SUPPLEMENTARY ISSUE

DAMS & RESERVOIRS

EMBANKMENT DAMS

INVESTIGATION, INSTRUMENTATION AND MONITORING

CONCRETE DAMS AND SERVICE RESERVOIRS

DAM SAFETY, STANDARDS, RESERVOIR MANAGEMENT

BDS

THE BRITISH DAM SOCIETY

Published by the British Dam Society at the
Institution of Civil Engineers, Great George Street
London SW1P 3AA

CONTENTS

PREFACE

This volume contains the complete record of discussions from the Ninth Conference of the British Dam Society entitled `The Reservoir as an Asset' which was held at the University of York, 11-14 September 1996.

The twenty-eight papers which were discussed were published as a separate book published by Thomas Telford Services Ltd and available from the bookshop at the Institution of Civil Engineers, Great George Street, London SW1P 3AA.

NINTH BRITISH DAM SOCIETY CONFERENCE

UNIVERSITY OF YORK, 11-14 SEPTEMBER 1996

THE RESERVOIR AS AN ASSET

The Society's Ninth Conference was held at the University of York which provided excellent facilities for the conference. Twenty-eight technical papers were presented covering a wide range of topics under the general conference theme of `The reservoir as an asset'. Individual sessions addressed the subjects of `embankment dams', `Investigation, Instrumentation and Monitoring', `Concrete Dams and Service Reservoirs', and `Dam Safety, Standards and Reservoir Management'. An additional paper was also given at the conference on the Environment Agency's proposed approach to reservoir enforcement; this will be applicable in the event that the Environment Agency becomes responsible for the enforcement of legislation in England and Wales.

There were 138 delegates at the conference and 16 accompanying persons for whom there was a full programme of visits and excursions. Yorkshire Water kindly hosted technical visits to Grimwith Dam (47 metre high embankment dam with a rolled clay core completed in 1983) and to Scar House (71 metre high masonry faced concrete gravity dam completed in 1936).

The keynote Geoffrey Binnie lecture was given on the subject `Reservoirs : Bane or Boon?' by Dr. Theo van Robbroek, president of ICOLD. The lecture was published in full in the November 1996 issue of `Dams and Reservoirs' and again in this volume representing a vigorous defence of dam construction and questioning the validity of the currently fashionable anti-dam and anti-development philosophies.

Since the conference many of us have been saddened by the death of Peter Milne of Severn Trent Water who, despite being very unwell, bravely insisted on presenting his paper in Session 4 of the conference. His obituary was printed in the July 1997 edition of `Dams & Reservoirs'.

Many people contributed to the success of the conference and particular thanks are due to the session chairmen, authors, presenters, technical reporters and contributors to the discussions. I would also like to thank my colleagues on the Organising Committee who worked so hard to make the conference a success.

Jonathan Hinks
Chairman, Conference Organising Committee

OPENING REMARKS

by Charles Perrings, Professor of Environmental Economics and Environmental Management, University of York.

In its last report on the state of the environment the World Watch Institute cited four environmental problems that are key to the sustainability of economic development [1].

Top of the list was water scarcity. Water scarcity is what lies behind such engineeringly daunting schemes as the proposal for a 1400 km canal to bring water from Southern China to Beijing to meet the problem of water deficit in Northern China — comparable to bringing water from the Mississippi to Washington DC. Water is also a common link in most other environmental problems. Three others currently attracting most attention in developing countries are deforestation, desertification and pollution. Deforestation and the desertification affect the the hydrological cycle, and are linked with water depletion. Pollution in the developing countries is above all pollution of water sources.

Water depletion is a concern for many reasons, not least being the scarcity of water for direct human consumption. From an environmental perspective, however, its main significance is the impact it has on plant available moisture and so the stucture and productivity of ecological and agro-ecological systems. Ironically, water pollution is important for much the same reasons.

Water depletion and dams

I recently had occasion to review the relative intensity of renewable water use and the sectorial distribution of renewable water withdrawals over the period 1972-1992. Only the Middle East and North Africa (73%) come close to using all the available renewable water resources. In most cases, developing countries used less than 10% of available renewable resources in this period.

The problem in these countries is the depletion of groundwater reserves at rates in excess of the recharge rate due to:

- a reduction in recharge rates as a result of the diversion of surface flows;
- increased runoff caused by deforestation;
- long-run changes in precipitation and temperature;
- increase in the direct depletion of groundwater reserves through private tubewells.

[1] *World Watch Institute, State of the World 1995, London, Earthscan, 1995*

Water availability in developing countries, 1970-1992

	Total annual internal renewable water resources (km³)	Total annual water w'drawal (km³)	Annual w'drawal as a share of total water resources (percent)	Per capita anual internal renewable water resources (m³)	Per capita annual water w'drawal (m³)	Sectorial withdrawal as a share of total water resources (percent)		
						Agri-culture	Dom-estic	Ind-ustry
Sub-Saharan Africa	3,713	55	1	7,488	140	88	8	3
East Asia & Pacific	7,195	631	8	5,009	453	86	6	8
South Asia	4,895	569	12	4,236	652	94	2	3
Europe	574	110	19	2,865	589	45	14	42
Middle East & North Africa	276	202	73	1,071	1,003	89	6	5
L. America & Caribbean	10,579	173	2	24,390	460	72	16	11
Other Economies	4,486	375	8	13,976	1,324	66	6	28

Source: The World Bank, Development Report 1992

The World Watch Institute report already referred to notes that two thirds of all water extracted from rivers and aquifers is used for irrigation, and that in many areas water demand for irrigation is significantly in excess of recharge.

GEOFFREY BINNIE LECTURE 1996
RESERVOIRS: BANE OR BOON ?

By Theo van Robbroeck PrEng BSc BEng PhD(Eng)hc CEng FICE FSAICE

INTRODUCTION

I have spent forty years of my life in water resource development and management in South Africa. Was my career in vain? Did I do more harm than good? Were the careers of Geoffrey Binnie, his father and grandfather in vain and did they do more harm than good? Did they leave the world a better place or did they assist in destroying our environment? Are the reservoirs created and managed by you, members of the British Dam Society, a bane or a boon for the community? Are ICOLD's members only in it for profit? These are not frivolous questions. There are many men and women, often well educated ones, who have been led to believe, and are genuinely convinced, that the creation of major storage reservoirs is an unmitigated disaster. We can shrug off these opinions as ill informed and naïve, but that would be short sighted, and would come to be regretted.

The very fact that the memory of Geoffrey Binnie is being honoured by this prestige lecture answers my questions decisively as far as you are concerned! I consider it a great honour to have been asked to follow in the footsteps of preceding speakers, eminent engineers like David Coats, Paul Back, Wolfgang Pircher and Michael Kennard, all of whom I came to know during my professional career. I even had the pleasure of meeting Mr Binnie himself, while his firm and I were working on the plans for the Lesotho Highlands Water Project, the first phase of which is now nearing completion. While reading his CV, I was particularly struck by the breadth and depth of his knowledge and experience and the major role he played in the development of the science and engineering of large dams! His involvement with the Mangla dam, which plays such an important role in the Indus Basin Treaty, and thus in the relative peace between India and Pakistan is especially noteworthy. I shall come back to that issue later.

THE ANTI DAM LOBBY

The first time I came into personal contact with the anti dam movement was during the San Francisco Congress of ICOLD in 1988, where an organisation calling itself ICALD: "International Committee Against Large Dams" had the temerity to rent space in the official ICOLD exhibition to put their case! Having spent my whole career in South Africa where large dams are at par with motherhood and apple pie, I was astonished, but not particularly worried. It was only later, when ordinary well meaning people began speaking to me about the evils of the Aswan dam, and other reservoirs created by man, did I come to realise that this campaign was a serious threat to such schemes in the future.

Typical objections against large dams/reservoirs can be divided into two categories: those directly related to the dam/reservoir, and those related to the use the water is put to:

Category 1:

- Resettlement of people, especially the poor and ethnic groups
- Loss of land and forests
- Loss of fauna and flora, especially threatened species
- Loss of fertilising silt downstream
- River bed and coastal erosion
- Reduction of water quality
- Loss of water to evaporation
- Reservoir sedimentation
- Loss of fisheries
- Loss of recreation potential
- Induced earthquakes
- Risk of failure
- Loss of cultural heritage

Category 2:

- Water borne diseases and pests
- Salination of soil
- Pollution resulting from water use
- Exaggeration of benefits and underestimation of costs

Some of these objections are real in particular cases, and must be addressed seriously. But should this cause the world to shy away from regulating its rivers and utilising their waters?

During my speech at the closing ceremony of the 1994 ICOLD Congress in Durban, at the start of my term of office, I said the following:

"I want to be the ICOLD President who in particular fosters the interest of that part of the world which is euphemistically called all sort of names such as developing countries, countries on the way to development, or third world. We need large dams, and we are not going to apologise for that. It is all very well for those who have everything, or even too much of everything to put stumbling blocks in the way of the have - nots while in pursuit of their hobbies in the comfort of their air conditioned and heated homes. We want to be a vibrant corps of dam engineers who assist in uplifting the people and freeing them of the bondage of poverty. We want our colleagues from the so called first world to push with us in the scrum, to pull with us on the rope, to jump with us over the hurdles. That will be my mission as President of ICOLD during the coming three years."

When Dr Geoff Simms invited me at that time to deliver this lecture here in York, I had this mission in mind and intended to speak about the excesses of the anti dam lobby and what to do about it. When Alan Johnston sent me some of the previous lectures, I discovered to my horror that my predecessor, Wolfgang Pircher had broadly used the same theme, and had treated it in a most competent way, impossible to improve upon. I nevertheless decided to press on, but to highlight the subject from the standpoint of one who has spent most of his career in the service of the Department of Water Affairs, the Central Government agency responsible for the development and management of South Africa's water resources; and South Africa is still very much part of those countries in need of development. Also, in the period that has elapsed since his lecture, some events took place that are worth mentioning.

1984 saw the publication of the often referred to "The Social and Environmental Effects of Large Dams" by E Goldsmith and N Hildyard, published by the Wadebridge Ecological Centre, here in the UK. I am grateful that this lecture caused me to read that book from cover to cover. That gave me an insight in the attitude of the authors and others of the same ilk. They are not opposed to large dams only, but indeed, they are opposed to any project that utilises water on any scale except on the smallest possible; in fact, they oppose economic development of any kind. Let me illustrate this.

Under the title "The Lure of Hydro Power", and referring to the proposed "Grande Carajas" project in Brazil, they mention that *"a total of 39 billion dollars will be spent on an assortment of mineral and metallurgic schemes, on agriculture, and on ranching and forestry in the area. Twenty two billion dollars will alone be invested in building the infrastructure the roads, motor ways, cities and ports necessary to "open up" the Carajas region."* I have no personal knowledge of this project and thus cannot confirm its merits or otherwise. I only want to illustrate the clear anti development bias that runs like a thread through the book. Let me give some further examples.

Throughout the book, the authors attack any form of modern irrigation, even the raising of two crops per year, on the grounds that it creates habitats for mosquitos and other pests to breed, thus increasing the incidence of diseases. In the process they do not even mention that undernourished people are likely to be fed and clothed with the produce. While discussing the fact that such people are more prone to infection they state: *"Indeed, the French have an old saying "Le traitement du paludisme est dans la marmite" (the cure for malaria lies in the cooking pot). That saying is particularly relevant where large scale water projects are concerned. Inevitably, such projects tend to draw immigrants to the area, attracted by the prospect of jobs. More often than not those immigrants are impoverished and under nourished"*

Yes indeed, in our part of the world people do need jobs, allowing them to eat a proper meal, and thus becoming more resistant to diseases.

Elsewhere, the authors make the scathing remark: *"Foreign exchange must take priority over health"*. We know that foreign exchange is needed to enable a country to progress beyond a subsistence economy. It is clear that for some, the underdeveloped world should stay in that state!

Even the "Green revolution", which enabled countries such as Indonesia to feed itself, where they had to import much of their food before, is being attacked on the ground that the "high response" varieties of rice and other crops require pesticides and artificial fertiliser. This Green Revolution and other development projects allowed Indonesia to increase the per capita income from $50 in the 1960s to $1000 in the 90s, notwithstanding an increase in population from 115 million to 204 million in the same period. (Newsweek July 8, 1996)

The fact that in many large scale irrigation projects cash crops are grown for export, instead of for local food consumption is criticised. No mention is made that these cash crops are generally of higher value and that, with the proceeds, more food could be imported than can be grown locally on an equivalent area!

On the same theme, Pravin Sheth quotes the extremist views of Lutzenberg, the Brazilian ecologist, speaking in Bangalore in 1993: *"In today's world no one is free but those who produce their own food. But because you are free, you are the highest threat to the system, and they will try to get rid of you. They will introduce technologies in the name of progress, destructive mechanisms to eliminate you. Technology is used as an instrument of enslavement."*

Agri business is attacked in the following paragraph: *"In Kenya, Pan African Vegetable Products, a company set up by Brueker Werker of West Germany and financed by, among others, Barclays Overseas Development grows some 18,000 tons of vegetables a year on 800 acres of irrigated land. Five thousand outgrowers supply the company with another 18,000 tons a year. Ninety per cent of all those vegetables are dehydrated and exported to West Germany and other European countries".*

The question can be asked on what grounds these people denigrate a venture that clearly provides work to so many people?

The following needs no comment: *"Elsewhere, the introduction of electric light has been sufficient to cause cultural breakdown."*

Maybe the most telling quote illustrating the anti development bias appear in the chapter on "Dams, Pollution and the Reduction of Food Supplies": *"To conclude, by building dams to increase the Third World's hydro electric capacity one provides power for further urbanisation and industrialisation, and that not only uses up the land and water which are so desperately needed to produce food but also generates pollution. That, in turn, can only serve to reduce crop growth and annihilate fish stocks, thus further exacerbating malnutrition and starvation."*

What these people seem to advocate is a return to the primitive life, at least for the "South". They would like to reintroduce the Persian Wheel and the Qanats (already in disuse since the 13th century but now advocated even for supplying Teheran!). Admittedly, these were admirable human endeavours, but surely cannot sustain vastly increased populations. Modern science and technology has upset the population balance, and now it is only science and technology that can come to the rescue, unless they consider mass starvation as an option. These same people also campaign against hydro electric projects, but then, neither do they want fossil fuel or nuclear stations.

A zero growth option might be acceptable in their part of the world where there is a stable population, or a declining one such as already in some countries. Even without further growth of their economies, these rich countries can provide a decent standard of living to their inhabitants, provided of course that they can keep the hungry masses out.

They want forests to be protected, which is laudable, but at the same time resist the introduction of electric power, which would largely obviate less developed people from having to rely on the forest for firewood. They look at the existence of tribal people through rose tinted spectacles. But do these people indeed have a future for their way of life, or do they just have to be kept that way as a curiosity or as a subject of study for the anthropologist? As Verghese puts it: *"There is a certain callousness and arrogance in attitudes that demand that tribal people be denied a choice and be compelled to live in romanticised misery as social relics".*

BENEFITS OF RESERVOIRS

There are many well meaning people in Europe and the United States who are not extremists like the fundamentalists who want to stop the world, but who nevertheless have been led to believe that large reservoirs are an evil. Maybe some of you may have started to doubt the merits of your work yourself.

Let us then look at the situation in South Africa, to see what the country would have looked like if we would have had to do without our storage reservoirs.

SOUTH AFRICA

I suppose that even without the early irrigation schemes planned and designed by British engineers who gained their experience in the colonial service in India and in Egypt, the country could have survived. But modern South Africa, with an infrastructure which is the envy of the rest of the continent would not have existed. Gold mining on the Witwatersrand, on the continental watershed, gave rise to a sophisticated service industry located near the mines. As it happens, most of the coal, which is the primary source of electric energy in the country, is also found in the general area. About a fifth of the country's population was attracted to this complex. Because there is no perennial substantial water resource nearby, and even the nearest substantial river, the Vaal River (the root of the name Transvaal) has insufficient dependable flow to be able to meet the demands imposed on it. As a result 7881 million m^3 of reservoir capacity created by 18 dams now exists to regulate the river sufficiently to meet the demands put on it. (Not counting numerous smaller reservoirs for cattle drinking and small scale irrigation). A further 1410 million m^3 of storage regulate neighbouring rivers for inter basin transfer to the Vaal River. The Katse Dam in Lesotho, will shortly be completed for the same purpose, with a live storage capacity of 1519 million m^3. This totals to some 10 800 million m^3, equal to 170 % of the total storage capacity in Great Britain. (Obtained from the latest edition of the World Register of Large Dams)

That these reservoirs were indeed needed was demonstrated conclusively during the prolonged drought which ended with heavy rains during the southern hemisphere summer of 95/96. Storage was depleted to such extent that draconian water restrictions had to be imposed. Only 29% of live capacity was left, without knowing whether the drought would not continue for another season or more! Severe water restrictions had to be imposed.

Without these reservoirs, these heavy rains would have caused far more havoc than they already did upstream of the reservoirs. The flood below the Vaal dam was attenuated from 4965 m^3/s (the highest since records started in 1895) to some 2400 m^3/s, just within the capacity of the river. Previous discharges, higher than this, but much lower than the incoming flood, caused major damage. A clear case where damaging discharges were converted into supplies to overcome the next drought.

There have no doubt been social and environmental costs associated with the building of these dams and the filling of these reservoirs. Most were constructed before the world became aware of such costs. It is probably too late to establish them in retrospect. But what is certain is that the direct and indirect benefits brought about by these reservoirs are so huge, that there is no comparison. Even more storage will be needed, because large parts of the country still lack a safe and dependable source of domestic water, and rapid industrialisation is essential to provide the growing population with a source of income. The rural areas are already severely over populated, causing over grazing, severe soil erosion and general destruction of the habitat. The previous Government of the country tried to keep the tribal people on the land, as now seemingly advocated by Çeco fundamentalists, with disastrous consequences. They are now streaming towards the cities, where they lead a far from ideal life, but where they are generally better off than where they came from. An almost immediate benefit of this urbanisation process is a substantial lowering of the birth rate. In Gauteng, the most urbanised province containing Johannesburg and Pretoria, fertility is 3,0 children per woman, compared to the largely rural Northern Province's 4,7. An excessive birth rate is the true cause of most of the ills our world is experiencing presently. A campaign to prevent further reservoirs being created is certainly not going to assist the South African people.

