MAHADAYI WATER DISPUTES TRIBUNAL

THE REPORT-CUM-DECISION

OF

THE MAHADAYI WATER DISPUTES TRIBUNAL
(Under Section 5(2) of The Inter-State River Water Disputes Act, 1956)

IN THE MATTER OF

REFERENCE NO. 1 OF 2011 RELATING TO WATER DISPUTES OF THE INTER-STATE RIVER MAHADAYI AND THE RIVER VALLEY THEREOF

BETWEEN

THE STATE OF GOA

AND

THE STATE OF KARNATAKA

AND

THE STATE OF MAHARASHTRA

VOLUME - IV

(V O L U M E S I - XII)

New Delhi
14th August 2018

REPORT OF THE MAHADAYI WATER DISPUTES TRIBUNAL

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REPORT OF THE MAHADAYI WATER DISPUTES TRIBUNAL

S H O R T I N D E X

VOLUME – IV

DETAILS OF ORAL EVIDENCE LED BY THE PARTY STATES

50. After the framing of issues, all the three-party States were afforded opportunity to lead their respective evidence. Vide an Order dated 17.07.2015, read with two other later Orders dated 01.09.2016 and 29.11.2016, this Tribunal had directed that since one of the important issues involved in this controversy pertains to the availability of water in the Mahadayi basin, therefore, the Parties were directed to produce their respective evidence on that aspect of the matter, by way of examining Hydrological Experts, at the first instance.

51. Accordingly, the party States produced the Hydrologists, as their respective expert witnesses.

The State of Goa produced Shri Chetan Pandit, AW1, who had retired as a Member (WP&P), CWC and Ex-Officio Additional Secretary to Government of India, on 31-03-2012, a Hydrologist, as an expert witness.

The State of Karnataka produced Prof. Ashwani Kumar Gosain, RW1, a Professor in Civil Engineering at Indian Institute of

Technology, Delhi, as its expert Hydrologist. It also produced Sh. A.K. Bajaj, RW2, a former Chairman of Central Water Commission, as another expert Hydrologist, in support of its case.

The State of Maharashtra produced Sh. S.N. Huddar, MW1, who retired in September 2006, from service as the Secretary (CAD), Water Resources Department, Government of Maharashtra, Mumbai, as its expert Hydrologist.

52. It would be pertinent to note here that the State of Goa, after producing its three other witnesses, namely Sh. Paresh Porob, AW2, Dr. Shamila Monteiro, AW3, and Sh. Rajinder P. Kerkar, AW4, sought to produce Sh. S.T. Nadkarni, AW5, who is employed as Chief Engineer of Water Resources Department and ex-officio Additional Secretary to Government of Goa.

At that stage an objection was raised by the learned Counsel for the State of Karnataka, by stating that the Affidavit filed by the aforesaid witness Sh. S.T. Nadkarni, AW5, revealed that as a matter of fact he had deposed on certain hydrology aspects of the matter and since, as per direction of this Tribunal,

the witnesses deposing on the hydrology aspect of the matter were to be produced at the first instance, before any other evidence was led, the evidence of the said witness, who was a Hydrologist, should not be permitted to be recorded.

Although, the learned Counsel for the State of Goa opposed the aforesaid objection, but this Tribunal, vide an Order dated 23.11.2017, upheld the said objection raised on behalf of the State of Karnataka, but observed that this Tribunal had directed the party States to file affidavit/s as evidence of witness/witnesses dealing with Hydrology, because there are serious disputes between the States regarding availability of water, but, at no stage, the Tribunal had restricted the Parties from leading any further evidence of any Expert Hydrologist, if the necessity so arose, at any subsequent stage.

Noticing the provisions of Section 9(1) (ba), of the Inter State Water Disputes Act, 1956, that this Tribunal has been specifically vested with the powers that enable it for requisitioning any data, and summon any witness/evidence, which may be necessary for adjudication of the Reference, it was observed that although this Tribunal had not exercised the

aforesaid powers, but when the State of Goa, on its own, had chosen to produce such data, and proposed to examine an expert witness in this regard, this Tribunal would not shut that evidence in any manner. Accordingly, the Tribunal allowed the deposition of AW-5 Shri Subrai T. Nadkarni to be recorded, and also ordered that the affidavit dated 14.11.2017 filed by him as Examination-in-Chief, would be so read.

However, to be equitable and fair to the opposite side, the Tribunal, also granted a liberty to the State of Karnataka, as well as to the State of Maharashtra, to examine any further expert witness on Hydrology, if so desired. It was also clarified that if any of the two States chose to re-examine any one of the expert witnesses on Hydrology, already so examined, it might do so, as well.

53. Besides the aforesaid expert Hydrologists, as expert witnesses, all the three-party States, further, examined other witnesses also, but no other witness on Hydrology was examined either by State of Karnataka or by State of Maharashtra, though opportunity to examine such a witness was granted as stated earlier.

54. The State of Goa examined three more witnesses, namely, Sh Paresh Porob, as AW2, In-charge Zoo Manager, Bondla Zoological Park, Goa Forest Department of Government of Goa; Dr. (Mrs) Shamila Monteiro, as AW3, who was holding the posts of the Director in the Directorate of Fisheries, Government of Goa from 01.04.2013 to 26.09.2017; Sh. Rajinder P. Kerkar as AW4, who stated that he was working for the awareness of environment, wildlife and forest related issues in the state of Goa and border area since the period of the last more than a quarter century. As already noticed above, Sh. S.T. Nadkarni, Chief Engineer of Water Resources Department and ex-officio Additional Secretary to Government of Goa, was examined as AW5, and was treated as an expert Hydrologist, by this Tribunal.

55. The State of Karnataka, besides the two expert Hydrologists, as noted earlier, produced Sh. S.M. Jamdar, RW3, who is a retired Indian Administrative Services Officer, having worked in various capacities in the State of Karnataka and was also the Managing Director of Karnataka Power Corporation Limited, and had retired from the Indian Administrative Service in 2012, as Principal Secretary to the Government of Karnataka in

the Home Department. Further, Karnataka produced Shri G.M. Madegowda, RW4, who is a retired Chief Engineer of the State of Karnataka, and had worked as Chief Engineer, KUWS & DB at Bengaluru and Mysuru, from April 2016 to December 2016.

56. Similarly, the State of Maharashtra, besides producing its hydrology expert witness, Shri S.N. Huddar as MW1, also produced Shri B.C. Kunjir, MW2, who was working with the State of Maharashtra in its engineering service, Maharashtra Service of Engineers, (MSE) and over the period of time, worked in various capacities. It is stated that he worked as Executive Director, which is equivalent to a Departmental Secretary of Government of Maharashtra, and also is stated to have worked as Chairman and Member of various committees constituted by the State Government of Maharashtra to look into specific issues in Water Resources and Development Projects. Thus, the State of Maharashtra has produced this witness MW2 as an expert witness.

57. At this stage it would be appropriate to enumerate the relevant contents of the statements of the various witnesses produced by the party States.

58. As noted above, at the first instance, all the three-party States produced the Hydrologists, as their respective expert witnesses, except Goa, which, produced Shri S.T. Nadkarni, as an expert Hydrologist, later on, after permission in that regard was granted by this Tribunal.

Oral evidence of AW-1 Shri Chetan Pandit for the State of Goa

59. Shri Chetan Pandit deposing as an Expert witness on behalf of the State of Goa filed his first Affidavit-in-Evidence on 15.09.2015 (Volume 165), as AW-1.

60. In para 2 of his Affidavit, Shri Chetan Pandit has stated that he is deposing limited to the part of hydrology evidence, more particularly, the aspect of water availability in river Mandovi, also known as Mahadayi. In paragraphs 3 to 10 of his Affidavit, the witness has claimed that he holds a Master's degree in Hydrology and has enumerated his qualifications and

experience, as according to him, in order to plan the utilization of water in a basin it is first necessary to make an assessment of the water availability in that basin. After mentioning that the rainfall is neither uniformly distributed in space nor is consistent in time, it is stated that within a catchment, the rainfall in some areas may be relatively more as compared to some other areas in the same catchment, and in some years it is less than average, and therefore the flow in the river also varies from year to year. In paragraph 13 of his Affidavit he has pointed out certain practical difficulties in the measurement of rainfall and river flow, and that the catchment areas are invariably very large extending over thousands of square kilometres, but the raingauge measures rainfall only at a point and therefore there is no escape from having to accept the measurement at a point as representative of the measurement over a large area. The witness has further explained in paragraph 15 of his Affidavit that assessment of the annual flow in the river is also a complex process and it cannot be measured directly and can only be estimated or assessed by indirect means and the hydrologist making such estimation has to make certain decisions on acceptability or otherwise on various data as well as the procedure to be followed based on the hydrologist's knowledge and experience. According to him, when

a water availability assessment is to be done for planning of utilization of water of a basin, practical considerations rule out taking a position that adequate and/or reliable data is not available and therefore water availability assessment will have to wait till adequate and reliable data becomes available. The witness has emphasized that the quantity and quality of data available is an important factor in determining what is the most reasonable method, whereas the scrutiny of the available data, rejection of suspect data, modification of data using statistical methods, are all part of the method of assessment. The witness has continued to state that most reasonable assessment of water availability is not static, and as mankind's understanding of the science improves and also as more data becomes available, the most reasonable assessment of water availability may undergo a revision and such periodic revisions are routine in the field of hydrology. The witness informed the Tribunal that the guidelines regarding minimum density of observation stations for various parameters for different geographical units are given in the World Meteorological Organization (WMO) publication No. 168 "Guide to Hydrological Practices", and as per these guidelines, for mountain region, the number of stations required in 2032 sq.km.

Mahadayi basin have been assessed and presented in a Table which is reproduced as under.

Parameter	**Area in SqKm per station**	**Minimum Number of stations**	**Actual number of stations in Mahadayi basin**
Precipitation	250	8	6(IMD stations) *Kanukmbi, Amagaon, Jamgaon, Valpoi, Mapusa, and Panjim*
Stream flow	1,000	2	1* (CWC stations)
Sedimentation	6,700	1	NIL

[* Number of CWC operated stream-flow stations is 2, at Ganjem and at Collem. But the Station at Collem measures a small catchment area and this area is hydrologically similar and adjacent to the area measured by the station at Ganjim. Therefore for all practical purposes there is only one stream – flow measurement station operated by the CWC, at Ganjem.]

61. The witness has stressed that there is not a single CWC gauging station on many significant tributaries of Mahadayi viz. Ragada, Kotni nadi, Bail nadi, and Surla nadi on which projects have been proposed by the States of Karnataka and Maharashtra. According to the witness, they are unguaged. According to the witness, hydro-meteorological data is a transient, i.e. if not correctly measured at the very moment a

hydro-meteorological event takes place, the data is lost forever and there is no way to resurrect that data. It is emphasized by the witness that the implication of this is that a post facto second measurement for verification of hydro-meteorological data is not possible and an assessment of the reliability of any hydro-meteorological data can be made only indirectly. After mentioning that he has personally visited various locations in the Mahadayi basin to obtain a “clinical picture” of the basin, the witness has mentioned that he had found wildlife sanctuaries; two famous waterfalls of Dudhsagar and Surla; some of the locations where projects are contemplated by the States of Karnataka, namely Kalasa Dam, Bhandura Dam, Haltara Dam, Surla Diversion site and those proposed by the State of Maharashtra namely Virdi Dam site. The witness has claimed that at Ganjim till the year 2000, the discharge observations were done by a method known as “float method” which is the least accurate and therefore accuracy of discharge data prior to the year 2000 is questionable. The witness has further deposed that at Ganjim site, a weir has been constructed downstream of and very close, to the observation site in the year 2006, which has changed the gauge-discharge relationship at Ganjim. The witness proceeds to state that he found that CWC had not made

necessary changes in its discharge measurement and had not taken into consideration the cognizance of the construction of the said weir. Therefore, the witness asserts that the data at Ganjim after the year 2006 is questionable. The Witness has further mentioned that the fact that CWC failed to take cognizance of the construction of a weir at Ganjim, raises a strong doubt on the competence of the observation staff and the quality of supervision. According to the witness, the CWC staff is not adequately trained and adequately supervised for taking correct observations in a correct manner and therefore, there is every possibility that before 2006 also, the incompetence and/or lack of supervision persisted, as a result of which the data prior to the year 2006 is also suspect. The witness has mentioned that his observations on the quality of discharge data are corroborated by the fact that in all the yield studies conducted by different agencies, the runoff factor, i.e. the percentage of rainfall volume flowing through the river as runoff is coming to be very high i.e. in some cases it is even more than 100%, but in most years it is as high as 80%. The witness has explained that the runoff coefficient is primarily determined by the losses from the rainfall and according to him higher the losses, the lower the rainfall and runoff coefficient. The witness has mentioned that

