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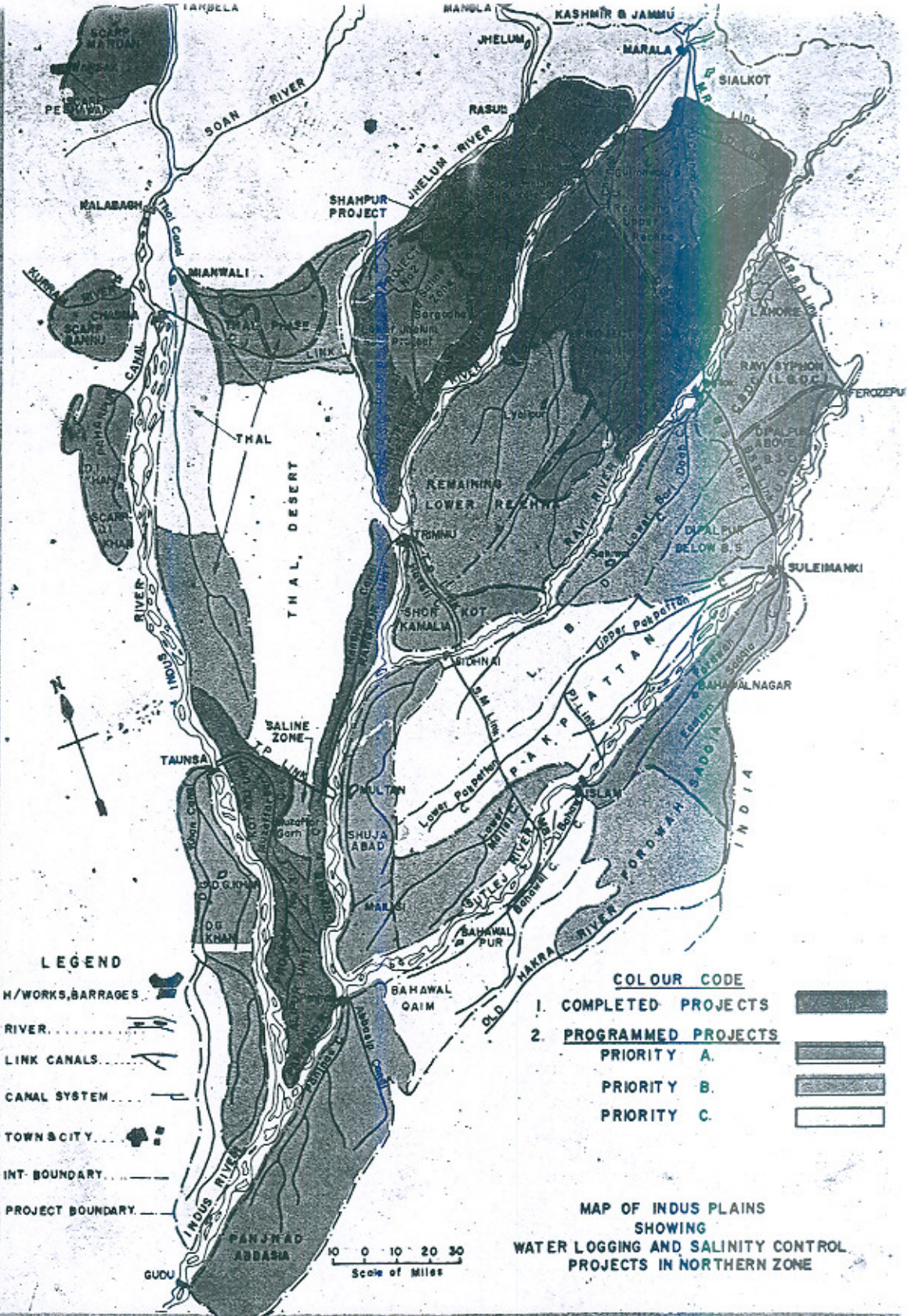

MAP OF INDUS PLAINS
SHOWING
WATER LOGGING AND SALINITY CONTROL
PROJECTS IN NORTHERN ZONE

Vol. XX No. 4

ENGINEERING NEWS

December 1975

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ENGINEERING NEWS

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Vol. XX DECEMBER 1975 No. 4

In this Issue

TITLE COVER

Map of Indus Plains Waterlogging & Salinity Control Projects in Northern Zone.

FOOD FOR THOUGHT

"There is no love sincerer than the love of food"
—George Bernard Shaw

Food has been both a motive and a means of major political upheavals in the world throughout the known history and, unless man undergoes a drastic and fundamental biological mutation, it will continue to exert a significant influence on world affairs for all times to come. A hungry man is never a free man. If he is not willing to trade his freedom for food, he will rob and steal because the last choice, starvation and death, is hardly attractive. In this unholy quest for food, what is true for an individual is gospel for the multitude.

Today, the problem has gone beyond the ethics of equitable food distribution between surplus, defficient and destitute areas. Malthus has risen from the grave with zeal and conviction to throw his old challenge whether, with all the available and projected resources of the world, there will be enough food for the many millions of additional hungry people that are likely to throng this planet within the next two or three decades.

For a country like Pakistan where, at present, almost every type of food is in short supply, and the population growth rate promises a two-fold increase in numbers by the end of the century, we should certainly have plenty of food for thought. There is no doubt whatever that the question of food production for our immediate and future requirements needs to be tackled on a war footing—receiving priority over most other problems.

There are several theories why Pakistan, with its 75 million acres of potentially cultivable land and a great majority of its people eternally toiling in the fields, has been unable to achieve food autarky in thirty years of independence.

One school of thought maintains that the land, so far at least, does produce enough food for all. The only problem is to stop hoarding and subsequent smuggling, eliminate wastage at various levels, and the apparent food shortage will disappear. The theory, if true, poses social and administrative

problems which must be tackled at appropriate levels.

Most theories, however, apart from their economic and financial aspects, fall under the domain of engineering. Surface water constraints; saline and sodic soils; primitive farming practices; lack of fertilizers, good seeds and modern farming implements and equipment; inadequate pest control measures during and after harvesting ; unsatisfactory storage facilities ; insufficient as well as inefficient road and rail communications ; waterlogging and salinity ; all are cited as major hurdles in the way of an agricultural breakthrough.

Waterlogging and Salinity is a hungry, twin-headed monster that has been ravaging fertile irrigated plains around the world for a long time. According to a recent estimate, it has already devoured 8 million acres in Pakistan, and continues to gobble up at the rate of 100,000 acres every year. It is further feared that about 17 million acres now lie within its reach ready for feasting, as the water table is only ten feet from the ground surface.

The Indus plain became a potential prey to waterlogging and salinity at the inception of the world's largest canal irrigation system with its vast network of unlined canals. Sure enough, the first signs of trouble were spotted way back in 1892, around Upper Rechna Doab, within a few years of the opening of the Lower Chenab Canal. Since then, almost continuous efforts have been made to study, eradicate or control the problem, but the twin-headed monster remains very much alive and un chained to this day.

The cotrol measures adopted so far have included control of canal seepage; frequent and extensive canal closures and lowering of canal water levels; construction of seepage drains; lining of canals; vertical drainage through installing of tube wells along main canals and branches; but these yielded limited results, if at all, while the overall situation remained un-affected or even deteriorated.

The corrective measures reached a promising high mark some sixteen years ago when SCARPS were launched. At the time the prevalent national philosophy was to do everything worth doing with the blessings of foreign consultants, using borrowed, foreign money, under the direct supervision of foreign experts.

There is a saying in the West tnat "an expert is simply a mechanic away from nome". Apparently, we did not come across the phrase or understand its full meaning for a long time, and then it was too late. One can seek consolation in the fact that nothing can be really learnt without paying for it one way or the other ; but Pakistan could ill afford the price specially when, as it turned out, the 'experts' did not have all that much to teach.

It is common knowledge how the SCARPS. have failed to live up to any of their bright promises just like many other promises of foreign experts that dwindled into thin air over the years. The latest episode in a long chain is the Tarbela tragedy which has really shaken our confidence in foreign expertise. If engineering means simply trial and error in the field then we are all first class engineers.

As for waterlogging & salinity, the People's Party Government has now launched a gigantic long term programme to tackle the problem at the National level. Similar National plans are under way in all related fields. The logical result of this comprehensive exercise should be adequate and even surplus food for our present and future needs. It is for the first time that very little reliance is being made on foreign consultants for planning and engineering of various projects being undertaken in this regard. This in itself will provide sufficient challenge and incentive to the local engineers.

The test of an engineer is his ability to provide at last adequate solutions to given problems within the available technological, material and financial resources. Let us prove to ourselves, our people and the world at large that Pakistani engineer is capable of passing this test with merit and distinction.

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Irrigation and Power Section

TARBELA'S SECOND COLLAPSE

'Taking risks I hope never to have to take again'

—Agent Don Kershaw

Damage caused by the latest rebellion of the River Indus at Tarbela is awesome. In one of the most dangerous civil engineering operations ever attempted, the Tarbela Joint Venture has begun to fill the enormous under-water caverns gouged out beneath the walls of the irrigation tunnel stilling basins.

Since 16 August, when the river burst through the basin floor, the 33m high walls have hung precariously over divers and workmen operating in the basin. Tension reached a climax this week as workers struggled to fix giant props below the undermined walls.

Brian Appleton witnessed the tense repair operations in progrsss and talked to the battle-weary engineers shocked by this second crushing blow, which follows last year's collapse of one of the dam's tunnels.

