Preventive measures
Preliminary assessment of area ecology
Effective sewage collection and treatment
Treatment or impounding of effluents in impervious basins
Engineering control of all effluents
No release of toxic effluents into air or water
Adequate drainage of project area
Monitoring of air, water, fish, and vegetation
Vector control in project area
Safe design of roadways
Driver education and license control
Demonstration of safe agricultural methods

C. Work Force Factors
Work accidents
Chemical and physical hazards
Exposure to local diseases
Nutritional status

Responsibility
Central Planning
Ministry of Health
Ministry of Labor

Implementing entities
Project Authority
Health and Sanitation Agency
Industrial Hygiene Agency
Contractors' Medical Units

Preventive measures
Medical, industrial hygiene and safety organization
Industrial hygiene assessment of risks
Engineering design to prevent job hazards
In-plant ventilation control
Medical examination of work recruits
Strict medical selection and preparation of overseas staff and dependents
Biologic monitoring of workmen exposed to chemical hazards
Work safety training
Treatment of communicable diseases
Immunizations
Vector control at work site
Supplementary feeding as indicated

D. Areawide Factors
Introduction of disease vectors
Infection of existing vectors
Increased propagation of vectors

Responsibility
Central Planning
Ministry of Health
Ministry of Agriculture

Implementing entities
Project Authority
Health and Sanitation Agency

Preventive measures
Organization of biologic control services (entomologists, malacologists, field control units, operational manuals, etc.)
Preliminary survey of project area for existing vectors of disease
Preliminary clinical survey of population in project area for vector-borne diseases
Continuous biologic surveillance of project area for introduction of vectors
Treatment of active and carrier cases of vector-borne diseases
Spraying of aircraft and vehicles arriving from areas where vector-borne disease is endemic
Specific preventive measures for the most important vector-borne diseases:

Malaria (37)
- identify, map and number *all* human habitations in project area
- periodically spray habitation walls with residual insecticide
- eliminate or spray mosquito breeding areas
- design irrigation systems and reservoirs for fluctuating water levels to discourage mosquito breeding
- prepare banks of reservoir by removing vegetation
- utilize predatory fish against mosquito larvae where feasible
- avoid open dumps; incinerate or bury solid wastes
- utilize antimalarial drugs as indicated

Onchocerciasis (38)
- identify Simulium breeding foci
- treat breeding streams with larvicide if feasible
- aerial spraying with insecticide where indicated
- screen local residents and new arrivals for infection
- treat active cases (with caution)

Schistosomiasis (12, 39, 40, 41)
- identify existing snail species before project work begins
- design canals to discourage snail breeding (sharply sloping sides, high water velocity, etc.)
- utilize piping for irrigation where feasible
- alternate irrigation and drying of fields where feasible
- provide adequate drainage from irrigated areas
- prepare reservoir sites before filling
- control vegetation growth along accessible shorelines
- control access to ponds and reservoirs where feasible
- provide piped water to reduce visits to the lake
- provide sanitary facilities in lakeside villages
- maintain constant surveillance for evidence of snails
- periodically introduce molluscicides into infested waters
- screen local residents and new arrivals for infection
- treat detected cases

E. Health Care Services
Need for base line health data
Services on project site
Community services

Responsibility
Central Planning
Ministry of Health

Implementing entities
Local Government
Project Authority
Contractors

Preventive and other Measures
The task of the health planner begins with the earliest conception of the development project. In order to determine the health needs of the project, a systematic assessment of the existing health situation in the project area is essential, with special emphasis on the acquisition of *base line data* on communicable diseases and the potential for contamination. A standard method for conducting such a health survey has been outlined by the World Health Organization (42).

Health services on the project site are designed primarily to insure the prevention and control of communicable disease, and to provide medical care for those injuries and illnesses that may arise out of work on the project. These requirements should be met without burdening whatever existing health services there may be in the area.

Project health services may be organized as follows

Therapeutic services
Comprehensive health care
Hospitalization
Ambulatory care

Preventive services
Occupational health and safety
Immunizations
Maternal and child health

Environmental services
Vector control
Sanitation
Safe water

A modest ten bed hospital of 6,000 square feet is shown in the sketch (Figure V 2) on page 66. This unit was planned to serve the needs of a development project in West Africa (43). It is of modular design and was prefabricated to allow for rapid erection at the work site at the very beginning of the project. Complete medical care was available for the treatment of work injuries and acute illnesses during the critical early days of project construction. An air-conditioned structure of this type can be provided for approximately $25 per square foot. It may serve as the intensive medical care unit. One or more simple satellite units at the work site may be required for first aid treatment of job injuries. Other satellite facilities for the care of ambulatory patients may be established nearer the housing areas. The cost of operation depends largely upon factors such as the *number of persons to be cared for, the availability of local* versus expatriate professional staff, the local availability of drugs and supplies, and the accessibility of referral centers.

