Pondage

Dr Cameron Miles

Indus Waters Treaty (Pakistan v India), PCA Case No 2023-01

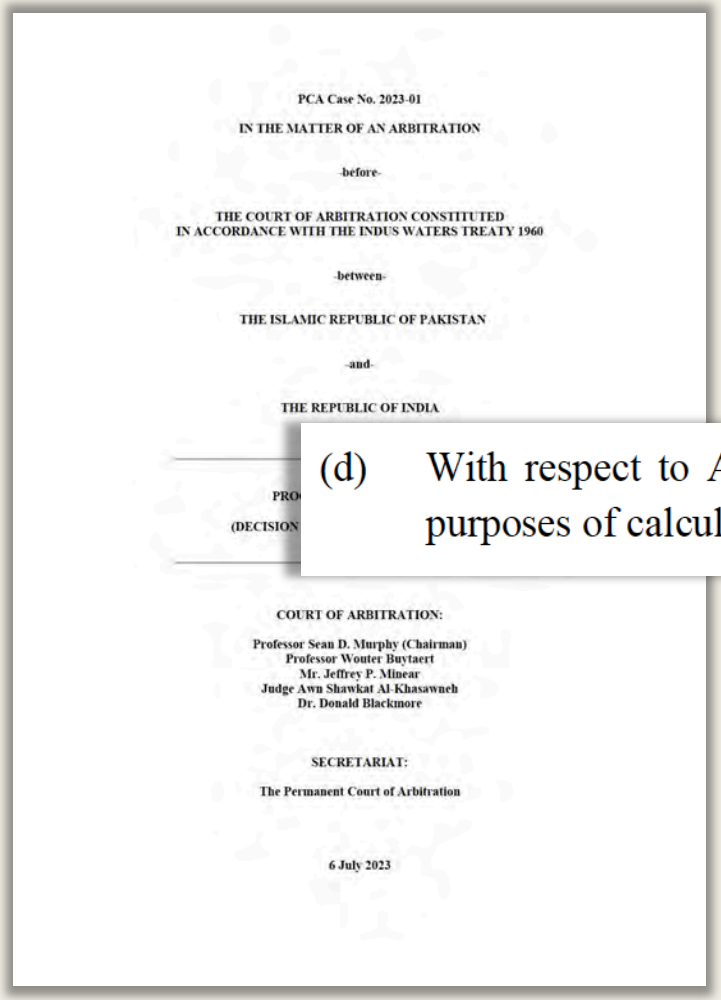
Hearing for the First Phase on the Merits

12 July 2024

Part I

Introduction

The Court's Pondage question



PCA Case No. 2023-01

IN THE MATTER OF AN ARBITRATION

-before-

THE COURT OF ARBITRATION CONSTITUTED
IN ACCORDANCE WITH THE INDUS WATERS TREATY 1960

-between-

THE ISLAMIC REPUBLIC OF PAKISTAN

-and-

THE REPUBLIC OF INDIA

PRO

(DECISION

COURT OF ARBITRATION:

Professor Sean D. Murphy (Chairman)
Professor Wouter Buytaert
Mr. Jeffrey P. Minear
Judge Awn Shawkat Al-Khasawneh
Dr. Donald Blackmore

SECRETARIAT:

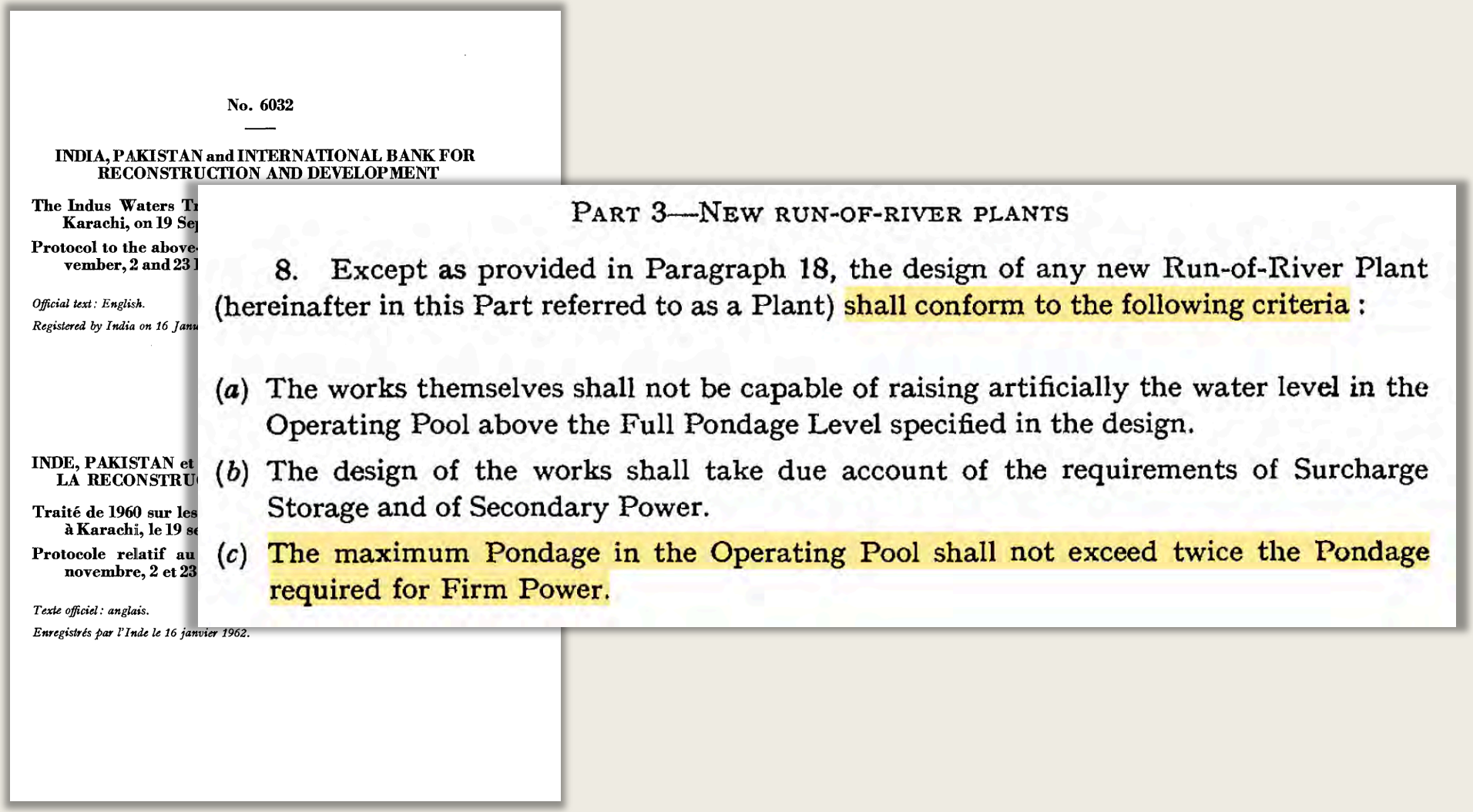
The Permanent Court of Arbitration

6 July 2023

(d) With respect to Annexure D, paragraph 8(c), what is to be taken into account for the purposes of calculating maximum pondage for a plant and what is to be excluded?

PO6, ¶ 35(d)

Annexure D, Paragraph 8(c)



No. 6032

INDIA, PAKISTAN and INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT

The Indus Waters Tr
Karachi, on 19 Sep
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LA RECONSTRU

Traité de 1960 sur les
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Texte officiel: anglais.

Enregistrés par l'Inde le 16 janvier 1962.

PART 3—NEW RUN-OF-RIVER PLANTS

8. Except as provided in Paragraph 18, the design of any new Run-of-River Plant (hereinafter in this Part referred to as a Plant) shall conform to the following criteria :

(*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*) The design of the works shall take due account of the requirements of Surcharge Storage and of Secondary Power.

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

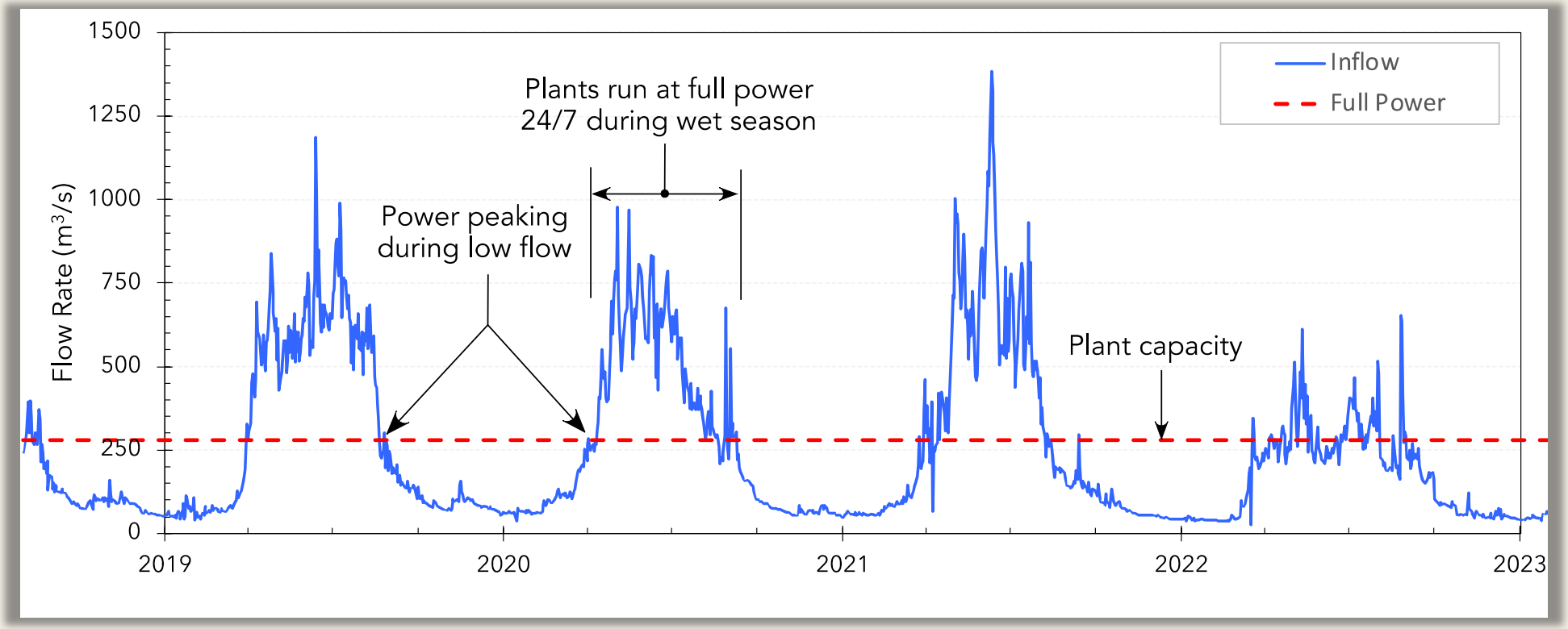
Outline of submissions

- **Part II:** Pondage in a run-of-river HEP
- **Part III:** Treaty provisions relevant to the calculation of maximum Pondage
- **Part IV:** Calculating maximum Pondage under Paragraph 8(c)
- **Part V:** India's approach to the calculation of maximum Pondage
- **Part VI:** Answering the Court's question on Pondage

Part II

Pondage in a run-of-river HEP

Natural flow versus design discharge



Site Visit Presentation 5, slide 13 (Mr Farooq)

Storage HEP

- Massive storage (in the order of weeks or months).
- Designed to permit flexible operation of the HEP year-round, as well as provide flood control.
- Notable example: Tarbela HEP (4,888MW), Khyber Pakhtunkhwa.

Run-of-river HEP with no storage

- No live storage; effectively a turbine placed in the river or on an adjoining canal.
- Entirely dependent on the river flow on a particular day and used only as base load power.
- Notable example: Salal HEP (690MW), Indian-administered Kashmir.

Run-of-river HEP with storage

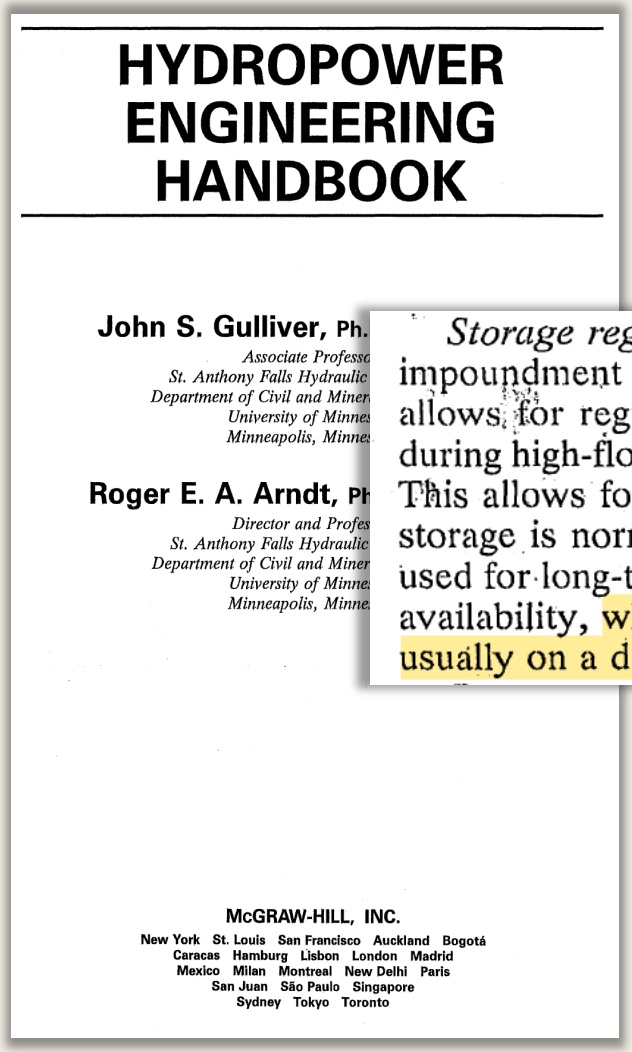
- Small reservoir constructed in narrow valley to improve head and power generation.
- Typically used for baseload power in the wet season and peaking power in the dry season.
- Notable example: NJHEP (969MW), Pakistan-administered Kashmir.

Flow solutions

- In sub-design discharge conditions, live storage may be used to improve an HEP's power production.
- Such storage must be incorporated into the HEP during the design phase.

Site Visit Presentation 5, slide 10 (Mr Farooq)

Defining pondage


HYDROPOWER ENGINEERING HANDBOOK

John S. Gulliver, Ph.
Associate Professo
St. Anthony Falls Hydraulic
Department of Civil and Miner
University of Minne
Minneapolis, Minne

Roger E. A. Arndt, PH
Director and Profes
St. Anthony Falls Hydraulic
Department of Civil and Miner
University of Minne
Minneapolis, Minne

McGRAW-HILL, INC.
New York St. Louis San Francisco Auckland Bogotá
Caracas Hamburg Lisbon London Madrid
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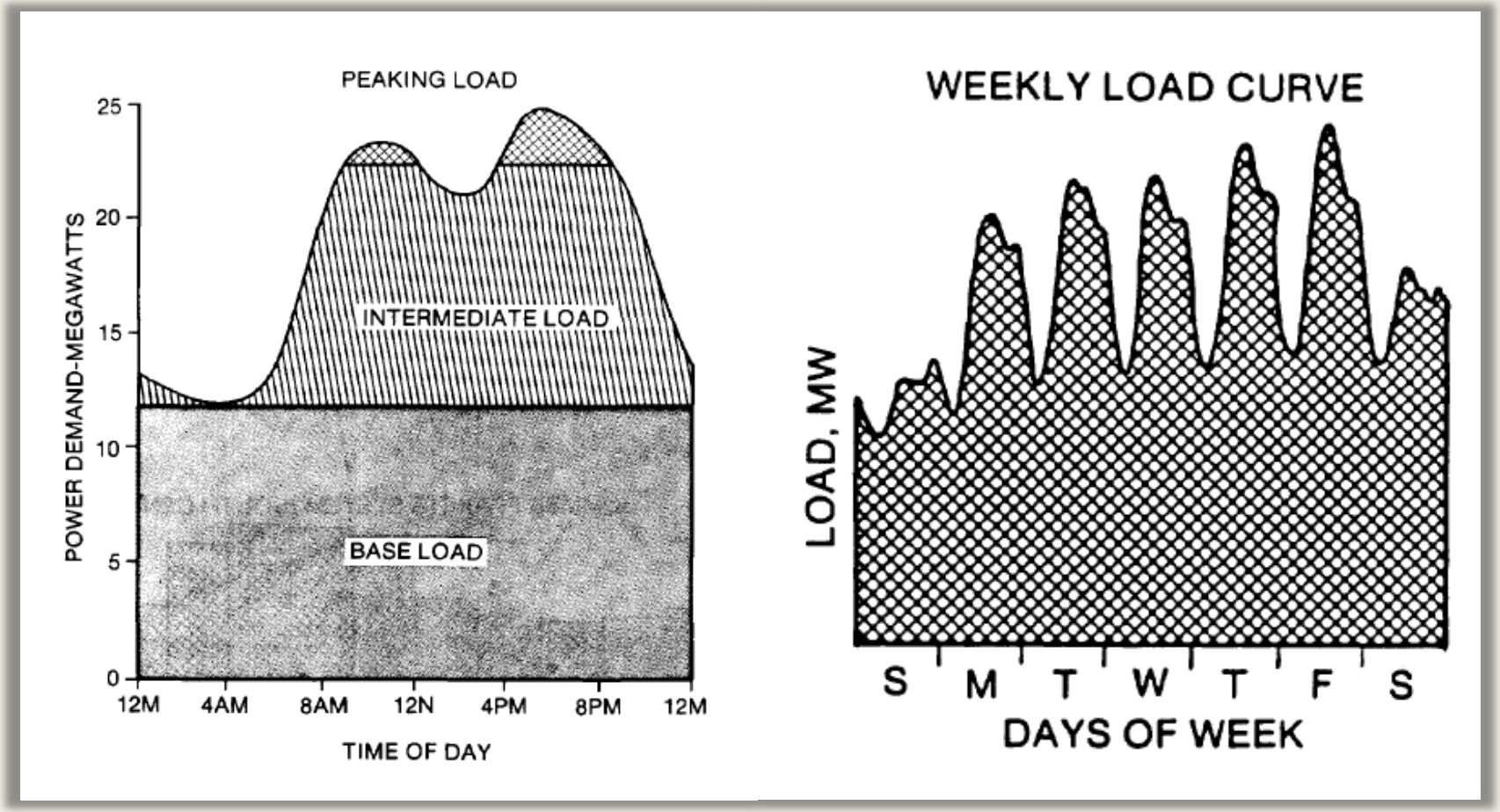
San Juan São Paulo Singapore
Sydney Tokyo Toronto

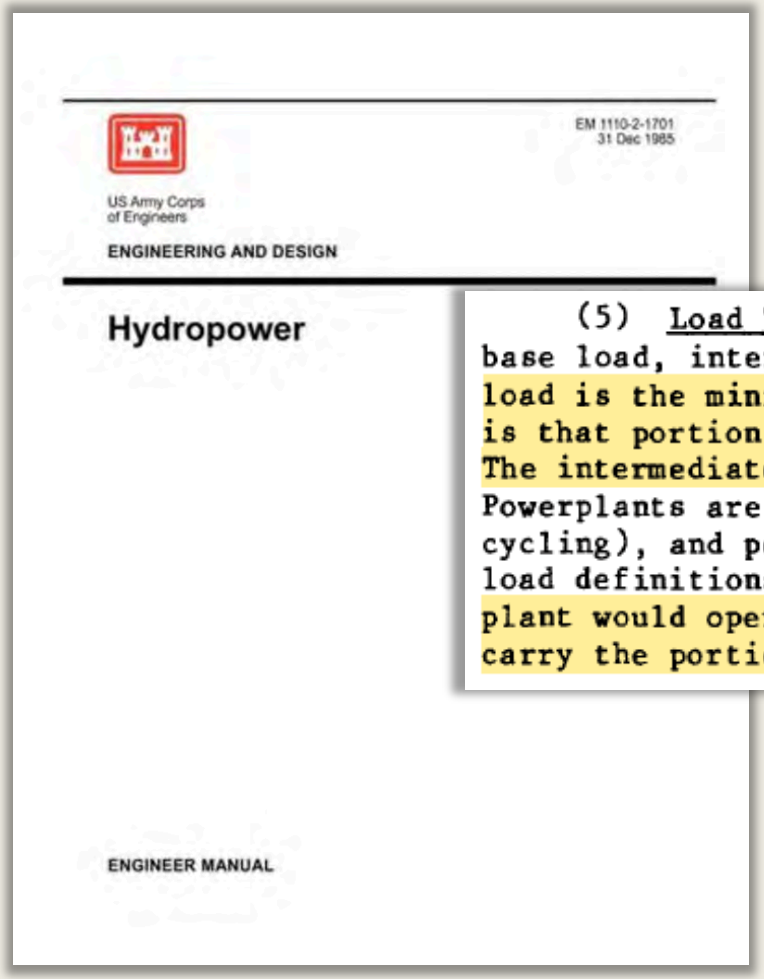
Storage regulation developments are defined as those in which an extensive impoundment at the power plant, or at the reservoir upstream of the power plant, allows for regulation of the flow downstream through storage. Water is stored during high-flow periods and is used to augment the flow during low-flow periods. This allows for a relatively constant supply of energy over the year. Significant storage is normally only used in large base-load plants. The word "storage" is used for long-term impounding of water to meet the seasonal fluctuation of water availability, whereas the word "pondage" refers to short-term storage of water, usually on a daily basis, to meet the diurnal variations in power demand.