the most important losses are evaporation, evapo-transpiration, and percolation and considering that the upper catchment of Mahadayi River particularly in Karnataka, is densely forested area, the direct evaporation from the rainfall intercepted by the forest canopy would be very high, whereas consumptive use of water by the forest would also be very high and the presence of a forest indicates porous soil and therefore, the percolation will also be very high. The witness has mentioned that rainfall/runoff coefficient as high as 80% is indefensible for this catchment. The witness has stated that error either in the rainfall data or the discharge data, can result in very high runoff factors, but, the number of rainfall stations is many and therefore, it is possible to check the data of one station against that of another. The witness has pointed out that it is highly unlikely that all the stations made an observational error of similar type in the same years. The witness has explained that measurement of rainfall is relatively a simple procedure, while the measurement of discharge is much more complicated and therefore requires a high degree of competence and diligence. The witness has proceeded to mention that the preferred method to compute 75% dependable, or 50% dependable, or any other percentage of dependable runoff, in a basin, is by analysis of time series

runoff data of that basin, and for such analysis, the science of hydrology neither specifies any rule as to what should be minimum length of the time series, nor specifies any rule as to what length of time series is adequate, and therefore a Hydrologist has to do with whatever data that is available. The witness claims that longer the length of time series data available, higher is the probability of results being closer to their true value, provided that the quality of data is good. The witness points out that shorter the length of time series data, there is lower probability of results being closer to their true value. The witness has mentioned that river valley projects inflict a huge cost on the people and there is financial cost in terms of money and also there are environmental costs like diversion of forest land for non-forest purposes and changes in the flow pattern in the river which further impacts the ecology. Further there are social costs in terms of people displaced from their homes and farms and loss of livelihoods. The witness therefore claims that when there is a doubt about the accuracy of water availability assessment, it is preferable to err on the safer side i.e. on the lower side. The witness further mentions that 75% dependable or 50% dependable or any other percentage dependable water availability assessment refers to only natural flow as what would

have been, had there been no human intervention and it only refers to the total water that is available for specified dependability and it does not necessarily mean that this quantity of water is available for human consumption because the nature also needs water for ecological functions. The witness has referred to Clause 1.3(v) of National Water Policy of 2012 to emphasize that water is essential for sustenance of eco-system and therefore, minimum ecological needs should be given due consideration. The witness has further referred to Clause 3.3. of the said policy to emphasize that a portion of river flows, should be kept aside to meet ecological needs to ensure that the low and high flow releases are proportional to the natural flow regime, including base flow contribution in the low flow season through regulated ground water use. The witness has asserted that as to whether Mahadayi basin is a surplus basin or a deficit basin can be determined only after the environmental needs are assessed through a scientific study, as stipulated in the National Water Policy, in the table given in paragraph 35 of his Affidavit. According to this witness Tennant DL (1976) has associated a likely quality of water of habitat with various ranges of environmental flow expressed as percentage of Mean Annual

Flows. This is shown by the witness in the Table given in paragraph 35(a) of his Affidavit, which is as under:

Quality of Habitat	Environmental flow as % of Mean Annual Flow	
	October to March	April to September
Outstanding	40%	60%
Excellent	30%	50%
Good	20%	40%
Fair or degrading	10%	30%
Poor or minimum	10%	10%
Severe degradation	<10%	

62. The witness has claimed that for maintaining even a good quality of habitat, the environmental flow will have to be 60% of the Mean Annual Flow (MAF), 20% during October to March i.e. dry season and 40% during April to September i.e. rains season. The witness stated that as to whether the water allocation should be based on 75% dependable flow or 50% dependable flow would depend upon if the distribution of runoff is exactly as per normal distribution then the 50% dependable flow would be the same as mean annual flow. However, the witness has hastened to add that the practice in India is that the projects are designed to use the 75% dependable flow, whereas

in some cases viz., in chronic drought prone areas, sometimes the projects may be designed to utilize the 50% dependable flow but the Western Ghats do not fall in that category and therefore the water availability should be assessed on a 75% dependable basis for Mahadayi basin and at the places where the State of Karnataka and the State of Maharashtra have proposed other disputed projects. The witness has described Mahadayi river in great detail in paras 39 to 43 and has stated in paragraph 44 that "the Mandovi river basin can geologically be broadly divided into four distinct sub-regions, west to east namely: (i) The coastal plains with dominant marine lands on the west; (ii) The vast etch plain adjoining the coastal plains; (iii) Low dissected denudational hills and table land; (iv) Deeply dissected high Western-Ghat denudational hills".

63. The witness has stated that Mahadayi river valley comprises the Western Ghat Zone in Karnataka, Maharashtra and Goa on the western slopes of the Sahyadris and the valley includes Mahadayi wildlife sanctuary, Bhagwan Mahavir Wildlife Sanctuary and Mollem National Park, Dr. Salim Ali Bird Sanctuary, Bondla Wildlife Sanctuary and Bhimgad Wildlife Sanctuary. The witness has informed that Mahadayi River Basin in Goa

comprises an area of 1580 sq.km. which is about 43% of Goa's total geographical area. The witness has claimed that Mandovi planes downstream comprise an intricate system of wetlands; tidal marshy areas cultivated paddy fields known as khazans; all intercepted by canals, base lagoons, creeks and is influenced by tidal actions upto Ganjim. According to the Witness, the Ministry of Environmental and Forest had appointed initially the Western Ghats Ecology Expert Panel and there is specific recommendation by the said Committee that no new dams or large scale storage be permitted in ecological sensitive zone, as also no interlinking of rivers be permitted anywhere in Western Ghats. The witness has claimed that although the report has very many features and diverse topics and has not been fully accepted by the Ministry of Environment & Forest, nonetheless the fact remains that ecology experts have categorically recommended that neither any dams nor any diversion of river be permitted in the Western Ghats.

64. In paragraph 51 of his Affidavit, the witness has broadly sub-divided Mandovi River into three zones of sub-regions based upon geographical utility features which are (i) The sub-region of about 530 sq.km. are in the upper most region of the river basin located in Goa and known as conservation zone;

(ii) The downstream of the conservation zone which is the drainage area of the Mandovi river basin admeasuring about 541 sq.km. at low altitudes above the sea level where most of the population is concentrated and is known as population/industrial zone; (iii) A stretch/sub-region of 509 sq.km. of basin area in its final reach is in salinity and very fragile river zone. This is the area/sub-region, where river meets the Arabian Sea. In the main river, this saline reach extends up to Ganjim where further ingress of salinity is arrested by a weir.

65. According to the witness, it is pertinent to note that the fresh water flow from any river restrains the extent to which salinity intrudes into that river and with global warming, the sea levels are bound to rise which would subsequently increase the proportion of saline water in the river. The witness has mentioned that the aquatic life is sensitive to the concentration of salts and increase in the salinity levels can be destructive to the aquatic ecology of the river. Thus, it is maintained by the witness that an increased fresh water flow would be required to restrict the salinity/concentration of salts. Diversion of water outside the basin by the State of Karnataka and/or by the State of Maharashtra would reduce the ground water recharge and

enable increased intrusion of salt water in the aquifer. Again in paragraph 57 of his Affidavit, the witness has emphasized, while addressing the matter on point of availability of water in Mahadayi basin, two important aspects should be considered, namely (a) the minimum environmental which is required for the purpose of sustaining the precious wildlife, biodiversity, forest and thick vegetation and (b) the implications and effect of any abstraction or diversion at the upstream level on the flow of the water level from such point. The witness has expressed opinion that abstraction of water on the upstream will have an impact of reducing the flow in the downstream which is particularly of concern in case of Mahadayi river, where there are two major waterfalls namely; Dudhsagar and Ladkycho Vozar, also known as Surla waterfalls, downstream of the disputed projects planned by Karnataka and in case of any abstraction the waterfalls will be severely affected. The witness has asserted that the proposed projects of the State of Karnataka, as also that of State of Maharashtra cannot be permitted to be undertaken. The witness stated that on the basis of assessment of water availability in the river and without taking into account, the environmental impact and implications of the projects, on the flow of the river itself and

their ecological consequences, particularly having regard to the ecological sensitive characteristics of the region.

66. Shri Chetan Pandit, AW1, the Expert witness on behalf of the State of Goa has also filed an Affidavit in evidence dated 4.8.2016 (Volume 191).

67. After emphasizing that through the aforesaid Affidavit he is deposing limited to the part of Hydrology evidence, he has stated in para 2 of his said Affidavit that he had conducted a study on water availability in Mahadayi basin and had prepared a Report dated 3.8.2016, which has been annexed by him as Annexure-A to his Affidavit. In paragraphs 3 to 13 of his this Affidavit, he has again given his bio-data and spoken about his expertise in the field of hydrology. In paragraph 14 of his Affidavit-in- Evidence, he has stated that based on his qualification, knowledge and experience in practice of water resources management and engineering hydrology he has conducted a study of the water availability in the Mahadayi basin. According to him, he has particularly examined the following aspects:

a. The rainfall data available, from IMD and also other sources.
b. The river discharge data available from the CWC.
c. The map of the basin, with location of the rainfall stations, discharge observation stations, and catchment boundaries, marked on it.

68. The witness has claimed that he had seen the earlier Report prepared by NWDA, CWC and IISc but without going through the details of their computations. He has mentioned that he had visited the various locations in the catchment trying to understand the topography and land use. He has further claimed that he had visited the gauge and discharge sites at Ganjim and Collem, to get a firsthand feel of the ground realities at those sites. He has stated that in his this Affidavit that he was aware of the facts that environment in the Western Ghats is a key issue and water environment are inextricably linked, and therefore he had read the report prepared by the Western Ghats Ecology Expert Panel to get a grasp of the environmental concerns in the Mahadayi basin.

69. Based on his inputs, he claims that he had analyzed the yield of Mahadayi basin and his conclusions are presented in the Table which is part of paragraph 19 of his this Affidavit. The said Table is reproduced hereunder.

Yield		MCM	TMC
Runoff over entire catchment. Area 2032 Sq. Km	50% Dependable	5039.8	178.0
	75% Dependable	4372.4	154.4
Usable Yield Catchment Area 1523 sq.km	50% Dependable	3777.3	133.4
	75% Dependable	3277.2	115.7

70. According to him, the rainfall is neither uniformly distributed in space, nor is consistent in time. He claims that within a catchment, the rainfall in some areas may be relatively more as compared to some other areas in the same catchment, whereas in some years the rainfall is more than average, while in some years, it is less than average and consequently the flow in the river also varies from year to year. After pointing out certain practical difficulties in the measurement of rainfall and river flow, the witness has stated in paragraph 2 of his this Affidavit that the catchment areas are invariably very large extending over

thousands of square kilometers, but the rain gauge measures rainfall at only a point and there is no escape from having to accept the measurement at a point as representative of the measurement over a large area. It is pointed out by him that the river flow measurement is an instantaneous measurement, i.e. at an instant of time, but is required to be taken as representative of the flow over a duration of time, typically 24 hours. According to him, when a water availability assessment is to be done for planning of utilization of water of a Basin, practical considerations rule out taking a position that adequate and/or reliable data is not available and therefore the water availability assessment will have to wait till adequate and reliable data becomes available. It is emphasized that the water available assessment of any basin including that of Mahadayi basin, will have to be done with whatever data that is available at the time of making assessment. The witness has explained in paragraph 26 of his this Affidavit that the most reasonable assessment of water availability is not static, and as mankind's understanding of the science improves, and also as more data becomes available, the most reasonable assessment of water availability would undergo a revision. It is claimed by the witness that such periodical revisions are routine in the field of Hydrology. In para 27 of his

Affidavit, he has mentioned that he has taken into consideration the guidelines given in the World Meteorological Organization (WMO) publication No. 168 “Guide to Hydrological Practices”, and has assessed the number of stations required for catchment area of 2032 sq.km. of Mahadayi basin as per these guidelines and the same is presented in a Table, contents of which are same as mentioned in the Table in para 19 of his Affidavit dated 15.9.2015 (Volume 165). The Table is already reproduced in para 60 of this Report.