This week's report describes the dangers and the reasoning which those involved have used to justify the alarming risks being taken in Pakistan. In a follow-up report next week, NCE will look at the potential causes of the disaster - still under investigation - and will assess some of the longer-term risks being taken by dam designers TAMS of New York and the international contractors

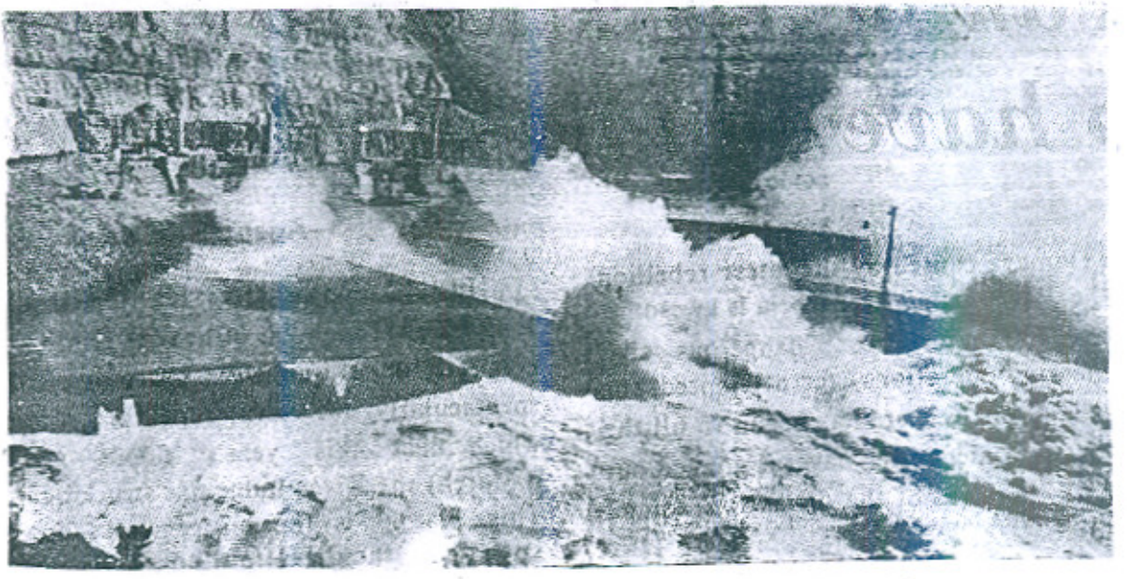
Just 12 months after blasting a 60m long hole through 2m of heavily reinforced concrete tunnel lining and sparking off the spectacularly successful repair programme which beat this year's floods (NCE 6 March) the River Indus has struck again. This time it is the outlet works downstream of the irrigation tunnels that have succumbed to the destructive force of 3,400m³/s of water tearing its way to the river channel beyond.

While this year's damage is less extensive than last year's tunnel collapse, it has presented engineers at Tarbela with an even more hazardous repair operation. Four 15m-long monoliths of the 33m-high dividing wall between stilling basins three and four were left virtually unsupported when erosion destroyed the 3m-thick reinforced concrete floor to basin number three and tore away 50,000m³ of rock from beneath the floor and walls. Large chunks of the 20m-thick walls were also ripped out by the surging water and now lie tumbled in heaps 10m below.

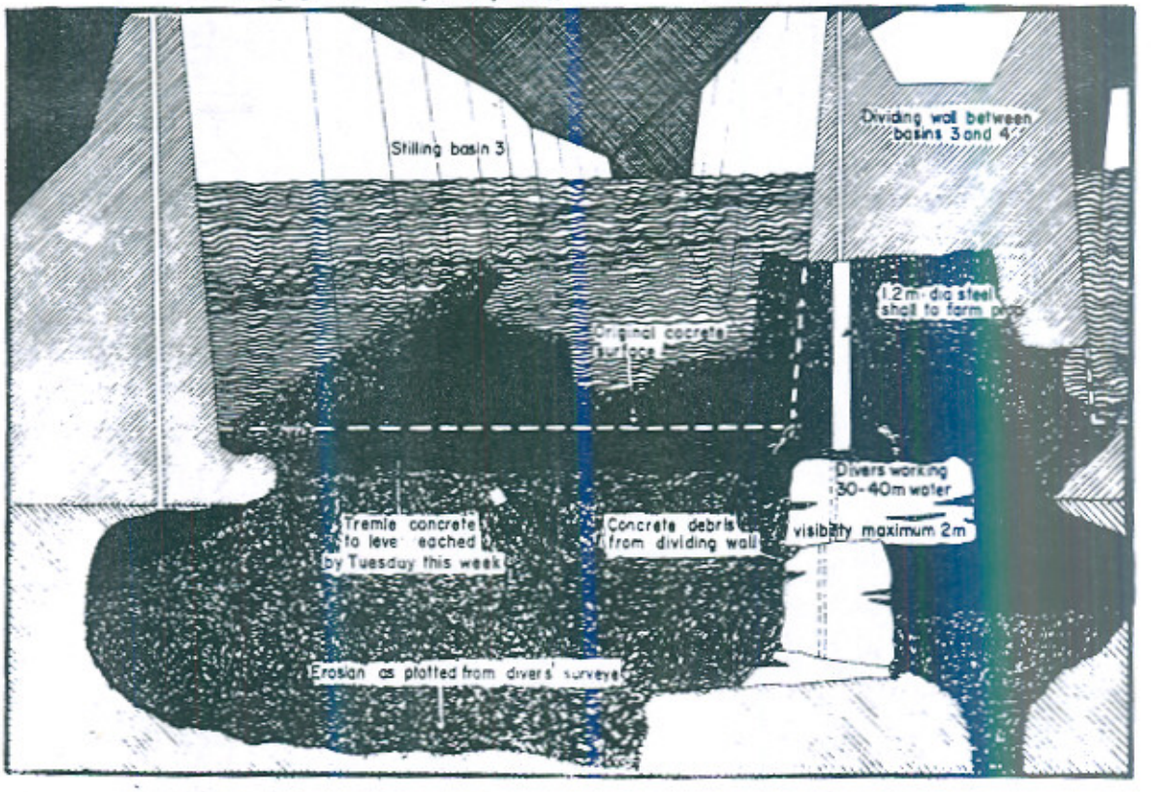
Only the quite accidental keying effect between the vertical joints prevents the 17,000t blocks from collapsing on to divers who are this week tackling the tricky task of manoeuvring 1.2m-dia steel tubes up to 10m-long into the space beneath them.

Reprinted from "New Civil Engineer" London, 9, Oct. 1975.

to disaster. Water pounds into the outlet works downstream of the irrigation tunnels at Tarbela during last summer's emergency drawdown operations. Erosion of the stilling basins, which occurred during the drawdown, was the first sign of trouble which recently mushroomed into the dam's latest major crisis.

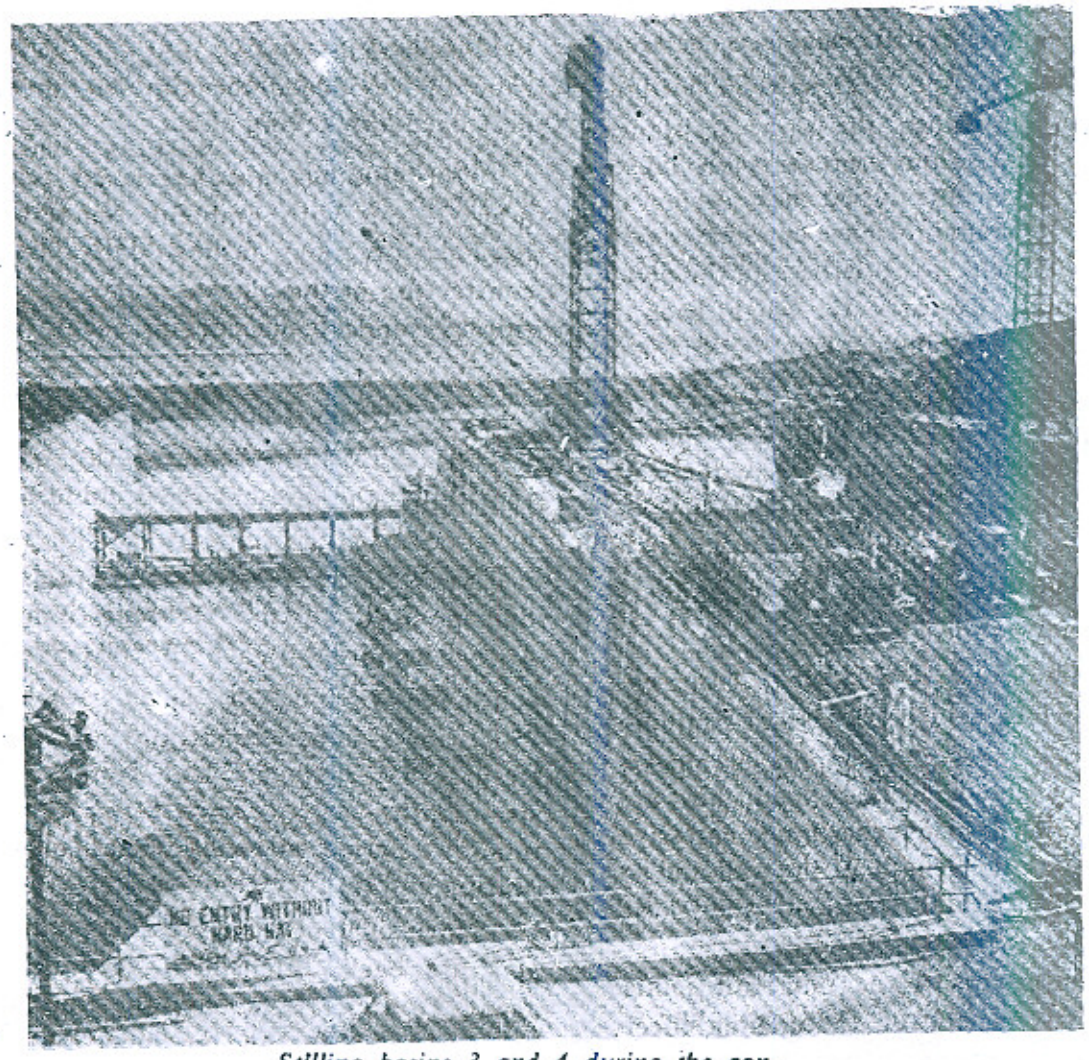


This perspective, based on site drawings produced from the divers' surveys, shows part of the damage to stilling basin 3. Four monoliths of the dividing wall (right) are held only by the keying action of the joints.