Daily versus weekly load curves



P-0302, figs. 2-3, 2-8

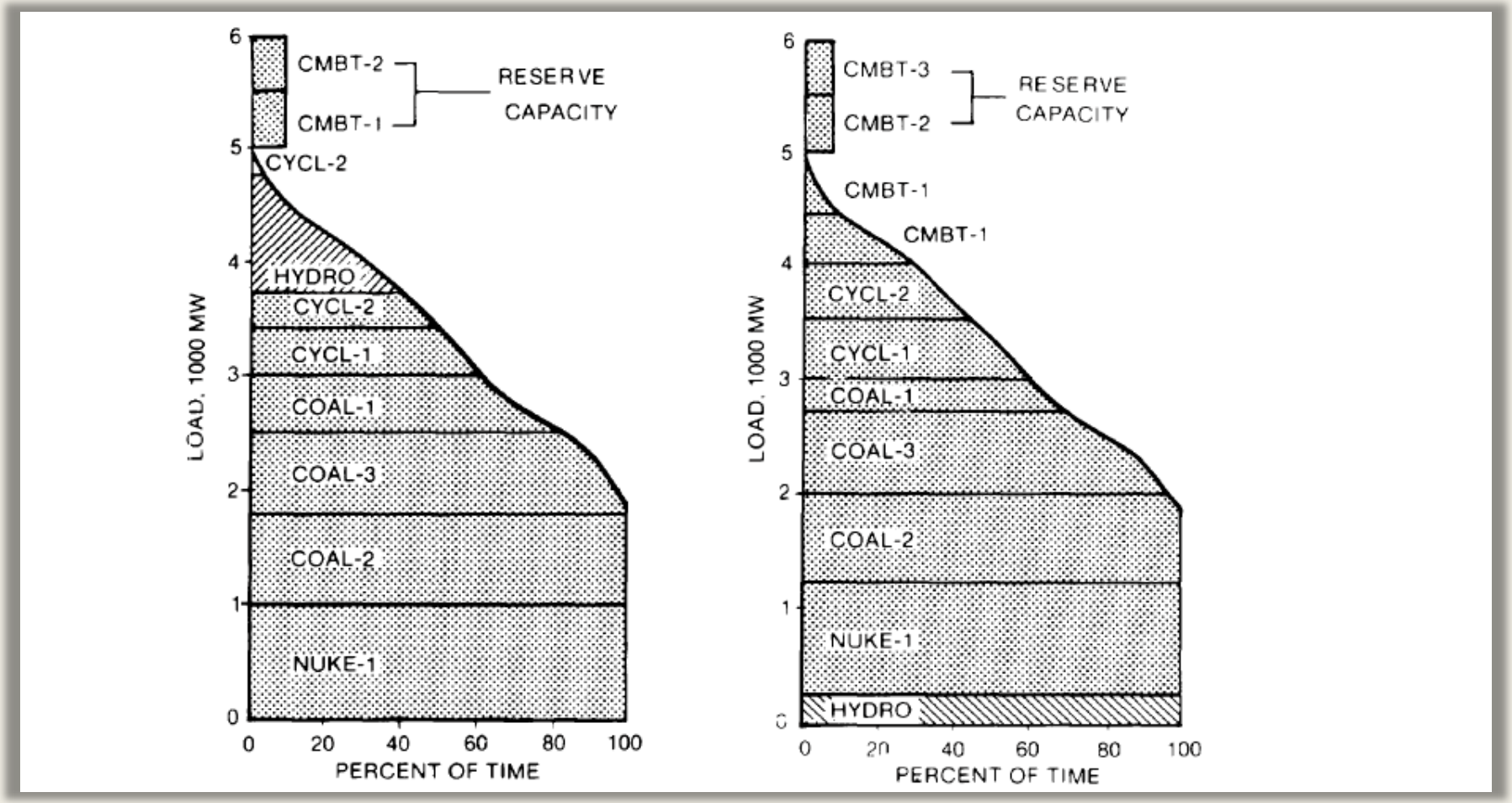
Power system loading



(5) Load Types. The load shape is divided into three segments: base load, intermediate load, and peaking load (Figure 2-3). The base load is the minimum load in a stated period of time. The peaking load is that portion of the load which occurs eight hours per day or less. The intermediate load is the load between the base and peaking loads. Powerplants are often categorized as base load, intermediate (or cycling), and peaking, but operational definitions vary somewhat from load definitions (see Section 6-3). An intermediate load or cycling plant would operate 8 to 14 hours a day, and a base load plant would carry the portion of the load below the intermediate plant.

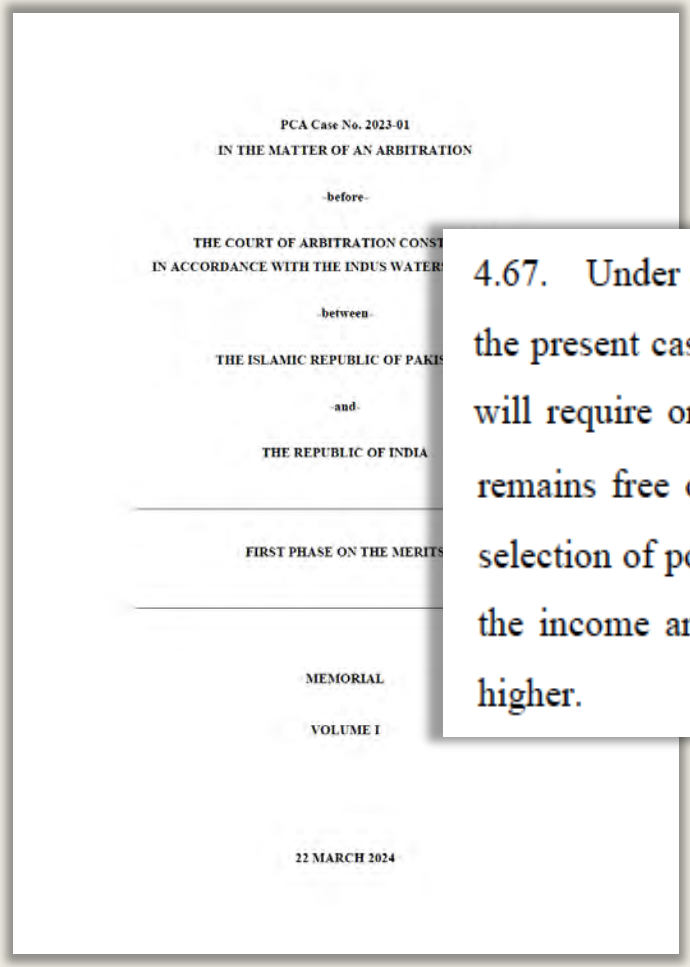
P-0302, 2-4

Hydropower within an integrated power system



P-0302, figs. 2-10, 2-11

Calculation of Pondage without the Treaty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-between-

THE ISLAMIC REPUBLIC OF PAKI

-and-

THE REPUBLIC OF INDIA

FIRST PHASE ON THE MERITS

MEMORIAL

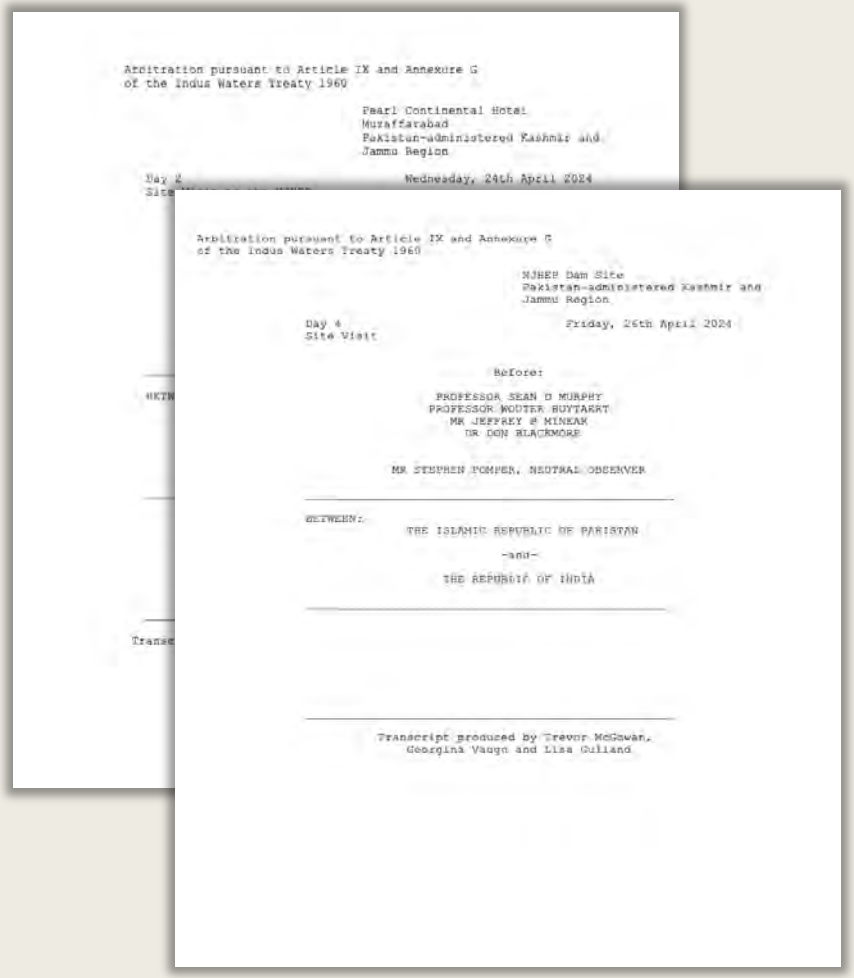
VOLUME I

22 MARCH 2024

4.67. Under *ordinary* principles of design—a point that requires emphasis in the context of the present case—there is no fixed methodology for determining how much pondage a HEP will require or be permitted to have. However, the provision of pondage, and ensuring it remains free of sediment, will incur both capital and operational costs. Thus, the rational selection of pondage capacity will usually balance these capital and operational costs against the income anticipated from delivery of power during peak hours when energy prices are higher.

Memorial, ¶ 4.67

Impact of legal regulation on Pondage



Arbitration pursuant to Article IX and Annexure G
of the Indus Waters Treaty 1960

Pearl Continental Hotel
Muzaffarabad
Pakistan-administered Kashmir and
Jammu Region

Day 2
Site

Wednesday, 24th April 2024

Arbitration pursuant to Article IX and Annexure G
of the Indus Waters Treaty 1960

NJHEP Dam Site
Pakistan-administered Kashmir and
Jammu Region

Day 4
Site Visit

Friday, 26th April 2024

Before:

PROFESSOR SEAN D MURPHY
PROFESSOR WOUTER BEYTAERT
MR JEFFREY P MINEAR
DR DON BLACKMORE

MR STEPHEN POMPER, NEUTRAL OBSERVER

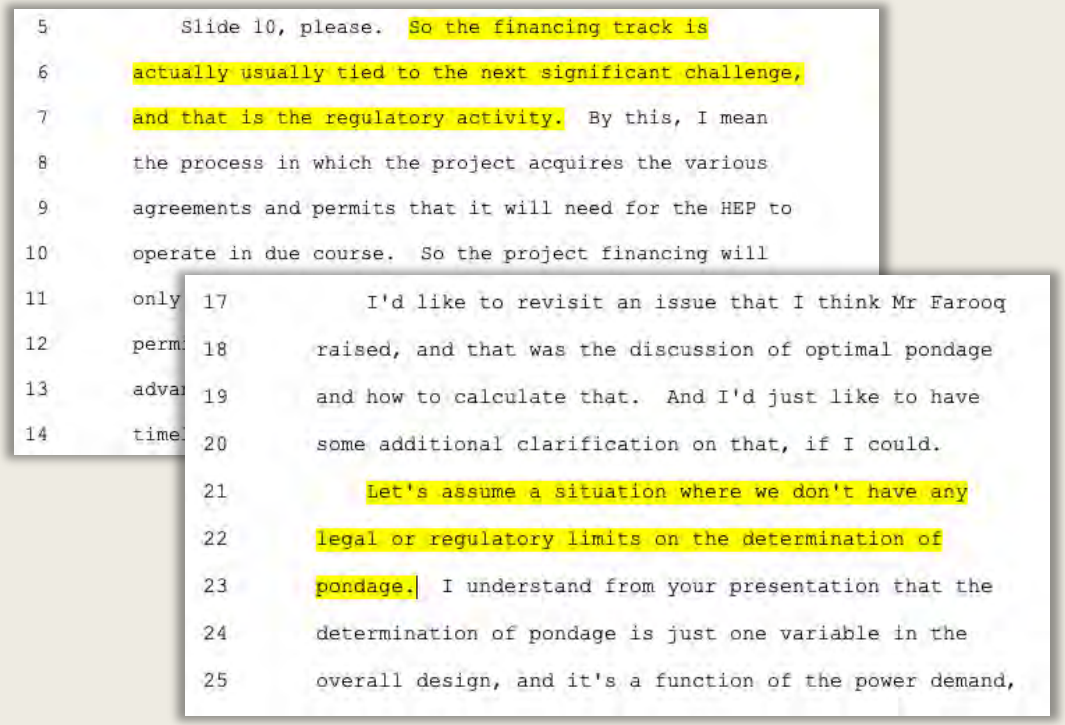
BETWEEN:

THE ISLAMIC REPUBLIC OF PAKISTAN

-and-

THE REPUBLIC OF INDIA

Transcript produced by Trevor McGowan,
Georgina Vaggs and Lisa Gulland



5 Slide 10, please. So the financing track is
6 actually usually tied to the next significant challenge,
7 and that is the regulatory activity. By this, I mean
8 the process in which the project acquires the various
9 agreements and permits that it will need for the HEP to
10 operate in due course. So the project financing will
11 only
12 perm
13 adva
14 time

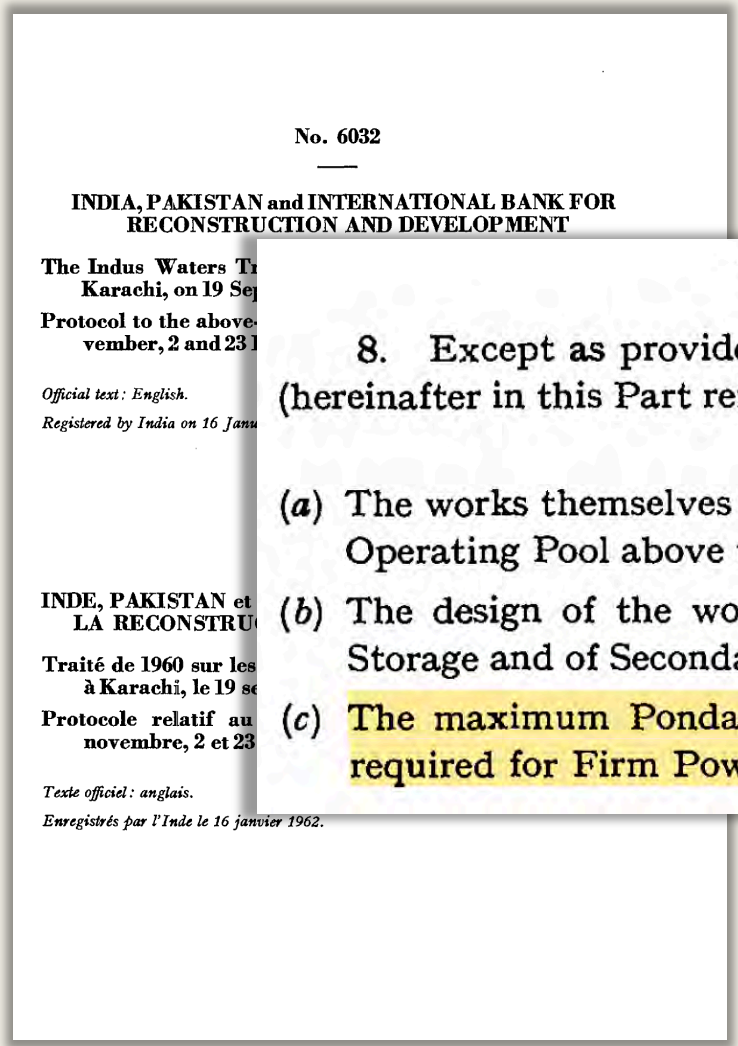
17 I'd like to revisit an issue that I think Mr Farooq
18 raised, and that was the discussion of optimal pondage
19 and how to calculate that. And I'd just like to have
20 some additional clarification on that, if I could.
21 Let's assume a situation where we don't have any
22 legal or regulatory limits on the determination of
23 pondage. I understand from your presentation that the
24 determination of pondage is just one variable in the
25 overall design, and it's a function of the power demand,

SVT2/36/14–19 (Dr Hayat); SVT4/119/21–23 (Mr Minear)

Part III

Treaty provisions relevant to the calculation of maximum Pondage

Annexure D, Paragraph 8(c)



No. 6032

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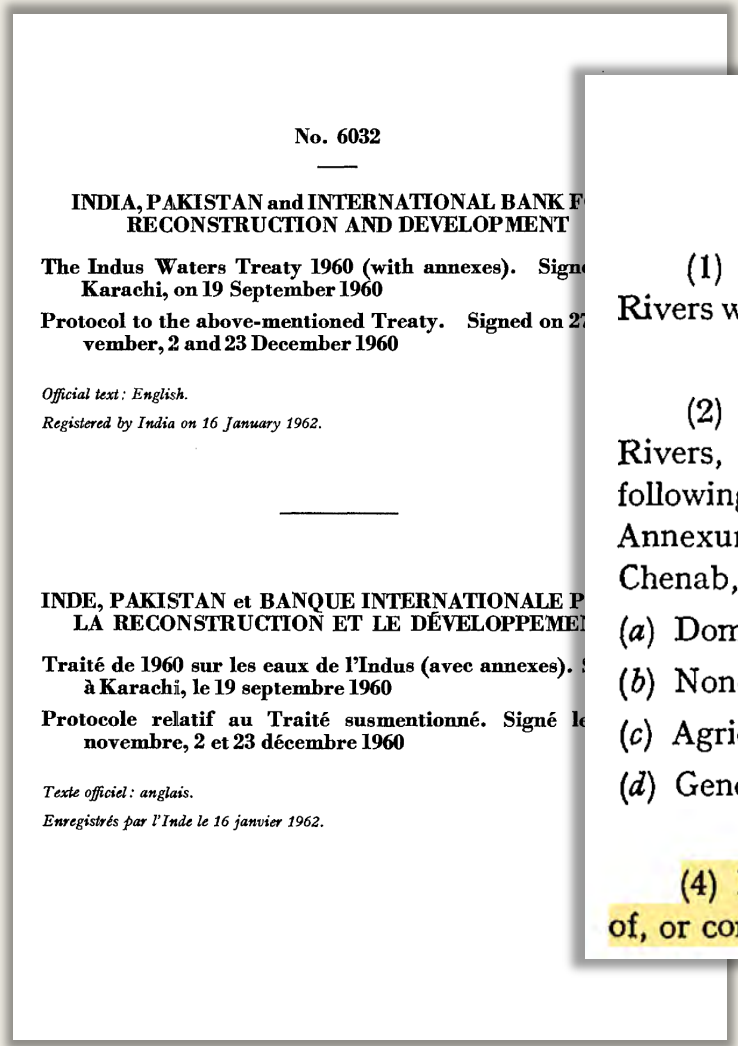
(*a*) The works themselves shall not be capable of raising artificially the water level in the Operating Pool above the Full Pondage Level specified in the design.

(*b*) The design of the works shall take due account of the requirements of Surcharge Storage and of Secondary Power.