71. What is important is that this witness has stated in paragraph 28 that there is no single CWC gauging station on many significant tributaries of Mahadayi, viz. Ragada, Kotni nadi, Bail nadi and Surla nadi on which projects have been proposed by the State of Karnataka and Maharashtra and that those rivers on which State of Karnataka has proposed projects are ungauged. In para 31 of his Affidavit, he has informed that at Ganjim, till the year 2000, the discharge observations were done by a method known as “float method”, which is the least accurate and therefore accuracy of discharge data prior to the year 2000 is questionable. He has further stated that at Ganjim site, the weir has been constructed downstream of and very close to the

observation site, some time in the year 2006, and this weir would change the gauge-discharge relationship at Ganjim, but, he had noticed that CWC had not made necessary changes in their observation of discharge measurement, nor taken cognizance of the construction of the said weir, and therefore the data at Ganjim after the year 2006 is questionable. He has pointed out that the fact that CWC failed to take cognizance of the construction of a weir at Ganjim, raises a strong doubt on the competence of the observation staff and the quality of supervision. The witness proceeds to state that if the CWC staff was not adequately trained and had not adequately supervised while taking correct observations in a correct manner, the data prior to the year 2006 becomes suspect. What is claimed by him is that in all the yield studies conducted by different agencies, the runoff factor, i.e., the percentage of rainfall volume flowing through the river as runoff, is coming to be very high and in some cases it is even more than 100%, but in most years, it is as high as 80%. After pointing out that the runoff coefficient is primarily determined by the losses from the rainfall, it is stated by him that higher the losses, lower the rainfall runoff coefficient. The witness has asserted that the most important losses are evaporation, evapotranspiration, and percolation and considering

that the upper catchment of Mahadayi River particularly in Karnataka is densely forested area, the direct evaporation from the rainfall intercepted by the forest canopy would be very high. The witness proceeds to state that the consumptive use of water by the forest would also be very high and the presence of a forest indicates porous soil and therefore, the percolation will also be very high. Based on his experience as a Hydrologist, the witness has stated that rainfall/runoff coefficient as high as 80% is indefensible for this catchment. After mentioning that the preferred method to compute 75% dependable, or 50% dependable, or any other percentage of dependable runoff in a basin is by analysis of time series runoff data of that basin, the witness has stated that the longer the length of time series data available, higher the probability of results being closer to their true value, provided, of course, that the quality of the data is good. The witness asserts conversely, that the shorter the length of time series data lowers the probability of results being closer to their true value. The witness has informed in para 40 of his Affidavit that the 75% dependable or 50% dependable or any other % dependable water availability assessment refers to only the natural flow as would have been, had there been no human intervention and it refers to the total water that is available for

specified dependability. The witness has made a reference to the National Water Policy of 2012 and informed that as per clause 1.3(v), water is essential for sustenance of eco-system and therefore minimum ecological needs should be given due consideration. The witness has made a reference to clause 3.3 of the said policy and has stated that a portion of river flows should be kept aside to meet ecological needs, ensuring that the low and high flow are proportional to the natural flow regime.

72. After emphasizing that the water availability should be assessed on 75% dependable basis for Mahadayi basin and at places where the State of Karnataka and the State of Maharashtra have proposed for disputed projects, it is stressed that the Mandovi River can geologically, be broadly divided into four distinct sub-regions west to east, namely. (i) The coastal plains with dominant marine lands on the west; (ii) The vast etch plain adjoining the coastal plains; (iii) Low dissected denudational hills and table land; (iv) Deeply dissected high Western Ghat denudational hills.

73. After mentioning that the river drains in total area of approximately 2032 sq.km., spread over the three States, it is

stated by the witness that Mandovi river in the State of Goa, can be broadly sub-divided into three zones or sub-regions based upon geographical utility features. (i) The sub-region of about 530 sq.km. are in the upper most region of river basis located in Goa i.e., Conservation Zone; (ii) The downstream of the conservation zone is the drainage area of the Mandovi river basin measuring about 541 sq.km. at low altitudes above the sea level, where most of the population is concentrated and this zone is known as population/industrial zone; (iii) A stretch/sub-region of 509 sq.km. of basin area in its final reach is in salinity and very fragile river zone. This is the area/sub-region, where river meets the Arabian Sea. In the main river, this saline reach extends up to Ganjim where further ingress of salinity is arrested by the weir.

74. What is reiterated by the witness is that any abstraction of water on the stream will have an impact of reducing the flow in the downstream and this is particularly, of concern in case of Mahadayi river where there are two major waterfalls namely Dudhsagar and Ladke-cho-Vazor also known as Surla waterfalls which are downstream of the disputed projects. The witness has stated that any abstraction of water would adversely affect global bio-diversity hotspots, five sanctuaries,

several rare species, and other richness of flora and fauna situated in the State of Goa. In para 71 of his Affidavit, the witness has mentioned that State of Goa has existing and proposed drinking water projects and irrigation projects and therefore any diversion or abstraction of water from the main Mahadayi river and/or its tributaries in the upstream by the States of Karnataka and/or Maharashtra would further reduce the flow in the rivers jeopardizing even the drinking water projects.

75. As noticed earlier, the witness has annexed his report dated 03.08.2016, as Annexure A, along with his Affidavit dated 04.08.2016. In the Report, the witness has mentioned in detail Mandovi river basin and after explaining as to what is meant by the yield of the basin, the witness has referred to Hydrology in paragraph 3 of his report. The witness has referred to 2001 CWC Report and has mentioned that two different estimates of 75% and 50% dependable runoff are given in the same Report, as if the hydrologist who conducted the yield study was not sure of what path to follow and therefore offered two different estimates. The witness has given the review of yield study done in the past in para 5 of his report, whereas in para 6 of the Report

general methodology to be adopted while making assessment of water availability has been given. After emphasizing that Thiessen Polygon and linear regression are used for want of any better method, the witness has enumerated the steps to be undertaken for filling of missing data. The witness has detailed the data availability in Mahadayi basin in paragraph 7 of his Report, whereas information relating to rainfall data is mentioned in paragraph 8 in the report and information relating to discharge data is mentioned in paragraph 9 of his Report. According to the witness, CWC measures gauge and discharge at two stations i.e., at Ganjim and that at Collem. Ganjim is on the main river Mandovi and intercepts a catchment of 880 sq.km., whereas Collem is on a tributary called Khandepar and intercepts only 117 sq.km. of catchment. Regarding river flow data, the witness has mentioned that the station at Collem measures a small catchment area and this area is hydrologically similar and adjacent to the area measured by the station at Ganjim, and therefore, the Collem data does not necessarily add to the information because data is what is observed in the field, whereas the information is defined as the “meaning attached to data”. The witness has mentioned that for visiting the gauging site at Collem, one has to park the vehicle at a certain location

and then walk along a railway line for about half a kilometer, where there is a railway line on the right hand side, and a steep vertical mountain side on the left hand side, with barely a couple of meters of space between the two. What is mentioned by the witness is that when he had visited the Collem site, no place could be seen by him where CWC personnel making the discharge observation could take shelter during heavy rainfall, or rest between the observations. The witness has further mentioned that CWC has not made necessary changes in its observation resulting to discharge assessments taking notice of the construction of the weir downstream. In paragraph 12 of his Report, the witness has mentioned about the selection of rainfall stations, whereas in paragraph 13 of his Report the witness has mentioned about consistency checks on data. In paragraph 14 of his report, the witness has stated as to how the missing data has been filled. After defining catchment which should be taken into consideration while estimating yield, the witness has mentioned in paragraph 15 of his Report that 509 sq.km. should be excluded while making assessment of the yield. The witness has referred to correction for discharge observed by float method and has ultimately computed the yield of Mahadayi basin in paragraph 19

of his Report the content of which are same as that of the Table reproduced in para 69 of this Report.

76. This witness AW-1, has filed his third Additional Affidavit of Examination-in-Chief on 12.09.2016 (Volume 192). The witness has mentioned that he has already filed his Affidavit of Evidence dated 4.08.2016 on the issues pertaining to the aspects of hydrology and water availability and a report on the Yield Study on Mahadayi basin. The witness has mentioned that his this additional Affidavit dated 12.09.2016 is a continuation of his earlier Affidavit-in-Evidence dated 04.08.2016, and that he is deposing as a witness of the State of Goa on some of the issues other than hydrology and water availability, upon which he is supposed to depose.

77. In paragraph 76 of his additional Affidavit, the witness has mentioned the case of State of Goa. According to this witness, India first formulated a National Water Policy in 1987, which was revised in 2002, and then again revised in 2012. According to the witness, though revision has been made in National Water Policy of 1987, certain principles have remained unchanged and two important principles are that (a) Basin as a

unit for all water planning (b) drinking water to have highest priority for allocation of water. In paragraph 79 of his additional Affidavit, the witness has reproduced Clause 3.2 of National Water Policy 1987, whereas in paragraph 80, the witness has reproduced Clause 1.3(vii) from National Water Policy of 2012. The witness has also reproduced Clause 2.3 of National Water Policy of 2012 in paragraph 82 of his additional Affidavit and maintains that the principle is that basin as a unit for hydrologic planning should be adopted. The witness has asserted that by formulating plans for water management in Malaprabha basin, based on diversion of water from the Mahadayi basin, this basic principle laid down in National Water Policy has been violated. The witness mentions that in the National Water Policy of 1987, the water allocation priorities have been defined in Clause 8 and drinking water is stated as priority 1, followed by irrigation and then for other uses. The witness mentions that the sequence of priorities in National Water Policy of 1987 was repeated in Clause 5 of the National Water Policy of 2002. The witness has stated that by the year 2002, importance of environmental flows was starting to get appreciated, and the National Water Policy of 2002 included ecology at 4th priority for uses of water. In paragraph 89 of his additional Affidavit, the witness has

emphasized that in the National Water Policy of 2012 Clause 1.3(vi) was introduced and inter-alia states that safe water for drinking and sanitation should be considered as pre-emptive needs, followed by high priority allocation for other basic domestic needs including needs of animals, achieving food security, supporting sustenance agriculture and minimum eco-system needs. According to the said policy, available water after meeting the above needs should be allocated in a manner to promote its conservation and efficient use. After mentioning that National Water Policy finalized in a meeting of National Water Resources Council, the witness has stated that various States, including the State of Karnataka who were present in the said meeting had not raised any objections on the two principles, namely basin as a unit for all planning; and drinking water to have first priority. What is mentioned by the witness is that if indeed there is a shortage of water for domestic use in Malaprabha basin, and then it is entirely because of disregard to the principle of highest priority to the drinking water and allocating water to other uses, including a Pepsico bottling plant, and sugarcane farming.

78. After referring to the Clause 1.3(vi) of the National Water Policy of 2012, the witness has mentioned that all the provisions of the National Water Policy have been openly flouted in the Malaprabha basin, by supplying water for sugarcane cultivation. The witness has stressed that water is being supplied to a water guzzling cash crop like sugarcane, over-riding the higher priorities of drinking water, ecology, food security and sustenance. The witness has in detail referred to the cropping pattern, as stated in the modified DPR of the Malaprabha project (Volume 33B) and referred to table titled "Salient Features" wherein cropping pattern is mentioned. The witness mentions that neither the cropping pattern, as per the approved project nor the cropping pattern as per the revised project, includes sugarcane. Therefore, cultivation of sugarcane is in violation of the cropping pattern, as stated in the DPR, which is an act of water mismanagement. In para 96 of the additional Affidavit, the witness has stated that the Pepsico unit in Dharwad district is a unit of a MNC soft drink company which is being supplied 4 lakh liters of water every day by the Karnataka Water Board and the witness mentions that it is learnt from information available on the internet, that the Agreement between the Karnataka Water Board and the Pepsico is for supply of only 2 lakh liters per day,

but the unit was being supplied 4 lakh liters of water every day. What is stated by the witness is that the above stated 4 lakh liters per day would satisfy the household domestic requirement of 16,000 people at 25 Liters Per Capita per Day (LPCD), year round. The witness has claimed that in many places in India, the soft drink plants are being shut down to restore water supply to rural areas, and the most well-known example is that of Plachimada in Kerala where a soft drink bottling plant of a Multinational Company was shut down after protest by the local people, despite being on the western side of Western Ghats, and in a higher rainfall area compared to Dharwad, which is on the eastern slope of Ghats. The witness has further mentioned about the industrial profile of Dharwad district, which is available at the website of the Union Ministry of Micro, Small and Medium Enterprises (MSMEs) and has stated that the number of total industrial units in Dharwad district is 18,877, of which only 924 are registered, which indicates an unplanned growth of the industry. The witness has referred to paragraph 5 of Annexure 11 to Document No. 183, wherein it is inter-alia stated that one of the issues is lack of basic amenities like drinking water. The witness claims that thus it is seen that far less water for the industrial process, there is no water even for drinking and yet

more industries are being promoted by the State of Karnataka. The witness asserts that newer industries continue to get promoted and on the website it is indicated that 57 new industry units were approved in 2016 in Dharwad district at an investment cost of Rs.282.51 crores. The witness asserts that water shortage in Malaprabha basin, if at all, is entirely man-made due to misplaced priorities for allocation of water and this alleged shortage cannot be made good by importing water from Mahadayi basin. The witness has mentioned in paragraph 101 of his additional Affidavit that the Malaprabha Reservoir Project in Naviluteertha in Belagavi District, in Karnataka was completed in the year 1974. The witness has stated that a DPR for this Project was approved by the Planning Commission in the year 1963, which was then revised in the year 2009, which is produced by the State of Karnataka at Volume 33B. The witness asserts that a comparison of the project features of these two project formulations reveals that as per the original approved DPR, the annual water availability at 75% dependability was assessed at about 47 tmc but in the revised DPR, the yield was reduced to about 27 tmc. What is mentioned by the witness is that in the years immediately following the completion of reservoir, the State of Karnataka should have observed that the reservoir was

not filling as often, as it should, and that the annual yield is less than the estimated yield and that the reduction in yield was because of an incorrect hydrologic study earlier, or because of direct pumping from the reservoir area by the lift irrigation schemes or some other reason. It is emphasized by the witness that the State of Karnataka should have controlled the further use of water to match the annual observed yield, by controlling the cropping pattern and promoting water saving techniques such as drip and sprinkler irrigation and conjunctive use of surface and ground water etc., but on the contrary, the State of Karnataka is supporting irrigation of sugarcane, which is a water guzzler crop to replace the crops which require less water. The witness has referred to replies provided by the State of Karnataka to the interrogatories raised by the State of Goa, and it is claimed that in Malaprabha command the area under sugar cane cultivation has increased from 224 Ha in the year 1979-80 to 2756 Ha in the year 2012-13. What is emphasized is that in the modified DPR only 0.216 tmc of water supply is earmarked for drinking and industrial requirement and water for not only sugar cane but any irrigation should have been supplied only after supplying the water for drinking.

