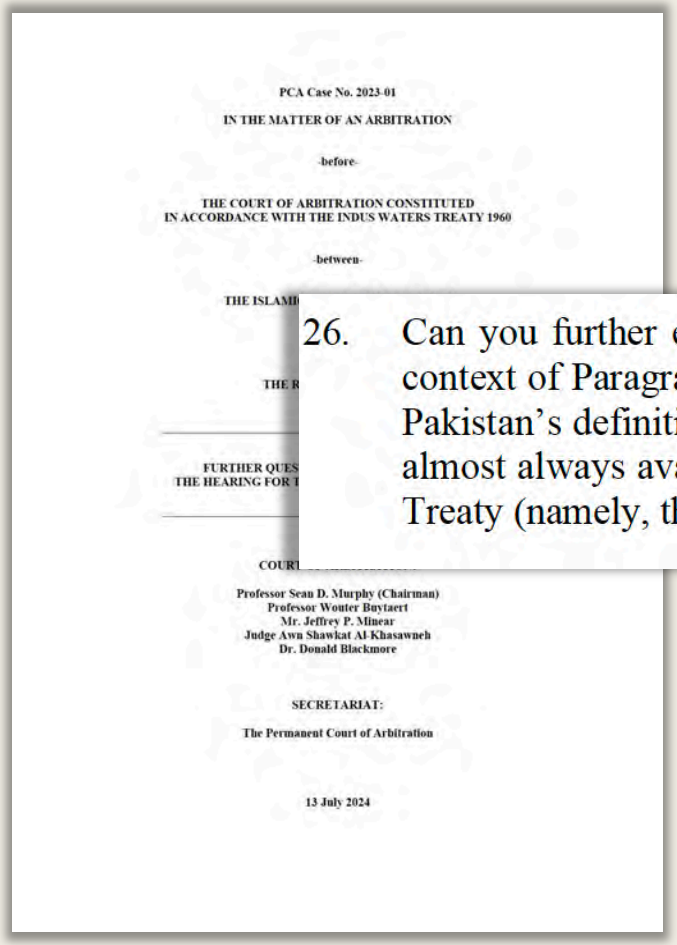
# Questions on Pondage

*Peter J Rae*

15 July 2024

# Question 26



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-

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

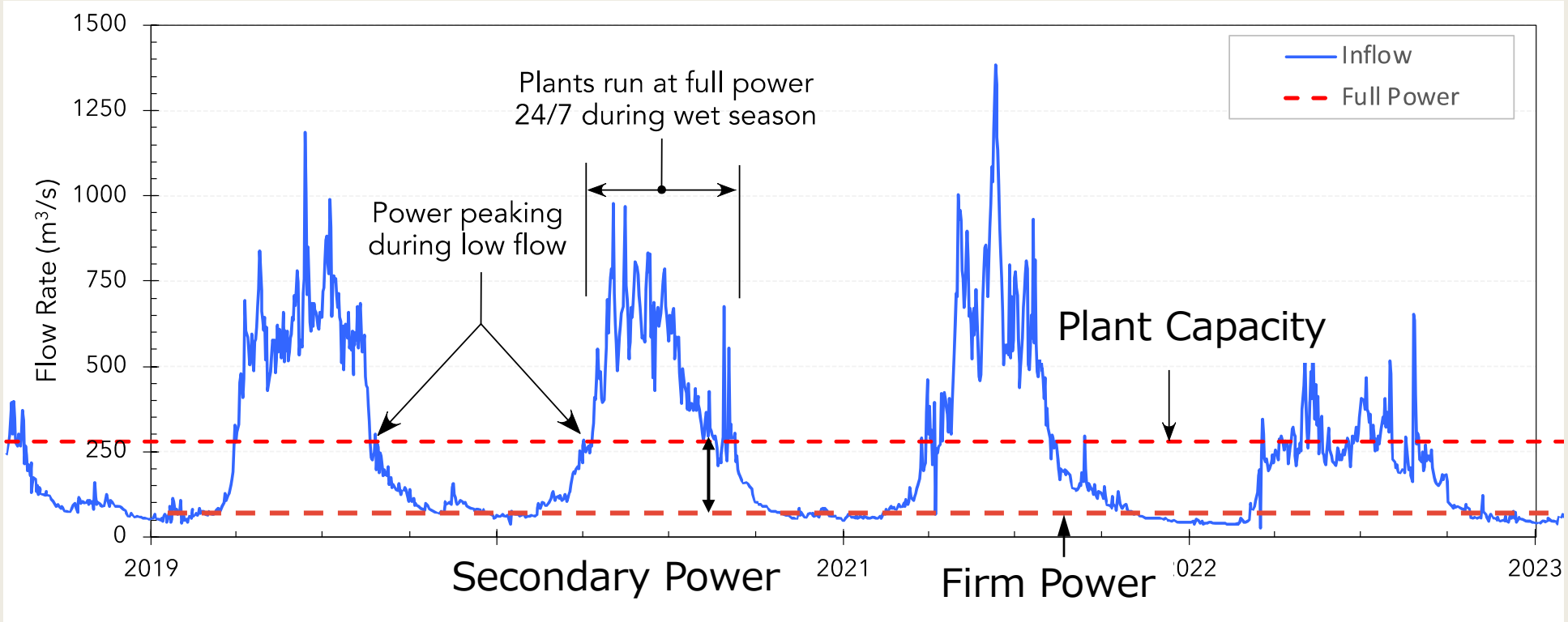
SECRETARIAT:

The Permanent Court of Arbitration

13 July 2024

26. Can you further explain: (a) the potential relevance of Secondary Power, in particular, in the context of Paragraph 8(b) of Annexure D; and (b) how it interacts with Firm Power? Assuming Pakistan's definition of Firm Power, is Secondary Power (that is, power other than Firm Power) almost always available? How is that consistent with the definition of Secondary Power in the Treaty (namely, that it is "available only during certain periods of the year")?

# Annual flow hydrograph



# Question 26(a)

26. Can you further explain: (a) the potential relevance of Secondary Power, in particular, in the context of Paragraph 8(b) of Annexure D; and (b) how it interacts with Firm Power? Assuming Pakistan's definition of Firm Power, is Secondary Power (that is, power other than Firm Power) almost always available? How is that consistent with the definition of Secondary Power in the Treaty (namely, that it is "available only during certain periods of the year")?

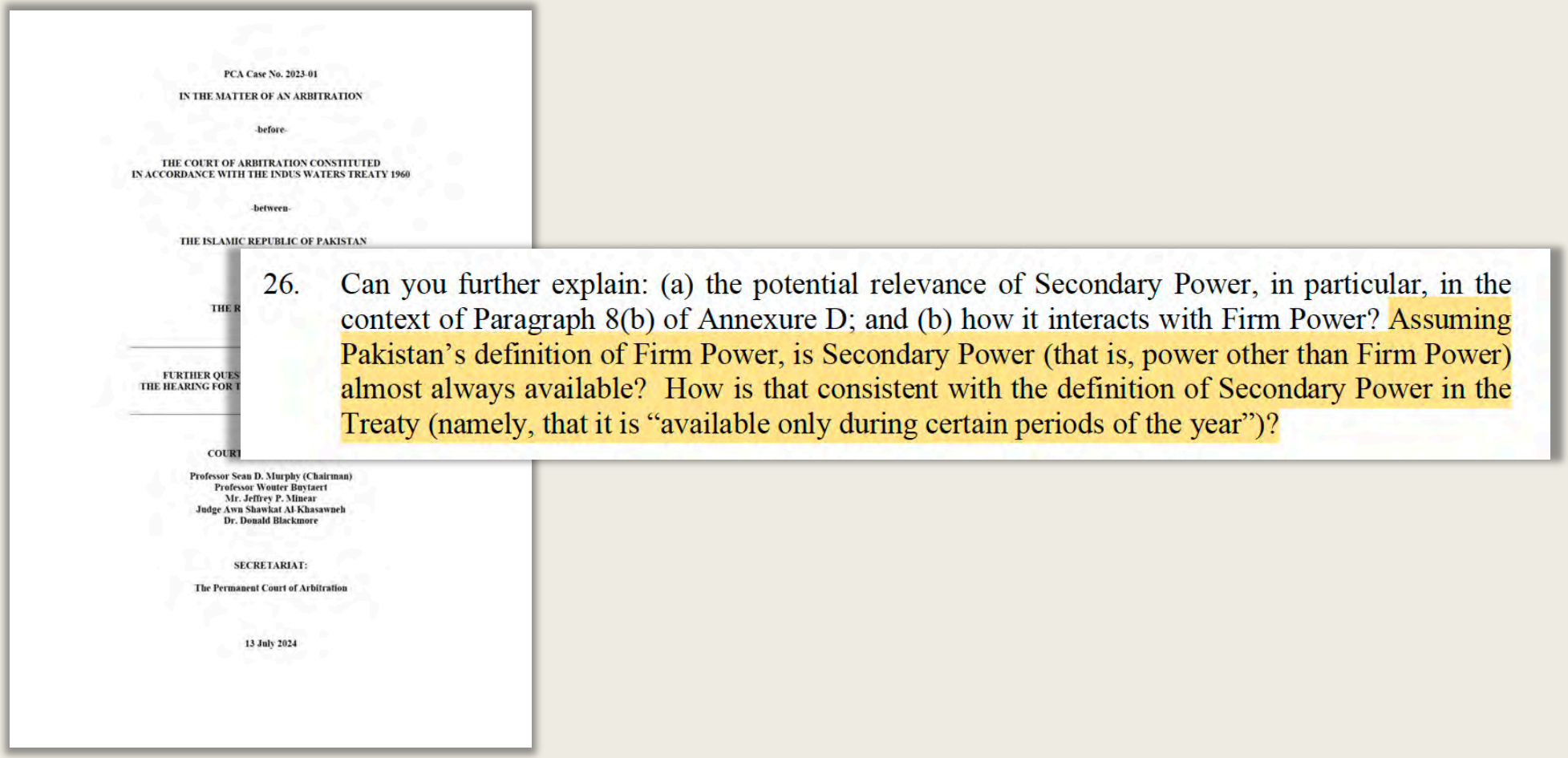
- Treaty allows for the design of a plant to accommodate the need for Secondary Power
- Para 8(b), Ann D: "*The design of the works shall take due account of the requirements of* [...] *Secondary Power*".
- Secondary Power is not included in any other Paragraph 8 design criteria

# Question 26(b)

26. Can you further explain: (a) the potential relevance of Secondary Power, in particular, in the context of Paragraph 8(b) of Annexure D; and (b) how it interacts with Firm Power? Assuming Pakistan's definition of Firm Power, is Secondary Power (that is, power other than Firm Power) almost always available? How is that consistent with the definition of Secondary Power in the Treaty (namely, that it is "available only during certain periods of the year")?

- Firm Power is determined from the Treaty (Para 2(i), Ann D).
- Installed capacity is determined by economic optimization.
- Secondary Power is the difference between the installed capacity of the HEP and the Firm Power provided by the hydrology.