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

Article III(1), (2) and (4)



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INDE, PAKISTAN et BANQUE INTERNATIONALE P
LA RECONSTRUCTION ET LE DÉVELOPPEME

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à Karachi, le 19 septembre 1960

Protocole relatif au Traité susmentionné. Signé le
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Texte officiel: anglais.

Enregistrés par l'Inde le 16 janvier 1962.

Article III

PROVISIONS REGARDING WESTERN RIVERS

(1) Pakistan shall receive for unrestricted use all those waters of the Western Rivers which India is under obligation to let flow under the provisions of Paragraph (2).

(2) India shall be under an obligation to let flow all the waters of the Western Rivers, and shall not permit any interference with these waters, except for the following uses, restricted (except as provided in item (*c*) (ii) of Paragraph 5 of Annexure C)[1] in the case of each of the rivers, The Indus, The Jhelum and The Chenab, to the drainage basin thereof :

(*a*) Domestic Use ;

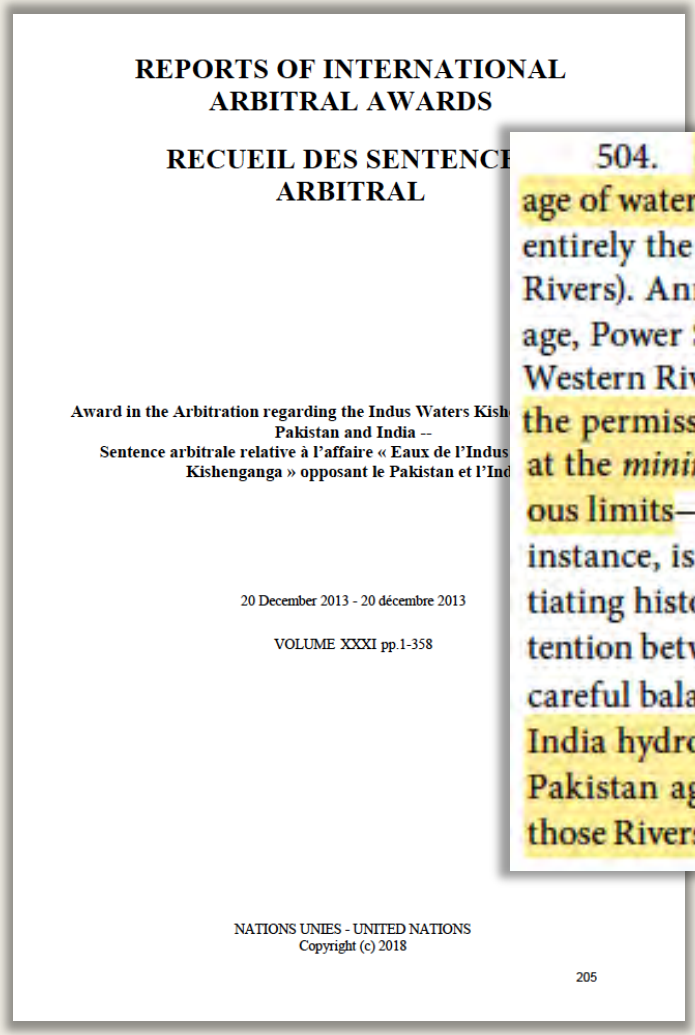
(*b*) Non-Consumptive Use ;

(*c*) Agricultural Use, as set out in Annexure C ; and

(*d*) Generation of hydro-electric power, as set out in Annexure D.[2]

(4) Except as provided in Annexures D and E,[1] India shall not store any water of, or construct any storage works on, the Western Rivers.

Pondage in the *Kishenganga* Partial Award


REPORTS OF INTERNATIONAL ARBITRAL AWARDS

RECUEIL DES SENTENCE ARBITRAL

Award in the Arbitration regarding the Indus Waters Kish
Pakistan and India --
Sentence arbitrale relative à l'affaire « Eaux de l'Indus
Kishenganga » opposant le Pakistan et l'Ind

20 December 2013 - 20 décembre 2013

VOLUME XXXI pp.1-358

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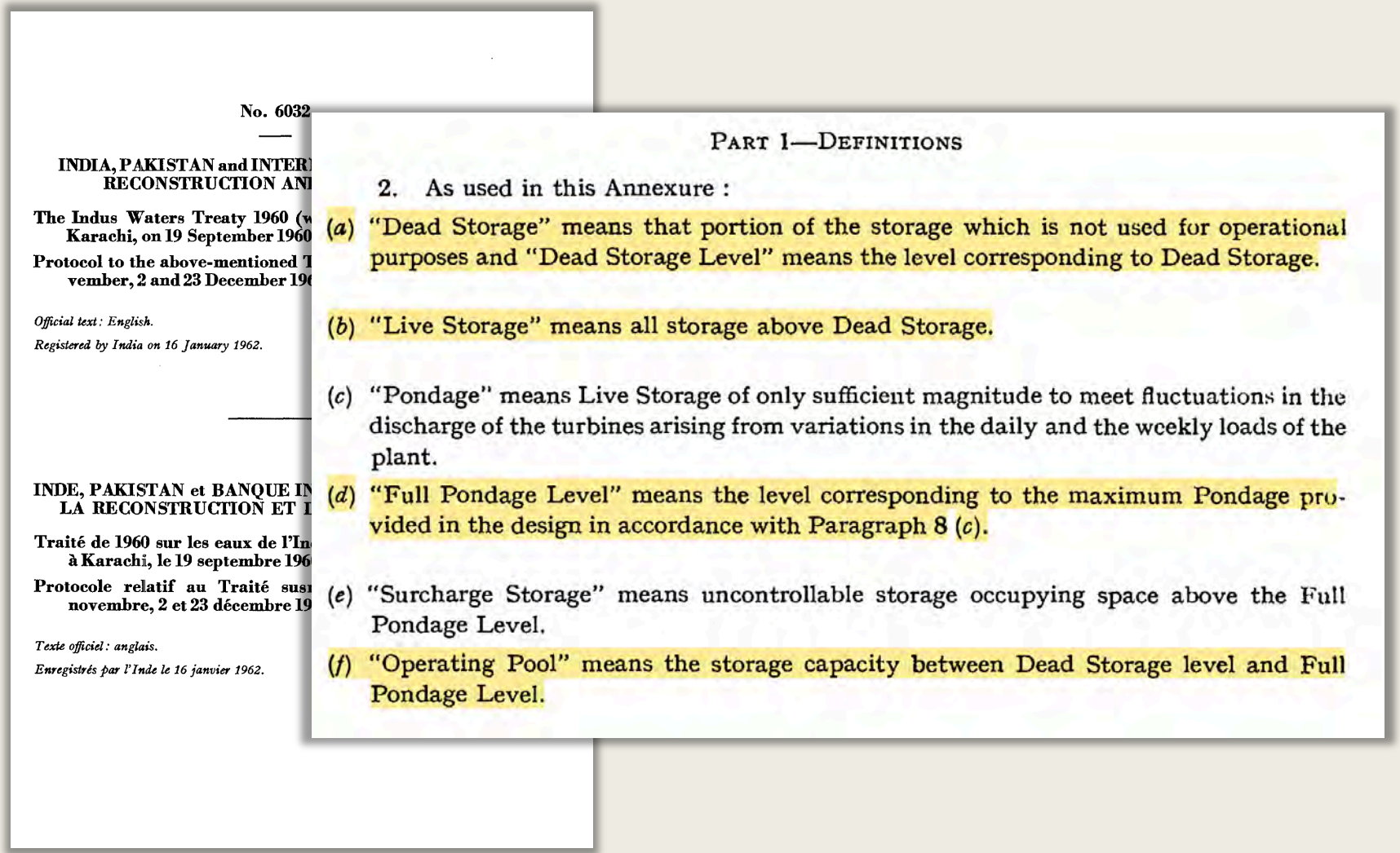
504. First, one of the primary objectives of the Treaty is to limit the storage of water by India on the Western Rivers (and, correspondingly, to prohibit entirely the storage of water by Pakistan on the upper reaches of the Eastern Rivers). Annexure E to the Treaty strictly limits the volume of General Storage, Power Storage, and Flood Storage that India may develop on each of the Western Rivers.[710] For new Run-of-River Plants, Annexure D likewise restricts the permissible volume of pondage, and pegs this limit to power generation at the *minimum* mean discharge calculated at the site.[711] These are not generous limits—the volume of storage permitted to India on the Jhelum Main, for instance, is zero—and even the limited available record of the Treaty's negotiating history suggests that these amounts of storage were a key point of contention between the Parties.[712] The outcome was significant in that it achieved a careful balance between the Parties' respective negotiating positions, allowing India hydro-electric use of the waters of the Western Rivers while protecting Pakistan against the possibility of water storage on the upstream reaches of those Rivers having an unduly disruptive effect on the flow of water to Pakistan.

Annexure D, Paragraphs 2(a), (b), (d) and (f)



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PART I—DEFINITIONS

2. As used in this Annexure :

(*a*) "Dead Storage" means that portion of the storage which is not used for operational purposes and "Dead Storage Level" means the level corresponding to Dead Storage.

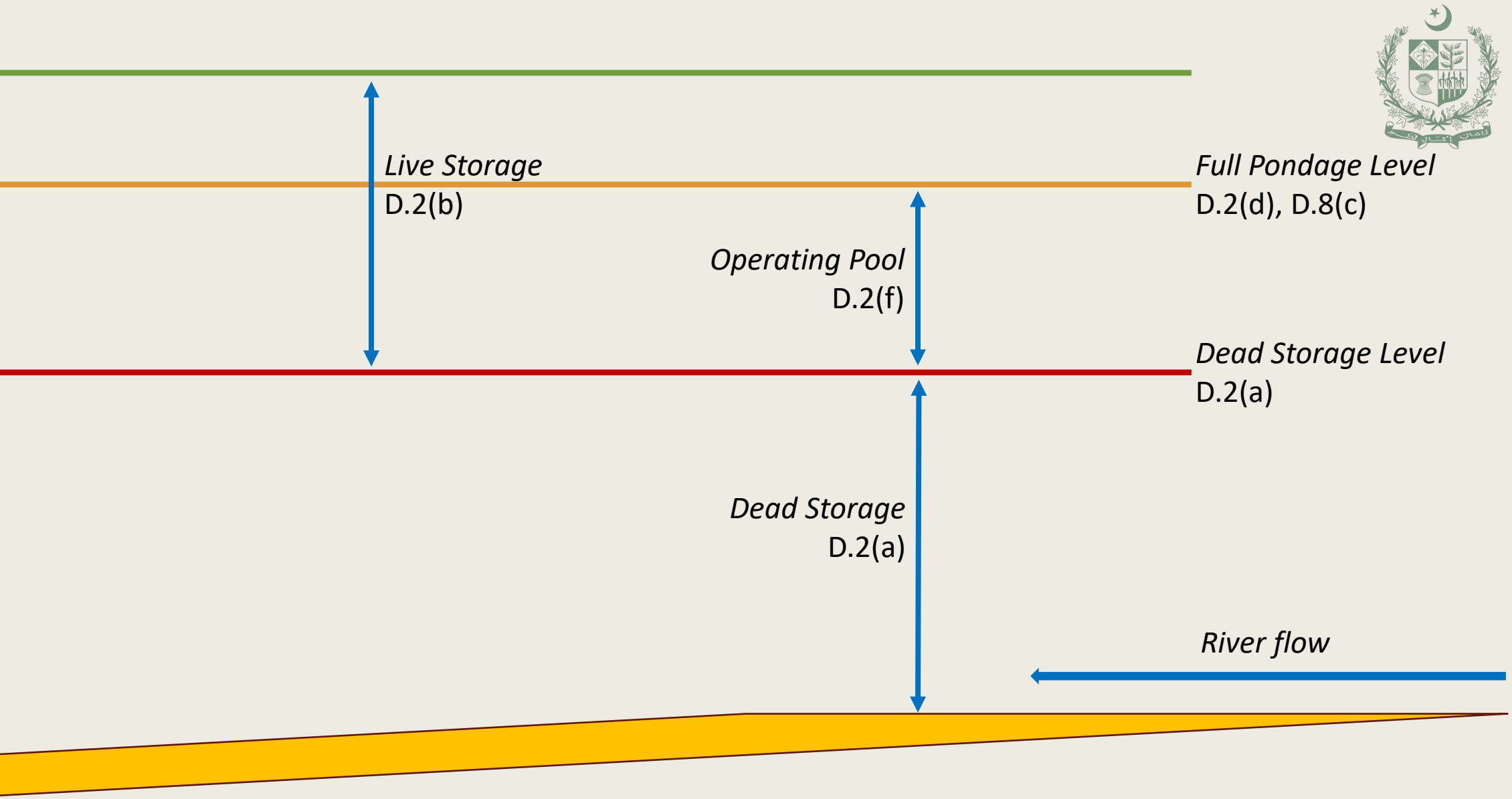
(*b*) "Live Storage" means all storage above Dead Storage.

(*c*) "Pondage" means Live Storage of only sufficient magnitude to meet fluctuations in the discharge of the turbines arising from variations in the daily and the weekly loads of the plant.

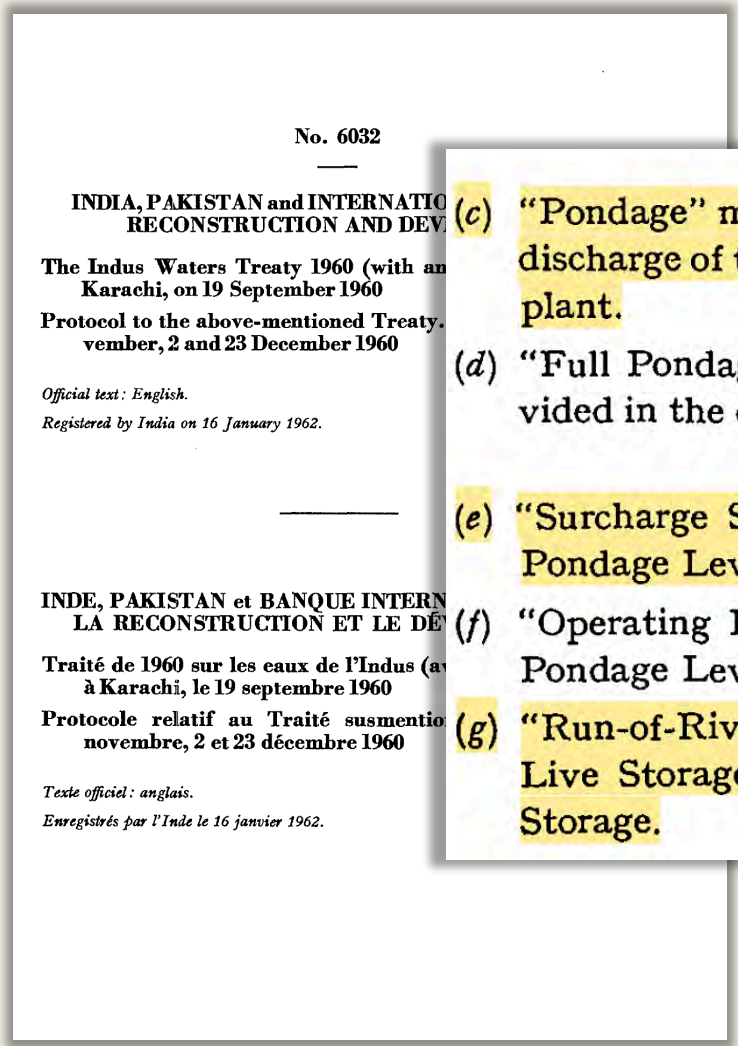
(*d*) "Full Pondage Level" means the level corresponding to the maximum Pondage provided in the design in accordance with Paragraph 8 (*c*).

(*e*) "Surcharge Storage" means uncontrollable storage occupying space above the Full Pondage Level.

(*f*) "Operating Pool" means the storage capacity between Dead Storage level and Full Pondage Level.


Live Storage
D.2(b)
Full Pondage Level
D.2(d), D.8(c)
Operating Pool
D.2(f)
Dead Storage Level
D.2(a)
Dead Storage
D.2(a)
River flow

Annexure D, Paragraphs 2(c),(e) and (g)



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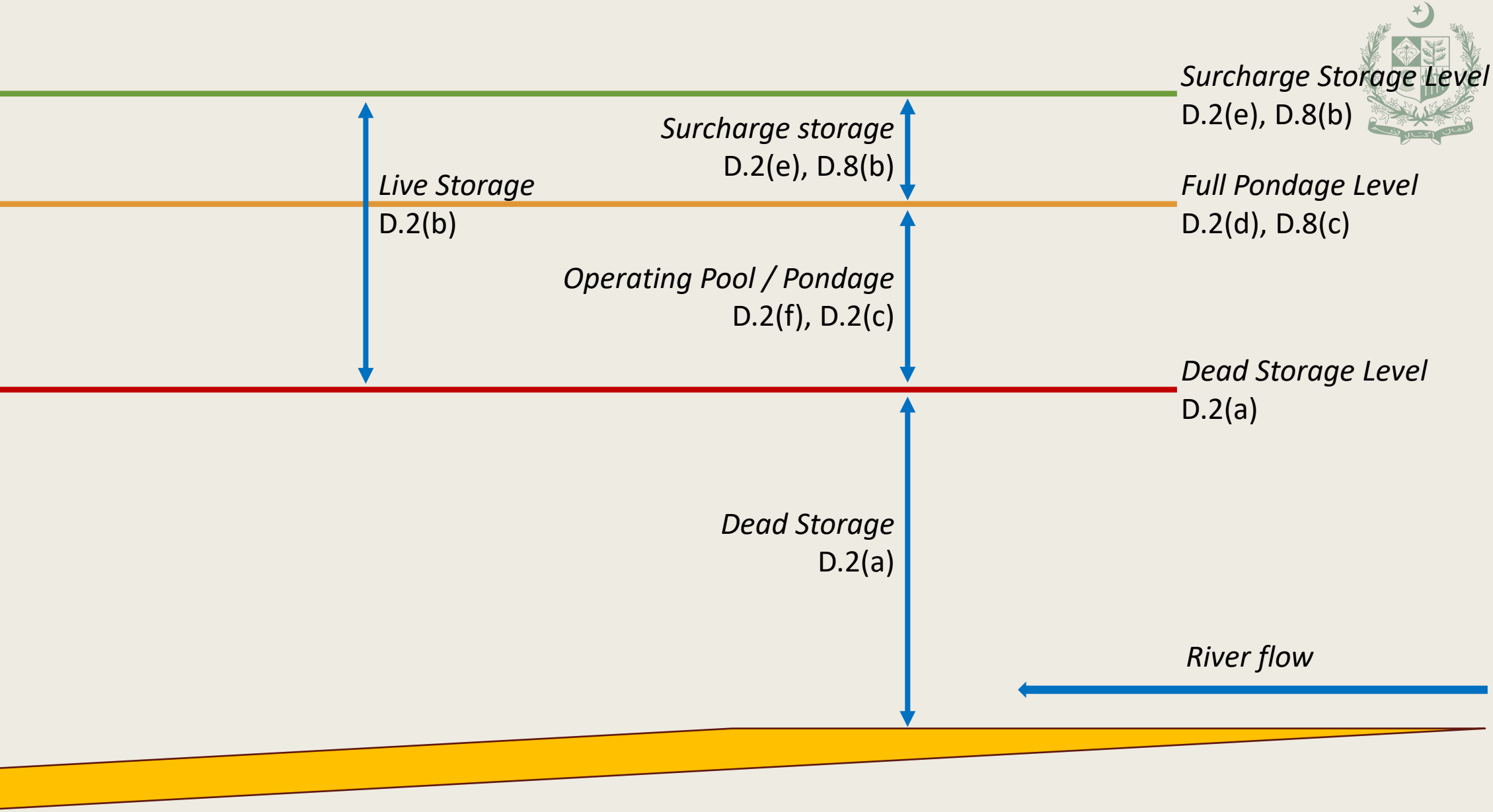
(*e*) "Surcharge Storage" means uncontrollable storage occupying space above the Full Pondage Level.

(*f*) "Operating Pool" means the storage capacity between Dead Storage level and Full Pondage Level.

(*g*) "Run-of-River Plant" means a hydro-electric plant that develops power without Live Storage as an integral part of the plant, except for Pondage and Surcharge Storage.


Surcharge Storage Level
D.2(e), D.8(b)
Surcharge storage
D.2(e), D.8(b)
Live Storage
D.2(b)
Full Pondage Level
D.2(d), D.8(c)
Operating Pool / Pondage
D.2(f), D.2(c)
Dead Storage Level
D.2(a)
Dead Storage
D.2(a)
River flow

Professor Briscoe on India's Live Storage

P-0325

INTERNATIONAL THE NEWS

War or peace on the Indus?

