GOVERNMENT
OF PAKISTAN

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GOVERNMENT
OF INDIA

THE INDUS WATERS TREATY 1960

BAGLIHAR Hydroelectric Plant

Expert Determination

on points of difference referred by the Government
of Pakistan under the provisions of the Indus Waters Treaty

Executive Summary

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EXECUTIVE SUMMARY

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Government of Pakistan – Government of India

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EXECUTIVE SUMMARY

1. INTRODUCTION

The water resources development of the Indus system of rivers is governed by the Indus Waters Treaty 1960 (referred to hereafter as the "Treaty") signed by the Government of India and the Government of Pakistan.

The Baglihar hydropower plant, a run-of-river plant with a capacity of 450 MW in its first stage, has been under construction since 2002 on the Chenab River, a tributary of the Indus, in the northern Indian state of Jammu & Kashmir.

On 15 January 2005, the Government of Pakistan sent a request to the World Bank (WB) to appoint a Neutral Expert (NE) stating that a "difference" had arisen between India and Pakistan under Article IX (2) of the Treaty, relating to the Baglihar Project.

After consultation with the Parties under the provisions of the Treaty, on 12 May 2005 the Bank appointed the undersigned, Mr. Raymond Lafitte, Professor at the Federal Institute of Technology of Lausanne, Switzerland.

The NE received the advice, with respect to legal issues, from Professor Laurence Boisson de Chazournes[1], and was assisted by Mr. Laurent Mouvet[2], Senior Civil Engineer.

At the request of the NE, the International Centre for Settlement of Investment Disputes of the World Bank (ICSID) assumed the coordination of the process and logistical support. Mrs. Eloïse Obadia, Senior Counsel, and Mrs. Martina Polasek, Counsel acted as coordinators.

[1] Professor, Faculty of Law, University of Geneva, Switzerland.

[2] Head of Dams Department, Stucky Consulting Engineers Ltd, Renens, Switzerland.

The Governmental Delegations of India and Pakistan were composed of eminent personalities: engineers and lawyers. They were led by

- Shri J. Hari Narayan, Secretary, Ministry of Water Resources of India, replaced in the same position since August 2006 by Mrs. Gauri Chatterji, and
  Shri R. Jeyaseelan, Chairman, Central Water Commission,
  for India, and by
- Mr. Makhdoom Ali Khan, Attorney General for Pakistan, and
  Mr. Ashfaq Mahmood, Secretary, Ministry of Water Power,
  for Pakistan.

Meeting No. 1 of the Parties and the NE was organized on 9 and 10 June 2005 in Paris at the World Bank Office. Mr. Roberto Dañino, Senior Vice President and General Counsel of the Bank welcomed the Delegations of the Parties and introduced the NE.

With the agreement of the Parties, the NE's work programme was fixed with the intention to produce his determination within the shortest possible time period. The fact that Baglihar power plant was under construction was certainly an important incentive for this. It was necessary for the NE to be briefed as fully as possible on the respective positions; but it was also essential, in his view, that each Party should have the possibility to present its arguments comprehensively.

The procedure proposed by the Parties, agreed by the NE, was to proceed to an exchange of written instruments. A programme was defined, which was adapted as it progressed, with the following order of events:

- 15 July 2005: Documents sent by India to Pakistan according to *Appendix II to Annexure D, Paragraph 9* of the Treaty as well as additional and updated documents
- 18 August 2005: Memorial dated 14 August 2005 filed by Pakistan
- 23 September 2005: Counter-Memorial filed by India
- 31 January 2006: Reply dated 25 January 2006 filed by Pakistan
- 20 March 2006: Rejoinder filed by India
- 2 and 3 October 2006: Final Draft Expert Determination
- 26 October 2006: Written comments of the Governments of Pakistan and India on the Final Draft Expert Determination
- 24 November 2006: Written additional comments of the Parties on their respective presentations
- 12 February 2007: Final Determination of the NE.

On 2 and 3 October 2005, a visit to the Baglihar site was organised for the NE and the Delegations of India and Pakistan. Then, on 5 and 6 October 2005, the Baglihar hydraulic model was visited at the Irrigation Research Institute (IRI) in Roorkee, India.