79. The witness states that from the index map of the Malaprabha Project, it is evident that there are at least two major tributaries on the right bank of Malaprabha River – Joul Nalla that borders the command area and joins near the village Konnur and the Bannehalla Nalla which cuts across the command area and joins Malaprabha River near the village of Menasagi. The witness has pointed out that Joul Nalla has a catchment area of 244 sq.km., whereas the Bennehalla Nalla has a catchment area of around 5048 sq.km., which is more than twice the entire Mahadayi basin catchment area. According to the witness, a proposal to utilize the waters of Bennehalla Nalla was prepared by Mr Sudheer Sajjan, who is/was an engineer with the Water Resources Department of Govt. of Karnataka, and in this proposal, Mr Sajjan had estimated the yield of the Benehalla Nalla as 10.92 tmc at 75% dependability, of which as per the same proposal hardly 1.5 tmc was put to use. In paragraph 107 to 112 of his additional Affidavit, this witness has mentioned about his familiarity with the implementation of inter-State water agreements and awards and maintains that a downstream State is placed in a geographically disadvantageous position and is at the mercy of the upstream State for release of water. The witness has explained that Mahadayi basin is a special case of its

encompassing four wild life sanctuaries and one bird sanctuary and generally being in the eco-sensitive zone of very rich bio-diversity. What is mentioned by the witness is that not only the main river Mahadayi, but some of its tributaries also, originate in the States of Karnataka or Maharashtra and flow down to the State of Goa, as a result of which projects for consumption of water for irrigation, drinking water and industrial use are located on these branches/tributaries. The witness maintains that in case this Tribunal permits any project on this inter-State river, then it is essential that the Award may give detailed instructions regarding quantity of water to be used by upstream State not only in each project but also at various period of time. In paragraph 115 of his additional Affidavit, the witness has spelt out the water sharing formulae for three scenarios namely, (a) Normal year (b) Wet Year and (c) Dry Year. The witness has further stated that whether any year as a whole is normal/wet/dry will be known only at the end of the monsoon season, but the water withdrawal and release decisions have to be taken throughout the year at regular intervals and therefore appropriate directions should be given by the Tribunal while passing the Award.

80. In paragraphs 121-135 of this additional Affidavit, the witness has emphasized the necessity of setting up of machinery for implementation of inter-State agreement or the Tribunal Award.

81. Pursuant to the liberty granted by the Tribunal vide its Order dated 29.11.2016, the Expert Witness AW1 (Shri Chetan Pandit) has filed an additional Affidavit on 04.01.2017 under head "ADDITIONAL AFFIDAVIT-IN-EVIDENCE OF SHRI CHETAN PANDIT, DEPOSING AS AN EXPERT WITNESS ON BEHALF OF THE STATE OF GOA" (Volume 196). The witness has mentioned in paragraph 2 of this additional Affidavit that he is deposing before the Tribunal limited to the part of hydrology evidence, more particularly the aspect of water availability in Mahadayi basin at certain specific locations. In para 3 of his additional Affidavit, the witness has stated that he has already filed an Affidavit-in-Evidence dated 4.8.2016 which is placed on record and that he is filing the present additional Affidavit in continuation of his earlier Affidavit dated 4.8.2016. The witness has repeated and reiterated the contents of said Affidavit dated 4.8.2016.

82. In para 4 of the additional Affidavit, the witness has stated that he had conducted a further study and as per Report dated 04.01.2017, which is annexed to the additional Affidavit as Annexure-A. The witness has stated that by filing the additional Affidavit he is proving the contents of the said Report dated 04.01.2017. According to the witness, the rainfall and discharge data and various maps and other reports were made available to him by the Water Resources Department, Govt. of Goa. In paragraph 8 the witness has stated that based on his study, the yield at particular project locations is mentioned in Table-1 and the same is reproduced hereunder.

Table 1: Summary of Results

	Catchment Area Sq.Km.	50% Dep Yield TMC	75% Dep Yield TMC
Kotni Dam (independent catchment)	93.19	8.9450	6.5881
Bhandura Dam	32.25	2.2140	1.4961
Bailnadi	32.25	2.5365	1.7667
Kalsa (including Haltara and Surla diversions)	25.5	2.9655	1.9767
Irti Diversion	8.78	0.7685	0.3968
Irti pickup dam	9.91	1.0084	0.8089
Diversion to			

Kali Basin			
(a)Katla-Palna Diversion	22.5	1.7337	1.5174
(b)Diggi Diversion	15.6	1.2021	1.0521
(c)Viranjole Diversion	9.5	0.8756	0.7320

83. According to the witness, the availability as given in Table 1 above is only the availability, and not necessarily the water available for use in the upstream area and that the quantity required for maintenance of eco-system in the highly eco-sensitive Western Ghats and also the quantity required for downstream users will have to be taken out and only the balance quantity, if any, will be the quantity available for use in the upstream area. The witness claims that as far as he is aware, the quantity of water thus required for maintenance of the eco-system, and also quantity of water required for meeting the needs of downstream users, has not yet been determined.

84. In the Report dated 04.01.2017, it is mentioned by the witness that when a project is planned on a river for use of water for domestic supply, irrigation, hydro power generation, industrial supply or any other objective, it becomes necessary to

estimate the yield at the proposed project location. What is maintained by the witness is that in Mahadayi basin, the State of Karnataka has planned several projects and as of 04.01.2017, far less there be an approval for any of the projects, neither the location of any of the projects is final, nor there is any approval for the quantity of water to be used for any particular purpose.

85. In para 2 of his report, the witness states that if the river flow data, also called discharge data, for a sufficiently long period are available at the proposed project location, then the yield can be estimated directly using the discharge data but if such discharge data at the project location are not available then the yield must be estimated indirectly using the discharge data available at some other location. The witness has pointed out that a commonly used method is to estimate the yield at some place where discharge data are available from which computation of the yield per unit catchment area (per sq.km.) can be arrived at and the same can be applied to the catchment area at the proposed projection location. The witness states that a correction is sometimes applied to account for difference in the mean rainfall in the gauged catchment and ungauged catchment. What is emphasized by the witness is that in case of Mahadayi

basin, the yield has been estimated by using the data at Ganjim and therefore the yield per unit area can be computed for the catchment area at Ganjim, and then applied to the catchment area of different projects; what is claimed is that since the catchment area at Ganjim is larger than the catchment areas at project locations, this is an exercise of estimating “part” from the “whole”. According to the witness, this method may be used if the “whole” and “part” are similar viz., the rainfall for the “whole” and for the “part” should be uniform; the rainfall in the “part” should occur roughly at the same time as in the “whole”. The physiography of the “whole” and the “part” should be similar; the land use in the “whole” and “part” should also be similar; and there should not be too much reduction in the catchment area.

86. According to the witness, in case of the River Mahadayi, none of the above stated conditions are sufficiently satisfied. The witness states that the catchment area at Ganjim is 880 sq.km., while the catchment areas at the project sites are much smaller, varying from 93.19 sq.km. for proposed Kotni dam to only 8.787 sq.km. for the proposed Irti diversion dam. The witness mentions that there is a wide variation in the rainfall in

different places in the catchment and the annual mean rainfall varies from 3042.6 mm at Jamagaon to 4870.8 mm at Krishnapura; what is reported by the witness is that to examine the time of occurrence of rainfall, a study was done to compare the monthly rainfall expressed as ratio to its own mean (as percentage) at station pairs and the outcome of one such study is shown in Table 3 of the report as an example, where July rainfall at Amagaon and Valpoi have been compared, the witness states that it is seen that in 1966, 1968, 1969, 1970, 1974, 1975 and 1982, rainfall in Amagaon is below mean, while in Valpoi it is above mean. According to the witness in 1990, 1992, 1996, 1997, 2000 and 2001 it is the other way round. In para 5 of the Report, the witness has pointed out that physiography and topography of the two areas are much different because the upper catchment is a plateau at a higher elevation and has a different type of forest and different climate than the middle and lower parts of the catchment. As reported by the witness a correction can be applied for the difference in mean rainfall, by multiplying the yield by ratio of mean rainfall in “part” and in “whole”, but, it is not possible to apply a correction for these other differences. It is claimed that the mean rainfall in upper catchment is more than the lower catchment. As a result, the yield per unit rainfall in

upper catchment can be less than that in the lower catchment, because discharge equals rainfall minus the losses, and in upper catchment the losses can be more. It is further stated by the witness that in upper reaches the rivers tend to be influent i.e. contribute to ground water while in lower reaches the river tends to be effluent, i.e. ground water (which has percolated in the aquifer in upper reaches) contributes to river flow. The witness claims that this is explained in an extract from the website of "Indian Agricultural Statistics Research Institute" enclosed at Appendix 1 of the Report at Annexure A. What is claimed is that in case of Mahadayi basin, the upper catchment in Karnataka is a plateau, which would increase retention time of the rainfall and thereby result in more percolation. The witness mentions that it is a known fact that the sum of 75% dependable yield for sub-catchments does not equal the 75% dependable value for the whole catchment and conversely 75% or 50% dependable yield for the whole, if distributed over the parts, will not equal the 75% or 50% dependable yield computed for the parts separately. What is emphasized is that to at least partially remove such errors in going from "whole" to "part", the methodology what is mentioned in para 7 was adopted by the witness. Ultimately on page 13 of the Report, the outcome is summarized by the witness

in Table 13, the contents of which are same as that of the Table-1. The Table 1 has already been reproduced in Para 82 of this Report.

87. The witness further points out that the availability as determined in this study is only the availability in nature, and not necessarily the water available for use in the upstream area. What is mentioned by the witness is that from this the quantity required for maintenance of eco-system in the highly eco-sensitive Western Ghats and also the quantity required for downstream users will have to be taken into account and only the balance quantity, if any, will be the quantity available for use in the upstream area.

88. The Examination-in-Chief of Expert witness, Shri Chetan Pandit deposing on behalf of the State of Goa was recorded on 30.08.2016. During the course of his examination he had tendered his Affidavit which was ordered to be treated as Examination-in-Chief. He had also tendered his report annexed to the Affidavit. According to him, in the Affidavit on page 8 at the bottom there is a table and that in the table there was a typing error. Therefore, he stated that 75% dependable yield for an area

of 2032 sq.km is shown as 3777.3 Mcum and 133.4 tmc, respectively, but it should read 4372.4 Mcum and 154.4 tmc. He also stated that correspondingly, the 50% dependable yield for an area of 1523 sq.km. shown as 4372.4 Mcum and 154.4 tmc should instead be read as 3777.3 Mcum and 133.4 tmc respectively. The witness informed the Tribunal that an identical correction should be carried out in another instance of the same table at page 58 of the report, Table 34-A. The corrections were accordingly carried out.

89. The witness was cross-examined by the learned Counsel of the State of Karnataka and the learned Counsel for the State of Maharashtra. Certain questions were put to the witness by the Tribunal also to elicit certain facts and information with regard to the details of the entire matter. The Tribunal proposes to adhere to the relevant questions and answers thereto.

90. In answer to Question No. 2, the witness stated that there is a difference between the estimation of yield for a basin of catchment vis-à-vis estimation of yield for the project. According to him, the main difference is that for a project, the entire catchment up to the project site will be considered,

whereas while estimating the yield of a basin, some part of the catchment, as the river nears the ocean or the sea, will have to be excluded, because a part of this final reach of the river will be affected by salinity ingress from the sea and also because a part of the catchment will directly drain into ocean/sea without the runoff ever joining the main river, and also because the landscape gets flatter and flatter near the coastal area.

91. In answer to question no. 3, witness candidly admitted that he had no experience for estimating the yields for a basin, however, the witness enumerated that the main procedure viz. making the Thiessen Polygon, making a rainfall runoff relationship, usually by linear regression, extension of rainfall series to runoff series using this relationship, assignment of probabilities to the discharge series and from there reading the 75% or 50% dependable flow, remain the same.

92. The Cross Examiner, by putting Question No. 5 to the witness wanted to know as to whether the witness had suggested that the float measuring site on any of the river should be changed to current meter measuring sites. The witness responded that river observations by whatever method are

carried out by the River Management Wing and it is in the jurisdiction of that wing to initiate action to modernize the river observations not only from Float to Current Meter but also further to telemetry etc.

It was put to the witness through Q. No. 12, if Goa were to construct some of the projects even that will impact the environment, and that how the witness proposed to reconcile the irrigation development in Goa with protection of environment. In answer, the witness stated that as and when a project is considered for construction, depending on whether it is major/medium/minimum project, there are certain rules and procedures regarding Environmental Impact Assessment to be carried out. Thereafter, the Cross Examiner asked whether his reply would hold good in case of Karnataka's projects also. The witness stated that EIA to be carried out as per the law of the land holds good for these projects also.