Saturday, April 03, 2010
By John Briscoe

Anyone foolish enough to write on war or peace in the Indus needs to first banish a set of immediate suspicions. I am neither Indian nor Pakistani. I am a South African who has worked on water issues in the subcontinent for 35 years and who has lived in Bangladesh (
Indian colleagues, an Oxford University Press
with fine Pakistani colleagues, one titled Pak

I was the Senior Water Advisor for the Work
Baglihar case. My last assignment at the Wo
Brazil. I am now a mere university professor

I have deep affection for the people of both
train wreck on the Indus, with disastrous co
objective conflict of interests between the co
of the need for a change in public discourse
before it is too late.

Is there an inherent conflict between India a

The simple answer is no. The Indus Waters
but allows India to tap the considerable hyd
Pakistan.

The qualification is that this use of hydropow
to interfere with the natural timing of those
timing. And timing is a very big issue, becau
water comes, but that it comes in critical per
virtually all of the available power without n

Is the Indus Treaty a stable basis for cooper

If Pakistan and India had normal, trustful re
would assure that there is no change in the
increase low-flows during the critical planting
small impacts on power generation in India.
negotiated, Pakistan would agree only if limi
hardwired into the treaty. This was done by limiting the amount of "live storage" (the storage that matters for changing the timing of flows) in each and every hydropower dam that India would construct on the two rivers.

While this made sense given knowledge in 1960, over time it became clear that this restriction gave rise to a major problem. The physical restrictions meant that gates for flushing silt out of the dams could not be built, thus ensuring that any dam in India would rapidly fill with the silt pouring off the young Himalayas.

This was a critical issue at stake in the Baglihar case. Pakistan (reasonably) said that the gates being installed were in violation of the specifications of the treaty. India (equally reasonably) argued that it would be wrong to build a dam knowing it would soon fill with silt. The finding of the Neutral Expert was essentially a reinterpretation of the Treaty, saying that the physical limitations no longer made sense. While the finding was reasonable in the case of Baglihar, it left Pakistan without the mechanism – limited live storage – which was its only (albeit weak) protection against upstream manipulation of flows in India. This vulnerability was driven home when India chose to fill Baglihar exactly at the time when it would impose maximum harm on farmers in downstream Pakistan.

If Baglihar was the only dam being built by India on the Chenab and Jhelum, this would be a limited problem.

But following Baglihar is a veritable caravan of Indian projects – Kishanganga, Sawalkot, Pakuldul, Bursar, Dal Huste, Gyspa… The cumulative live storage will be large, giving India an unquestioned capacity to have major impact on the timing of flows into Pakistan. (Using Baglihar as a reference, simple back-of-the-envelope calculations, suggest that once it has constructed all of the planned hydropower plants on the Chenab, India will have an ability to effect major damage on Pakistan. First, there is the one-time effect of filling the new dams. If done during the wet season this would have little effect on Pakistan. But if done during the critical low-flow period, there would be a large one-time effect (as was the case when India filled Baglihar). Second, there is the permanent threat which would be a consequence of substantial cumulative live storage which could store about one month's worth of low-season flow on the Chenab. If, God forbid, India so chose, it could use this cumulative live storage to impose major reductions on water availability in Pakistan during the critical planting season.

Annexure D, Paragraphs 15 and 16

No. 6032

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Enregistrés par l'Inde le 16 janvier 1962.

15. Subject to the provisions of Paragraph 17, the works connected with a Plant shall be so operated that (*a*) the volume of water received in the river upstream of the Plant, during any period of seven consecutive days, shall be delivered into the river below the Plant during the same seven-day period, and (*b*) in any one period of 24 hours within that seven-day period, the volume delivered into the river below the Plant shall be not less than 30%, and not more than 130%, of the volume received in the river above the Plant during the same 24-hour period: Provided however that :

(i) where a Plant is located at a site on the Chenab Main below Ramban, the volume of water received in the river upstream of the Plant in any one period of 24 hours shall be delivered into the river below the Plant within the same period of 24 hours ;

(ii) where a Plant is located at a site on the Chenab Main above Ramban, the volume of water delivered into the river below the Plant in any one period of 24 hours shall not be less than 50% and not more than 130%, of the volume received above the Plant during the same 24-hour period ; and

iii) where a Plant is located on a Tributary of The Jhelum on which Pakistan has any Agricultural use or hydro-electric use, the water released below the Plant may be delivered, if necessary, into another Tributary but only to the extent that the then existing Agricultural Use or hydro-electric use by Pakistan on the former Tributary would not be adversely affected.

16. For the purpose of Paragraph 15, the period of 24 hours shall commence at 8 a.m. daily and the period of 7 consecutive days shall commence at 8 a.m. on every Saturday. The time shall be Indian Standard Time.

Annexure D, Paragraph 8(c)

No. 6032

INDIA, PAKISTAN and INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT

The Indus Waters Tr
Karachi, on 19 Sep

Protocol to the above-
vember, 2 and 23 I

Official text: English.

Registered by India on 16 Janu

INDE, PAKISTAN et
LA RECONSTRU

Traité de 1960 sur les
à Karachi, le 19 se

Protocole relatif au
novembre, 2 et 23

Texte officiel: anglais.

Enregistrés par l'Inde le 16 janvier 1962.

PART 3—NEW RUN-OF-RIVER PLANTS

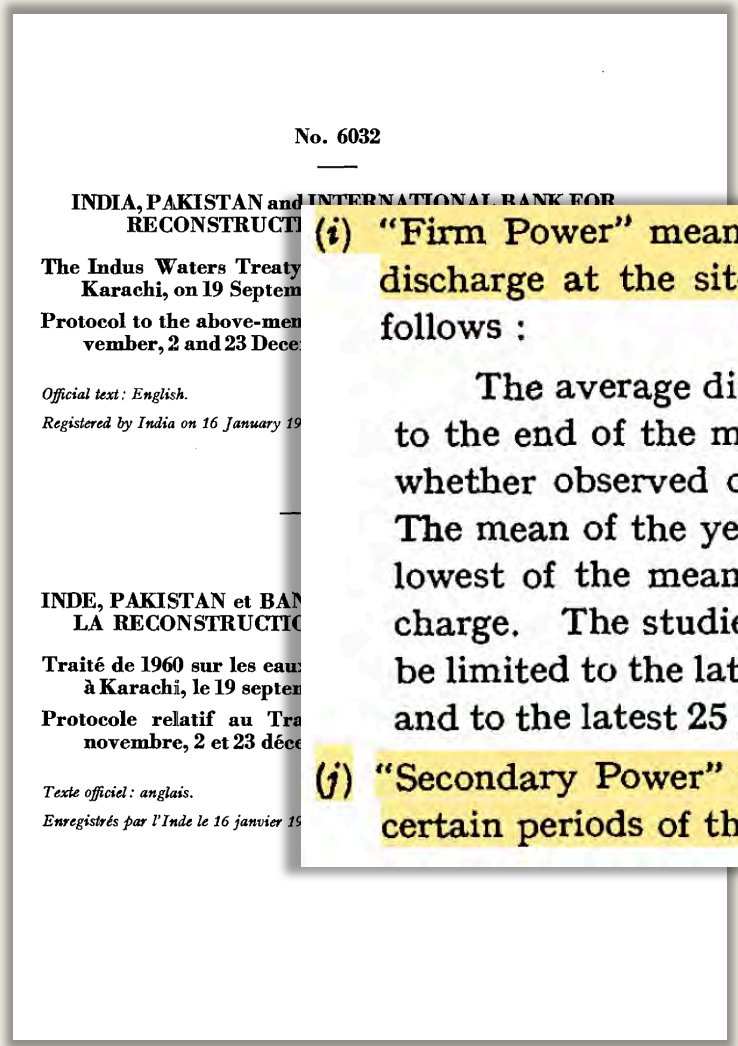
8. Except as provided in Paragraph 18, the design of any new Run-of-River Plant (hereinafter in this Part referred to as a Plant) shall conform to the following criteria :

(*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*) The design of the works shall take due account of the requirements of Surcharge Storage and of Secondary Power.

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

Annexure D, Paragraphs 2(i) and (j)



No. 6032

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The Indus Waters Treaty
Karachi, on 19 Septem

Protocol to the above-men
vember, 2 and 23 Dece

Official text: English.

Registered by India on 16 January 19

INDE, PAKISTAN et BAN
LA RECONSTRUCTIO

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à Karachi, le 19 septer

Protocole relatif au Tra
novembre, 2 et 23 déce

Texte officiel: anglais.

Enregistrés par l'Inde le 16 janvier 19

(*i*) "Firm Power" means the hydro-electric power corresponding to the minimum mean discharge at the site of a plant, the minimum mean discharge being calculated as follows :

The average discharge for each 10-day period (1st to 10th, 11th to 20th and 21st to the end of the month) will be worked out for each year for which discharge data, whether observed or estimated, are proposed to be studied for purposes of design. The mean of the yearly values for each 10-day period will then be worked out. The lowest of the mean values thus obtained will be taken as the minimum mean discharge. The studies will be based on data for as long a period as available but may be limited to the latest 5 years in the case of Small Plants (as defined in Paragraph 18) and to the latest 25 years in the case of other Plants (as defined in Paragraph 8).

(*j*) "Secondary Power" means the power, other than Firm Power, available only during certain periods of the year.

$P = Q \times g \times h \times \rho \times \eta$

P = Power (W)

Q = Flow rate (m^3/sec)

g = Gravity (m/sec^2)

h = Generating head (m)

ρ = Density of water (kg/m^3)

η = Plant efficiency (%)

Measuring HEP output

- A HEP is a **power plant**, being a system used to generate electrical power that can be used to perform work.
- HEP output is measured in **power**, reflecting rate at which energy is produced, measured in W.
- 1,000,000W = 1MW.

esentation 10, slide 13 (Mr Khan)

Firm Power for Kiru HEP

P_F = Firm Power (W)
Q_{MMD} = Flow Rate (m^3/sec)
H_n = Generating head (m)
ε = Efficiency (% of power retained)
ρ = Water density (1000 kg/m^2)
g = Gravity (9.81m/sec^2)

Assume Kiru HEP has an H_n of 100 and an ε of 90% (0.9)

$$P_F = Q_{MMD} H_n \varepsilon \rho g$$

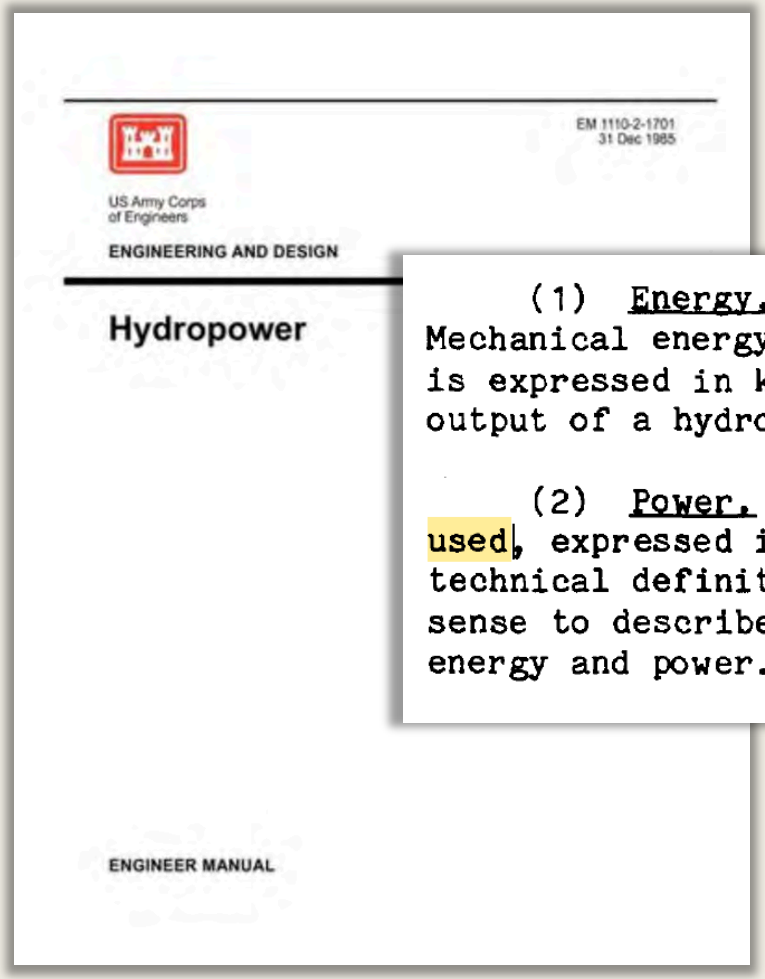
$$P_F = 65.3 \times 100 \times 0.9 \times 1000 \times 9.81$$

$$P_F = 57{,}653{,}370\text{W}$$

$$P_F = 57.65\text{MW}$$

fig. 11.2

Power versus energy (I)


EM 1110-2-1701
31 Dec 1985

US Army Corps
of Engineers

ENGINEERING AND DESIGN

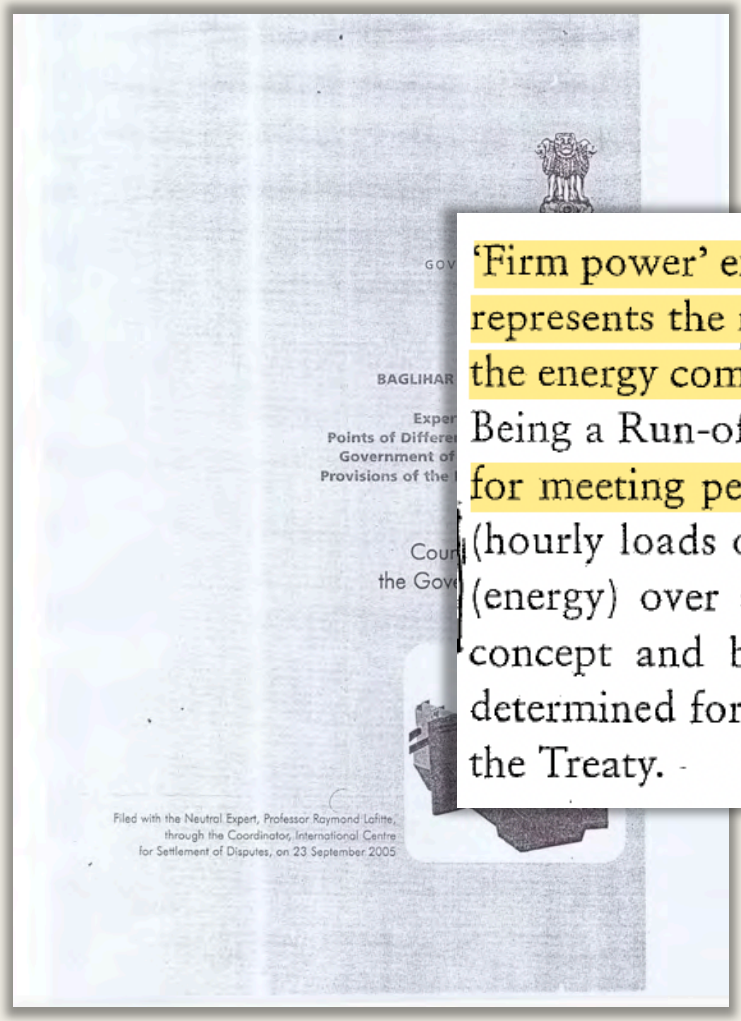
Hydropower

ENGINEER MANUAL

(1) Energy. Energy is that which is capable of doing work. Mechanical energy is expressed in foot-pounds, while electrical energy is expressed in kilowatt-hours (1 kWh = 2,656,000 ft-lbs.). The output of a hydroelectric plant is called electrical energy.

(2) Power. Power is the rate at which energy is produced or used, expressed in either horsepower or kilowatts. While this is the technical definition of power, the term is often used in a broad sense to describe the commodity of electricity, which includes both energy and power.

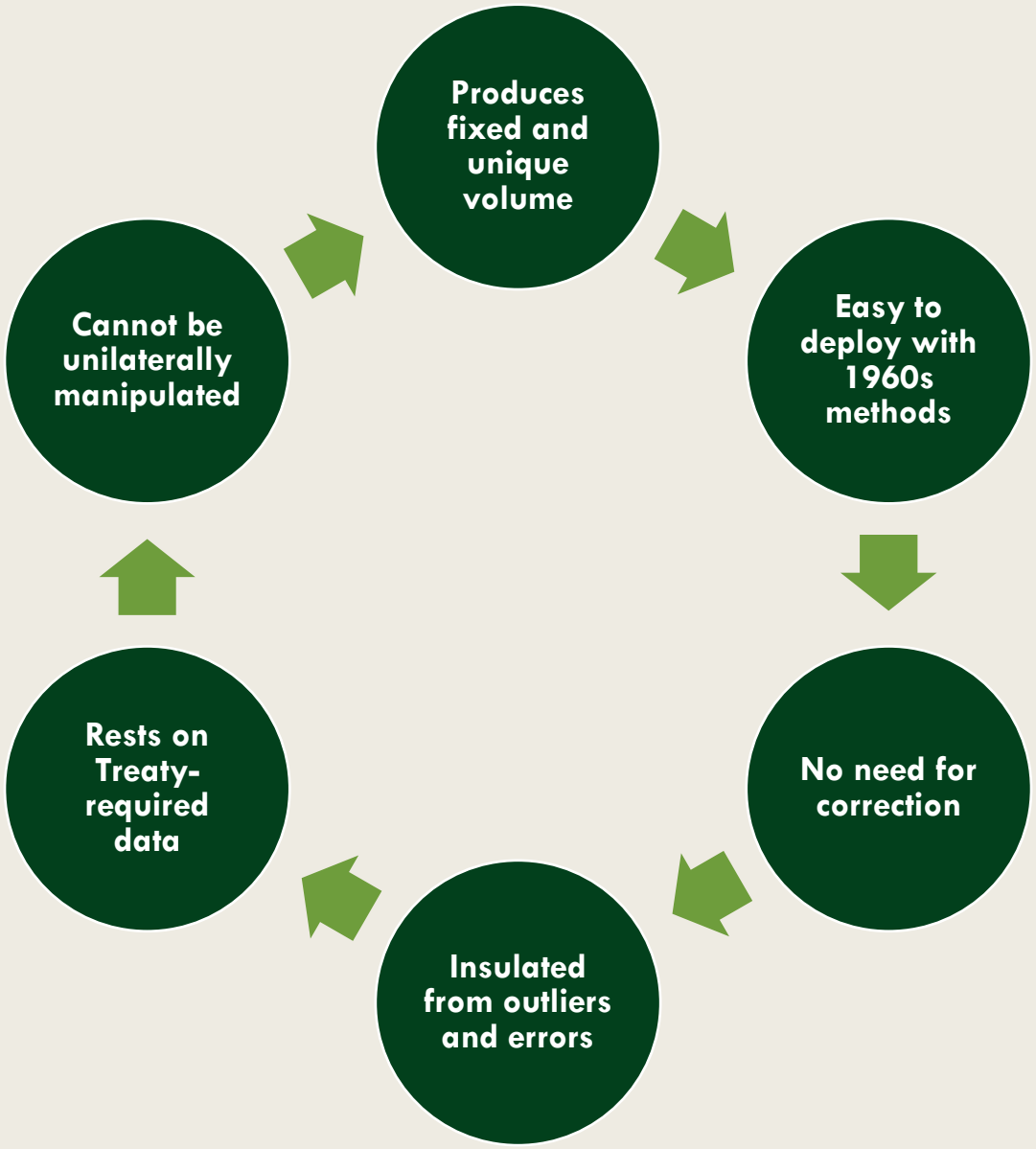
Power versus energy (II)



'Firm power' expressed in MW (worked out from minimum mean discharge) represents the minimum quantum of energy that would be available to meet the energy component of power demand on all the days throughout the year. Being a Run-of-River Plant with weekly Pondage, this firm energy is utilised for meeting peak demands of the system by varying the *turbine discharges* (hourly loads of the Plant) within the restrictions on the *volume* of releases (energy) over a weekly cycle, i.e. conforming to Firm Power. This is the concept and basis for determination of Pondage. Twice the amount so determined for Firm Power generation is permitted under Paragraph 8(c) of the Treaty.