# Question 26 (further)



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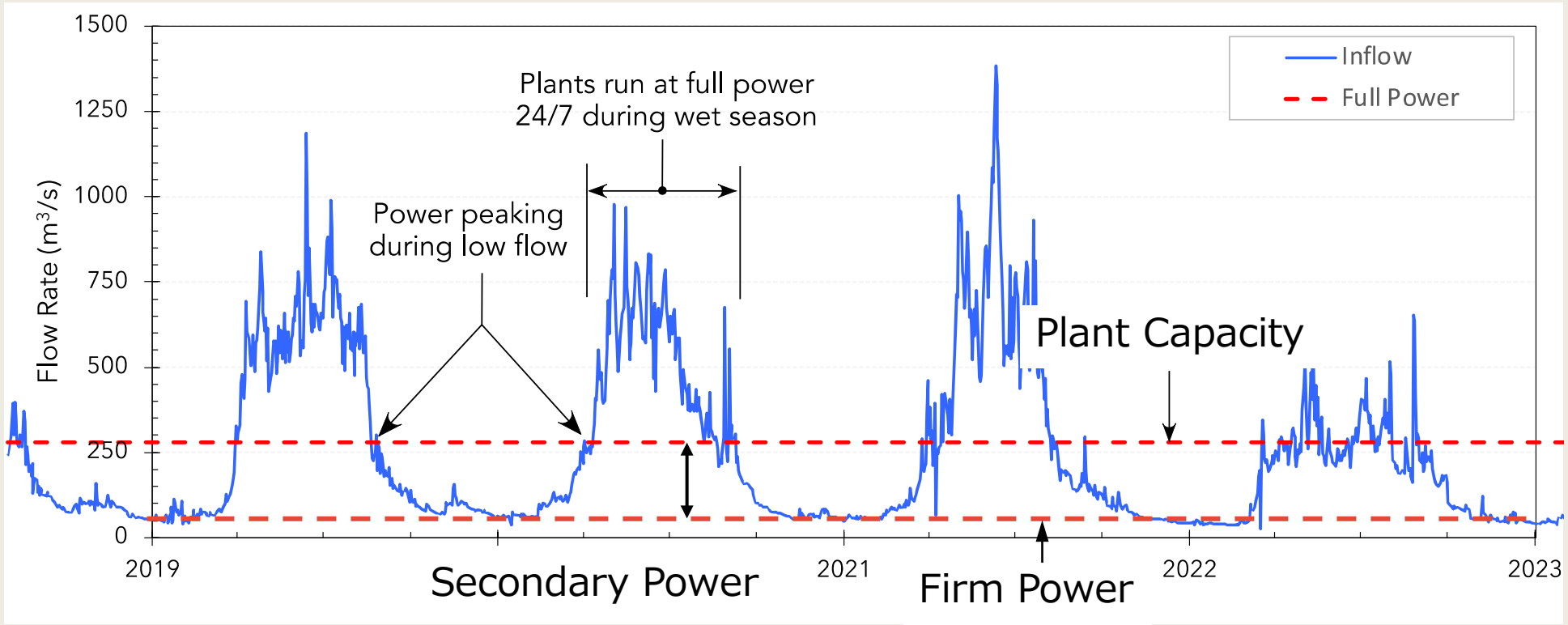
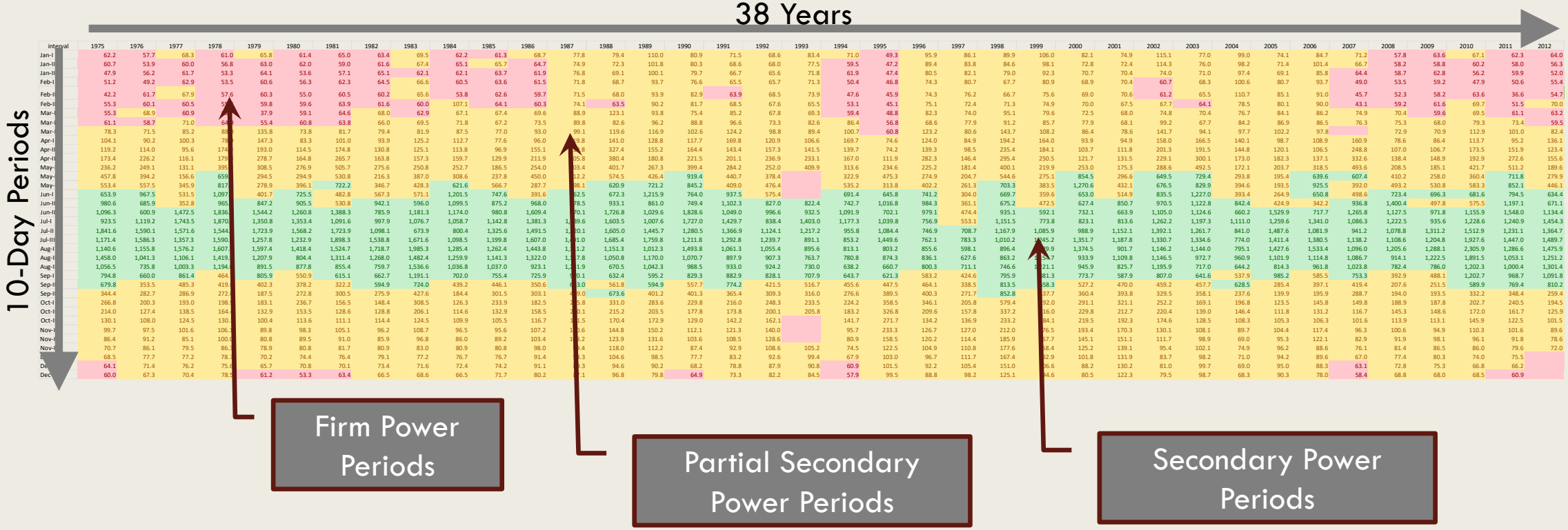