Nevertheless, notwithstanding the great care taken in minimising negative social and environmental impacts in the case of the Katse Dam, already mentioned, "World Rivers Review" (May 1995), published by the "International Rivers Network" refers to a report mentioning worsening conditions there. *"Insufficient provision of water and sanitation to communities and schools was among those "worsened" conditions. The Panel refers to a 1993 study conducted by the Lesotho Highlands Development Authority, which documented that more than 80 percent of children surveyed in the local area drank and washed in unprotected springs and nearly 50 percent of children attended schools with no latrines. The use of unsafe water and poor sanitation conditions have contributed to an increase in typhoid and child mortality in villages. The Panel's findings predict that health conditions will continue to deteriorate."*

This article creates the impression that the conditions there are the result of the Lesotho Highlands Project. I was personally intimately involved in this project, and know that the opposite is true! The project, as part of the associated social and environmental programme in fact makes provision for the improvement of sanitary conditions and water supply in the area, even far beyond the influence of the reservoir and associated works! This is a clear case of distortion bordering on lies. In June this year, these same people wrote to President Mandela questioning the LHWP apparently mainly on the grounds of its "massiveness" and its effect on the people and environment of Lesotho and areas downstream in both South Africa and Namibia. At the same time they admit that securing water for the millions without it is necessary. If one takes into account that the first two phases of the project are only sufficient until 2006, and that water in the recipient river is already recycled to such extent that hardly any reaches the sea, it is clear that only massive projects are able to meet the demands. The only alternative is stagnation and poverty, because the population continues to increase regardless. Their argument about the effect in South Africa and Namibia also hold no water: virtually the total length of the river there has already been regulated by the two largest reservoirs in South Africa, and the only effect is increased abstraction, which would take place regardless of the presence of the LHWP. Even within Lesotho, the releases for in stream requirements ensure a healthy river, while the country benefits from massive royalty payments.

MANGLA

I have already mentioned the Mangla Dam in Pakistan, where Geoffrey Binnie played such an important role. I asked ICOLD Vice President Asif Kazi for some information on the benefits brought about by this dam since its commissioning almost 30 years ago, because in my preparation for this lecture, I came across the usual criticism. He was so kind as to produce a brief write up from the enormous literature available on Mangla Dam, for which I am very grateful. I would like to mention the facts here, even if they may be familiar to some of you:

When the Indian sub continent was partitioned in 1947 along a line crossing the highly developed irrigation systems of the Indus Basin, India, which is the upstream riparian State, cut off the water in the canals crossing into Pakistan. This obviously created a major dispute and war threatened.

Davis E Lilienthal, formerly of the Tennesse Valley Authority, suggested an "engineering solution", to be financed by the World Bank. This resulted in the Indus Waters Treaty of 1960. The use of the three eastern tributaries, the Ravi, Beas and Sutlej were allocated to India and the three western rivers, the Indus, Jhelum and Chenab to Pakistan. Certain link canals from the western rivers were to be constructed to replace Pakistan's irrigation use on the eastern rivers. However, these measures were not sufficient, and storage within Pakistan was also required. Mangla Dam became a major component of the replacement engineering works. The reservoir assured a regular supply of irrigation water to Pakistan, and thus played a key role in maintaining peace in the sub continent.

Mangla now supplies irrigation water to approximately 3.25 million ha. The winter supplies of the Jhelum River were increased 200% from 3 700 million m^3 to 11 100 million m^3. This allowed effective distribution and efficient utilization during the critical dry period, resulting in a tremendous impact on the agricultural economy and eliminating crop failures of the past.

With the envisaged raising of Mangla Dam, an additional storage of 4 600 million m^3 would be available. A 9 900 million m^3 of future off channel storage reservoir at Rothas has been made possible by the construction of Mangla Dam. Since the commissioning of Mangla Dam in 1967, 120 billion kWh of cheap and environmentally friendly hydro electric power has been generated. If the water and power benefits alone are converted into direct financial gains, the Project has returned over 2 billion pounds by mid 1996, as against the total project construction cost of 200 million pounds.

While there is no specific reserve for flood control, its capability to regulate and mitigate flood peaks is considerable. For instance, the PMF peak of 73 600 m^3/s, when routed through the reservoir, will be reduced to a peak flood below Mangla to 34 000 m^3/s. The Mangla Dam was properly tested in 1992 when a historic flood exceeding 28 000 m^3/s was successfully routed through the dam.

Fisheries at Mangla are in operation since 1967. Since then, 14,700 metric tons of fish have been produced. According to Kazi: *"If factors like employment, fisheries, ecological improvement and other social benefits are taken into account, Mangla Dam can be considered as one of the most beneficial and successful projects in Pakistan's national development."*

Comparing these benefits to the economic, social and environmental devastation brought about by war, as experienced in Ruanda and in the former Yugoslavia, it seems churlish to attack the Mangla Dam for whatever shortcomings it may have, without even mentioning what it has meant, and continues to mean for the region.

ASWAN

One of the most viciously denigrated water resource developments is the High Aswan Dam with Lake Nasser behind it. Those of you who attended the one day symposium held in Cairo during the week of the 1993 Executive Meeting of ICOLD will be in possession of the papers presented there, which contain the facts about the pros and cons of this "pyramid for the living" as President Nasser put it at the time. The then Secretary General of ICOLD, Joannes Cotillon while summarising the proceedings made some telling remarks:

- that the stored water saved Egypt from famine in 1972/73 and again in the nine successive drought years 1979-87;
- that the reservoir protected the Nile valley from major floods in 1964, 1975 and 1988;
- that it enables double the previous population to be fed.

I doubt whether many well meaning critics know this. For them, it has become axiomatic that the High Aswan is a failure and a disaster for Egypt.

NARMADA

The controversy surrounding the development of the Narmada River in India, chiefly for irrigation and for urban water supply, has become a *cause célèbre* and has had a major influence on the policies of the World Bank and other financing agencies. Through the good offices of Mr Varma, Secretary General of the Central Board of Irrigation and Power, and a past Vice President of ICOLD, I obtained two books dealing with the Narmada and other controversial cases in India:

"Narmada Project Politics of Eco Development" by Pravin Sheth and "Winning the future From Bhakra to Narmada, Theri, Rajasthan Canal" by B.G. Verghese. The former is a Social Scientist and the latter a columnist on ecological issues. I found both books rather difficult to read, containing numerous abbreviations and some strange units of measurement for Westerners, but they contained detailed information both on the objections to the projects and on their benefits.

Briefly, the Narmada River, in contrast with most other major rivers in India, was largely unutilized, mainly because of the topography. It is shared by the States of Madhya Pradesh, Maharashtra and Gujarat, while Rajasthan, although not a basin state, was also allocated a share of its waters. The two principal dams proposed were the Indira Sagar Dam and the Sardar Sarovar, "temples of modern India", as Jawaharlal Nehru once called dam projects.

Originally, the campaign against these dams, and especially against the latter one, revolved around resettlement issues. Earlier disagreement between the States, mainly about water allocation, and the height of the proposed dams had been resolved amicably by the middle of 1974. After certain clarifications, this was made an order of a Tribunal under the Inter State Water Disputes Act at the end of 1979. This Tribunal also set out a "Resettlement and Rehabilitation Scheme", which at the time was considered very liberal. Every major son was to be treated as a separate family. Nevertheless, the World Bank insisted on even higher standards. Landless farm labourers and so called "encroachers" were to receive 2 ha compensation, often more than the area possessed by the communities among whom they were to be resettled. It had been planned to resettle some of the displaced people on degraded forest land. In the meantime a new "Forest Conservation Act" had been passed in 1980, forbidding any forest land to be diverted to other purposes, unless specifically sanctioned by the Central Government. This led to a shortage of land needed for resettlement and played into the hands of opponents. According to Verghese *"The Sardar Sarovar Project was caught on an escalator of evolving environmental cum land rehabilitation policies both on the part of the Government of India and the World Bank."* (p 134)

To give an idea of the scale of the problem for Sardar Sarovar, I would like to quote some figures: 34 867 ha of land were to be submerged, of which 11 279 was agricultural and 10 719 ha forest land. The rest consists of river bed and waste land. 248 villages were to be submerged, mostly partially, affecting some 100 000 population. NGOs such as ARCH (Action Research in Community Health Association), who were originally opposed to the Project because of what they considered insufficient compensation for the affected population, later accepted the improved measures and supported the continuation of construction.

In the meantime, other opponents, such as the NBA (Narmada Bachao Andola), an Indian NGO, and a number of foreign NGOs had started to attack the Project on other fronts, mainly environmental, human (tribal) rights, the economics of the Project etc., largely under the influence of Goldsmith and Hilyard's book. They started to employ radical protest techniques such as marches, hunger strikes, traffic disruptions, intimidation of those wanting to be resettled. They even instituted a "mass drowning rather than relocate" campaign at the first village threatened by the rising waters. Much was made of the fact that many of the so called "oustees" were still tribal. A lot of incitation of these relatively primitive people took place. All this led to Japan withdrawing its financial support and the World Bank President to appoint an Independent Review Mission, under Bradford Morse, which appears to have done more harm than good, and eventually to the Indian Government's decision to do without the help of the World Bank. It is true that substantial areas will be flooded and that a large number of people are required to be resettled. But weigh this up against the benefits, which the critics hardly ever mention: irrigation of some 1.8 million ha, 1450 MW of hydro, drinking water to 131 towns and 1450 villages, flood protection for 210 villages with a aggregate population of 750 000 and other less important benefits. In addition, most of the "oustees" are now better, and in many cases, much better off than they were before.

The opponents managed to mobilise a substantial number of people in India and elsewhere against the project, but large scale popular support for it was shown by 1 000 000 people turning up for a pro project demonstration. Massive support was also shown by the success of the public issue of bonds offered to the public, as described by Varma. (1995) Was this one of the rare cases where the "silent majority" made its voice heard above the din created by more vocal opponents?

IS SMALL BEAUTIFUL?

Some well meaning critics advocate many small reservoirs instead of the large ones which submerge thousands of hectares of land. I went to the trouble of analysing Great Britain's entries in the latest edition of the World Register of Large Dams. Britain's largest reservoir is Quoich, controlled by a dam of the same name on the Gear Garry near Fort Augustus in the Scottish Highlands. The 38 m high earth rockfill dam raised the lake of the same name, increasing its area from 80 ha to 1922 ha. The reservoir is capable of storing 382,8 million m^3. I ranked all British reservoirs in ascending order of size and aggregated their volumes and surface areas. From this I established that the total volume of the 327 smallest reservoirs would be needed to replace the volume of the largest, and that the total submerged area would be 6 705 ha, 3.5 times the area of Quoich!

A similar analysis for South Africa shows that 433 small reservoirs would be needed to replace the volume (5 246 million m^3) of the Gariep dam reservoir, with an aggregate area 2.22 times larger. Verghese quotes a comparison in India between the proposed Girna dam in the Bahanadi basin in Orissa and a smaller Girna dam plus 8 satellite storages making up the same volume. The cost would be 150 % higher, 60% more land would be submerged and less energy could be generated.

Although social and environmental problems are probably not in direct proportion to the area submerged, it can be safely deduced that a large number of small reservoirs will be far less acceptable from that point of view. The economics would also be much worse: loss of advantage of scale, more site establishment, more spillways, diversion and outlet works. Silt accumulation is also substantially less, as the United States Department of Agriculture figures, quoted by Goldsmith and Hildyard show: reservoirs smaller than 10 acre feet silted up at an average rate of 3.5%/a, smaller than 100 a.ft. at 2.7%/a and smaller than 1 000 000 a.ft. at 0,16%/a. This alone is already a powerful argument against a large number of small reservoirs.

WHAT SHOULD ICOLD DO?

It is clear that the threat of Ecofundamentalism cannot be wished away or ignored, as some among us appear to advocate. It exists, and it has to be dealt with, especially by those in the Third World who genuinely have the interest of the majority of the people in their countries at heart. They generally have to rely on outside finance to get their projects off the ground. What we have to do is to obtain and then keep the goodwill of the moderate environmentally conscious public, especially that of the scientific community. This can be done by feeding them the correct facts and information at an early stage, and where appropriate, drawing them into the studies. In this way, the fanatics can often be marginalised. We must accept criticism from informed sources, and act on it.

It cannot be denied that in some cases mistakes have been made in the past. For water supply to Bloemfontein, the capital or the Free State Province in South Africa, a dam was constructed in the Caledon River, which carries a heavy silt load. It was hoped that a barrage type would allow most of the silt to pass through the reservoir, but this did not happen. Within 8 years half the capacity was lost. But South Africa has learned from this mistake and has since constructed an off channel reservoir (Knellpoort), filled by pumping, so that most of the silt is allowed to pass.

In my view, the two largest storage reservoirs on the Orange River in South Africa were constructed years too soon, thus unnecessarily loosing capacity. Storage to regulate the river could have been created in the mountains of neighbouring Lesotho, where there is little silt load and also far less evaporation. But then, the political relations between the countries were such that it would probably have been difficult to reach agreement.

Similarly, political difficulties, wars and civil unrest prevented the basin states of the Nile developing the river more rationally than has been the case. There also, reservoirs on the upper reaches of the river, especially the Blue Nile, would have been less subject to siltation and evaporation. Because of the resulting flattening of the flood peak, flooded areas in the Sudd would be reduced, thus saving on some of the vast evaporation losses.

Before embarking on the construction of a dam, the promoter should have looked at other means of meeting the objectives as well. These means should include demand management, minimization of wastage, more effective use of existing developed resources, combating of pollution, recycling and improvement of irrigation practices. Doing that may pre empt accusations in this respect.

What is needed, before any substantial project is undertaken, is a credible balance sheet setting out the direct and indirect costs and the direct and indirect benefits. Environmental and social costs and benefits must be established by experts in their field and be given their due weight, but expressions such as "conserve x or y at all cost" should not be tolerated. In the case of public works projects, alternative uses of the resources required for the project in a particular country should be considered.

It is self evident that a reservoir cannot be evaluated like that in isolation. The balance sheet must similarly reflect the cost and benefits of the various uses that the water will be put to. That is a tall order, and it cannot be expected from engineers asked to study the creation of a reservoir by means of a dam to go so far. In fact, it goes far beyond the discipline of the engineer. A multi disciplinary team of engineers, geologists, economists, agronomists, biologists, botanists, limnologists, anthropologists, archaeologists, sociologists etc. is needed. I do not include somebody called an environmentalist, because such an all encompassing profession does not really exist.

Armed with the true facts, and a well conducted public relations campaign, the onslaught of ecofundamentalists will be easier to withstand than was often the case in the past, where developers were on the defensive, trying to establish facts to refute easily made allegations. Such allegations, except the most far fetched ones, can be foreseen, especially in the light of the experience gained at great cost during the controversies surrounding the Aswans, and Narmadas.

In this way, I am sure that we can get the support of the majority. But even then, the more moderate views of well meaning people and agencies in the First World can be dangerous for poor countries. Developing countries possess only limited resources, which are often urgently needed for social upliftment; better education, health, housing, clean water and proper sanitation. If these resources are used to meet exaggerated demands for the protection of the environment and/or the resettlement of affected people, less is left for what objectively might be more worthy causes. For example, demanding that borrow areas be restored to land fit for agriculture might require funds that could be more effectively used for soil conservation elsewhere, say in the catchment area.

Sometimes, these same well meaning people want the implementation of a particular project delayed, or even stopped, because of the lack of knowledge of some long term effect or another. This may be acceptable in wealthy countries, but conditions in the Third World do not allow such "paralysis by analysis"!

ICOLD's members, as specialists in dam engineering, can only contribute their part to these broader issues. They will have to answer technical questions on dam safety, the stability of slopes of reservoirs, earthquake resistant design, erosion below the dam, expected rates and patterns of sedimentation (without being responsible for the state of the catchment controlled!), the conservatively estimated likely costs, safe passage of floods and releases, water quality as affected by storage, care for the immediate environment of dam and reservoir etc. All these aspects are treated by ICOLD during its congresses and by its technical committees.

ICOLD issued a "Position Paper on Dams and Environment" in November 1995. This Paper, already adopted by the Advisory Committee to the President, is now under discussion among the broader membership. Some criticism has already been voiced, but that is to be expected. I doubt whether anybody can seriously differ with the lofty ideals expressed in it. However, it might be said that perhaps too much is expected from the dam engineer in the document. But, among ICOLD's members are also water resource planners, senior public servants, developers, managers and decision makers, and many of the issues can only be influenced by those, rather than the ordinary engineers specialised in dam design, construction, operation and maintenance. It cannot be expected from the latter to determine whether generating electric power below a dam is better than some form of thermal generation, or whether in a particular instance underground water is better or worse to supply a town than a regulated river. They can predict with some confidence to what extent a reservoir can protect a valley from likely floods, but they cannot be expected to promote legislation to prevent people from settling in a flood plain. Neither can they be expected to accept responsibility for shortcomings in irrigation systems below reservoirs or for the ills of towns and industries supplied from its waters! In the public debate about the merits of a particular proposal, we should contribute by putting the facts, gained by applying our expertise, clearly and unambiguously at the disposal of the decision maker and the public, regardless of whether it promotes a project or detracts from it. That is part of our professional ethics. Of course, many of our more senior members will also have to bear the wider responsibilities attached to their position.

Earlier this year, I attended the inaugural meeting of the Interim Board of the World Water Council. This new organisation aims to draw together all organisations involved with water.

Founding members are:

- International Water Resources Association (IWRA)
- International Commission on Irrigation and Drainage (ICID)
- Canadian International Development Agency (CIDA)
- The World Bank (WB)
- International Association on Water Quality (IAWQ)
- International Water Supply Association (IWSA)
- United Nations Development Programme (UNDP)
- The World Conservation Union (IUCN)
- The Water Supply and Sanitation Collaborative Council (WSSCC)
- International Association of Hydraulic Research (IAHR)
- International Commission on Large Dams (ICOLD)

In addition government agencies, professional organisations, municipalities, NGOs, private firms etc are also eligible for membership.

Its mission is to: *"Promote awareness about critical water issues at all levels including the highest decision making level and the general public, and to facilitate the efficient conservation, protection, development, planning, management and use of water on a sustainable basis for the benefit of all life on this earth."*

In my view this is the organisation that should address the wider issues of the use water is put to, and assist in providing the facts about these issues. They should take up the cudgels in defence of beneficial water projects, including those involving reservoirs.

The WWC should take the initiative in launching a programme of objective and in depth ex post facto evaluations of a few selected high profile mega water projects. Financing agencies such as the World Bank, should be prevailed upon to help. In this way they can assist the poorer parts of the world to counteract unjustified attacks on some of their projects.

At the 1995 ICOLD symposium in Oslo, Alan Johnston, speaking on behalf of Ted Haws, proposed the establishment of an ICOLD river basin committee for each of the great international river basins of the world. The aim would be to give advice to governments and the United Nations until river basin authorities can be set up. While I agree fully with the general idea, I do not think that this rightly belongs within ICOLD. The WWC, with strong representation from ICOLD, would be a more suitable organisation to drive such an initiative.

I have put a proposal to this year's Executive Meeting of ICOLD to form an *ad hoc* committee entrusted with the task of determining the mission and strategy of ICOLD for the coming years. We want to establish our niche in this wider family of water related organisations. If other organisations within the World Water Council would do the same, we would avoid overlap and confusion, each contributing its own expertise in counteracting the unreasonable onslaught of the ecofundamentalists, or 'ecoterrorists' as one of our members calls them.

A clearly formulated and communicated mission and strategy will assist us in proving to the world that most of the reservoirs we created in the past, and all of those we shall create in the future, are, and will be, a boon to mankind.'