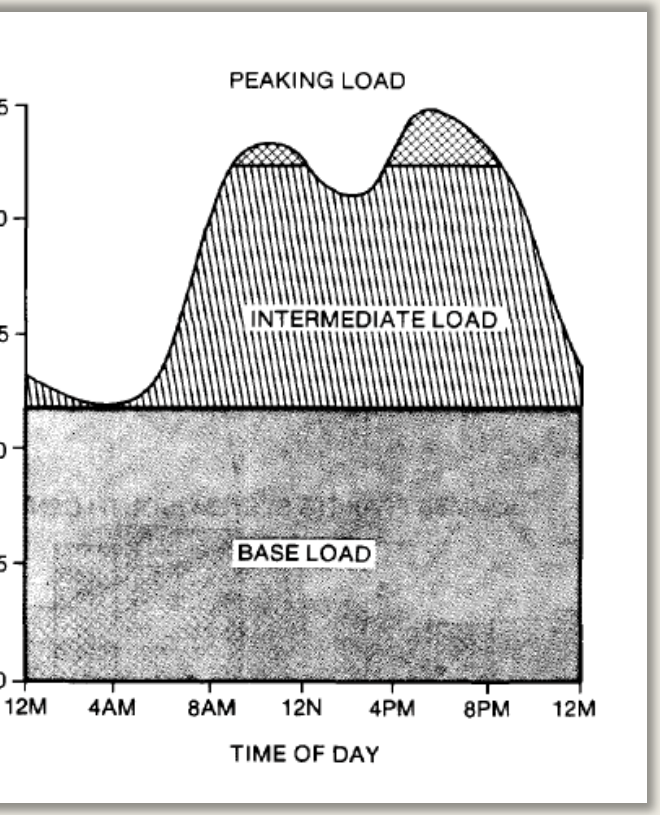
Part IV

Calculating maximum Pondage under Paragraph 8(c) of Annexure D

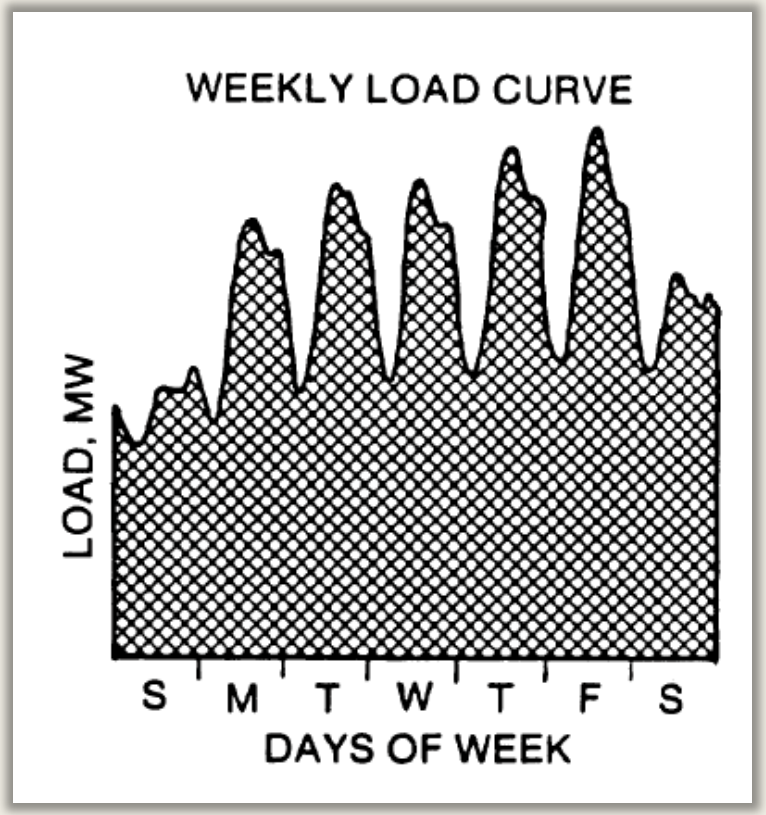


Sufficiency criteria for calculation of maximum Pondage

Daily Pondage and HEP operations



Storage regulation developments are defined as those in which an extensive impoundment at the power plant, or at the reservoir upstream of the power plant, allows for regulation of the flow downstream through storage. Water is stored during high-flow periods and is used to augment the flow during low-flow periods. This allows for a relatively constant supply of energy over the year. Significant storage is normally only used in large base-load plants. The word "storage" is used for long-term impounding of water to meet the seasonal fluctuation of water availability, whereas the word "pondage" refers to short-term storage of water, usually on a daily basis, to meet the diurnal variations in power demand.



0;
s, 2-3, 2-8

Daily references

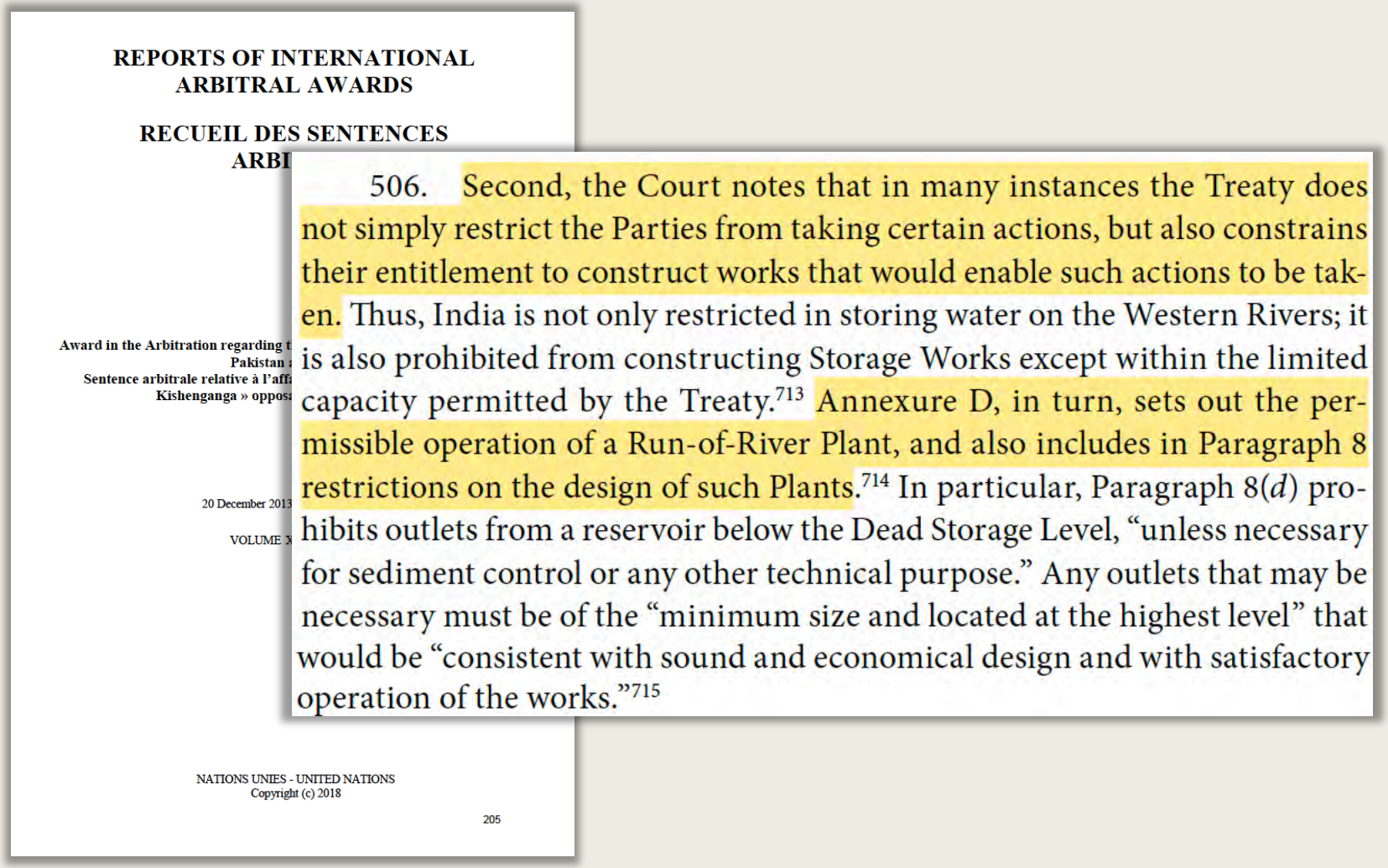
- Art I(15)(b)
- Art VI(1)
- Ann D, Para 2(c)
- Ann D, Para 2(h)
- Ann D, Para 15
- Ann D, App II, Para 2(b)
- Ann D, App II, Para 4(h)

Weekly references

- Ann D, Para 2(c)
- Ann D, Para 2(h)
- Ann D, App II, Para 2(b)
- Ann D, App II, Para 4(h)

Daily versus weekly reference in the Treaty

Paragraph 15 and Pondage (I)



REPORTS OF INTERNATIONAL ARBITRAL AWARDS

RECUEIL DES SENTENCES ARBI

Award in the Arbitration regarding t
Pakistan
Sentence arbitrale relative à l'affa
Kishenganga » opposa

20 December 2013

VOLUME X

506. Second, the Court notes that in many instances the Treaty does not simply restrict the Parties from taking certain actions, but also constrains their entitlement to construct works that would enable such actions to be taken. Thus, India is not only restricted in storing water on the Western Rivers; it is also prohibited from constructing Storage Works except within the limited capacity permitted by the Treaty.[713] Annexure D, in turn, sets out the permissible operation of a Run-of-River Plant, and also includes in Paragraph 8 restrictions on the design of such Plants.[714] In particular, Paragraph 8(*d*) prohibits outlets from a reservoir below the Dead Storage Level, "unless necessary for sediment control or any other technical purpose." Any outlets that may be necessary must be of the "minimum size and located at the highest level" that would be "consistent with sound and economical design and with satisfactory operation of the works."[715]

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Paragraph 15 and Pondage (II)

No. 6032

INDIA, PAKISTAN and INTERNATIONA
RECONSTRUCTION AND DEVELO

The Indus Waters Treaty 1960 (with annex
Karachi, on 19 September 1960

Protocol to the above-mentioned Treaty. Si
vember, 2 and 23 December 1960

Official text: English.

Registered by India on 16 January 1962.

INDE, PAKISTAN et BANQUE INTERNATI
LA RECONSTRUCTION ET LE DÉVEL

Traité de 1960 sur les eaux de l'Indus (avec
à Karachi, le 19 septembre 1960

Protocole relatif au Traité susmentionné.
novembre, 2 et 23 décembre 1960

Texte officiel: anglais.

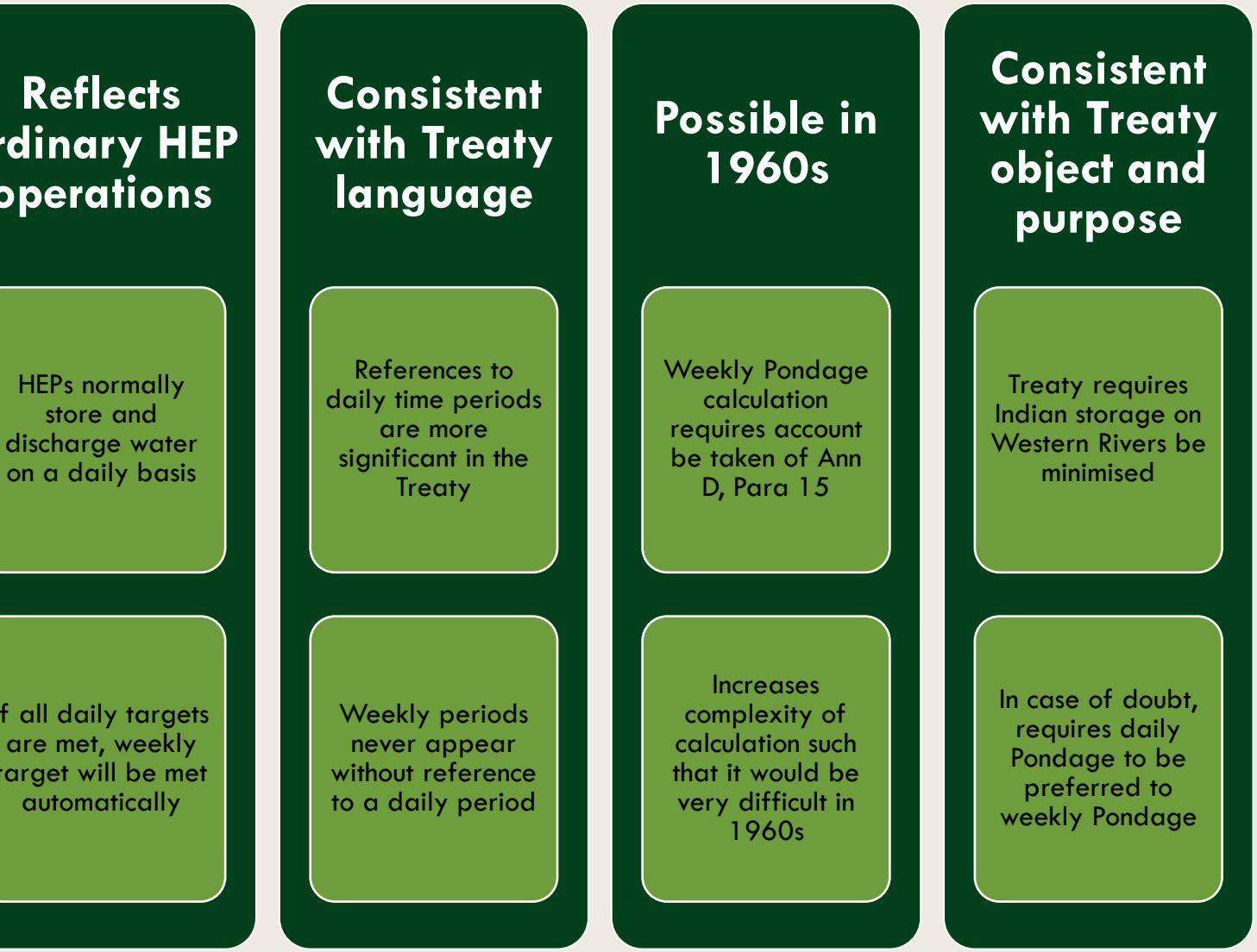
Enregistrés par l'Inde le 16 janvier 1962.

15. Subject to the provisions of Paragraph 17, the works connected with a Plant shall be so operated that (*a*) the volume of water received in the river upstream of the Plant, during any period of seven consecutive days, shall be delivered into the river below the Plant during the same seven-day period, and (*b*) in any one period of 24 hours within that seven-day period, the volume delivered into the river below the Plant shall be not less than 30%, and not more than 130%, of the volume received in the river above the Plant during the same 24-hour period : Provided however that :

(i) where a Plant is located at a site on the Chenab Main below Ramban, the volume of water received in the river upstream of the Plant in any one period of 24 hours shall be delivered into the river below the Plant within the same period of 24 hours ;

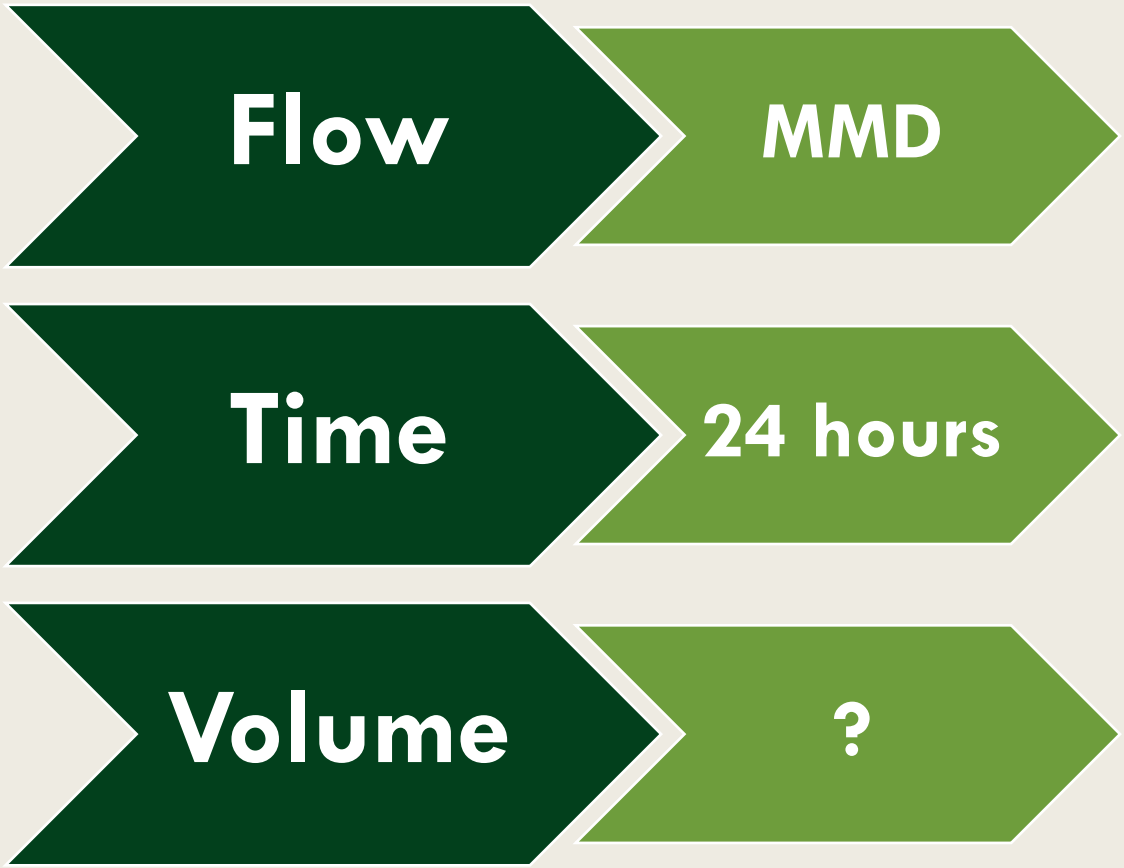
(ii) where a Plant is located at a site on the Chenab Main above Ramban, the volume of water delivered into the river below the Plant in any one period of 24 hours shall not be less than 50% and not more than 130%, of the volume received above the Plant during the same 24-hour period ; and

iii) where a Plant is located on a Tributary of The Jhelum on which Pakistan has any Agricultural use or hydro-electric use, the water released below the Plant may be delivered, if necessary, into another Tributary but only to the extent that the then existing Agricultural Use or hydro-electric use by Pakistan on the former Tributary would not be adversely affected.



Daily Pondage calculation plainly preferred

Pondage "*required for Firm Power*" (I)



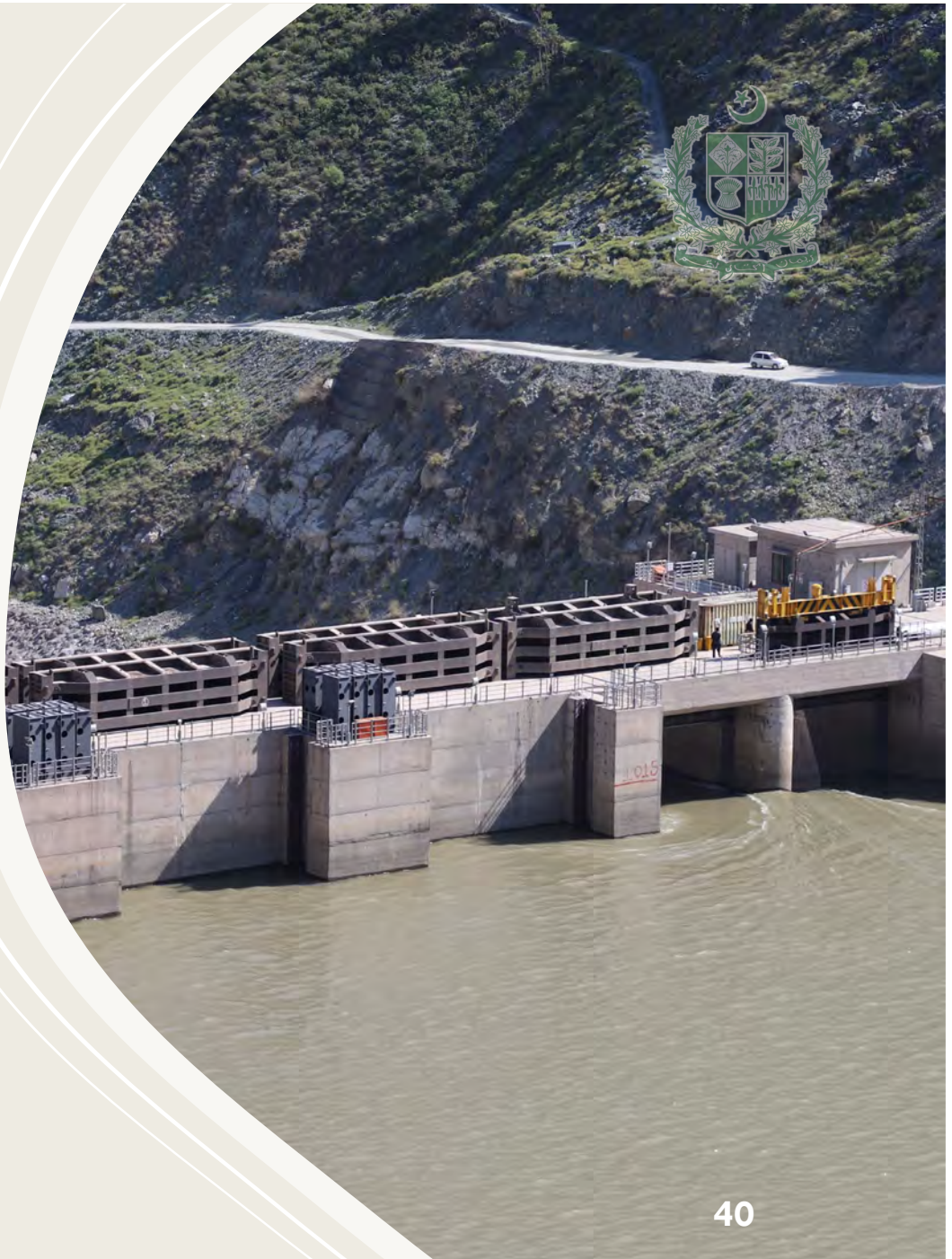
- Pondage is required to help the river achieve **MMD flow** so the HEP can produce **Firm Power.**
- The time period for assessment is **24 hours.**
- Only remaining question is the **Pondage volume** required to achieve this objective.