The plan is to form concrete piers between the underside of the unstable wall blocks and the rising surface of tremie concrete that is pouring into the caverns at a rate of 1,400m³/day. Steel cables threaded through vertical drainage holes in the walls help to support the tubes and guide the divers, whose visibility 30m below the surface is restricted to a couple of metres. The steel tubes will be winched and cajoled into position below the drainage holes at 4.6m centres, and then filled with concrete fed down from the crest of the wall through 150mm tremie pipes.

The speed of this second Tarbela rescue operation is breathtaking. It was 29 September when TAMS partner John Lowe III brought the steel-tube plan to the site from New York. The contractor agreed that this method looked preferable



Stilling basins 3 and 4 during the concreting operation. Damage to the basin floor stayed hidden under 20m of silt until March this year.

to his own fabricated steel under-pinning proposals. By 1 October the tubes had been fabricated in the site workshop and latest news from Tarbela on 6 October is that divers have sucessfully placed four in position, two more are on the way, and the final one or two-depending on a detailed survey of the last suspect block-are expected to follow before the end of this week.

Only when the pier concreting operation is complete will engineers breathe easily and workers feel safe in Stilling Basin 3. Until then the shear resistance of the joint alone prevents collapse. Shutter movements during the pouring of the leading monoliths have apparently produced sufficient irregularities in the plane of the joints to carry the weight back to the sound blocks at each end.

Early plans to dewater the stilling basins to make the repair job easier had to be abandoned when engineers saw the scale of the erosion. With physical support from the rock almost totally destroyed, the buoyancy effect of the 20m water depth is a crucial stabilising force.

Ernie Bowles, TAMS chief design engineer on site, also believes that straining of the rock under the supporting blocks, caused by the additional load they are now carrying has induced extra compressive forces along the length of the wall and so increased the total frictional and shear resistance.

From surveys of the monolith joints and an assessment of the arching effect due to rock strain, Bowles calculates a safety factor of 1.5 against collapse of the walls. TAMS' optimism that the walls will stay there, is increased by the fact that they didn't come down when the tunnel was discharging at full bore immediately after the damage occurred. 'If they could stand with the basin running' says Bowles, 'they must be OK Now'.

Calculations or not, TAMS is clearly surprised that the shear resistance of the wall joints ever came to be mobilised. The 15m joint-spacing was chosen to allow individual blocks to act independently.

By rights, drying shrinkage and loss of the heat generated during hydration should have opened the joints by now and destroyed any keying effect

Why this has not happened remains a puzzle, but with ambient temperatures in Pakistan now falling daily, natural contraction of the blocks makes the fortuitous support mechanism seem fragile indeed.

For Tarbela Joint venture, the contractor consortium led by the Italians Impregilo, the present crisis could hardly have come at a worse time. Physically and mentally exhausted from the superhuman efforts of the previous 12 months —when senior staff gave up all leave and continuously put in 7-day weeks of 75-80 hours under conditions of intense strain—TJV engineers had seen the next six months as a comparatively gentle run-down period, allowing time for celebration and recuperation.

Now, suddenly, the pressures and dangers are back, intensified—according to agent Don Kershaw—by the apparent belief of the client and engineer that with one miracle behind you the second comes automatically.

Proud as he is of last year's triumphs,

Kershaw confesses that 'no-one was more surprised than me when we finished on time', and adds, with some significance, that it was achieved only by 'taking risks that I hope never to have to take again'.

But kershaw now has been forced by events to tie himself to a six-month repair schedule that involves divers working underneath, and engineers and labourers in the shadow of, the precariously balanced walls of Stilling Basin 3, as 50,000m³ of termie concrete is poured into the underwater caverns. The pressure to take these risks—even greater than last year—is obviously intense. For client WAPDA (Water and Power Development Authority —the Pakistan Government's national agency controlling the whole Indus Basin development) time is vital.

Last year's tunnel collapse and the consequent loss of a full year's irrigation water caused the government considerable political embarrassment, as well as costing an estimated £60M in lost crops. The prospect of similar losses this year—only the small amount of storage now retained above spillway level (less than 1/5th of usable capacity) will be available until the repairs are completed—makes WAPDA unwilling to consider anything but another miracle. As WAPDA general manager Manan Khan put it, 'We must try to expedite these repairs. We are not fully reconciled to the contractor's schedule'. Manan Khan wants to clip at least two months off TJV's programme.

But the real driving force behind Kershaw's willingness to gamble on the stability of the threatening walls is an overriding desire to be rid of Tarbela.

With most of TJV's Tarbela resources already earmarked for other projects, notably the recently begun Lar dam in Iran, sponsor firm Impregilo would find the additional commitment in Pakistan acutely embarrassing.

Kershaw has told WAPDA and TAMS that realistic programming of the repairs shows completion at the end of April 1976, but that, with everything going right, the target could be brought forward to the end of March. With October to April the critical months for irrigation releases, even the optimistic target means virtually another full year's loss of water, which explains WAPDA's predicament.

This week's progress report offers some encouragement. Tremie concreting has raced ahead of schedule—peaking at 2,500m³/day—with 32,000m³ of concrete in by 5 October. Don Kershaw is now predicting completion of the tremie operation during the third week in October, saving about ten days.

And the ingenious if hair-raising, propping system now underway could lop another two weeks off the programme. TJV's original plan was to dewater the basins once the termie concrete was in, taking the level down slowly and watching for any movement of the three monoliths still without firm support. A structural steel frame was then to be installed between the surface of the tremie concrete and the underside of the blocks, to allow replacement concrete to be poured.

By installing the steel tubes as the tremie concrete goes in, the whole exercise is speeded and concreting of the walls can begin as soon as the basins bave been drained.

Unfortunately these gains are likely to be short-lived because other decisions

taken on 23/24 September make future prospects bleak. The TAMS panel of special consultants, which gathers regularly in New York to monitor progress and direct operations on site, this date rejected the design modifications on which TJV's repair schedule was based.

Of the many qualifications that TJV put on its six-month programme, three relaxations of TAMS' original design requirements were regarded as crucial. First, the 3m thick basin floor was to be reduced to 2.3m—this would allow the tremie concrete to come up above wall foundation level, building up enough head to force the concrete into voids beneath the walls; second the drainage system under the structural slab was to be omitted and the interface with the tremie concrete pressure-grouted; and third there were to be no transverse joints in the concrete slabs and no dowels into the tremied concrete.

The panel's rejection of any changes to the original design will be a bitter blow for WAPDA, removing any hopes of irrigation water from tunnels 3 and 4 this winter. The panel must, of course, have recognised the effects of its decision, but as TAMS partner Wilson Binger exampled last week, 'we could find no reason for changing the stilling basin design'.

Don Kershaw has not yet worked out the full effect of the panel's uncompromising stance, and even with the sort of production performances that TJV has been turning in at Tarbela, it is dangerous to speculate. But it is hard to see how reconstruction of underdrains and the drilling and grouting of dowels can add less than a couple of months to the repair programme.

International Conference on Waterlogging & Salinity held in Lahore

October 13-18, 1975

Organised in collaboration with FAO, the conference was sponsored jointly by the University of Engineering & Technology, Lahore and WAPDA, with active help from the Irrigation, Drainage & Flood Control Council, the Agricultural Research Council, Pakistan Science Foundation and the University Grants Commission. The proceedings of the conference have been edited by FAO & published by the University of Engineering & Technology, Lahore, as a comprehensive document. The main conclusions & recommendations of the conference, together with the final comments of Mr. Dieleman, the leader of the FAO team are reproduced here for the benefit of our readers.—Ed.

MAIN CONCLUSIONS AND RECOMMENDATIONS

The following main conclusions and recommendations of the Conference arise from the results of the Seminar supplemented by studies and discussions under Phase II of operations. They relate to both technical and institutional constraints and means.

TECHNICAL CONSTRAINTS AND MEANS

Allocation and Distribution of Water Supplies :

Efficient management of the available water supplies is as important as securing additional supplies It implies timely and adequate allocation of water which may be achieved by applying models. A simulation already exists for the Indus Basin. However, good management may be more effectively achieved by also applying an optimization model. Such a model either maximises or minimises water losses, and it may be made to reflect constraints in the existing canal system. Much of the data required for the development of a model is already available.

It is recommended therefore that an optimization model be developed, with all

necessary inputs for establishing operating rules for the distribution of surface and groundwater. It may be practical to use two types of models, one for major works and one for smaller portions of the system. At the same time the institutions and laws related to surface and groundwater should be reviewed to minimise the constraints for effective water distributio... Better coordination should be established between the various government agencies so that maximum use can be made of the water resources by farmers.

Tubewell Design and Maintenance :

In spite of all precautionary measures adopted in design and construction of public tubewells the performance and efficiency of these has deteriorated to a point where a broad-based approach to identify the causes and remedies has become essential.

It is suggested that an experienced foreign crew, with all necessary equipment, be brought to Pakistan to demonstrate the best ways of rehabilitation and to train Pakistani crews.

Responsility for keeping up with improved well designs, material and techniques of construction and ancillary equipment (pumps, motors, etc.) should rest with a suitable agency—either an existing unit or a new one—which could provide advice and assistance to the private tubewell sector, including farmers, drillers, suppliers and manufacturers. The agency could also be made responsible for developing a regular programme to rehabilitate tubewells and standardizing pumps manufactured in Pakistan, and have funds available for special research such as skimming well design and prevention of upcoming of saline water.