SPEECH MADE AT CONFERENCE DINNER BY BDS CHAIRMAN MR T A JOHNSTON

The following is the Editor's summary of the remarks made by Mr Johnston.

Thank you Professor Perrings for the kind things you have said about BDS and reservoir engineers.

Most of us claim that we are more than mere technocrats, that we do try to take account of all the competing demands when building new reservoirs, restoring existing ones or removing redundant ones.

We shall take your comments as an encouragement to continue the dialogue with other professions so that we learn from each other.

BDS is a pretty old-fashioned organisation in some ways and so today all the accompanying persons are Ladies and a very knowledgeable bunch about dams too. Let me warn Frank Lawson and Andrew Robertshaw and the others who will be guides tomorrow at Grimwith and Scar House. Your most penetrating questions may come from the ladies — some of them have learned an awful lot about piezometric pressures and probable maximum floods, being dragged around sites by their husbands. Though a small group, the ladies have a key role in adding colour this evening and in maintaining our discussions on an elevated plane. They are an integral part of the conference and when we toast the guests and the new members we shall also toast the ladies.

We have another special group with us this week — our overseas visitors who play an important part in widening our perspectives. Three delegates I mention in particular Sam Johansson and Malte Cederstrom of Sweden are here as a reward from SWEDCOLD for the excellent organisation of a European Club conference in Stockholm in June. Sam and Malk I hope you have time to visit the YORVIK museum here. In Stockholm and in Oslo at the ICOLD Meeting last year, we enjoyed a propaganda barrage on behalf of "The Vikings". What a friendly group of goodwill ambassadors they were! We were told. I am not sure we are taught the same history here, but certainly the Vikings are welcome now.

Mr Y C Lee is here from Hong Kong. Two weeks ago he arranged for me to visit reservoirs in Hong Kong. I hope that you find your site visit tomorrow just as interesting. We also have delegates from Austria, Germany and Ireland. The overseas delegates are especially welcome and so when we Toast the Guests we will also toast the overseas visitors.

Which brings us to our three Principal Guests, and first of all to Mr John Layfield who is Director of Production and Technology at Yorkshire Water Services Ltd.

Yorkshire Water has earned the appreciation of BDS and its members for a number of reasons and the first is for being a good example,which may surprise those who take their technical news from the Sun newspaper. Yorkshire Water probably have two or three too few reservoirs but that can be put right, John.

What I am referring to in describing Yorkshire Water as a good example is the professional way in which they care for their existing stock of reservoirs. They have been in the forefront in various fields, assessing siltation, monitoring by new forms of instruments, contingency planning, area seismic studies are some examples I know of. And what is most important, they have made the results available to others by published papers and other means. They have supported individuals who are willing and able to contribute to learned societies and I think of the part played in BDS by Jim Claydon and Andrew Robertshaw.

So John while criticism plays around your head, take some comfort from the fact that much of what you are doing in caring for your reservoirs sets the industry standard.

However, here in Yorkshire this evening we have a particular reason to thank you. Tomorrow your colleagues will be hosts at three reservoir sites and I hope to have the chance to thank them then. Can you, John, please pass on our thanks to the Board.

John, as the only engineer on your Board, you must find it a lonely life. So remember you do have friends in BDS and we hope that Susan and you find this out this evening with us.

Professor Perrings is here in a dual role. Representing our hosts, the University of York, he is making sure that we are comfortable and well fed. It is always wise to suspend judgement until one has had a night's sleep but I think I know why there is no Faculty of Engineering — the student accommodation is too luxurious for civil engineers.

However Professor Perrings is also representing the wider world, reminding us that everything which we do has an impact beyond the technical. For the part you have played in our Conference, Professor Perrings, we are grateful.

Our third Principal Guest is the man with the highest fax bill in Pretoria, South Africa. A couple of centuries ago the Jacobites used to drink a Toast to the exiled Prince Charlie. The Toast was "The Prince across the water". Our equivalent is "The President across the Continent". Being President of ICOLD is well up on any list of "The impossible jobs" and we are fortunate in the calibre of the holders of the position.

By the critical yardstick "are we glad to have Theo van Robbroeck speaking on behalf of dam engineers?" the answer is a firm "yes". In BDS we only assure him of our continued support, while reserving the right to moan about the number of French francs spent on producing ICOLD Congress proceedings.

However, this evening your prime duty has been to deliver the Geoffrey Binnie Lecture. Geoff Sims has already expressed our appreciation of the lecture and I look forward to reading it in "Dams & Reservoirs". In due course I hope that your wife Irma and you will enjoy sharing fine South African wine from the BDS Quaich.

So I hope that by now you all know where you all stand or sit.

If you are a Lady, a new member, an overseas visitor or a Principal Guest, please sit. I ask the members of BDS to rise and drink with a toast to "The Ladies, the New Members, the Overseas Visitors and the Principal Guests".

SPEECH MADE AT CONFERENCE DINNER BY MR JOHN LAYFIELD, DIRECTOR OF PRODUCTION AND TECHNOLOGY, YORKSHIRE WATER SERVICES

Mr Chairman, Ladies and Gentlemen.

Although I am here as a guest of your Society and it is my pleasant task to reply to the toast to the guests, may I first of all welcome you to Yorkshire on behalf of my company, Yorkshire Water.

It seems to me particularly appropriate that the British Dam Society should be meeting in Yorkshire this year. Firstly, of course, there are many examples of the dam engineer's art in this county. My own company operates 108 impounding reservoirs; the oldest constructed in 1827, the newest commissioned in 1983. That, of course, was Grimwith Reservoir, one of the reservoirs you will see on your technical visit. Indeed, it gives me particular pleasure to note that, among your members attending this conference, is the resident engineer who supervised the construction of Grimwith.

Secondly, the events of the last 18 months have brought the activities of our profession into the full glare of the public spotlight. Now is not the time to go over the whys and wherefores of the water supply situation in this county over this period, but the drought of 1995/96, with its unprecedented severity and length, has undoubtedly brought home to our customers in Yorkshire the importance of the legacy which members of this Society and its predecessors have left in our county. Apart from anything else, the low water levels which existed particularly at this time last year, exposed the full beauty of the dam structures to the public eye right across Yorkshire in a way which many people had never seen. The empty reservoirs of Yorkshire became quite a tourist attraction. Perhaps more importantly, without those impounding reservoirs and the water that was stored in them, what was an extremely difficult situation would have become unmanageable.

My own involvement with the dams of Yorkshire has always been on the operation and maintenance side. I was never a good enough engineer to be trusted with the design of a dam. During your technical visit you will also visit Scar House Reservoir in the Nidd Valley. I have been connected with the Nidd Valley Reservoirs for almost 20 years now. The story of the Nidd Valley Reservoirs and the way in which this has stayed in the public's mind is an interesting example of the softer legacy which you as dam constructors leave behind. The last reservoir to be built in the Nidd Valley, Scar House, was built by Bradford Corporation during the Twenties and Thirties. It took 15 years to build and the biggest problem was finding the money to build it with. It was, of course, the years of the great depression but Bradford Corporation knew that if they were to maintain their position as the premier wool textile city, then they must guarantee adequate supplies of good, clean water. They had the vision and they had the faith to continue through difficult times.

That struggle and the importance of it to Bradford has left an impression which has lasted to the present time. Every year, and last year in particular, the words of the then chairman of the water committee in Bradford, Alderman Anthony Gady, were repeated over and over to us in

Yorkshire Water - "we will now have enough water for all time" - said Alderman Gady in 1936. And he was right for about 30 years which is a proud record for any politician, but of course, he had never heard of dishwashers or automatic washing machines, or stood under a power shower. Our customers in Bradford remember his words and we owe it to them to leave them a similar legacy. We must understand the special position the water supply holds in the public's mind if we are never again to fall into some of the problems that we fell into last year. A good example of that was a conversation I had with a customer on a radio phone-in. As part of the struggle to finance Scar House Reservoir a special penny rate was levied on the customers of Bradford and many of our existing customers last year could not understand why some of "their" water from Bradford was going to foreign places such as Leeds and Huddersfield who had not paid the penny rate in the 1930s. That particular customer berated me for some time about the penny rate and finally, in desperation, I asked him how old he was. "I'm 52" he said. "Well", I said, "You can't have paid the penny rate". "Nay lad", was his response, "but my father did". End of conversation.

When you visit Scar House, look out for the extensive remains of the navvy village which was constructed in Nidderdale to house the large number of people brought in for the reservoir construction. Driving to Scar House today is a pleasant day out, and one can forget how remote and desolate that area must have seemed to the people brought in for the dam construction and, indeed, Bradford had to build and operate their own railway system to cope with the building of the reservoirs. I have had the privilege over the years to work alongside a number of people who were actually born in that village and brought up there and went on to spend the rest of their career in the water industry in Yorkshire. You may have noticed at Scar House a memorial to those navvies and their families, which was placed there by the Friends of Scar House, an organisation which still exists and is largely made up of people born and brought up in that village. I believe this is a unique organisation, certainly I know of no other in Yorkshire. But, when we think of the navvy village and the people who lived there, it is perhaps worth remembering that life was tough and very hard for the engineers and for the construction workers who were based there. A good example of that was brought home to us when we discovered in our archives a file on a major industrial dispute which took place at Scar House far away from the glare of present day media publicity. I refer to the affair of the great cheese sandwich strike.

Apparently, the masons of Scar House had the temerity or the audacity to write to the resident engineer and question the price of food in the works canteen, in particular the price of a cheese sandwich. The response of the engineer illustrates, perhaps, how wide and how different in many respects was the position of the engineer on these sites some years ago. His response can only be described as autocratic, and in the end the stone masons on the site were dismissed and non union labour brought in. The dispute continued to drag on even though all the participants apart from the resident engineer had left the valley, and some 5 years later acrimonious correspondence was still going backwards and forwards between the resident engineer's successor and the general secretary of the masons' trade union. Time has passed and when one visits Scar House today, the beauty and the passivity of the Dale hides what must, at the time, have been a lot of anguish and undoubtedly some tremendous feats of engineering and hard work.

So a tremendous legacy has been left for us, water engineers, and water companies, to manage for the future. We must maintain the structures we own and pass them on to our successors with their integrity maintained and enhanced as necessary. I am happy that the relationship between my company and its inspecting engineers, many of whom are represented in this room today will ensure that, under the statutory framework, this will be guaranteed.

If I can now briefly return to the events of the last 18 months, this has also begun to open up new opportunities for the dam engineers and members of your society. Undoubtedly for the last few years up until 1984, the water industry had concentrated, of necessity, on issues of water quality both clean and dirty and large parts of our capital programme continue to be dedicated to overcoming these problems and meeting the requirements of various Brussels directives. However, I think everybody in this country now realises that water resources are a major issue, certainly we do here in Yorkshire. I think you will all know of our activities over the last 18 months, the strengthening and enhancing of our water grid, and beginning the process of linking that grid to the Kielder water supply system to the North. Of necessity, we have had to move quickly and this has ruled out any immediate work on reservoirs, either to enlarge them or to construct new reservoirs.

We all in this room know the timescales that new reservoir construction demands, and unlike at Scar House, the problem is not now finding enough money to pay the labourers before the first sod is cut. So in having to move quickly we have had to move via transmission development and by using existing resources, even those outside our area of supply. We are now engaged in Yorkshire, and I believe every other company is engaged, in reviewing our long term water supply strategies, and I am sure that in time enhanced storage will be required as part of our system. So I look forward to a healthy future for the British Dam Society in maintaining the assets that you have already given to us and enhancing them so that never again can customers in Yorkshire or anywhere else in this country, face the prospect of running out of water. Your skills will continue to be in great demand, and on behalf of your guests I thank you for inviting us here tonight and wish you well as we travel forward into the 21st Century.

SESSION 1
EMBANKMENT DAMS

Chairman Dr A K Hughes

Technical Reporter Dr P Tedd

Papers presented

1. The design of an auxiliary spillway at Dove Stone reservoir using tipping fusegates.
   K D Gardiner
2. Walshaw Dean Reservoirs : Spillway improvements.
   P C Harrison and J Drabble
3. Remedial works at Rivelin/Redmires Reservoirs.
   J R Claydonand N Reilly
4. Construction of a concrete face to a rockfill dam:
   Messochora Dam, Greece.
   P J Williams
5. Embankment dams in the developing world.
   A D M Penman
6. Design, construction and environmental aspects of Kau Sai Chau dam, Hong Kong.
   D Gallacher and J D Ridley

Papers not presented

1. Spillway capacity augmentation on three UK dams.
   E McKenna
2. The refurbishment of Winterburn Reservoir.
   J M Warrington and P Howlett
3. The Hydroplus fusegate system four years on.
   S Chevalier, S T Culshaw and J P Fauquez
4. Great Northern Reservoir Works.
   R B Binnie, I C Macdonald and M C Sweeney
5. Embankment dams in Nigeria.
   J W Findley and Kerr

SESSION 1

Contributions and responses

The design of an auxiliary spillway at Dove Stone reservoir using tipping fusegates.

Dr A K Hughes (Rofe Kennard & Lapworth)
A number of slides illustrating a fusegate that had tripped out of a spillway in France. Severe damage had occurred to the filling well. The fusegate was replaced in a morning.

Dr Hughes stated that the concrete gates that he designed at North West Water were cheaper to construct and can be designed to tip at various levels either to act as a fuseplug spillway or to provide more storage.

Mr Gardiner was asked to give some information on the cost of the fuse gates and what if any public consultation was undertaken with respect to the sudden floods that might be released downstream should the gates tip?

Dr A D M Penman.
We have seen from this morning's Papers some of the difficulties caused to old dams, many that have behaved well for a century, by the adoption of the Probably-never-to-occur-Maximum Flood. Such a large flood could be accommodated by use of radial gates over a low sill, but there is the danger that if the flood came, the power might fail, the reservoir keeper might not be able to reach the dam because the access road was flooded, and if he did, manual operation of the gates could be delayed due to jamming and lack of manpower until the dam was overtopped.

We have always preferred simple overflow weirs for the relatively small overflows from our small dams because they are automatic, and where it is not feasible to extend the lengths of existing weirs because of abutment shape or cost, a solution is to reinforce the crest and downstream slopes to permit emergency spilling over the embankment dam.

Another alternative is the use of tipping weirs; a form of automatic gate that does not need a reservoir keeper to operate. The Hydroplus design, with its labyrinth shape, provides an extended length of weir, enabling a higher water level to be used, providing the potential for increased storage capacity, which could be an attractive feature, more than covering the cost of alterations to the existing spillway. In addition they have a guaranteed pre-set level for tipping, and individual units can be set to tip at water level interval of 50 mm, so that if the first gate to tip does not prevent the level rising, successive gates will fall out.

I would like to ask the Authors how the Hydroplus gates compare with the more substantial looking and simpler concrete tipping weirs used at Yeoman Hey and Greenfield dams, described by Dr Hughes in the 1988 Manchester Conference.

Owen J Williams (First Hydro Co.)
Model Testing and Fuse Gates
It concerns me that Client approval for the model test of Dove Stone was obtained on condition testing was financed by consequential construction savings. This seems to convey an incomplete understanding by the Client of the intent of, and inappropriate measure of the success of, model testing. I would hope designers can robustly promote the justification of model testing in terms of long term spillway performance and safety, including when it is found to be necessary for the final structure to be more expensive. The alternatives of conservative and/or inadequate seem always likely, sooner or later, to incur a higher cost.

What matters has the Construction/Inspecting Engineer noted that "need to be watched" by the Supervising Engineer on the operation, maintenance and durability of these first fusegates in the UK?

Response
It was stated in the design brief that the savings resulting from the model tests should pay for the cost of the model test. It was pointed out that the system might not work and that savings might not materialise from the model tests and therefore a caveat was included into our design brief.

Corrosion protection was a problem as North West Water required that any paint protection system should be DWI approved even in raw water reservoirs which restricted the materials that could be used. We used Hunting Waterline which is rather a brittle material and there were problems on site because the gates could get chipped during installation. The Hunting Waterline did have a site coating certification from DWI and therefore any damage was made good on site. The paint system is expected to last to 20 years and there is a 1-2 mm of sacrificial thickness of metal to the gates.

With regard to recommendations for the Supervising Engineer, no instructions had been issued by the Inspecting Engineer. The gates can be easily inspected when the reservoir level is drawn down by 1.6 m below the overflow level. Blocking of overflows and drain holes was not considered a problem. There are no moving parts to the gates, they go under gravity and therefore deterioration such as seals are not considered a safety problem.

Walshaw Dean Reservoirs : spillway improvements

Dr A K Hughes (RKL)

1. You described an event in May 1993 — what was the return period of the flood?
2. You describe a two part slab construction — is there any worry that the slabs will separate?
3. What velocity can be sustained by the open stone asphalt?

Response
The possibility of slab separation was taken into account in the design by linking the two slabs with stainless steel tie bars. The velocity that can be sustained by open stone asphalt was not known. However, in the situation where it was used high velocities were not anticipated as much of the energy of the water would have been dissipated by the time it reached the open stone asphalt. In the event of damage there would be no adverse effect on the dam structure.

Mr J E Massey (Mott MacDonald)
Mr Massey congratulated Paul Harrison and John Drabble on their excellent paper on the Walshaw Dean Reservoirs, and considered it would be of interest to the meeting to give the background to the works now being constructed.

Mott MacDonald were commissioned to carry out flood studies for the three reservoirs, and physical models were made and tested by Hydraulic Models Ltd.

We examined two lines of approach:-

1) To increase the overflow capacities on each reservoir.
2) To provide additional flood storage in the Upper Reservoir.

In the first of these, it was decided to design the overflows to give maximum retention levels within the existing freeboard of the embankments, and avoid any raising.

In the second alternative, ie the additional upstream flood storage, two possibilities were examined:-

(i) To lower the TWL to provide increased flood storage up to the maximum PMF.

A new level overflow would then be necessary, and it was found this had to be almost 6 metres below the present overflow sill, representing a 57% loss of usable storage.

This was considered undesirable — a very wise decision in view of the present drought situation.

(ii) To retain the existing TWL and raise the embankment crest. The overflow structure would be designed to restrict outflow to a nominal figure, and the peak reservoir level under PMF conditions was found to be some 4 metres above the overflow.

For this amount of raising, a completely new embankment would have been necessary, and clearly this would be very costly.

For these alternatives, (termed the "Retention Options"), it was found that the works were still not entirely confined to the Upper Reservoir.

Due to the relatively large residual catchment between the Upper and Middle reservoirs, the flood study indicated that the overflows of the Middle and Lower reservoirs would still need enlargement, although somewhat less than the option where increased flood storage was not provided.

Consequently it was recommended that the "Retention Options" should not be adopted, and that the overflows on all three reservoirs should be increased in capacity.

Rivelin/Redmires Reservoirs

Mr T A Johnston (Babtie Group)
The paper and the presentation on the Rivelin/Redmires Reservoirs contain a wealth of information and it would be worthwhile having a further paper as work proceeds. At this stage could the authors expand on two aspects:

1. The Rivelin dams incorporate some unusual hydraulic equipment in the form of siphon draw-offs. How was the vulnerability of the hydraulic equipment dealt with in the seismic assessment?