The provision of *community health services* may become the responsibility of the Project Authority, at least temporarily, if government or private services are not established. It is highly desirable that what is done in this respect is consonant with the aims of national health planning in the country. There is a pronounced tendency to "spin off" the responsibility for nonindustrial health services from development projects to community organizations or to government as the project matures (44).

F. Proposed Administrative Structure for Implementation

Responsibility
Regulations
Funding

The *responsibility* for attention to health factors on a development project is *often shared by the Project Authority and the Ministry of Health.* Under these circumstances, the Project Authority may assign a portion of its task to construction contractors under the terms of a master agreement. The Authority may also operate a separate health unit, perhaps with personnel posted to it from the Ministry of Health, which is likely to serve as the main technical resource on health matters. Depending upon project requirements, control teams may be organized for health survey work, environmental sanitation, vector control, and for other special measures deemed necessary. Provisions should also be made for the staffing and operation of hospitals, clinics or dispensaries that may be established.

Various sanitary *regulations* are desirable for many development projects. These spell out specific responsibilities for each of the several entities that may be engaged in the project, such as government agencies, contractors and the Project Authority.

Adequate *funding* of provisions to carry out health measures is an essential part of project planning, since even the most basic and indispensable health conservation activities cannot be carried out in the absence of fiscal provisions.