# Kiru HEP 10 day mean flows



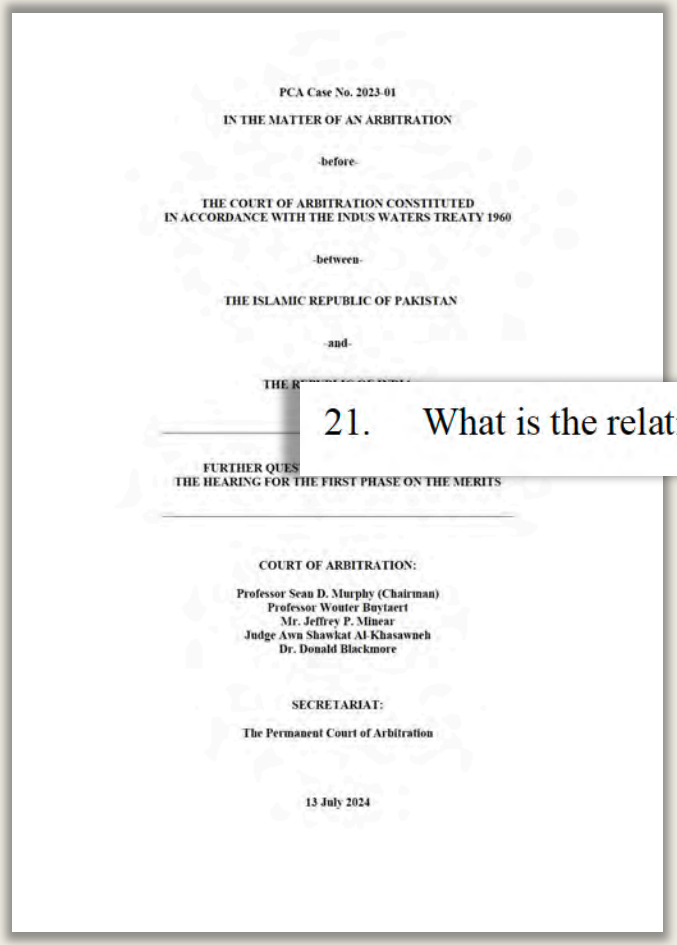

| interval | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan-I | 62.2 | 57.7 | 68.3 | 61.0 | 65.8 | 61.4 | 65.0 | 63.4 | 69.5 | 62.2 | 61.3 | 68.7 | 77.8 | 79.4 | 110.0 | 80.9 | 71.5 | 68.6 | 83.4 | 71.0 | 49.3 | 95.9 | 86.1 | 89.9 | 106.0 | 82.1 | 74.9 | 115.1 | 77.0 | 99.0 | 74.1 | 84.7 | 71.2 | 57.8 | 63.6 | 67.1 | 62.3 | 64.0 |
| Jan-II | 60.7 | 53.9 | 60.0 | 56.8 | 63.0 | 62.0 | 59.0 | 61.6 | 67.4 | 65.1 | 65.7 | 64.7 | 74.9 | 72.3 | 101.8 | 80.3 | 68.6 | 68.0 | 77.5 | 59.5 | 47.2 | 89.4 | 83.8 | 84.6 | 98.1 | 72.8 | 72.4 | 114.3 | 76.0 | 98.2 | 71.4 | 101.4 | 66.7 | 58.2 | 58.8 | 60.2 | 58.0 | 56.3 |
| Jan-III | 47.9 | 56.2 | 61.7 | 53.3 | 64.1 | 53.6 | 57.1 | 65.1 | 62.1 | 62.1 | 63.7 | 61.9 | 76.8 | 69.1 | 100.1 | 79.7 | 66.7 | 65.6 | 71.8 | 61.9 | 47.4 | 80.5 | 82.1 | 79.0 | 92.3 | 70.7 | 70.4 | 74.0 | 71.0 | 97.4 | 69.1 | 85.8 | 64.4 | 58.7 | 62.8 | 56.2 | 59.9 | 52.0 |
| Feb-I | 51.2 | 49.2 | 62.9 | 53.5 | 60.6 | 56.3 | 62.3 | 64.5 | 66.6 | 60.5 | 63.6 | 61.5 | 71.8 | 68.7 | 93.7 | 76.6 | 65.5 | 65.7 | 71.3 | 50.4 | 46.8 | 74.3 | 80.7 | 67.7 | 80.9 | 68.9 | 70.4 | 60.7 | 68.3 | 100.6 | 80.7 | 93.7 | 49.0 | 53.5 | 59.2 | 47.9 | 50.6 | 55.4 |
| Feb-II | 42.2 | 61.7 | 67.9 | 57.6 | 60.3 | 55.0 | 60.5 | 60.2 | 65.6 | 53.8 | 62.6 | 59.7 | 71.5 | 68.0 | 93.9 | 82.9 | 63.9 | 68.5 | 73.9 | 47.6 | 45.9 | 74.3 | 76.2 | 66.7 | 75.6 | 69.0 | 70.6 | 61.2 | 65.5 | 110.7 | 85.1 | 91.0 | 45.7 | 52.3 | 58.2 | 63.6 | 36.6 | 54.7 |
| Feb-III | 55.3 | 60.1 | 60.5 | 5 | 59.8 | 59.6 | 63.9 | 61.6 | 60.0 | 107.1 | 64.1 | 60.3 | 74.1 | 63.5 | 90.2 | 81.7 | 68.5 | 67.6 | 65.5 | 53.1 | 45.1 | 75.1 | 72.4 | 71.3 | 74.9 | 70.0 | 67.5 | 67.7 | 64.1 | 78.5 | 80.1 | 90.0 | 43.1 | 59.2 | 61.6 | 69.7 | 51.5 | 70.0 |
| Mar-I | 55.3 | 68.9 | 60.9 | 5 | 37.9 | 59.1 | 64.6 | 68.0 | 62.9 | 67.1 | 67.4 | 69.6 | 88.9 | 123.1 | 93.8 | 75.4 | 85.2 | 67.8 | 69.3 | 59.4 | 48.8 | 82.3 | 74.0 | 95.1 | 79.6 | 72.5 | 68.0 | 74.8 | 70.4 | 76.7 | 84.1 | 86.2 | 74.9 | 70.4 | 59.6 | 69.5 | 61.1 | 63.2 |
| Mar-II | 61.1 | 58.7 | 71.0 | 64 | 55.4 | 60.8 | 63.8 | 66.0 | 69.5 | 71.8 | 67.2 | 73.5 | 89.8 | 82.6 | 96.2 | 88.8 | 96.6 | 73.3 | 82.6 | 86.4 | 56.8 | 68.6 | 77.9 | 91.2 | 85.7 | 77.9 | 68.1 | 99.2 | 67.7 | 84.2 | 86.9 | 86.5 | 76.3 | 75.3 | 68.0 | 79.3 | 73.4 | 59.5 |
| Mar-III | 78.3 | 71.5 | 85.2 | 88 | 135.8 | 73.8 | 81.7 | 79.4 | 81.9 | 87.5 | 77.0 | 93.0 | 99.1 | 119.6 | 116.9 | 102.6 | 124.2 | 98.8 | 89.4 | 100.7 | 60.8 | 123.2 | 80.6 | 143.7 | 108.2 | 86.4 | 78.6 | 141.7 | 94.1 | 97.7 | 102.2 | 97.8 | | 72.9 | 70.9 | 112.9 | 101.0 | 82.4 |
| Apr-I | 104.1 | 90.2 | 100.3 | 78 | 147.3 | 83.3 | 101.0 | 93.9 | 125.2 | 112.7 | 77.6 | 96.0 | 119.8 | 141.0 | 128.8 | 117.7 | 169.8 | 120.9 | 106.6 | 169.7 | 74.6 | 124.0 | 84.9 | 194.2 | 164.0 | 93.9 | 94.9 | 158.0 | 166.5 | 140.1 | 98.7 | 108.9 | 160.9 | 78.6 | 86.4 | 113.7 | 95.2 | 136.1 |
| Apr-II | 119.2 | 114.0 | 95.6 | 174 | 193.0 | 114.5 | 174.8 | 130.8 | 125.1 | 113.8 | 96.9 | 155.1 | 147.8 | 327.4 | 155.2 | 164.4 | 143.4 | 157.3 | 141.5 | 139.7 | 74.2 | 139.3 | 98.5 | 235.4 | 184.1 | 103.7 | 111.8 | 201.3 | 191.5 | 144.8 | 120.1 | 106.5 | 248.8 | 107.0 | 106.7 | 173.5 | 151.9 | 123.4 |
| Apr-III | 173.4 | 226.2 | 116.1 | 179 | 278.7 | 164.8 | 265.7 | 163.8 | 157.3 | 159.7 | 129.9 | 211.9 | 205.8 | 380.4 | 180.8 | 221.5 | 201.1 | 236.9 | 233.1 | 167.0 | 111.9 | 282.3 | 146.4 | 295.4 | 250.5 | 121.7 | 131.5 | 229.1 | 300.1 | 173.0 | 182.3 | 137.1 | 332.6 | 138.4 | 148.9 | 192.9 | 272.6 | 155.6 |
| May-I | 236.2 | 249.1 | 131.1 | 395 | 308.5 | 276.9 | 505.7 | 275.6 | 250.8 | 252.7 | 186.5 | 254.0 | 303.4 | 401.7 | 267.3 | 399.4 | 284.2 | 252.0 | 409.9 | 313.6 | 234.6 | 225.2 | 181.4 | 400.1 | 219.9 | 253.0 | 175.3 | 288.6 | 492.5 | 172.1 | 203.7 | 318.5 | 493.6 | 208.5 | 185.1 | 421.7 | 511.2 | 189.6 |
| May-II | 457.8 | 394.2 | 156.6 | 659 | 294.5 | 294.9 | 530.8 | 216.3 | 387.0 | 308.6 | 237.8 | 450.0 | 512.2 | 574.5 | 426.4 | 919.4 | 440.7 | 378.4 | | 322.9 | 475.3 | 274.9 | 204.7 | 544.6 | 275.1 | 854.5 | 296.6 | 649.5 | 729.4 | 293.8 | 195.4 | 639.6 | 607.4 | 410.2 | 258.0 | 360.4 | 711.8 | 279.9 |
| May-III | 553.4 | 557.5 | 345.9 | 817 | 278.9 | 396.1 | 722.2 | 346.7 | 428.3 | 621.6 | 566.7 | 287.7 | 498.1 | 620.9 | 721.2 | 845.2 | 409.0 | 476.4 | | 535.2 | 313.8 | 402.2 | 261.3 | 703.3 | 383.5 | 1,270.6 | 432.1 | 676.5 | 829.9 | 394.6 | 193.5 | 925.5 | 392.0 | 493.2 | 530.8 | 583.3 | 852.1 | 446.1 |
| Jun-I | 653.9 | 967.5 | 531.5 | 1,097 | 401.7 | 725.5 | 482.8 | 567.3 | 571.1 | 1,201.5 | 747.6 | 391.6 | 762.5 | 672.3 | 1,215.9 | 764.0 | 937.5 | 575.4 | | 691.4 | 645.8 | 741.2 | 304.0 | 669.7 | 359.6 | 653.0 | 514.9 | 835.5 | 1,227.0 | 393.4 | 264.9 | 650.8 | 498.6 | 723.4 | 696.3 | 681.6 | 794.5 | 634.4 |
| Jun-II | 980.6 | 685.9 | 352.8 | 965 | 847.2 | 905.5 | 530.8 | 942.1 | 596.0 | 1,099.5 | 875.2 | 968.0 | 978.5 | 933.1 | 861.0 | 749.4 | 1,102.3 | 827.0 | 822.4 | 742.7 | 1,016.8 | 984.3 | 361.1 | 675.2 | 472.5 | 627.4 | 850.7 | 970.5 | 1,122.8 | 842.4 | 424.9 | 342.2 | 936.8 | 1,400.4 | 497.8 | 575.5 | 1,197.1 | 671.1 |
| Jun-III | 1,096.3 | 600.9 | 1,472.5 | 1,836 | 1,544.2 | 1,260.8 | 1,388.3 | 785.9 | 1,181.3 | 1,174.0 | 980.8 | 1,609.4 | 1,170.1 | 1,726.8 | 1,029.6 | 1,828.6 | 1,049.0 | 996.6 | 932.5 | 1,091.9 | 702.1 | 979.1 | 474.4 | 935.1 | 592.1 | 732.1 | 663.9 | 1,105.0 | 1,124.6 | 660.2 | 1,529.9 | 717.7 | 1,265.8 | 1,127.5 | 971.8 | 1,155.9 | 1,548.0 | 1,134.4 |
| Jul-I | 923.5 | 1,119.2 | 1,743.5 | 1,870 | 1,350.8 | 1,353.4 | 1,091.6 | 997.9 | 1,076.7 | 1,058.7 | 1,142.8 | 1,381.3 | 1,139.6 | 1,603.5 | 1,007.6 | 1,727.0 | 1,429.7 | 838.4 | 1,403.0 | 1,177.3 | 1,039.8 | 756.9 | 553.1 | 1,151.5 | 773.8 | 823.1 | 813.6 | 1,262.2 | 1,197.3 | 1,111.0 | 1,259.6 | 1,341.0 | 1,086.3 | 1,222.5 | 935.6 | 1,228.6 | 1,240.9 | 1,454.3 |
| Jul-II | 1,841.6 | 1,590.1 | 1,571.6 | 1,544 | 1,723.9 | 1,568.2 | 1,723.9 | 1,098.1 | 673.9 | 800.4 | 1,325.6 | 1,491.5 | 1,120.1 | 1,605.0 | 1,445.7 | 1,280.5 | 1,366.9 | 1,124.1 | 1,217.2 | 955.8 | 1,084.4 | 746.9 | 708.7 | 1,167.9 | 1,085.9 | 988.9 | 1,152.1 | 1,392.1 | 1,261.7 | 841.0 | 1,487.6 | 1,081.9 | 941.2 | 1,078.8 | 1,311.2 | 1,512.9 | 1,231.1 | 1,364.7 |
| Jul-III | 1,171.4 | 1,586.3 | 1,357.3 | 1,590 | 1,257.8 | 1,232.9 | 1,898.3 | 1,538.8 | 1,671.6 | 1,098.5 | 1,199.8 | 1,607.0 | 1,241.0 | 1,685.4 | 1,759.8 | 1,211.8 | 1,292.8 | 1,239.7 | 891.1 | 853.2 | 1,449.6 | 762.1 | 783.3 | 1,010.2 | 1,045.2 | 1,351.7 | 1,187.8 | 1,330.7 | 1,334.6 | 774.0 | 1,411.4 | 1,380.5 | 1,138.2 | 1,108.6 | 1,204.8 | 1,927.6 | 1,447.0 | 1,489.7 |
| Aug-I | 1,140.6 | 1,155.8 | 1,576.2 | 1,607 | 1,597.4 | 1,418.4 | 1,524.7 | 1,718.7 | 1,985.3 | 1,285.4 | 1,262.4 | 1,443.8 | 1,151.2 | 1,151.3 | 1,012.3 | 1,493.8 | 1,061.3 | 1,055.4 | 895.6 | 813.1 | 803.2 | 855.6 | 598.1 | 896.4 | 1,009.9 | 1,374.5 | 901.7 | 1,146.2 | 1,144.0 | 795.1 | 1,427.6 | 1,533.4 | 1,096.0 | 1,205.6 | 1,288.1 | 2,305.9 | 1,286.6 | 1,475.9 |
| Aug-II | 1,458.0 | 1,041.3 | 1,106.1 | 1,419 | 1,207.9 | 804.4 | 1,311.4 | 1,268.0 | 1,482.4 | 1,259.9 | 1,141.3 | 1,322.0 | 1,137.8 | 1,050.8 | 1,170.0 | 1,070.7 | 897.9 | 907.3 | 763.7 | 780.8 | 874.3 | 836.1 | 627.6 | 863.2 | 1,134.7 | 933.9 | 1,109.8 | 1,146.5 | 972.7 | 960.9 | 1,101.9 | 1,114.8 | 1,086.7 | 914.1 | 1,222.5 | 1,891.5 | 1,053.1 | 1,251.2 |
| Aug-III | 1,056.5 | 735.8 | 1,003.3 | 1,194 | 891.5 | 877.8 | 855.4 | 759.7 | 1,536.6 | 1,036.8 | 1,037.0 | 923.1 | 1,211.9 | 670.5 | 1,042.3 | 988.5 | 933.0 | 924.2 | 730.0 | 638.2 | 660.7 | 800.3 | 711.1 | 746.6 | 1,121.1 | 945.9 | 825.7 | 1,195.9 | 717.0 | 644.2 | 814.3 | 961.8 | 1,023.8 | 782.4 | 786.0 | 1,202.3 | 1,000.4 | 1,301.4 |
| Sep-I | 794.8 | 660.0 | 861.4 | 464 | 805.9 | 550.9 | 615.1 | 662.7 | 1,191.1 | 702.0 | 755.4 | 725.9 | 930.1 | 632.4 | 595.2 | 829.3 | 882.9 | 828.1 | 707.9 | 643.7 | 621.3 | 583.2 | 424.6 | 795.9 | 581.3 | 773.7 | 587.9 | 807.0 | 641.6 | 537.9 | 985.2 | 585.5 | 753.3 | 392.9 | 488.1 | 1,202.7 | 968.7 | 1,091.8 |
| Sep-II | 679.8 | 353.5 | 485.3 | 419 | 402.3 | 378.2 | 322.2 | 594.9 | 724.0 | 439.2 | 446.1 | 350.6 | 633.0 | 561.8 | 594.9 | 557.7 | 774.2 | 421.5 | 516.7 | 455.6 | 447.5 | 464.1 | 338.5 | 813.5 | 558.3 | 527.2 | 470.0 | 459.2 | 457.7 | 628.5 | 285.4 | 397.1 | 419.4 | 207.6 | 251.5 | 589.9 | 769.4 | 810.2 |
| Sep-III | 344.4 | 282.7 | 286.9 | 272 | 187.5 | 272.8 | 300.5 | 275.9 | 427.6 | 184.4 | 301.5 | 303.1 | 419.0 | 673.6 | 401.2 | 401.3 | 365.4 | 309.3 | 316.0 | 276.6 | 389.5 | 400.3 | 271.7 | 852.8 | 337.7 | 360.4 | 393.8 | 329.5 | 358.1 | 237.6 | 139.9 | 195.9 | 288.7 | 194.0 | 193.5 | 332.2 | 348.4 | 259.4 |
| Oct-I | 266.8 | 200.3 | 193.0 | 198 | 183.1 | 236.7 | 156.5 | 148.4 | 308.5 | 126.3 | 233.9 | 182.5 | 215.8 | 331.0 | 283.6 | 229.8 | 216.0 | 248.3 | 233.5 | 224.2 | 358.5 | 346.1 | 205.8 | 579.4 | 392.0 | 291.1 | 321.1 | 252.2 | 169.1 | 196.8 | 123.5 | 145.8 | 149.8 | 188.9 | 187.8 | 202.7 | 240.5 | 194.5 |
| Oct-II | 214.0 | 127.4 | 138.5 | 164 | 132.9 | 153.5 | 128.6 | 128.8 | 206.1 | 114.6 | 132.9 | 158.5 | 210.1 | 215.2 | 203.5 | 177.8 | 173.8 | 200.1 | 205.8 | 183.2 | 326.8 | 209.6 | 157.8 | 337.2 | 216.0 | 229.8 | 212.7 | 220.4 | 139.0 | 146.4 | 111.8 | 131.2 | 116.7 | 145.3 | 148.6 | 172.0 | 161.7 | 125.9 |
| Oct-III | 130.1 | 108.0 | 124.5 | 130 | 100.4 | 113.6 | 111.1 | 114.4 | 124.5 | 109.9 | 105.5 | 116.7 | 141.5 | 170.4 | 172.9 | 129.0 | 142.2 | 162.1 | | 141.7 | 271.7 | 134.2 | 136.9 | 233.2 | 184.1 | 219.5 | 192.3 | 174.6 | 128.5 | 108.3 | 105.3 | 106.3 | 101.6 | 113.9 | 113.1 | 145.9 | 122.5 | 101.5 |
| Nov-I | 99.7 | 97.5 | 101.6 | 106 | 89.8 | 98.3 | 105.1 | 96.2 | 108.7 | 96.5 | 95.6 | 107.2 | 120.6 | 144.8 | 150.2 | 112.1 | 121.3 | 140.0 | | 95.7 | 233.3 | 126.7 | 127.0 | 212.0 | 176.5 | 193.4 | 170.3 | 130.1 | 108.1 | 89.7 | 104.4 | 117.4 | 96.3 | 100.6 | 94.9 | 110.3 | 101.6 | 89.6 |
| Nov-II | 86.4 | 91.2 | 85.1 | 100 | 80.8 | 89.5 | 91.0 | 85.9 | 96.8 | 86.0 | 89.2 | 103.4 | 114.2 | 123.9 | 131.6 | 103.6 | 108.5 | 128.6 | | 80.9 | 158.5 | 120.2 | 114.4 | 185.9 | 167.7 | 145.1 | 151.1 | 111.7 | 98.9 | 69.0 | 95.3 | 122.1 | 82.9 | 91.9 | 98.1 | 96.1 | 91.8 | 78.6 |
| Nov-III | 70.7 | 86.1 | 79.5 | 86 | 78.9 | 80.8 | 81.7 | 80.9 | 83.0 | 80.9 | 80.8 | 98.0 | 99.4 | 118.0 | 112.2 | 87.4 | 92.9 | 108.6 | 105.2 | 74.5 | 122.5 | 104.9 | 110.8 | 177.6 | 138.4 | 125.2 | 139.1 | 95.4 | 102.1 | 74.9 | 96.2 | 88.6 | 76.1 | 81.4 | 86.5 | 86.0 | 79.6 | 72.0 |
| Dec-I | 68.5 | 77.7 | 77.2 | 78 | 70.2 | 74.4 | 76.4 | 79.1 | 77.2 | 76.7 | 76.7 | 91.4 | 93.3 | 104.6 | 98.5 | 77.7 | 83.2 | 92.6 | 99.4 | 67.9 | 103.0 | 96.7 | 111.7 | 167.4 | 132.9 | 101.8 | 131.9 | 83.7 | 98.2 | 71.0 | 94.2 | 89.6 | 67.0 | 77.4 | 80.3 | 74.0 | 75.5 | |
| Dec-II | 64.1 | 71.4 | 76.2 | 75.6 | 65.7 | 70.8 | 70.1 | 73.4 | 71.6 | 72.4 | 74.2 | 91.1 | 89.3 | 94.6 | 90.2 | 68.2 | 78.8 | 87.9 | 90.8 | 60.9 | 101.5 | 92.2 | 105.4 | 151.0 | 116.6 | 88.2 | 130.2 | 81.0 | 99.7 | 69.0 | 95.0 | 88.3 | 63.1 | 72.8 | 75.3 | 66.8 | 66.2 | |
| Dec-III | 60.0 | 67.3 | 70.4 | 78.9 | 61.2 | 53.3 | 63.4 | 66.5 | 68.6 | 66.5 | 71.7 | 80.2 | 97.1 | 96.8 | 79.8 | 64.9 | 73.3 | 82.2 | 84.5 | 57.9 | 99.5 | 88.8 | 98.2 | 125.1 | 94.6 | 80.5 | 122.3 | 79.5 | 98.7 | 68.3 | 90.3 | 78.0 | 58.4 | 68.8 | 68.0 | 68.5 | 60.9 | |