Pondage "*required for Firm Power*" (II)

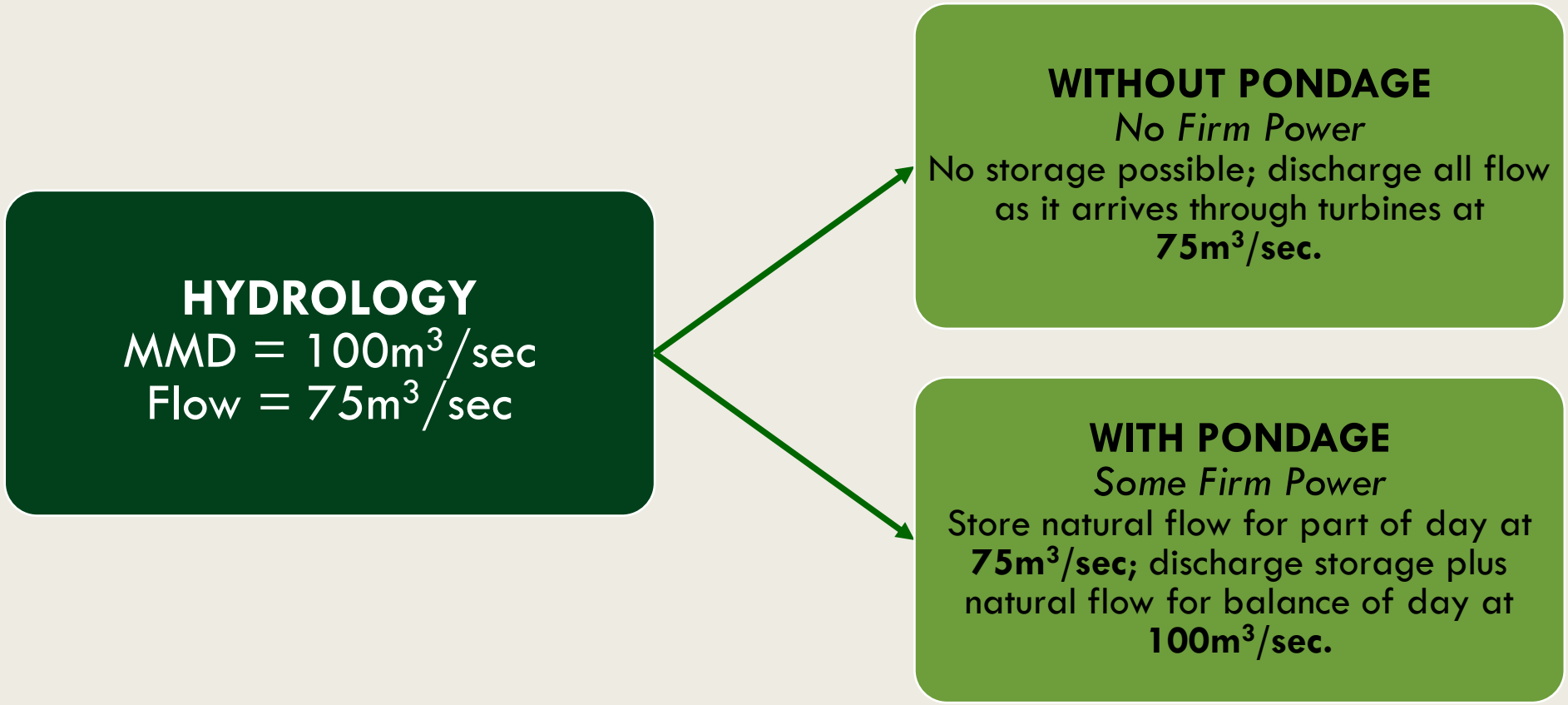
1. Where the river flows **at or above the MMD**, no Pondage is required for Firm Power production.
2. Where the river flows **less than the MMD**, Pondage is required for Firm Power production.
3. Paragraph 8(c) assumes that Pondage is required for Firm Power where the river flow is **less than the MMD**.
4. The volume of Pondage required for Firm Power depends on the difference between the **natural river flow** and the **MMD** over a **24-hour period**.
5. Paragraph 8(c) **cannot** be interpreted to require a HEP to produce constant Firm Power throughout the dry season.

Pondage "*required for Firm Power*" (III)

Pondage "*required for Firm Power*": the **volume of storage** required to ensure that **all inflow** received in a HEP's reservoir in **each 24-hour period** can be discharged through the turbines **at the MMD** within the **same 24-hour period.**



Pondage "*required for Firm Power*" (IV)



Pondage "*required for Firm Power*" (V)

MMD = 100m^3/sec
DAILY FLOW = 75m^3/sec

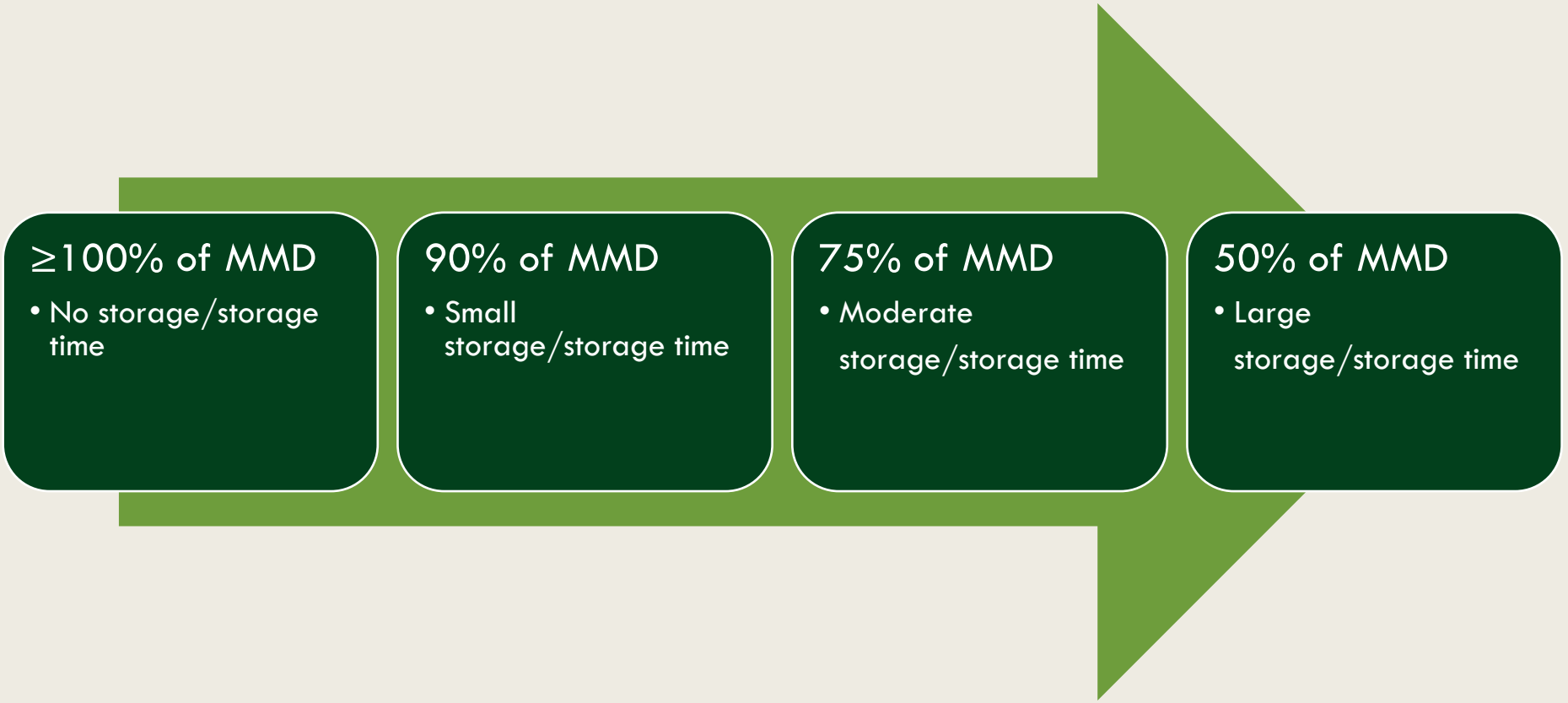
75m^3/sec × 60 sec × 60 mins × 24 hours = 6,480,000m^3
Total daily inflow = 6.48Mm^3

6,480,000m^3 ÷ 100m^3/sec = 64,000 sec
18 hours of Firm Power production

100,000 seconds – 64,000 sec = 36,000 sec
6 hours of Pondage storage

75m^3/sec × 36,000 sec = 1,620,000m^3
1.62Mm^3 of Pondage required for Firm Power

Pondage "*required for Firm Power*" (VI)

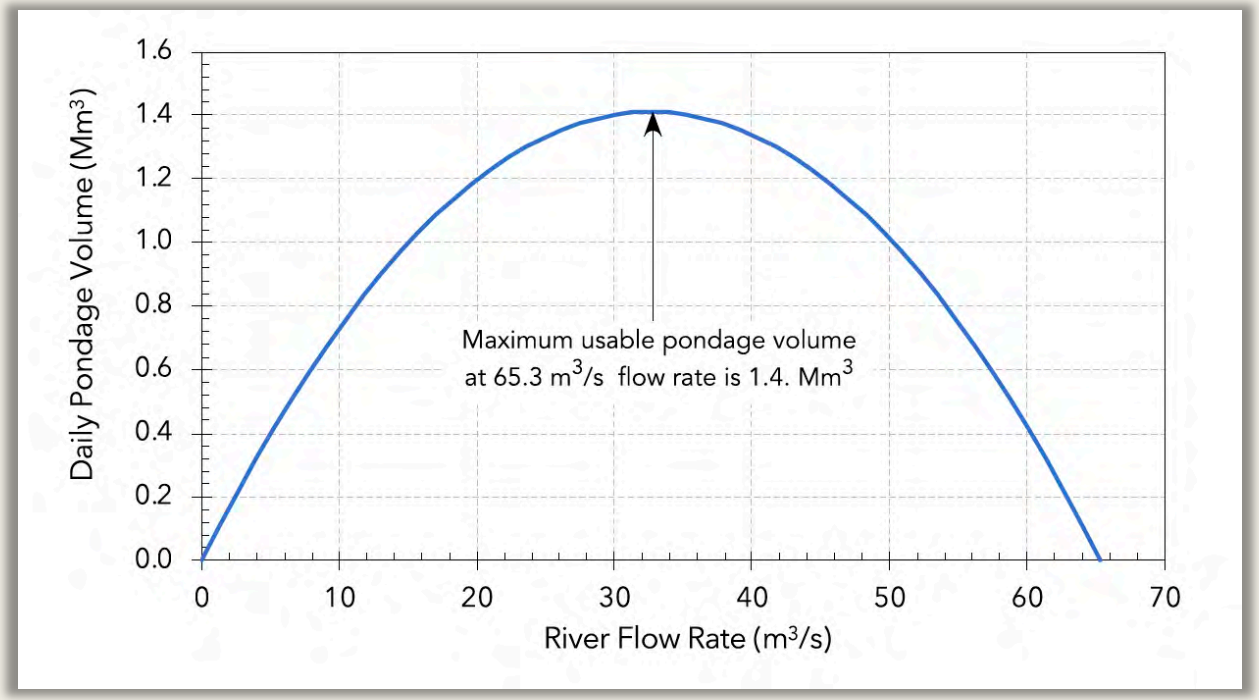


Pondage "*required for Firm Power*" (VII)

[A] Inflow (MMD %)	[B] Production time (hours)	[C] Filling time (hours)	[D] Volume stored (hours of MMD)	[E] Pondage volume (Mm^3)
100	24	0	0.00	0.00
75	18	6	4.50	1.06
66.7	16	8	5.33	1.25
58.3	14	10	5.83	1.37
50	12	12	6.00	1.41
41.7	10	14	5.83	1.37
33.3	8	16	5.33	1.25

Fig 11.3

Pondage "*required for Firm Power*" (VIII)

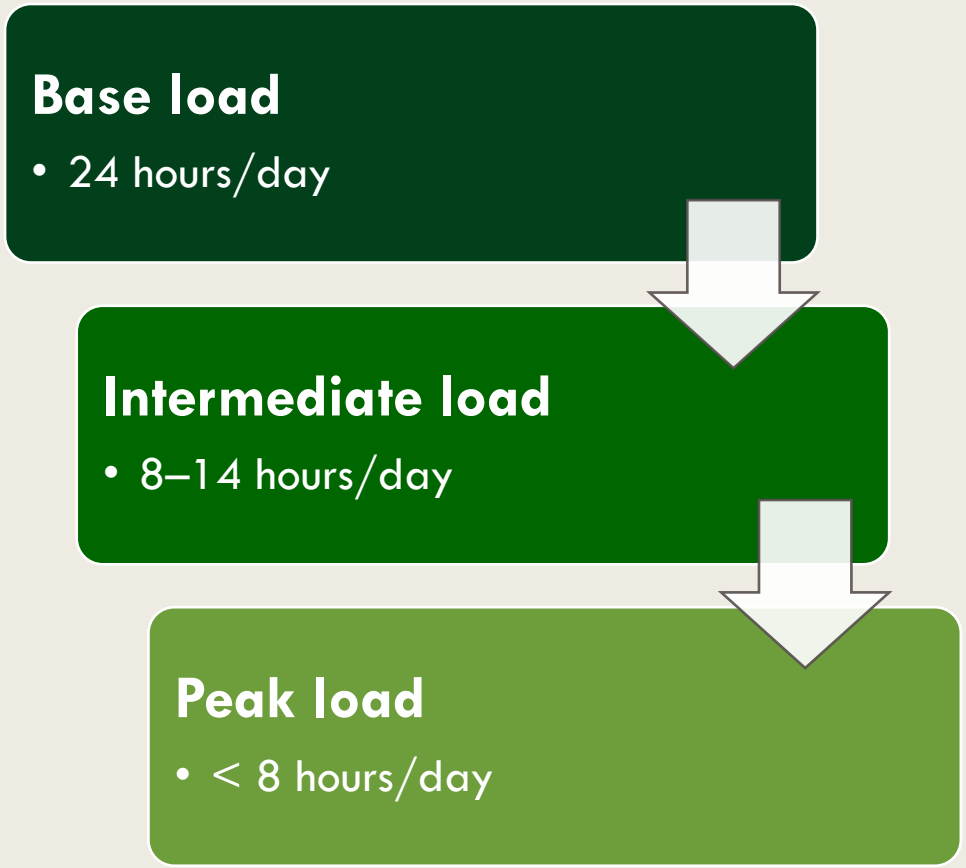


- Past a certain level of inflow, the quantum of usable storage decreases.
- The largest amount of useable storage fixes the Pondage "*required for Firm Power*".
- Guarantees the HEP can produce Firm Power for the longest amount of time per day in any sub-MMD flow conditions.

Result always equals 12 hours of storage at 50% of MMD.

Fig 11.4

Pondage "*required for Firm Power*" (IX)



KIRU HEP

- **≥ 58.3% of MMD:** greater than intermediate Firm Power produced.
- **33.3% –58.3% of MMD:** intermediate Firm Power produced.
- **< 33.3% of MMD:** peaking Firm Power produced.

RATLE HEP

- Lowest recorded flow is **24.72m^3/sec** (23% of MMD).
- **5 hours** of Firm Power produced from **19 hours** of storage.
- Sufficient to meet at least **one daily peak.**

4
¶ 11.83(c) (fn 886)

Calculating the Operating Pool (I)

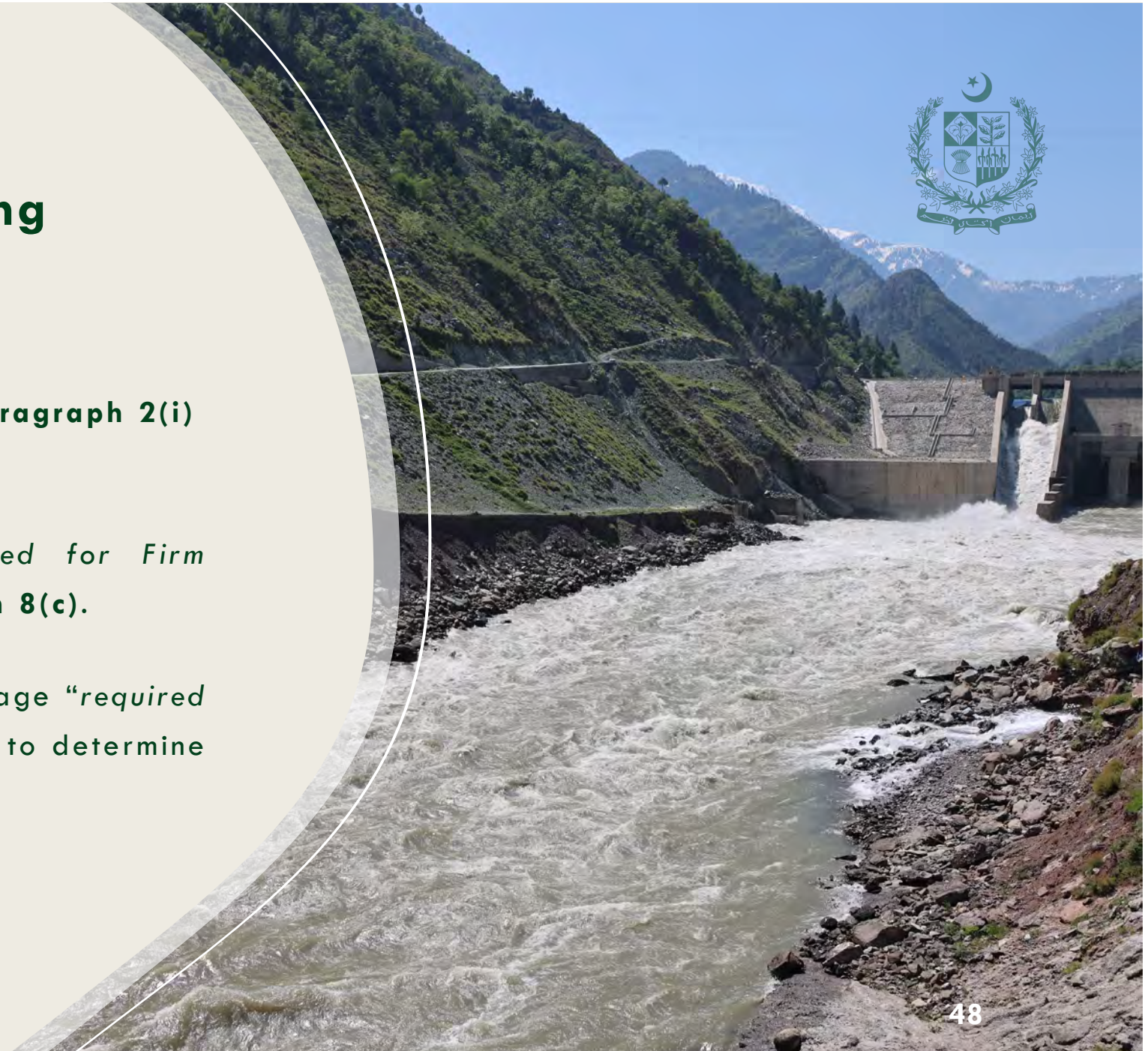
- Paragraph 8(c) provides that **maximum Pondage** is "*twice the Pondage required for Firm Power*".
    - Kiru HEP Pondage "*required for Firm Power*": **1.41Mm³**.
    - Kiru HEP Operating Pool: **2.82Mm³**.
- Doubling allows operating flexibility – including ability to take advantage of **Paragraph 15**.
- Paragraph 8(c) is an **essential safeguard** for Paragraph 15.