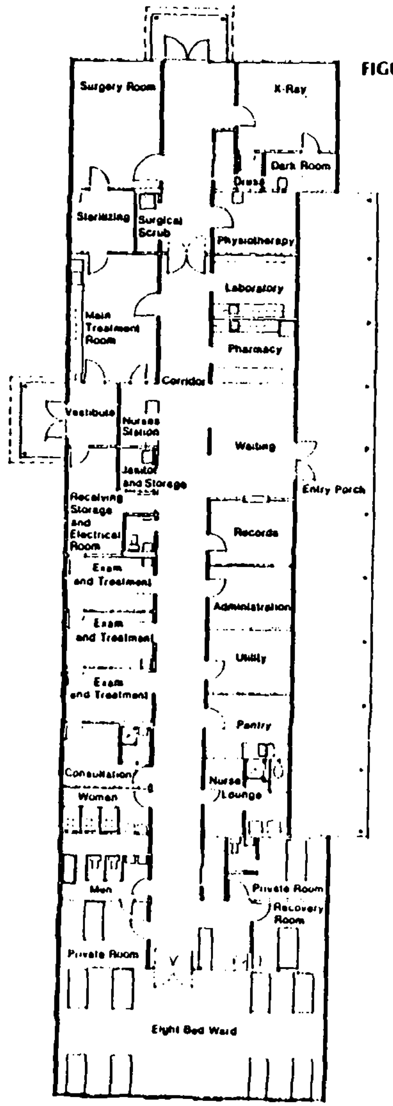
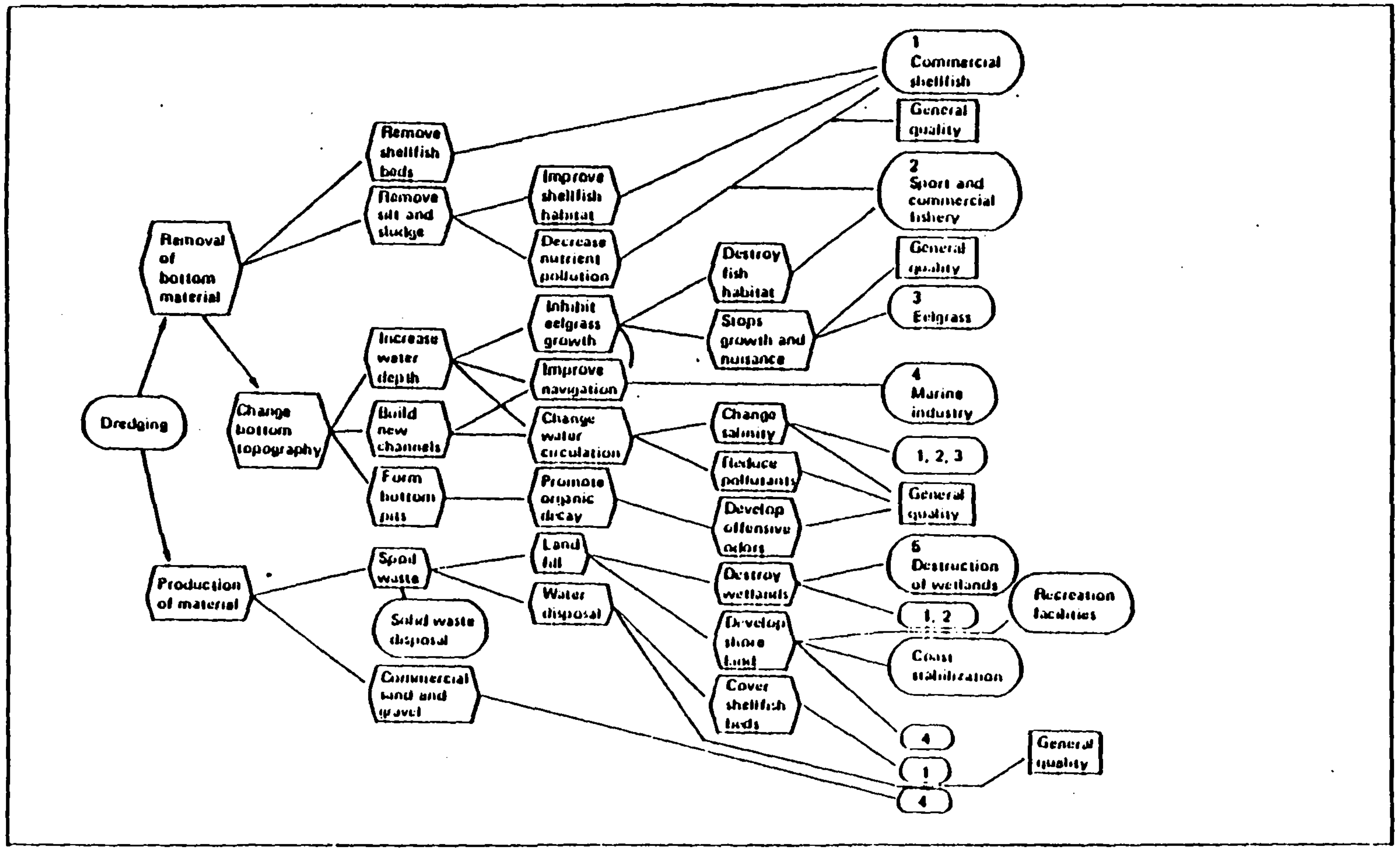


FIGURE V.2 Hospital Plan

Source: World Bank. Environmental Health and Human Ecologic Considerations in Economic Development Projects. World Bank: Washington, 1974, updated 1983.

ATTACHMENT 6: A NETWORK OF ENVIRONMENTAL IMPACTS



(N.B. For Coastal Zone EIA, USA application)

Source: Sorensen, J.C.; A Framework for Identification and Control of Resource Degradation and Conflict in the Multiple Use of the Coastal Zone; Department of Landscape Architecture, College of Environmental Design, University of California, Berkeley, USA, 1971.

ATTACHMENT 7: EXAMPLE OF VERBAL RATING SYSTEM

Rating Assignment System for Evaluation Matrix:

+5 Major long term, extensive benefit (highest possible rating).

+4 Major benefit, but characterized as either short term or of limited extent.

+3 Significant benefit; either long term covering a limited area, or short term covering an extensive area.

+2 Minor benefit, but of a long term or extensive nature.

+1 Minor benefit over a limited area.

0 No impact.

-1 Minor adverse effects over a limited area.

-2 Minor adverse effects, but of a long term or extensive nature.

-3 Significant adverse effects; either long term covering a limited area, or short term covering an extensive area.

-4 Major adverse effects but characterized as either short term or of limited extent.

-5 Major long term, extensive adverse effects (lowest possible rating).

Source: Environmental Impact Statement for the Construction of a Waste Water Treatment Plant for Jackson, USA.