2. It is encouraging to see a new monitoring technique described at our 1994 Conference, i.e. the use of oblique photography, being tried on Redmires Middle and Upper dams. Is there any further information on the effectiveness of the technique?

An earlier contributor asked about the calculation of the 3 tonne weight limit on the crest of Rivelin Lower dam. It was arrived at with the assistance of highway engineers in Babtie Group using the normal approach to vehicle wheel loads on road surfaces.

Response

A quasi analysis was carried out in accordance with the Panel Engineer's instructions and it was found that only very small distortions of the embankments would occur under the evaluation earthquake. With regard to the hydraulic equipment, they are deep down, generally in the foundation and it is not anticipated considering the calculated movements in the embankment that there would be any problem with the valves and pipework.

Response from A C Robertshaw on oblique photography

It has been installed at two dams with one set of repeat photographs. The system is to observe movements over a long period of time. After a year the repeatability appears to be very good in that little movement was anticipated and little was observed.

Mr C Makinson (Gibb)

Wavewall inclusion in wave freeboard allowance

I would like to draw attention to a common thread in at least two papers with regard to the inclusion of the wavewall in the embankment wave freeboard allowance.

Spillway Capacity Augmentation on Three UK Dams, E McKenna

In two of the dams reference is made to inclusion of a wavewall on the embankment section as part of the wave surcharge allowance.

Historically many designers have insisted on the wavewall being additional to the dam freeboard measured at embankment crest level. The design was after all tailored to the statistically derived specific wave height Hs which by definition is exceeded by 14% of waves, following Saville's classic paper, (ASCE, May 1962). Would the author comment on the date of the designs and whether they were influenced by prior knowledge of the 3rd edition of the ICE flood guide which appears to encourage taking the wavewall soffit level as the top of the freeboard. Which factor was applied to raise the specific wave height H_S to H_D the design wave height? Table 6 page 27 of the Flood Guide refers.

What were the cross-section and joint detailing of the Carron Dam wavewall to satisfy the requirement of Fig 14 for a solid wall (Page 56 of Flood Guide)?

What was the cost (estimated and actual) per linear metre of wavewall, given that a 200m wavewall alternative was ruled out for Glensherup Dam on economic grounds in favour of substantial spillway works?

Response from D Gallacher
The designs reflect the needs for the particular situations. Carron dam is at a very exposed site and there was a need for a solid concrete wave wall curved from the top of the embankment to turn the waves back. The new wavewall was combined with a slight raising of the dam. We designed for a concurrent wind speed with PMF. In terms of wave run up, it could be argued that the formula in the ICE Guide is not appropriate to wave run up in the bucket of a wavewall.

Several options were examined for Glensherup. Based largely on economic considerations a full wave wall was not appropriate. There may have been foundation problems with a solid wave wall approach.

Great Northern Reservoir Works, RB Binnie *et al*
Similarly, the gabion wavewall added to sections of the embankment of the Great Northern Reservoir Works (Whittle Dene) appears to be a device to provide or increase the wave surcharge allowance, from a crest level just above still water flood level. Should this less robust form of construction, in comparison with precast concrete wavewall units, be considered as solid?

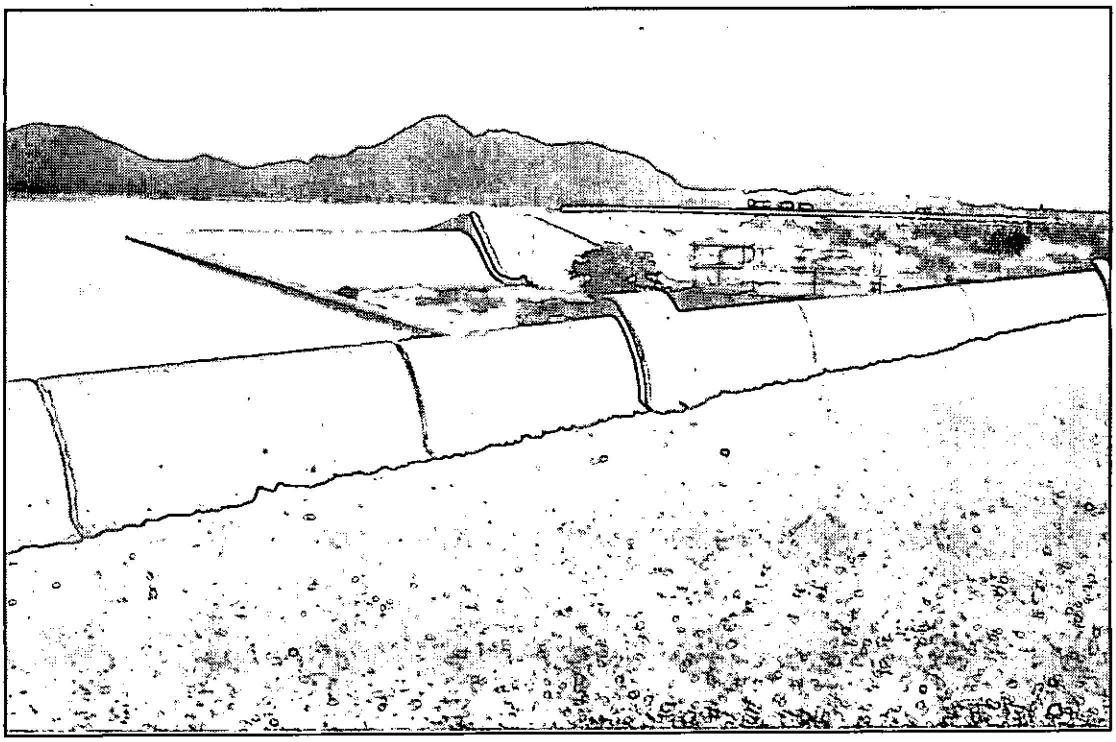


Figure 1. Gaborone Dam Raising, Botswana - Wave wall detail of 0.8m high precast concrete units with curved upstream face

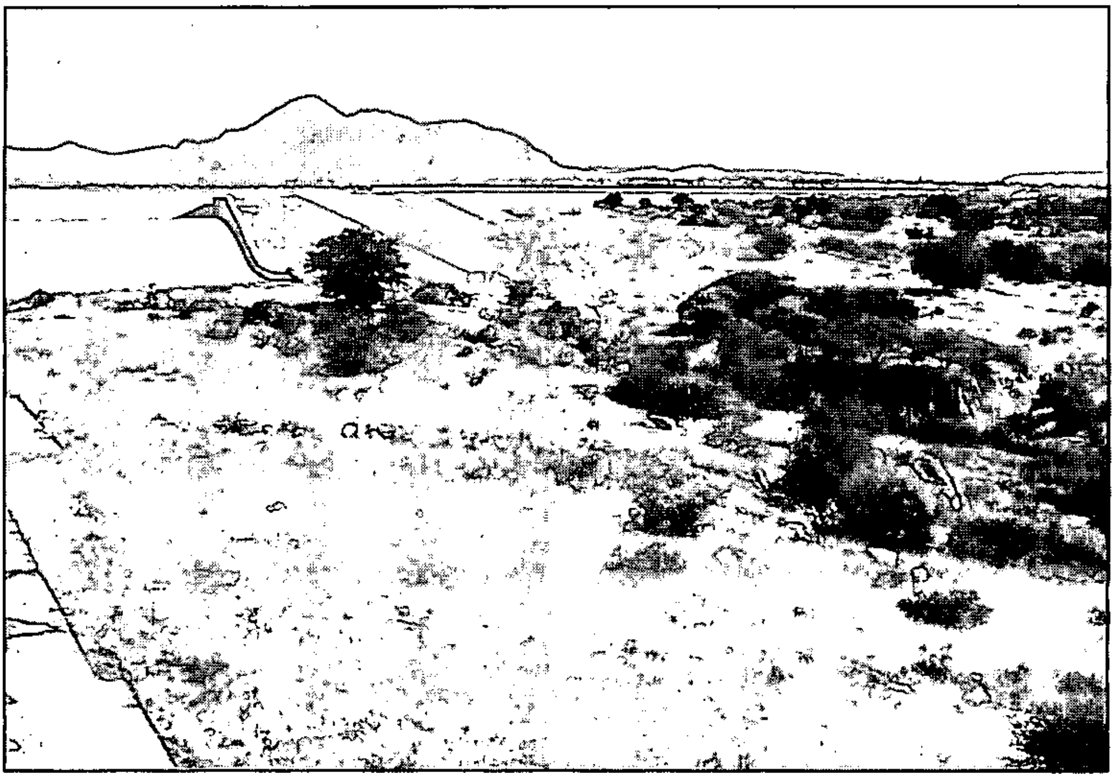


Figure 2. Emergency fuse spillway section of embankment beyond service spillway concrete weir

My interest in this aspect of the papers was aroused since GIBB first used a concrete wavewall as an integral part of embankment freeboard allowance at the raised Gaborone Dam, Botswana, completed as long ago as 1985 (Fig. 1). The wavewall adds 0.8 m wave freeboard allowance to the flood freeboard of 3.5 m for PMF discharges, saving 1.07 m of embankment crest height with respect to the original pre-raising freeboard arrangement for an 8 m increase in Full Supply Level. This was judged satisfactory given the infrequency of a full reservoir (about once in 10 years), and hence low probability of a superimposed maximum wind speed. Within five years the reservoir was being operated on permanently full basis thanks to water transfer agreements.

The concrete spillway weir only discharges about half the PMF, at which stage the erodible fuse section of the embankment begins to operate (Fig. 2). To prevent premature erosion of the fuse, the difference in crest level between embankment and fuse is only 0.55m. To guarantee fuse operation before overtopping of the whole embankment crest by wave slop action the additional 0.8m provided by the solid wavewall is an essential comfort factor.

To prevent the total loss of an essential water supply reservoir, only the top half of the fuse is permitted to erode by the inclusion of rockfill shells and a stepped gabion discharge cascade in the lower half of the fuse cross- section. The unexpected presence of a deeply weathered dolerite dyke at the toe of the fuse section required so much infill concrete that the economy of building a fuse section instead of extending the spillway crest was not realised in practice. (Ref. Raising of Gaborone Dam, ICOLD Durban 1994, Q70 R41 by Knight and Makinson).

In a current construction project at Karameh Dam in Jordan, GIBB are incorporating a gabion wavewall. However, it represents only one metre of a six metre freeboard allowance for earthquake slump and fault movement. Only in exceptional circumstances will it get wetted, and then only for a few hours until emergency drawdown lowers the reservoir.

We are thus still a long way on overseas projects from the casual inclusion of wavewalls within the primary wave freeboard as is apparently now accepted practice in the UK. Both the operating conditions and the economic solution can be easily misjudged at the design stage.

Response from R B Binnie
Part of the works carried out at the reservoir were protection to the upstream face of the embankments in the form of gabion construction. The wave wall was a continuation of that method. The economics of the construction had a major influence choice of gabions in that 60% of the reservoir perimeter was formed by embankments. This method has been used on other reservoirs owned by North East Water.

Messochora dam

Mr I Carter (Montgomery Watson)
I have two questions for Paul Williams regarding reinforcement and cracking of the face slab at Messochora Dam in Greece.

Evolutionary trends in the design and construction of concrete faced rockfill dams have been described on numerous occasions by J Barry Cooke. One feature that intrigues me is that of the arrangement of the face slab reinforcement. Current practice world wide seems to be to position a single layer of steel at mid depth of the slab, supposedly to enhance face slab flexibility. I understand that your slab was up to 750 mm thick near the base and I am interested to know whether you adopted conventional practice. Also could you comment upon the reasons for doing so? Secondly, you made reference to transverse cracking of the slabs which occurred within six weeks of placement. I am aware that on 1 on 1.4 smooth slope some 200 m long can be a very difficult and dangerous surface to work and manoeuvre upon. Could you please expand on how you managed to detect and monitor the transverse cracks. Similarly, how did you examine the performance of the vertical joints between individual panels?

Response
A central position was adopted for the single reinforcement mat following current practice. This positioning was used for the full height of the dam. I am not aware of the reinforcement mat being placed nearer to one surface than the other on any other projects.

Detection of the transverse cracks was made relatively easily when the curing water flow was stopped as the cracks took considerably longer than the sound concrete surface to dry out. Once identified these were marked and monitored by making use of a wheeled trolley on the dam face lowered from a winch.

Mr T A Johnston (Babtie Group)
In designing a rockfill dam, once the decision has been taken to use an upstream facing there is usually a debate on the advantages and disadvantages of the two main options, a bituminous

facing i.e. asphaltic concrete and a concrete facing. What were the particular reasons for choosing conventional concrete at Messochora Dam?

Response
The decision for a concrete face rockfill dam had been made by the time Halcrows became involved although other forms of construction had been considered including an asphaltic membrane.

John Cowie (Mott MacDonald)
Why was there no gallery in the toe block? Can further details be provided about the depth and frequency of the grouting holes?

Response
A gallery was not included in the toe block because of cost. Some concrete faced dams have galleries incorporated in the toe block for leakage monitoring and further grouting if required. The main grout curtain was 50 m deep with holes at 2 m intervals on each of 2 lines staggered 1.5m apart.

Tom Read (TMI)
Was there any segregation in chuting the concrete down 200 m with a slump of 50 mm and was there any problem with the concrete holding firm after placing?

Response
Initially there were problems with segregation on the chutes but these were resolved after a number of trials to adjust the mix. There were two points of remixing to reduce the problem. With regards to the concrete staying in place after removal of the slip forming, the concrete was generally placed as close as possible to the initial set of the concrete. Slip forming was at a rate of between 1.5 and 5 m per hour. On a couple of occasions when the rate was faster there were blow outs but these were very infrequent.

Douglas Gallacher (R H Cuthbertson)
Obvious critical zones are the triangular sections at the sides of the dam and the differential movements that occur in those areas. Can you comment on the magnitude of the anticipated movement, the provision to accommodate the movement and the method of monitoring?

Response
There was provision to include for 3D movement meters between the main slab and the plinth at various levels. The joint design was for a maximum shearing movement of 200 mm, but the anticipated movements were only 100 mm. The movement is accommodated with a fold in the copper waterstop. There is also a mastic filler in case the 200 mm is exceeded. No records of movement are available yet as impounding has not commenced. If there should be a problem with leakage at the perimeter due to failure of the water stop there is no way of identifying where the leakage is coming from other than drawing the reservoir level down and monitoring the leakage downstream. The piezometers in the rockfill are unlikely to be able to detect the location of the leakage as the rockfill is very open.

Dr A D M Penman

In connection with the movements that can be tolerated by copper water seals, I can give as an example the 85 m high Cogoti rockfill dam, built in 1938, with an upstream concrete membrane. This was constructed in 10 m squares, interconnected by 600 mm wide copper waterstops with riveted joints, The dam was subjected to four major earthquakes of magnitude 7.9 (1943), 7.1 (1965), 7.5 (1971) and 7.7 (1985), causing crest settlement of 1.080 m. No seismic damage to the concrete face has been detected and observation of joints in the exposed face slab indicates intact joints.

Embankment dams in the developing world

J Findlay (Babtie Group)

Dr Penman rightly points out some of the reasons why storage of water is such a valuable objective in developing countries where rainfall, though limited, often comes at the wrong time and in excessive amounts.

In my paper on Embankment Dams in Nigeria I sought to emphasise this view of the reservoir as an asset. However, the paper notes that the effort put into planning and design must be continued through construction to produce a structure that requires the minimum maintenance and that this is appropriate to the resources and capabilities available.

The protection of downstream slopes on embankment dams in semi-arid countries is a particular case in point. Poor detailing and construction control of grassed slopes lead to severe erosion that can be difficult to repair.

At Tiga and Ruwan Kanya dams, where Babtie have carried out a number of inspections and have suggested remedial works, poor construction control of crest levels and slopes has led to severe gullying. This is difficult to rectify but was achieved by the use of crushed stone placed and compacted by bulldozer.

The choice of surfacing on downstream slopes is a design decision that has to recognise cost, practicality and effectiveness, including the susceptibility to problems such as those noted above. Using quarry products for beaching or pitching of the downstream face can eliminate run-off damage but is expensive and may make the dam more visually intrusive. The use of grassed slopes can be very effective but may be difficult to sustain in semi-arid countries.

The Driekopies Dam in South Africa highlighted by Dr Penman is shown as having a grassed downstream slope and I would be interested to hear how its protection was ensured, how it has performed and whether a pitched face was considered. Also, whether Dr Penman, in his overseas experience, has had difficulty with the protection of downstream slopes.

In response to another question, Dr Penman referred to the core material of the Chilean dam being placed dry of optimum moisture content as per advice given by the US Bureau of Reclamation. Some engineers are nervous of placing core dry of optimum and I would be interested to know the design objectives behind this specified requirement and whether current knowledge supports this approach.

Response

In relation to the grass protection on the downstream slope no special provision was made and as far as he was aware there was not a problem with grass growing. The dam was not designed to overtop.

It is interesting to hear that some engineers are nervous of placing cores dry of optimum; usually it is the other way round. USBR used to recommend the placement of rolled clay cores dry of optimum so that they could be compacted and produce a dense, impervious core. This practice was copied all over the world, eg Matahina dam in New Zealand constructed in the mid 1960s, and in dams in Chile built during this period. In this country, after a era of puddle , the first rolled clay cores were placed too dry, permitting hydraulic fracture, eg at Balderhead. Realisation of the need for more flexible cores has brought almost everyone, even USBR, round to using much wetter placement. An excellent early example was Monasavu Falls dam, described by Knight et al (1982).

Reference. Knight D J, Worner N M and McClung J E (1982).
Materials and construction methods for a very wet clay core rockfill dam at Monasavu Falls, Fiji. Trans. 14th ICOLD, Rio de Janeiro, vol 4, pp 294 -303.

Dr A K Hughes (RKL)

On the dam in South Africa you say the foundation was improved by dynamic compaction. What was the predicted settlement on impounding?

Response

No information is available as impounding has not yet taken place.

Design of Kau Sai Chau dam

Mr T A Johnston (Babtie Group)

The selection of the site for Kau Sai Chau dam is an excellent example of dam engineers and environmental scientists working together. Let us hope that this approach is followed on a larger scale elsewhere in the world to the benefit of the many schemes that are needed to meet the increasing demand for water.

There are two engineering aspects on which more information would be welcome.

1. Hong Kong is in a typhoon area. What wind speeds and wave heights had to be considered and what was the selected size of the rip rap which forms the protection on both faces of the main dam?

2. The central concrete core wall is required to be flexible and as watertight as possible. Could we have some more information on the design details, such as the partial contraction joints, which were adopted to meet these objectives?

Response

Strong winds do occur in Hong Kong from the NE typhoon and mean hourly wind speeds of 45m/s have been measured at Plover Cove. The rip rap was designed for fairly substantial wind speeds but the reservoir has a small fetch. The stone rip rap size was taken from the larger rockfill and had a D_{50} of 400 to 500 mm. There was no problem with upstream protection.

