

**FINAL REPORT OF IPOE
FOR REVIEW OF STUDIES ON
WATER ESCAPAGES BELOW KOTRI BARRAGE**

**Fernando J Gonzalez
Thinus Basson
Bart Schultz**

**Delft, the Netherlands
20th of November 2005**

IPOE:

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Signed on behalf of the IPOE

Delft 20th of November, 2005
Bart Schultz

EXECUTIVE SUMMARY

- I. Three studies were commissioned to reach consensus on the minimum required escapages below Kotri Barrage, which is the main outstanding item of the Water Apportionment Accord (WAA). It concerns:
- Study I: *Water escapages below Kotri Barrage to check seawater intrusion;*
 - Study II: *Water escapages downstream of the Kotri Barrage to address environmental concerns;*
 - Study III: *Environmental concerns of all the four provinces.*
- In order to have an independent external review of the studies an international panel of experts (IPOE) was appointed. The IPOE took good note of the historical developments and the WAA, especially of para 7 on *The need for certain minimum escapages to the sea, below Kotri, to check sea intrusion*. The IPOE reviewed the studies at relevant stages, had in depth discussions with government staff at Federal and Provincial level, as well as with the consultants, and analysed international experiences and practices.
- II. The following aspects primarily justify the need for water escapages below Kotri Barrage: (i) salinity encroachment in the river, aquifer and coastal zone; (ii) requirement of coastal stability; (iii) requirement of a sustainable environment; (iv) fisheries; (v) prevention of salinity accumulation in Indus Basin. In addition other factors may play a role: riverine forests, riverine agriculture, pollution control and drinking water supply.
- III. In the determination of the IPOE's recommendations on the minimum escapages the following considerations have played a role: (i) to check seawater intrusion downstream of Kotri Barrage as identified in Study I; (ii) the needed environmental flows upstream of Kotri Barrage as provisionally indicated in Study III; (iii) the impact of the recommended environmental flows on the availability of water for economic and social needs (irrigation, domestic and industrial water supply) as indicated in Study III; (iv) the minimum needs for fisheries and maintenance of mangroves in the Expanded Delta as indicated in Study II; (v) flows to keep the river morphology in good condition; (vi) the international developments and practices with respect to environmental flows; (vii) the recognition that a structural solution will not be feasible.
- IV. An escape at Kotri Barrage of 5000 cfs throughout the year is considered to be required to check seawater intrusion, accommodate the needs for fisheries and environmental sustainability, and to maintain the river channel. The IPOE likes to stress that seawater intrusion only concerns problems related to surface water, because salinity in the aquifer is predominantly due to fossil water salinity from geological origin.
- V. The IPOE understands the problem of sea intrusion/coastal erosion as occurring in the Indus Delta area and considers this as a National problem. The reasons for this problem are primarily: (i) reduction in sediment supply by Indus River as indicated in Studies I and II; (ii) reduction in the mangrove vegetation as indicated in Study II; (iii) prevention of flooding of the outlying delta areas due to the river bunds; (iv) sea level rise; (v) recent extreme weather conditions possibly due to climate change. With respect to the required sediment supply and mangrove vegetation the IPOE likes to give the following observations and recommendations.

IPOE:

I

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

- VI. As far as the sediment supply is concerned a substantial reduction has taken place over the years due to the diversion of most of the water for irrigation. The original supply of sediment is estimated at 400 million tons/year. Then the coastal accretion was about 30 m/year. A substantially smaller amount of sediment is needed to establish a stable coastline, especially when this supply is combined with coastal protection measures. By far most of the sediment is supplied during peak flows. It is recommended that a total volume of 25 MAF in any 5 years period (an annual equivalent amount of 5 MAF) be released in a concentrated way as flood flow (Kharif period), to be adjusted according to the ruling storage in the reservoirs and the volume discharged in the four previous years.
- VII. As far as the mangrove vegetation is concerned a certain flow and sediment supply will be required, together with control of camel grazing and fire wood cutting, and mangrove replanting. In order to spread the water over the flats a concentrated high flow would be needed during the Kharif season. The amounts of fresh water as mentioned under item VI will be sufficient for a sustainable mangrove growth. It is considered to be of utmost importance to manage the mangroves in such a way that a sufficiently wide mangrove belt is being maintained in front of the coastline. The IPOE recommends that this be considered to be a National responsibility.
- VIII. Based on the above considerations the IPOE recommends the escapages below Kotri Barrage as shown in Table I. The flows can be adjusted according to the proportions of the allocations delivered to irrigation. In addition the IPOE recommends that peak discharges during the Kharif period, as explained in item VI, will be made to supply sediment to the delta, sustain mangrove vegetation and preserve river morphology.

Table I. Recommended escapages below Kotri Barrage in cfs and MAF

	Kharif						Rabi *)						Totals		
	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Year	Rabi	Kharif
In cfs	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000			
In MAF	>=0.3	>=0.3	>=0.3	>=0.3	>=0.3	>=0.3	0.3	0.3	0.3	0.3	0.3	0.3	3.6 +**)	1.8	1.8 +**)

*) In a dry year the amount can be proportionally reduced in relation to the reductions in irrigation water supply

**) A total volume of 25 MAF in any 5 years period (an annual equivalent amount of 5 MAF) to be released in a concentrated way as flood flow (Kharif period), to be adjusted according to the ruling storage in the reservoirs and the volume discharged in the four previous years

- IX. Based on the post Tarbela flow data the above recommendations would result in a required additional release downstream of Kotri Barrage during low flow months of 1.26 MAF in an average year and 2.20 MAF in a typical dry year. This will require additional storage capacity to prevent a reduction of water availability for irrigated agriculture. Environmental flows would as and when appropriate be routed via upper rivers before release downstream of Kotri Barrage.
- X. The IPOE recommends that the proposals as made by Study III with respect to the environmental concerns of the provinces, not reducing the escapages downstream of Kotri Barrage as recommended in item VIII and acceptable to the concerned province, be prioritised for implementation.

IPOE:

II

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

1 Background

- 1.1 The Indus Basin Irrigation System provides irrigation to about 40.0 Mac (million acre) (16.2 Mha [million hectares]) (73% of the total cultivable area in Pakistan) and generates about 90% of the nation's total value of agricultural output. Provision of irrigation on a controlled year around basis started in 1859. A rapid expansion occurred during the last 50 years with large investments in dams that provided about 13 MAF (million acre feet) (16 Bm³ [billion cubic metres]) of live storage (Tarbela, Chasma and Mangla are the main storages), and greater use of groundwater to increase both the irrigated area and the cropping intensity. Today the system comprises 19 barrages and head works, 12 link canals, 43 commands and some 107,000 watercourses. Some background information is given in Annex I.
- 1.2 In March 1991 the Water Apportionment Accord (WAA) was signed by the provinces, which replaced previous agreements to distribute the Indus River waters among the provinces and command areas. It established the water rights among the provinces and protects future water rights, including the effect of future storages. A formula is available for sharing river flows. The Indus River System Authority (IRSA) was created as the regulatory authority for monitoring and distribution of the water sources of the Indus River in accordance to the WAA. The WAA recognized:

'The need for certain minimum escapages to the sea, below Kotri, to check sea intrusion. Sindh held the view that the optimum level was 10 MAF (12.3 Bm³), which was discussed at length, while other studies, indicated lower/higher figures. It was therefore, decided that further studies would be undertaken to establish the minimal escapages needed below Kotri.'

- 1.3 Since 1991 several studies have indicated a range of minimum flows to check seawater intrusion, none of which had been agreed upon. It is important that consensus be reached on the minimum escapages required below Kotri Barrage, which is the main outstanding item of the WAA. Therefore three studies jointly agreed to by the stakeholders were commissioned in this respect. The main objective of Study I - *Study on water escapages below Kotri Barrage to check seawater intrusion* - was to determine the minimum quantity of the Indus River water that needs to pass below Kotri Barrage to control seawater intrusion at desirable levels, and to suggest alternative measures to alleviate adverse impacts. Study II - *Study on water escapages downstream of the Kotri Barrage to address environmental concerns* - was to investigate and address environmental impacts from river water and sediment flows and their seasonal distribution below Kotri Barrage (forests, mangrove forests, fisheries, riverine agriculture, population, flora and fauna, seawater intrusion), identify mitigation measures and evaluate trade offs. Study III - *Study on environmental concerns of all the four provinces* - was to identify and address environmental concerns of all four provinces and needed to address a wide range of issues related to the management of water resources in the Indus Basin upstream of Kotri Barrage. The current studies had to verify the data on salinity of the water entering into Sindh Province. The Terms of Reference (TOR) for the present three studies were the product of intensive negotiations in which the provinces expressed their

IPOE:

1

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

concerns about the issue of minimum flows needed to check seawater intrusion. However, they also address more general environmental concerns.

- 1.4 In order to have an independent external review of the studies at various relevant stages an international panel of experts (IPOE) was appointed. The three members of the IPOE were Fernando J Gonzalez, Thinus Basson and Bart Schultz. The Terms of Reference (TOR) for the IPOE stated clearly 3 objectives:

- Review work of consultants for the three studies in 3 stages. Namely inception, interim and draft final reports;
- Review recommendations given by the consultants in the light of the scope of work envisaged in the TORs for all the three studies;
- Analyse the recommendations of the consultants in full perspective and suggest judicious trade-offs and interventions amongst various requirements.

In Annex II a brief overview is given of IPOE's activities with respect to its TOR.

- 1.5 The first visit to Pakistan by the IPOE took place during the period 19th of March to 15th of April 2005. At that moment the draft Inception Reports for the three studies were available. The findings and recommendations of the IPOE, based on the three Inception Reports and the discussions held during the visit, were laid down in its 1st report, dated 14th of April 2005. The second visit of the IPOE took place from 12th to 23rd of August 2005. Draft Interim Reports of the three studies were received before the visit. The IPOE could submit its written comments on the draft Interim Reports of Studies I and II before the visit. The IPOE received the draft Interim Report of Study III too late to give comments beforehand. These comments were submitted during the visit. All the three consultants accommodated a substantial part of the comments and recommendations by the IPOE and submitted a large amount of additional information during the visit. It was agreed that the Interim Reports would not be revised, but that all comments and suggestions would be included in the draft Final Reports. The findings and recommendations of the IPOE, based on the draft Interim Reports and the discussions held during the visit, were laid down in its 2nd report, dated 23rd of August 2005.

- 1.6 The third visit of the IPOE took place from 7th to 16th of October 2005. Draft Final Reports of the three studies were received shortly before the visit. Therefore the IPOE could only submit their written comments during the visit. The IPOE had:

- Regular meetings with Mr. I.B. Shaikh, Chairman Federal Flood Commission (FFC) and Mr. A. Kamal, Project Director Kotri Studies;
- A meeting with the Secretary of the Ministry of Water and Power, Mr. A. Mahmood;
- A meeting in Karachi with the Secretary of the Sindh Irrigation and Power Department (SIPD) and his delegation and in Lahore with the Secretary of the Punjab Irrigation and Power Department (PIPD) and his delegation;
- Meetings respectively in Islamabad (Study I, II and III) and in Lahore (Studies I and II) with the project leaders and team members of each consultant to ask for clarifications and to make suggestions for finalisation of the draft Final Reports;
- A meeting with Mr. Muhammad Karim Khan, NWFP Provincial Coordinator and Mr. Naseem Bazoi, Provincial Coordinator Balochistan;

IPOE:

2

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

- Attended the Steering Committee meeting at the FFC on 12th and 13th of October 2005. During the meeting Thinus Basson presented the findings and recommendations of the IPOE.

The slides of this presentation are attached as Annex III. The comments of the IPOE on the draft Final Reports of the three Studies that were submitted during the visit are attached as Annexes IV to VI.

- 1.7 Subsequent to the visit the IPOE has received the revised Final Reports of the three consultants and have submitted their remaining comments, especially on the Executive Summaries, by e-mail to the FFC and the consultants. Based on these facts the IPOE recommends that the reports for Studies I and III be approved. As far as Study II is concerned the IPOE has made quite some observation and recommendation with respect to the submitted explanatory notes and various draft versions of the Final Report. Major issues were that considerations on environmental items below Kotri Barrage would have to be based on relevant data, clear identification of the relevant areas and the requirement of an integrated analyses of the relevant processes. In addition there were quite some inconsistencies in the report. The consultant has finally submitted a report that may be considered acceptable. We therefore recommend that the report of Study II will also be approved.
- 1.8 The IPOE recognizes the prominent role of Mr. I.B. Shaikh and Mr. A. Kamal in managing the studies and facilitating the work of the IPOE. The IPOE especially recognizes the support of Mr. Kamal and his staff.