ATTACHMENT 8: CHECKLIST OF ENVIRONMENTAL COMPONENTS

PHYSICAL COMPONENT

Water Quality Category

Water Quality Standards
Non-Point Source Problems
Constraints by Water Quality Problems

Air Quality Category

Conformence with Air Quality Standards
Extent of Environmental Degradation
Adverse Impacts on Flora
Air Quality Problems Attributable to Human Activity

Sound Quality Category

Critical Sound Levels
Temporal Distribution of Sound Problems
Institutional Mitigation Measures

Visual Quality Category

Scale
Variety
Naturalness
Human Usage

Land Quality Category

Land Use
Land Degradation
Land Use Regulations

Geological Resources Category

Processes and Formations
Fossil Beds
Uniqueness
Educational and Scientific Value
Legal and Administrative Protection

ECOLOGICAL COMPONENT

Biological Resources Category

Aquatic Flora
Trees
Grasses and Shrubs
Aquatic Animals
Terrestrial Animals
Endangered and Threatened Species
Unique Biota
Educational and Scientific Value
Legal and Administrative Protection

Ecological Systems Category

Ecosystem Type
Ecosystem Quality
Uniqueness
Educational and Scientific Value
Legal and Administrative Protection

Wetland Areas Category

Wetland Areas
Water Quality
Productivity
Uniqueness
Educational and Scientific Value
Legal and Administrative Protection

Wilderness, Primitive and Natural Areas Category

Size
Significant Topographic Features
Significant Water Features
Educational and Scientific Value

CULTURAL COMPONENT

Historical and Archaeological Resources Category

Sights
Level of Investigation
Educational Value
Symbolic Land Features
Extent Used by Public
Protection of Significant Sights

RECREATIONAL COMPONENT

Streams and Stream Systems Category

Amount of Significant Land/Water Features
Degree of Flow Regularity
Type of Flow
Stream Use for Recreation

Shores Category

Availability for Recreation
Susceptibility to Adverse Impacts
Physical Acceptability
Projected Shoreline Use
Development Controls

Lakes and Reservoirs Category

Number of Lakes
Area of Lakes
Water Quality
Productivity
Uniqueness
Recreation
Legal and Administrative Protection

Open Space and Greenbelts Category

Sufficiency of Open Space
Diversity of Land Uses Classified as Open Space
Extent to which Open Space Can be and Is being Used
Diversity of Public Use Facilities Available
Extent of Development Controls in Area

Source: Duke, K.M. et al., Battelle Columbus Laboratories.

ATTACHMENT 9: CHECKLIST OF ENVIRONMENTAL FACTORS

G6 : COMPONENTS AND SUBCOMPONENTS OF THE ENVIRONMENT

PHYSICAL

1. Geology

- 1.1 Unique Features
- 1.2 Mineral Resources
- 1.3 Slope Stability/Rockfall
- 1.4 Depth to Impermeable Layers
- 1.5 Subsidence
- 1.6 Consolidation
- 1.7 Weathering/Chemical Release
- 1.8 Tectonic Activity/Vulcanism

2. Soils

- 2.1 Slope Stability
- 2.2 Foundation Support
- 2.3 Shrink-Swell
- 2.4 Frost Susceptibility
- 2.5 Liquefaction
- 2.6 Erodibility
- 2.7 Permeability

3. Special Land Features

- 3.1 Sanitary Landfill
- 3.2 Wetlands
- 3.3 Coastal Zones/Shorelines
- 3.4 Mine Dumps/Spoil Areas
- 3.5 Prime Agricultural Land

4. Water

- 4.1 Hydrologic Balance
- 4.2 Ground Water
- 4.3 Ground Water Flow Direction
- 4.4 Depth to Water Table
- 4.5 Drainage/Channel Form
- 4.6 Sedimentation
- 4.7 Impoundment Leakage and Slope Failure
- 4.8 Flooding
- 4.9 Water Quality

5. Biota

- 5.1 Plant and Animal Species
- 5.2 Vegetative Community
- 5.3 Diversity
- 5.4 Productivity
- 5.5 Nutrient Cycling

6. Climate and Air

- 6.1 Macro-Climate Hazards
- 6.2 Forest and Range Fires
- 6.3 Heat Balance
- 6.4 Wind Alteration
- 6.5 Humidity and Precipitation
- 6.6 Generation and Dispersion of Contaminants
- 6.7 Shadow Effects

7. Energy

- 7.1 Energy Requirements
- 7.2 Conservation Measures
- 7.3 Environmental Significance