# Question 26 (further)

26. Can you further explain: (a) the potential relevance of Secondary Power, in particular, in the context of Paragraph 8(b) of Annexure D; and (b) how it interacts with Firm Power? Assuming Pakistan's definition of Firm Power, is Secondary Power (that is, power other than Firm Power) almost always available? How is that consistent with the definition of Secondary Power in the Treaty (namely, that it is "available only during certain periods of the year")?

- Firm Power is available when flow rate is at or below the MMD.
- Secondary Power is available when the flow rate is above the MMD.
- Treaty sets no expectation as to when Secondary Power might be available.

# Question 21



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 R

FURTHER QUES
THE HEARING FOR THE FIRST PHASE ON THE MERITS

COURT OF ARBITRATION:

Professor Sean D. Murphy (Chairman)
Professor Wouter Buytaert
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Dr. Donald Blackmore

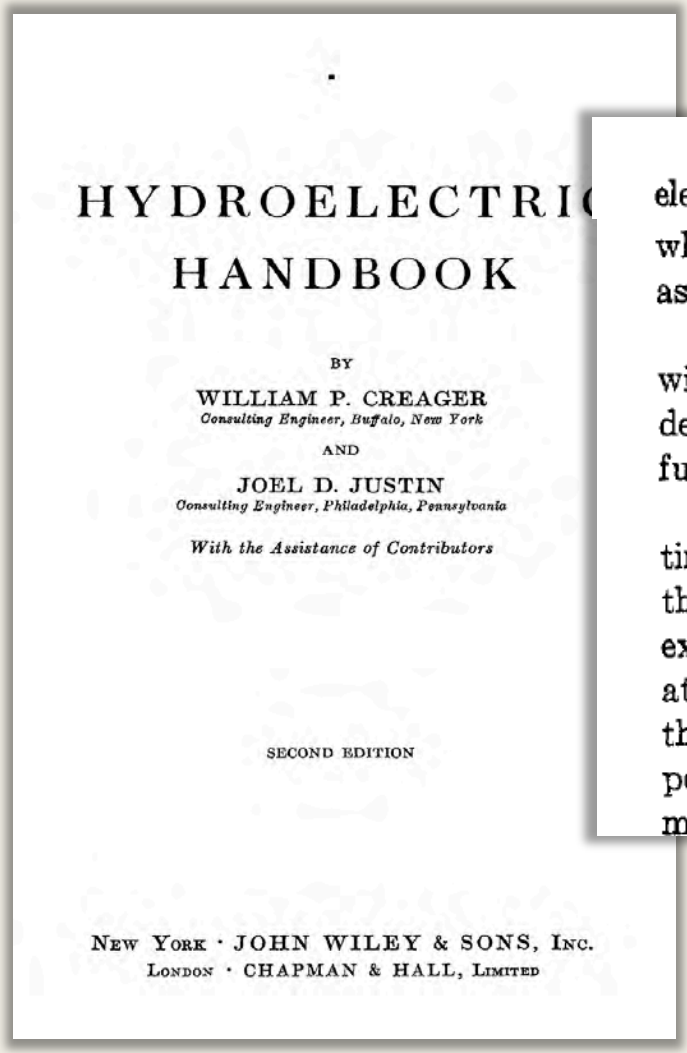
SECRETARIAT:

The Permanent Court of Arbitration

13 July 2024

21. What is the relationship between Firm Power and firm capacity? (Tr., (Day 5) 95:17–96:7).

# Creager and Justin



HYDROELECTRIC
HANDBOOK

BY

WILLIAM P. CREAGER
*Consulting Engineer, Buffalo, New York*

AND

JOEL D. JUSTIN
*Consulting Engineer, Philadelphia, Pennsylvania*

*With the Assistance of Contributors*

SECOND EDITION

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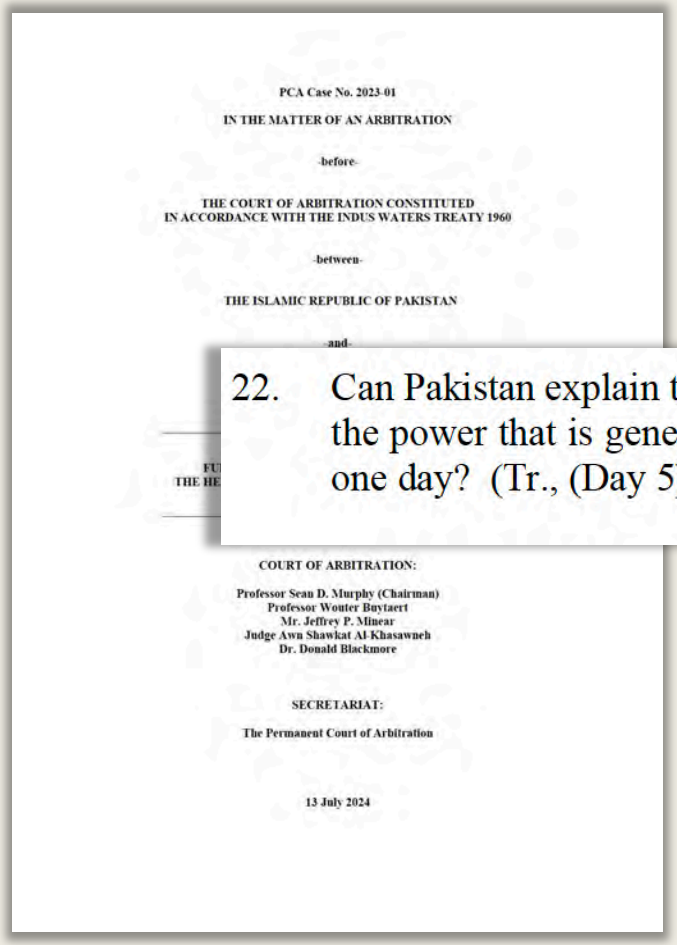
LONDON · CHAPMAN & HALL, LIMITED

**3. Firm Capacity of Hydro Plants.** The firm capacity of a hydroelectric plant can be defined as that portion of its total installed capacity which can perform the same function on that portion of the load curve assigned to it as alternative steam capacity could perform.

Thus, the 13,000 kw of hydro capacity indicated in Fig. 6, Chapter 14, will be firm capacity if there is available during that week of maximum demand at least the 608,000 kw-hr of hydro energy required for it to fully function on its portion of the load curve.

Firm capacity is, therefore, dependent on the minimum stream flow at time of peak load, on the pondage available, on the installation provided, on the shape and size of the connected load curve, and on the interrelation of existing plants. Occasionally engineers speak of the minimum 24-hr power at a hydro plant as the firm power capacity of the plant. The two can be the same only where no pondage at all is available at the plant. With large pondage and favorable load conditions, firm capacity may be many times the minimum 24-hr power at the site.

# Question 22



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22. Can Pakistan explain the basis for its position that Firm Power is to be calculated by reference to the power that is generated instantaneously, and not power averaged over a period, for example one day? (Tr., (Day 5) 75:7–76:9).