2 Findings of the IPOE on the draft Final Reports

- 2.1 The needs of and concerns on the environment play an important role in the studies. The relatively new approach of environmental flows is being introduced in Pakistan. In the development of practices in various other countries and river basins basically three approaches to determine environmental flows may be distinguished. These are:
 - *A fixed percentage (around 10%) of the average annual flow.* This approach has to be considered as an initial estimate;
 - *Hydrological analysis.* In such an analysis normally a low flow for different duration is taken as a reference;
 - *Analytical assessment of the basic needs of the ecosystems in the riverine area.* This is the most comprehensive approach. In fact this approach has been followed in the present studies. However, it has to be realised that in practice not all the environmental needs can be accommodated, and a realistic optimum of the needs of society and of the environment will have to be formulated.
- 2.2 *Main findings with respect to the Final Report of Study I: Study on water escapages below Kotri Barrage to check seawater intrusion*

The Final Report of Study I is well written, it focuses on the issues of relevance, is based on a good database, reliable calibrations and to the point modelling. The study is of a high

IPOE:

3

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

professional standard and in compliance with the TOR. In the draft Final Report there were some important issues to be solved and points to be clarified, which concerned:

- The period 1955 - 1975 is not really a homogeneous one, while the diversion of flows to India started during this period. Therefore it is not optimal for comparison of the desirable conditions encountered in the past. However, it is the best possible option that is available and therefore considered to be acceptable;
- The recommendations about the feasibility to build a barrage to check seawater intrusion were not fully clear. It was considered to be important to make the recommendations clear and to explain in more detail the basis for the proposed option;
- The justification for eliminating zero discharges and application of 1000 cfs as minimum flow would have to be explained. The IPOE believes that the minimum volume to keep seawater intrusion checked is not dependent on a hydrologic year selected as the 10% driest or 10% wettest year. The source of the water to be released can be different and could be calculated by making a simple simulation of the post 1975 period;
- According to results of the groundwater model, there was a need to clarify the conclusion that groundwater quality has not been affected by seawater intrusion. The results of dating the groundwater samples still needed to be included;
- The draft report needed to be checked for consistency and the proper use and unit prescription of levels compared to MSL (Mean Sea Level). In addition a check was needed, in consultation with the consultant for Study II, on the text where overlaps occur and for the use of names for different areas. This referred especially to the hydraulic computations, the sediment figures, the groundwater data and the names and areas for different types of the riverine and delta area.

The detailed findings of the IPOE with respect to the draft Final Report of Study I are given in Annex IV.

In its Final Report the consultant has accommodated these comments and therefore the IPOE recommends that the Final Report be approved.

2.3 Main findings with respect to the Final Report of Study II: Study on water escapages downstream of the Kotri Barrage to address environmental concerns

The draft Final Report of Study II needed substantial improvement, before it could become acceptable. Although the consultant had accommodated a substantial part of the comments that were made by the IPOE on its Interim Report, another substantial part of the comments that was discussed with and approved by the consultant were not accommodated in the draft Final Report. These comments have been given again in the detailed findings of the IPOE as given in Annex V.

Reading and understanding the draft Final Report was very difficult because each section seemed to have been written by a different team without the needed integration. The consultant had collected and showed in the draft Final Report a substantial amount of data. In general it was also made clear where the gaps in the data are. It was, however, not always shown what was the source of the data and under what conditions, or for which area the given data are applicable. In addition in different parts of the report different data for the same topic

IPOE:

4

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

were given. Several times the same data were repeated at different places. At the Interim phase it was discussed that there is a need to develop a spatial zoning and distribution to understand the main phenomena and forces acting in each of them. It was often unclear for what area and under what conditions the comments, observations, suggestions and proposals of the consultant are applicable. This referred especially to the different parts of the Delta and whether an issue is applicable to the land, the sea, or the transition zone.

During the visit there have been several meetings with the consultant. Following the meeting of the Steering Committee the consultant has submitted a revised Executive Summary and attached explanatory notes on: mangroves, sediment and fisheries. However, these documents were still not acceptable, because of lack of analysis and inconsistencies. There was still no analysis of the relevant processes, nor an integration of related issues. In a study like this an overall/integrated analyses for understanding of the processes at stake, assessing the relative contributions and a justification of the conclusions and recommendations is an absolute requirement. This is more valid in the complicated environments and processes we have to deal with. For details of the comments made by the IPOE on these issues reference is made to Annex V where other detailed findings of the IPOE with respect to the draft Final Report of Study II are given.

In addition a check was needed in consultation with the consultant for Study I on the text where overlaps occur and for the use of names for different areas. This referred especially to the hydraulic computations, the sediment figures, the groundwater data and the names and areas for different types of the riverine and delta area. Also a check with the consultant of Study III was needed on the requirements for the riverine ecosystem, forests and agriculture.

After the visit a new revised Executive Summary was submitted. In this summary the consultant still did not show the requested analyses and integration and came with several new data that were not based on his own study. Therefore, also this Executive Summary was still not acceptable. The IPOE has separately given its comments on this revised Executive Summary as well and expects that these comments be taken into account in finalising the Executive Summary, the explanatory notes and the Final Report. As already stated under item 1.7, after several revised versions the consultant has finally submitted a report that may be considered acceptable. The IPOE therefore recommends that the Final Report be approved.

2.4 Main findings with respect to the Final Report of Study III: Study on environmental concerns of all the four provinces

Study-III addresses the water related environmental concerns of all the four provinces with respect to the Indus Basin upstream of the Kotri Barrage as well as for the Non-Indus irrigated area of Balochistan, together with a number of specific issues as of interest to the relevant provinces. Only the main findings of common interest to most provinces are summarized below. The findings and recommendations with respect to the individual TORs were considered too voluminous for the purpose of this summary, and reference is made to the Executive Summary of Study-III in this regard.

IPOE:

5

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

The diversion of river flows, following on the Indus Water Treaty (IWT) with India in 1960, had a major impact on the flow regime of the Indus River and Eastern Rivers. Long reaches of the Eastern Rivers have very low flows and are dry for extended periods during the year, while flows in the Indus River below Tarbela Dam and the Chashma Barrage are highly altered and reduced. The impacts of the above on wildlife, fisheries, riverine forests, riverine agriculture, groundwater, water quality, associated social impacts and others, have been assessed and quantified where possible. A clear need has been identified for certain minimum flows for environmental purposes.

Estimates were made with respect to the quantification of environmental flows in the Eastern Rivers and the middle reaches of the Indus River. These were used as basis for the mathematical modelling of different representative flow scenarios. Although there is not sufficient information at this stage for specific decisions to be taken on environmental flows in these rivers, the combined flows for the rivers upstream of Kotri Barrage is of the same magnitude as what is recommended for the reach below the Kotri Barrage.

The pumping of groundwater for irrigation has significantly increased during recent years, resulting in a general, although limited, overall decline of the groundwater table. Mining of groundwater is evident in several areas, particularly in parts of Balochistan, around Lahore and some others. Recommendations are made with respect to the possible recharge of groundwater from river flow. In contrast, waterlogging from irrigation canals is experienced in certain areas.

Water quality and pollution surveys have been carried out in various parts of the study area. The chemical quality of surface water is generally of a high standard, but biological/bacteriological contamination is of wide spread concern and can only be addressed by the implementation of more complete wastewater treatment over time. The salinity of groundwater is increasing in several areas, while some bacterial contamination was recorded.

Individual TORs of the provinces were addressed as covered in the Executive Summary and Main Report of Study III. During the visit some parts of the report had not satisfactorily responded to the TORs and required substantiation by the consultant. Separate meetings were held, especially with representatives of NWFP and Balochistan. Improvements have been made in the consultants Final Report.

A check with the consultant of Study II was needed on the requirements for the riverine ecosystem, forests and agriculture.

An extensive computerized database on water and environmental related information was established, which could form the basis for a national database. In its Interim Report the IPOE had advised that the data of the other studies will in the future be included in the database and that adequate provisions be made to have issues relating to:

- Environmental flow models;
- GIS of all the four provinces with similar perspective;
- Establishment of the above in Government Offices.

Shortly after its second visit the IPOE had submitted a general framework for a TOR to get

IPOE:

6

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

this implemented in practise. It is understood that project preparation is on going to get this implemented at short notice.

The detailed findings of the IPOE with respect to the draft Final Report of Study III are given in Annex VI.

After the visit the IPOE has received the revised Final Report, including a revised Executive Summary. In general the comments made have been accommodated in the final version. The IPOE therefore recommends that the Final Report be approved.

3 Overall findings of the IPOE

Based on its findings the IPOE considers that the following aspects primarily justify the need for water escapages below Kotri Barrage:

- Salinity encroachment in the river, aquifer and coastal zone;
- Requirement of coastal stability;
- Requirement of a sustainable environment;
- Fisheries;
- Prevention of salinity accumulation in Indus Basin.

In addition other factors may play a role: riverine forests, riverine agriculture, pollution control and drinking water supply.

With respect to these aspects the following has been made clear in the present studies:

- *Salinity encroachment in the river, aquifer (below Kotri Barrage) and coastal zone.* Seawater intrusion only concerns problems related to surface water, because salinity in the aquifer is predominantly due to fossil water salinity from geological origin. The results of the groundwater measurements and modelling as presented in Study I clearly show this fact;
- *Requirement of coastal stability.* The present coastal instability is to a certain extent a consequence of the economic and social developments in the country, resulting in lower water escapages to the delta and less sediment supply than in the past. It is also a consequence of uncontrolled local activity, especially with respect to camel grazing and fire wood cutting. For the coastal stability two aspects play a major role, being the supply of fresh water and sediment and a controlled growth of the mangroves, at least in a wide belt in front of the coastline. May be additional coastal protection measures would need to be required. However, at present it is very difficult to determine the need of such measures, while the effect of a better insight in the processes at stake by better monitoring, future water and sediment supply and a controlled growth of the mangroves cannot yet be quantified. While the supply of fresh water and sediment, as well as the management of the mangroves are considered to be of major importance with respect to coastal stability, these two items will be separately described in the next sections;
- *Requirement of a sustainable environment.* There is globally an increasing awareness that measures will have to be taken in light of the creation of sustainable environments. When no due attention is being paid to this aspect, sooner or later substantial problems will be encountered, generally resulting in huge cost for the compensation and

IPOE:

7

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

- mitigation measures to be taken;
- *Fisheries.* With respect to escapages below Kotri Barrage the needs of fisheries concern a certain minimum flow as indicated in Study II;
 - *Prevention of salinity accumulation in Indus Basin.* Due to the large-scale development of irrigation in the Indus Basin a gradual accumulation of salts will occur when not a certain discharge of salts, that are disposed through the drains, or are entering into the rivers through the groundwater, is taking place towards the Arabian Sea.

It is found that with respect to the escapages downstream of Kotri Barrage the needs for riverine forests, riverine agriculture, pollution control and drinking water supply play a marginal role and will therefore not be further discussed in underneath considerations. For these aspects reference is made to the Final Report of Study II.

While a principle question concerns the choice of a structural, or a non-structural solution, in section 3.3 attention will be paid to the relevant issues with respect to this choice.

3.1 Findings with respect to the sediment transport

The Indus Delta is in a complex and delicate transition from the original dynamic equilibrium before the diversion of irrigation water, when the average annual sediment supply from the Indus River was estimated at about 400 million tons, to a new state. The river used to periodically change its course near the coast leaving a series of dead rivers or dorohs and advancing the shoreline towards the sea at an estimated rate of 30 m/year. The flow regime and its associated sediment transport built up the delta and a long gentle foreshore slope below sea level.

The new state will also be dynamic according to the changes in the Indus River hydrologic and sediment regimes, the storms in the Arabian Sea and the coastal protection during storm surges. The fragile equilibrium among fluctuating river discharges, tidal and littoral currents, storm surges and sediment supply and transport has been changed. Increased water use in the Indus Basin, mainly for the expansion of irrigated agriculture, has changed the water flow and the sediment load that had built the delta over geologic time. Sediment measurements below Kotri Barrage estimate an annual sediment transport of 126 million tons in post-Tarbela period. Construction of the bunds for flood protection has also fixed the position of the river near its mouth and concentrated the pattern of the discharge.

The observed changes at macro scale have been interpreted, by some experts, including scientists from the National Institute of Oceanography (NIO), as a *shrinking* of the Active Delta - an area of 91,331 ha around the mouth of Indus River - and this fact seems to be confirmed by the finding of oceanic origin organisms in the tidal creeks by the same scientists. Satellite image interpretation by Study II shows that the Expanded Delta - an area of 151,887 ha, including the Active Delta - is apparently changing its shape having erosion at the river mouth in the Active Delta, because of the decreasing sediment inflow and (lateral) transport of sediment under the influence of the tides, littoral currents and storm surges, and is building up at parts of the Expanded Delta and the remaining part of the Tidal Delta - the much larger tidal zone (about 620,000 ha), which spans from the Korangi Creek area near

IPOE:

8

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

Karachi and the Sir Creek near the border of India. - away from the river mouth. This change in shape (with zones of erosion and deposition) will continue until bathymetry and shape of the coast reach a new dynamic equilibrium with the sediment transport.