Policy on Private and Public Tubewells :

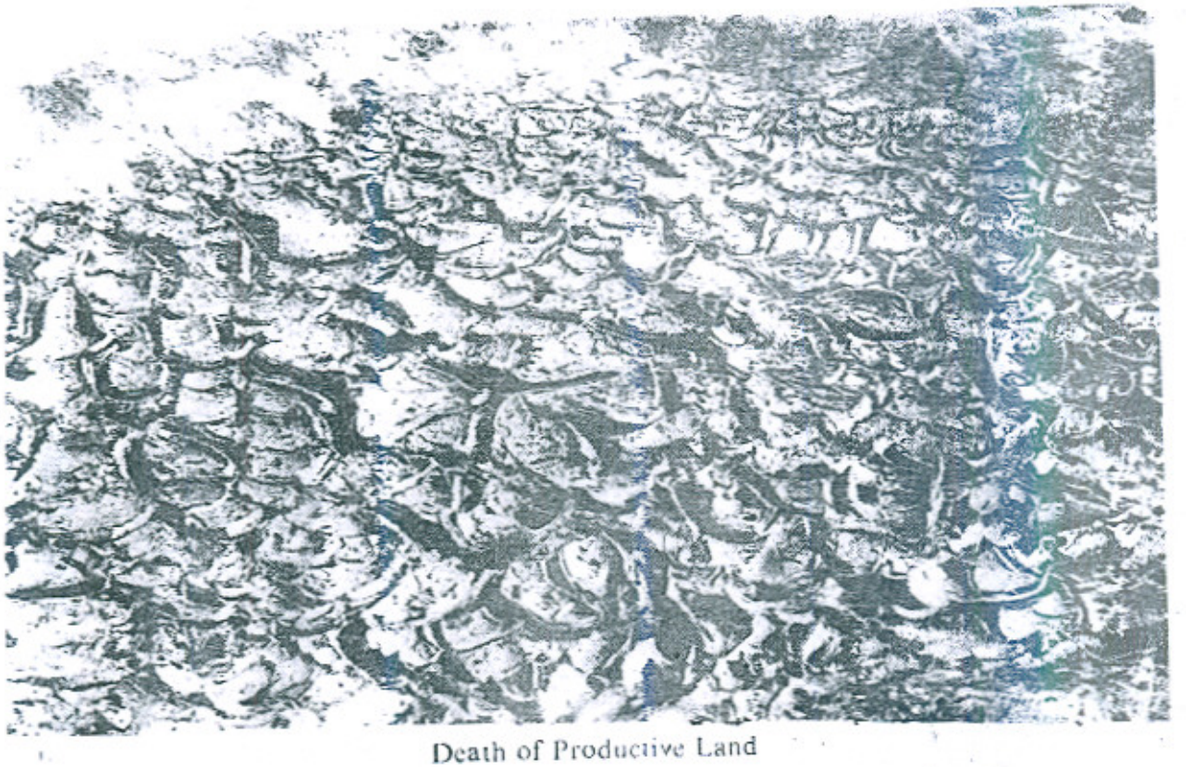
Private tubowells have given farmers the advantage of being in control of their own water. They are also cheaper to install than public wells. However, indiscriminate private development may raise problems of aquifer control Public wells should therefore preferably be used in saline areas suitable for vertical drainage, in areas where control is necessary to prevent the advance of saline water, and where mixing with canal water is required Consideration should be given to the development of laws regulating the exploitation of the vast aquifers and their use in conjunction with surface water.

Usable Groundwater Quantities :

Estimates are complicated by such factors as advancing saline/fresh water interfaces, uncertainties about water quality standards to be applied and recirculation of salts. The quantity of groundwater which can be safely utilized should therefore be reappraised on a regular basis, as data become available, and from area to area.

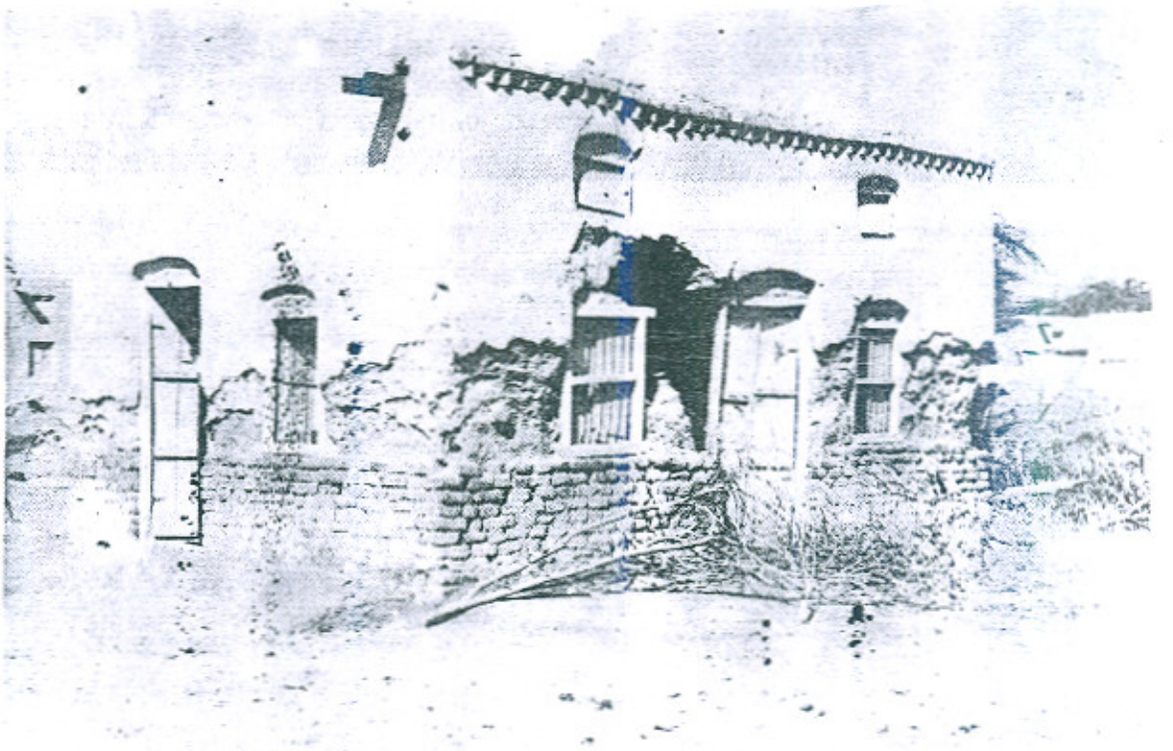
The ultimate quantity of availabe groundwater is not known; it will vary with agricultural practices and conditions of distribution systems. Considerable work has been done with groundwater models in Pakistan, but a more complex analysis appears to be needed While the existing laboratory for analogue models may be used for some purposes, it is suggested that digital computer models be used in order to

A view of waterlogged land along Left Bank of T.S. Link

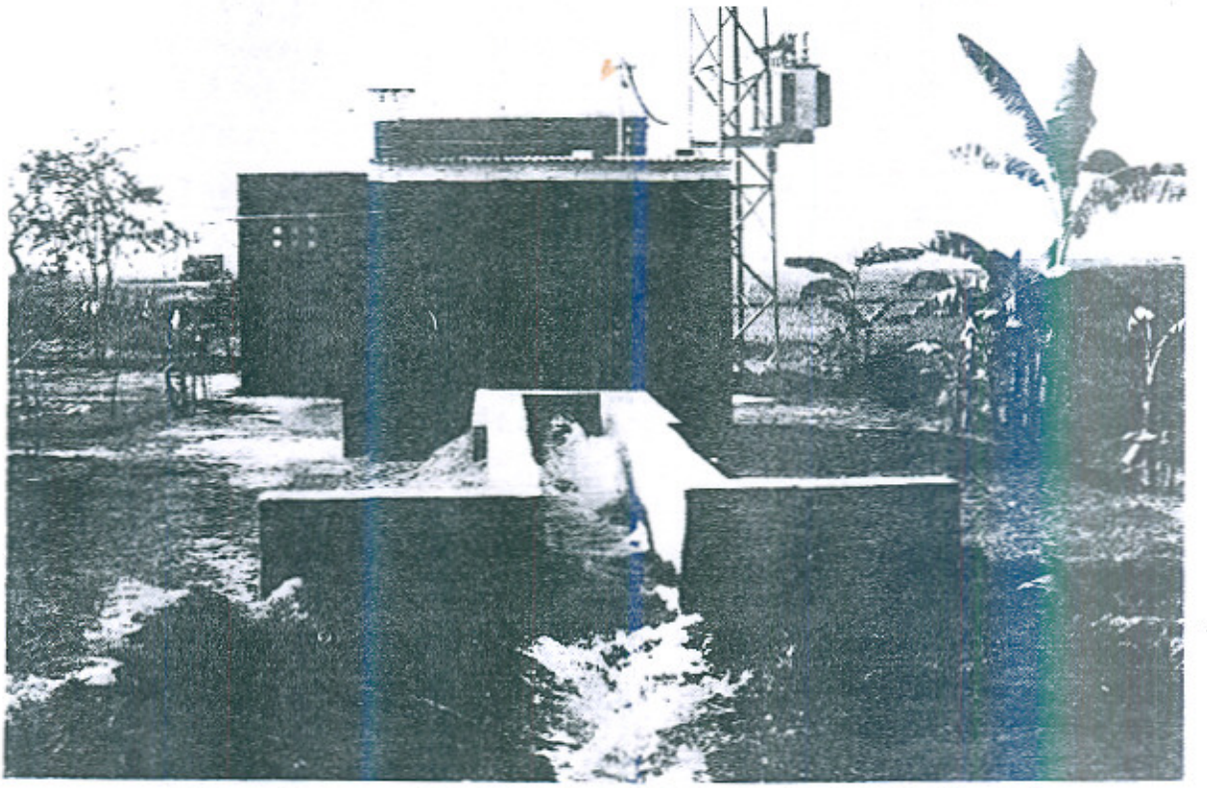


Death of Productive Land

When a piece of good land ceases to produce food and fibre for the sustenance of man, waterlogging and salinity is often the cause. What the afflicted land looks like is eloquently depicted by the Photograph



A view of damaged house as a result of water logging near T.S. Link



View of a tubewell installed in Public Sector in Salinity Control and Reclamation Project No. I (SCARP-I)

forecast the long term response of the saline groundwater body and the deterioration of water quality due to recirculation.