# Calculating Firm Power

(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 :

$$P = Q\rho g H_n \in$$

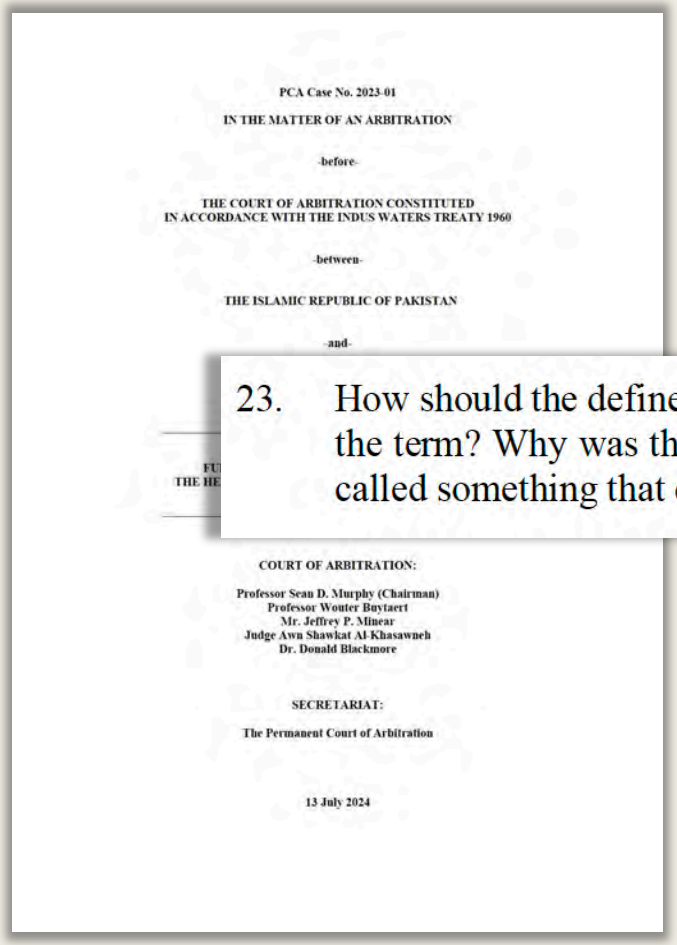
Values

- Q – defined as Minimum Mean Discharge
- $H_n$ – determined by the "*site of a plant*"
- $\rho$ – fluid mass density
- g – acceleration of gravity
- $\in$ - efficiencies

$$W = \frac{m^3}{s}\frac{kg}{m^3}\frac{m}{s^2}m$$

$$W = \frac{kg\ m^2}{s^3}$$

# Question 23



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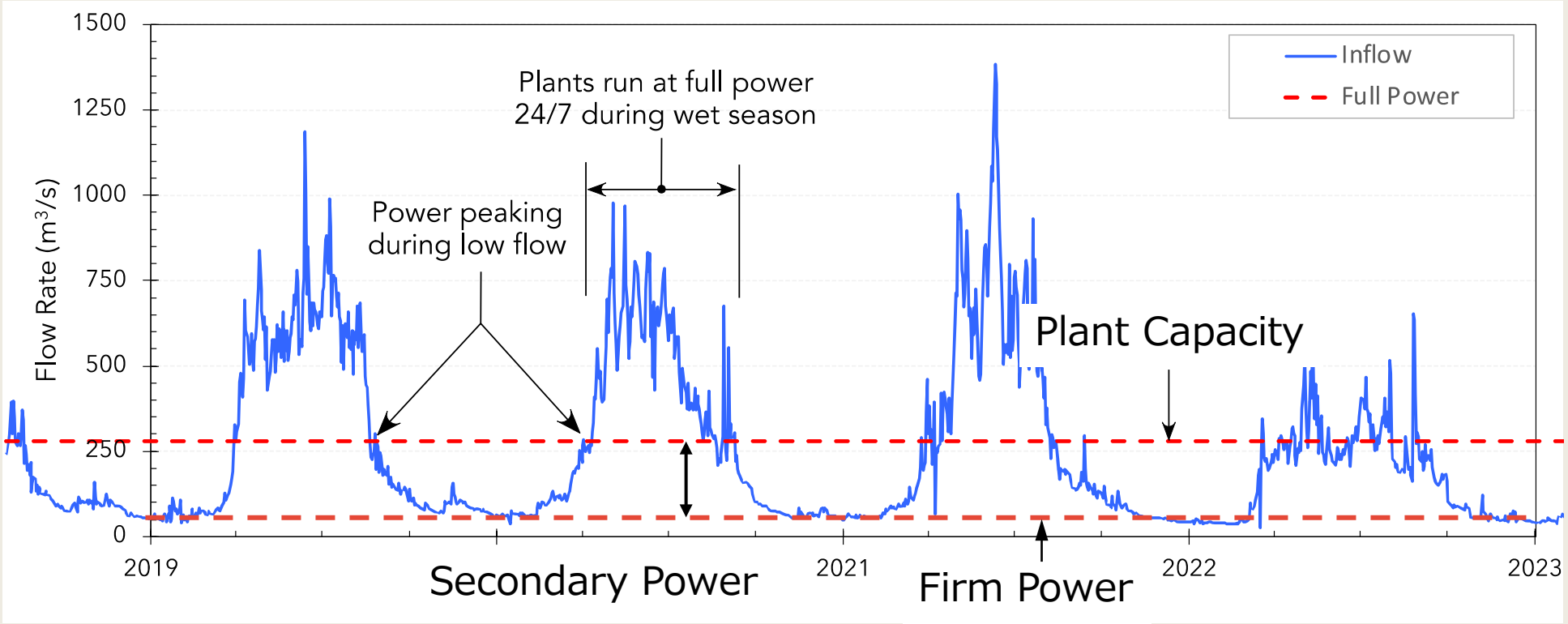
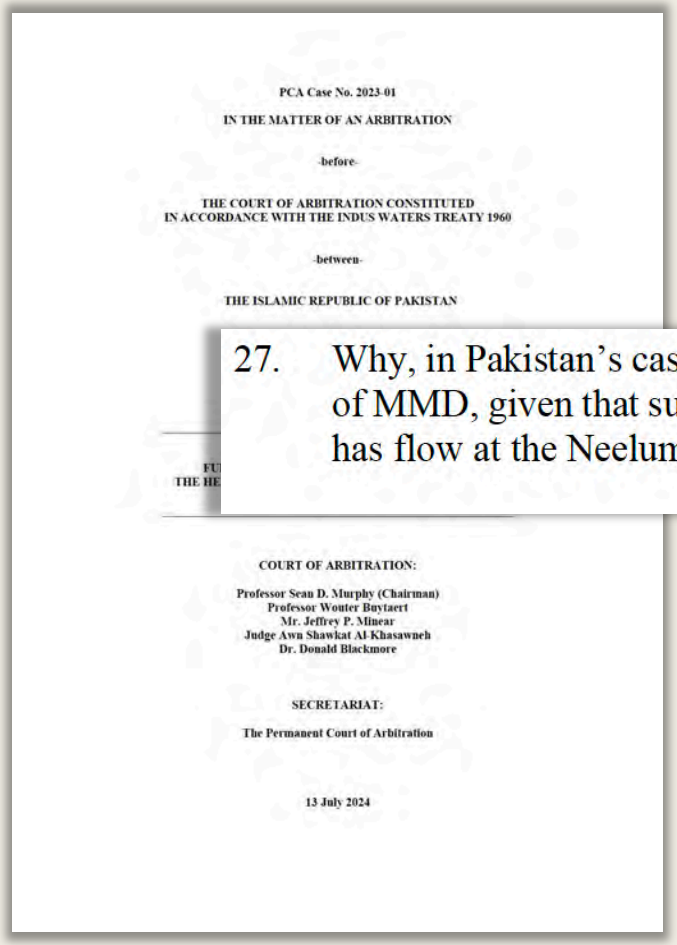
23. How should the defined term "Firm Power" be interpreted in the light of the ordinary meaning of the term? Why was this term chosen given that, on Pakistan's interpretation, it could have been called something that did not already have a defined general meaning? (Tr., (Day 5) 97:9–13).

# Annual flow hydrograph



# Question 27



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27. Why, in Pakistan's case, is the calculation of maximum Pondage premised on a flow rate of 50% of MMD, given that such a situation is rarely to occur in practice? In the past 25 years, how often has flow at the Neelum-Jhelum and Kiru HEPs fallen to, or below 50% of MMD?

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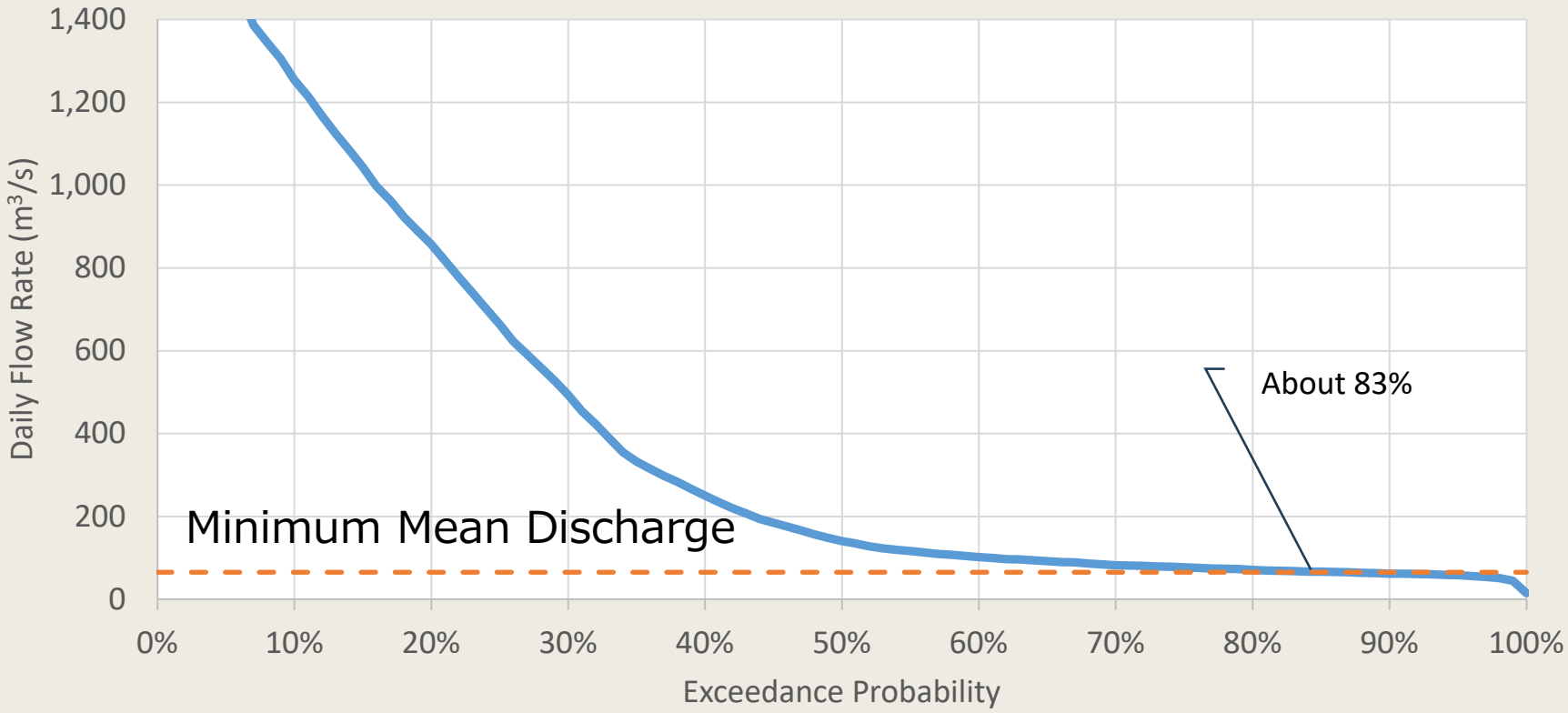
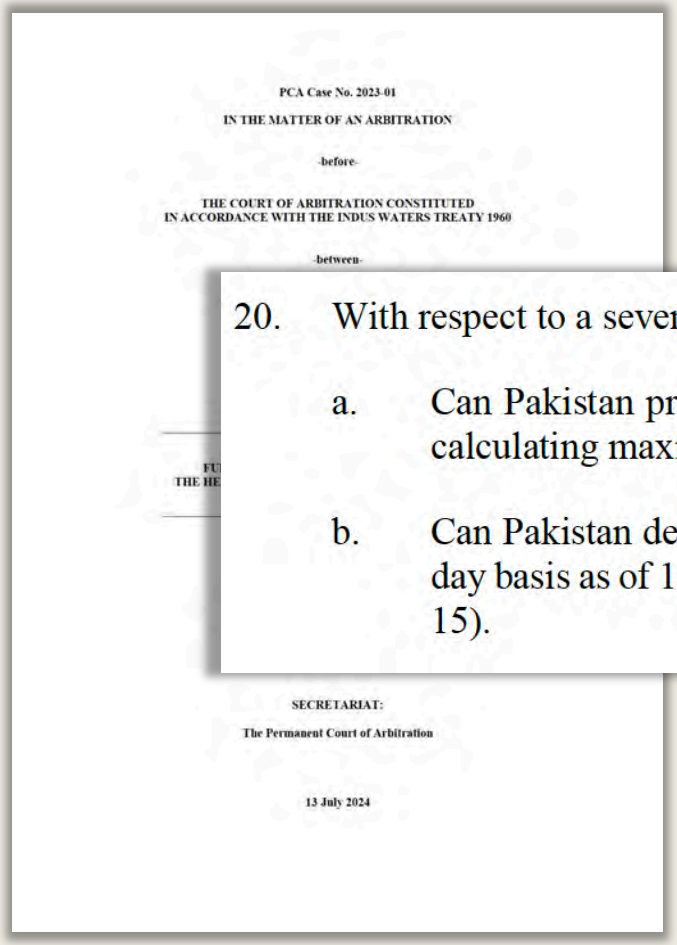
# Kiru HEP flow duration curve