Stable river cross-sections depend on the sediment bed load and the distribution of high and low discharges. In an alluvial river like the Indus River below Kotri Barrage, there are two different kinds of sediment transport processes, the bed load and the wash load. The bed load depends on the flow of the river and the sizes of the bed material. Therefore there is a relation between the flow of the river and the bed load sediment transport. The wash load is composed of the finer material (usually fine silt and clay) that is transported in suspension along the cross-section of the river. Wash load depends on the inflow of sediment from watershed soil erosion and does not have a fixed relation with the flow of the river in any particular time.

The wash load in Indus River has been modified due to the deposition of fine sediment in the Tarbela and Mangla reservoirs and the diverted volumes to the irrigation canals. A storage dam can stop the inflow of bed load sediment in a river reach producing a scour immediately downstream of the dam until the relation of flow and bed load is re-established. Therefore the slope and the section of the river downstream of the dam would gradually change to attain a new equilibrium according to the flow regime defined mainly by the large and medium floods. Figures 1 and 2 show how the recorded sediment flows below Kotri Barrage change with flow rate. In Figure 2 it is clearly shown that most of the sediment is discharged during the peak flows. As said, the concentration of the wash load will be more or less independent of the flow. The difference will therefore be primarily caused by the increase in the bed load in relation to the increase in discharge.

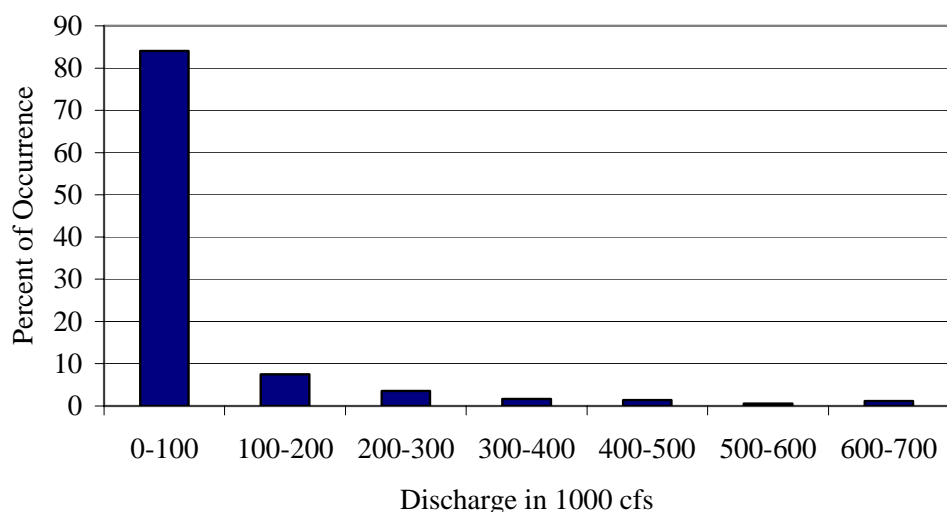


Figure 1 Distribution of the discharge below Kotri Barrage in percent of occurrence, based on data over the period 1972 - 2004

With respect to monitoring of the sediment in the Indus River generally a distinction is made in sand, silt and clay. When released beyond the river mouth the sand will be first deposited,

IPOE:

9

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

followed by the silt and the clay. The understanding exists that most of the deposition in the Active Delta consists of the sand and the silt particles and not so much of the clay particles. It is expected that at least a substantial part of these clay particles and a certain part of the silt particles are disposed further in the Arabian Sea. How the ratios of sand, silt and clay change in relation to the magnitude of the flow and over the river reach downstream of Kotri Barrage is not really known. It is therefore also not really known which part of the sediment contributes to the accretion of the Active Delta. In order to develop a better insight in these important processes a careful monitoring of the sediment load and its composition downstream of Kotri Barrage, as well as in the mouth of the river will be required.

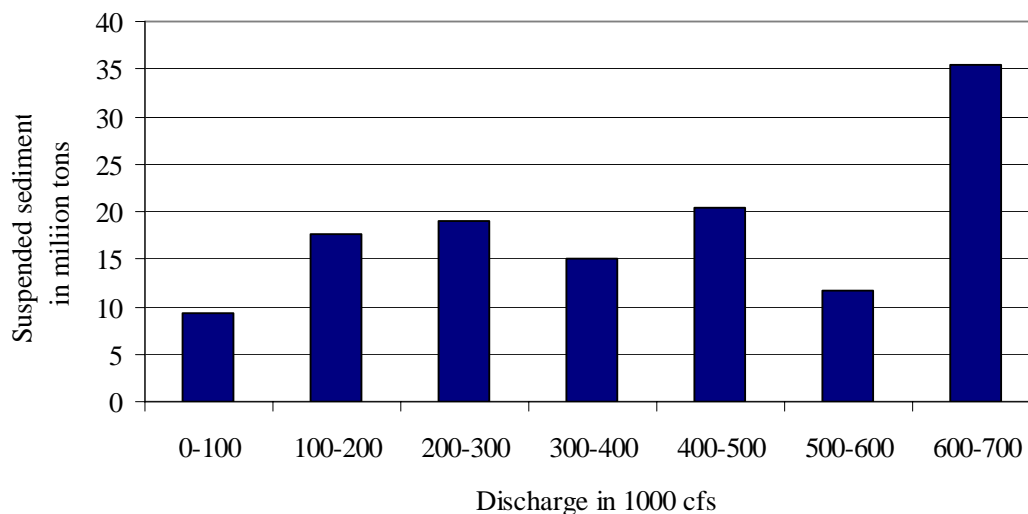


Figure 2 Distribution of the average suspended sediment flow in million tons per year below Kotri Barrage, based on data over the period 1972 - 2004

Maintaining frequent flood flows below Kotri Barrage is essential for preserving adequate river morphology. The stable river cross-section below Kotri Barrage is a function of the flow regime defined by large and medium flood flows. In a barrage like Kotri Barrage the river flow changes drastically and the bedload upstream of the diversion is larger than at the downstream side of the barrage. This change is especially important for relatively low flows and produces a deposition of bed load downstream of the barrage (accumulation of sand in the river bed) until the modified slope and section attain a new equilibrium according to the river regime.

The IPOE believes that maintaining an acceptable river morphology (cross-section, level of the channel bed and slope) requires periodic high discharges that can only be possible during the monsoon months, especially July, August and September. They are not needed every year but long periods of more than 5 years without considerable flood flows would induce vegetation growth and sedimentation that could irreversibly change the river morphology and the resulting habitat.

IPOE:

10

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

3.2 *Sustaining the mangrove vegetation*

Mangroves may play an important role in coastal protection, especially while they can act as a 'natural barrier during storm surges'. In addition they have a high value in the coastal ecosystem and can be used for camel grazing and fire wood cutting. According to data as presented in Study II, especially camel grazing and to a smaller extent the cutting of fire wood is taking place at a large scale and will undoubtedly have substantially contributed to the reduction in the mangrove area. By their impact on the mangroves these uses of the area have therefore also contributed to the process of coastal erosion. Sustaining the mangrove vegetation is of importance for:

- Their ecological role and economic value;
- Coastal protection and stabilisation (a broad mangrove belt along the coast would be needed).

Although the dominant species in the Tidal Delta have proven to be able to survive in purely marine conditions and seem to require a relatively small physiological freshwater amount, a certain freshwater flow and sediment supply during the Kharif season will be beneficial to ensure a healthy growth and reproduction of the mangroves. However, a high flow rate is needed to spread the fresh water over the Active Delta and may be over the remaining parts of the Expanded Delta. Flow rates and sediment supply that are needed for coastal stability, should also meet the needs of mangroves. In light of their role for coastal protection it is essential that the human use of mangroves be managed in such a way that a belt is being created and can be maintained.

3.3 *Findings with respect to a structural and a non-structural solution*

In Study I it has been investigated whether a structural solution - submerged weir, flap gates, or a barrage - could be implemented to prevent seawater intrusion and whether such a solution would be advisable compared to a non-structural solution. It was concluded that in principle a structural solution is possible. It would have the advantage of water saving and enabling the use of that water for other purposes. It was found that a barrage could be a solution, but it was not recommended.

There are important negative aspects related to the structural solution. The IPOE has analysed these aspects and likes to mention especially the following:

- The barrage would have to be closed, especially during the low flow periods. This may extend over several months with negative impacts to the environment. When it would be opened from time to time (during a low flow period to overcome this problem) its effect to water saving would be reduced;
- The river reach downstream of Kotri Barrage will be frequently dry during low flow periods, which also will have a negative impact on the environment;
- From a construction point of view the barrage will have to be built in a very unstable soil. In addition it will be required to connect the barrage to the bunds along the river while otherwise the river will flow around the barrage during peak flows and will find its new course;
- While the barrage will have to be operated in a tidal environment and from time to time

IPOE:

11

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

- be exposed to storm surges its operation will be complicated, maintenance cost will be high and there will be a serious risk of failure of the barrage or certain components of it;
- By connecting the barrage to the bunds, during peak flow periods high water levels may develop at the upstream side of the barrage, because the discharge will be constrained due to the barrage and the connecting bunds. In the type of soil that prevails in the area, piping may easily develop resulting in collapsing bunds and the river finding its course through the developed breach.

Because of the negative aspects as stated above the IPOE strongly recommends not to choose a structural solution and will therefore base their recommendations on the non-structural option.

4 Recommendations

Based on the findings as explained in the previous chapters the IPOE has formulated its recommendations as shown in the next sections.

4.1 Recommendations on escapages below Kotri Barrage

In the determination of the IPOE's recommendations on the minimum escapages below Kotri Barrage the following considerations have played a role:

- To check seawater intrusion downstream of Kotri Barrage (at the end of the bunds) as identified in Study I;
- The needed environmental flows upstream of Kotri Barrage as provisionally indicated in Study III;
- The impact of the recommended environmental flows on the availability of water for economic and social needs (irrigation, domestic and industrial water supply) as indicated in Study III;
- The minimum needs for fisheries of about 5000 cfs, more or less during the year, as indicated in Study II
- Maintenance of mangroves in the Expanded Delta as roughly indicated in Study II;
- Flows to keep the river morphology in good condition;
- Provision for general environmental sustainability (species diversity and habitat needs not yet fully known);
- The international developments and practices with respect to environmental flows;
- The recognition that a structural solution will not be feasible.

An escape at Kotri Barrage of 5000 cfs throughout the year is considered to be required to check seawater intrusion, accommodate the needs for fisheries, environmental sustainability, and to maintain the river channel.

The IPOE understands the problem of sea intrusion/coastal erosion as occurring in the Indus Delta and considers this as a National problem, because it is to a large extent the consequence of the developments in the country, especially of the diversion of water for irrigation. As far as the sediment supply is concerned it is of importance that by far most of the sediment is

IPOE:

12

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

supplied during peak flows as explained in section 3.1. The sediment supply is required to maintain a stable coastline, sustain mangrove vegetation and preserve river morphology. It is recommended that a total volume of 25 MAF in any 5 years period (an annual equivalent amount of 5 MAF) be released in a concentrated way as flood flow (Kharif period), to be adjusted according to the ruling storage in the reservoirs and the volume discharged in the four previous years.

As far as the mangrove vegetation is concerned a certain flow and sediment supply will be beneficial to sustain a healthy growth and reproduction of the mangroves, together with control of camel grazing and fire wood cutting, and mangrove replanting. It is considered to be of utmost importance to manage the mangroves in such a way that a sufficiently wide mangrove belt is being maintained in front of the coastline. The IPOE recommends that this be considered to be a National responsibility. It will therefore be of importance to prepare a coastal zone management plan.

The plan would have to describe:

- The coastal morphological processes under the influence of the river discharges, sediment supply, tidal and littoral currents, storm surges;
- The needed location and width of the mangrove belt with respect to their role for coastal protection;
- The locations where camel grazing and wood cutting can be permitted and the conditions for these activities;
- A replanting scheme for the mangroves;
- A description of the other relevant activities with respect to the coastal areas.

The plan would have to be the basis for the future management of the coastal area.

In order to spread the water over the flats a concentrated high flow would be needed during the Kharif season. The amounts of fresh water as mentioned above would be sufficient for a healthy mangrove growth. Based on the above considerations the IPOE recommends the escapages below Kotri Barrage as shown in Table 1. The flows can be adjusted according to the proportions of the allocations delivered to irrigation.

Table 1. Recommended escapages below Kotri Barrage in cfs and MAF

	Kharif						Rabi *)						Totals		
	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Year	Rabi	Kharif
In cfs	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000			
In MAF	>=0.3	>=0.3	>=0.3	>=0.3	>=0.3	>=0.3	0.3	0.3	0.3	0.3	0.3	0.3	3.6 +**)	1.8	1.8 +**)

*) In a dry year the amount can be proportionally reduced in relation to the reductions in irrigation water supply

**) A total volume of 25 MAF in any 5 years period (an annual equivalent amount of 5 MAF) to be released in a concentrated way as flood flow (Kharif period), to be adjusted according to the ruling storage in the reservoirs and the volume discharged in the four previous years

IPOE:

13

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

4.2 Recommendations on storages

Based on the post Tarbela flow data the above recommendations would result in a required additional release downstream of Kotri Barrage during low flow months of 1.26 MAF in an average year (Figure 3) and 2.20 MAF in a typical dry year (Figure 4) (Table 2). The storage capacity in the Indus Basin is only 9% of the average annual river flow and is reducing because of siltation - thus difficult to maintain recommended flows in dry years. Therefore additional storage capacity will be required to prevent a reduction of water availability for irrigated agriculture.