With regards to the partial contraction joints. The object was to make the wall continuous. The wall was made straight over the central section of the dam. Partial contraction joints were incorporated at all the vertical joints consisting of 50% of the reinforcement being taken through to ensure having continuity, and having a joint sealant at all the joints.

Dr A K Hughes (RKL)

Could you provide details of the connection of the cut-off and the concrete core wall?

Response

There is a mass concrete plug constructed into the foundation with a slightly inclined horizontal water bar at the junction. The top section of the core wall is constructed directly onto the concrete plug but with an interface layer to allow some movement at the junction. It is a floating joint with a water bar. Substantial seals also were arranged at the upstream and downstream sides of the core wall by forming a recess. It is a waterbar through the centre running horizontally which then connects with the vertical waterbars at all the partial contraction joints. The waterbars from that junction are then taken down through the cut-off blocks down into the foundation.

Mr J P Millmore (Babtie Group)

The authors describe the environmental monitoring at Kau Sai Chau but not the monitoring associated with the safety of the embankment. Since the reservoir is associated with a golf course there must be a wealth of green keepers who could assist with simple monitoring systems. Could the authors provide information on the systems of monitoring adopted /

The paper identifies that seismic loading was considered and the associated permanent deformation assessed but no details are provided. Could the author provide such details particularly with respect to the central core wall /

Response

As the dam was a small embankment only simple surface surveying measurements were undertaken consisting of alignment stations in the core. There was no instrumentation installed within the embankment. Vibrating-wire piezometers were installed in the foundation of the dam which showed the dam to be behaving satisfactorily. It is not possible to measure leakage at the dam because the downstream side is below sea level.

A seismic study in Hong Kong was used in the design of the embankment. There is generally a very low level of seismic activity in Hong Kong. No problems were anticipated with the reinforced core wall built into a very solid rockfill embankment.

Mr J Findlay (Babtie Group)

The involvement of Friends of the Earth as an objector at the proposal stage is not a surprise. However, I am interested to know if they retained their interest during design and construction, whether they contributed to the debate on avoidance and mitigation, and if they expressed any views on the success of the environmental aspects of the completed works. Were they in fact objecting to the dam scheme on principle and therefore had no interest once approval was given?

Response

The environmentalist dealt directly with the Friends of the Earth. Their original objections were mainly concerned with the mangroves. The Environmental Protection Department of Hong Kong made regular two weekly visits to the site during construction so they were able to monitor what was going on. There is also a scheme of environmental management to be carried out for several years after construction.

SESSION 2
INVESTIGATION, INSTRUMENTATION AND MONITORING

Chairman Dr J A Charles

Technical Reporter Mr I C Carter

Papers presented:

1 New Guide. `Investigating embankment dams: a guide to the identification and repair of defects'. J A Charles, P Tedd, A K Hughes and H T Lovenbury.

2 New Guide. `Valves pipework and associated equipment in dams: a guide to condition assessment'. R A Reader, M F Kennard and I Hay.

3 `Walshaw Dean Lower: Embankment behaviour during prolonged reservoir drawdown'. I R Holton, P Tedd and J A Charles.

4 `Cow Green Dam : Interpretation of earth pressure measurements 25 years after construction'. J F Prentice, M Fletcher and P Tedd.

5 `Barrow No 3 Reservoir: a case history of simplified seismic evaluation'. N G Swannell (presented by J L Hinks).

SESSION 2

Contributions and Responses

R A Reader and I Hay introduced an outline of CIRIA report No. RP506 "Valves, pipework and associated equipment in dams - guide to condition assessment" which has been written in response to a recommendation by Dr D J Coats in his March 1993 report to the DoE.

D J Coats (Babtie Group)

CIRIA Report "Valves, pipework & associated equipment in dams - guide to condition assessment"

I am of course delighted that two of my recommendations in my "Assessment of Reservoir Safety Research" (DoE March 1993) have been implemented. I have been privileged to read a final proof of "Valves, pipework and associated equipment in dams". I congratulate the authors on producing a well researched and wide ranging report with much practical guidance stemming from extensive experience which will be of great value to Inspecting and Supervising Engineers. The many checklists or tabulated data are particularly welcome and the References and Bibliography are a useful reminder that there is a lot of knowledge which we can tap when desperate! I look forward to the other recommendations in my report being implemented.

When I prepared my report I understood that the DoE already had research in hand or intended on assessment of valves and pipes, and the Water Research Centre had a draft report on the inspection of pipes and valves which I considered to be far too specialised and limited. I felt that "it would be helpful if the objectives were to be widened to include descriptions and related problems likely to be met with pipes and valves with old dams and how an assessment could be made, if at all, of their condition and continuing acceptability". Among my recommendations for future research was "assessment of the condition and acceptability of pipes, valves and related equipment and methods of estimating their remaining life".

I was particularly anxious to get help on the thorny question of acceptability. If I may be allowed a little criticism, the nearest the guide gets to directly addressing that question is a single paragraph (1.13) headed "Indicators of Potential Failure" and paragraph (6.3) and diagram (Fig. 12) on evaluation of exposure, but I think that I always knew what I was looking for was a nigh impossible and that there is no substitute for engineering judgement!

When reading the report I found that its style more resembled the "Help Topics" accessible in Microsoft's "Windows 95" than the more basic "Guides for Dummies". As you will know, the Help Topics have clearly been written by experts (as has the report) and are most interesting (as is the Report) but they usually tell us much that we don't need to know and are sometimes very coy about giving a direct answer to a direct question, whereas the Guides for Dummies give straightforward instructions, assume you know nothing and is very easy to find instructions to which one wants to refer again. I prefer this but that probably tells you more about me than about the report!

The question which I put to the authors is:-

"There are some Inspecting Engineers of my generation who find it helpful to tap the body of a valve or the barrel of a pipe with a hammer to obtain some indication of their condition. Would the authors approve of such "integrity testing" and if so, what size or weight of hammer should be used, how hard may one hit the equipment, and what can be deduced from the exercise?"

Mr R Reader (Rofe, Kennard & Lapworth)
In response

Dr Coats' kind remarks, and his criticisms, are welcomed. The report is not yet finalised but includes some comments on the soundness testing of pipes and castings by tapping them with a suitable hammer. The size of hammer and hardness of the blow is a question of judgement! Finalising the report is difficult on the equipment side as advances in techniques of inspection are particularly rapid. One intention of the report was to encapsulate experience gained by engineers during the period of dam construction after the Second World War that could be lost now that so few dams are being constructed in the UK. The authors were conscious how easy it was for any advice to be taken out of context and this had led to the structure of the Guide which did not lend itself to dipping-into for rapid answers in isolation.

Mr O P Williams (First Hydro)
Valves, pipework and associated equipment in dams - guide to condition assessment

I endorse Mr Reader's remarks on the rapid advance in techniques available. At Dinorwig Power Station and dams we use North-Sea contractors for internal inspections of deep and remote intakes, shafts and tunnels by remotely operated submersible vehicles (ROV).

Ten years ago ROV reliability/availability on site was about 50% and videos were in black and white. Five years ago ROV performance improved to 75%, videos and retrieved stills were colour and dye release was used in areas of possible leakage.

We plan within a year to utilise 95% site reliability/availability, colour video, instant colour printing and profile the thickness of coatings. Trials of other proven N. Sea developments are under consideration for continuous assessment of key inaccessible elements in the future.

Mr G P Sims (Graham Consulting Group)
Remotely operated vehicles

I have had the experience of bidding for the inspection of a hydroelectric tunnel several tens of kilometres long in the Peruvian Andes. Even though unsuccessful, I become aware of the impressive capability of remotely operated under water vehicles. This awareness came from the specification and also from reports of what was achieved. Not only are they capable of detailed inspection under the hostile conditions of an active tunnel, a vehicle can also be designed able to carry tools. These tools are able not only to investigate the nature of the conditions in the tunnel, but also to remove samples.

My question is to the authors of the document "Valves, pipework and associated equipment in dams - a guide to condition assessment". I enquire whether such vehicles are available in sizes suitable for them to be used in the inspection of the pipework associated with dams.

Mr I Hay (Rofe, Kennard & Lapworth)
In response

The authors had become aware that remotely-operated vehicles were particularly effective for the inspections of pipes greater than 600 mm dia. Smaller versions appeared likely in the near future. The obvious advantage of using such vehicles was that pipes could be inspected full, without the need to drain down and cause major interruptions to supply.

Mr J Lewin (Independent Consultant)
Comment on "Valves, pipework & associated equipment in dams - a guide to condition assessment"

It is suggested that the new guides should be supplemented by two additional guides;

- Gates and other reservoir appurtenances - a guide to their condition and hazard assessment; and
- A survey of emergency procedures, standby operation and equipment of reservoir control structures.

Mr R Reader (Rofe, Kennard & Lapworth)
In response

I agree that additional complementary guides on these subjects would be worth commissioning and I commend that to CIRIA as potential projects. Gates are really a subject on their own and emergency procedures are certainly an important aspect of reservoir operation that is not covered fully in this guide.

Mr J Dornstadter (GTC Kappelmeyer GmbH)
Sensitive monitoring

Internal erosion caused by seeping water constitutes a significant threat to the safety of embankment dams and other water retaining structures. Temperature measurements offer a *highly sensitive, reliable and cost effective possibility for the inspection and monitoring of* embankment dams.

The temperature distribution inside embankment dams is controlled by seasonal temperature variations transported into the dam mainly by heat conduction and by the advective heat transport inevitably coupled to percolating water. The temperature of the water seeping through a dam can be used as a natural tracer, thus allowing to localize and narrow down leakage zones.

During the last ten years a total of 250 km of embankment dams and other water retaining structures in Germany and France have been successfully inspected with a patented thermometric method developed by GTC. Many leakage zones could be localised and narrowed down thereby allowing considerable cost reduction for the remedial work to be carried out.

As an example, soil temperatures were measured inside a 6 m high earthfill dam as shown in Figure 1. The scope of the measurement was to clarify the question whether water percolates through the core or the foundation of the dam. In the temperature plot one can see that both cases are relevant. Between 30.620 km and 40.650 km water is seeping through the dam foundation and at 40.700 km water from the reservoir is seeping through the core possibly causing internal erosion. The endangered zones can be emphasized by subtracting the average temperature depth curve of an intact section of the dam from the data containing the observed anomalies. The resulting image is the temperature disturbance caused by the seepage (Figure 1, lower part). The percolation underneath the dam is due to the natural geological structure of the foundation and is not critical for the safety of the dam. On the other hand, the detected leak in the core of the dam is subject to further investigations, eg long-term monitoring or repeated measurements based on a risk analysis.

The data for the second example shown in Figure 2 were collected from a 9 m high dam with impervious facing along a river. The surface sealing of the dam is penetrated by water at several points. Measurements were made to localise seepage zones and to detect the depth where the maximum fluid velocity is reached. The temperature contour plot indicates clearly seepage zones between 2.45 km and 2.54 km. The biggest anomaly was found near 2.5 km in about 3 m depth with a temperature value of 3°C. Since the water temperature of the river was 2.8° C it is obvious that the anomaly indicates the area with the maximum fluid velocity. In order to prevent the stability endangering material transport, the leaks in the impervious facing of the dam should be fixed or at least the flow velocity should be carefully monitored.

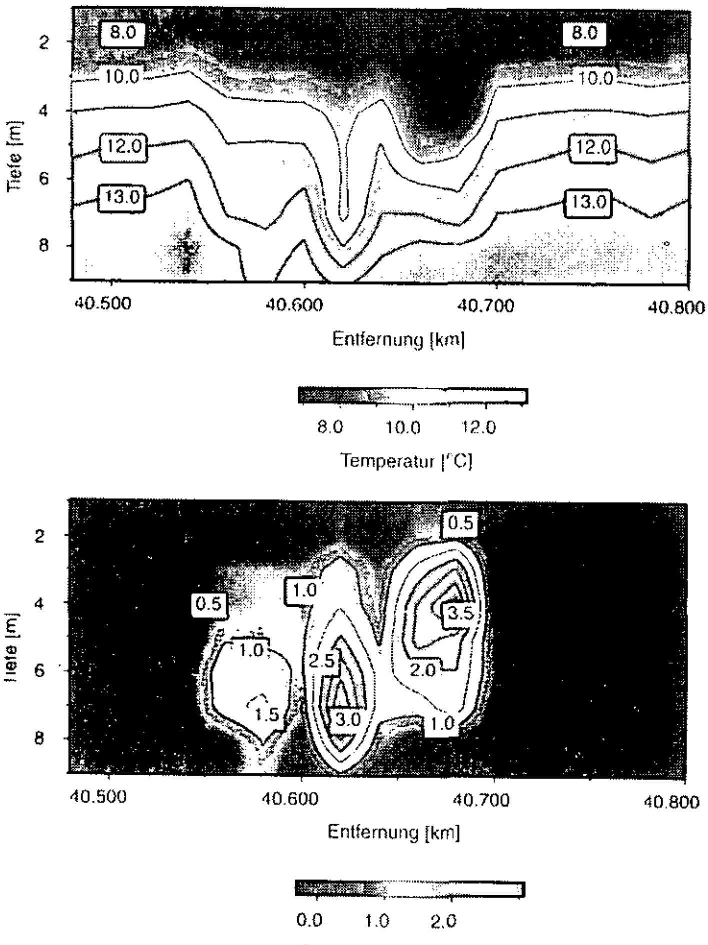


Figure 1

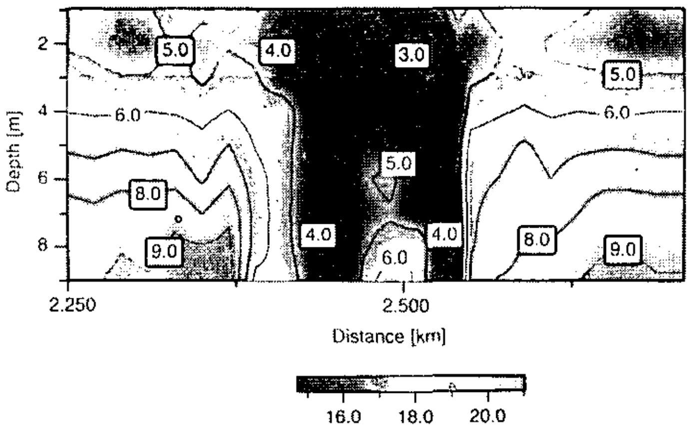


Figure 2

Mr J E Massey (Mott MacDonald)
Walshaw Dean Lower Reservoir

The paper presented by Holton, Tedd and Charles referred to the earlier investigation in 1980, when the cut-off trench and foundation rock were grouted. Mr Massey described this work, in which he had been involved, in collaboration with Professor Peter Rowe, and had presented the information to a BNCOLD meeting in Manchester in October 1984.

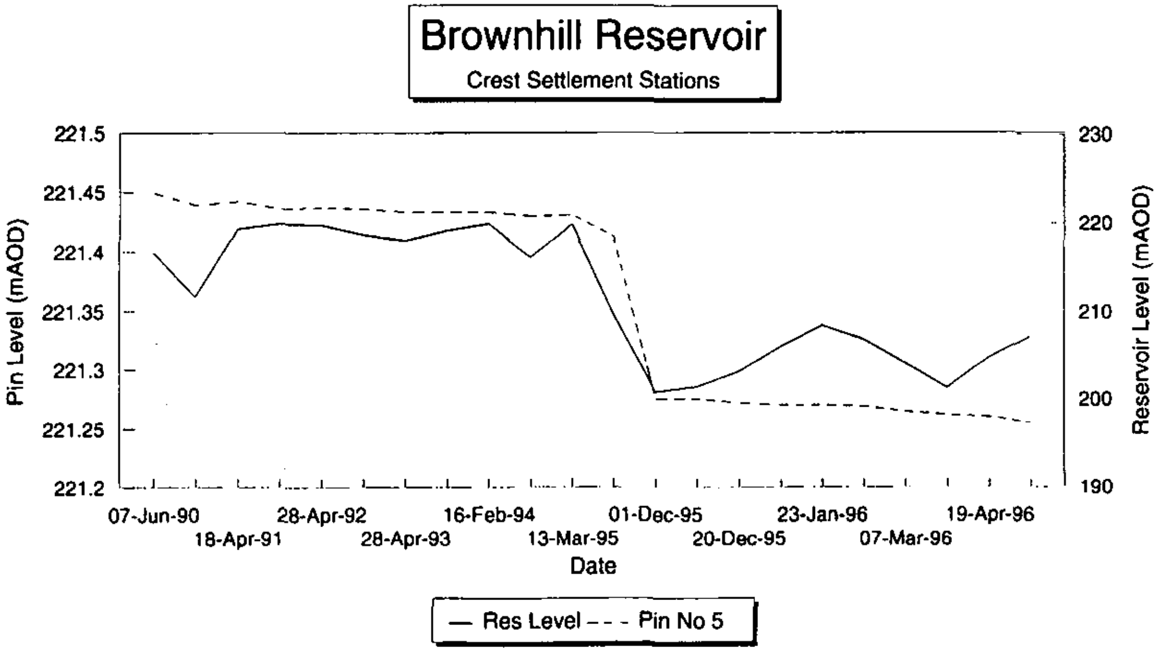
The investigation consisted of a series of cone-penetrometer probes by Fugro, and with the aid of overhead projections, it was shown that there was a noticeable softening of the clay below original ground level. To verify the results of the cone penetrometer tests, boreholes were put down on two cross sections. These showed a degree of softening of the clay below ground level, so pronounced in places as to prevent the taking of samples, and occasionally showed a sudden drop in the casing to the hole. .

The foundation rock through which the cut-off trench has been taken was found to be highly fissured. It was decided to grout this rock on the downstream side of the trench, and to follow this with grouting of the clay. The paper states that settlement of the crest of the embankment is continuing at an average rate of 8 mm per year, but it is difficult to say whether this would have been greater, had the grouting not taken place.

Mr A Robertshaw (Yorkshire Water Services)
Settlement of Brownhill Reservoir embankment

The drought of 1995 resulted in significant drawdowns within Yorkshire Water Services reservoirs and led to increased settlement rates at several earth embankment dams. The largest recorded settlement occurred at Brownhill Dam, near Holmfirth, which is an earth embankment with puddle clay core and concrete filled cut off completed in 1932. The height of the dam is approximately 30 metres. Between August and November it settled by a maximum of 138 mm in response to a reservoir drawdown of over 20 metres.

A graph is presented which shows the settlement pattern of the dam compared to reservoir level changes between June 1990 and April 1996. The graph clearly shows that a long term settlement pattern had been established between 1990 and the spring of 1995 but the reservoir drawdown during the summer and autumn caused a major increase in settlement following which the long term pattern was resumed. It is anticipated that a relatively small recovery of the dam will occur when the reservoir eventually refills but that a significant net settlement will remain.



An important side effect of this settlement is that the flood retaining wave wall at the dam, which was only constructed in 1986, is now 250 mm lower in the centre than at the ends and is likely to require raising in the near future to maintain the appropriate freeboard.