Following Meeting No. 1, in Paris, five subsequent meetings were organized:

- Meeting No. 2, from 19 to 21 October 2005, in Geneva, at the World Meteorological Organisation. This meeting was devoted to additional questions from the NE which had arisen following the site visit to Baglihar.
- Meeting No. 3, from 25 to 29 May 2006, in London, at the International Dispute Resolution Centre Ltd. After the filing of the Rejoinder, this meeting was devoted to oral presentations of the Parties.
- Meeting No. 4, from 2 to 4 October 2006, in Paris, at the World Bank Office. The NE presented his Final Draft Determination.
- Meeting No. 5, from 7 to 9 November 2006, in Washington, D.C. The Parties made their comments on the Final Draft Determination.

On 12 February 2007, in Bern, both Ambassadors of Pakistan and of India received, from the hands of the NE hard and soft copies of his Determination.

2. POINTS OF DIFFERENCE REFERRED BY PAKISTAN AND INDIA'S POSITION

a. Pakistan is of the considered view that the design of the Baglihar Plant on Chenab Main does not conform to criteria (e) and (a) specified in Paragraph 8 of Annexure D to The Indus Waters Treaty 1960 and that the Plant design is not based on correct, rational and realistic estimates of maximum flood discharge at the site.

   The Indian side does not agree with Pakistan's position.

   Paragraphs 8 (e) and 8 (a) of Annexure D of the Treaty read as follows:

   8 (e) "If the conditions at the site of a Plant make a gated spillway necessary, the bottom level of the gates in normal closed position shall be located at the highest level consistent with sound and economical design and satisfactory construction and operation of the works."

   8 (a) "The works themselves shall not be capable of raising artificially the water level in the Operating Pool above the Full Pondage Level specified in the design."

b. Pakistan is of the considered view that the Pondage of 37.722 MCM exceeds twice the Pondage required for Firm Power in contravention of Paragraph 8 (c) of Annexure D to the Treaty.

   The Indian side does not agree with Pakistan's position.

   Paragraph 8 (c) of Annexure D of the Treaty reads as follows:

   (c) "The maximum Pondage in the Operating Pool shall not exceed twice the Pondage required for Firm Power."

c. Pakistan is of the considered view that the intake for the turbines for the Plant is not located at the highest level consistent with satisfactory and economical construction and operation of the Plant as a Run-of-River Plant and is in contravention of Paragraph 8 (f) of Annexure D to the Treaty.

   The Indian side does not agree with Pakistan's position.

   Paragraph 8 (f) of Annexure D of the Treaty reads as follows:

   (f) "The intakes for the turbines shall be located at the highest level consistent with satisfactory and economical construction and operation of the Plant as a Run-of-River Plant and with customary and accepted practice of design for the designated range of the Plant's operation."

3. THE TREATY AND ITS INTERPRETATION

In Interpreting the Treaty, the NE has relied on the rules of the Vienna Convention on the Law of Treaties which reflect customary international law with regard to ordinary methods of treaty interpretation. The Treaty was negotiated and concluded during a period of tension between India and Pakistan. However, in the view of the NE, because of this tension, those who drafted the Treaty aimed for predictability and legal certainty in its drafting, so as to ensure sound implementation. The Treaty contains clear language and wording on how and to which extent India and Pakistan may be allowed to utilize the waters of the Indus system of rivers. The Treaty also gives a clear indication of the rights and obligations of both Pakistan and India. These rights and obligations should be read in the light of new technical norms and new standards as provided for by the Treaty.

Furthermore, and taking account of the ordinary methods of interpretation, the NE is of the opinion that interpretation of the Treaty must be guided by the principle of integration and the principle of effectiveness. These two principles provide for the Treaty to find effect in its whole and to ensure that each of the object(s) and purpose(s) of the Treaty is given fullest weight and effect when interpreting the rights and obligations under the Treaty. According to the Preamble of the Treaty, the object(s) and the purpose(s) of this Treaty are to attain the most complete and satisfactory utilisation of the waters of the Indus systems rivers, to fix and delimit the rights and obligations of each party in relation to the other concerning the use of these waters, and to provide for the settlement of questions arising from the application or the interpretation of the Treaty. The objectives set out in the Preamble cannot be read in isolation from each other. They are all complementary in light of the principles of integration and effectiveness and no hierarchy can be deduced from the wording of the Preamble. The rights and obligations contained in Part 3 of Annexure D must be interpreted so as to allow for the fulfilling of the object(s) and purpose(s) of the Treaty in “a spirit of goodwill and friendship” and in “a co-operative spirit”, taking into account the best and latest practices in the field of construction and operation of hydro-electric plants.