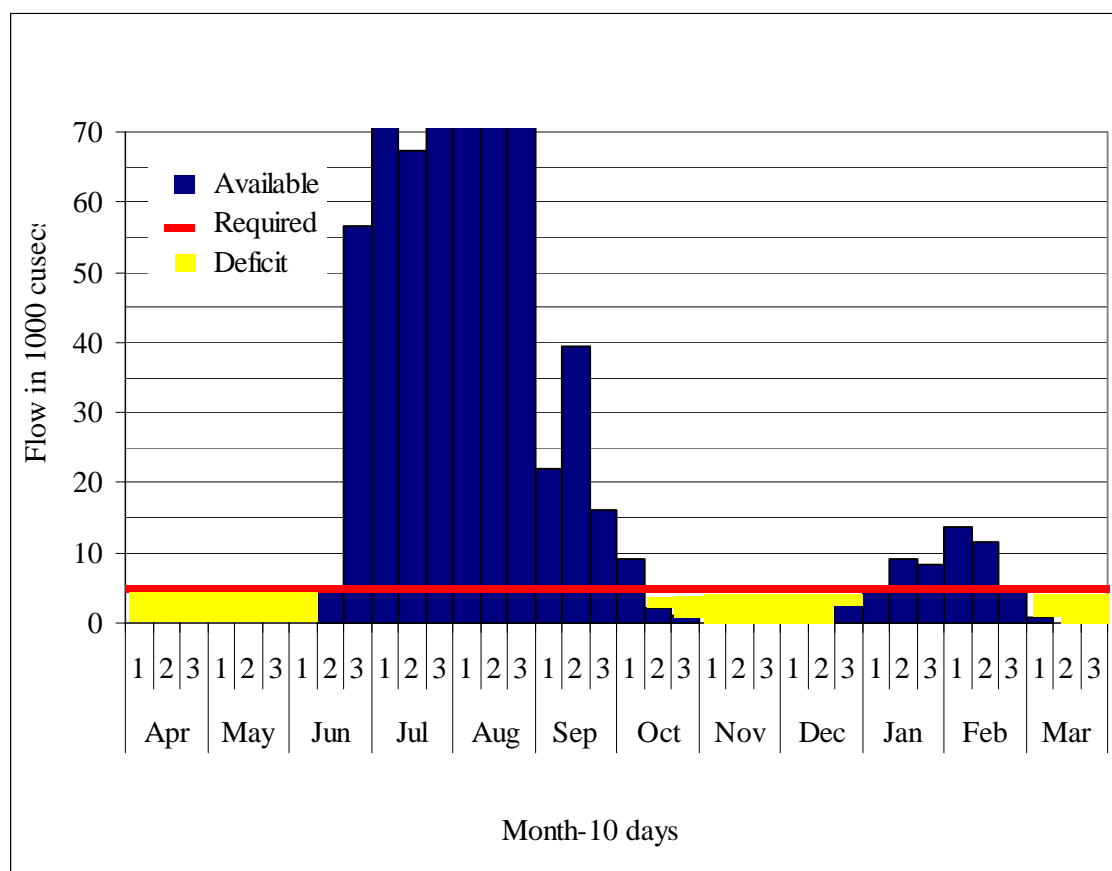


Figure 3 10-day average flows of Indus River below Kotri Barrage for a typical average year 1980 – 1981

Table 2 Summary of flows and deficits

Representative Average/dry year	Escapages in MAF			Deficit in MAF		
	Kharif	Rabi	Year	Kharif	Rabi	Year
Average year	1.80	1.80	3.60	0.59	0.67	1.26
Dry year	1.74	1.22	2.96	1.02	1.18	2.20

IPOE:

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

14

Signed on behalf of the IPOE

Delft 20th of November, 2005
Bart Schultz

As said, the storage capacity is very low and does not sufficiently provide for the efficient management of the basin's water resources. The storage capacity is also reducing due to high sediment inflows and retention. It therefore imposes constraints on the ability to maintain the recommended environmental flows during low flow months, in particular during dry years.

4.3 Recommendations for the development upstream of Kotri Barrage and in non-Indus areas

In Study III a comprehensive set of proposals has been formulated that refer to the development upstream of Kotri Barrage, or to areas outside the Indus Basin. The IPOE recommends that the proposals as made by Study-III with respect to the environmental concerns of the provinces, not reducing the escapages downstream of Kotri Barrage as recommended in section 4.1 and acceptable to the concerned province, be prioritised for implementation.

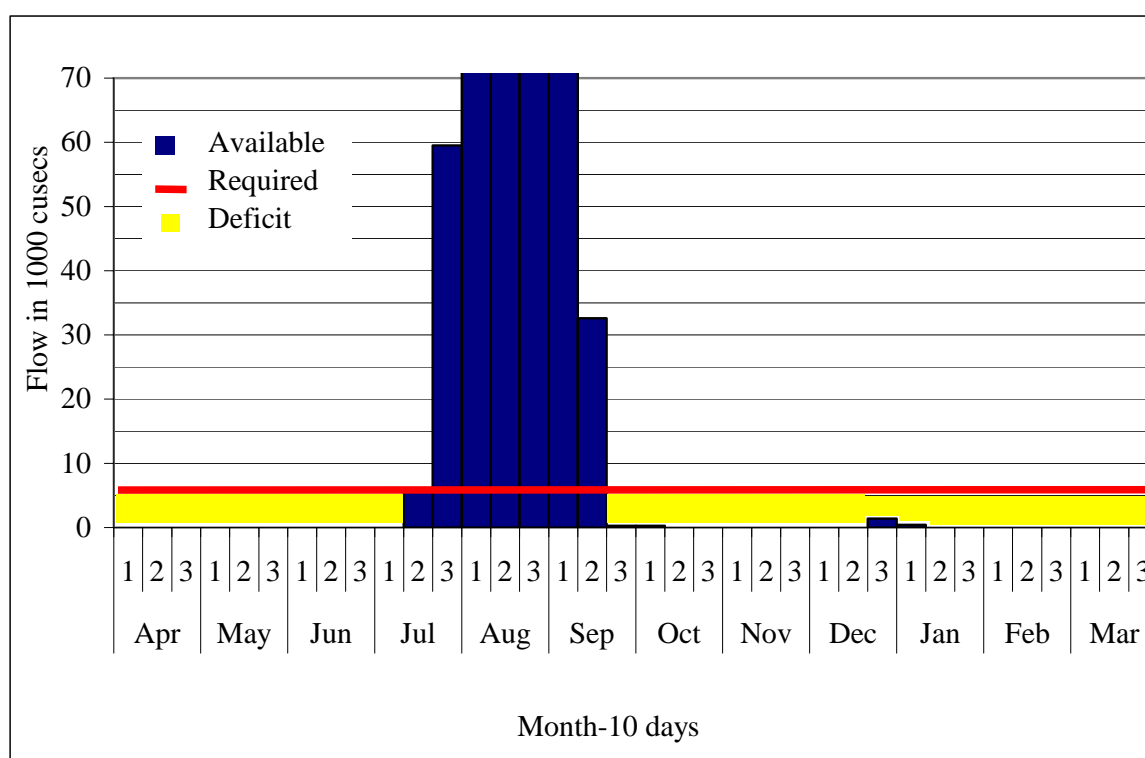


Figure 4 10-day average flows of Indus River below Kotri Barrage for a typical dry year 1985 - 1986

4.4 Recommendations on implementation of environmental flows

In accordance with international practice it is recommended that detailed planning with respect to the implementation of environmental flows be done, prior to commencing with actual implementation. This normally requires investments in management and institutional

IPOE:

15

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

arrangements, the introduction to technological refinement (such as to improve the efficiency of irrigation water distribution and application), as well as in infrastructure developments (storage and conveyance works), in order to mitigate the negative impacts on existing users. It may be required that the environmental flows are introduced over a period of time to allow for implementation of at least the primary mitigating measures.

Should new regulation infrastructure (dams, canals) be built in future, it is recommended that the following be taken into account:

- Provision of bottom outlet facilities to allow for the through flow of sediment during periods of high flow;
- Provision, already during the planning stage, for the management of releases in such a way that high flows can be achieved downstream of Kotri Barrage. The preference would be for higher flows of short duration, rather than lower flows of longer duration; within the limits of technical and economic feasibility;
- Environmental flows would preferably be routed via the upper rivers where required and where feasible, to also realise the benefits in these rivers before flowing into the reach downstream of Kotri Barrage.

It is essential that the environmental releases and key environmental indicators and parameters be monitored and regularly assessed as background to the possible future improved management of the system.

4.5 General recommendations

In its 2nd report the IPOE had advised that the database as developed by the consultant for Study III be transferred to a Government Office. The IPOE was informed that project preparation is on going to get this implemented at short notice. While the consultant of Study III developed the present database the IPOE recommends that implementation will take place under contract with this consultant.

Continued monitoring and assessment of key environmental parameters and indicators is needed for the whole Indus Basin, in order to improve the environmental and water resources database. The IPOE recommends that a plan for such a monitoring be developed. This could be included in the project for the transfer of the data base.

Well-planned and executed sediment sampling and monitoring of the escapages is required downstream of the Kotri Barrage. Study I has included a proposal for such a monitoring.

5 Concluding remarks

The flow regime in the Indus River downstream of the Kotri Barrage during the post-Tarbela period is not sufficient for environmental sustainability in the lower reaches of the river and the delta. The construction of a barrier on the river will only control seawater intrusion in the river and will not serve the other environmental needs, while creating additional negative impacts. It is also realised that it is not realistically possible to re-instate the past. A balance

IPOE:

16

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

therefore needs to be found between maintaining the benefits from upstream developments whilst also meeting the needs for environmental sustainability.

Man-made changes in the Indus Basin have substantially contributed to the food production and development of Pakistan. However, also negative impacts may be observed, like water shortage, dry river sections, coastal erosion, and reduction in environmental values. The present studies have substantially improved the insight and understanding of such processes. They have enabled the formulation of a proposal for escapages below Kotri Barrage as shown in this report, based on a judicious approach to release certain minimum flows downstream of Kotri Barrage throughout the year, supplemented by short duration peak flows.

IPOE:

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

17

Signed on behalf of the IPOE

Delft 20th of November, 2005
Bart Schultz

Annex I Some background information

- I.1 The Indus Basin Irrigation System provides irrigation to about 40.0 Mac (million acre) (16.2 Mha [million hectares]) (73% of the total cultivable area in Pakistan) and generates about 90% of the nation's total value of agricultural output. Provision of irrigation on a controlled year around basis started in 1859. A rapid expansion occurred during the last 50 years with large investments in dams that provided about 13 MAF (million acre feet) (16 Bm³ [billion cubic metres]) of live storage (Tarbela, Chasma and Mangla are the main storages), and greater use of groundwater to increase both the irrigated area and the cropping intensity. Today the system comprises 19 barrages and head works, 12 link canals, 43 commands and some 107,000 watercourses.
- I.2 The increase in use of Indus River water for irrigation has significantly changed the hydrological balance of the basin. The annual water flow to the Arabian Sea diminished from 170 MAF (210 Bm³) to approximately 10 MAF (12 Bm³) at present and its distribution is basically in the Kharif season (July - September). This year the flow was 24.4 MAF (30.1 Bm³) during the Kharif season. Sediment transport was also altered. It was estimated that only a certain fraction of the original 400 million tons per year now reaches the delta.
- I.3 River flows are almost fully utilized except in some years during the Kharif period. The use of floodwater is limited for agricultural purposes unless additional storage is provided. There are a number of new dams that are now under consideration, among them Basha-Diamer, Kalabagh and Skardu. Future construction and raising of dams would increase water availability for irrigation, also improve usability of water and could as well enable better management of escapages over the year from Kotri Barrage to the Arabian Sea.
- I.4 Kotri Barrage was built in 1955. It is the most downstream barrage on the Indus River, before it discharges into the Arabian Sea. There is about 178 mi (miles) (286 km [kilometres]) of river reach from Kotri Barrage to the sea. If there is fresh water flow in this section it provides recharge to the aquifer and irrigation for agriculture in the riverine area. It also maintains low salinities in the Indus River last reach, prevents seawater intrusion, avoids environmental hazards and maintains growth of forests and certain mangrove species.
- I.5 The Indus Water Treaty (IWT) signed by Pakistan and India in 1960, resulted in an altered distribution of flows in the river system. Extensive infrastructure development took place that included link canals, barrages and reservoirs, to mitigate for the allocation of waters from the Beas, Sutlej and Ravi rivers to India. It is estimated that 1,057 mi (1,700 km) of the eastern rivers have now reduced flows during the Rabi season with impacts on riverine ecology, fisheries and groundwater flows to and from the rivers. There is no evidence that environmental aspects were considered during the discussions preceding the IWT.