Mixing Tubewell Water with Surface Water :

Deterioration of pumped water quality has been observed in several areas. This may be due to upward moving saline groundwater and perhaps also to recirculation of salts. Estimates of mixing ratios have been mostly based on total dissolved salts alone. According to experience gained in SCARP project for the last decade this appears inadequate. It is considered important to include sodicity hazard due to high sodium and bicarbonate contents as well.

Careful investigations of groundwater salinity should precede the installation of new tubewells, particularly in suspected areas. Existing tubewells here should be closely monitored and the mechanisms for quality deterioration identified. This information should be used to detemine action needed in existing SCARP areas and as design criteria for new SCARP areas.

DRAINAGE

Vertical versus Horizontal Drainage :

Probably Pakistan has more knowledge and experience on vertical drainage through the use of tubewells than anywhere else in the world There is, however, little experience with horizontal subsurface drainage by open or tile drains. No tile drainage projects of any importance have been carried out so far, but considerable though has been given to the possibilities as an alternative to tubewell drainage. There does seem to be a tendency to stress the technical problems of tubewell drainage relative to those of tile drainage. The choice between tubewell and tile drainage should, however, primarily be made on the basis of the aquifer characteristics and the quality of the water. There should be early implementation of tile drainage projects in suitable areas in order to gain experience in this technique.

Groundwater Quality :

Some believe that, in areas of saline groundwater, tile drains will cause groundwater to become rapidly fresh and available. This would appear to be valid only where good quality water is applied and where there is a shallow drainage barrier or the drains are spaced close together.

Saline Water Disposal :

The disposal of saline water is a problem which has yet to be solved. Interim measures include the disposal of saline effluent to the rivers or large canals and the possibility of large evaporation pans on abandoned saline areas. Further studies are needed, especially in the northern zone, which should take account of long term simulation studies, to determine when such a system may become essential.

On-farm Improvement :

The SCARP Tubewell Programmes have substantially increased the amount of irrigation water delivered into watercourses but less than half of the additional water reaches the farmer's field due to seepage losses. A considerable portion of these losses can be saved by reconstruction of banks, filling of borrow pits, pakka lining of main channels, and rehabilitating junctions. It costs less to do this work by hand lobour than by pumping the same amount lost. Therefore, to obtain an

immediate increase in available water supplies to the field, it is recommended that emphasis be placed on using low cost hand labour methods for water course improvements.

Due to unsatisfactory land levelling on 75-90 per cent of the fields, and inadequate layout of the fields, water application efficiency is very low, resulting of drowning crops in some areas and water stress and salinity problems in other areas. It is suggested that local labour be used to level and shape fields as an interim solution until land consolidation begins to provide immediate benefits at the small farm level. It is also recommended that the engineering services necessary to implement on-farm improvements be provided by the Government.

On-farm Water Use :

Present on-farm water use is very inefficient due to physical constraints beyond the farmer's control, accentuated by the lack of reliable water supply. At present canal deliveries are at fixed intervals depending on crop area without consideration of actual needs. Tubewells have provided an additional supply along with control of the watertable. Data on consumptive use, however, are sufficiently advanced in Pakisean to provide good estimates of water requirements. It is recommended that crop needs provide the basis for the operation of the canals and the tubewells wherever this is possible within the existing constraints of the canal system and waterable control.

Water is lost and fertilizer is leached due to intentional over-application of water because the farmer does not know when he will receive his next water delivery. It is recommended that a water supply prediction programme be established and that the developed information be communicated to the actual water users.

Cultural Practices :

Research and development has been done on improved farm implements and machinery for use in irrigated areas. It is recommended that this programme be strengthened particularly to develop efficient implements for bullock operation. Regular demonstrations will also be needed to keep farmers informed on the availability and performance of new equipment.

Intensified fertilizer use to increase crop production should be praetised, particularly on the best lands under production where improved management techniques are being applied in order to obtain the necessary high yields to support the improvement programme.

The Institutional Constraints and Means Need to Integrate Land and Water Disciplines :

The over-riding need is to integrate land and water disciplines in the agricultural education system for application at the farm level. The means required for this puspose do not appear to be sufficiently developed in Pakistan. Elsewhere this multidisciplinary expertise is disseminated or applied by specially trained land and water use specialists and/or agricultural engineer. A start has been made by training such specialists at the Agricultural Universities, In order to train sufficient men with a truly multidisciplinary approach this course should be energetically encouraged and strengthened, If necessary by expatriate experts in this field.

Research :

It is felt that research programmes should have more relevance to the main management problems facing the farmer than they do at present. In addition, an improved flow of relevant research results, as well as more awareness of practical problems facing the farmer by research workers appears to be indicated. A realistic and multidisciplinary approach to specific research efforts would ensure maximum impact on the most important restraints to increased agricultural production.

It is recommended that more emphasis be placed on developing cultural practices to increase production on existing cultivated land, investigating farmers' problems arising from having to use poorer quality tubewell waters, on irrigation timing for maximum crop production, and on irrigation methods to increase water use efficiency.

Extension Services :

Extension Services have been considered in almost all the reports of planners, commissions and foreign consultants. The Revelle Report (1964) concluded that it was a case of "too few men with too little material trying to deal with too large a problem" This report can but support this view and stress some further points.

The Field Assistant with the help of the Agricultural Assistant is the man-on-the-ground that causes extension work to be effective or inffective At present he is inade quately equipped to do the job expected of him. His formal and in-service training is limited, and his status and pay scale do not attract the more able candidates for employment. In addition his facilities in the form of housing and transport are inadequate It is suggested that the Government should recognize that the provision of adequate facilities and attractive career prospects for the field staff would be a major step towards improvement of the effectiveness of extension services,

Training :

Another essential step is to upgrade in-service training and technical back-stopping, primarily for Field Assistants and Agricul tural Assistants.

Currently, the services of specialist officers in plant protection, horticulture and publicity are available from the staff of the Agriculture Department. This capability needs to be strengthened considerably to cover all fields of farmers' problems and activities. It is suggested that a nucleus of specialist officers in disciplines in greatest demand be placed at the District or even Tehsil level.

There is also a need for the the present field staff to receive further training in extension methods. The specialist officers would supply the essential in-service training and they in turn, would receive their in-service training from the Agricultural Universities, colleges and research groups.

Additional training at the post graduate level is needed for the expansion of technical services as public and private tubewell programmes expand. Such training might best be obtained at the Universities which may repuire further financial and teaching support.

Techinicians and mechanics are needed for well and pump installation, maintenance

and repair, Means for the training of this category should be promoted,

Supply and Credit Services :

Production may be severely limited by a shortage of essential inputs and by a lack of coordination of the supply system. The lack of efficient seed distribution has probably been one of the reasons for declining production from high yielding varieties of wheat. The current seed industry which is now being developed is designed to overcome this problem.

Fertilizers and pesticides do not appear to be available in sufficient quantities or the farmers cannot afford to buy the repuired amounts due to lack of finance.

Supply problems associated with the use of tractors include unavailability of adequate implements and spare parts. There appears to be much scope for the further introduction and development of improved hand tools and animal drawn equipment. A better flow of information, credit and other inputs to agriculture will call for farm supplies far beyond those now availble.

Water-Users' Organization :

Centralized contacts are required for the communications to and from water users, to facilitate joint action in operating and maintaining irrigation systems at the farm level and arranging joint purchase, handling and utilization of farm supplies. It is considered that this could best be accomplished by the formation of local water user's organization or farmer associations.

Overell Service for Water and Soil Management at the Farm Level :

The estalishment of an overall service for water and soil management was considered. The alternative would be to inject the expertise required into one of the existing organizations in the Department of Agriculture. It is felt that the ultimate choice should be left open to further evaluation.

Final Comments of FAO on Accelerated Programme of Walerlogging and Salinity Control

Dear Mr. Vice-Chancellor,

In accordance with our agreement of 18 October, 1975, I have pleasure in sending you herewith the summary report of the International Conference on Waterlogging and Salinity held in Lahore from 13 to 18 October 1975. The report has been edited by us and I understand it will be published by the the University, together with the Conference papers.

The document is based on a consensus of the participants of the Conference, and Particularly of the three Working Groups on Water Supply and Drainage, Soil and Water Management (at the farm level) and Agricultural Support Service respectively. The team of FAO officials and consultants has contributed to this consensus, and its views are largely in line with the conclusions reached. The team has been requested, however, to make a further contribution by briefly commenting on some major issues and concepts discussed at th Conference in the light of the Government's Accelerated Programme of Waterlogging and Salinity Control.

1. Control of Waterlogging and Salinity Requires Better on-Farm Water Management

The Accelerated programme provides for the construction of tubewells, the phased implementation of outfall drains, tile drainage and surface drainage for storm water discharge. These are all needed activities outside the scope of the individual farmer. There is no mention of improvement of on-farm water and soil management practices. It is recognized in Pakistan, however, that the considerable inefficiency in water use at farm level and the otherwise inadequate irrigation practices contribute directly to waterlogging and salinization or sodization. It also implies that good quality water is lost while pumped water may be more salty and more expensive too. The team believes that any programme aiming at controling waterlogging and salinity must include on-farm activities to conserve water and apply it to the land according to crop needs.

2. On-Farm Development : A Government Responsibility

On-farm development does not take place, or at least not at the desired rate, if left entirely to the farmers themselves. The farmers' knowledge of how to improve water courses, how to prepare land for irrigation, how to schedule water applications, how to irrigate the land and how to adapt soil tillage and related cultural practices is usually insufficient. They need help in these and other technical fields. They also need financial facilities and assistance in getting themselves organized and prepared to effectively participate in the improvement of their soil and water use.

The brochure on "Proposals for an Accelerated Programme of Waterlogging and Salinity Control in Pakistan Government of Pakistan, Planning Commission, September 1973" does not include specific programmes for on-farm water and soil development as a means to better manage these resources and prevent waterlogging and salinization.