# Question 20



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20. With respect to a seven-day calculation:

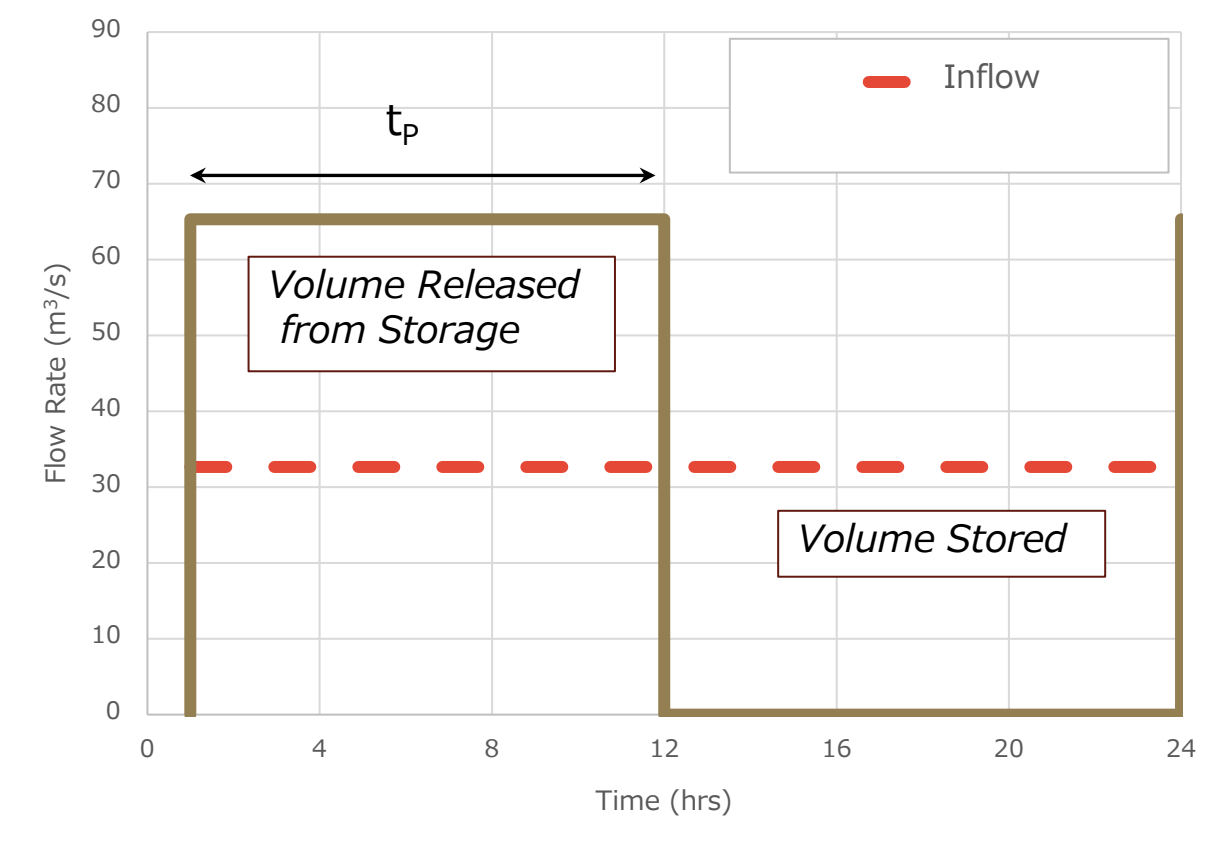
a. Can Pakistan provide a seven-day calculation as it would be done under its approach for calculating maximum Pondage? (Tr., (Day 5) 71:2–5).

b. Can Pakistan demonstrate the difficulties with calculating maximum Pondage on a seven-day basis as of 1960 with respect to either Pakistan or India's approach? (Tr., (Day 5) 70:2–15).

# Pakistan's Pondage calculation (I)

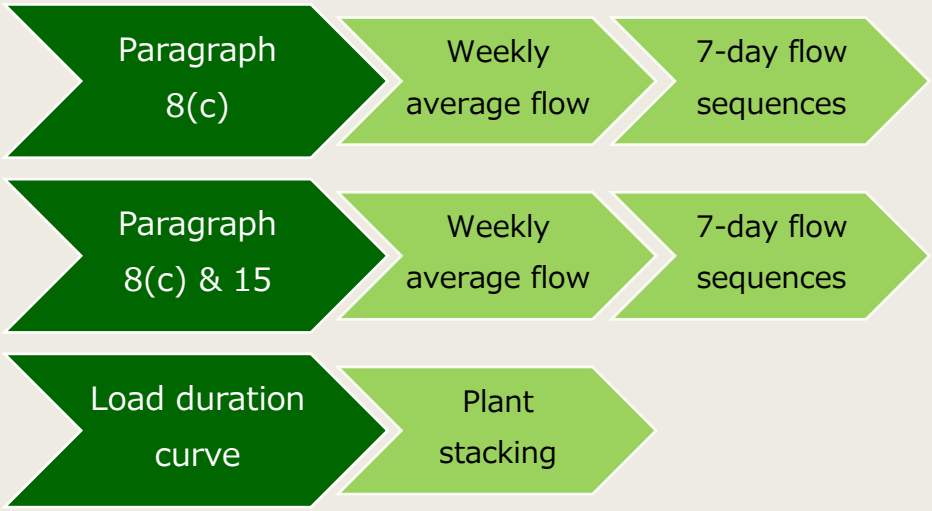
| | |
|---|---|
| Basic principle | • Firm Power must be available daily. |
| Information required | • Daily hydrological data.<br>• Minimum mean discharge. |

# Pakistan's Pondage calculation (II)




- Compute Firm Power (Para 2(i), Ann D).
- Compute daily Firm Power production from available flow volume.
- Compute daily Pondage.