93. It was put to the witness as to whether he had any knowledge with regard to the Ganjim data for the period during 1979-2012 and in answer thereto the witness stated he had used data only up to 2005 and not up to 2012. The witness

emphasized that hydro meteorological data has to be observed when the event takes place and there is no way to verify an observation after the event. It was put to the witness that the discharge data at Ganjim from 1979-80 to 2012-13 published by the CWC in the Water Year Books is a processed and authenticated data and the witness stated that as far as he was aware, CWC itself subjected its own data to various checks, which meant that the data is not taken as validated and authentic at face value even by CWC itself.

94. The witness in answer to question no. 48 referred to a list of 61 projects, as given in Govt. of Goa, Irrigation Department Master plan for Madei, Mandovi River Basin, a Report by the Panel of Experts (Volume II) May, 1999. The witness further stated that out of 61 projects listed therein, two had already been completed, whereas DPR for six hydro-power projects have been prepared by the National Hydro Power Corporation (NHPC), and the DPR of the remaining 53 projects was prepared by the WRD (Water Resources Department) of the Govt. of Goa. He further clarified that his advice to WRD, Govt. of Goa was about the general format and the content of DPRs again and not project specific.

95. The learned Counsel for the State of Karnataka drew attention of the witness to the response of the CWC in letter dated 17.02.2016 to the Secretary, WRD, Karnataka to questions at Sl. No. (ii) and (iii) and put to the witness that his answer to Q.No.29 was incorrect. In reply, the witness stated that from the document MARK-KA-1 he had learnt that there were still some sites that continued to use the Float Method. The witness maintained that CWC had taken up modernization of its hydrologic observation network through a programme called Hydrology Project – 1 (HP-1) and that he was not able to recall the exact year in which Hydrology Project was introduced but according to him it was roughly around 1997, which was followed by further modernization through Hydrology Project – 2 (HP-2), and that this project was under progress when he was superannuated in March 2012. The witness further informed that CWC was in fact, in the process of further modernization by automatic telemetry stations and as at present even the third phase Hydrology Project-3 (HP-3) was underway, which has been renamed as the National Hydrology Project (NHP). It was put to the witness that in view of the clarifications given by CWC in MARK-KA-1 his adverse comments on page 13 of his Affidavit and page 48 of his report, on the Float Method of measurement of

flows at Ganjim and Collem gauge stations of the CWC, were incorrect and misleading and the witness responded by stating that those comments are not adverse remarks, and maintained that saying that an older technology was less accurate did not amount to making adverse remarks. The witness stated that the data measured by Float Method needs to be corrected by applying an appropriate correction factor before using it.

96. The Cross Examiner wanted to know from the witness as to whether there was any scientific literature to support the views of the witness that the data generated by Float Method required to be corrected by the data generated by Current Meter Method, and in answer the witness mentioned that the correction factor used by him was computed from the data itself, and as an expert he was competent to exercise the judgment that such correction needs to be applied.

It was put to the witness that he had classified Mandovi/Mahadayi basin into four sub regions and whether the first two sub-regions had plain lands. The answer of the witness was that the word ‘plain’ is a qualitative description and if it said that the first two sub-regions had plain lands that should not be

taken as if they comprised only of flat land and nothing else; elaborating the said aspect further, it was stated that plain land is the dominant feature in these two sub-regions and the Western Ghats comprise of very tall mountains, which gradually flatten out to sea level in a relatively very short width.

97. It was put to the witness that the third sub-region mentioned by him is an undulating terrain and in answer thereto, the witness stated that the term undulating terrain means the land where the level is more or less over a long distance but in between the terrain is not flat but has small local ups and downs which should be described “low dissected” which means land which has been weathered by the action of elements but the dissection is relatively low in height.

98. In answer to Question No.61, the witness emphasized that not only the mankind but other forms of life, flora and fauna, also have a claim to the river water and the flow that is required to maintain a satisfactory state of aquatic eco-system called environmental flow, which comprises not only a flow rate in terms of cumecs but also includes physical parameters such as the velocity of flow, depth of flow, turbidity, sun light

penetration, temperature and also water chemistry viz., pH, dissolved oxygen and other dissolved substances. It was suggested to the witness that the concept of summer flow, minimum flow and ecological flows are one and the same. The witness emphatically disagreed with the suggestion and stated that minimum flows was a term used initially in the discourse on environmental flows, before the term e-flows or ecological flows, sometimes also called environmental flows, came into use. The term minimum flows refer to a minimum flow rate, expressed as volume per unit to be maintained in the river for environmental objectives.

99. In answer to Question No. 68, the witness reproduced part of para 43(b) of his Affidavit relating to environmental flows and stated that the recommendation of the Expert Body had not clarified 50% or 30% of what, i.e. 50% of 75% dependable flow or 50% of 50% dependable flow or of mean annual flow or anything else and that it was most likely that the Expert Body meant 50% of the non-monsoon flow. The witness was asked as to whether taking the 75% dependable non-monsoon flows and 50% dependable non-monsoon flows separately, whether he would be able to work out the 50% of non-monsoon flows in

quantitative terms. In reply thereto, the witness stated that he had not worked out anywhere the 75% dependable or 50% dependable non-monsoon flows, and the yield study is about 75% dependable and the 50% dependable yield for the year as a whole. It was further stated by him that the Expert Body has not clarified 50% of what and, therefore working out the arithmetic of 50% of 50% dependable non-monsoon flows, which has neither been recommended by the Expert Body nor estimated by him and therefore is purely hypothetical exercise. The witness asserted that Mahadayi river basin is not a "Typical Indian basin", and it originates in the Western Ghats, which preserve rich bio-diversity hot-spot. He further mentioned that a relatively small basin, little more than 2000 sq.km. is house to 4 or 5 wildlife sanctuaries and most of the Western Ghats have been identified as eco-sensitive areas. Further, referring to Exh. GOA/AW-1/2(Colly), the witness mentioned that on page 1 paragraph marked 1, the Float Method is explained and it is stated that because surface velocities are typically higher than mean, or average velocities can be obtained by applying a correction factor and that this factor ranges from 0.8 to 0.9 and 0.85 is a commonly used value. The witness further referred to Exh. GOA/AW-1/3(Colly) and stated that document is from the

specifications prepared for the Hydrology Project of the Ministry of Water Resources and after explaining the Float Method, it is stated that Floats are not at all accurate and the error is stated as +/-20% as Current Meters and Acoustic Doppler Current Profiler (ADCP). The witness further referred to Exh. GOA/AW-1/4(Colly) and stated that in the last paragraph, approximately midway, it is stated that "Taking 0.8 of the surface velocity as measured by the float gives an approximate value for the average velocity." What is asserted by the witness is that on page 38 (Volume 15) of the yield study report prepared by CWC in the year 2003, then CWC had itself stated that "prior to the year 2001, the discharge measurement was by float observations. Thus, the discharge figures up to the year 2000 may have larger error as compared to current meter observations". In view of the above stated position having been accepted by the CWC, the witness reiterated that he had said in his answer to Question No.55 that as an expert, he was competent to exercise the judgment with such correction needed to be applied. It was suggested to the witness that the discharge observation by float observation up to the year 2000 was satisfactory and in any case, the errors in the float measurements would tend to cancel each other and on an annual basis, the errors may not be significant.

In answer to the said suggestion, witness emphatically stated that if a particular method of observation is known to consistently give a higher or lower measurement, then this did not cancel out over a period of time. The witness explained that CWC had explained that they were carrying out observations by float method with due care. But that will not remove the problem with the float method because it measures velocity at the surface which is consistently higher than the mean velocity and to say that over a period of time this error will also cancel out goes completely against the science of hydraulics.

100. It was put to the witness that the two G&D curves mentioned in CWC Report 2003 were practically identical which proved that the type of consistently higher or lower measurements in the Float Method pointed out by the witness did not happen. In answer thereto, the witness mentioned that the Float Method measures velocity at the surface which is higher than the mean velocity. He also mentioned that this is to be found in text books of Hydraulics. The witness explained that CWC Report does not say that the G&D curves are “practically identical” but it says that “these do not show any large variation”. The witness emphasized that whether the variation is

large or small, is a subjective judgment and if CWC concludes that the two G&D curves do not show large variation then it can mean that either (i) there is some mistake in drawing the graphs, or (ii) while taking the observations the staff was inadvertently making some other error on the negative side which gave an incorrect value than what it should have been.

101. Again the witness explained that it is not the CWC but the Float Method that measures the velocity at the surface and all velocity measurements are corrected by applying a coefficient to make it representative or mean velocity before being recorded. It was suggested to the witness that the correction in coefficient mentioned in Exh. GOA/AW-1/2(Colly) is to convert surface velocity to average velocity in the Float Method of measurement and that it has nothing to do with the correction the witness had made in his Report at page 56 between Float and Current Meter data. In response, it was stated by the witness that the discharge equals velocity multiplied by cross sectional area of the flow, and thus, a correction factor applied to velocity or to discharge has the same outcome. The witness stated that he had applied the correction factor to correct the systemic error inherent in float method, which gives higher velocity readings

and since the discharge is proportional to velocity, he had applied the correction factor of 0.84.

102. In further question, it was put to the witness that systemic error occurred only when there is a change in measurement site or when measuring equipment is damaged, but none of these have been reported by the CWC and in response thereto, the witness stated that he had used word 'systemic error' to indicate an error inherent in a particular method of measurement and in the Float Method, the velocity is measured at surface which is known to be higher than the mean velocity of the flow and since this is not a random error or an error made by the person taking the observation, therefore, the word systemic error was used.

103. The witness has produced Exh.GOA/AW-1/5 (Colly) which is 5th edition published in 1994 by the WMO. The witness further mentioned that the objective of referring to tables 20.1 and 20.3 of the WMO publication No. 168 was to assess the number of rain gauge stations and the stream flow stations required in the basin. After mentioning that para 52 of his Affidavit is a general introduction to the basin, it was stated that

Mahadayi is relatively a very small basin and its width from the top of the mountains to the sea shore is very small, whereas the level above Mean Sea Level at the origin of the river is more than 1000 meters and therefore no useful purpose would have been served by splitting the basin into mountainous and other features for the purpose of assessing the number of rain gauges and stream flow stations required. The witness emphasized that for the purpose of yield study, he would have preferred to use a method called “Isohytes” for estimating the weighted average rainfall and this method is preferable to the method of Thiessen Polygon which has been used by him but has not been used by him because that required more stations, closely spaced. The witness stated that he had not only used the data from IMD but also used the data from some rain fall stations maintained by the organizations under Government of Karnataka and considering all this, he believed that the classification of the basin as mountainous, not for the purpose of an introductory chapter but for the purpose of rain gauge stations required is correct. In answer to Question No. 85, which related to distinct sub-regions mentioned in the report prepared by the witness, it was stated that WMO Publication No. 168, 5th Edition of 1994 referred by him is a guideline for setting up the raingauge network, and as

per the said guideline, the number of raingauge stations required for Mahadayi basin considering it as mountainous works out to 8, whereas the next revision of same publication No. 168, 6th Edition has also retained the same recommendations for the rainfall stations. It was pointed out by the witness that the WMO had not defined what they meant by mountainous, which means that it was left to the judgment of the hydrologists/meteorologists. The witness informed that in his yield study, he had used the data from 13 stations. According to him, more raingauge stations were required irrespective of the fact whether the basin is classified as entirely mountainous or only some part as mountainous. It was put to the witness that 7 raingauge stations considered by the CWC in its study of 2003 were adequate and there was no reason to increase the number of raingauge stations because the density per raingauge station works out to be 125 sq.km., which is less than the required density for raingauge stations in hilly/undulating physiographic unit region. The witness responded that the WMO guidelines are for the minimum number of stations suggested and that does not bar a consulting hydrologist from using the data from more stations, if it is available. It was further explained by the witness that if the number of IMD raingauge stations was adequate then

there would have been no need for anyone to set up any more raingauge station, but the very fact that different organizations, including some under the Government of Karnataka, have set up more raingauge stations, is simple proof that he is not the only one who thinks that the IMD rainfall stations were not adequate for the purpose of present yield study. With reference to CWC yield study of 2003, the witness stated that he has disagreed with a number of things mentioned in the yield study, and limiting a number of raingauge stations is one major point of disagreement. According to the witness the said study is not applying a correction in the discharge data measured by Float Method, and further disagreement is about the catchment area used by it for the determination of the yield, where it has not excluded the area affected by salinity and where conservation of water is not possible for various reasons. The witness further faulted CWC report on account of runoff factor i.e. ratio of runoff as percentage of rainfall is coming very high and in several places it is more than even 100%, which is not only incorrect, but in fact absurd and the runoff factor being so high more than once should have, in fact, alerted a hydrologist, as to whether there is some mistake in selection of stations, etc.

It was put to the witness that the correction of Ganjim data undertaken by him at page 56 of his report is not supported by any scientific material and therefore not reliable. The witness maintained that the three documents submitted by him do not suggest a correction and merely discussed some difficulties and what was pointed out was the fact that velocities measured by the Float Method are on the higher side is established not only in the document but in Text Books of Hydraulics also. After referring Exh. GOA AW-1/2(Colly), the witness asserted that the surface velocities observed by the Float Method are typically higher than the mean or average velocities by a factor which generally ranges from 0.8 to 0.9, and a commonly used value for correction is 0.85. Having said so, the witness has asserted that it was open to him to simply take this value as quoted in a scientific literature and use it but he had made an attempt to determine the same from the available data and it turned out to be 0.84.