In the view of the team, the Government should be instrumental in promoting on-farm development and should assume direct responsibility for, and leadership in, its planning and further guidance, through the establishment of the required institutional framework, the technical and scientific backstopping, and related activities.

3. Improved on-Farm Water and Soil Management Requires Mobilization of Human Resources

The absence of waterlogging and salinity is in itself no guarantee for better crop yields. It has become clear that in most improved areas, i e. in areas where water of good quality is available in reasonable quantities, where salinity is not a problem and where the water table is deep, agriculture production has not come up to expectations. This suggests that other factors have become critical and that work must now be done on these. Better still, work should be done on them simultaneously with water development and drainage activities. The constraints relate primarily to farm level operations in soil and water management. The technical solutions are available. What is needed is the mobilization of the available human and financial resource to effectively implement the solutions.

4. Farmers' Participation Through Increased Knowledge

Full and active participation of the farmers, in all stages of planning and implementation, of on-farm development programmes is indispensable. To obtain and maximise this participation, the farmers should acquire a clear view of the constraints and possibilities, solutions to problems and the related costs and benefits. There should be a continuous flow of knowledge from educational, research and Governmental agencies to the farmers. There should also be a continuous flow of information from the farmers back to these agencies. The team concurs with the recommendotions to better achieve this aim.

5. Water Management Specialists Needed

Improved irrigation and soil management at the farm level requires the services of engineers specially trained for that purpose. This type of agricultural engineers is presently being educated in small numbers at the Lyallpur Agricultural University.

Reinforcement of the curriculum in irrigation and drainage, however, appears necessary at this university as well as at others. Of equal importance is the establishment of programmes in vocational training ; they will be instrumental in the transfer of knowledge, particularly to extension services and, ultimately, to the farmer.

6. A Special Water and Soil Management Service in the Ministry of Agriculture

Water and soil management engineers are unlikely to make a significant impact unless they can work within an established institutional framework. The team agrees with the suggestion to establish, at the provincial or national level, a Water and Soil Management Service that would serve to co-ordinate and direct all ongoing and planned programmes in this field. Given its immediate scientific and technical ties to crop production, such a Service should preferably be housed in the Ministry of Agriculture.

7. Area Development Projects Under Unified Command

Improved production requires a multi-disciplinary approach. To that end the team considers development on an area basis as having considerable advantages over a sub-sector approach. Since the technology and expertise are available, the implementation of large-scale Area Development Projects may be embarked upon without delay. Effective implementation requires a unified, i.e. a project administration that is responsible—and has the authority—for all phases and all types of development work, whether improving irrigation canals, installing tubewells, supplying seeds fertilizers to farmers, or improving water courses and irrigation practices. Regarding the latter, much can be accomplished by utilizing the manpower that is abundantly available in the rural areas, thus keeping cash layouts to a minimum.

8. Tubewells : To be continued and expanded but combined with Programmed maintenance operations

Tubewells have played a major role in lowering the water table and in providing additional irrigation water. The programme should be expanded wherever soil and groundwater quality permit There are obviously problems of corrosion and incrustation, operation and maintenance, but it is believed that these can be overcome and that they do not provide a reason to cut back on the programme suggestion to embark on a programme to restore and maintain the capacity of tubewells as well as to demonstrate systems of inspection that provide advance information on maintenance needs, is fully endorsed.

For some time in the future there is probably little danger of groundwater mining by the wells because of the inhibiting economics of deeper pumping unless crop yields are significantly increased. Before ground-water mining becomes a major issue the Government of Pakistan should develop a national policy on the extent to which it is desirable to regulate private tubewell drilling and pumping. Irrigation farmers using tubewells will need reasonable advance notice of any such policy so as to amortize their capital investments in wells and related equipment.

9. Water Quality : Need for a National Policy

The water supply delivered to farms is limited in quantity and quality. Continued

use of tubewells Intensifies quality considerations. Therefore Pakistan should give serious consideration to a national policy regarding the future use of good quality surface water for reclaiming lands : using such water for reclamation increases water shortages for good land especially during the rabi season. When the quantity of a renewable resource is limiting production, then the optimum "matching of resources" for maximum production is essential. For agricultural production, Pakistan should treat its water and land in this fashion by using its surface water on its best lands first.

Several quality standards have been proposed over the last several years to govern the use of tubewell water. Recent research shows that, under specified conditions, the 1954 USDA standards may be relaxed. Standards, however, should be assessed in the relation to such factors as climate, irrigation practices, drainge and soil type. It is therefore unlikely that one set would equally apply to all of the Indus Basin. Rather, standards must be developed area-wise.

The recommendation to develop models which would permit to forecast the effects of recirculation of salts and the long-term response of salty ground water bodies to pumping is strongly endorsed.

10. Drainage : Tile Drainage to be Initiated, Surface Drainage Extended to Farm Level

Horizontal drainage is the normal alternative to watertable control where tubewells are not feasible. This may refer to open ditch drains, tile drains, or a combination of both. There is a vast expertise available on either, for widely differing conditions in many humid and arid regions of the world. As a rule, it would therefore appear possibe to embark on implementation of tile and other drainage schemes without resorting to prior elaborate research programmes. Normal design surveys in project areas, possibly coupled with quick field tests, are probably sufficient.

Disposal drains are also needed when tile drainage is applied and the team concours with the recomemendation that studies be initiated to assess their urgency in various areas.

Surface drainage (primarily for overland flows) should not be restricted to major channels but should include minor drains at the farm level. The Government should provide guidance to the farmers for design and construction of these, as part of overall farm water management.

The report contains recommendations for action that serve to obtain improved production at a sizeable scale in a short period of time. They relate to the immediate initiation and establishment of area development projects, pioneer projects and educational research and institutional programmes. These projects and programmes are all urgently needed. They are also interdependent, the success of each depending on progress made with the others. Simultaneous undertaking of each is therefore essential. FAO is prepared to provide any further assistance that may be needed.

I should like to thank you sincerely, Mr. Vice-Chancellor, for the opportunity the team was given to participate in the discussions on waterlogging and salinity, problems whose solutions are of so great importance to Pakistan. I hope that the views outlined briefly above, as well as in

the reports of the Working Groups and in the recommendations for follow-up action, will contribute to serving the goals that you have set for the Conference.

yours sincerely,
Sd.
Pieter J. Dieleman, Teams Leader
Land and Water Development Division.

FOLLOW-UP PROGRAMMES

Three broad aspects of the recommendations have emerged :

(a) The need for continuous monitoring and refinement of ongoing development programmes in the technical field.

(b) The need for technical, managerial and institutional coordination in the implementation of development schemes.

(c) The need for improvement of the existing agricultural support services.

To implement the recommendations, a programme must be launched on a broad front in the form of specific projects whose technical, managerial and institutional approaches are based on those which have been shown to be successful elsewhere under similar social, economic and production conditions. The following suggestions are offered :

Area Development Projects under Unified Authority :

Such land and water development projects need to be large enough to make a significant contribution to the economy. They may include new irrigation projects, reclamation areas as well as areas already long developed but where production is still low. The actions proposed relate to the identification of the projects, their preparation, design and implementation in cooperation with and financed by national or foreign lending agencies. On-farm development programmes from an integral part of the project's services and financing. Responsibility for all activities in all sectors rests with one agency.

Pioneer Projects for Integrated On-farm Development with Minimum Cash Input :

The purpose is to achieve increased levels of production by the simultaneous improvement of watercourses, irrigation practices and cultural methods. This will be done on the basis of self-help, relying on persuation, demonstration and training of farmers, and joint actions relative to water use. An essential element will be the use of locally available manpower and simple tools, thus reducing cash outlays to a minimum. Each project area is about 10,000 acres in extent and comprises a series of watercourses.

Establishment of New Food and Agriculture Commission :

The purpose of this project would be to ascertain the reasons for the achievements and shortcomings of all past and present activities with the current development projects and progrommes to result in firm guidelines for requirements in staff, facilities,

finance and development needs. Such a Commission might be composed of senior Pakistanis including governmental and private participation, and assisted by representatives from the most interested aid giving agencies such as FAO and the World Bank.

Tubewell Rehablitation and Maintenance Pragramme :

Some 9,000 SCARP tubewells have been installed. Different screen materials and designs have been used. In all cases there has been some deterioration, and many wells need maintenance or rehabilitation. Pakistan has no contractors or crews experienced in this work and there is no orderly programme of rehabiltating wells or projecting the timing and costs of future maintenance, rehabilitation and replacements. It is proposed that one or more foreign crew be brought into Pakistan with the necessary equipment to demonstrate the best methods of rehabilitating and maintaining wells ; set up a systematic procedure of inspection and record keeping to provide for advance scheduling of maintenance, rehabilitation and replacement ; and train Pakistan crews and managers in both activities.

On-farm Water and Soil Management Programmes at Agricultural Universities :

These progrommes are intended to reinforce or help establish teaching and further training facilties, primarily at the Universities of Lyallpur and Hyderabad. Lyallpur has progrommes in agricultural engineering but their water and soil management elements need to be strengthened and expanded considerabls in view of increased emphasis on on-farm development. The University of Hyderabad embarked on similar programmes and appears in need of support as well.

University of Engineering and Technology :

The Government of Pakistan is setting up "Centres of Excellence" at various universities. One of these is at Lahore and will be for post-graduate training and research in Water Resources.

The University is at present unable to meet its undergraduate teaching programme because of shortage of staff and serious problems will arise in staffing the post-graduate programme. This suggested project serves to reinforce the staff and to further assist in establishing and implementing training and research programmes.

National Institute for Applied Research on Agricultural Water and Soil Management

Some applied research work is being done in a few stations. A national institute is needed to coordinate and guide such scattered investigations in the country and to investigate problems in water and soil management that arise at the farm level within and outside ongoing projects. And, furthermore, to disseminate experience gained and knowledge acquired to training institutions, advisory services, etc. The institute may be established as a new organization or the programmes may be established in an existing institute that will be equipped for the purpose.