4. TECHNICAL DATA CONCERNING THE BAGLIHAR PROJECT

For clarification, the main characteristics of the project, as presented during the site visit in October 2005 and provided by India, are repeated below. Corresponding plates are also given in Annexes 1 to 5 to the Executive Summary.

DAM BODY

Type	Concrete Gravity
Height above deepest foundation [m]	144.50
Length of dam crest [m]	317
Crest elevation [m asl]	844.50

RESERVOIR CHARACTERISTICS

Full pondage level FPL [m asl]	840
Dead storage level DSL [m asl]	835
Pondage [$M.m^3$]	37.50
Dead storage capacity [$M.m^3$]	358.45
Gross storage capacity [$M.m^3$]	395.95

HYDROLOGY

Catchment area [km^2]	17,325
Mean annual inflow [$M.m^3$]	25,000
Mean discharge [m^3/s]	790
Median annual discharge [m^3/s]	450
Peak flood discharge [m^3/s]	
1 year return period	2,300
10 year return period	5,100
100 year return period	8,100
1000 year return period	12,100
PMF	16,500

SPILLWAYS

Type	Sluice spillway with 5 openings, and Chute spillway with 3 bays
Maximum discharge capacity [m^3/s]	16,500 [peak of PMF flood]

a) Sluice Spillway

Type	Submerged orifice with ogee-shaped chute
Type of gates	Radial with hydraulic hoists
Number of gates	5
Size of gates	10 m (W) x 10.50 m (H)
Spillway Sill Elevation [m asl]	808
Head above sill [m]	
Normal conditions	32
Maximum extreme conditions	36.50
Energy dissipation	Splitter and ledge along chute, lined stilling basin
Capacity at FPL [m^3/s]	10,772

b) Chute Spillway

Type of gates	Radial with hydraulic hoists
Size of gates	12 m (W) x 19 m (H)
Number of gates	3
Spillway sill elevation [m asl]	821
Head above sill [m]	
Normal conditions	19.0
Maximum extreme conditions	23.50
Energy dissipation	Flip bucket and lined plunge pool
Capacity at FPL [m^3/s]	5,728

c) Auxiliary Spillway

Purpose	Evacuation of floating debris
Type	surface chute
Size of gate	6 m (W) x 3 m (H)
Spillway sill elevation [m asl]	837
Location	Right side of the dam, close to power intakes
Capacity at FPL [m^3/s]	53

POWER INTAKE

Stages	Stage I: Right intake Stage II: Left intake
Type	Lateral submerged intake
Location	On the right bank, forming an angle of 120° with dam
Sill level [m asl]	818
Size of gated section	2 x 10.0 m (W) x 7.5 m (H) for stage I
Size of headrace tunnel	10.15 m diameter circular
Capacity [m^3/s]	430

POWERHOUSE

Location	Underground, on the right bank
Installed capacity [MW]	450
Number of unit	3 (x 150 MW)

5. EXPERT DETERMINATION

5.1. MAXIMUM DESIGN FLOOD

The design flood, generally accepted in the world, has a probability of occurrence of 1/10,000 per year, or expressed differently, has a return period of 10,000 years.

According to India's approach, the design flood is the Probable Maximum Flood, which appears to be identical, in this region, to the 10,000 year return period flood. India has correctly applied the statistical approach, but unfortunately the series of peak annual discharges is limited. The deterministic approach was also applied. Probably, for such a large catchment area, India has developed all possible methods of analysis; the NE thinks especially of both the climatological and geomorphological analyses.

The analysis done by India results in a value of 16,500 m^3/s.

Pakistan has used its own statistical approach with a longer annual peak series of 80 years that it obtained by correlation of the discharge measured at the Marala barrage.

The result of Pakistan's calculation is 14,900 m^3/s. The point of view of the NE is that this value is one value among the others, which is not unreasonable.