104. The witness was questioned that average rainfall data of Krishnapura was only available for 10 years i.e. 1979-1988 but the witness had extended by 17 years i.e. from 1989 to 2005, by filling the missing data, and therefore the data filled by the witness constituted about 63% in the series of 1979 to 2005, and

the witness responded that the arithmetic 17 divided by 27 is about 63% is correct, but that does not mean that 63% of the data was missing and filled because the Krishnapura data is available from 1964 onwards and the complete series was considered. It was put to the witness that Krishnapura data has upwardly impacted his study of re-estimation of weighted average monsoon rainfall up to Ganjim, because he had assigned the second highest weightage and that too based on the data of 63% of the filled up data. The witness denied this suggestion and stated that the method of calculating the weightage is very geometrical. It is explained by the witness that the stations are located on a map; the Thiessen Polygon is drawn and the areas are measured by a planimeter or a suitable devise; and from these areas, the weights are calculated.

105. A question was put to the witness that if the reasons for exclusion of rainfall of 509 sq.km., is the non-usability of the water, as maintained by him, and then did he mean to say that this entire water in 509 sq.km. cannot be used at all for any purpose. The answer given by the witness was that there are three reasons why it is necessary to exclude some areas towards the end of the river as it meets the sea or ocean. According to

the witness the first reason was rainfall falling on a lot of this area may not even reach the river channel of Mahadayi river for which the yield is being determined, and it may directly drain out into the sea or ocean through numerous small drains; the second reason was that the final reach of the river as it nears the sea or ocean is affected by salinity due to ingress of saline water from the sea/ocean, due to tidal effect rendering it unusable; the third reason was that the land in this area is quite flat and does not permit the engineering interventions necessary to use the water. Finally the witness added that similar areas had been excluded from the yield in past cases also viz., Narmada, Krishna, Godavari and Cauvery the details whereof have been mentioned in his Affidavit.

106. It was put to the witness that in this 509 sq.km. Mahadayi basin in Goa, there is rice cultivation and cultivation of other crops to which the witness stated that he could not say for sure if rice was being cultivated but there could be some rain fed agriculture. It was further put to the witness that he had chosen to exclude rainfall falling in 509 sq.km., which is a large quantity of water, without conducting any study. After denying the said suggestion, the witness stated that he had studied the report

(Volume 31) submitted by the Panel of Experts, wherein the said figure of 509 sq.km. is mentioned and also shown on a map. The witness emphatically stated that he did not agree that this is a large area. According to the witness, the area excluded in other basins mentioned above is much larger, and in any case the area to be excluded in any given basin will be determined by the topography, and is not an abstract decision. It was put to the witness that the Report of Panel of Experts is not an independent report, but a report to boost the case of Goa during the stage of negotiations, to which the witness replied that he had no personal knowledge about the Members or their domicile but he knew at least two names who went on to occupy very senior positions in the Central Water Commission and in the Union Ministry of Water Resources and he did not agree with the implicit suggestion that a professional gives a decision based on which State he comes from, and stated that though he himself is a Maharashtrian settled in Pune, but he is exercising his professional judgment to the best of his ability.

A clarification was sought by the Cross Examiner relating to the answer given by the witness to Question No. 99, and the witness asserted that he had not stated that the water from the

rainfall on this catchment of 509 sq.km, is required for salinity control, but on the contrary, the witness emphasized that he had pointed out that this water may not even reach the main river Mahadayi and may drain out directly into the sea/ocean and then the scenario of salinity ingress is likely to worsen in the future because of expected increase in the sea level due to global warming. It was clarified by the witness that the water is required in a channel not only for salinity control but also for sediment transport and to maintain the aquatic ecology and bio-diversity. The witness was confronted with relevant part of the report of the Krishna Water Disputes Tribunal and a suggestion was put to him that the excluded area of 1686 sq.km. in Krishna basin constitutes only 0.7% of the total basin area of 2,58,514.7 sq.km., to which the witness also agreed. The witness also agreed to the suggestion that the area of 509 sq.km. excluded by him from the total area of the basin of 2032 sq.km. constitutes 25.05%. In order to answer question No. 108, the witness admitted that he had not come across a case where about 25% of the area was excluded from the estimation of the yield of the basin.

107. In answer to Question No.110, the witness stated that he had not read the Irrigation Commission Report entirely and would not expect the Irrigation Commission to make such basin wise recommendations but he was able to recall the extracts from the Awards of the Tribunals for Narmada, Krishna, Godavari, and Cauvery, wherein certain areas were excluded, and that exclusion was not based on the recommendations of Irrigation Commission. It was suggested to the witness that exclusion of 25% of the catchment in Mahadayi from the estimation of the yield is misleading and solely intended for reducing the total yield of the basin but the witness denied the said suggestion. The witness was confronted with letter dated 17.02.2016, MARK KA-1, wherein CWC had replied that velocity area method using current meter for measurement of velocity or Float Method are most common techniques at its sites and therefore his answer to Question No. 29 is incorrect. The witness informed that in the previous evening he had consulted the person concerned i.e. Mr. D. P. Mathuria, Director, CWC as to how was it that the Float Method still continues to be used and according to the witness the reasons explained to him were that when a new gauge site is to be started, it takes some time to obtain the financial approvals, etc. and procure the current meter and related

equipment and till then the observations are started with float method to save time. According to the witness, there are some sites, particularly in the north east, where the terrain is too difficult for current meter observations, and at these sites also float method continues to be used as a *fait accompli.* The witness was questioned about "Typical Indian basin" and it was suggested to him that Cauvery and Krishna are also not typical Indian basins, since their upper catchments are in the Western Ghats. In answer, the witness explained that there are certain major differences between the Cauvery and Krishna on the one hand, and the Mahadayi on the other, and two most important differences are that in Mahadayi basin there are four Wildlife Sanctuaries and one Bird Sanctuary, within a very small area, and second, the Cauvery and Krishna basins already have a human interventions and river valley projects and in contrast the Mahadayi basin is what is called by Hydrologists a virgin basin. The witness mentioned that the panel appointed by the Ministry of Environment and Forests under the chairmanship of Prof. Madhav Gadgil went to the extent of recommending a blanket ban on all water resources projects in Western Ghats, and particularly and specifically recommended against any diversion

of water from one basin to another and thus Mahadayi basin is in no way comparable to Krishna or Cauvery.

108. It was put to the witness that his Affidavit dated 04.08.2016 and the accompanying report estimating the yield by re-estimating the rainfall and correcting the Ganjim gauge data of the CWC are wholly irrational and completely contrary to the hydrological practices, but the witness denied the suggestion and stated that as regards extension of runoff data using a rainfall runoff model and historical rainfall Data, it was a standard hydrological practice.

109. It was suggested to the witness that the basin planning may involve water to be transferred from a basin to the contiguous basin and in response the witness has stated that the basin planning exercise does not per se include transfer of water from one basin to another, because that involves planning for the donor basin also and such planning involving more than one basin is a separate exercise.

110. In answer to question No. 123, the witness mentioned that para 1.3(vi) of the National Water Policy of 2012 refers to

priorities in allocation of water. The witness specifically referred to the last sentence of the said clause that “available water after meeting the above needs, should be allocated …”. Thereafter, the witness concluded that obviously, the water of one basin is not “Available water” to another basin, unless such transfer from one basin to another has already been agreed to by the donor party also. It was suggested to the witness that the suggestion made by the witness in para 86 of his additional Affidavit that diversion of Mahadayi water to Malaprabha basin for meeting the drinking water requirement and agricultural requirements as planned by Karnataka violates National Water Policy of 2012 is incorrect and misleading, and the witness stated that in paragraph 86 of his Affidavit what he has stated is that formulating the plans for water management in Malaprabha basin based on some expected diversion from Mahadayi basin when there is no prior consent of the donor parties, is not in accordance with the policy.

111. It was put to the witness that transfer of Mahadayi water to Malaprabha basin for meeting drinking water requirement and agricultural requirements, and further transfer of Mahadayi water to Kali basin for production of power from the existing infrastructure of Supa Dam, is justified under the Policy

MARK-KA/4. In answer to the said suggestion, the witness made a clear distinction between three scenarios, i.e. (a) Diversion of water from one basin to another after a share in the donor basin has been allocated; (b) Making a claim on water from one basin to meet a demand, real or perceived, in another basin; (c) There is also the question of consent of all stakeholders. The witness categorically mentioned that as a thinker in water policy issues, he did not agree with the above scenario (b) and it is also not supported by the National Water Policy.

In question No. 132, the Cross Examiner asked the witness whether industrial and commercial development is an integral part of economic development. The witness has replied that he has not questioned the need for economic or commercial development of State of Karnataka and has stated that in paragraph 99 of his Affidavit what he had stated is that "while acknowledging the right of the State of Karnataka to develop the State economy in whichever way they want, I state that the NWP enjoins up on the State of Karnataka to plan the same based on the water resources available in each basin, as repeatedly stated in the NWP from 1987 to 2012". It was put to the witness that the suggestion that the State of Karnataka has mismanaged the

water by allegedly supplying 4 lakh liters of water per day to Pepsico is misleading as the total supply is a small quantity of only 0.005 tmc annually. In answer to the said suggestion, the witness stated that the National Water Policy gives some guidelines about the priorities. The priority is a sequence and is not based on the quantities. The witness explained that whether the quantity of water supplied to Pepsico is 0.005 tmc or some other quantity; whether it is small or large, which in any case is a relative term, is not the issue but the issue is as to what should have been the priority, the drinking water or Pepsico, and the people, who might have been benefitted, if this 0.005 tmc water was supplied to them for domestic use, are not likely to think that it is a small quantity. Lastly, it was suggested to the witness by the learned counsel for the State of Karnataka that the contents of his additional Affidavit are not reliable. This suggestion was denied by the witness.

112. After the cross-examination of Shri Chetan Pandit by Shri Mohan V. Katarki, the learned Counsel for the State of Karnataka was over and complete, Shri Chetan Pandit was cross-examined by Shri D. M. Nargolkar, the learned Counsel for the State of Maharashtra.

113. In answer to Question No.136, the witness stated that he was associated with the River Management Wing and during his tenure, as additional charge, as Chief Engineer, Narmada and Tapi Basin Organization (Gandhinagar) he was required to discharge all the functions that a Chief Engineer would. The witness has stated that soon after the Tribunal's visit to the sites in December, 2013, he had started working on the matter and visited the Ganjim site, whereupon the fact that a weir which was constructed close to the discharge site, was brought to his attention, and after that it was a continuous process of examining the discharge sites at Ganjim and at Collem, which went on for quite some time, and during that time the discrepancies came to his notice. The witness was confronted with the map at Exh. GOA/152 and requested to identify the portion in the catchment area which drains directly into the sea and the witness had accordingly marked the relevant portions on the map. The witness was confronted with a lecture note given by Mr. R. Azhagesan, Executive Engineer, Upper Krishna Division, Central Water Commission, Pune, in which under caption "Velocity" it is mentioned that the mean velocity is equal to 0.89 times the surface velocity at the vertical. The witness agreed

with the said fact but further stated that in the same paragraph Mr. R. Azhagesan has also pointed out that “However, we are also conducting experiments on vertical distribution of velocity to verify the assumptions” which according to the witness shows that the author himself admits the factor 0.89 is only an assumption which is subject to further verification through experiments, which he said he is conducting. The witness was again confronted with Document MARK MAH-1 and put a suggestion as to whether the witness agreed that velocity considering while computing the discharge is mean velocity and not surface velocity. In answer to the said suggestion, the witness maintained that this is just an explanation of the theory in a training programme and it does not necessarily mean that the theory as explained therein is being practiced at Ganjim, or Collem, or at any particular site.

114. The witness was asked a question as to whether the correction factor worked out by the witness is the ratio of average discharges of two different periods and is it not necessary that the same should always be less than one? The witness referred to two documents MARK-MAH/1 and MARK-MAH/2, and stated that the two documents referred to above

established firmly the principle that data observed by Float Method needs to be corrected which is now even supported by the BIS code. He further explained that the ratio computed by him was not an origin of two different periods but also of two different methods during those two periods, and since the average discharges were taken for both the periods, and if the data in each period was representative of the catchment characteristics then the overall discharge by Current Meter Method divided by Average Discharge would always be less than one. It was put to the witness that the correction factor worked out by him has nothing to do with the correction factor/coefficient/reduction coefficient to be applied for converting the surface velocity to mean velocity and it is sheer coincidence that the correction factor worked out by him has become close to the range in which reduction coefficients are generally arrived at. The witness denied the said suggestion.

115. The witness did not agree with the suggestion that import of water from Tillari basin would add to the water availability of Mahadayi basin, and further stated that import of water from one basin to another basin can be construed to increase the water availability in the recipient basin only if it was

an import for general use, where it gets added to the common kitty, from which allocations were made to various stakeholders. According to the witness, the case mentioned in the question, namely import of water from Tillari basin is a case of bilateral arrangement between the two parties and for a very specific pre-determined purpose which is for irrigation in a pre-determined area and therefore cannot be construed to increase the water availability of Mahadayi basin.