IPOE:

18

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

Draft Final Report of IPOE for Review of Studies on Water Escapages Below Kotri Barrage

- I.6 The increase in irrigated area, on-farm percolation due to irrigation, percolation from distribution canals and lack of drainage infrastructure, have resulted in a gradual rising of the groundwater table causing critical problems of waterlogging and salinity over a substantial part of the commanded area. The groundwater table has risen about 100 ft (feet) (30 m [metres]) in some areas and it is estimated that salinity and waterlogging are causing a 25% reduction in agricultural productivity. This condition is worse in Sindh Province and especially in the Kotri district where the groundwater is naturally brackish or saline in more than 50% of the territory. On the other hand a gradual and sometimes rapid lowering of the groundwater table is taking place in other areas, due to the large-scale extraction of groundwater, primarily for irrigation purposes. The recent dry years have contributed to this lowering of the groundwater tables.
- I.7 Since the IWT was signed almost 30 years passed to get agreement among the provinces on the sharing of water. The Water Apportionment Accord (WAA) signed by the provinces in March 1991 replaced previous agreements to distribute the Indus River waters among the provinces and command areas. It established the water rights among the provinces and protects future water rights, including the effect of future storages. A formula is now available for sharing river flows. The Indus River System Authority (IRSA) was created as the regulatory authority for monitoring and distribution of the water sources of the Indus River in accordance to the WAA. The WAA recognized:

'The need for certain minimum escapages to the sea, below Kotri, to check sea intrusion. Sindh held the view that the optimum level was 10 MAF (12.3 Bm³), which was discussed at length, while other studies, indicated lower/higher figures. It was therefore, decided that further studies would be undertaken to establish the minimal escapages needed below Kotri.'

- I.8 Water quality of the rivers, canals and drains is deteriorated by direct wastewater discharges from cities, industries and agricultural lands. It is estimated that only a small percentage of domestic and industrial wastewater is treated. Even at large cities like Islamabad and Karachi that have wastewater treatment plants; these are not operated according to acceptable standards. Disposing wastewater without treatment is causing health problems and environmental impacts. According to the available information a special program to address this issue is being considered in the National Water Strategy.
- I.9 Since 1991 several studies have indicated a range of minimum flows to check seawater intrusion, none of which had been agreed upon. It is important that consensus be reached on the minimum escapages required below Kotri Barrage, which is the main outstanding item of the WAA. The current three studies jointly agreed to by the stakeholders were therefore commissioned in this respect. The Terms of Reference (TOR) for the present three studies were the product of intensive negotiations in which the provinces expressed their concerns about the issue of minimum flows needed to check seawater intrusion. However, they also address more general environmental

IPOE:

19

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

Draft Final Report of IPOE for Review of Studies on Water Escapages Below Kotri Barrage

concerns. The main objective of Study I - *Study on water escapages below Kotri Barrage to check seawater intrusion* - was to determine the minimum quantity of the Indus River water that needs to pass below Kotri Barrage to control seawater intrusion at desirable levels, and to suggest alternative measures to alleviate adverse impacts. Study II - *Study on water escapages downstream of the Kotri Barrage to address environmental concerns* - was to investigate and address environmental impacts from river water and sediment flows and their seasonal distribution below Kotri Barrage (forests, mangrove forests, fisheries, riverine agriculture, population, flora and fauna, seawater intrusion), identify mitigation measures and evaluate trade offs. Study III - *Study on environmental concerns of all the four provinces* - was to identify and address environmental concerns of all four provinces and needed to address a wide range of issues related to the management of water resources in the Indus Basin upstream of Kotri Barrage. The current studies had to verify the data on salinity of the water entering into Sindh Province.

- I.10 The studies had to verify the data on salinity of the water entering into Sindh Province. According to the International Panel of Experts (IPOE) for reviewing the Drainage Master Plan (DMP), the data do not indicate a worsening of the salinity content of the Indus River water at Kotri Barrage over a 30-year period. Additional measurements will have to provide more information about the salinity and water quality entering into Sindh Province.
- I.11 Information that may be derived from the three studies concerns:
- Study I transformed discharges at Kotri Barrage into salinity distribution along the river and the estuary and sediment discharge for a range of selected discharges;
 - Study II indicated benefits/costs of the range and distribution with respect to the ecological considerations and economic activities below Kotri Barrage;
 - Study III identified a way to operate the system above Kotri Barrage in order to deliver a certain distribution of discharges in the main river and its branches above Kotri Barrage.
- I.12 It is evident from the information, and already stated in several reports, that storage in the Indus River system is insufficient for an effective management of the waters of the system. Some of the existing storages are also silting up at an alarming rate which can have a detrimental impact on the efficiency with which water can be used for irrigation, for power generation as well as on the ability to beneficially manage the flow of water for environmental purposes (accepting that the system is already highly altered from the natural state).

IPOE:

20

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

Annex II Brief overview is given of IPOE's activities with respect to its TOR

The international panel of experts (IPOE) for review of studies on water escapages below Kotri Barrage consisted of Fernando J Gonzalez (Mexico), Thinus Basson (South Africa) and Bart Schultz (the Netherlands). The Terms of reference (TORs) for the IPOE stated clearly 3 objectives:

- Review work of consultants for the three studies in 3 stages. Namely inception, interim and draft final reports;
- Review recommendations given by the consultants in the light of the scope of work envisaged in the TORs for all the three studies;
- Analyse the recommendations of the consultants in full perspective and suggest judicious trade-offs and interventions amongst various requirements.

Underneath a brief overview is given of IPOE's activities with respect to its TOR.

Review work of consultants for the three studies in 3 stages. Namely inception, interim and draft final reports

The first visit to Pakistan by the IPOE to review the work of consultants at the end of the inception phase took place during the period 19th of March to 15th of April 2005. At that moment the draft Inception Reports for the three studies were available. Main activities by Fernando Gonzalez included a visit to Sindh's coastal and the Kotri district area. He had meetings with main officials of the Ministry of Water and Power, Sindh Irrigation and Power Department (SIPD), Sindh Irrigation and Drainage Authority (SIDA), National Institute for Oceanography (NIO), World Conservation Union (IUCN) and WWF-Pakistan offices in Karachi and local authorities and social organizations in the lower Kotri basin. He also made a trip to Lahore to meet with the different consultants for Studies I and II in their Lahore offices. He also had a meeting with the Punjab Provincial coordinator for the studies. Meetings in Islamabad with the Federal Flood Commission (FFC), and the Chairman of the Indus River System Authority (IRSA) were an important part of the agenda of Fernando Gonzalez and Thinus Basson. They also attended and gave initial impressions during the Steering Committee meeting on 28th of March 2005. All IPOE members had regular meetings and feed back with Mr. I.B. Shaikh, Chairman FFC and Mr. A. Kamal, Project Director Kotri Studies and visited the consultants of study III in their Islamabad offices. Thinus Basson and Bart Schultz visited the Water and Power Development Authority (WAPDA), Punjab Irrigation and Power Department (PIPD) and consultants for Studies I, II and III in Lahore. They attended the Steering Committee meeting on 7th of April 2005 where Thinus Basson presented the draft conclusions and recommendations of the IPOE. After this Steering Committee meeting Bart Schultz paid a visit to Karachi to discuss in more detail the draft Inception Reports of Studies I and II with the SIPD officials and the consultants for these studies. However, at the latest stage the consultant for Study II could not attend this meeting. The comments of the IPOE on the draft Inception Report of Study II are in line with what was agreed during the Steering Committee meeting and the follow-up meeting in Karachi. The IPOE analysed the draft Inception Reports presented by the consultants and had meetings

IPOE:

21

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

Draft Final Report of IPOE for Review of Studies on Water Escapages Below Kotri Barrage

with them to ask for clarifications and to make suggestions for improvements to be presented at the Steering Committee meetings on 28th of March and 7th of April. During the meeting of 28th of March it was agreed that the Steering Committee would be the forum to examine and discuss the reports and recommendations for the three studies. The Steering Committee was therefore a very important body for mutual acceptance of the results and recommendations of the studies. The suggestions and recommendations (minutes of the meetings) formed part of the final Inception Reports. During the mission all the three consultants already accommodated a substantial part of the comments and recommendations by the IPOE in their revised draft Inception Reports. The findings and recommendations of the IPOE, based on the three Inception Reports and the discussions held during the visit, have been laid down in its 1st report, dated 14th of April 2005. In this report only the remaining IPOE comments of general nature and issues that needed careful attention during the further implementation of the studies are shown.

The second visit of the IPOE to Pakistan took place from 12th to 23rd of August 2005. Draft Interim Reports of the three studies were received before the visit. The IPOE could submit its written comments on the draft Interim Reports of Studies I and II before the visit. The IPOE received the draft Interim Report of Study III too late to give comments beforehand. All the three consultants already accommodated a substantial part of the comments and recommendations by the IPOE and submitted a large amount of additional information during the visit. It has been agreed that the draft Interim Reports would not be revised, but that all comments and suggestions would be included in the draft Final Reports. During the visit the IPOE had: (i) regular meetings with Mr. I.B. Shaikh, and Mr. A. Kamal; (ii) a meeting with the Secretary of the Ministry of Water and Power, Mr. A. Mahmood; (iii) a meeting with the Chairman of the Technical Committee on Water Resources, Mr. A.G.N. Abbasi; (iv) a meeting with the Secretary of the Sindh Irrigation and Power Department (SIPD) and his delegation; (v) two meetings with the project leaders and several members of each consultant to ask for clarifications and to make suggestions for the next steps to be taken; (vi) attended the Steering Committee meeting at the FFC on 17th and 18th of August 2005. During the meeting Thinus Basson presented the findings and recommendations of the IPOE. In addition Fernando Gonzalez and Bart Schultz paid a visit the consultant for Study III. Thinus Basson had meetings in Karachi with the Secretary of the SIPD, World Conservation Union (IUCN) and the consultant for Study III. He made a trip to Lahore to meet with the different consultants for studies I, II and III in their Lahore offices, and with the Punjab Provincial Coordinator for the studies. He also made a trip to Peshawar to meet with the NWFP Provincial Coordinator and the Deputy Team Leader for NWFP of the consultant for Study III. Bart Schultz made a trip to Lahore to meet with the Secretary of the Punjab Irrigation and Power Department (PIPD) and his delegation, Punjab Provincial Coordinator for the studies, Team Leaders and other staff members of the consultant for Study II and III. He also made a trip to Karachi to meet with main officials of the SIPD, the General Director and staff of the NIO, and the General Director of the Coastal Development Authority of Sindh.

The third visit of the IPOE to Pakistan took place from 7th to 16th of October 2005. Draft Final Reports of the three studies were received shortly before the visit. Therefore the IPOE

IPOE:

22

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

Draft Final Report of IPOE for Review of Studies on Water Escapages Below Kotri Barrage

could only submit its written comments during the visit and in this draft Final Report. The IPOE had: (i) regular meetings with Mr. I.B. Shaikh and Mr. A. Kamal; (ii) a meeting with the Secretary of the Ministry of Water and Power; (iii) a meeting in Karachi with the Secretary of the Sindh Irrigation and Power Department (SIPD) and his delegation and in Lahore with the Secretary of the Punjab Irrigation and Power Department (PIPD) and his delegation; (iv) meetings respectively in Islamabad (Study I, II and III) and in Lahore (Studies I and II) with the project leaders and team members of each consultant to ask for clarifications and to make suggestions for finalisation of the Final Reports; (v) a meeting with the NWFP Provincial Coordinator and the Provincial Coordinator Balochistan; (vi) attended the Steering Committee meeting at the FFC on 12th and 13th of October 2005. During the meeting Thinus Basson presented the findings and recommendations of the IPOE. The slides of this presentation are attached as Annex III.

In addition to the activities by the IPOE during the visits to Pakistan, substantial work was also done by the members of the IPOE from their home offices. This included reviews of advance copies of draft reports prior to the Pakistan visits as well as continued communications with and recommendations to the FFC and the Study consultants throughout the duration of the studies. Substantial time was spent after the last visit in assisting with the finalisation of the reports and also preparing the draft scope of the work for the implementation of the recommendations.

Review recommendations given by the consultants in the light of the scope of work envisaged in the TORs for all the three studies

At the three stages the IPOE has had meetings with the three consultant teams and with the government representatives at Federal and Provincial level as outlined above. In all these meetings the IPOE has presented its questions, ideas, (preliminary) analyses and (preliminary) recommendations. In the meetings with the consultant teams the IPOE has generally focussed on the consultants' considerations behind his analysis and recommendations. Especially in the meetings with the Federal and Provincial representatives, the IPOE has asked for their opinion with respect to certain items. The IPOE appreciates that the meetings had an open character and that generally the items could be discussed at a professional level. During the meetings the IPOE has requested clarification on a broad spectrum of items, both from the consultants as well as from the representatives at Federal and Provincial level. Besides the improvement of the IPOE's own insight in the matter, these questions have in various instances resulted in modifications in the consultant reports as well.