But finally the choice of the design flood should be based on an analysis of all the results obtained, and supplemented by a strong engineering judgement.

DETERMINATION D1 relating to the maximum design flood [point (a) of the difference referred by Pakistan]

> In view of all the uncertainties of flood analysis, the NE has decided to retain the value of 16,500 m^3/s for the peak discharge of the design flood. Climate change, with the possible associated increase in floods, also encourages a prudent approach.

5.2. SPILLWAY, UNGATED OR GATED

Referring to the Treaty, in *Annexure D - Part 3-New Run-of-River Plant, Paragraph 8 (e),* Pakistan declared that a gated spillway is not necessary,

The determination of the possible arrangement of spillways must be driven by the general conditions of the site, *i.e.* hydrology and sediment yield, topography, geology and seismicity.

Based on a statistical analysis of 13,000 existing spillways in the world, it has been demonstrated that the provision of gates on large spillways is common practice. Furthermore, it appears that the sole use of ungated free overflow spillways is marginal when the required capacity for flood releases is higher than 15,000 m^3/s.

Free overflow spillways require a higher dam to be able to release the design flood than is the case with gated spillways. The cost of this dam heightening has been compared with the cost of a corresponding gated spillway. A simplified calculation has demonstrated that, with a dam type and size comparable with Baglihar dam, and considering the same discharge requirements, a purely economic comparison always favours a gated spillway.

The maximum water level of the reservoir cannot exceed el. 840 m asl to avoid flooding of Pul Doda town as well as some infrastructure upstream. The potential head of the site (ca. 130 m) should be totally utilized for energy production. The Full Pondage Level (FPL), according to the design submitted by India, is fixed at el. 840 m asl. If the design flood should occur, the spillway gates would be opened and the reservoir level would not rise above FPL. On the contrary, if the spillway were ungated, the level of water on the spillway crest would rise by about 12 m to allow for the discharge of the design flood. The reason is the short length of the dam crest which limits the length of the spillway weir. To avoid flooding of the upstream shores, the crest of an ungated overflow spillway should be fixed at el. 828 m asl. The 130 m head of the power plant will be reduced by 12 m, which would represent a loss of 9% in energy production throughout the life of the plant.

DETERMINATION D 2 relating to the issue of gated or ungated spillway [point (a) of difference referred by Pakistan]

The Treaty provides in *Paragraph 8 (e) of Part 3 of Annexure D the following*:

"If the conditions at the site of a Plant make a gated spillway necessary,[3] *the bottom level of the gates in normal closed position shall be located at the highest level consistent with sound and economical design and satisfactory construction and operation of the works.*

The NE considers, in conformity with the state of the art, that the conditions at the site of the Baglihar plant require a gated spillway. An analysis done by the NE on 13,000 existing spillways in the world shows that 89% of these structures, having a design discharge higher than 14,000 m^3/s, are gated.

This decision is consistent with the provisions of the Treaty, requiring a sound and economical design, and satisfactory construction and operation of the works. It is also in accordance with the Preamble of the Treaty, which provides that "[t]he Government of India and the Government of Pakistan, being equally desirous of attaining the most complete and satisfactory utilization of the waters of the Indus system of rivers (…)."

[3] The underlining is by the NE.

5.3. SPILLWAY, LEVEL OF THE GATES

Referring to the Treaty, in *Annexure D - Part 3-New Run-of-River Plants, Paragraph 8 (e)*, which reads as follows:

> *"If the conditions at the site of a Plant make a gated spillway necessary, the bottom level of the gates in normal closed position shall be located at the highest level consistent with sound and economical design and satisfactory construction and operation of the works."*[4]

Pakistan declared that even if it could be assumed (without conceding) that a gated spillway is necessary, the orifice spillway proposed by India is not located at the highest level consistent with the provisions of the Treaty.

The position of India is that the three-bay design for the chute spillway, the five-bay design for the sluice spillway, and the auxiliary spillway are necessary to ensure safe passing of the design flood, and also a silt-free environment near the intakes for trouble-free operation, by transporting sediments together with flood discharges through the sluice spillway. Consequently, the chosen spillway configuration is at the highest possible level consistent with a sound and economical design and satisfactory construction and operation of the works.