116. With the above said answer, the cross-examination of Shri Chetan pandit, by Shri D. M. Nargolkar, the learned Counsel for the State of Maharashtra, was over and complete. With the objective to have clarity on some of the important issues flagged by the witness in his Affidavit and the facts presented in his report, the Tribunal proposed to put a few questions to the witness as the Tribunal was of the opinion that such exercise would enable the Tribunal to reach rational conclusions through the expert advice of the witness, irrespective of the claims or otherwise of the party States in respect of various issues which are under consideration of the Tribunal. Hence, the Tribunal had put certain questions to the witness.

117. The witness stated that the main requirement of data for estimation of water availability is the river data which comprises the observed flow in the river and any significant abstractions in the upstream. According to the witness, the river data after correction for the upstream abstractions is subjected to a probability analysis.

118. The attention of the witness was drawn to paras 24 and 25 on page 10 of the Affidavit of the Examination- in-Chief filed by the witness on 04.08.2016 and the Tribunal wanted to know from the witness that as to how he would proceed with the process of estimation of water availability at a specific point along a river for a basin or sub-basin in India, when the hydrological and hydro-meteorological data are not adequate. The Tribunal also wanted to know from the witness as to whether it is possible to estimate the availability of water at specific point along a river for a basin or sub-basin in India if requisite hydrological and hydro-meteorological data are not at all available.

119. In answer to the above stated two questions, the witness stated that if the inadequacy is so high that even the

process of filling a few missing data does not serve the purpose then the entire project would change. The witness explained that the extreme case of inadequate data is - no data. The witness explained that many years ago a British Engineer by name Strange developed a Table, which is known as Strange's table, which helps determine the water availability based on only a few parameters like the catchment area, mean rainfall etc. The witness added that such methods are called Empirical methods and for other aspects of hydrologic analysis viz., flood studies etc., there are other Empirical formulae available viz., Inglis formula, Nawab Shri Bhadaur Jung Formula etc. and these formulae may be used, but, Empirical formulae will give only a water availability figure without any attached dependability like 50%, 75% etc.

120. In answer to question No. 154, the witness stated that after correcting the formula, the 75% and 50% dependable yield for 2032 sq.km and 1523 sq.km. are as below:

Yield		Mcum	Tmc
Runoff over entire catchment.	50% Dependable	4960.10	175.16
	75%	4289.07	151.47

Area 2032 sq.km.	Dependable		
Usable Yield Catchment Area 1523 sq.km.	50% Dependable	3717.60	131.30
	75% Dependable	3214.70	113.50

121. According to him, he requested the officials from WRD, Goa to take water samples from the river and test the same in a lab for salinity and for the first such sample he had personally supervised the operation and guided the concerned persons as to how to take the samples. What is asserted is that the lab test subsequently verified the salinity. According to him, his general observation that the catchment has a thick cover of vegetation in the upstream areas enabled him to form an opinion about possible losses from the rainfall by way of evapo-transpiration and, thereby, the runoff factor expected in this catchment.

122. In his Affidavit at para 21, page 9, he had stated that "the river flow measurement is an instantaneous measurement i.e. at an instant of time, but it is required to be taken as representative of the flow over a duration of time, typically 24 hours." However, in WMO-1044-Manual on Stream Gauging, stream flow or discharge and streamflow measurement are

defined and the attention of the witness was drawn to said Manual. It was put to the witness that stream flow, or discharge, is defined as the volumetric rate of flow of water in an open channel, including any sediment or other solids that may be dissolved or mixed with it and is usually expressed in dimensions of cubic meters per second (m^3/s) but stream flow cannot be measured directly and must be computed from variables that can be measured directly, such as stream width, stream depth and flow velocity.

123. It was put to the witness that "river flow measurement" as such cannot be considered as an "instantaneous measurement", although measurement of variables such as depth are instantaneous in nature whereas instantaneous discharge is computed by using observed instantaneous gauge, and the rating curve developed for the site. Therefore, the witness was requested to elaborate as to what he meant by "river flow measurement as an instantaneous measurement". In reply, the witness stated that strictly speaking no measurement is instantaneous and any act of reading any instrument takes a finite time. However, it was explained by the witness that it is a colloquial expression that river flow

measurement is instantaneous in the sense that even though the actual act of measurement by moving the Current Meter at various locations across the river and taking the readings etc., it takes a finite amount of time but at the end of it, the measurement is recorded as cubic meters per second at an instant of time. The witness also explained that if a river gauge is read at 0830 hrs, and discharge is computed, one would not call it as the river flow during the previous 24 hours or any other duration and it would be considered as the river flow at 0830 hrs, and in that sense the river flow is an instantaneous measurement. The witness has mentioned in his Affidavit in para 23 that the hydrologist making such assumption has to make certain decisions on acceptability or otherwise of various data; the procedure to be followed etc. based on the Hydrologist's knowledge and experience. The Tribunal felt that all hydrologists may not be highly knowledgeable and experienced and in such circumstances it may not be appropriate to leave the process of checking the data and the choice of procedures or methodologies to be adopted for estimating hydrological inputs to be considered during decision making process at the sweet will of the Hydrologists. The Tribunal further wanted to know as to why the Tribunal should not insist on following the procedures laid down

in standard codes or guidelines such as; (a) relevant Codes Bureau of Indian Standards; (b) Guidelines for Preparation of Detailed Project Reports of Irrigation and Multipurpose Projects published by the Ministry of Water Resources; and (c) State-of-Art Report on Development of Hydrological Design Aids prepared under Hydrology Project-II. In answer thereto, the witness mentioned that we are still a long way off from eliminating the role of human judgment in practice of hydrology. The witness mentioned that when an "expert system" software is developed; or guidelines are developed; or Standard Operating Procedures are developed; in all such cases one or more experts are consulted and their judgment, their way of thinking, their approach is translated into a software or a guideline or an SOP and anyone using that software or guidelines or SOP, thereafter, is actually using the judgment of the people who wrote that software etc. and therefore there is elimination of judgment. Moreover, it was pointed out by the witness that the guidelines can only give a broad guidance and guidelines cannot go into the details, such as which probability distribution to use; which method to use for determining the parameters; etc. and all that is left to the judgment of the consulting hydrologist.

124. The Tribunal had noticed that in paras 27 and 28, pages 11-12 of his Affidavit, the witness had mentioned about inadequate number of CWC gauging stations on river Mahadayi and its tributaries, but the State of Goa, Karnataka and Maharashtra had reported observed hydrological data at (i) Daucond from the year 2010 to 2013;(ii) Khadki from the year 2010 to 2012; (iii) Kudchire from the year 2009 to 2013; (iv) Paikul from the year 2009 to 2013; (v) Chapoli from the year 1985-86 to 1991-92 and from 2000-01 to 2013-14; (vi) Virdi from the year 1986 to 2004 and from the year 2006 to 2011. However the Tribunal noticed that the above mentioned data had neither been analyzed for consistency checks nor used for assessment of water availability. Therefore, the Tribunal wanted to know from the witness as to why the data, observed and collected by the respective State Governments, cannot be used for assessment of water availability. The answer to the said question by the witness was that the table given in the question relating to gauging stations of Doucond, Khadki, Kudchire and Paikul, the data was available only from 2009 to 2010 onwards, and that he had used data only upto 2005, and therefore the data of these stations was ruled out. The witness further mentioned that at Chapoli, the data available is one chunk from 1985-86 to 1991-92, and

another chunk from 2000-01 to 2013-14, and as there was significant gap between 1992-93 to 1999-2000, in the second chunk, the useable data for him was only upto 2005, whereas in case of Virdi, the data for his purpose was available from 1986 to 2004, hence he had decided not to use the data after 2006. He further asserted that he did not recommend developing of rainfall runoff relationships for small catchments because as the catchments get smaller and smaller the relationship becomes; less and less stable.

125. It was noticed by the Tribunal that in the table given in para 27 at page 11 of Affidavit of the witness, the information relating to minimum number of stations and actual number of stations in Mahadayi basin had been furnished by him. The Tribunal found that the 4th column of table indicates the actual number of stations in Mahadayi basin, wherein the witness had indicated six stations for precipitation and one station for streamflow. It was also noticed by the Tribunal that from the information included in various records filed by the States of Goa, Karnataka and Maharashtra, it was apparent that the number of raingauge stations in the basin is much more than six and even in his report, the witness had included information about

availability of data of 18 stations in Table 2 and Table 3 on page 60 and page 61, respectively. But out of available data for 18 stations, the witness had used the data of 13 raingauge stations, as is apparent from the table No. 34 on page 94, and figure 3 on page 96. Therefore the Tribunal wanted to know from the witness as to why complete information regarding the rain gauge stations and stream gauging stations, had not been provided and that only limited information in respect of rain gauge stations of IMD and Stream gauging stations of CWC had been provided. In answer to the said question, the witness mentioned that most of what is in the first Affidavit had already been submitted much earlier on 15.09.2015, and much later, when the yield study report by Dr. V. Jothiprakash was withdrawn, and he had started working on the yield study report some time in July, 2016, the focus was on doing the yield study with the data which had already been assembled, and perhaps for this reason a detailed data inventory does not appear in his yield study report. The witness admitted that he was not aware of the methods or techniques used for discharge measurement at the sites of Doucond, Khadki, Kudichire and Paikul, which were established and maintained by the State of Goa. The witness could not offer any comments on the question whether he was satisfied that the

discharge data observed at four discharge measurement sites namely; Doucond, Khadki, Kudichre and Paikul by the State of Goa are as per the standard practice and can be considered as reliable. The witness was confronted with the information culled out from the data submitted by Central Water Commission (vide report titled "Consistency Analysis of Flow Data in Mahadayi Basin" filed on 01.12.2014) and that by the State of Goa in compliance with para 4 of the Order dated 03.09.2014 passed by the Tribunal on 22.12.2014. The said data forms parts of Question No.63 put to the witness.

126. It was noticed by the Tribunal that there were wide variations in annual runoff in terms of depth in mm, at different sites and in particular, the variations in the annual runoff in mm, in respect of Khadki, and Kudichire sites maintained by the State of Goa during the years 2012-13 and 2013-14 and the variations were on very high side. Therefore, the witness was asked to offer his comments on the variations noticed by the Tribunal. The reply given by the witness was that he had not analysed the data at any station beyond 2005 and had not analysed the data at Khadki and Kudichire for any duration, and therefore he was not able to explain the variations in annual runoff at different sites.

127. The Tribunal further noticed that in para 27 at page 1 of his Affidavit, the witness had indicated that six precipitation stations are required for catchment area of 2032 sq.km. of Mahadayi basin on the basis of the Table for "Recommended minimum densities of stations (area in km^2 per station)" provided in the World Meteorological Organization (WMO) publication titled "Guide to Hydrological Practices". On going through the guide to Hydrological Practices, the Tribunal found that the guidelines can also talk about the minimum network that will avoid serious deficiencies in developing and managing water resources on a scale commensurate with the overall level of economic development of the country. Further IS 4987: 1994 – and the observations made in the WMO publication while identifying minimum number of stations had made certain recommendations and whether the witness had followed the same. The answer of the witness was that the contents of paragraph 27 on page 11 of his Affidavit were based only on the WMO Publication No. 168 downloaded from the CWC website, and he had not taken the IS 4987:1994 into account while writing the said paragraph. What was claimed by the witness was that the network of raingauges had already been set up by other

agencies and he was only required to use the data if found reliable and useful. It was noticed by the Tribunal that in para 30 on page 12 of his Affidavit, the witness has mentioned that he had personally visited various locations in the Mahadayi basin to obtain a clinical picture of the basin from a hydrologist's perspective. The Tribunal called upon the witness to inform it as to what precisely the witness meant by clinical picture of the basin from a Hydrologist's perspective, and how the above stated clinical picture of the basin differs from understanding the topography and land use, as already mentioned by him at para 17 on page 8 of his Affidavit. In answer, the witness mentioned that the term "clinical picture" is borrowed from the world of medicine and refers to such observations and conclusions, which an expert might draw, which cannot be quantified and cannot be expressed in terms of numbers. As regards, what specific information and data had been gathered during his visits and how the information and data have been used, the witness replied that the same had been dealt with at length, in answer to question number 156. In para 31 on page 13 of his Affidavit, the witness mentioned that the Float Method is the least accurate, and therefore the accuracy of discharge data prior to the year 2000 is questionable, however, it was noticed by the Tribunal

that Measurement of velocity of flow by using float is an accepted procedure, as is evident from the fact that after going through the International Standard Code "ISO 748:2007 Hydrometry-Measurement of liquid flow in open channels using current-meters or floats", and this code has been adopted by Bureau of Indian Standards as IS 1192:2013. It was further noticed by the Tribunal that IS 3911:1994 also dealt with Surface Floats – Functional Requirements. Moreover the Central Water Commission in its report "Consistency Analysis of Flow Data Mahadayi Basin" (Volume 99) has reported that the cable way was erected at Ganjim site in the year 2001 and that the discharge observations were carried out with current meters using boat and cableway during monsoon at higher stages and by wading during non-monsoon at lower stages. The CWC had also stated that before the year 2001, float was used for discharge observations during higher depth. Under the circumstances, the Tribunal was of the opinion that Float Method was used due to lack of facilities for the use of current meters at higher flows and that the same was in accordance with the provisions of Bureau of Indian Standards Code IS 3991:1994. Therefore the Tribunal wanted to have opinion of the witness as to what could have been the option other than use of Float Method during high flow

prior to the year 2001, when there was no cableway. In response, the witness clarified that he had not challenged the use of Float Method and had not discarded the data collected by Float Method. The witness mentioned that in fact he had used CWC discharge data from 1979 onwards which, till the year 2000, was by Float Method, and therefore, his comments on the Float Method may not be taken as rejection of Float Method. The witness agreed that in certain stations, the Float Method may be necessary and Float Method continues to be used when a new site is opened and current meter is yet to be procured. The witness further explained that there could be one more reason for continuing to use the Float Method and that is financial constraints, because Current Meter itself costs some significant amount and requires frequent re-calibration in specialized hydraulics laboratories, and all this requires money and trained people, and probably non-availability of these were the reasons why upto 2001 the discharge measurements were continued by CWC by Float Method.