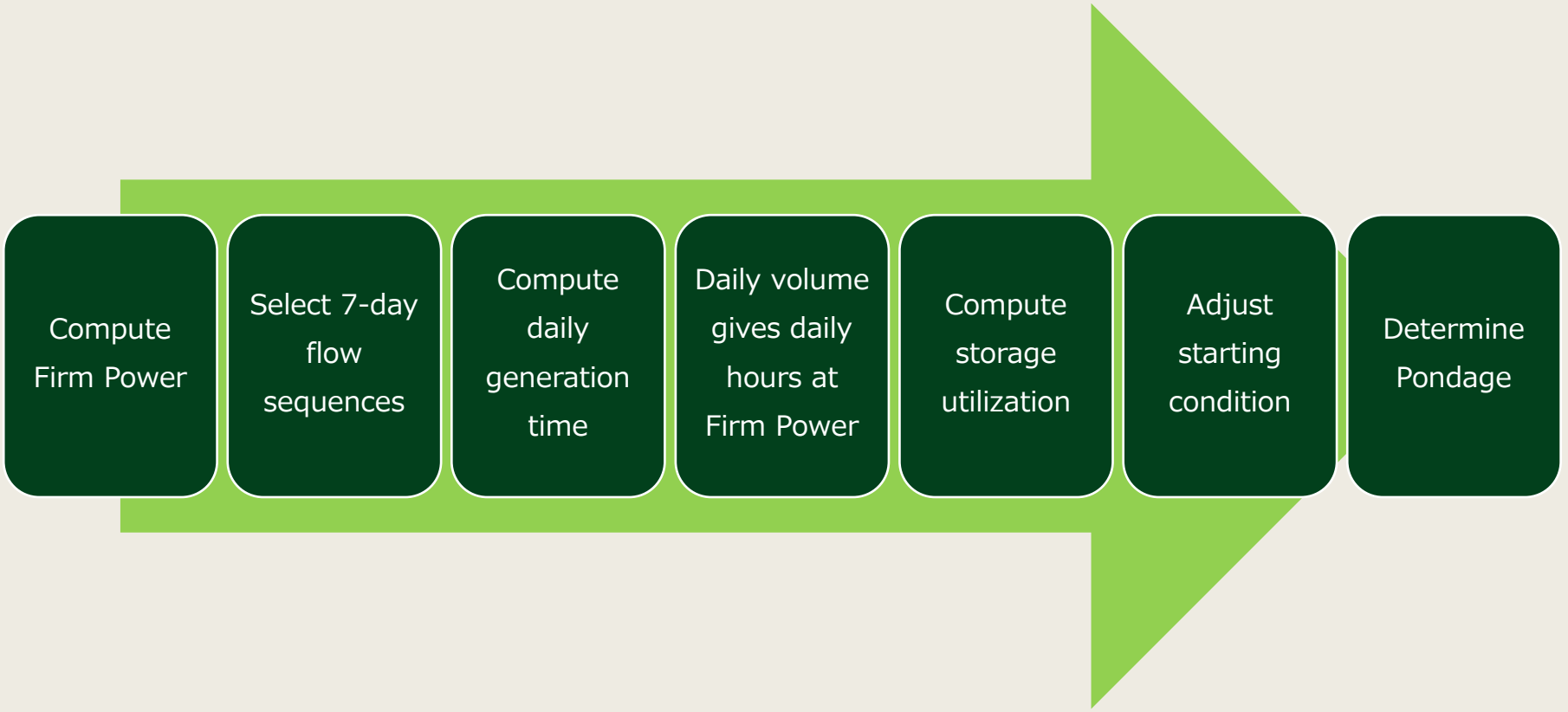
# Weekly analysis options



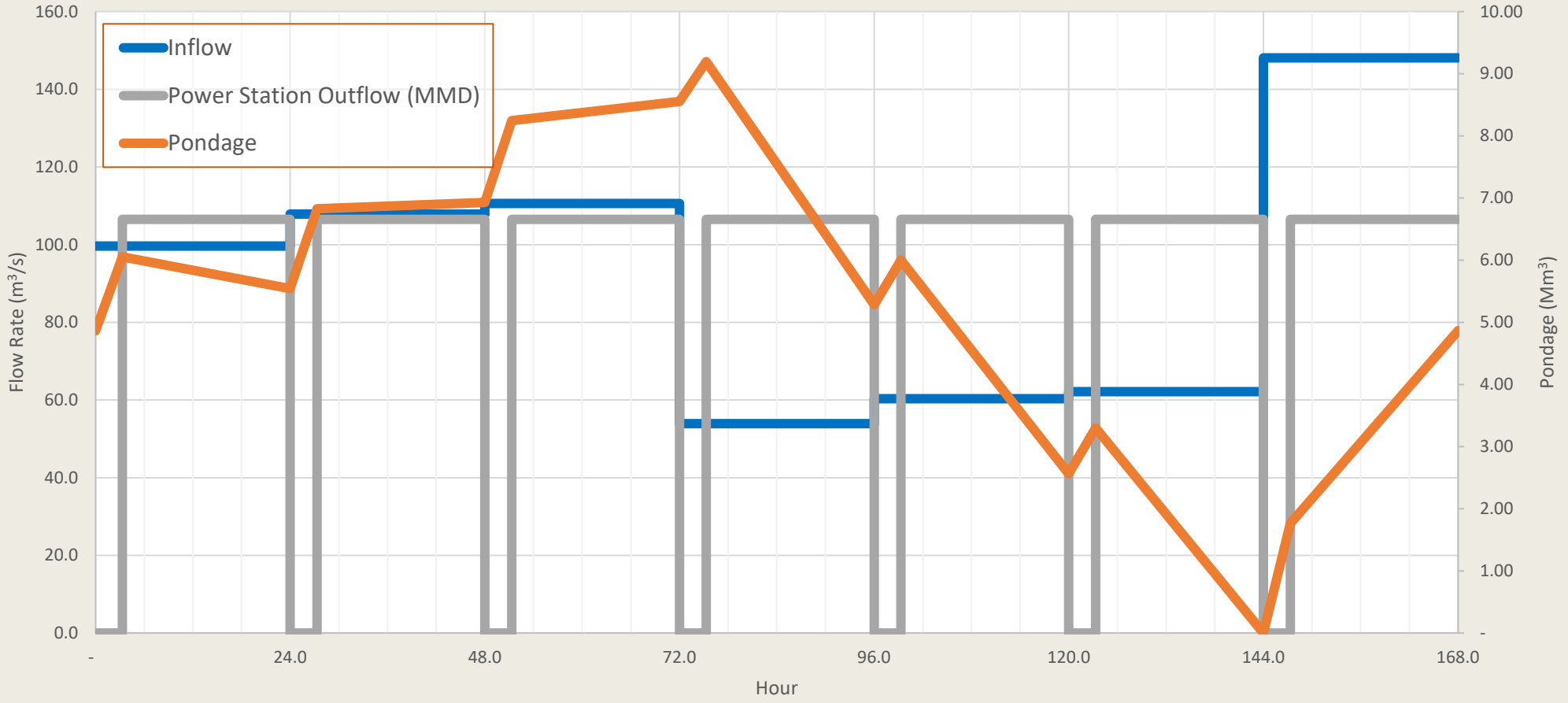

COMMON PRINCIPLES

- ✓ Peaking at Firm Power
- ✓ Daily hydrology

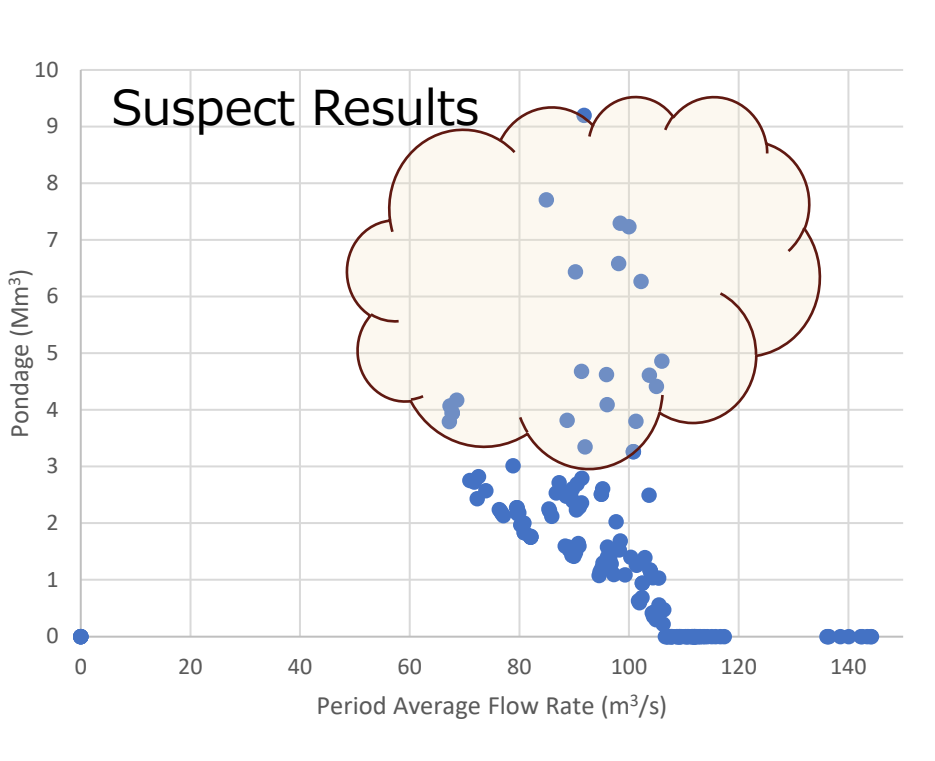
# Weekly alt 1: Para 8(c) (I)



# Weekly alt 1: Para 8(c) (II)

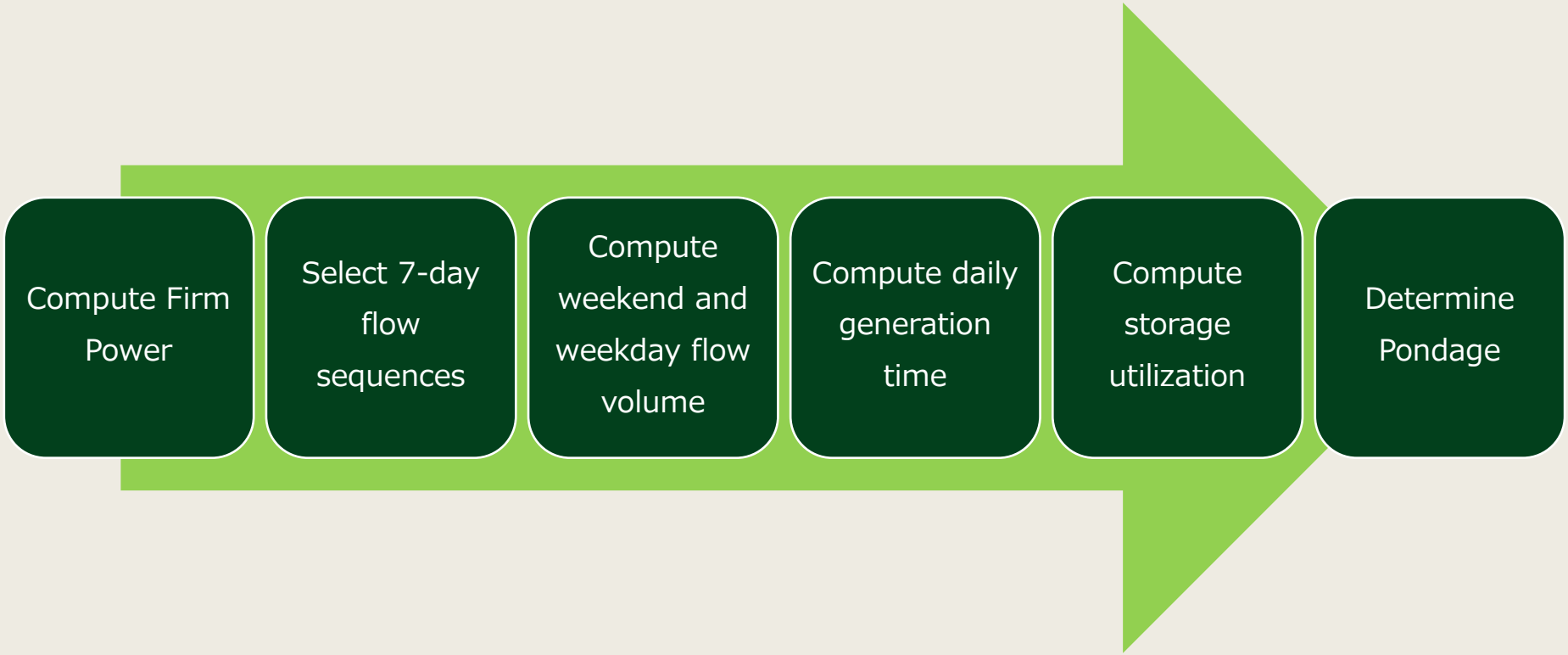


# Weekly alt 1: Para 8(c) (IV)




- Large number of computations
- *Select periods*
- *Distribute energy daily*
- *Compute Pondage*
- *Adjust starting Pondage*
- Very sensitive to data errors
- High Pondage from suspect data periods
- Assumes uniform loading

# Weekly alt 2: Paras 8(c) & 15 (I)



# Weekly alt 2: Paras 8(c) & 15 (II)

No. 6032

INDIA, PAKISTAN and INTERN
RECONSTRUCTION AND

The Indus Waters Treaty 1960 (wit
Karachi, on 19 September 1960

Protocol to the above-mentioned Tr
vember, 2 and 23 December 1960

*Official text: English.*

*Registered by India on 16 January 1962.*

INDE, PAKISTAN et BANQUE INT
LA RECONSTRUCTION ET LE

Traité de 1960 sur les eaux de l'Indu
à Karachi, le 19 septembre 1960

Protocole relatif au Traité susm
novembre, 2 et 23 décembre 196

*Texte officiel: anglais.*

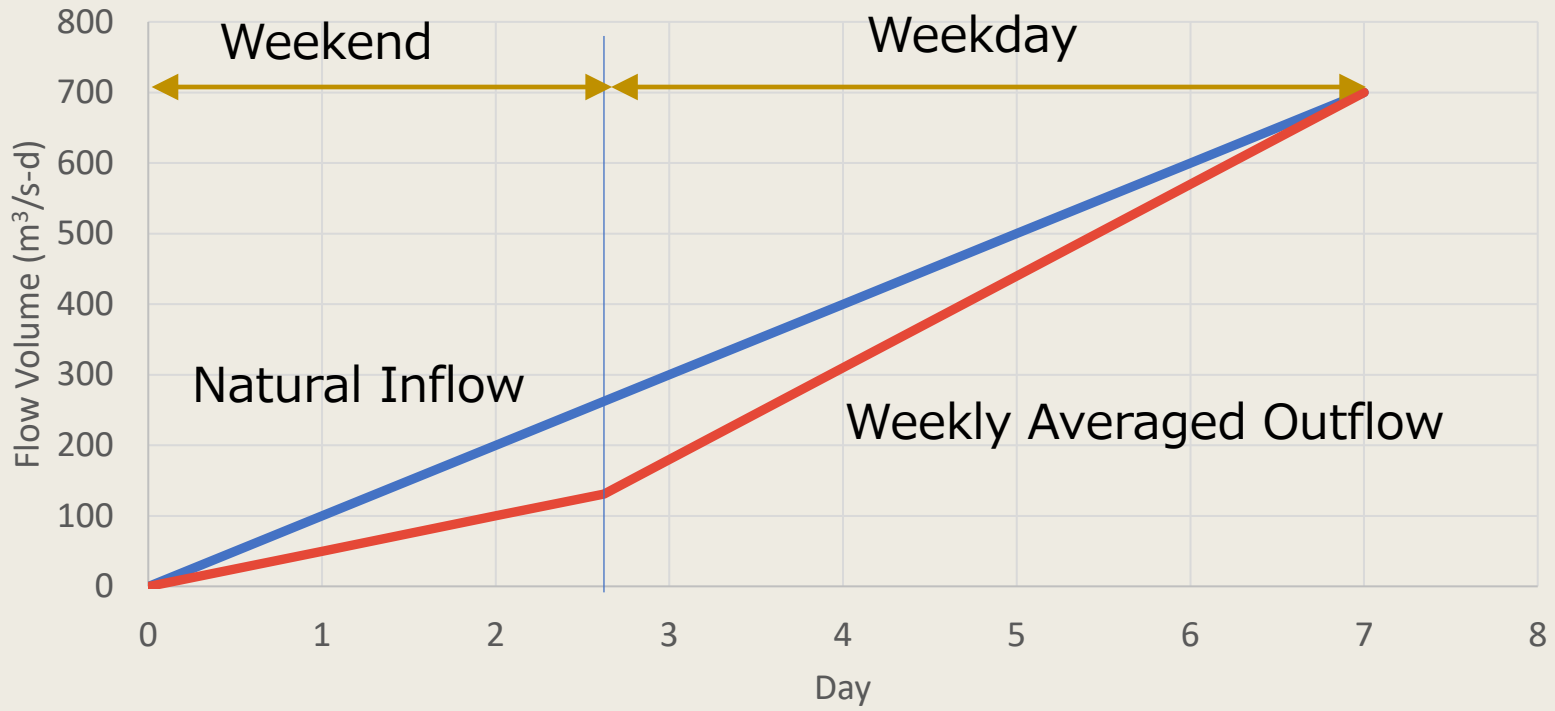
*Enregistrés par l'Inde le 16 janvier 1962.*

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 :