It appears clearly to the NE that the keystone of the design of the appurtenant works of Baglihar is not the problem of the flood discharge, but the flow of sediments which could create the following risks:

- Sedimentation of the operating pool (the pondage).
- Sedimentation of the power intake by bed load sediments.
- Suspended sediment with a high concentration and size entering the power intake and power tunnel, causing erosion of the turbines.
- Heightening of the river bed at the entrance of the reservoir and flooding of the town of Pul Doda.

Referring to Bulletin 115 of the International Commission on Large Dams (ICOLD), "Dealing with reservoir sedimentation" (1999), the state of the art today is that "[b]ottom outlets may be used for under sluicing of floods, emptying of reservoirs, sluicing of sediments and preventing sediment from entering intakes, etc."

For its part, the Treaty in *Annexure D - Part 3 - New Run-of-River Plants, Paragraph 8 (d)* reads as follows:

> *"There shall be no outlets below the Dead Storage Level, unless necessary for sediment control or any other technical purpose; any such outlet shall be of the minimum size, and located at the highest level, consistent with sound and economical design and with satisfactory operation of the works."*[5]

[4] The underlining is by the NE.

[5] The underlining is by the NE.

The NE considers that the two provisions *8 (e)* and *8 (d)* of the Treaty should be applied to the design of the spillway, and especially to the level of the gates, which also plays in part the role of a bottom outlet.

To support his determination, the NE conducted an analysis on some important aspects of reservoir sedimentation, the results of which are given below.

In 1960, when the Treaty was signed, the phenomenon of reservoir sedimentation was not recognized everywhere to its full degree of significance. It was only 20 years later, in 1980, that the concept of an integrated reservoir sedimentation management began to be clear and coherent. This simple principle was announced succinctly by the engineers of China stating: “[s]tore the clear water and discharge the muddy water”.

It appears that the Treaty is not particularly well developed with respect to its provisions on sediment transport. This is not a criticism: the Treaty reflects the status of technology on reservoir sedimentation in the 1950s. The consequence is that the provisions of the Treaty which explicitly mention sediment acquire a special significance.

Everybody recognizes the necessity to take into consideration the lessons of the past, in particular the last decades, from the design, construction and operation of dams and hydropower plants on rivers with important sediment transport. We refer to, among others cases, Sanmenxia in China commissioned in 1960, Warsak in Pakistan, 1960, and Salal in India, 1987.

The definition of the Dead Storage given in the Treaty states that it cannot be used for operational purposes. The operational purpose of Baglihar is power generation, and so this purpose is not allowed for the Dead Storage. This is precisely the role of the Live Storage which has the purpose of generating power. But the capacity of the Live Storage should be protected against sedimentation. This is an essential matter of sustainability. To meet this objective, “maintenance” of the Live Storage and of the Dead Storage should be carried out – and this is not excluded by the Treaty – in accordance with the various known processes of sedimentation control, and in particular, drawdown sluicing and flushing.

DETERMINATION D 3 relating to the level of the spillway gates [point (a) of the difference referred by Pakistan]

Referring to the Treaty in ***Annexure D Part 3-New Run-of-Rivers Plants, 8 (e)*** provides: *"If the conditions at the site of a Plant make a gated spillway necessary, the bottom level of the gates in normal closed position shall be located at the highest level consistent with sound and economical design and satisfactory construction and operation of the works."*[6]

The NE considers that the gated chute spillway on the left wing, planned in India's design, which has its sill located at el. 821, is at the highest level consistent with sound and economical design and satisfactory construction and operation of the works.

Annexure D Part 3-New Run-of-Rivers Plants, 8 (d) states: *"There shall be no outlets below the Dead Storage Level, unless necessary for sediment control or any other technical purpose; any such outlet shall be of the minimum size, and located at the highest level, consistent with sound and economical design and with satisfactory operation of the works."*[7]

The NE considers that the sluice spillway, planned in India's design and composed of five outlets, has two functions: sediment control of the reservoir and evacuation of a large part of the design flood. In conformity with international practice and the state of the art, he considers also that the proposed outlets (five gates of 105 m^2) should be of the minimum size and located at the highest level (808 m asl), consistent with a sound and economical design and satisfactory construction and operation of the works. But to ensure protection against flooding of Pul Doda, the outlets should preferably be located 8 m lower, at about el. 800 m asl.