As is described in the three reports of the IPOE, with respect to several items the IPOE could not agree with the draft analysis, or the draft recommendations as formulated by the consultants. In all these cases the IPOE has made clear to the concerned consultant, what were considered the reasons for the difference in opinion, or analysis, and what would be the recommendations of the IPOE. The IPOE has also raised such issues in its meetings with the government representatives and asked for their opinion as well. Last but not least the IPOE

IPOE:

23

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

Draft Final Report of IPOE for Review of Studies on Water Escapages Below Kotri Barrage

has reported on such issues in the Steering Committee meetings. In many instances this has resulted in modifications of the consultant reports, especially with respect to Study II and Study III. The items are listed in the annexes of the three reports of the IPOE.

Analyse the recommendations of the consultants in full perspective and suggest judicious trade-offs and interventions amongst various requirements

During all stages the IPOE has carefully analysed the recommendations of the consultants in full perspective and has suggested judicious trade-offs and interventions amongst various requirements. It has reported on its (initial) findings and recommendations during the individual meetings, the three meetings of the Steering Committee and in its three reports.

The findings and recommendations as presented in this report are based on the review of the studies at relevant stages, the in depth discussions with government staff at Federal and Provincial level, as well as with the consultants, and an analysis of the international experiences and practices. In this report the IPOE's has formulated its own recommendations. The considerations to come to these recommendations are given in the text. The following factors have played a major role in the formulation of the recommendations:

- The understanding that the following aspects primarily justify the need for water escapages below Kotri Barrage:
 - salinity encroachment in the river, aquifer and coastal zone;
 - requirement of coastal stability;
 - requirement of a sustainable environment;
 - fisheries;
 - prevention of salinity accumulation in Indus Basin.In addition other factors may play a role: riverine forests, riverine agriculture, pollution control and drinking water supply;
- The consideration that in the determination the minimum escapages below Kotri Barrage the following factors play a role:
 - to check seawater intrusion downstream of Kotri Barrage as identified in Study I;
 - the needed environmental flows upstream of Kotri Barrage as provisionally indicated in Study III;
 - the impact of the recommended environmental flows on the availability of water for economic and social needs (irrigation, domestic and industrial water supply) as indicated in Study III;
 - the minimum needs for fisheries and maintenance of mangroves in the Expanded Delta as roughly indicated in Study II;
 - the need for certain flows to keep the river morphology in good condition;
 - the international developments and practices with respect to environmental flows;
 - the recognition that a structural solution will not be feasible.

IPOE:

24

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

Draft Final Report of IPOE for Review of Studies on Water Escapages Below Kotri Barrage

Annex III General findings and recommendations of the IPOE as presented during the Steering Committee meeting on 13th of October 2005

Indus River, Pakistan

Studies on Water Escapages Below Kotri Barrage

Review of Draft Final Reports
and Integrated Overall Recommendations by IPOE
Fernando Gonzalez, Bart Schultz, Thinus Basson

13 October, 2005

Approach Followed

- Reviews at home offices and in Islamabad
- Detailed discussions with Study Teams in Pakistan
- In depth discussions with Federal and Provincial Officers

Recommendations based on above, plus other relevant work and international experiences and practices

Study – I: Sea Water Intrusion

- Work again of high technical standard, good data base, reliable calibrations and modeling
- Report clear, concise, focused on issues of relevance
- Section on groundwater submitted later, and was presented at Steering Committee
- Additional results presented at Steering Committee
- The work completed and in compliance with the TOR

Study – I: Results

- Position of saltwater interface and salinity profiles determined for flows of 5,000, 10,000 and 15,000 cfs
- No possibility of seawater intrusion into groundwater (high salinity groundwater of ancient origin)
- Post Tarbela sediment discharge below Kotri on average 126 million tons/year, largely in high flows
- Structural option for prevention of seawater intrusion not favoured
- Recommendation for dry, average and wet years not acceptable

**Study-II: Environmental Impacts
Downstream of Kotri**

- Valuable information gathered and documented
- An overall integrated analysis of processes at stake, assessment of relative contributions and justification of conclusions and recommendations not given
- Report still requires integration of components plus refinement. Presentation disappointing
- Erroneous statements had unfortunate impacts
- Assessment of overall impacts associated with different salinity profiles not addressed
- New executive summary + revised report

Study –II: Results

- Freshwater requirements given for mangroves, fishery and riverine agriculture (some uncertainties)
- Water requirements also given for riverine forest, domestic water and pollution control (to be revised)
- Highlights various social and ecological impacts and aspects of specific importance - such as related to mangroves
- Documentation of processes and key factors re mangroves, coastal sustainability, fisheries in progress

IPOE:

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

25

Signed on behalf of the IPOE

Delft 20th of November, 2005
Bart Schultz

Draft Final Report of IPOE for Review of Studies on Water Escapages Below Kotri Barrage

Study – III: Environmental Concerns of Provinces

- Substantial work done and most of earlier comments addressed
- Main report clearly presented in accordance with TOR
- Conclusions and recommendations not always following from or addressing the TORs - particularly in draft Executive Summary
- All TORs addressed; some still in general terms
- Expectations in some cases were ambitious

Study – III: Findings

- Long reaches of rivers are dry at times, requiring environmental flows
- Groundwater in some areas being mined
- Quality of both surface and groundwater problematic in certain areas
- Assessed and where possible, quantified environmental impacts
- Modeled selected scenarios of environmental flows in upstream rivers
- Independent TORs individually addressed

Summarising statements by IPOE - 1

Need for water escapages below Kotri Barrage primarily justified by:

- Salinity encroachment in river and coast zone
- Instability of deltaic coastline
- Requirement of a sustainable environment
- Fisheries
- Prevention of salt accumulation in Indus Basin
- Considerations on riverine forests, agriculture, domestic water, pollution control

Statements by IPOE - 2

Main considerations backing IPOE recommendations:

- To check seawater intrusion in river (not in groundw.)
- Minimum needs of fisheries
- Maintenance of mangroves in the expanded delta
- Maintaining of river bed morphology
- Environmental flows needed upstream of Kotri and need to flush salts from Indus Basin
- Recognition that structural solution is not feasible
- Relatively limited impact of position salinity interface
- International practices on environmental flows

Statements by IPOE - 3

Flow of 5,000 cfs considered to be required:

- To check seawater intrusion (at end of bunds)
- Accommodate needs for fisheries (5,000 cfs in June, 4000 cfs in November – February)
- To maintain the river channel for low flows
- Provide for general environmental sustainability (species diversity and habitat needs not yet fully known)

Statements by IPOE - 4

Coastal erosion primarily ascribable to:

- Reduction in sediment supply by Indus River
- Reduction in mangrove vegetation (stabilisation)
- Restricted area of flooding due to bunds
- Sea level rise
- Possible more extreme weather due to climate change

IPOE:

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

26

Signed on behalf of the IPOE

Delft 20th of November, 2005
Bart Schultz

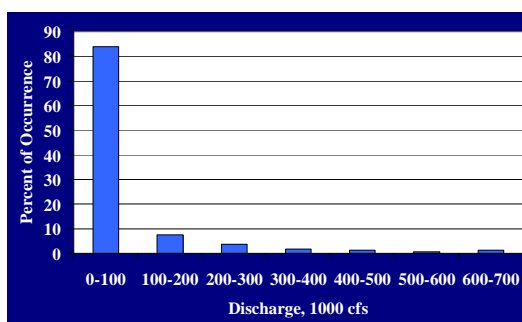
Draft Final Report of IPOE for Review of Studies on Water Escapages Below Kotri Barrage

Statements by IPOE - 5

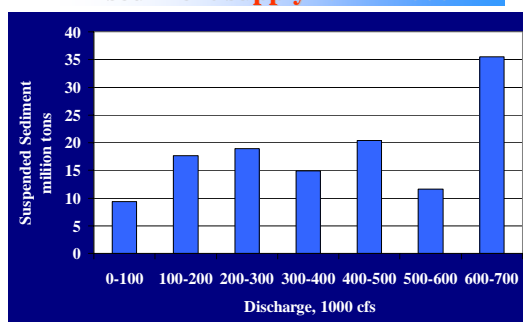
Coastal erosion – continued:

- Original 400 million tons/year sediment: accretion about 30 m/year. In post Tarbela period estimated 25 million tons/year average shortfall to prevent decrection. Composition of sediment important
- Important to ensure periodic high flows (short period), also in future, for deposition of sediment on coast and delta area

Discharge distribution 1972 - 1999



Discharge and average annual sediment supply 1972 - 1999



Statements by IPOE - 6

Sustaining the mangrove vegetation:

- Required for its ecological role and economic value;
- Of specific importance for coastal protection and stabilisation (need broad mangrove belt along coast)
- Certain freshwater flow and sediment supply beneficial to ensure healthy growth
- Relatively small physiological freshwater requirements. However, high flow rate needed to spread water over the area

Statements by IPOE - 7

Mangrove vegetation – continued:

- Flow rates and sediment for coastal stability, should also amply meet needs of mangroves
- Essential that human use of mangroves be properly managed

Coastal stability recognised by IPOE of National importance, and management of mangrove as a National responsibility

Recommended escapages

	A	M	J	J	A	S	O	N	D	J	F	M
Cfs *)	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
MAF	0.3	0.3	0.3	>= 0.3	>= 0.3	>= 0.3	0.3	0.3	0.3	0.3	0.3	0.3

>= high flow to be released in a concentrated way, to be adjusted according to the storage in the reservoirs and the volume discharged in the four previous years (equivalent of 5 MAF, currently 30 MAF)

*) In a dry year the amount in any month has to be proportionally reduced in relation to the reductions in irrigation water supply

IPOE:

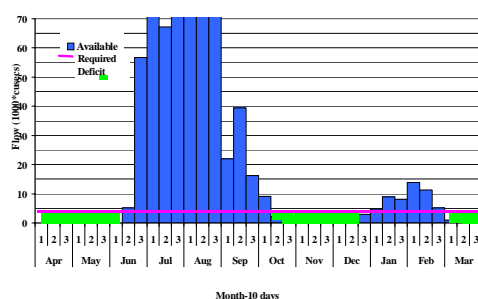
- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Signed on behalf of the IPOE

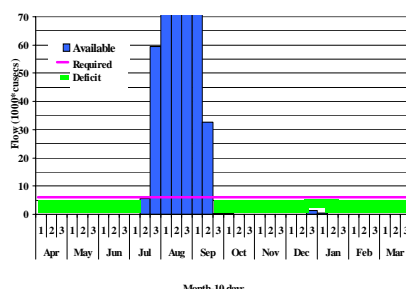
Delft 20th of November, 2005
Bart Schultz

Draft Final Report of IPOE for Review of Studies on Water Escapages Below Kotri Barrage

Average year and minimum flows



Dry year and minimum flows



Summary of Flows and Deficits

Representative Average/dry year	Escapages (MAF)			Deficit (MAF)		
	Kharif	Rabi	Year	Kharif	Rabi	Year
Average year	1.80	1.80	3.60	0.59	0.67	1.26
Dry year	1.74	1.22	2.96	1.02	1.18	2.20

Statements by IPOE - 8

Storage in Indus Basin is limited (only 9% MAR) and reducing – thus difficult to maintain recommended flows in dry years

International practice to have detailed implementation planning for environmental flows:

- Normally requires investments in management, technology and infrastructure
- Implemented over time to mitigate negative impacts on existing users

Statements by IPOE - 9

Possible new storages in future:

- Provision to be made for bottom release of sediment during high flows
- Provide for high flows downstream of Kotri Barrage, probably of shorter duration
- Environmental flows to be routed via upper rivers where appropriate, then for release downstream of Kotri

Statements by IPOE - 10

Upstream of Kotri and non-Indus areas:

- to proceed with further investigations, monitoring, implementation planning

For the whole basin:

- need for continued monitoring and assessment to improve environmental and water resources data base

Downstream of Kotri Barrage:

- Well planned sediment sampling
- Coastal management and protection works

IPOE:

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Draft Final Report of IPOE for Review of Studies on Water Escapages Below Kotri Barrage

Finalisation arrangements

- All executive summaries to be updated and finalised by 18 October
- Study I report to be finalised by 18 October
- Study II and III main reports and appendices to be finalised 27 October for final comments and 31 October final
- Draft report by IPOE to FFC by 16 October
- Final report by IPOE to FFC by 31 October

Concluding remarks

- Not realistically possible to re-instate the past
- Judicious approach is to release water for environmental purposes, supported by proper monitoring and assessment
- Not recommended to implement structural measures

IPOE:

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

29

Signed on behalf of the IPOE

Delft 20th of November, 2005
Bart Schultz

Annex IV Review of the Draft Final Report of Study I

General comments

The IPOE likes to give the following general comments:

- I.1 The report is well written, of a high professional standard and covers the TOR. There are, however, some important issues to be solved and points to be clarified, which will be specified in our comments.
- I.2 The period 1955 - 1975 is not really a homogeneous one, while the diversion of flows to India started during this period. Therefore it is not optimal for comparison of the desirable conditions encountered in the past. However, the IPOE understands that it is the best possible option that is available and therefore considered to be acceptable;
- I.3 The recommendations in section S9 about the barrage to check seawater intrusion are not clear. Are you recommending its construction or not? Can the river flow be simulated?
- I.4 Item 10 needs more examination. Why do you want to eliminate the zero discharges and apply 1,000 cfs as minimum flow? The IPOE believes that the minimum volume to keep seawater intrusion checked is not dependant on the hydrologic year selected as the 10% driest or wetter. The source of the water to be released can be different and could be calculated by making a simple simulation of the post 1975 period.
- I.5 A minimum flow of around 5,000 cfs seems appropriate for the low flow months. This flow can be changed if there is a deficit in the water for irrigation in the same proportion. Water for escapages could then be similar to the water for one additional canal.
- I.6 The salinity distribution for zero (0) flow is not correct. Explain the results in terms of diffusion and dispersion.
- I.7 Exhibit S-4 needs to be reviewed if the 5,000, 10,000 or 15,000 cfs are to be maintained.
- I.8 Is it possible to calculate a minimum flow to maintain the river section during the Kharif season?
- I.9 What would be the influence of additional storage on low flows and flow to maintain the river flood channel?
- I.10 There is a need to clarify the conclusion that the groundwater has not been affected by

IPOE:

30

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

Draft Final Report of IPOE for Review of Studies on Water Escapages Below Kotri Barrage

the seawater intrusion and the results of the dating analysis.