Vocational Training in Agriculture, with Special Reference to Water and Soil Management :

The purpose of this project would be to examine present vocational training facilities, programmes and structures, as well as present and future needs of such training. It would also formulate proposals to meet present and future needs.

LIST OF PAPERS PRESENTED

PROJECT CONCEPTS AND PERFORMANCE EVALUATION

Salt Water Intrusion into Sweet Waterzone ... ...
Javed Saleem Qamar

Watertable Behaviour and Safe Yield in SCARP-1 ... ...
Haji Muhammad

Prospects of irrigated Agriculture with Saline Water in Pakistan ... ...
Sardar Allah Bakhsh and Ch. M. Hussain

Antiwaterlogging Measures of Shikarpur Town ... ...
Khan Nadir Khan

Pakistan Experience with Vertical Drainage: its Problems and some Remedies ...
Nazir Ahmad

WATER MANAGEMENT—DRAINAGE

Keynote Address on Drainage ... ...
W. S. Hulsbos and R. Stoner

Farm-water Management Effects on Waterlogging and Salinity in Pakistan ...
M. Ashraf, Wayne Clyma, Arshad Ali

Irrigation Scheduling for Waterlogging and Salinity Prevention ... ...
A. C. Early

Improvement and Maintenance of Earthen Watercourses to Reduce Waterlogging and Increase Water Supply for Crop Production

W. D. Kemper, Wayne Clyma & M. Ashraf

improved Water Management Through Precision Land Levelling ... ...
Wayne Clyma and Arshad Ali

Improving Organizational Linkages ... ...
Garland P. Wood

The Adequacy and Improvement Possibilities in the Lateral Spacing of Drainage Systems
Osman Tekinel, and Yildirim Kumova

SOIL-WATER-PLANT RELATIONSHIP

SOIL SALINITY AND RECLAMATION

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Detecting Water Pollution

The Victorian Water Commission's Pollution Control Section, now in its third year of operation, is well established as Victoria's water pollution control agency for country areas.

The Pollution Control Section was set up by the Water Commission in 1973 when the Environment Protection Authority, which administers the Environment Protection Act (1970) delegated to the Commission responsibility for the licensing and supervision of waste discharges in rural and urban areas covering more than 80% of the State.

Control of water pollution in certain defined areas such as the Latrobe, Yarra and Dandenong Valleys and the Melbourne metropolis, was delegated to other appropriate individual water authorities.

The Commission's Pollution Control Section is located in the Town Water Supplies and Local Authorities Branch. At the present time the Section has five professional staff, one senior inspector, nine inspectors, six administrative staff and two typists.

The pollution inspectors are located at Frankston, Geelong, Ballarat, Wangaratta, Bendigo, Shepparton, Horsham, Wodonga and Warrnambool. The remainder of the staff is temporarily located in offices in Prahran, about one kilometre from the Commission's Head Office.

Organisation and inspection, so far, has been concerned with establishing control over areas where the Commission has little or no permanent staff.

A training program has now commenced for Commission staff located in the irrigation districts to assist in pollution control on a part-time basis in those areas.

The pollution inspectors are kept very busy visiting premises where applications have been made for a wastewater licence, conducting licence eligibility surveys, sampling licensed discharges and investigating public complaints of pollution.

Each inspector is equipped to perform a number of water analysis tests in the field. For the more complicated tests he carries an ice box and sample bottles to forward samples back to the Commission's Melbourne laboratories. Other equipment includes a Polaroid camera and dye to trace effluent discharges.

Besides assessing conditions for wastewater licences, technical staff are becoming increasingly involved in advising on effluent requirement on proposed developments. For instance, the Section is currently examining sewage discharge standards for a proposed convention centre at Daylesford the Mt. Hotham ski resort.

The 3,000 licence applications received to date are recorded on a computer file to assist in the issue and monitoring of licences.

The Environment Protection Act (1973)

The Act was established to preserve and improve the environment by the control of polluting discharges of wastes

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to the air, water, and land, as well as the control of noise. Controls are exercised by a system of licensing (subject to certain exemptions), and the legislation contains general provisions prohibiting pollution.

Waste discharges to water currently exempted by the Authority include :—

- wash waters from dairy farms with less than 150 milking cows ;
- wash waters from piggeries with less than 100 pigs ;
- small commercial premises which work less than 40 man hours per day ; and
- septic tanks serving domestic premises or less than 12 tenements.

These exemptions were necessary to allow early licensing activities to be concentrated on the more significant discharges such as large industrial premises and sewerage authorities. It is expected that, eventually, more control will be exercised over these smaller discharges—either by extending the licensing system or by issuing appropriate regulations.

Philosophy of Licensing

The essential aim of wastewater licensing is to protect the quality of the receiving watercourses required for beneficial uses. Typical examples of beneficial use are :—

- domestic water supply ;
- agricultural water supply ;
- stock watering ;
- industrial water supply ;
- maintenance and protection of natural aquatic ecosystems and wildlife ;
- bathing, water skiing and other primary water contact (body-contact) recreations ;
- boating, fishing and other secondary contact recreations ;
- maintenance of banks, foreshore and other vegetation ; and
- aesthetic enjoyment.

Differing water qualities are required for the various beneficial uses. For example, the presence of pathogenic organisms in a stream resulting from the discharge of an unchlorinated sewage effluent may not be of much concern to an industrial user requiring the water solely for cooling purposes, but would certainly be of concern if the stream was used for bathing in summer months.

Consequently, before a wastewater licence is issued, the beneficial uses to which the receiving water might be put must be established to enable proper consideration to be given to the discharge licence conditions.

Industrial Discharge

A wide variety of industries and commercial premises which are not connected to a sewer require a licence to discharge their wastewaters to a water cours Discharges licensed to date have included whey and wash water discharges from dairy factories, quarry seepage waters, electroplating rinse waters, wastewaters from sand mining operations, fruit canning, "package" sewage treatment plants, canneries and meat processing works.

A typical wastewater licence for an industrial discharge would specify the following :—

(a) the discharge location ;
(b) the maximum daily flow of the discharge ;
(c) the annual licence fee (from $ 5 to $ 5,000) ;
(d) the mean or maximum concentrations permitted for various characteristics of the waste.
(e) provision of a sampling point to

permit sampling of the discharge at all times.

(f) details of the regular sampling and reporting of the quality of the discharge which must be undertaken by the company.

The first licence issued often contains temporary conditions that, in essence, give the licensee a reasonable time to instal facilities to meet the higher quality of discharge required for the waste concerned.

Licence Monitoring

In addition to requiring licence holders themselves to sample and analyse their discharge and to keep proper records of same, inspectors from the Pollution Control Secion may also sample all discharges at any time, without previously advising the licence holder of their impending visit. Such check sampling would be reasonably frequent but not at regular intervals.

Such a system ensures that the Commission is soon aware of discharges that are not complying with the conditions of the licence.

Subdivisons

A major source of pollution in unsewered areas is septic tanks. These may have been installed incorrectly, or in unsuitable areas, or have been poorly maintained.

It is now widely accepted that the average domestic household wastewaters cannot be retained via a septic tank on a quarter acre site. The Commission therefore requires reticulated sewerage facilities to be provided on most new subdivisions under powers conferred by the Local Government (Subdivision of Land) Act 1973.

As a consequence, the Pollution Control Section is frequently engaged in assessing the suitability of proposed areas for septic tank absorption fields, or the licence conditions for a sewage treatment plant serving the subdivision. Many of these plants may be considered as temporary—where, for instance, the connection to a large municipal sewerage works could be expected within five years. The remainder must be regarded as permanent plants and required to comply with the usual discharge standards for such effluents.

Prosecutions

The Environment Protection Act provides for penalties to be imposed on persons who do not comply with the conditions of their wastewater licence, or who cause "pollution of waters". Pollution can be proven by demonstrating that a discharge has significantly affected the beneficial uses of a lake, stream, drain, channel or other watercourse. Fines up to $5,000 for a single offence and $2,000 per day for a continuing offence can be imposed.

To date, six prosecutions have been launched and all have been successful. Brief details of these cases, the nature of the pollution, and the fines imposed by the Court, are as follows :—

- oil spill to Campaspe River ($ 200) ;
- unlicensed package sewage plant treating hotel effluent ($ 200) ;
- shopping centre package sewage treatment plant with effluent quality not meeting licence conditions ($ 1,000) ;
- unlicensed sand washing discharge to Gellibrand River ($ 300) ;
- winery effluent discharged to a private

drain ($ 200) :

- whey effluent discharged to a creek ($ 300).

The following occurrences are under investigation :—

- disturbance of gold mining tailings on a river bed ;
- abattoir run-off to a creek at Ballarat:
- aerial spraying of insecticide to channel near Shepparton ;
- oil discharge to a channel near Shepparton.

The list of prosecutions indicates that many of these offences are accidental or irresponsible discharges rather than continuing violations of a wastewater licence.

It is pleasing to report that most people appreciate the need for a wastewater licensing system and generally are willing to co-operate in improving their waste discharges where required.

HEAVY FINES OR JAIL FOR US POLLUTERS

NEW CONTROLS on water pollution in the United States mean that companies offending for the first time can face fines of $US25,000 per day or risk their senior officials being jailed for up to one year.

A second offence doubles the penalties that can be imposed.

"These stringent measures were found necessary as lighter penalties meant that it was cheaper for a company to pay the fines and continue polluting instead of installing a treatment plant," professor W. W. Eckenfelder said at Massey University last month.

Professor Eckenfelder, one of the world's leading authorities on effluent treatment, addressed a conference on Waste-Water Treatment organised by the biotechnology department at Massey and sponsored by the NZ Committee on Water Pollution Research, the National Water & Soil Conservation Authority, and the New Zealand-United States Educational Foundation.

Professor Eckenfelder is distinguished professor of environmental & water resources engineering at Vanderbilt University, Tennessee, and senior partner in a consulting firm, Associated Water & Air Resources Engineers.