Sound operation of the outlets will necessitate carrying out maintenance of the reservoir with drawdown sluicing each year during the monsoon season. The reservoir level should be drawn down to a level of about 818 m asl, that is to say 17 m below that of the Dead Storage Level. For this level, the free flow discharge is the annual flood of the order of 2500 m^3/s. This is in conformity with the Treaty, which provides that the *"'Dead Storage' means that portion of the storage which is not used for operational purpose"*. Operational purpose means power generation (and this is impossible for the Dead Storage because of the high level of the power intake). The reservoir drawdown below the Dead Storage Level will be done for maintenance purposes. It is commonly agreed in practice that maintenance is an absolute necessity, with its ultimate objective of ensuring the sustainability of the scheme.

[6] The underlining is by the NE.

[7] The underlining is by the NE.

5.4. ARTIFICIAL RAISING OF THE WATER LEVEL

Paragraph 8 (a) of Annexure D of the Treaty reads as follows:

> *"The works themselves shall not be capable of raising artificially the water level in the Operating Pool above the Full Pondage Level specified in the design."*

The only way to limit the technical possibility of raising the full pondage level is to limit the freeboard to the minimum required. In the case of Baglihar dam, utilizing a gated spillway, the Full Pondage Level is at 840 m asl, and the total freeboard above Full Pondage Level is 4.5 m. Pakistan considers that this value is exaggerated and that the dam crest elevation could be lowered.

Freeboard is the vertical difference in elevation provided between the maximum reservoir level during a routing of the design flood and the dam crest.

Thus the elevation of the dam crest is determined by:

- The full pondage level;
- The raising of the reservoir level required to allow for the release of extreme floods. The outflow discharge depends on the extreme flood hydrograph, the arrangement of spillway weirs and outlets, the operating rules of the spillways and the geometrical characteristics of the reservoir; and
- Safety criteria, which depend on: the dam type (concrete, masonry or embankment), the spillway type (gated or ungated), and local conditions, such as wind conditions.

The analysis carried out by the NE allowed him to define objective criteria, based on ICOLD guidelines and sound engineering. The freeboard is an essential safety element to protect the dam against overtopping. The criteria applied took into account the residual risk of malfunctioning of a gate.

The NE could also determine realistic parameters and coefficients for calculating the spillway discharge rating curves. He admitted that the design could be optimised to achieve these coefficients.

Based on these considerations, the NE determined the minimum required freeboard according to internationally accepted safety criteria.

DETERMINATION D 4 relating to the artificial raising of the water level [point (a) of difference referred by Pakistan]

In application of the provisions of the Treaty, the NE considers that the dam crest elevation should be set at the lowest elevation compatible with a sound and safe design based on the state of the art.

The dam crest elevation of the Baglihar dam, fixed in the design submitted by India at el. 844.5 m asl, resulting from a freeboard above the Full Pondage Level of 4.50 m, is not at the lowest elevation.

The Determination of the NE is that the freeboard should be 3.0 m above the Full Pondage Level leading to a dam crest elevation at 843.0 m asl. This is possible if the design of the chute spillway is optimised by minor shape adjustments in order to increase its capacity.

5.5. PONDAGE

Pakistan is of the considered view that the Pondage (which is the Live Storage for a run-of-river plant) calculated by India, exceeds twice the Pondage required for Firm Power and as a consequence is in contravention of the provisions of the Treaty.

The volumes of Pondage calculated by the Parties are:

- Pakistan: Maximum pondage P = 6.22 M.m^3, (2 x 3.11)
- India P = 37.5 M.m^3, (2 x 18.75)

The Treaty provides in *Annexure D, Part 1 – Definitions, 2 (c):*

> *"'Pondage' means Live Storage of only sufficient magnitude to meet the fluctuations in the discharge of the turbines arising from variations in the daily and the weekly loads of the plant."*[8]

and in *Annexure D, Part 3 - New Run-of-River Plants, 8 (c)*:

> *"The maximum Pondage in the Operating Pool shall not exceed twice the Pondage required for Firm Power".*[9]

Applying these provisions, and based on the state of the art, the NE considers that the role of the pondage is to regulate the river flow to meet consumer demand. When the pondage is calculated on this basis, it can also be used to regulate fluctuations in the river inflow.