- I.11 Please check proper use and unit prescription of levels compared to +MSL (Mean Sea Level).
- I.12 Please consult with the consultant of Study II for consistency of text where overlaps occur and for the use of names for different areas. This refers especially to the hydraulic computations, the sediment figures, the groundwater data and the names and areas for different types of the riverine and delta area.

Detailed comments

The IPOE likes to give the following detailed comments per chapter or section:

- I.13 Review exhibit S-7 including the source of the water.
- I.14 If possible add in the definitions the definitions for:
- BCM;
 - Bilateral slope;
 - Coastal erosion;
 - Fossil groundwater;
 - RL.
- I.15 *Section 2.3.1*
- With respect to the flow regulation there are also several barrages and link canals;
 - With respect to the decrease of flow the percolation to groundwater may have to be added.
- I.16 Figure 2.1 will have to be modified.
- I.17 *Section 2.8.* Review the confining of the river effect on the delta.
- I.18 *After section 2.13.3.* Add a brief description on storm surges.
- I.19 Add in Exhibit 2.1 the location of the outfall drains
- I.20 *Page 4-1.* Please comment on the validity of previous studies for the present results. A period of 4 months without flow for an impact (page 3-7) of several days (page 3-9) or 2 weeks.
- I.21 *Section 7.1.* We still wonder if the anisotropy should not be given as 100:1, instead of 1:100 as is done now in the text. Please check.

IPOE:

31

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

Draft Final Report of IPOE for Review of Studies on Water Escapages Below Kotri Barrage

I.22 *Section 6.8.*

- Please explain scenario 1 in page 6-10;
- The IPOE has not recommended certain discharges, but has requested to investigate certain discharges.

I.23 *Section 7.6.2.* The sentence: *However, the shallow zone of fresh groundwater layer developed will be now impacted by seawater intrusion.* This sentence may be misleading. Please clarify to which area this applies.

I.24 *Section 8.3.2 second paragraph.* Please clarify how many hectares this concerns and what it would mean in financial terms.

I.25 *Page 9-2.* Why is Dandho the appropriate place for the interface? Why not to select the one for 5,000 cfs. The last paragraph needs to be reviewed.

I.26 *Page 10.3.* The use of the DE Index is not clear.

I.27 A monitoring and evaluation program seems to be a good idea. Please add sediment monitoring.

IPOE:

32

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

Annex V Review of the Draft Final Report of Study II

General Comments

The IPOE likes to give the following general comments:

- II.1 Although the consultant has accommodated a substantial part of the comments that were made by the IPOE in its Interim Report, another substantial part of the comments that was discussed with and approved by the consultant have not been accommodated in the draft Final Report. Therefore several of our comments as made during the Interim phase will be repeated in these comments, taking into account what has been shown in the draft Final Report.
- II.2 The draft Final Report does not integrate related issues. In our opinion in a study like this an overall/integrated analyses for understanding of the processes at stake, assessing the relative contributions and a justification of the conclusions and recommendations is an absolute requirement. This is the more valid in the complicated environments and processes we have to deal with.
- II.3 Reading and understanding the draft Final Report is very difficult because each section seems to be written by a different team without the needed integration. The consultant has collected and shows in the draft Final Report a substantial amount of data. In general it is also made clear where the gaps in the data are. It is, however, not always shown what is the source of the data and under what conditions, or for which area the given data are applicable. In addition in different parts of the report different data for the same topic are given. Several times the same data are repeated at different places. This refers especially to:
- Data on discharge and sediment transport/supply of Indus River;
 - Mangrove grows, types and location in time;
 - Economic value of the activities in the riverine area and of fisheries;
 - Etc.
- II.4 At the Interim phase it was discussed that there is a need to develop a spatial zoning and distribution to understand the main phenomena and forces acting in each of them. It was often unclear for what area and under what conditions the comments, observations, suggestions and proposals of the consultant are applicable. This referred especially to:
- II.4.1 *The different parts of the Delta.* Although the consultant now gives definitions or prescriptions for: Core Delta, Expanded Delta, Tidal Delta and Active Delta, we find the following other names in the report, which need to be made consistent to enable a reader to follow the text:
- *Core Delta, core delta, Active Indus delta, active delta, active delta area and active delta region.* It has been agreed that the consultant will call this area the Active Delta. It is an area of 91,331 ha. It is the yellow area

IPOE:

33

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

Draft Final Report of IPOE for Review of Studies on Water Escapages Below Kotri Barrage

in Figure 5. It has to be carefully checked throughout the report that the same terminology be used;

- *Expanded Delta and expanded Indus delta.* It has been agreed that the consultant will call this area the Expanded Delta. This is an area of 151,887 ha. It is the yellow and the green area in Figure 5.
- *Tidal Delta and tidal delta.* It has been agreed that the consultant will call this area the Tidal Delta. The area represents a much larger tidal zone (about 620,000 ha) beyond the study area and it spans from the Korangi Creek area near Karachi and the Sir Creek near the Indian border of India. Tidal Delta is the entire shore land base inundated by the sea characterized by mangroves, mudflats and salt shrub with most of the area beyond the influence of the Indus River freshwater and floods. This area is not shown in Figure 5;
- All other names as mentioned underneath would have to be changed in the above-mentioned three names, unless there is a reason not to do this.
 - o Indus River Delta, Indus Delta, Indus delta and Indus delta area;
 - o Delta, delta, Delta area and delta area;
 - o subaerial delta;
 - o delta land base;
 - o lower delta;
 - o deltaic islands;
 - o southern delta, Southern Indus Delta and southern Indus Delta;
 - o lower active delta;
 - o delta study area;
 - o mouth of the delta;
 - o deltaic region and delta region;
 - o central delta area;
 - o delta estuarine area;
 - o inter tidal delta (385,000 ha);
 - o river delta;
 - o delta communities;
 - o delta district;
 - o Indus delta population;
 - o extreme deltaic districts;
 - o Indus Deltaic Eco-region and Indus Delta Eco-region;
 - o South-eastern part of the delta;

We still have the impression that when just the words delta, or Indus delta are used, they may have a different meaning at different places. We consider it therefore required that the terminology is carefully checked and be made consistent, and that the remaining areas and their names are clearly shown in Figure 5 and its legend;

- II.4.2 Whether an issue is applicable to the land, the sea, or the transition zone. In our comments to the Interim Report we have expressed that it would be useful if a clear distinction is made in the following areas and that these areas are shown

IPOE:

34

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

Draft Final Report of IPOE for Review of Studies on Water Escapages Below Kotri Barrage

as good as possible on a map as well:

- Areas that can be flooded from the river
- Areas that are never flooded from the sea;
- Areas that can be flooded during a storm surge;
- Areas that can be flooded during spring high tide;
- Areas that are flooded during every tide;
- Areas that are permanently under water.

In our perception this is very relevant, while then it becomes clear to a reader which process occurs where. In the draft final report it is shown that in fact only downstream of the flood protection bunds flooding from the river outside the bunds may occur. The other areas are not shown on a map, nor is attention paid to this classification in the report. In section 16.8, Table 52 is given with land under seawater intrusion in Thatta and Badin Districts of Sindh (repeated in section 7.1 of the appendices, and most probably also reflected in the text of 3.2.4 H). However, these areas are not shown on a map, nor is it explained how often they are flooded and what is the reason of the flooding. In addition in section 18.6.1 some information is given with respect to Ketī Bandar, or Ketī Bunder (both names are used in the same section).

- II.5 In our comments to the Interim Report we have stated that the time or period in the analysis needs to be the same and be clearly specified whether it is before Kotri, before Tarbela, the present or the future conditions. In the draft Final version it is only for some items fully clear what time horizon is taken into account. We have the impression that for different items different time horizons have been taken into account, although we are not fully clear about this while it has not been clearly described.
- II.6 Although, compared to the Interim Report, substantial improvements can be observed, in several of the chapters still a substantial part of the text is going beyond the issues at stake and therefore can better be deleted to get more focus on the things that really matter in this study.
- II.7 Page and figure numbers are inconsistent. The same applies to the use of units, which is quite different at different places in the report. It would be most helpful if this can also be made consistent.

Detailed comments per chapter or section

The IPOE likes to give the following detailed comments per chapter or section:

- II.8 First of all we like to repeat several of our comments as given on the Interim Report that we consider of importance and that in our opinion are not yet accommodated in the draft Final Report. These concern:
- if possible to indicate the part of the delta area that received water before the dams

IPOE:

35

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

Draft Final Report of IPOE for Review of Studies on Water Escapages Below Kotri Barrage

were built, or before the Kotri Barrage was built;

- to pay much more attention to the past, present and potential future role and requirements of the mangrove forests for coastal protection;
- silt and nutrient demand of the mangroves eco-system and the proportion provided by the Indus River discharge. As said we fully underline the importance of this issue. However, it is described that there were five types of mangrove species in the Indus Delta. Each species has a different salt tolerance as shown in Table 4 and requires a different environment, also with respect to flushing with fresh water and sediment supply. Out of these species *Avicennia marina* covers by far the largest area and seems to be able to grow in purely marine conditions. We suppose that this is the species that growth at the mudflats near to the open see as can be seen on the satellite images (Figures 9, 10 and 11). Two other species - *Ceriops tagal* and *Aegiceras corniculatum* - cover small areas and seem to be more in need of flushing with fresh water and sediment as mentioned above. The remaining two species in the Table seem to have totally disappeared. We understand from the report that it is not possible to show in a map where the three remaining species are growing. In the report only one figure on the need for flushing is given which is 1 cusec per 100 acres. Is this figure also applicable to *Avicennia marina*? In addition we like to remark that at different places in the report, different requirements are formulated for the growth of the mangroves. This needs to be made consistent;
- The report mentions the three important issues for the damage to mangroves, being: (i) lack of freshwater and silt; (ii) camel browsing; (iii) fire wood cutting. We had requested to clarify what can be the contribution of each of these items. We cannot find such a clarification in the draft Final Report. Figures are given for the camel grazing 67,000 tonnes of twigs and leaves per year, 18,000 tonnes per year. Can any indication be given how this compares to the annual regrowth? Although not mentioned in the report, we see from Figure 11 that important reasons for the disappearance of mangroves are: shrubs, sand and sediment (in total 34,184 ha). This gives us the impression that the flats have become (slightly) higher at such places and that the loss doesn't have to do so much with lack of sediment, or of fresh water. Is this understanding right, or do we misinterpret the processes at stake.

II.9 *Executive summary 1.1.*

- See our previous comments on the mangroves;
- We understand that the 15 MAF is based on a mistake and wait for the corrected data;
- How do you know that the increase in salinity is the main reason in the decrease of mangroves if you cannot put in perspective the contributions of Camel grazing and fire wood? See also our remark above, based on Figure 11;
- What is meant with the existing flow regime;
- Why should the Management plan for the protection of the mangroves only be developed for the Active Delta;

IPOE:

36

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

Draft Final Report of IPOE for Review of Studies on Water Escapages Below Kotri Barrage

II.10 *Executive summary 1.2.*

- To which delta apply the figures of loss and gain;
- ‘.... seawater can intrude further inland’. What is meant here?
- It is unclear how we have to interpret the cumulative discharge volume of 36.3 MAF and 2.3 MAF of low flow discharge during the Rabi season.

II.11 *Executive summary 1.3.*

- ... no over bank flow... What is meant here, the riverbed?
- It is said that there are drought problems for the riverine forest. However, when we see the flow simulations in the Figures 34 – 38 there would already be more or less full coverage of the flood plain area at 10,000 m³/s (about 350,000 cfs) flow. According to Table 24 this flow can be expected at least once in two years. So the question is, is there really such a drought problem for the riverine forest that you have to irrigate it.
- To what areas are the 974, 1,105 and 1,591 cusecs applicable (45,283 ha, 51,376 and 73,979)? Will this be river water, or existing canal water?