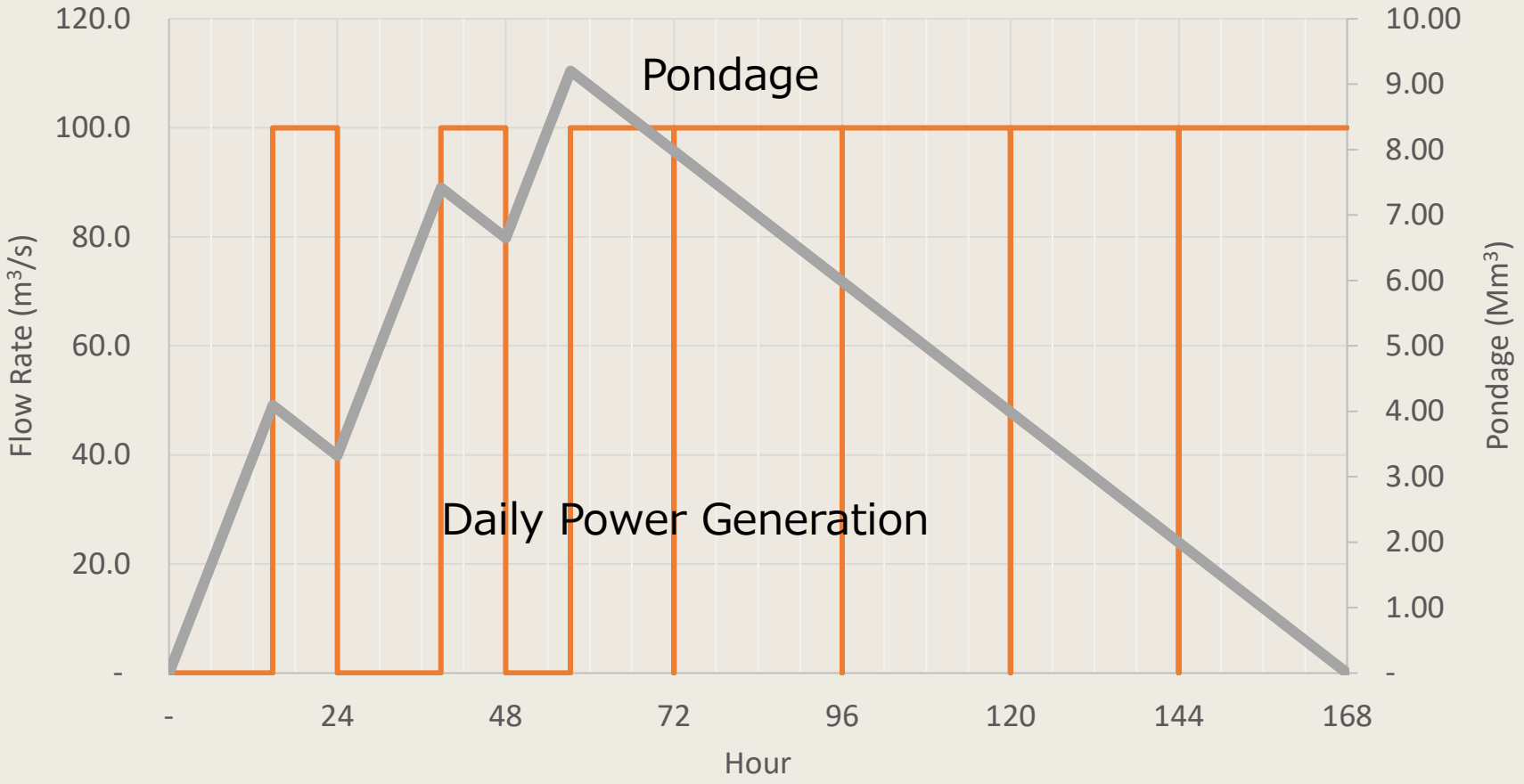
(i) where a Plant is located at a site on the Chenab Main below Ramban, the volume of water received in the river upstream of the Plant in any one period of 24 hours shall be delivered into the river below the Plant within the same period of 24 hours ;

(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

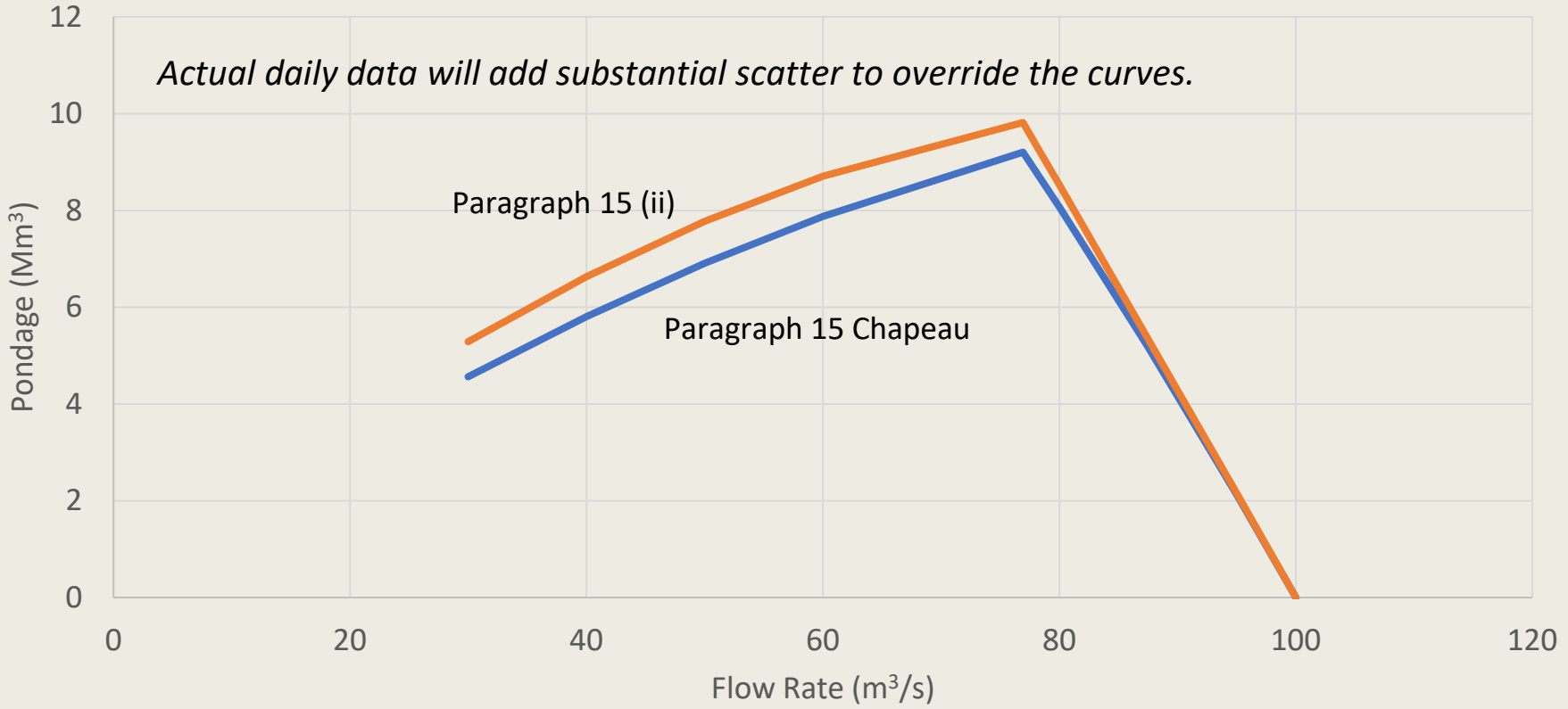
# Weekly alt 2: Flow balance



# Weekly alt 2: Generation



# Weekly alt 2: Schedule

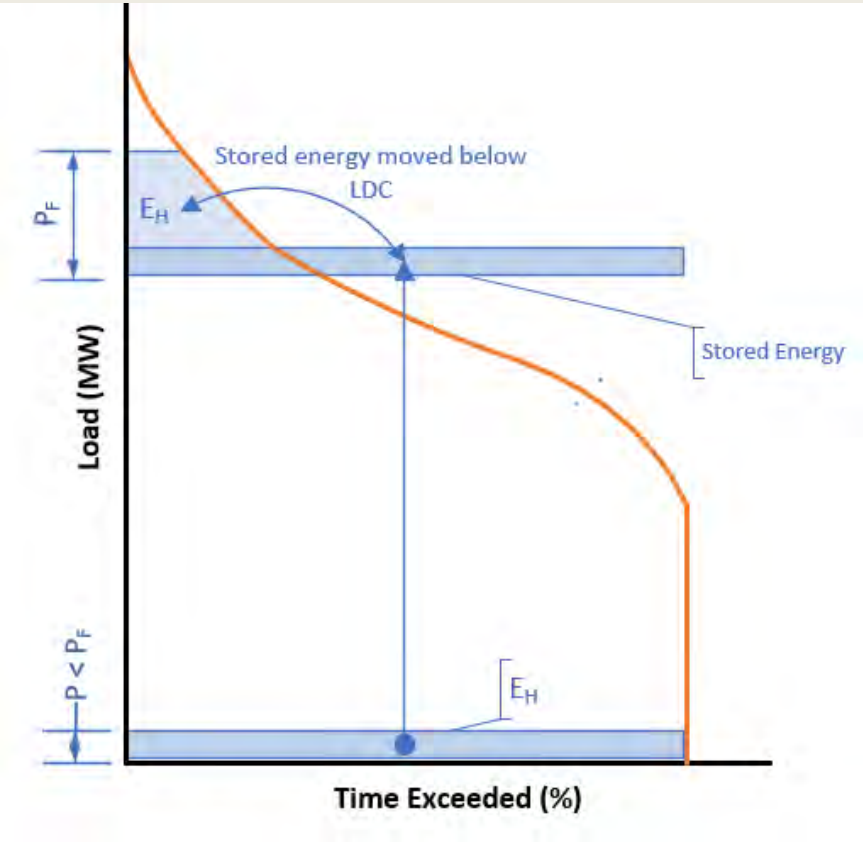


# Weekly alt 3: Load duration curve

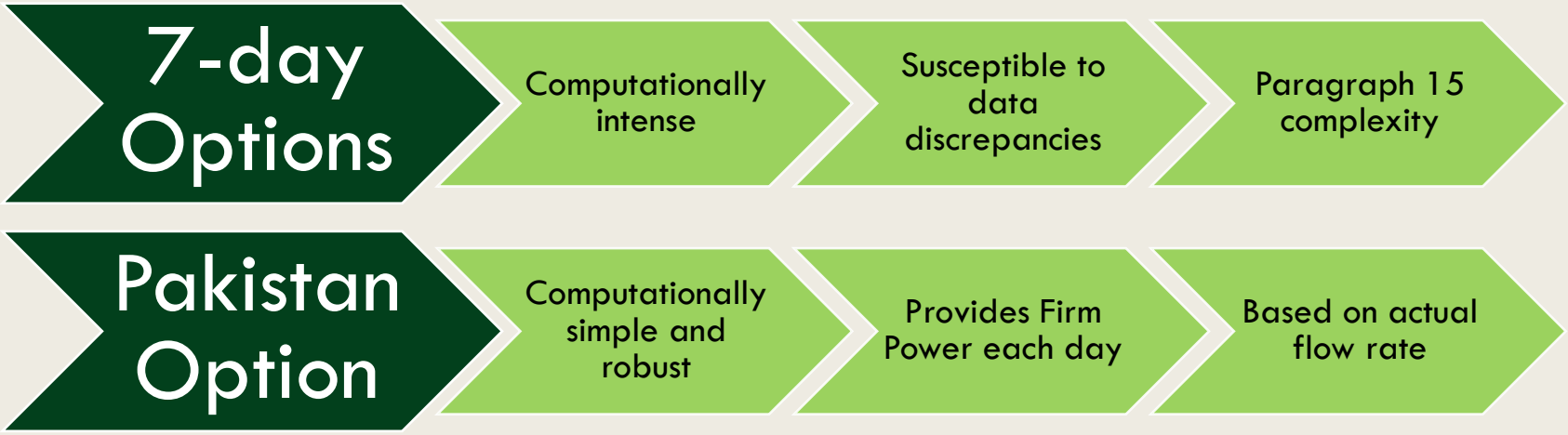
Compute Firm Power

Find position with Firm Power and energy in LDC

Stored Energy from LDC



# Question 20 (summary)




ایمان اتحاد نظم