The pondage is the operating volume necessary to produce firm power corresponding to the minimum mean discharge at the site of the plant. The method of calculating this minimum mean discharge is clearly explained in the Treaty, and no difference of opinion has arisen between the Parties concerning the value of this discharge.

The pondage calculation presented by Pakistan has been done with the objective of operating the plant at constant power, while regulating the fluctuations in the river flow. The NE cannot agree to this objective.

The pondage calculation presented by India is done with the objective of operating the plant with a constant river inflow, while regulating the fluctuations in power. The NE agrees with the principle, but not with the hypothesis concerning the time peak load hours on which the calculation should be based; this is not clearly justified.

Logically, the time of peak load each day should be the result of a forecast of the power demand over 15 or 20 years in the region of Baglihar: the Northern Region. Without these data, the NE has made his estimation only on the basis of the graph of power demand in December 2004 provided by India. He is aware of all the uncertainties of this approach, but it is the best available to him at this time.

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[8] The underlining is by the NE.

[9] The underlining is by the NE.

The calculations made by the NE give a volume of pondage necessary for operation of 16.28 M.m^3. The maximum pondage is double this amount: 32.56 M.m^3. This volume would allow, in addition to the operation of the plant during peak load hours, for regulation of the variations in river flow, if any.

DETERMINATION D 5 relating to the volume of the pondage [point (b) of the difference referred by Pakistan]

Applying the provisions of the Treaty and based on the state of the art, the NE considers that the first objective of pondage is to regulate the flow of the river to meet consumer demand.

He considers also that the values for maximum pondage stipulated by India as well as by Pakistan are not in conformity with the criteria laid down in the Treaty.

The Determination of the NE is that the maximum Pondage should be fixed at 32.56 M.m^3, and the corresponding Dead Storage Level at el. 836 m asl, one meter higher than the level of the Indian design.

5.6. LEVEL OF THE POWER INTAKE

Paragraph 8 (f) of Annexure D of the Treaty reads as follows:

> *"The intakes for the turbines shall be located at the highest level consistent with satisfactory and economical construction and operation of the Plant as a Run-of-River Plant and with customary and accepted practice of design for the designated range of the Plant's operation."*

Pakistan estimates that the design submitted by India does not conform to this criterion and that the intake for the turbines is not located at the highest level consistent with the Treaty requirements. Pakistan also considers that all design choices related to the level of the power intake should be made so as to minimize the submergence of the power intake.

The design submitted by India considers an intake structure with two openings, as shown in Annex 5. The sill level of the intake is 818.0 m asl, 17.0 m below the Dead Storage Level, while the minimum submergence depth is 9.5 m.

In the design submitted by India, a second intake is shown, for a future extension of the Plant. As this future extension is not actually under discussion, it will not be considered, even if it has an impact on the project layout.

Pakistan has developed and proposed an alternative design, with the purpose of demonstrating that higher intake structure elevations are possible.

The design of a power intake structure must be based on the following objectives:

- to minimize hydraulic head losses,
- to prevent entry of floating material,
- to avoid sediment deposition in the intake structure,
- to minimize sediment suspended load in the diverted flow, and
- to prevent air entrainment to the turbines.

Regarding the last criterion, it is well known that eddies can appear in front of the intake, and that vortices can develop and entrain air into the intake and the turbines when concomitantly the reservoir is at a lower operating level and the diverted discharge is high. This criterion fixes the level of the power intake.

The first remedy is to locate the intake structure at a sufficient depth. Several other constructive or operational measures can be taken to avoid the development of these vortices. Finally, resorting to a specifically designed anti-vortex device may be considered under certain conditions.

In the application of the provisions of the Treaty, and based on the state of the art, the NE considers that the elevation of the power intake should be determined to avoid the development of vortices at the Dead Storage Level and air entrainment to the turbines, without limitation of the operation discharge.

He observes that recourse to anti-vortex devices at the design stage is not common practice, and should be limited to particular cases where other measures cannot be undertaken to provide protection against the development of vortices.