II.12 *Executive summary 1.5.*

- On which condition is the 4,000 cusecs in the main channel from November to February based. What goes wrong when it would be 1,000 cusecs in a dry Rabi as proposed by Study I, or respectively 8,000, 6,000, 3,000 and 3,500 for an average year as proposed by Study I;
- We wonder if the second part of the recommendations as given here is applicable to this study, which is dealing with flow requirements to Indus River downstream of Kotri barrage.

II.13 *Executive summary 1.6.*

- In our opinion pollutants will have to be treated at the source. Dilution is basically no solution to pollution, it can only be applied as an intermediate, preferably short term, solution;
- ‘... Indus water can be treated by slow or rapid sand filtration ...’ what is meant here in light of this study?

II.14 *Executive summary 1.7.*

- We wonder if there is no overlap in the areas identified for riverine forestry and riverine agriculture;
- We also wonder whether it will not be better for the government to discourage riverine agriculture, because of the risk of flooding and resulting responsibility questions. Agriculture at own risk could be acceptable, but then the farmers would have to take care for their own provisions and own risk. We therefore don’t recommend that the government will supply water for riverine agriculture;
- If nevertheless it will be decided to supply 0.615 MAF, the question arises will this be water from the river, or irrigation canal water the has been diverted

IPOE:

37

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

Draft Final Report of IPOE for Review of Studies on Water Escapages Below Kotri Barrage
upstream of Kotri barrage.

II.15 *Executive summary 1.8.* It is unclear for us how the 0.36 MAF for domestic use from Indus River water downstream of Kotri Barrage has been determined.

II.16 *Executive summary 1.9.* It is unclear for us what are the consequences of this item for use of Indus River water downstream of Kotri Barrage.

II.17 *Glossary of Terms*

- It would be most welcome if this can be put in alphabetic order;
- Several terms are missing, like FPB, EEZ, MST. At several places the text starts directly with the abbreviation without the full term first. This makes reading not easy.

II.18 *4. Introduction*

- To what area is the 30 m/year applicable?
- At page 17 and 18 different figures are given for the tidal amplitude, the discharge and the basin area;
- What is the meaning of Figures 2 and 3 and Table 1 for this study?

II.19 *8. Riverine Forest*

- the statements in this chapter are in our opinion not in agreement with the data and simulations on flooding as given at page 88 section 12.4, nor with Table 24 on page 112;
- we also have the feeling that section 8.4.3. is not in agreement with the results shown in Figures 34 – 39 at pages 130 – 18
- Memon (2000) gives a total figure for fire wood demand of $31.6 + 40.9 = 72.5$ tonnes per year. For 45,283 ha this would imply 1.6 kg/ha, which in our opinion is neglectable. Is our interpretation right?
- What is the impact of the livestock figures as given on the Riverine forest?
- The Figures as given in Table 5, page 38 work on average out in our opinion for respectively Hyderabad, Thatta and Badin as: 3.5 cft/ha, 22.4 cft/ha and 15.3 cft/ha. These figures look very low. Is our interpretation right?
- It is stated on page 38 that *Riverine forests act as a barrier to inundating floods*. Is that really applicable in this case?
- ...1345 MAF.... How has this been computed? It cannot come from 974 cusecs.

II.20 *9. Wildlife habitats*

- *page 40 first paragraph.* It looks like other species of mangroves are mentioned here than in the mangrove chapter. Please check;
- *page 40 third paragraph* nine snakes. At page 43 eight snakes;
- *page 40* from 62,720 to 60,406 is not an increase, but a decrease;
- *page 40* on the bottom 14 Dolphins, page 46 600 dolphins, please check;

IPOE:

38

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

Draft Final Report of IPOE for Review of Studies on Water Escapages Below Kotri Barrage

- several items in this chapter are just duplications;
- *page 45 on top*. Is the increase of the farmland from 4,352 to 18,346 ha at the cost of the riverine forest? See also page 48;
- *9.7.1* Is this applicable to the study area?
- It would be useful to show the sites in Table 6 and 7 on a map;
- *9.8.1 second paragraph*. What does this mean under what conditions?
- 8,181 is different from the figure that is given at other places in the text;
- *9.8.2* extinction of the Indus Dolphin population. Is this right in light of page 46?
- *9.8.2* we don't have Appendix W. Droughts.

II.21 *10. Indus delta mangroves*

- see our previous remarks;
- *10.3.1* we cannot find the list with organizations consulted;
- what are the experiences with the replanted mangroves, while these have had very dry (saline conditions)?
- *Figure 15, page 61*. Does the Figure imply a loss of about 50 million tones per year? What is supposed to be the increase in height of the shallows?
- *Page 62*. On which reference is the story on wave energy in the second paragraph based?
- We had asked to give an indication of the required width of the mangrove belt for coastal protection. Can such information be added?
- What are the units for clay, silt and sand in Table 9?
- What would be the requirements for the management of the mangroves?

II.22 *11. Fishery impact studies*

- *page 71*. 675.3 million tons and 675,000 metric tons are mentioned. What is right?
- Also in this chapter there are several duplications with previous texts;
- *Page 76* 218,880 metric tons. Is this high, normal or low per unit area?
- *Page 77*. several amounts of fish catch are given. The question would be what are sustainable amounts;
- What requirements would there be for Indus River flow with respect to coastal fish production?
- *11.4.1*. It is unclear in this section what is the gain and what is the loss?
- *11.4.3* We thought it was agreed that 1000 ppm would be used, or are for sea fish the 2000 and 5000 ppm levels more relevant?

II.23 *12. Hydrologic studies*. Are the results consistent with Study I, and if not what to decide?

II.24 *14. Sediment transport*

- how do the results relate to the results of Study I?
- *Table 35*. How has the sediment load of 88322 tons/day been determined?

IPOE:

39

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

Draft Final Report of IPOE for Review of Studies on Water Escapages Below Kotri Barrage

II.25 *15. Ecologically alternative agricultural practices*

- a fundamental question is why to promote agriculture in the riverine area. See also our earlier remarks;
- *15.3 page 22.* What means 5,00000 cusecs and 5,00,000 cusecs;
- *page 23.* The figure of 95,038 acres is as far as we can see not in agreement with previous figures;
- *15.8 page 19.* We recommend that agriculture in the riverine area will not be supported for reasons as mentioned before;
- where does the figure of 1500 ppm comes from. We thought it would be 1000 ppm;
- *page 20.* To which area are the income figures applicable?

II.26 *16. Pollutant control*

- *16.2.* The Water Apportionment Accord is wrongly quoted here;
- *16.10.* The recommendation in the first paragraph is not considered to be realistic.

II.27 *17. Water demand to sustain ecosystem*

- *17.1.* What is the reason to suppose that the per capita water requirement for the domestic sector will not change over 20 years?
- *Page 30 last paragraph.* Where should the water come from and if from the river what would it mean in cusecs?
- *17.3.1 first sentence.* As far as we can see, this is not in agreement with the findings in Study I;
- *Figure 47.* Is this Figure in agreement with the results of Study I?

Note: Following the meeting of the Steering Committee the consultant for Study II has submitted a revised Executive summary and attached explanatory notes on: mangroves, sediment and fisheries. The IPOE has separately given its comments on the revised Executive Summary and expects that these comments be taken into account in finalising the Executive Summary, the explanatory notes and the report as a whole. In addition it was found that the formula showing the relation between discharge and sediment load can not be right, while the exponent would have to be larger than 1.

IPOE:

40

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

Annex VI Review of the Draft Final Report on Study III

III.1. Substantial work has been done since the Interim Report stage and the draft final report has been presented in a logical and comprehensive way. Most of the earliest comments of the IPOE have been addressed and with singular exceptions, all the items of the TORs have been addressed.

III.2. From the comments of the provinces, it is evident that several of the TORs have not yet been satisfactorily addressed by the consultants. These need to be reviewed in direct consultation with the provincial coordinators to ensure that all TORs are satisfactorily addressed.

III.3. Whilst the main report is rather complete, substantial improvement of the executive summary is still required. Some specifics on the executive summary are given below, as also discussed with the study team on 8th of October, 2005. It is important that these are to be carried through to the main report where applicable.

III.3.1. Units should be standardized throughout the reports. Currently use is made off various mixes of metric, imperial, and other units. (MAF, maf, acres, ha, lac Acres, Mds, cusec, cumec, etc.)

III.3.2. *page 1-35:*

- Resources given as 145.5 MAF compared to 175 MAF on p2-2 of main report;
- 'Physical shortage' and accompanying paragraph: to be reworded and expanded upon in proper context. Several statements are not clear;

III.3.3. *page 2-35:* Paragraph referring to WAA to be reworded;

III.3.4. *page 3-35:*

- Numbering of sub heading (also further on);
- To refer to 'water balance' rather than 'groundwater deficit';
- Item-iii: to be expanded upon and properly put in context;

III.3.5. *page 4-35:*

- Wording of section on groundwater sustainability to be refined;
- Reference made to 75 MAF groundwater recharge, compared to 50 MAF elsewhere;
- Minimum flow of thousand cusecs to be motivated or to be put in context;

III.3.6. *page 5-35:*

- Scenarios in upper table to be expanded upon. Also to bring in context of the environmental flow requirements;
- Middle table: correct heading 'volume in river downstream Kotri'. Second row of headings to be moved to correct columns;

III.3.7. *page 7-35:* Second best option' to be reworded;

III.3.8. *page 8-35:*

IPOE:

41

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

Draft Final Report of IPOE for Review of Studies on Water Escapages Below Kotri Barrage

- To clarify the reference to IBT replacement works intended as reference in time;
 - Statements in last paragraph refers to 'most countries', not only to Pakistan neither world wide;
 - Quite some of the text that is given for Punjab is of a general nature for Pakistan and would have to be moved to the previous sections;
- III.3.9. *page 9-35:*
- Increased groundwater recharge to be explained in broader context together with interdependence with surface flows;
 - Distinction to be drawn between natural and artificial or induced recharge. Also elsewhere and in the main report;
- III.3.10. *page 13-35:* 12000 cusecs to be verified and motivated or adjusted.
- III.3.11. *page 14-35:* Future growth in last paragraph to be addressed in context of constrained water resources potential
- III.3.12. *page 16-35':*
- The recommendations given do not really address the concerns of the provinces, and do not respond to the TORs. To be completely re-assessed and re- written;
 - Conclusions under item 2.3.1 completely out of context with TORs. To be re-written;
- III.3.13. *page 18-35:* The recommendations not properly justified or substantiated. To be reconsidered and re worded.
- III.3.14. *pages 18-35 to 32.35:*
- All the conclusions to be reviewed against the TORs to ensure that the TORs are properly responded to;
 - In some cases the TORs have not or could not be fully addressed. This need to be clearly stated where applicable;
- III.3.15. *page 26-35:* Item-6 refers to water scarcity, while item-ii on previous refers to surplus resources still available. Reword to clarify and avoid confusion.
- III.4. Condensed comments on main report, in addition to relevant comments under item-3 above:
- III.4.1. Quite a lot of statements and responses are of a very general nature. If it will be not possible to address these in detail, they would have at least be made relevant and site specific;
- III.4.2. Different dates for the completion of Kotri barrage given by the different study teams. To verify and co-ordinate with study-I and study-II;
- III.4.3. GIS maps showing the geographic locations and extent of impacts addressed in the report will be of great value in describing these. (It is understood that GIS maps will be given in a separate volume.);
- III.4.4. *page 2-7:* Reference to 'sub- tropical and moist temperate climate zones' and 'permanent snow-covered mountain ranges' for apparently the same area, appears contradictory;
- III.4.5. *page 2-12, 2-13, and 2-15 and elsewhere:* Various units used, to standardize.

IPOE:

42

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz

Draft Final Report of IPOE for Review of Studies on Water Escapages Below Kotri Barrage

- III.4.6. *page 3-12*: The quantifications of rainfall to be explained in proper context in relation to surface and groundwater resources.
- III.4.7. *Groundwater (page 3-13 onwards, 3-34, volume-II)*:
- To distinguish between natural recharge/resource potential and artificial and induced recharge;
 - Feasibility, practicality of artificial recharge to be assessed in context of overall resource (IWRM);
 - Be specific about what conditions appear in which areas (where salinity built-up, mining/ continued lowering of the groundwater table, waterlogging, etc.). Generalized statement may be misleading;
- III.4.8. *page 3-15*: Statements on future agricultural water requirements to be put in context of resource potential;
- III.4.9. *page 3-23*: Surface water storage at 90% of total surface flows not correct.
- III.4.10. *page 2-7*: Some items of the NWFP TORs not directly compiled with. To be addressed and clarified.

IPOE:

43

Signed on behalf of the IPOE

- * Dr. Fernando J Gonzalez
- * Dr. Thinus Basson
- * Dr. Bart Schultz

Delft 20th of November, 2005
Bart Schultz