He has been involved, in the course of a distinguished career, with the waste disposal problems of a very wide range of industries and his consultancy work has taken him overseas on many occasions.

In Israel, for example, he drew up a water resources plan for the whole country.

Delegates from industry, government, local authorities, consulting firms, and research institutions have heard papers presented on all aspects of the treatment of waste and participated in workshops led by Professor Eckenfelder and another visiting expert from the UK, Dr. A. L. Dowing.

"The major problems concerning waste treatment in the US," says Professor Eckenfelder, "are social and political, rather than technological."

Federal laws require that, by 1977, all discharged wastes will have to receive secondary treatment — that is, soluble organic material must be removed as well as the floatable and suspended solids.

Professor Eckenfelder points out that, although States will retain the right to impose stricter standards on specific rivers or streams, they cannot allow a lower level of treatment than the federal standard.

Industries must instal monitoring equipment to check the effectiveness of their treatment and meet the operating costs of the treatment. In addition to the heavy fines and stiff sentences, failure to comply with the law may result in the factory being closed down.

"By 1983", Professor Eckenfelder says, "a higher level of treatment will be insisted upon, that will eliminate nitrates, phos-

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A quarterly Magazine of National Water and Soil Conservation Organisation.

phates, and dissolved salts from the effluent."

Professor Eckenfelder says that it was not until the early sixties that the United States began to organise national goals and policies for controlling water pollution. This is the critical first step he believes for a country hoping to beat the problem.

Bulletin of the International Hydrological Programme

Scientific Projects of IHP

The applications of hydrology to water management and the overall influence of man's activities on the water cycle together constitute the major, underlying conceptual theme of the new International Hydrological Programme.

As the logical successor to the International Hydrological Decade, IHP will, of course, continue to pursue the central objective of the Decade of improving the study of water resources and the scientific methodology used to assess them. New emphasis will, however, be placed on the evaluation of the effects of human activities on the water cycle considered in relation to environmental conditions as a whole.

In the course of its first session, held at Unesco headquarters in Paris from 9 to 17 April 1975 (see *Nature and Resources*, Vol. XI, No. 2), the Intergovernmental Council for IHP examined the scientific projects included in the outline plan for the Programme for the period 1975-80 as approved by the General Conference of Unesco at its eighteenth session.

The council decided that during the first phase of the Programme (1975-76) the main effort would be concentrated on the following eight scientific projects.

Project No. 1: Development and improvement of methodology of computation of water balances and their elements, including groundwater. The first question any user of a water resource must ask is how much water is available and where he can draw his supply from. As the amount of water withdrawn approaches more and more closely to the amount available, the reply to this question requires the establishment of more and more accurate water balances both for small basins and for larger regions and for the great international basins. A great deal still remains to be done to improve the computational methods employed as well as the actual compilation of these balances and these are the objectives of the first two projects of IHP.

IHP Project No. 1 is concerned with the improvement of methods for computation of the components of the short-term water balances of river basins, lakes and reservoirs, swamps and groundwater. In 1974, Unesco published an international manual on the computation of the water balances of river basins which established unified principles and methods that could be applied in different countries for the calculation of the water balance and its components. National and regional seminars are to be organized to evaluate the practical applications of the manual and to propose improvements to it.

Particular attention is to be paid to the computation of water balances of lakes

Reprinted from "Nature and Resources" Vol. XI. No. 3, July-Sep. 1975 (UNESCO Publication)

and reservoirs as well as to the improvement of methods of extrapolation of the results of the study of groundwater balances to large areas, especially by the application of mathematical and physical models to unsteady groundwater flow and to water movement in complex aquifers (see also Project No. 8)

In order to make possible a comparison between the terrestrial and the atmospheric approaches to the evaluation of balances, a state-of-the-art report is to be prepared, in collaboration with WMO, on methods of computation of large-scale water balances based on airmoisture flux and distributed system modelling.

Project No. 2 : Compilation of regional, continental and global water balances. Closely linked with the previous project, IHP Project No. 2 is concerned with the assessment of long-term regional, continental and global water balances.

In 1974, the U.S.S.R. National Committee for IHD published a monograph on the *World Water Balance and Water Resources of the Earth* containing basic information on the water balance and water resources of the continents, the polar regions, the oceans and the world's largest lakes and reservoirs. In order to give this monograph a wider dissemination, it is to be translated into English and possibly into Spanish. The bibliography of works published concerning the world water balance is also to be completed.

Work is to be continued on the definition of the scientific and practical approaches to be adopted for the evaluation of the water balance of Europe; the second stage of this task will be to establish an estimate of the water balance of the western hemisphere.

Preparatory work is to be continued with a view to the publication of *Water Balance of Lakes and Reservoirs of the World* and of Volume III, Part 3, of *Discharge of Selected Rivers of the World*

The world inventory of variations of snow and ice, undertaken by the IAHS Commission on Snow and Ice, will be continued with the completion of the global inventory of perennial and annual snow masses, a worldwide study of glacier variations, and the estimation of water, ice and heat balance measurements at selected representative glacier basins.

Project No. 3 : Research into hydrological regimes and development of methods for computation of their elements for water planning. The assessment of those parameters of the hydrological règime that are necessary for various water resource development projects is a key probelm in hydrology. A great deal remains to be done to improve assessment methods applicable in relatively little studied climatic regions such as the arid and semiarid zones and the humid tropics.

Work is to continue on the generalization of results of research and computation of average, minimum and maximum flow under various natural conditions, including the case of inadequate data. This will take the form of a guidebook on methods of hydrological computations for water projects, with particular reference to floods, low flow and drought.

While hydrological parameters such as average and extreme discharges are essen-

tial for designing the basic elements of a water use system, the fluctuations in the hydrological rèGime constitute a fundamental component of water management aimed at adapting the available time-space water resources to water needs. The Council therefore requested the Secretariat to prepare, in co-operation with WMO, an outline study programme for 1977-80 on fluctuations and long-term trends in the hydrological rèGime as related to climatic factors.

The council decided to appoint a *rapporteur* whose task would be to prepare a general description of droughts including an analysis of their frequency as linked with their duration, area of influence and magnitude of their effects, as well as an analysis of droughts as aspects of the evolution of climatic conditions on the regional and global scale.

Greater attention is to be given to water resources systems analysis, simulation and optimization and an attempt will be made to develop a reference mechanism for operations research and computer programmes.

The study of sedimentation processes, started under IHD in collaboration with IAHS, is to be followed up; studies will be concerned with erosion and sedimentation parameters the carrying capacity of river systems and the relationships between the transport of sediments and water quality.

Project No. 4: Development of investigations on representative and experimental basins. The scientific importance of studies on representative and experimental basins was amply demonstrated during IHD. The overall objective of research on these basins is the understanding of the interrelationships and totality of the elements of the hydrological rèGime both under natural conditions and as affected by man's activities.

The Council is to establish a small working group which will compile a casebook on the applications of studies on representative and experimental basins with particular reference to their usefulness to management and their contribution to water resource surveys, environmental monitoring and for the advancement of understanding of hydrological processes and concepts.

Owing to the large number of variables and the great amount of data involved in representative and experimental basin research, mathematical models and systems analysis are indispensable tools for the understanding of the water cycle processes. Special studies are therefore to be made of the application of these new and sophisticated techniques to the prediction of basin flow, the extrapolation of data from small to large regions, and the evaluation of the influence of man's activities on the hydrological cycle.

Project No. 5: Investigation of the hydrological and ecological effects of man's activities and their assessment. The scope of this project is vast since the assessment of man's management activities on the hydrological cycle is a basic problem in modern hydrology, especially considering the increasing scale of river runoff regulation and groundwater use.

During 1975-76 a working group is to prepare a casebook on methods of compu-

tation of quantitative changes in the hydrological rèGime of river basins due to human activities. The casebook will contain examples representative of different climatological regions and of different levels of basin development; it will indicate methods of computation that have been effectively used to predict or evaluate changes.

A report will be drawn up on the state of knowledge concerning the influence of land use practices and of hydraulic works on channel erosion and sedimentation as well as on the changes in the hydrological rèGime resulting from irrigation.

An attempt will be made to estimate changes in the salt-fresh water balance in coastal areas resulting from hydraulic works and groundwater exploitation. Particular attention will be paid to the study of the hydrological consequences of the exploitation of new energy sources.

The possibility will be examined of establishing hydro-ecological indices, to be used in conjunction with normal economic indices, for the evaluation of water projects and their potential effects on the environment.

Project No. 6 : Hydrological and ecological aspects of water pollution. Water constitutes an excellent vehicle for the discharge and dispersion of many types of waste products resulting from human activities. These wastes are discharged into rivers, lakes and estuaries either in concentrated form, in urban and industrial areas, or in more diluted form, in rural areas. It is important, therefore, to develop methods for evaluating the 'acceptance' capacity of the various environments into which liquid effluents or solid wastes are discharged in dispersed form, before the damage thresholds are reached.

'Acceptance' levels depend upon conditions at the site under consideration and on the physical and chemical processes of diffusion, dispersion and self-purification at work in different types of surface water.

In order to take stock of existing knowledge, a small working group will prepare a state-of-the-art report on the mechanics of the movement and dispersion of pollutants in rivers, lakes, reservoirs and estuaries and on self-purification processes. A significant waste product discharged into the aquatic environmet in the industrialized countries is the thermal energy waste from electrical power plants. It is therefore desirable to take stock of the tools already available for the forcasting and monitoring of temperature rises in aquatic environments affected by thermal discharge and of their hydrological, atmospheric and ecological consequences.

The findings of the state-of-the-art review will be set out in technical reports dealing with the hydrodynamic and thermodynamic aspects of thermal discharge as well as the ecological consequences in various kinds of receiving waters (salt and fresh waters).

Project No. 7 : Effects of urbanization on hydrologieal regime and on quality of water. Water plays a vital role in the extremely complex processes of urbanization and these processes in turn have a major impact on the hydrological rèGime and on the quality of water. In order to achieve a wider and more effective use of existing data as well as information from