SOCIAL

8. Services

- 8.1 Education Facilities
- 8.2 Employment
- 8.3 Commercial Facilities
- 8.4 Health Care/Social Services
- 8.5 Liquid Waste Disposal
- 8.6 Solid Waste Disposal
- 8.7 Water Supply
- 8.8 Storm Water Drainage
- 8.9 Police
- 8.10 Fire
- 8.11 Recreation
- 8.12 Transportation
- 8.13 Cultural Facilities

9. Safety

- 9.1 Structures
- 9.2 Materials
- 9.3 Site Hazards
- 9.4 Circulation Conflicts
- 9.5 Road Safety and Design
- 9.6 Ionizing Radiation

10. Physiological Well-Being

- 10.1 Noise
- 10.2 Vibration
- 10.3 Odor
- 10.4 Light
- 10.5 Temperature
- 10.6 Disease

11. Sense of Community

- 11.1 Community and Organization
- 11.2 Homogeneity and Diversity
- 11.3 Community Stability and Physical Characteristics

12. Psychological Well-Being

- 12.1 Physical Threat
- 12.2 Crowding
- 12.3 Nuisance

13. Visual Quality

- 13.1 Visual Content
- 13.2 Area and Structure Coherence
- 13.3 Apparent Access

14. Historic and Cultural Resources

- 14.1 Historic Structures
- 14.2 Archaeological Sites and Structures

USE OF VERBAL SCALES OF IMPACT SIGNIFICANCE

IMPACT SCALE

A+ **Desirable**

Effects which are clearly beneficial are generated. (For some subcomponents, this level of impact is generally unlikely to occur.)

A **Acceptable**

Based upon all available information, there is a low likelihood that an environmental problem will occur if the project is implemented as planned.

B **Questionable or Uncertain**

Based upon available information, there is a small likelihood that an environmental problem may occur, but its severity is such that discretion is permitted. Mitigative action can reduce or alleviate the potential problem if implemented. (Implementation of mitigative action, if verified, would suggest that an A rating may be given.)

C **Undesirable**

Based upon available information, there is a high likelihood that an environmental problem will occur if the project is implemented as proposed. (That is, no mitigative action is proposed, or none is possible.)

C- Information indicates that the project will violate a HUD standard or that of another Federal, state, or local agency. (For some subcomponents, no generally accepted standards have been developed.)

SUBCOMPONENT - WETLANDS

A+ The project will not encroach upon existing wetland in any way.

A The project may encroach upon an existing wetland but measures can be taken to reduce or eliminate any potential adverse impacts.

B The project will encroach upon an existing wetland. Mitigative techniques may reduce adverse impacts.

C The project will encroach upon an existing wetland.

C- The project does not comply with state or local regulations governing wetlands.

ATTACHMENT 9 (Continued): A SUGGESTED IMPACT SUMMARY TABLE

TECHNICAL ASSESSMENT FORM

	Normal Clearance
	Special Clearance
	EIS

Subcomponent	Impact	Scale of Impact					?	Additional Information Required	Higher Level Tests Performed
		A+	A	B	C	C-			
All 80 Principal Components from the Technical Assessment Guidelines would be listed here	The impact question of each Subcomponent from the Technical Assessment Guidance Material would be listed here	The assesser places (✓) in appropriate column based on Initial Screening or Higher Level Tests					*	The assesser places (✓) here if Critical Concern cannot be answered through information and procedures from Initial Screening Test	The assesser places a (✓) here if a (✓) under the Scale of Impact was a result of Higher Level Tests

*The assesser places a (✓) here if there is a lack of sufficient information on which to base assessment.

(N.B. for USA application)

Source: Planning Environment International. Interim Guide for Environmental Assessment. Department of Housing and Urban Development. USA, 1975.

ATTACHMENT 10: CRITERIA FOR ASSESSING SIGNIFICANCE

LIST OF CONSIDERATIONS FOR EVALUATING SIGNIFICANCE

1. Impacts that may be both beneficial and adverse. A significant effect exists even if the Federal agency believes that on balance the effect will be beneficial.

2. The degree to which the proposed action affects public health or safety.

3. Unique characteristics of the geographic area, such as proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas.

4. The degree to which the effects on the quality of the human environment are likely to be highly controversial.

5. The degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks.

6. The degree to which the action may establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration.

7. Whether the action is related to other actions with individually insignificant, but cumulatively significant impacts. Significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment. Significance cannot be avoided by terming an action temporary or by breaking it down into small component parts.