The required minimum submergence depth depends on the inflow approach conditions. The proposed location of the intake structure leads to asymmetrical approach conditions. Another arrangement with more symmetrical approach conditions could reduce the required minimum submergence depth.

The NE found that the alternative design proposed by Pakistan would not give sufficient guarantees for protection against sediment deposition in the intake structure and minimum sediment suspended load in the diverted flow.

DETERMINATION D 6 relating to the level of the power intake [point (c) of the difference referred by Pakistan].

The NE considers that the elevation of the intake stipulated by India is not at the highest level, as required by the criteria laid down in the Treaty.

The determination of the NE is that the intake level should be raised by 3 m and fixed at el. 821.0 m asl.

The required minimum submergence depth depends on the discharge and the inflow approach conditions. The location of the intake structure proposed by India leads to asymmetrical approach conditions. A different arrangement, with more symmetrical approach conditions could reduce the required minimum submergence depth.

The NE believes that at the design stage the normal practice is to avoid the development of vortices by an appropriate arrangement of the intake structure and sufficient submergence or operating restrictions at the minimum water level. In particular cases where these measures cannot be implemented for technical or economic reasons, then recourse to anti-vortex devices would be the best alternative.

He recommends that all possible structural measures should be taken to limit the circulation of flow within the intake structure and in its vicinity, especially avoiding sharp bends inside the intake structure and in its vicinity.

POSTSCRIPT

The points of difference referred by Pakistan were not trivial and their complexity required from the claimant Party as well as from the respondent a major work of analysis and of synthesis to present their theses. The exchanges between the Parties were documented with great care; the oral presentations during three meetings and the visit to the site of Baglihar and to the hydraulic laboratory of Roorkee, were found to be of a high technical, scientific and legal interest. The process lasted one year. The work of the NE, of his assistant and of his legal adviser was also not easy. These are the reasons why the NE believes that the process was equally fruitful for all the participants.

The NE considers that his decision has not been rendered against one or the other Party.

His opinion is that, in fact, specific Parties emerge successfully from the treatment of this difference: the Authors of the Treaty. The Treaty is the successful document.

Professor Raymond Lafitte
Neutral Expert

With the support of

Professor Laurence Boisson de Chazournes,
Legal adviser,

and of

Mr Laurent Mouvet, Senior engineer,
Assistant.

Lausanne, Switzerland
12 February 2007

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The analysis of the Points of Difference referred by the Government of Pakistan, under the provisions of the Indus Waters Treaty 1960, and of the position of the Government of India, to achieve a Determination, was a delicate exercise. It could have not been realized without the fair collaboration of all those involved. So it is for me a real pleasure, jointly with Professor Laurence Boisson de Chazournes, who advised me with respect to legal issues, and with my assistant Mr Laurent Mouvet, to thank all those who contributed to this work.

The Parties made a great effort within a relatively short time, to transmit to me all their information. The best Experts, national and international, were required. The written instruments and the responses to my questions, explaining the points of view of the Parties, with all their arguments and counter-arguments, were very well developed in both content and form. These included a synthesis of the studies made by India during the past years for the design of the Baglihar scheme and its critical assessment by Pakistan, with constructive proposals on some aspects. New developments were implemented by the Parties, model tests and numerical analyses, to support their theses.

The oral presentations by the Parties, on both technical and legal aspects, also documented, were extremely clear and of a very high standard, demonstrating competence and honesty.

The Parties then paid great attention to making their written and oral remarks on the final draft determination of the author, allowing him to complete his report with full knowledge of the case.

The organization of the site visit to Baglihar was excellent and I wish to thank the Indian Government for its hospitality, and in particular Mr D.K. Mehta, Commissioner, Mr Vikrant Sharma, Assistant Director in Jammu, and Mr R.C. Gupta, Vice President of the JP Venture.

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Finally, as I am not particularly expert in some fine points of the English language, it was necessary that this document be reviewed by a native English speaker who was made aware of the confidential nature of the expert determination. This was done by Mrs Alison Bartle, Honorary Member of the International Commission on Large Dams, and Director of Aqua-Media International Ltd. I would like to express my personal deep gratitude to her.

Raymond Lafitte

Lausanne, Switzerland
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