Calculating the Operating Pool (II)

- **Step 1:** Calculate the MMD using **Paragraph 2(i)** and HEP site historical flow data.

- **Step 2:** Derive Pondage "*required for Firm Power*" from the MMD under **Paragraph 8(c)**.

- **Step 3:** Double the amount of Pondage "*required for Firm Power*" under **Paragraph 8(c)** to determine size of the Operating Pool.



Advantages to Pakistan's approach

Complies with the Treaty — Rooted in Paragraphs 8(c) and 2(i) of Annexure D.

Provides meaningful Firm Power — Provides Firm Power in all flow conditions – then doubles it.

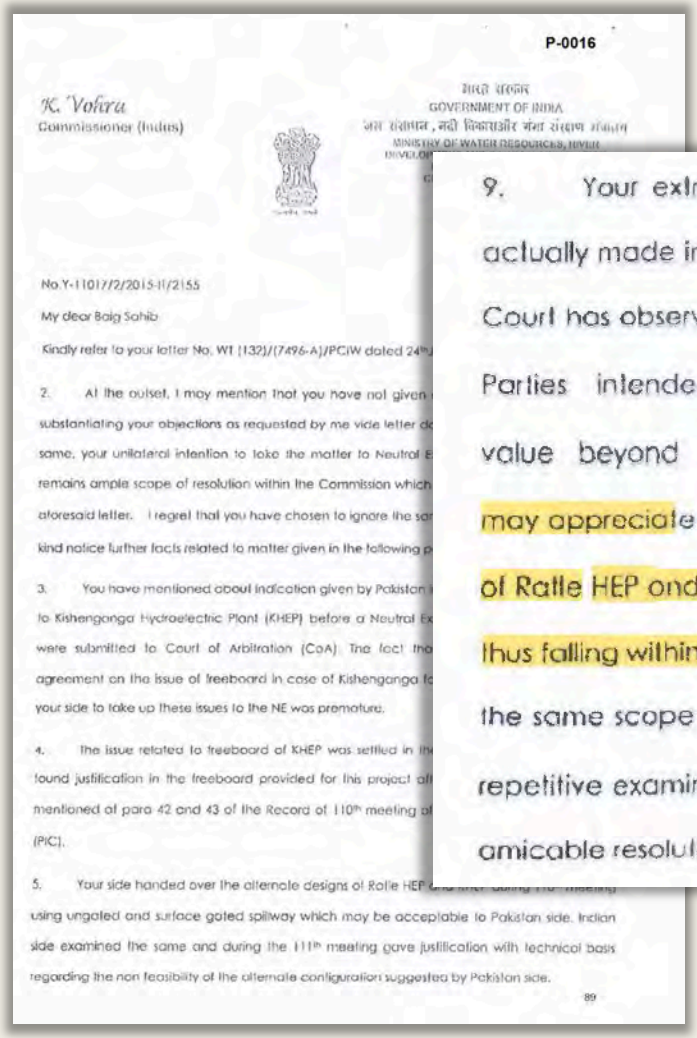
Meets sufficiency criteria — Meets all Treaty-derived sufficiency criteria.

1. **Provides a fixed and unique volume of Pondage derived from the MMD.**
2. **Can be easily deployed using 1960s tools.**
3. **Does not require constant correction and remains fit for purpose.**
4. **Is not sensitive to errors or omissions in input data.**
5. **Is rooted in data that India must provide under Appendix II of Annexure D.**
6. **Does not allow either Party to manipulate the result unilaterally.**

Part V

India's case on Pondage

India adopts the *Baglihar* approach



P-0016

K. Vohra
Commissioner (Indus)

GOVERNMENT OF INDIA

No.Y-1101/7/2015-II/2155

My dear Baig Sahib

Kindly refer to your letter No. WT (132)/(7496-A)/PCIW dated 24th

2. At the outset, I may mention that you have not given substantiating your objections as requested by me vide letter d same, your unilateral intention to take the matter to Neutral E remains ample scope of resolution within the Commission which aforesaid letter. I regret that you have chosen to ignore the sa kind notice further facts related to matter given in the following p

3. You have mentioned about indication given by Pakistan to Kishenganga Hydroelectric Plant (KHEP) before a Neutral Ex were submitted to Court of Arbitration (CoA). The fact tha agreement on the issue of freeboard in case of Kishenganga fa your side to take up these issues to the NE was premature.

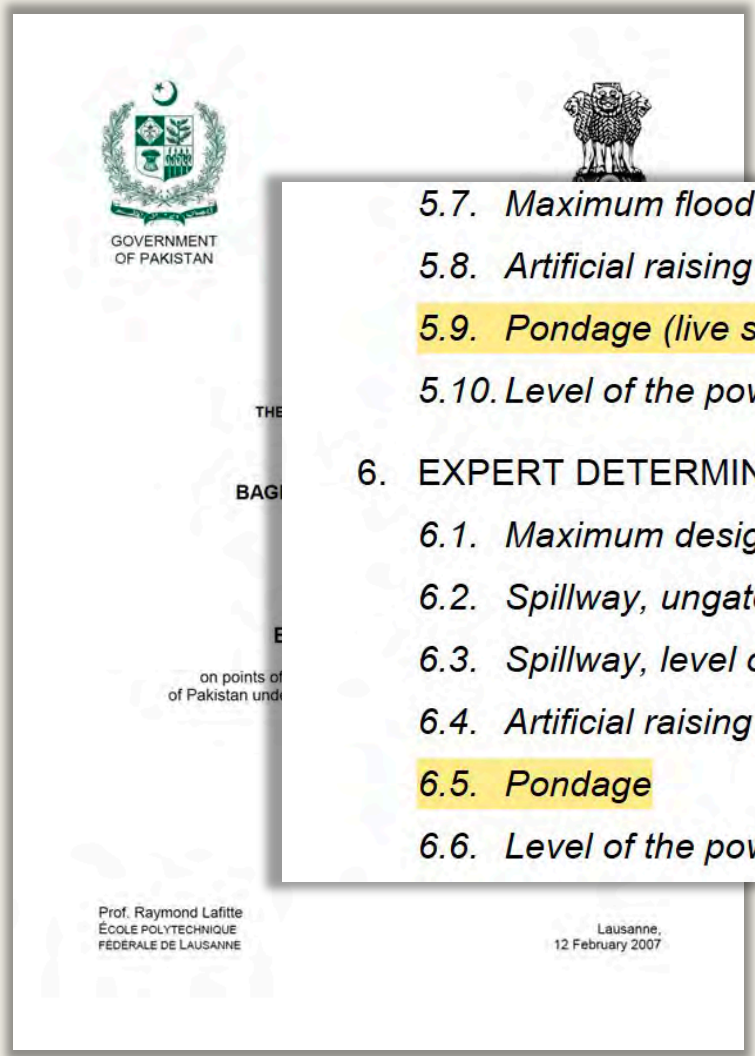
4. The issue related to freeboard of KHEP was settled in the found justification in the freeboard provided for this project af mentioned at para 42 and 43 of the Record of 110th meeting of (PIC).

5. Your side handed over the alternate designs of Ratle HEP using ungated and surface gated spillway which may be acceptable to Pakistan side. Indian side examined the same and during the 111th meeting gave justification with technical basis regarding the non feasibility of the alternate configuration suggested by Pakistan side.

89

9. Your extrapolation of Court's observation at para 8 of your above letter, which was actually made in context of admissibility of drawdown flushing, is not relevant to Pondage issue. Court has observed that "the Court does not see in Annexure F any indication that the Parties intended a neutral expert's determination to have a general precedential value beyond the scope of the particular matter before him" (emphasis supplied). You may appreciate that your present objections on the principle of calculation of pondage in case of Ratle HEP and KHEP are same as the one raised before the Neutral Expert in case of Baglihar, thus falling within the same scope. Indian side has always maintained that a neutral decision on the same scope obtained through Treaty-based dispute-resolution mechanism would eliminate repetitive examination of the same issue thereby serving as a template to achieve quicker and amicable resolution in the Commission itself in an expeditious manner.

The *Baglihar* approach to maximum Pondage (I)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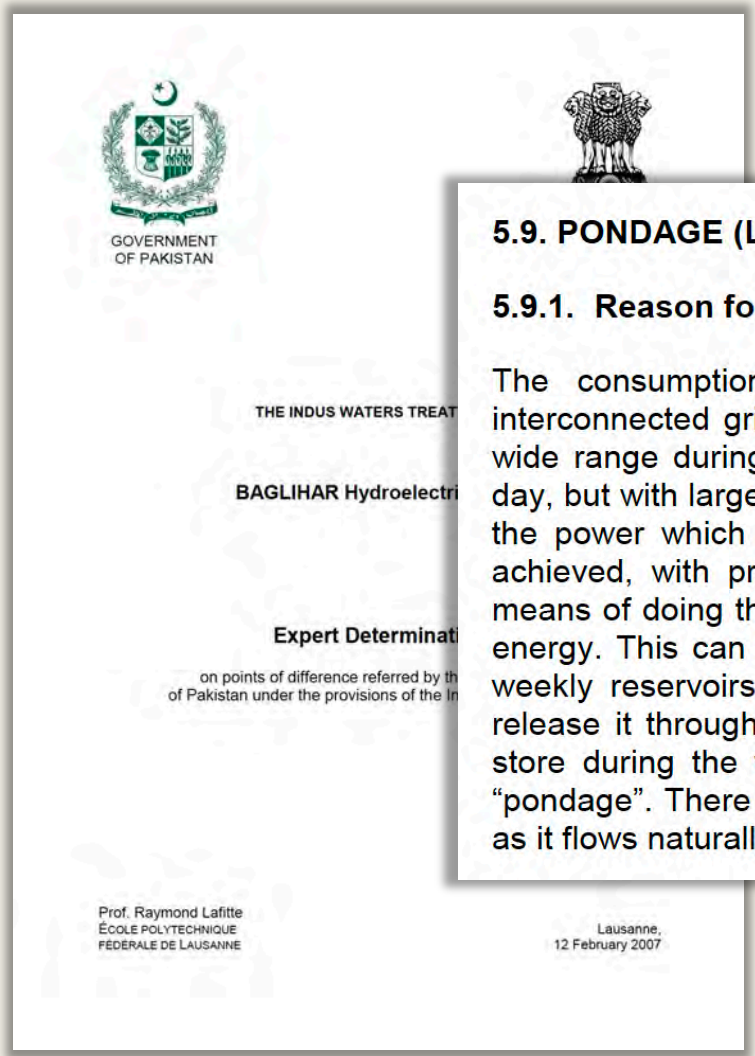
Prof. Raymond Lafitte
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Lausanne,
12 February 2007

The *Baglihar* approach to maximum Pondage (II)



GOVERNMENT
OF PAKISTAN

THE INDUS WATERS TREAT

BAGLIHAR Hydroelectri

Expert Determinati

on points of difference referred by th
of Pakistan under the provisions of the In

Prof. Raymond Lafitte
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

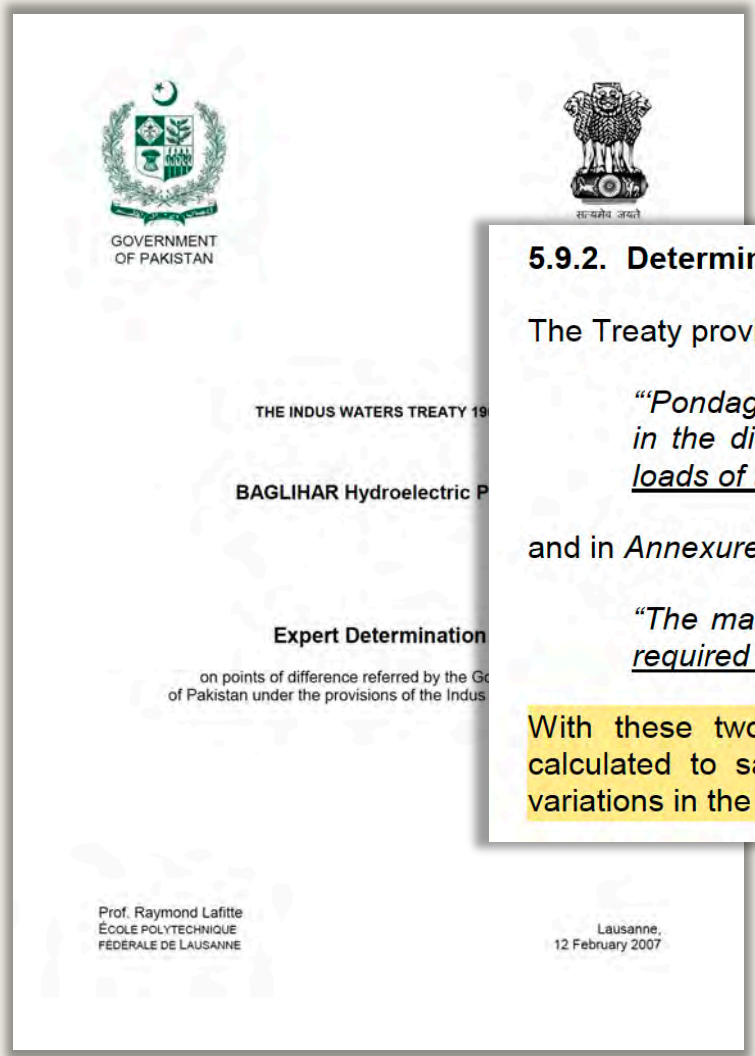
Lausanne,
12 February 2007

5.9. PONDAGE (LIVE STORAGE)

5.9.1. Reason for pondage

The consumption of electrical energy by industrial or domestic consumers in an interconnected grid varies throughout the year, and the available power also varies over a wide range during the day. On the other hand, river flows fluctuate moderately during the day, but with large seasonal variations. So an imbalance occurs between power demand and the power which can be produced by a river with its natural flow. A balance should be achieved, with production being adapted to meet consumer demand. One of the major means of doing this is to store water; this is the most efficient system for large quantities of energy. This can be done with a seasonal reservoir, or by run-of-river plants, with daily or weekly reservoirs. In this case they can, for example, store water during the night and release it through turbines during the day, principally during peak load hours, or they can store during the weekend and operate the plant during working days. This is known as "pondage". There are also pure run-of-river plants, without pondage, which exploit the water as it flows naturally.

The *Baglihar* approach to maximum Pondage (III)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OF PAKISTAN

THE INDUS WATERS TREATY 19

BAGLIHAR Hydroelectric P

Expert Determination

on points of difference referred by the Go
of Pakistan under the provisions of the Indus

Prof. Raymond Lafitte
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Lausanne,
12 February 2007

5.9.2. Determination of pondage

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

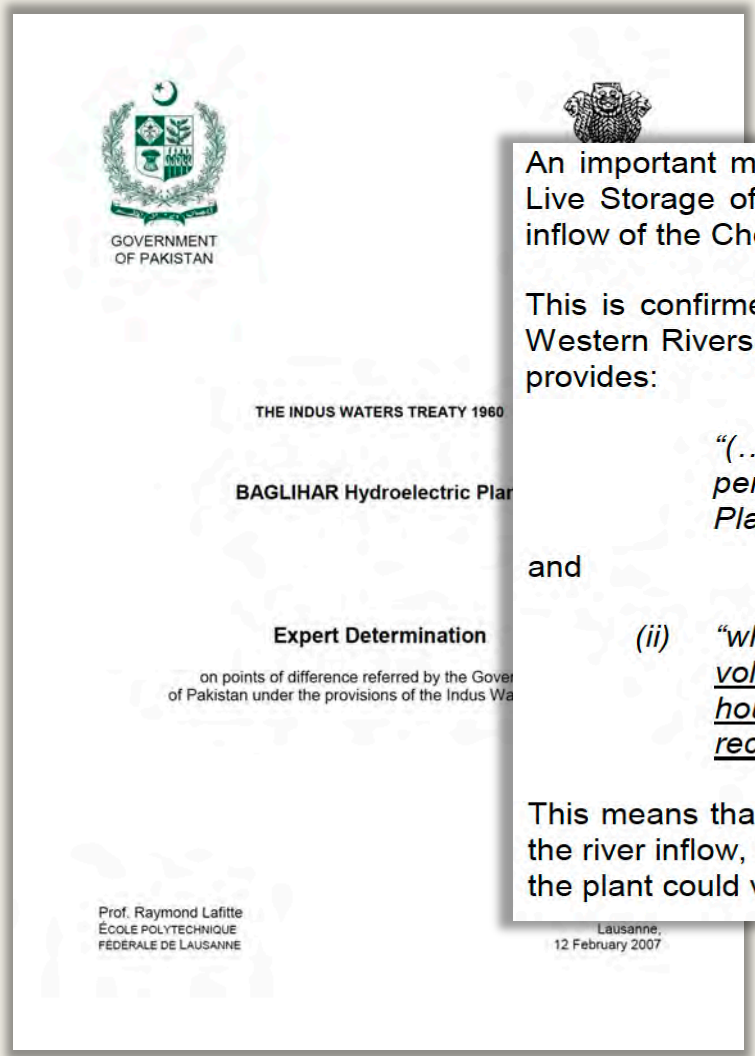
> *"'Pondage' means Live Storage of only sufficient magnitude to meet the fluctuations in the discharge of the turbines arising from variations in the daily and the weekly loads of the plant."*[103]

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".*[104]

With these two provisions, the Treaty specifies that the pondage volume should be calculated to satisfy daily or weekly load variations of the plant and consequently the variations in the turbine discharge necessary to produce this variable demand of power.

The *Baglihar* approach to maximum Pondage (IV)



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Lausanne,
12 February 2007

An important matter to be stressed is that the Treaty does not say that "Pondage" means Live Storage of only sufficient magnitude to meet the fluctuations of the daily and weekly inflow of the Chenab river.

This is confirmed by the Treaty which fixes the limitation of India's use of water from the Western Rivers. According to *Annexure D, Part 3 - New Run-of-River Plants, Paragraph 15* provides:

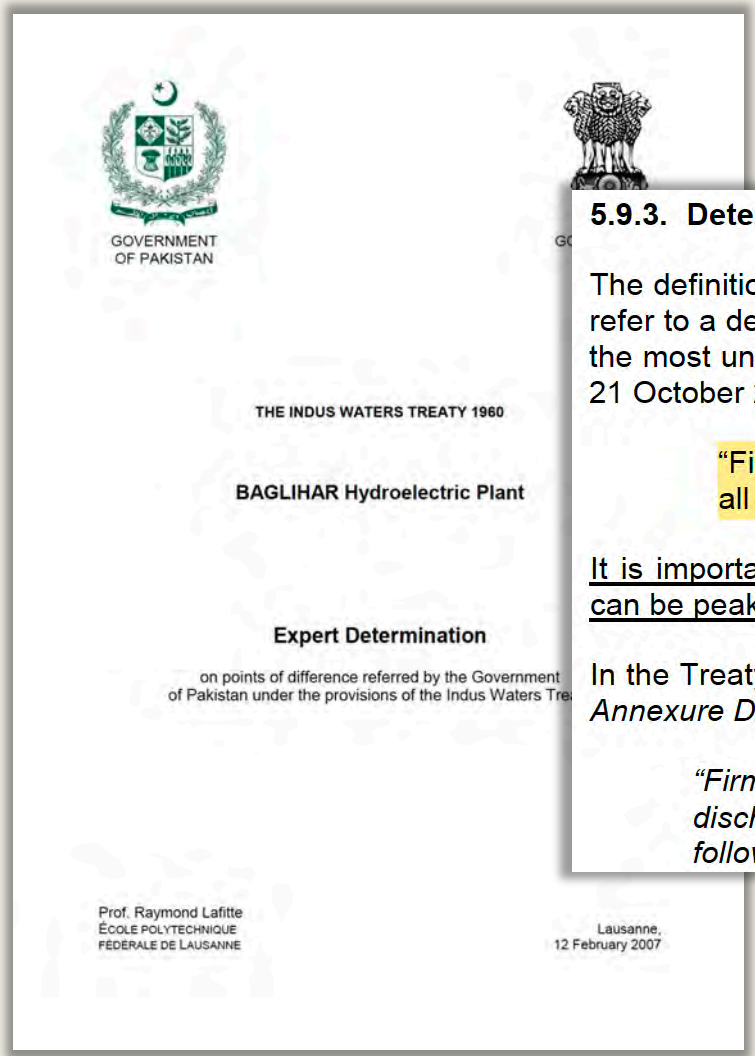
> *"(…) the volume of water received in the river upstream of the Plant, during any period of seven consecutive days, shall be delivered into the river below the Plant during the same seven-day period (…)"*

and

> *(ii) "where a Plant is located at a site on the Chenab Main river above Ramban, the volume of water delivered into the river below the Plant in any one period of 24 hours shall not be less than 50% and not more than 130% of the volume received above the Plant during the same 24-hour period; (…)"*[105]

This means that the plant could turbine, during one day, a discharge which is different from the river inflow, but not lower than 50% and not higher than 130%; consequently the power of the plant could vary.