8. The degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or may cause loss or destruction of significant scientific, cultural, or historical resources.

9. The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act of 1973.

10. Whether the action threatens a violation of Federal, State or local law or requirements imposed for the protection of the environment (40 CFR 1508.27)

(N.B. for USA application)

Source: Department of Agriculture, Forest Service. The NEPA Process Handbook Draft. FSH 1909.15. USA, 1980.

ATTACHMENT 11: ORGANISATION OF INFORMATION SHOWING IMPACTS OF DIFFERENT USERS

Group 3: Users of facilities

Sub group users of: –	Effect	Units	Modified Blue	Modified Green	District Council Route	Do Minimum	Comments
a. Town Centre Shoppers High St./Market St. (100,000-140,000 shoppers per week)	Reduction of vehicle/pedestrian conflict	Verbal description of effect	Reduces and diverts traffic sufficient to allow pedestrianisation	As modified Blue	As modified Blue	Existing pedestrian/vehicle conflict will increase with traffic growth	Based on updated County Council 1967 Shopping Study amended in 1975 Structure Plan
b. Community Centre (i) Civic Theatre. (Used by average of 300 people each week in 1977)	Change in traffic noise in auditorium	dB(A)L_{10}	5dB(A)L_{10} reduction	3dB(A)L_{10} reduction	3dB(A)L_{10} reduction	To maintain current noise level will require extensive sound proofing and air conditioning	Reductions are mainly in peak traffic periods and significant mainly at weekends
(ii) Public Library. (Used by average of 1,200 people each week in 1978)	Change in traffic noise in reading room	dB(A)L_{10}	3dB(A)L_{10} reduction	3dB(A)L_{10} reduction	3dB(A)L_{10} reduction	Existing noise will increase with traffic growth	
(iii) Day Care Centre. (Used by average of 400 old age pensioners and helpers each week in 1978)	Effect on access for the elderly	% change in traffic flow	35-40% reduction in traffic	35-40% reduction in traffic	35-40% reduction in traffic	Increase in traffic	Average age of members 74 years
c. Warren Street shops	Convenience of customers	Verbal description	No facilities on new route	As modified Blue	As modified Blue	No effect	
d. Horton Golf Club (382 members in 1977)	Reduction of amenity due to land take	Verbal description	No effect	Reduced to 17 holes. Substantial redesign and construction could restore it to 18 holes but would require closure for 2 growing seasons	Remains at 18 holes but edge of course adjacent to 12th hole is taken	No effect	
e. Sailing Club (106 members in 1977)	Reduction in amenity (visual intrusion, sailing conditions, etc.)	Verbal description	7.6m embankment and river bridge effectively prevents sailing on last 200m of course	8.5m embankment and river bridge effectively prevents sailing on last 100m of course	7m embankment and river bridge cut sailing course approx. in half	No effect	Few sailing clubs in the area. Recently built club house supported by Sports Council
f. Horton Hunt (236 members in 1978)	Severance	Verbal description	2 fox runs north of town severed	As modified Blue	As modified Blue	No effect	
g. North Waston Ornithological Society (57 members in 1977)	Loss of abandoned gravel pits	Verbal description	Gravel pits partly filled. Proximity of new road will disturb birds	As modified Blue	Eastern part of gravel pits filled. Proximity of new road will disturb birds	No effect	
h. Barchester Fishing Club (85 members in 1978)	Loss of fishing rights in gravel pits	Verbal description	Gravel pits partly filled preventing fishing	As modified Blue	Eastern part of gravel pits filled leaving only a quarter of original area for fishing	No effect	
i. Low Road Methodist Chapel (Average congregation 35)	a. Noise increase	dB(A)L_{10}	5dB(A)L_{10} increase	3dB(A)L_{10} increase	9dB(A)L_{10} increase	No effect	These increases are less apparent on Sundays
	b. Visual obstruction	Verbal description	6m embankment 30m from church	As modified Blue	8m embankment 25m from church		
	c. Severance from main part of town	Verbal scale	Slight severance	Slight severance	Moderate severance	No effect	Land take effects appear in Group 2. Compensation in Group 6

(N.B. For Highway EIA, UK application)

Source: Department of Transport; Trunk Road Proposals - A Comprehensive Framework for Appraisal; The Standing Committee on Trunk Road Assessment (the Leitch Committee), UK, HMSO 1979

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