Mr J L Beaver (Sir William Halcrow & Partners Ltd)
Question regarding Walshaw Dean Lower

Can the results and conclusions for Walshaw Dean Lower Dam be considered as being typical for puddle clay core dams with deep cut-off trenches and similar embankment cross section, particularly in respect of crest settlement and deflection?

Mr I R Holton
In response

The deformation data for Walshaw Dean Lower can be considered as typical for puddle clay core dams of similar construction. However, it is important to emphasise that for similar dams, the depth and duration of reservoir drawdown, and recent history of reservoir operation can have a significant effect on the magnitude of both the maximum (sm) and permanent (sp) crest settlement. The following table summarises settlement data from four Pennine dams which have been included in a study by BRE and Yorkshire Water and that has been described by Tedd et al (1997). Where reservoirs are emptied, significantly larger crest settlements can be expected compared to normal annual drawdowns. However, if the reservoir frequently undergoes substantial drawdowns most years as at Walshaw Dean, reservoir emptying does not cause excessive settlement. Complementary analytical studies carried out by Imperial College (Kovacevic *et al*, 1997) indicate that these movements do not appear to compromise the stability of the dam, however settlement from whatever cause can reduce the freeboard of the dam, a point raised by Andrew Robertshaw when describing the settlement of Brownhill dam.

Dam	Height (h) m	Age Years	Reservoir Max. Depth	Drawdown Duration months	Crest Settlement s_m mm	s_p mm	s_p/s_m %
Walshaw Dean	22	85	10	8	12	7	58
			13	8	14	8	67
			12	5	12	8	67
			17	23	21	16	76
Ramsden	25	100	17	9	58	52	90
			6	6	16	8	50
Ogden	25	135	20	24	138	130	94
			10	10	12	8	67
Widdop	20	110	17	10	61	52	85

Table 2 Summary of permanent crest settlements measured during drawdown and refilling of reservoir

It would be valuable for the UK dam community to have access to a larger database of high quality settlement observations.

References

Tedd P, Charles JA, Holton IR and Robertshaw AC (1997). The effect of reservoir drawdown and long term consolidation on the deformation of old embankment dams. Geotechnique, vol 39, No 4, pp701-710.

Kovacevic N, Potts D M, Vaughan P R, Charles J A and Tedd P (1997). Assessing the safety of old embankment dams by observing and analysing movement during reservoir operation. Transactions of 19th International Congress on large Dams, Florence, vol 2, pp 551-566

Mr J L Beaver (Sir William Halcrow & Partners Ltd)
Barrow No. 3 Reservoir

The calculations have indicated that displacements may be expected during the seismic evaluation earthquake, which has a peak ground acceleration of 0.2g. Thus it has been necessary to check and ensure that there is sufficient freeboard to prevent overtopping at the normal maximum operating water level.

Barrow No. 3 is a non-impounding reservoir with a somewhat checkered history of failures and major displacements. There is total control of inflow, a spillway and outflow pipes with capacity sufficient to drawdown the reservoir to half- pool level quickly in the event of an emergency.

The reservoir owners, Bristol Water, have prepared a comprehensive operating and maintenance manual which covers in some detail all the important facts of the reservoir.

Surveillance and monitoring is carried out at least weekly with walk-over checks of the embankment. This includes monitoring of the outlets to the embankment toe drains both for the rate of flow and for the quality of the water discharged to check for any sediment content.

Mr T A Johnston (Babtie Group)
Application of Guide to seismic risk to dams in the UK

As some of you will know the ICE Reservoirs Committee is supporting the work of a Working Party which has been set up to examine the experience gained from the use of the "Engineering Guide to seismic risk to dams in the United Kingdom" that was published in 1991. The Chairman of the Working Party is Mr Roy Coxon and the Secretary is Dr Andrew Charles of BRE.

A questionnaire has already been issued to major dam owners seeking information on the results of seismic assessments. In addition to owners, the working party would like to draw on the experience of the dam engineering community in general. So delegates who would like to participate are asked to contact Dr Charles. The working party is particularly interested in learning of any cases where the seismic assessments have led, or are likely to lead toward, strengthening works to dams.

One reason for setting up the Working Party was the belief that engineers have found some sections to be ambiguous and this has raised the concern that the Guide may not be applied uniformly. Again delegates may wish to comment to Dr Charles on any problems of interpretation.

The paper on Barrow No. 3 Reservoir appears to contain an example of an ambiguity. The paper indicates that a level of safety evaluation Ec has been considered appropriate and states that "the Guide recommends at least a relatively simple form of seismic analysis". This appears to me to overstate the recommendations in the Guide. The dam is in Category III "where it may often be appropriate to carry out some form of seismic analysis to assess seismic safety, particularly where the dam is greater than 15 metres high". The dam has a maximum height of 12 metres and so it would be interesting to know more about the reasons which led to a pseudo-static analysis.

It is encouraging to see that a pseudo-static factor of 0.85 is considered acceptable. There may be some engineers to whom a factor of safety less than 1 is unacceptable and it is good to see that the engineer and the owner have considered the implications of the instantaneous low factor of safety and, in this case, have found that the calculated displacements are acceptable. The low factor of safety is associated with the residual shear strength of an existing failure plane in the foundation material. If the failure plane had not been present would the analysis have been based on the undrained shear strength rather than the residual shear strength.?

Mr J L Beaver (Sir William Halcrow & Partners Ltd)
In response

As the Panel Engineer responsible for the Section 10 inspection, and in view of the past history of the dam in respect of excessive settlements, slips failures and leakages, I considered it entirely appropriate to request a seismic analysis of the section, in accordance with the 1991 BRE seismic guide. The cost of four shallow boreholes, some straightforward Laboratory testing and the resulting analytical work was relatively cheap and well worthwhile in confirming the performance of the embankment under seismic loading.

Mr C J Sammons (Independent Consulting Engineer)
Earth pressure measurement at Cow Green

As discussed in the paper by Prentice, Fletcher and Tedd, performance of Cow Green dam would not have been a concern except for the continued reading of earth pressures 25 years after the end of construction. There were no other signs of distress. It is a credit to those who built, installed and have since maintained the pressure cells that the instruments have continued to function for so long. I concur, however, with the authors' suspicion that the apparent decrease in pressure, which led to the concern, may be due to instrument zero drift or to creep in the backing material to the cell.

In relation to the earth pressure measured with hydraulic piezometer, I understood crack closing pressure is thought to give a better indication of minimum principal earth pressure than the crack opening pressure. Crack opening pressures seem to have been used. Is that correct? If we assume the earth pressure readings were correct, would the contact pressure against the concrete face necessarily be the minimum pressure in the core?

Dr P Tedd (BRE)
In response

Most of the tests undertaken at Cow Green dam were close up pressure tests however the test were not altogether satisfactory. It is important to remember that the piezometers had been in service for 25 years and this may have contributed to less than satisfactory critical pressure tests. It is not possible to determine if the contact pressures would be the minimum in the core.

Dr J H Martin (Scottish Hydro-Electric)
Cow Green Dam : Interpretation of earth pressure measurements 25 years after construction.

I respond to John Sammons' point about lift off and closure pressure during hydraulic fracture tests using piezometers and to Paul Tedd's question of whether this had ever been done before on a core contact zone.

In 1987 I undertook such tests on the 90 m high El Chocon Dam in Argentina. The integrity of the core contact with the steep abutment was in doubt because the owner had drilled into the contact zone and caused internal erosion of core material into the drilling fluid. The core, a well graded gravely silt, met the sandstone abutment on a flat surface, included in the cross valley direction, quite similar to the concrete surface at Cow Green. The contact was instrumented with nine Bishop-type hydraulic piezometers that were all in excellent working order after 16 years. Therefore, it was decided to undertake hydraulic fracture tests through these piezometers. Advice was sought from BRE (Penman 1975) and the original BRS apparatus shown in Figure 6 of the present paper (Prentice, Fletcher and Tedd 1996) was exported to Argentina.

Because the permeability of the core material was similar to that of the Bishop piezometer tip, there was considerable head loss across the ceramic filter. Limits were set to avoid bursting the piezometer itself. Spares from the original construction were available at the site so that both head- loss tests and bursting pressure tests were made on saturated ceramic tips.

We found that the BRS apparatus was unable to sustain steady pressures at the high flow rates so that a simpler alternative was developed. Buckets of de-aired water were used as header tanks for the flow and return piezometer lines. This enabled the applied head to be controlled precisely. Flow rate was determined by measuring the speed of air bubbles introduced as full cross section pistons in 2 mm bore piezometer tube laid out on a measuring board.

The lift off and crack closure pressures were measured repeatedly and quite sharp critical knee points were obtained with little hysteresis between the charge and decay curves. (Penman and Charles 1981). I agree with Sammons that the closure values were the more reliable. The results, including a zone showing zero minor principal effective stress near the crest were presented by Knight (1989).

The testing was carried out at various reservoir elevations and was reassuring. However, the greatest comfort came from the knowledge that the core was designed with a self filtering particle size distribution and was well encased both downstream and upstream by properly designed filter layers of adequate thickness together with downstream blanket filters on the bedrock to gravel shell-material contact. I concluded that testing the core to abutment contact using hydraulic piezometers as reported by Tedd is practical and valuable and that as an owner investing in a new asset the greatest reassurance comes from the quality of the original design and detailing.

References

Penham A D M (1975). Earth pressures measured with hydraulic piezometers. Proc. ASCE Specialty Conference on In Situ Measurements of Soil Properties. North Carolina State University Vol. 2 pp 361-381.

Prentice J F, Fletcher M and Tedd P (1996). Cow Green Dam. An interpretation of earth pressure measurements 25 years after construction. Proceedings of the ninth conference of the British Dam Society. University of York. Thomas Telford pp 105-115.

Penman A D M and Charles J A (1981). Assessing the risk of hydraulic fracture in dam cores. Proceedings of the 10th International Conference of Soil Mechanics and Foundation Engineering Stockholm, Vol. 1 pp 457-462.

Knight D J (1989). The proven usefulness of instrumentation systems on varied dam projects. Proceedings of the Conference on Instrumentation in Geotechnical Engineering, Thomas Telford. P 221-234.

Dr Ray Baker (University of Salford)
Reduction of erosion from cells in reinforced grass spillway protection blocks

Last week I presented a paper at the International Conference on Aspects of Conflict in Reservoir Development and Management at City University titled "Methods of reducing the erosion from cells in an aesthetically acceptable spillway protection block" (pages 651 - 656 in the conference proceedings). The work is also covered in briefer detail in a Technical Note in the September 1996 issue of Proceedings of the Institution of Civil Engineers, Water Maritime and Energy (pp 199 - 203). I would like to thank the chairman for giving me a few minutes to give a synopsis of the work.

Since publication of the CIRIA design guide for reinforced grass waterways, pre-cast concrete grass reinforcement blocks are commonly used as auxiliary spillway protection. However, when a flood comes it is expected that material will be washed out of the cells in the block and the design guide recommends the use of a geotextile under the block to avoid the risk of erosion of the underlying embankment.

To investigate the erosion mechanism tests were conducted on a cell in a purpose built test facility constructed in the bed of a flume in the hydraulic laboratory at the Department of Civil and Environmental Engineering at the University of Salford. Water was passed over the cell at velocities up to 6 m/s and it was noted that a single vortex was formed in the cell irrespective of the aspect ratio (depth/length) of the cell. Shear stress generated by the vortex reduced as the cell became deeper and in erosion tests on granular material an equilibrium depth of erosion was reached when the shear force produced by the vortex matched the tractive force of the cell material.

The interesting part of the work related to modifications that were made to the cell, to limit the strength of the vortex and hence reduce the erosion. Two simple modifications are proposed in the paper, a bar across the centre of the cell or a step in the downstream wall.

Bar across the centre of the cell. This involves placing a plastic or metal bar across the upper surface of the cell as shown in Figure 1. It was observed in the laboratory that the bar deflected the flow into the cell generating two vortices of reduced strength. The location of the bar from the upstream edge of the cell, x, was varied and minimum erosion occurred with the bar at the centre of the cell generating two equal vortices. The data also indicates that the bar can reduce the erosion by 53% (Figure 2). Other tests showed that the bar width had very little effect on the erosion, a suitable bar dimension could thus be selected for strength and durability considerations.

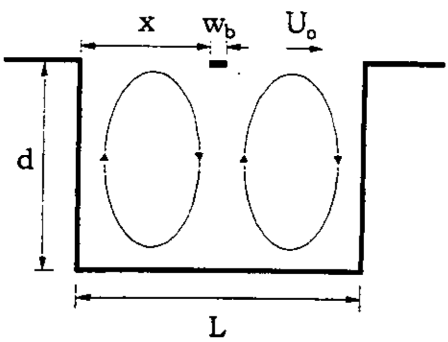


Figure 1. Bar details

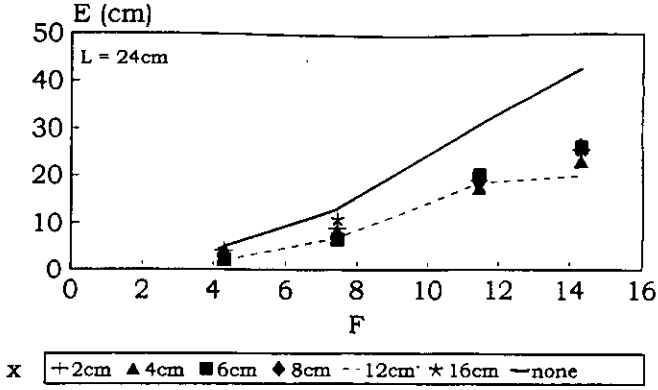


Figure 2. Effect of sdding a bar across the cell

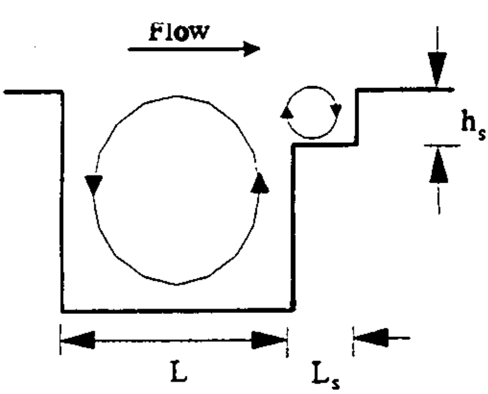


Figure 3. Step in cell wall

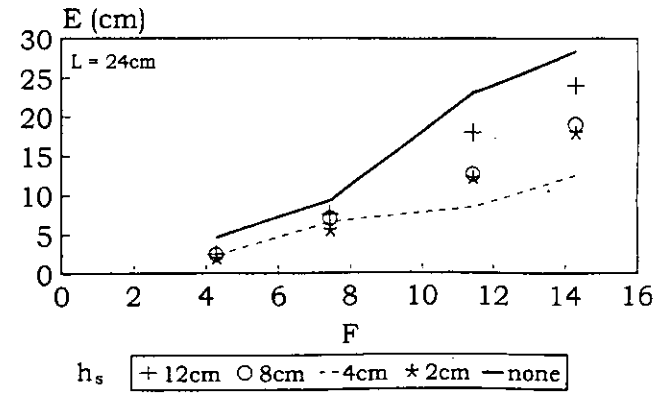


Figure 4. Effect of adding a step to both sides of the cell

Step in the downstream wall. By placing a step in the downstream wall as shown in Figure 3, a strong vortex was generated above the step with a weaker vortex in the cell, leading to a reduction in erosion depth between 60% and 63%. However, with a modification of this type there is always the risk that the block is laid the wrong way round, resulting in erosion depths at least twice those expected, with possible catastrophic consequence. It may thus be preferable to construct a step in each side of the cell. This change moved the point of maximum erosion to the centre of the cell and reduced the effect, even so erosion depths of 55% to 60% of the case with no step could be achieved (Figure 4).

Both of these modifications could be used to reduce the reliance upon the geotextile and minimise the degree of maintenance necessary after a flood.

Mr G P Sims (Graham Consulting Group)
Erosion on grass spillways

My question relates to the contribution by Dr Ray Baker of Salford University. He reported experiments that showed the intensity of the vortices formed within the armour elements could be reduced. The method proposed comprises the addition of a bar set transversely across the element at the level of the surface of the spillway chute.

It appears that such a device, in causing two vortices within the cell, reduces the erosive capability of the water circulating there and coming into contact with the soil beneath the protective elements. My question is whether this effect is magnified by the two vortices rotating in such a way that their contiguous surfaces are moving in opposite directions. If this is so what are the design guidelines to be followed to ensure that this effect is achieved?

Dr Ray Baker (University of Salford)
In response to the question by Mr Sims relating to conflicting rotational directions for the vortices in the modified cell.

The tests showed a conflict in rotation between the vortices. In one case the conflict occurs within the cell, whilst in the other the conflict is between the larger vortex in the cell and the main flow. These must contribute to a loss of energy and thus the mechanism causing less erosion.

SESSION 3
CONCRETE DAMS AND SERVICE RESERVOIRS

Chairman Dr J H Martin

Technical Reporter J L Hinks

Papers presented

1 Refurbishment of Flood Gates at Torr Achilty. N M Sandilands and M Seaton

2 Wala, Mujib and Tannur Dams, Jordan. L J S Attewill (presented by A J Brown)

3 Muela Dam : Design aspects and construction. M Airey and E L Patterson

4 Meriden No 2 Reservoir : renovation Works. G Feakes and D N Williams

5 Evolution of Service reservoir Design and Construction in the Loch Lomond Water Supply Scheme. R B Binnie, I C MacDonald and M C Sweeney

6 Service Reservoirs in Hong Kong. D Gallacher, R J Mann and K L Chan

SESSION 3

Contributions and Responses

Dr A D M Penman (Independent Consulting Engineer)
There are two points. One is that in South Africa what we call the reservoir is called the dam and what we call the dam is called the dam wall. The other is that a figure of 2800 litres/head/day is quoted as the World Bank Recommended minimum for the Middle East. This appears to be an enormous figure and I wonder if there might be a typing error. Should there be a decimal point?

A. J. Brown (Howard Humphreys, UK)
I would agree that it appears to be a typing error but I am not sure of the correct figure.

Dr Coats (Babtie Group)
I was the Inspecting Engineer for Loch Achonachie at which is the Torr Achilty Dam.

The operating gear for the flood gates were refurbished in 1983 and I inspected the reservoir in 1985. After a basic stability check, I recommended that "the stability of the dam under flood conditions be re-assessed". As is the Hydro Board's practice, the matter was referred to the original designers of the dam. As a result, post-tensioning was introduced in 1989/90. I again inspected the reservoir in 1993.

As will be appreciated, it was not practicable to fully open the gates and all I could say was that "they were lifted and lowered sufficiently to demonstrate that they were in acceptable working order. "However, as is mentioned in the paper, the gates were refurbished in 1995 as a matter of routine maintenance. This would give an opportunity to inspect the frames etc.

My question therefore is - had the post-tensioning resulted in any distortion or stressing of the gate frames?

N Sandilands (Scottish Hydro-Electric)
There was no evidence of any adverse effect on the gate frames.