The *Baglihar* approach to maximum Pondage (V)



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5.9.3. Determination of firm power

The definition of firm power is given in many manuals and guidelines. The NE has chosen to refer to a definition given by American Society of Civil Engineers, which appears to him to be the most understandable and which was mentioned by the Parties during Meeting No. 2, 19-21 October 2005, in Geneva,[106] providing:

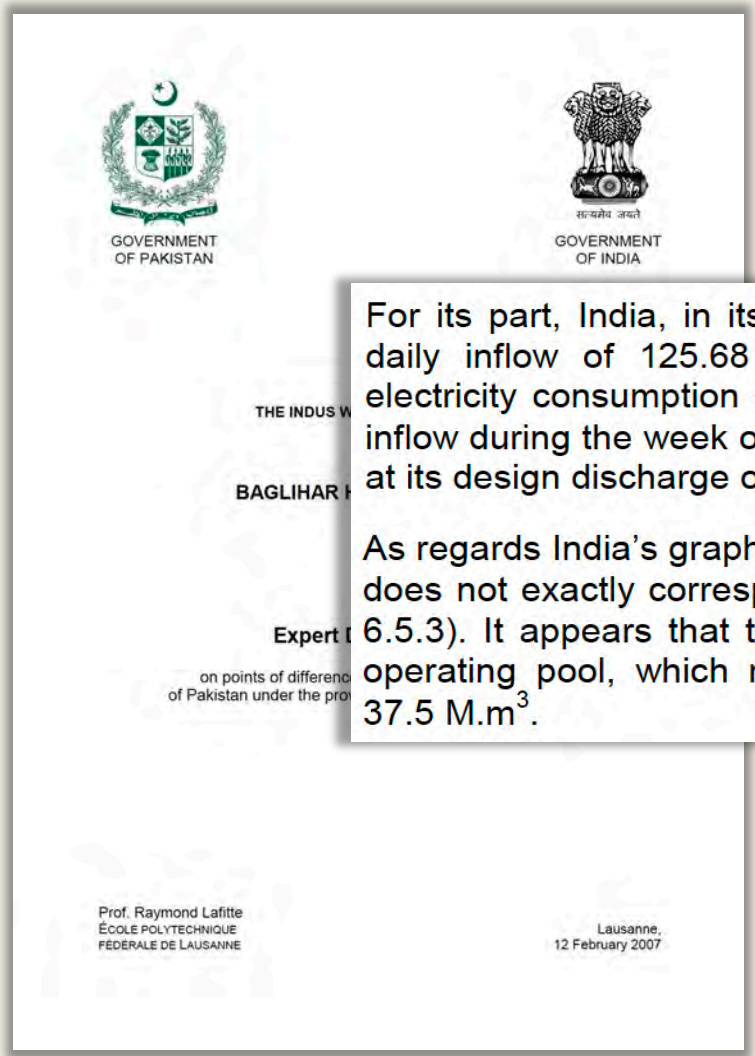
> "Firm Power: Power intended to have assured availability to the customer to meet all or any agreed upon portion of his load requirements."

It is important to highlight[107] that firm power, according to the requirements of consumers, can be peak load or base load.

In the Treaty, the definition of firm power, which is in fact a method of calculation, is given in *Annexure D, Part 1 – Definitions, 2(i) stating*:

> *"Firm Power" means the hydro-electric power corresponding to the minimum mean discharge at the site of a plant, the minimum mean discharge being calculated as follows:*

The *Baglihar* approach to maximum Pondage (VI)



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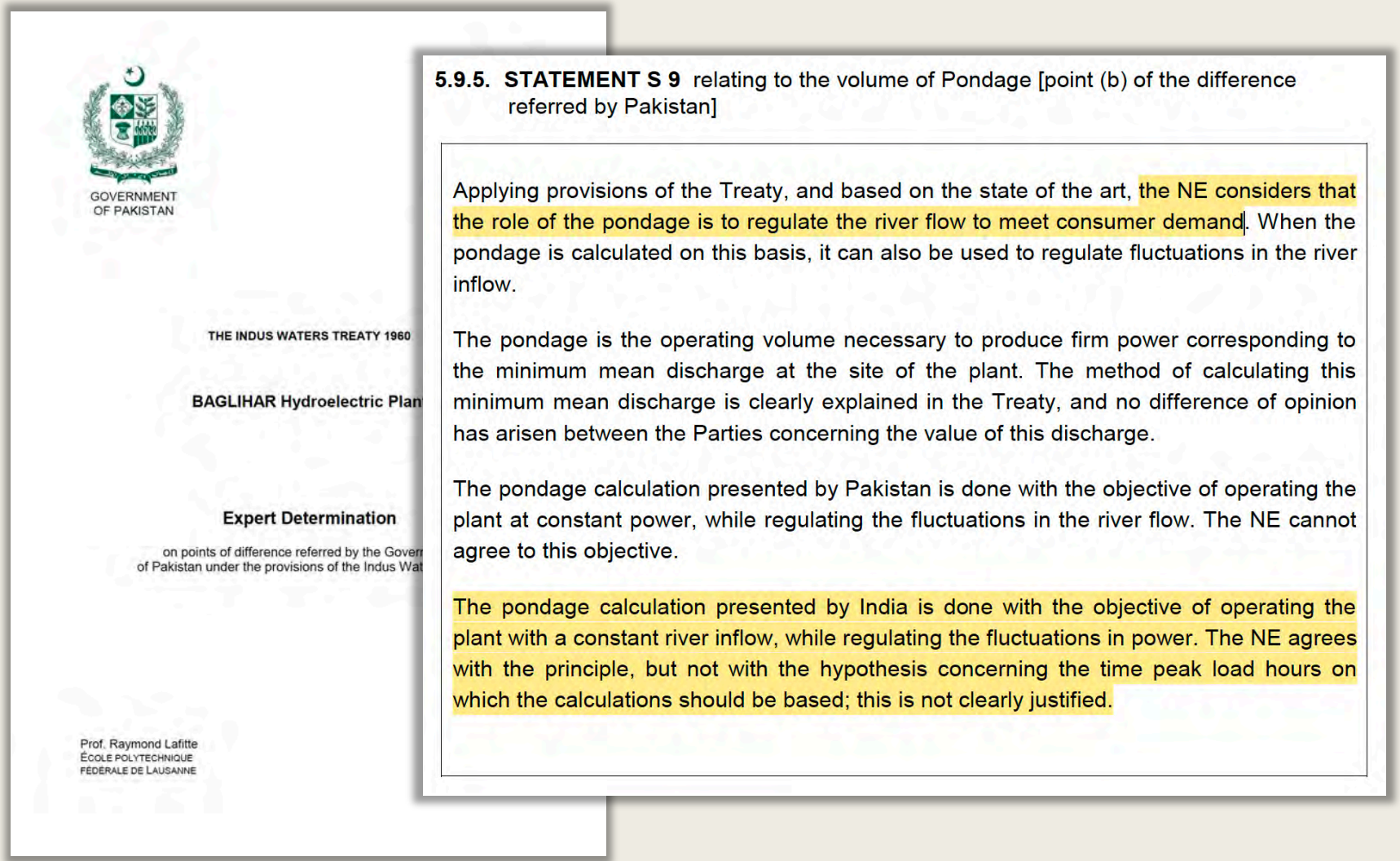
For its part, India, in its Counter-Memorial, determined the pondage based on a constant daily inflow of 125.68 m^3/s and with variations in turbine discharge corresponding to electricity consumption and especially to the peak load hours. Respecting the mean value inflow during the week of 125.68 m^3/s, the plant would only operate for 49.11 hours per week at its design discharge of 430 m^3/s and its installed capacity of 450 MW.

As regards India's graph, the time of peak load hours on Tuesday, Wednesday and Thursday does not exactly correspond to the power demand of the Northern Region in winter (Annex 6.5.3). It appears that this pattern of peak load hours is favourable to the increase of the operating pool, which reaches 18.75 $M.m^3$, and finally to the pondage which is double: 37.5 $M.m^3$.

The *Baglihar* approach to maximum Pondage (VII)



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5.9.5. STATEMENT S 9 relating to the volume of Pondage [point (b) of the difference referred by Pakistan]

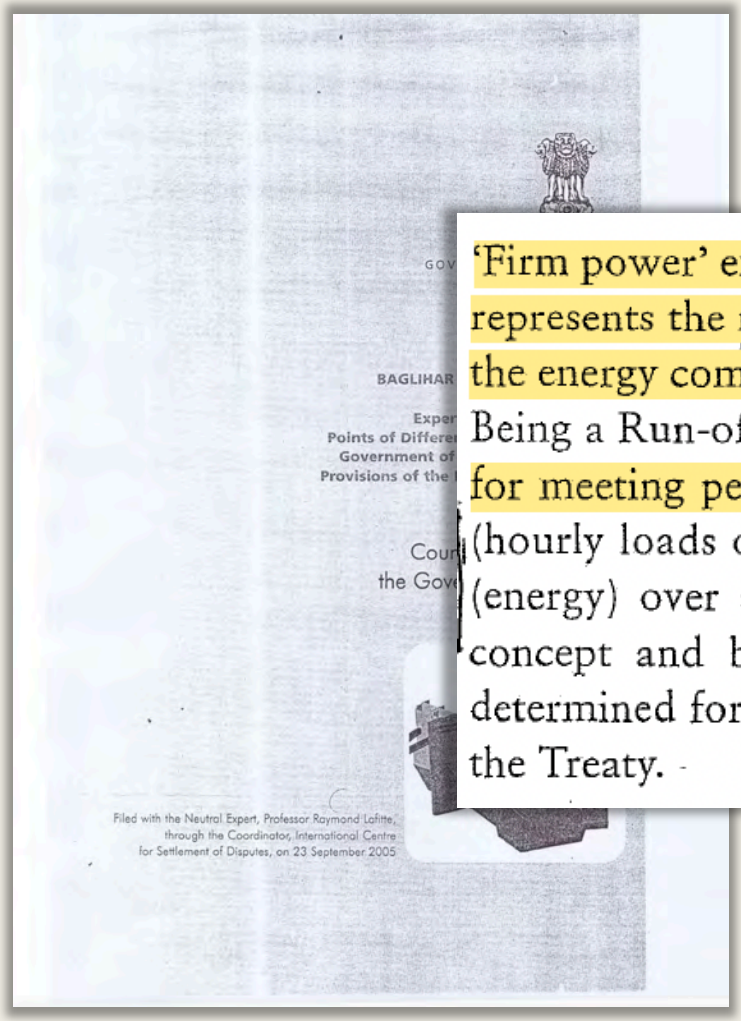
Applying provisions of the Treaty, and based on the state of the art, the NE considers that the role of the pondage is to regulate the river flow to meet consumer demand. When the pondage is calculated on this basis, it can also be used to regulate fluctuations in the river inflow.

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 is 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 calculations should be based; this is not clearly justified.

The *Baglihar* approach to maximum Pondage (VIII)



'Firm power' expressed in MW (worked out from minimum mean discharge) represents the minimum quantum of energy that would be available to meet the energy component of power demand on all the days throughout the year. Being a Run-of-River Plant with weekly Pondage, this firm energy is utilised for meeting peak demands of the system by varying the *turbine discharges* (hourly loads of the Plant) within the restrictions on the *volume* of releases (energy) over a weekly cycle, i.e. conforming to Firm Power. This is the concept and basis for determination of Pondage. Twice the amount so determined for Firm Power generation is permitted under Paragraph 8(c) of the Treaty.

The *Baglihar* approach to maximum Pondage (IX)

Step 1
- Assume all inflow into the HEP reservoir for entire week is at the MMD.

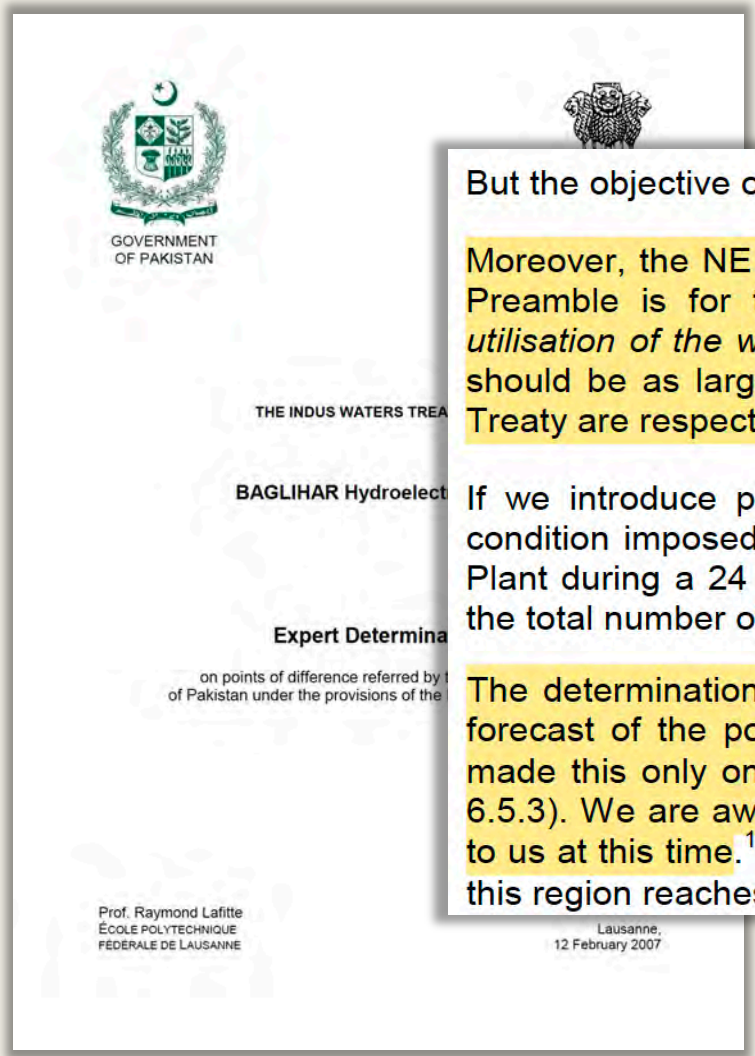
Step 2
- Assume the HEP will operate continually during the week with a discharge through the turbines above or below the MMD.

Step 3
- Set a schedule in accordance with Paragraph 15 of Annexure D, assuming there will always be increased storage during the weekend and increased discharge during the week.

Step 4
- Use a series of mass curves to determine the total Live Storage required for such an operation to take place week-by-week.

Step 5
- Double the Live Storage so calculated pursuant to Paragraph 8(c).

The *Baglihar* approach to maximum Pondage (X)



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12 February 2007

But the objective of the pondage is to enable operation during peak load hours.

Moreover, the NE cannot ignore the fact that one of the object(s) and purpose(s) of the Preamble is for the two parties to attain *"(…) the most complete and satisfactory utilisation of the waters of the Indus system of rivers (…)"*. In this context, the pondage should be as large as possible, with the condition, naturally, that the provisions of the Treaty are respected. In particular, the rule mentioned in Point 2 above is fundamental.

If we introduce peak load hours in the mode of operation described in Point 2, the condition imposed by the Treaty, the volume of water delivered into the river below the Plant during a 24 hour day (no less than 50%, no more than 130%) determines exactly the total number of peak load hours during the week and the distribution each day.

The determination of the time of the peak load during each day should be based on a forecast of the power demand over 15 or 20 years in the Northern Region. We have made this only on the basis of the graph of power demand in December 2004 (Annex 6.5.3). We are aware of all the uncertainties of this approach, but it is the best available to us at this time.[153] The 49.1 hours of peak load are produced when the total demand in this region reaches approximately 22,500 MW.

The *Baglihar* approach to maximum Pondage (XI)

Baglihar HEP Pondage volume: **32.56Mm³**			
72 hours of continuous Firm Power discharge (131MW).	**21 hours** of continuous installed capacity discharge (450MW).	**8.5 times** the size of the NJHEP (969MW) operating pool (3.8Mm³).	**3 days to fill** if Chenab Main flows at the MMD (125.68m³/sec).

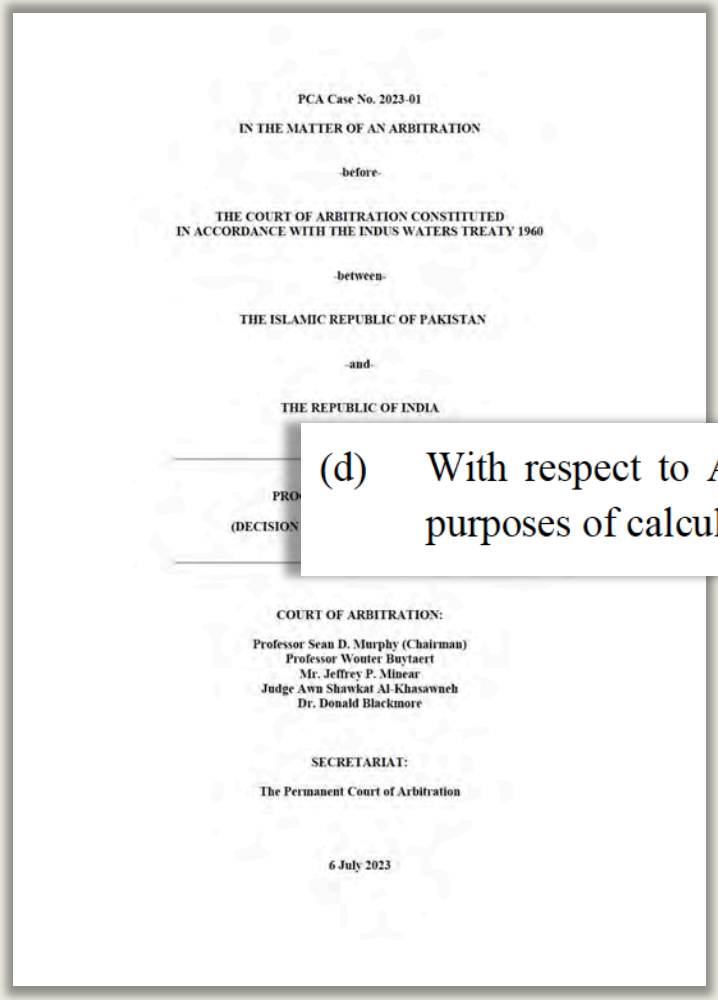
Disadvantages to India's approach

Does not comply with the Treaty	Neglects and distorts Paragraphs 8(c) and 2(i) of Annexure D.	**1. Does not derive Pondage from the MMD.**
		2. Computation using 1960s tools not straightforward.
Gives more Pondage than required for Firm Power	Predicated on giving India the capacity to produce Secondary Power	**3. Requires correction and is quickly rendered unfit for purpose.**
		4. Is sensitive to errors or omissions in input data.
Does not meet sufficiency criteria	Fails all Treaty-derived sufficiency criteria.	**5. Is not rooted in data that India must provide under Appendix II of Annexure D.**
		6. Allows India to manipulate the result unilaterally.

Part VI

Answering the Court's question on Pondage

The Court's Pondage question reconsidered



PCA Case No. 2023-01

IN THE MATTER OF AN ARBITRATION

-before-

THE COURT OF ARBITRATION CONSTITUTED
IN ACCORDANCE WITH THE INDUS WATERS TREATY 1960

-between-

THE ISLAMIC REPUBLIC OF PAKISTAN

-and-

THE REPUBLIC OF INDIA

PRO

(DECISION

COURT OF ARBITRATION:

Professor Sean D. Murphy (Chairman)
Professor Wouter Buytaert
Mr. Jeffrey P. Minear
Judge Awn Shawkat Al-Khasawneh
Dr. Donald Blackmore

SECRETARIAT:

The Permanent Court of Arbitration

6 July 2023

(d) With respect to Annexure D, paragraph 8(c), what is to be taken into account for the purposes of calculating maximum pondage for a plant and what is to be excluded?

d)

Relevant and irrelevant factors for Pondage calculation

Relevant factors

- Paragraphs 8(c) and 2(i) of Annexure D
- Relationship between Firm Power and MMD
- Need to pass all inflow received in 24 hours through turbines at the MMD in the same 24 hours
- Need to double resulting amount

Irrelevant factors

- Paragraphs 2(c) and 15 of Annexure D
- Information not required to be provided by India under Appendix II of Annexure D
- Any other extra-Treaty material
- Any calculation techniques not available in 1960
- Any other matters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