Professor J Lewin (Independent Consulting Engineer)
With regard to Mr Sandilands paper I have noticed that in many cases operators allow gates and valves to deteriorate until refurbishment is no longer an option and this problem is equally acute in river control structures. It would be very helpful if operational data and information of malfunction of reservoir control structures could be disseminated. It would also assist in the assessment of lifetime costs. Much lip service is paid to lifetime costs. In my experience present cost considerations often still predominate. The absence of recorded service experience makes assessment of hazard and reliability of gates and other reservoir appurtenances of uncertain value. Reservoir safety is a major consideration and considerable investigation is devoted to it. Reservoir flood control appurtenances are equally important, failure can negate the reservoir safety. I suggest there should be a systematic collection of data under the aegis of the Society.

N Sandilands (Scottish Hydro-Electric)
I don't think there is actually a question there but I can only agree with Professor Lewin's point. As a company we obviously try and avoid the situation that you initially referred to where gates are allowed to deteriorate to the point where they become beyond refurbishment. We have had a couple of cases where we have had to replace equipment and we have also had a couple of cases where it is actually cost effective to replace because the operating costs involved were actually greater than the refurbishing costs and by shortening the period during which the operations were closed down there was a benefit in carrying out replacement.

We are now making an effort to collect data particularly from testing of operational equipment and I did hint that it is an uphill struggle because it is natural in what is basically a production process like ours that the operators have somewhat different priorities and the difficulty is that we have a shortage of operational information. When we started off developing our policy on gate and valve refurbishment it was done very much on a "suck it and see" basis rather than having actual data to base it on. Fortunately, I think the procedures that we have adopted have turned out during the course of time to be reasonably effective but that is really down to judgement and good luck rather than to having any basis to do it on. I would fully support Professor Lewin's suggestion that it would be worthwhile to gather such data.

I Moffatt (University of Newcastle)
One or two points I would like Alan Brown to clarify with regard to the three dams in Jordan. Firstly with respect to the concrete characteristics quoted in the paper. There is no indication of age I presume these are 90 day figures for compressive strength. Secondly quoting from the figures in the paper there appears to be a bit of a mismatch between the assumptions as regards

the concrete characteristics and what was actually obtained. Particularly with regard perhaps to tensile strength where I believe you indicated that the requirement was 1.4 Megapascals and the figures quoted range from .89 to 1.3 and likewise there appear to be some differences in the quoted values of the moduli. The other thing that I find slightly surprising, bearing in mind the emphasis placed upon seismic loading, is that no mention is made of any requirement for interlayer shear strength in the design.

A J Brown (Howard Humphreys, UK)
The concrete age I am not sure. The concrete testing was a preliminary testing to obtain the best guess for the tender document but it is appreciated that there will be a need for two of the sites. There is still a final decision to be made on the type of aggregate to be used and there is also the decision to be made on the source of pozzolan to be used. Whether the source in Israel would be politically practical as a source or whether it should be imported. So it is recognised that the concrete mix design does need some refinement but there is provision for that in the tender documents. This does not answer the question about the tensile strength and the moduli in terms of inter-layer shear strength. Again my understanding is that it was assumed that there would be some interlayer strength, but again I am not sure of the exact details. It will have to be dealt with in terms of written discussion with Lawrence who I am sure would be happy to answer it.

Dr J H Martin (Scottish Hydro-Electric)
I notice that in your paper you were also controlling at 90 day strengths. Are you in fact using shorter life strengths and projecting out to 28 days for quality control purposes on site?

M Airey (Mott MacDonald)
Yes the question there on strengths we do control it at 7 and 28 days and then retain a few cubes for 90 and even 120 days. If it appears that there is a problem with the 90 day strength then we will hold the cubes back to check at the 120 days. It is the longer term strength that is the real issue as long as we have sufficient strength for the stripping of the shutters.

J Cowie (Mott MacDonald)
Question for Neil Sandilands. You have described the repairs that went onto the gate but there is a very brief section in your paper about the repairs to the roller path. Would you care to expand a little on that?

N Sandilands (Scottish Hydro-Electric)
You are referring to the roller trains at Torr Achilty, John?

The parts that the roller trains run on. In the case of Torr Achilty the actual roller paths are in good condition and no work was carried out on them.

Dr J Martin (Scottish Hydro-Electric)
Malcolm you have some supplementary material I believe on the RCC designs for the dams in Jordan that Alan has described in Lawrence's paper.

Dr M R H Dunstan (Malcolm Dunstan & Associates)
I would like to say a few words about four RCC dams.

Upper Stillwater Dam in the United States is 91m high and contains 1.25 million cubic metres of concrete. The concrete was transported to the dam by conveyor and is placed by 35 tonne trucks. The dam was completed in about 10 working months spread over 3 construction seasons. There was a 70°C temperature range and all the concrete was placed in the summer with maximum temperatures of 30-35°C on site and a maximum placing temperature of 10°C allowed.

The concrete having been dumped was spread by a dozer. The concrete was being placed at a rate of roughly 500-600 m^3/hr. Concrete placing was guided by laser receivers to make sure it went in at an even thickness.

The concrete came along a conveyor before being loaded into trucks and placed by dozers before being compacted by vibrating roller. There were typically 13 people working on the dam and they were placing 500-600 m^3/hr.

The Platanovryssi Dam is presently under construction. It is 95 m high and contains about 450,000 m^3 of concrete and has a fairly sizeable spillway with a unit discharge over the top of 110 m^3/sec per metre. The power house is downstream and the auxiliary spillway is a ski jump over the top of the powerhouse. There is a separate shaft spillway into the diversion tunnel.

The site is somewhat unusual because at most RCC dams the concrete is transported onto the dam surface by conveyor. In this particular case the batching plant is up on the right abutment. Concrete is taken along the conveyor and there is a gravity pipe down the dam. Very few people or plant work on the dam.

Porce II dam is just starting construction at the moment in Columbia. It is 130 m high and contains 1.3 Mm^3 of concrete. The river diversion has just been done. The earthfill dam has an interface between the RCC dam and the earthfill dam and rockfill dam. So 3 dams actually meet

Finishing off what was said last night, a dam called Longtan. This is the largest RCC dam presently being considered and the construction has started on the access roads. Eventually it is going to be 217 m high and the volume is infact going to be 7,500,000 m^3 of concrete. Reservoir capacity is 20 billion m^3. Unfortunately this dam seems to fall quite high up the chart as one of the worst dams because there are 73,000 people having to be moved, but there is a fairly sizeable installed capacity here and a huge annual output; and the PMF is quite large at 42,000 m^3/sec. The structure will dam the Hongshi River which is about 250 m wide at the dam. This shows that in fact there are no real limits at the moment to RCC dam construction; this will be one of the largest dams in the world.

T A Johnston (Babtie Group)
Testing Dam Outlets

In presenting his paper Mr Sandilands commented on the difficulties which can occur in testing gates and outlet pipes at dams and, in particular, on the need to carry out this task in conjunction with the river authorities. It is vital that these difficulties are not allowed to become an excuse for not carrying out regular testing. Indeed, if it is not acceptable to test a scour valve or a gate regularly, I would question whether it is proper to rely on the valve or gate in an emergency.

Seismic Analysis of Dams in Jordan
It would be helpful to have some further information on the seismic analyses of the dams in Jordan. The designers have accepted that some damage will occur to the structures in the Maximum Credible Earthquake. Can they give examples of the acceptable damage. In a concrete dam, the tensile strength is always a subject of debate. Is it possible to add the tensile strength to the information on material properties in Table 4? What is the assumed relationship between the static and dynamic strengths.

Muela Dam
No site investigation can reveal everything about a dam site and the design of many dams is modified as work proceeds. This was the case at Muela and the paper describes the introduction of a near "gravity" section on the right abutment. With hindsight, would a concrete gravity section or a rockfill dam be a more appropriate design?

N. Sandilands (Scottish Hydro-Electric)
I think that the point that has to be considered is a balance of risks. As an inspecting engineer your automatic reaction would be for a gate to be opened fully at some stage. If you take the example of Pitlochry dam by doing that you are creating a flood of 600 m^3/sec. The largest flood passed at Pitlochry dam since construction is 1100 m^3 that flood caused considerable damage in Perth. By carrying out the tests you are creating a event which has a probability of 100%, whereas the design floods are extremely low probability events. We have to be extremely careful that we don't create more risks through testing than actually exists through the events that we are trying to cater for.

Dr J H Martin (Scottish Hydro-Electric)
I would like to also add as supplementary to that as Civil Engineers we have to accept that we are taking decisions every day which cannot be verified by testing. This is commonly classified as engineering judgement and in the operational duties the desire to test is understandable and one does test what one can, but if you move into the realms of process plants, chemical plants, a lot of their large hazards such as escaping toxic gas and flammable gas clouds are also designed for and have just as much safety consequence where there are local communities surrounding the area as the rest that we face, and they by definition are also untestable. So I think it puts a premium on our engineering designs and maintenance to approach these things other than by full scale testing.

T A Johnson (Babtie Group)
I would certainly like to come back on this but it is certainly a very large topic and one which deserves a lot longer than we can afford at this time.

Dr J H Martin (Scottish Hydro-Electric)
The second question was to do with the tensile static and dynamic strengths of the RCC mix in

the dams in Jordan. I have got two experts flanking me, but I have a supplementary of my own quoting the late Bill Mee, Consultant for Sir Alexander Gibb & Partners, when I think Malcolm gave his presentation at the civils in London. I had a supplementary - what about the foundation? Bill's hypothosis was when talking about tensile strength of RCC that is all very well but does that mean that the foundation knows about this and is it therefore to be interpreted that the dam falls over in one lump.

A.J. Brown (Howard Humphreys, UK)
I am afraid that I will plead ignorant again. Clearly there were two parts. What was the equivalent tensile strength at maximum credible earthquake and I afraid I don't know and I would say it is clearly more reasonable to compare tensile stresses obtained from under dynamic loading with reliable factors under high loading not with static tests.

Dr M R H Dunstan (Malcolm Dunstan & Associates)
Regarding the foundation on large concrete dams the maximum stress is under dynamic loading and not at the foundation. They are about b the way up the dam.

Dr J.H. Martin (Scottish Hydro-Electric)
The final question from Alan is why is an arch dam being built at Muela.?

M Airey (Mott MacDonald)
As you are probably aware various dam types were considered for the Muela site at different stages, including an RCC dam at one stage, and also the initial design was for a gravity arch that was subsequently changed at the design review stage to a conventional arch which gave a cost saving. Referring to the problems of the upper right abutment, these were well understood from the site investigation and did not in themselves preclude the use of an arch. During the construction phase a greater understanding of those problems was revealed and the modification to the semi-gravity section over that upper abutment was introduced.

The main purpose of that modification was, whilst retaining an arched type structure, to effectively give us a gravity abutment section against which the normal arch could thrust, and had the effect of driving the resultants downwards into the competent bedrock below rather than into the abutment downstream which was affected by the intrusive actions of the dyke. In itself it is a semi gravity section. Over that part the problems that were encountered would have been the same problems had it been a conventional mass concrete gravity dam. There would still have been a potential for sliding on those bedding planes. That's not to say that the problems could not have been solved, but that was the history on how we got to the arch dam and solved the problems on that abutment.

J Millmore (Babtie Group)
I think that my question relates to all of the speakers and relates particularly to joints within reservoirs. On the whole, as in Hong Kong, the UK service reservoirs are in pretty good condition but the place where I have found troubles tend to occur is at joints. With time, sealant does cease to be as flexible as when it was initially installed, and one question that I have been asked in my inspections by virtually every owner of service reservoirs is why bother replacing the sealant because, after all, we have a good water bar system behind the sealant and therefore

the sealant provides no useful value beyond its initial installation. That is a question for all of the speakers fortheir experience and their views.

The second point I would like to make, Mr Chairman, is some recent experience I have of overflows on reservoirs. The experience I have had of late is in the UK service reservois are generally constructed in semi-urban areas and overflows, because of the nature of service reservoirs, tend to be very long, and therefore there is a growing trend for construction along the route of the overflow pipes and I have experiences of overflows having been damaged by piling from new buildings. For example the overflow pipe totally blocked by concrete, sheet piling and excavations and I was wondering if the speakers have had similar experiences.

R B Binnie (Halcrow Crouch)
My response to the first question is yes we would recognise that the joint locations are always the elements that are most likely to cause difficulties in service reservoirs. I can say that within the Lomond scheme all of the Phase 1 reservoirs have been reinspected in the last 5 years and the joint sealants, which are bituminous material, generally speaking are in good condition and required only minor replacement work. If a joint sealant was found to be defective my preference would be to replace it, for two reason. Firstly, I would always prefer to have not one single line of defence; I would prefer to have the full protection system as it was originally designed in place. The second is that joint sealant is one of the areas that can readily be inspected by supervising and inspecting engineers within service reservoirs and gives an early indication of potential difficulties that might not be so readily identified in the waterbars.

The overflows within the service reservoirs in the Lomond scheme are contained within the structures.

G Feakes (Sir Alexander Gibb & Partners)
I have very little to add to the comments already made on the joints but I think that we must consider in much more detail the purpose of the joint whether it be a construction joint, expansion joint, the nature of the joint, its behaviour and also the mechanism of the control of thermal shrinkage of the concrete. In many cases I've noted a standard wall width has been dictated as being the criteria, that should not be exceeded, whereas in some cases it is far better to go for a large width initial pour with a small infill section done at a later date so that contraction is related to a smaller wall dimension. If you use this control with the actual concrete then you control the temperature of the concrete, and during its hydration process you are more likely to control the amount of movement that that joint is susceptible to. Nevertheless, I still feel that you need a backup, rearguard waterbar, or some form of substantial waterbar plus an internal sealant and I would still go for replacement of the sealant; it is something that can be done relatively easily.

D Gallacher (R.H. Cuthbertson & Partners)
I would definitely replace the sealant. If you have tested it without the sealant, fine, but if you haven't tested it then I would put the sealant back.

Quite often I have found with service reservoirs in Hong Kong that once you have drained them down back pressure tends to push the sealant out and I would tap it back with a batten before putting the reservoir back into service.

On the overflow question this has been a big question in Hong Kong. We actually adopted a policy not to overflow because you are never quite sure whether the drainage system could actually accommodate it.

D N Williams (Severn Trent Water)
We have taken the decision not to replace the joints sealants where the joint has been sealed and is a construction joint because we saw no purpose to the joint themselves. Where we have expansion joints we have been able to concentrate on retaining our joints because of the importance of the joint itself.

SESSION 4
DAM SAFETY, STANDARDS, RESERVOIR MANAGEMENT

Chairman Professor C J A Binnie

Technical Reporter Mr D P M Dutton

1 River Liffey reservoirs : 50 years protecting and supplying Dublin City. B J Mangan and T A Hayes

2 Reservoir sedimentation : some aspects of reservoir asset management. J N Duder (presented by I Moffat)

3 European dam safety regulations from a British perspective. J A Charles and C E Wright

4 Reservoir Inspections : Time for a Change? I Hay

5 The Management of Reservoir Safety. P Milne

6 The Reservoirs Act 1975 and the Environment Agency. K Barton

SESSION 4

Contributions and Responses

J R Claydon (Yorkshire Water Services)
Question on reservoir sedimentation

Sedimentation may not be recognised as a general problem in the UK but Yorkshire Water takes it seriously enough to have funded research into catchment erosion since 1980. The problem areas are loss of storage and blockage of bottom outlets.

I do not agree that sedimentation is always regarded as a detriment. The delta formed at the head of Gouthwaite Reservoir contains 1 million cubic metres of material;. It is grass covered, attractive and has been designated as a site of special scientific interest (SSSI). There are no environmentally acceptable ways of removing the sediment, without destroying the SSSI. The sediment could form a tip on the adjoining hills or be taken out of the valley by road through the minor local roads and villages.

Does the presenter, or anyone else, know of a case where it has been shown to be economic to remove silt from a water supply reservoir?

Yorkshire Water's present policy is to minimise sedimentation by catchment management, where possible, and operation and maintenance of existing sediment trap arrangements in the gathering grounds.

A I B Moffat (Newcastle University)
In reply to Mr Claydon's question, I am not aware of any instances in this country, but there is reference to one particular New Zealand case in J Duder's paper : it is a hydro-scheme and I am not aware of any in connection with water supply schemes. I do take the point, though, that sedimentation is not always disadvantageous; I believe that in some of the Longdendale valley reservoirs they used to sell the silt from the residuum lodges and return quite a handsome profit to North West Water.

A K Hughes (Rofe, Kennard & Lapworth)
Question on the River Liffey Reservoir

Could the authors tell us whether the public are aware that inundation maps have been produced, and if they are aware what was their reaction?

In response to previous comments concerning sedimentation, residuum lodges at North West Water reservoirs were cleared out periodically and the silt was sold to a local garden centre. Also, as an example of desilting a reservoir, RKL is currently devising a scheme for a reservoir in North Devon.

J W Findlay (Babtie Group)
Question on the River Liffey Reservoir

Reference was made to the inundation maps being plotted on aerial photographs. I am interested to know which software was used, how the output was related to aerial photographs and at what scale the final maps were produced.

Reservoir sedimentation
In Britain, sedimentation of reservoirs is not generally considered a problem in terms of significant lost storage. However, public perception runs contrary to this and there is increasing pressure to consider dredging as a means of restoring lost storage or even creating additional storage as an alternative to new resource development. A clear case has to be put by the engineering community to explain why dredging is not a cost effective or technically desirable solution in most cases.

The situation in other countries, particularly those with relatively young and varied geology, and as described in New Zealand, is often very different. Mr Moffat, in presenting J Duder's paper, made reference to Tarbela and Mangla in Pakistan. Babtie Group's work in the North West Frontier Province of Pakistan (NWFP) found that predicted sedimentation often discounted plans for small irrigation reservoirs due to the rapid loss of storage (1-10 years).

While catchment management can have an important role to play in sediment control it has to be appreciated that in developing countries the social and administration structures are often unable to progress catchment management in advance of reservoir construction, if at all. It is also worth noting that much of the erosion in areas such as NWFP is geological and cannot be effectively reduced. Traps and intakes, if well designed and operated, can reduce sediment entering a reservoir but even off channel storage is not immune and the medium sized Tanda dam in NWFP, which is fed by a gated river structure and a long canal, has reportedly lost some 30% of live storage in 10 years.

R Freer
Question on European dam safety regulations

In his collection of information on reservoirs in this country, has Dr Charles raised with the owners their wishes, views or inclinations towards funding what is now funded by the DoE; safety research? If we ever move to entirely private arrangements, would the funding still be there from private sources as distinct from DoE sources?

J A Charles (BRE)
In reply to Mr Freer, I have not raised that with all reservoir owners in the UK. I suspect it would not.

M Airey (Mott MacDonald)
Question on reservoir sedimentation

Has consideration been given to the economics of desilting a reservoir at a time when remedial works involving a reservoir drawdown are being undertaken or when a natural drawdown is anticipated?

J R Claydon (Yorkshire Water Services)
In reply to Mr Airey, on three occasions when reservoirs have been empty for repairs we have attempted to promote silt removal on a marginal cost basis. None of these has been shown to be economic and none has proceeded.

T A Johnson (Babtie Group)
Reservoir sedimentation

Reservoir sedimentation is an increasing problem and practical experience is being gained on methods of clearing bottom outlets. The European Club 1996 conference in Stockholm contained a particularly interesting example of unblocking the bottom outlet of Barahona Reservoir in Spain using a jetting technique with air and water to loosen the silt which had built up to a depth of 18 metres against the dam. The problems in the UK are less dramatic but it may be worthwhile devoting more time to this topic at a future conference.

Sedimentation is not always detrimental. Silt can act as a natural seal to escapes of water from a reservoir. Broomhead Reservoir near Sheffield is a good example of this. When first impounding took place there was considerable leakage from the reservoir basin with high uplift pressures under the dam. The basic problem was open-jointed rock in faults which "daylighted" in the reservoir basin and acted as a channel for the reservoir water. The seepage losses have declined over the years and this is attributed partly to the silting up of the floor of the reservoir.

Question on the River Liffey Reservoirs

Dambreak analysis and contingency planning are topics which have been raised at the meetings of the European Club of ICOLD. Professor Raymond Lafitte of Switzerland, the Chairman of ICOLD's committee on Dam Safety, has described how, in valley bottoms in Switzerland, buildings and lampposts are marked with the level of flooding which would occur if a dam should collapse. It appears that this information is regarded as helpful to the public. So far in the UK, as in Ireland, information on the consequences of a dam failure has not been actively distributed to the public. Do engineers have a duty to make this information known?

Many water companies have carried out emergency exercises with the emergency authorities and now have contingency plans for some or all of their reservoirs. It would be reasonable for plans to be prepared for reservoirs whic pose a hazard and to mount an exercise in Ireland and in the UK to educate but not alarm the public.

C J A Binnie (W S Atkins)

Question on the River Liffey Reservoirs

Should a dam break occur and there be serious damage or even loss of life there will be an inquiry.

It is now technically possible to carry out inundation studies as done on the Liffey, pass these to the Emergency Planning Services, and set up appropriate emergency planning and control procedures. As an instance of one important feature it is no good relying on an emergency control centre which is likely to be swept away or has already been destroyed. There was a good paper presented at the Exeter BDS Conference (1994) by Jim Claydon and others from Yorkshire. I remember Jim saying in the presentation that the most difficult part is the emergency planning. Society will expect us to have carried out all these activities and will also be critical if we have not placed this information in the public domain.

What is the situation on the Liffey study? Have the inundation results been passed to the emergency services, the local planning authority and the public?

B J Mangan and T A Hayes (ESB International)

Answers to questions on the River Liffey Reservoirs

A K Hughes, T A Johnston and C J A Binnie

The ESB, the owner and operator of the Liffey Dams, has a policy of making the results of inundation studies available to the relevant local authorities and emergency services. The decision to make the inundation maps available to the general public rests with the management of the local authorities. The general publication of maps showing widespread inundation would, in our opinion, cause major concern and fear among those people likely to be affected, irrespective of any steps taken to educate the general public. It would be difficult to convince people of the extremely low risk of a dam failure. The inclusion of results of inundation studies in emergency planning with other hazard scenarios may be the best solution.

J W Findlay
The dam break software used was the US National Weather Service model `DAMBRK'. The final inundation maps were produced at a scale of 1:5000. The flood contours were prepared on contour mapping of the Liffey valley and registered in raster form with the scanned digital imagery.

R J Vincent (Department of the Environment)
The Reservoirs Act 1975; proposed deregulation order

There are four components to the deregulation order: (i) transfer of enforcement authority duties to the Environment Agency; (ii) removal of the requirement for continuous supervision of low-hazard reservoirs of less than 100,000 cu m capacity; (iii) simplification of the system for appointment of Panel Engineers; and (iv) removal of silted- up reservoirs from the scope of the Act.

A consultation paper on these changes was issued in 1993. In the light of this consultation, work commenced on the preparation of a draft deregulation order. It was intended to lay an order before Parliament in 1995, but other demands on officials resulting from the continuing drought have delayed progress. However, earlier this summer we addressed the financial arrangements necessary for the transfer of enforcement authority duties by asking each local authority currently having responsibility to estimate its annual expenditure on fulfilling those duties.

Not all authorities have yet replied, but the best estimate which can be made shows that the aggregate expenditure by local authorities is only some 50% of the sum which the Environment Agency would need to have transferred to it in order to establish enforcement authority arrangements satisfactorily within its operation. Therefore officials are presently reassessing this component of the proposed deregulation. It is unlikely that a transfer will take effect in 1997. We are also considering how best to take forward the three other components of the proposed order.

J L Hinks (Sir William Halcrow & Partners Ltd)
Reservoir inspections

I found Mr Hay's paper extremely interesting but far from reassuring. In particular he draws attention to the tendency for absolutely basic inspection reports to be prepared in response to fee competition based on lump sum quotations.

There is a current tendency to go for lump sums which are sometimes as low as £700 for Section 10 inspections on Category A dams. This represents an input of around 12 hours which is only enough for the Inspecting Engineer to visit the dam and write down what he saw.

We have to ask ourselves whether 12 hours once every 10 years is enough for dams where lives are at risk in communities. I do not think that it is, even though I recognise that it only represents a small part of owners' expenditure on reservoir safety, surveillance and monitoring.

What then is the right level of inputs for the average inspection of a Category A dam? Fifteen years ago my firm's average input on inspection reports was about 100 hours which allowed us to produce fairly detailed reports with appendices on geology, history, hydrology and stability. Perhaps this was a bit generous but I would suggest that an input of 40 or 50 hours is needed to produce a decent report covering all the relevant topics in sufficient depth.

I recently visited a number of dams overseas and saw the reports that have been prepared for them. Technical inputs were at least ten times the average in the UK and the reports included comprehensive appendices covering such matters as stability and hydrological analyses.

40 or 50 hours is very modest by comparison and is not, I think, excessive for UK conditions.

Lump sums are fine for dams in Categories C or D but I would like to suggest to the major owners that they discontinue fee competition based on lump sums for Category A dams. They could invite competition on the basis of hourly rates but I do not think that it is in anybody's interest for them to squeeze inputs below 40 - 50 hours.

In short, I agree with the conclusions of the OSTEMS mission that "dam safety in Britain requires more attention than it is receiving". I would like to see the allocation of increased resources so that we can justly claim that UK arrangements for reservoir safety are fully up to international standards.

On a personal note I would like to add that my career started in 1969 in the aftermath of Aberfan. We had a large office with ample resources checking spoil heaps in South Wales. These tips had been badly neglected over the years with very few resources allocated to their care. After Aberfan the resources were very ample but it all came too late. We should be vigilant to see that such a situation cannot arise with our dams.

T A Johnston (Babtie Group)
The Reservoirs Act 1975

The Reservoirs Committee of the Institution of Civil Engineers plays an important role in respect of reservoir safety in advising the President on the tasks he is required to fulfil in respect of the Reservoirs Act 1975. The committee has recently decided to look beyond the changes contained in the current draft deregulation order and it has set up a working party to review the operation of the Act and to consider how it might be modified in the future.

The present working party comprises N M Parr (North West Water), three panel AR Engineers (J Beaver, D Gallacher and G P Sims) and representatives of the Building Research Establishment (Dr J A Charles) and the British Dam Society (T A Johnston). The Secretary is R Freer, Secretary of the Reservoir Committee at ICE. BDS has welcomed the invitation to be represented on the working party and to work more closely with the Reservoirs Committee. As the representative of BDS I will attempt to pass on members' views. In addition, members can help initially in two ways, by writing to Robert Freer with any points they wish to be considered and by responding to questionnaires which the working party issues to owners and panel engineers.

The working party's first tasks relate to the existing Act, the associated certificates and the prescribed form of record. They will welcome information on sections which cause difficulty in application and delegates are invited to write to Robert Freer with a description of any problems. If there are suggestions for improvement, they will also be welcome.

In due course the working party will look beyond the present Act and consider wider topics such as the ambit of the legislation and hazard classification.

C J A Binnie (W S Atkins)
Would Mr Vincent like to comment on the prospect of there being Parliamentary time for changes to be made to the 1975 Act in the light of the review currently being undertaken by the BDS working party?

R J Vincent (Department of the Environment)
It is a tribute to the work of the BDS, in particular the Panel Engineers amongst its membership, and also to the quality of the reservoir structures we have inherited, that reservoir safety is not an issue in the perception of the public or of politicians. Therefore, any Government is likely to afford a very low priority to any changes to the current reservoirs primary legislation. Clearly, that perception would be changed if any significant difficulties were seen to arise. The advent of any firm proposals for European Community legislation would also necessarily change the situation.

A K Hughes (Rofe, Kennard & Lapworth)
The Reservoirs Act 1975 : proposed deregulation order

I wish to make a plea to Mr Vincent — if the decision to make the Environment Agency the Enforcement Authority under the Reservoirs Act 1975 is being delayed due to a small amount of money (when compared with the DoE budget) then it should be realised that it is money well spent. The uniformity of approach which would be provided by a single organisation will result in significant improvements to reservoir safety in the UK.

A D M Penman (Independent Consulting Engineer)
The Reservoirs Act 1975

Following the failures of Malpasset and Baldwin Hills dams and the devastating overtopping of Vajont dam that killed 2043 people, the proposal was made during the 8th International Congress on Large Dams, held in Edinburgh in 1964, that all member countries of ICOLD should review their reservoir safety regulations. I served with the *ad hoc* committee set up by our Institution of Civil Engineers to submit proposals for a revision of our Reservoirs (Safety Provisions) Act 1930, and draft the blue `Report on Reservoir Safety' published in 1966. In that report, the committee suggested that the enforcement of the Act should be the responsibility of a Government department to whom copies of all certificates and reports of inspection should be sent, and which would have the duty to see that any work recommended was carried out. We felt that a relatively small office with five or six people would be able to handle the work, and it would have a great advantage of keeping reservoir records in a central place so that they could be referred to by future engineers concerned with the reservoirs. Even at that time, in the 1960s, amalgamation and changes of offices were causing records to be lost. I am delighted to hear from what has just been said by Mr Barton and Mr Vincent that a national centre is to be set up at long last, and I am sure that I can speak for the ad hoc committee, even though the majority of its 11 eminent members have unfortunately already passed on, in expressing pleasure that this recommendation is to be put into effect.

N M Sandilands (Scottish Hydro-Electric)
Reservoir inspections
With regard to the Inspecting Engineer being part of a team, Hydro-Electric tend to restrict appointments to engineers in companies who we believe have adequate resources to provide the necessary back up.

Hydro-Electric favour the issue of draft reports. This allows factual information to be verified to the benefit of both parties.

With regard to fees, Hydro-Electric favour payment on hourly rates. I endorse the comments of Jonathan Hinks. The average fee is £2,500 to £3,000 which corresponds with the level of input which Jonathan suggested. With seven or eight dams to be inspected this equates to an annual cost of around £20,000, compared with an annual civil engineering budget of around £5 million.

D J Coats (Babtie Group)
Reservoir inspections

I have been an Inspecting engineer since 1968 and have, therefore, seen many changes in the approach to inspections. I agree that there is now a need for further change and it is good that we are now discussing these matters and not just explaining or defending the 1975 Act.

There is need for back-up for the Inspecting Engineer and his team but I would not support prescriptive legislation. Undertakers have opportunity of referring an Inspecting Engineer's recommendations to a referee but this is very seldom used. The use of a review panel during the design or construction of a dam can be helpful as I, as Construction engineer for the Carsington reconstruction, found, although in that case the help was in discussing our intentions or actions rather than changing them. I can recall only one occasion when we had to change a drawing and that was to increase the height of the filter behind the core by half a metre. Using a review panel employed by the Undertaker to interfere with an inspection is quite another thing.

I feel that an alternative might be considered where a review might be carried out by a Dam Safety Officer (but not the Enforcement Authority), a kind of independent appeal court. I think that this would be welcomed both by Undertakers and Inspecting Engineers. The following advantages could follow.

It could:
a) encourage uniformity of standards;
b) protect Engineers from pressure from Undertakers;
c) protect Undertakers from over-cautious recommendations;
d) provide added pressure to implement recommendations.

D B Wickham (North West Water)
Management of reservoir safety

I support Peter Milne's comments on fee payments. In North West Water we adopt a policy of lump sum fees for straightforward inspections for which the scope is readily determined. We accept that should additional work be required then further payment is appropriate. Previous reports often contain detailed appendices which do not need to be repeated, although some updating may be called for.

J H Martin (Scottish Hydro-Electric)
The Reservoirs Act 1975

The discussion over fee competition, time-charged panels to check the competitively-bid, lump-sum inspections and committees redesigning primary legislation under a climate of low parliamentary interest links straight to Professor Perrings' warning to engineers in last night's conference dinner speech. He told how other professions had skillfully avoided execution at the guillotine by concealing the knot in the rope which prevented the blade achieving its designed purpose, and then claiming glory for the `miracle'. The apocryphal engineer, meanwhile, ensured his own downfall by diligently pointing out the knot and removing it himself.

Returning the reservoir safety, we appear to be competing with each other for guillotine maintenance (inspection), to be abetting the establishment of panels of our professional colleagues to ensure that we have undone the knot properly and now we have set up a committee to design knot-free guillotine ropes (review of the Act).

Richard Vincent in his talk on the deregulation order made it clear that he was seeking clarity and an economic way of delivering an ongoing reservoir safety system as good as, or better than, we have now. We in this room, stimulated by Ian Hay's paper have the knowledge and organisation to offer Richard a comprehensive solution. Therefore my question is, would the Department of the Environment welcome a tender from the British Dam Society with the Institution of Civil Engineers, to establish a strong and durable reservoir safety system for the future?

Richard Vincent (Department of the Environment)
We would welcome any sensible bid in the spirit of pursuing all reasonable routes to deregulation and economically ensuring that public obligations are properly achieved.

O P Williams (First Hydro Co)
Question on management of reservoir safety

In his paper Peter Milne states "Normally, Supervising Engineer Reports are not forwarded to the Enforcement Authority"

I would welcome clarification whether this means that supervising engineers' advice in annual statements under the Act, reports or other communication normally contain no recommendations at all to the Undertaker to take any action. Clause 20(4)(e)(i) of the Act refers.

D N Williams (on behalf of P Milne)
In reply to Mr Williams' question, at Severn Trent water the supervising engineer's advice in the annual statement is contained within a much fuller report to the Undertaker and includes issues beyond that of reservoir safety. Unless this advice includes the recommendation to the Undertaker that the reservoir be inspected under Section 10 of the Act, then the report would not be forwarded to the Enforcement Authority.

PAPER ON THE ENVIRONMENT AGENCY'S PROPOSED APPROACH TO RESERVOIR ENFORCEMENT, BY MR K BARTON

As part of the Government deregulation initiatives in October 1993 the Department of the Environment and Environment Division of the Welsh Office issued a Joint Consultation Paper which included a proposal to make the NRA the enforcement authority for the Reservoirs Act 1975. The latest proposal is that it is likely to be progressed through a Deregulation order at some stage. A Project Board was assembled from senior NRA personnel to consider the implications for the Environment Agency of taking on this role.

The Project Board comprised the following:

Peter Kite	Project Executive
Kevin Bond	Chief Executive
Bryan Utteridge	Head of Flood Defences
Richard Logan	National Emergencies Co-ordinator
Ken Barton	Project Manager

A Project Team was assembled to address specific issues identified by the Project Board. The Project Team comprising personnel from the NRA and specialist consultants Rofe, Kennard & Lapworth (RKL) was as follows:

Ken Barton	Regional Flood Defence Co-ordinator Northumbria & Yorkshire Region NRA
Hilary Aldridge	Solicitor, Head Office NRA
Adrian Birtles	South East Area Manager, Thames Region NRA
Gwyn Williams	Regional Authorisations Manager, Severn-Trent Region NRA
Phil Younge	Area Technical Manager, North West Region NRA
Mark Fletcher	Regional Manager, RKL - Secretary & Technical Advisor
Dr Andy Hughes	All Reservoirs Panel Engineer, Partner RKL - Technical Advisor

It was evident that there will be two main roles for the Environment Agency within the legislative framework following implementation of the deregulation proposals.
These are:

(i) as the enforcement authority for England and Wales,
(ii) as an undertaker.

It is considered vitally important that the enforcement and undertaker roles are clearly separated and managed as separate services within the Environment Agency to avoid any conflict of interest and ensure internal independence.

SCOPE

This presentation will deal with the proposed role as enforcement authority, it is based on the deregulation order as we understood it at that time, the actual details could alter our proposals.

TASK

The task of the project team was to:

- identify the implications for the Environment Agency taking on the enforcement role and make recommendations on how best to undertake it.

APPROACH

We examined the legislation using our experience and formed our own views on the:

- basic requirements of the role,
- scope of the role,
- the interface with existing Environment Agency Activities
- IS Systems,
- resource Options.

In doing this we also looked at practice in other countries.

CONSULTATION

We consulted widely:

10 existing enforcement authorities		we found what they were doing and also what they thought they should do
3 water authorities	}	
1 water company	}	
BWB	}	
ICE	}	We asked what their views were, and what they wanted from the Enforcement Authority.
BDS	}	
DoE	}	
BRE	}	

We then re-visited our proposals.

ORGANISATION

The organisational options we considered were for the task to be resourced at Area, regional, Supra-Regional or National Level.

REQUIREMENTS

Our objectives were: Consistency
Effectiveness
Efficiency

We were looking for logical procedures carried out in a comprehensive and efficient manner.

A uniform approach without excessive bureaucracy.

Local knowledge is also important including contact with local authority emergency planners and access to the public register.

PROPOSAL

The team's preferred solution is for a national centre with regional representation.

REGIONALLY

This approach will provide separation of our undertaker and enforcement roles. However there will be some overlap, as it is proposed that Regional Liaison Officers are designated and that these will be the staff who are also responsible for overseeing our own reservoirs. They will give us informed local knowledge and provide public access at a local level.

NATIONALLY

The national centre will aid clear communication between the Undertakers, Panel Engineers and the Enforcement Authority.

It will be a focus for liaison with the DoE.

It will be an administrative centre for undertaking the role nationally, equipped with a computerised database.

The national centre will consist of a small permanent team headed by an experienced chartered civil engineer with access to retained All Reservoir Panel Engineers.

These proposals will be considered by the EA Board this Autumn.

APPROACH TO ENFORCEMENT

We intend to operate as far as possible by agreement.

We will be proactive in enforcing the legislation.

We will enforce recommendations in the interests of safety within a reasonable timescale.

BENEFITS

I would like to conclude by summarising the benefits that we believe would result in the Environment Agency becoming the enforcement authority for reservoir safety.

1	Consistent national approach.	DoE, Undertakers, Panel Engineers
2	Proactive approach to legislation.	Public, DoE
3	Single point of contact with the Enforcement Authority.	DoE, Undertakers, Panel Engineers
4	Single database.	DoE
5	Annual report as part of Environment Agency report.	DoE