128. The Tribunal had noticed in para 32 on page 13 of his Affidavit that the witness had mentioned that construction of this weir would change the gauge-discharge relationship at Ganjim

and that he had found that CWC had not made necessary changes in its observation procedures, i.e., discharge measurement procedures taking cognizance of the construction of the said weir. The Tribunal wanted to know from the witness as to why changes in the observation procedures are necessary because of likely changes in the gauge discharge relationship and would the development of a revised gauge discharge relationship not serve the purpose and what should be the changes in observation procedures. In answer, the witness maintained that construction of weir causes water to head up behind the weir and this extends to some distance upstream. According to the witness, this heading up of water is known as back water profile and when the gates of weir are closed, as they are during the lean season, it creates a stagnant pool of water behind the weir and in that situation no gauge discharge relationship will hold true. The witness explained that in his opinion this is what is happening at Ganjim site post 2005, and considering the fact that the gates of the weir are closed during lean season, the only solution is to shift this site to suitable location upstream, beyond the effect of back water profile.

129. It was noticed by the Tribunal that in para 34 on page 13 of his Affidavit, the witness had stated that when the CWC staff is not adequately trained and adequately supervised for taking correct observation in a correct manner, then there is every possibility that before 2006, the incompetence and/or lack of supervision persisted and therefore the data prior to year 2006 is suspect. However, it was also noticed by the Tribunal that in para 17 on pages 56-57 of his report, the witness had considered observed data at Ganjim for the period from 2001-2005 as correct. Therefore, the witness was requested to explain this contradiction. The witness explained that he had stated in paragraph 33 that the fact that CWC failed to take cognizance of the construction of a weir raised a strong doubt on the competence of the observation staff and the quality of supervision. According to the witness, he was perplexed by the fact that after 2005 i.e. when a weir was constructed, the CWC staff had proceeded to take discharge observations as if nothing had happened. The witness further explained that there is no contradiction in using the data before 2005, because, as he had stated that a hydrologist has to do the best possible with the available data, and it is not acceptable position for the

Hydrologist to say that yield study will have to wait till data of his satisfaction becomes available.

130. In para 39 on pages 15 and 16 of his Affidavit, the witness stated that the river valley projects inflict a huge cost on the people; there are financial costs in terms of money; there are environmental cost like diversion of forests land for non-forest purposes and changes in the flow pattern in the river, which further impact ecology; there are social costs in terms of people displaced from their homes and farms and there is loss of livelihood; etc. and therefore, the witness opined that in case of doubt about the accuracy of water availability assessment, it is preferable to err on the safer side i.e., on the lower side. The Tribunal wanted to know from the witness as to why he felt that various standard practices for assessment of water availability are not based on rational approach and that they cannot be relied upon for the purpose of water resources assessment and that the financial considerations should decide the quantum of available water resources for planning purposes. The Tribunal felt that the approach mentioned by the witness in para 39 would lead to non-optimal planning of scarce water resources. In reply, the witness mentioned that his comments on paragraph 39 as

reproduced in question 170 have been misunderstood. He asserted that it is a fact that river valley projects inflict a huge financial and environmental and social costs and another aspect of river valley projects is, that they are irreversible and mistakes cannot be repaired. Therefore, according to the witness decisions on a river valley projects need to be made with great care and it is his experience that projects that underperform are in fact counter-productive, in the sense that it builds a huge public opinion against such projects. The witness mentioned that there are comments, on regular basis, in the popular media, newspapers etc. that such and such State has constructed so many large dams, and yet the water problems remain unsolved. The witness elaborated that in his Affidavit he has stated that hydrology is a very crude science and therefore, predicting the future water availability, based on the past rainfall and river flow amounts to saying that the natural processes are constant with respect to time, but in reality we are painfully aware that natural processes are not constant and in fact climate change science tells us that the future is going to be significantly different from the past. The witness therefore claimed that under those circumstances, a hydrologic yield study for predicting the water availability in the future is very difficult exercise, and must be

approached with great caution and that it is absolutely necessary to conserve the scarce water resources, not only for the mankind, but also for the ecological services the rivers provide. It was noticed by the Tribunal that on page 43 of his Affidavit, the witness had mentioned that drawing of isohyets requires the raingauges to be many and evenly spaced all over the catchment and that this condition is rarely satisfied. Further, the witness explained in the map annexed to his report at figure 3 on page 96, that it can be seen that the rain gauges of Amagaon, Chapoli, Kotni Dam, Gavali, Jamagoan and Krishnapura are located relatively close to each other in a small segment of the catchment in the north-east of the basin whereas Valpoi is located even farther away from Krishnapura and then Ponda, Quepem, and Sanguem are located even farther away. The witness further stated that Mapuca and Panjim in the east are also located very far away. The witness claimed that he would not attempt to draw Isohytes in the Mahadayi catchment in the region roughly to South-West of a line joining Kankumbi and Krishnapura, because he considered raingauges in this region to have located too far away from each other for the purpose of drawing Isohytes.

131. The attention of the witness was drawn to pages 49 and 50 of his Affidavit and it was pointed out that in view of what is stated on those pages, the witness had selected a very simple linear equation with total monsoon rainfall as independent variable, and the total monsoon runoff as dependent variable, however in para 22, page 9, it is stated by him that the relationship of the runoff to rainfall is complex, and for a given quantity of rainfall the resultant runoff could be different at different times. The Tribunal prima facie was of the view that preliminary analysis of discharge data of Ganjim site supplied by the Central Water Commission and the high resolution gridded daily rainfall data of India Meteorological Department also exhibit high degree of variations in rainfall and runoff. Therefore, the Tribunal had requested the witness to justify the adoption of the simplest form of rainfall and runoff relationship, using the total "monsoon rainfall and total monsoon runoff through linear regression analysis" which in his view had no basis for whatsoever in the hydrometeorology. Witness was further requested to inform the Tribunal as to why model using data at shorter interval, say, monthly data had not been considered more appropriate. The witness in his answer mentioned that the observation that complex and laborious computations, many

checks, graphs etc. do not necessarily lead to better results was drilled into their heads, the 1986-87 batch of M.Tech in Hydrology, by Prof. Nash, a father figure in the field of hydrology. According to the witness, better results come from better insight into the science of hydrology and his observations were related to not doing too many statistical tests, and were not related to the choice of model for rainfall runoff relationship. The witness explained that unfortunately, the community of hydrologists has not made as much use of modern computers as have been made by their counterparts in the field of meteorology. The witness enumerated new models introduced as well as proposed, and referred to a book written by Prof. Vijay P. Singh which runs into two volumes which is simply a compilation and review of many different models. The witness stated that this is still in the "Lab" stage and it is yet to make the final journey from lab to field. According to the witness, the practice of hydrology continues with rather simple techniques like linear regression for monsoon or annual rainfall and runoff and as a Hydrologist, he is rather unhappy with this situation and had expressed himself thus in various seminars, workshops etc. The witness also mentioned that as for the NAM model used by the DHI in their software, the same is a rather simple model and the software Mike-11 was

originally developed by DHI for dam break analysis, and was later modified for flood forecasting and also for hydraulic river modeling. The witness stated that in flood forecasting, the main issue is to get the peak runoff and the time of its occurrence correct and the volume of flow is not the issue of interest in flood forecasting, but in contrast for the yield study the key issue is the volume of flow and not the peak flow or its time of occurrence. The witness asserted that he did not consider NAM model suitable for this purpose.

132. In question No. 173, the attention of the witness was drawn to paras 179L and 179M of the amended Statement of the Case of the State of Goa, filed on 23.04.2015, and it was put to the witness that the Tribunal finds that the yield of Drainage Basin has been defined in the IS:4410(Part XI/Sec2)-1972 at para 2.66 as "Total volume or flow from a drainage basin for a long stipulated period of time, for example 'annual yield of a drainage basin' is mean annual runoff" and that the term yield of a river has been clearly defined in the report of Cauvery Water Disputes Tribunal states that "The yield of a river system is the annual virgin flows at its terminal site". The Tribunal found that in the context of river flow, annual yield is synonymous to annual runoff

or annual flow, and therefore the witness was requested to inform the Tribunal as to whether he agreed with the above mentioned definition of yield, as given in the Indian Standard code or that included in the report of the Cauvery Water Disputes Tribunal, and in case he disagrees to detail the reasons for disagreeing. In answer to the said question, the witness stated that in paragraph 179L and 179M of State of Goa's amended Statement of Case filed on 23.04.2015, there is a reference to the said report which is perhaps an yield report prepared by Prof. V. Jothiprakash, and in that report the terms run-off and yield were used in a particular manner. The witness explained that he used the term runoff to indicate the water accruing from rainfall over the entire catchment, and the term 'yield' to indicate the usable part of the run-off by excluding some part of the catchment, from where the run-off cannot be utilized for various reasons. The witness also mentioned that CWC did not use the terms the way Prof. Jothiprakash had used them, but the underlying concept that a part of the catchment which directly drains into the sea/ocean; where the rivers may be saline due to tidal effects; where the topography may not permit construction of dams and barrages for utilization of waters holds true i.e., the terminology may differ but the concept is same. The witness added that IS

4410 (Part XI/Sec2)-1972, Mark 13, defines the yield of drainage basin as “Total volume or flow from a drainage basin for a long stipulated period of time, for example ‘annual yield of drainage basin’ is the mean annual runoff.” The witness further stated that in the photocopy of page 9, the heading of the concerned paragraph 2.66 is qualified with an ‘*’ mark indicating that probably there is a foot note, but this footnote is not seen in the page 9. According to the witness, there are two issues i.e. it defines the yield as mean annual runoff, and mean is arithmetic mean. What was stated by the witness is that if the data follows normal distribution then arithmetic mean is the same as 50% dependable value, whereas natural data usually is very close to normal distribution, but for the purpose of water resources planning in India traditionally 75% dependable yield is used which is a deviation from what the IS Code defines. According to the witness the second issue is, as to what is the definition of a drainage basin. After informing the Tribunal that in IS Codes there is no distinction between a tributary, which meets a larger river at a specific point vis-à-vis a large river which outfalls into the sea/ocean and the river which outfalls into the sea/ocean would pass through a delta and estuarine phase, whereas a tributary has no delta, no estuary and therefore obviously the

definition of catchment for the purpose of allocation of utilizable yield of a river which is a tributary, will have to be different from the definition for a river which may be small, but is an independent river out falling into a sea or an ocean. The witness claimed that from an internet search he had found that without necessarily modifying the definition, in earlier cases also while allocating the waters of an independent basin, the 'terminal point' has been taken some distance upstream of the final outfall of the river.

133. On 7.10.2016, the witness had given supplementary reply to question no. 163, and in that the witness had stated that Khadki site is located on the main river Mahadayi, approximately 7 kms, upstream of the Ganjim site and there are no major diversion works between the Khadki site and Ganjim site and therefore there is no logical reason for the flow at Khadki to be more than the flow at Ganjim. The witness stated that the flow at Khadki for the years 2010-11 to 2013-14 is not only more than the flow at Ganjim but in 2011-12 and 2012-13, it is significantly more and therefore in his opinion, this data is not reliable. The witness explained that the Kudchire site is located on river Bicholim which is a tributary of Mahadayi and meets the main

river Mahadayi downstream of Ganjim site. The witness mentioned that one way to form an opinion about the flow observed at Kudchire site is by comparing it with the rainfall in its catchment for the years concerned and this data is not readily available and therefore he expressed his inability to give any opinion about reliability of the data at this site. The witness claimed that he was informed by the WRD Goa Engineers that both these sites have been newly established under the Hydrology Project and, perhaps in 2010 to 2014 the observation procedure was yet to stabilize.

134. In Question no. 175, it was pointed out to the witness that it had been mentioned by him at page 57 of his Affidavit that the ratio was found to be 0.84, which means the discharge as measured by float should be multiplied by 0.84 to correct it and bring it at par with the data measured by the current meter method, however, it was noticed by the Tribunal from Table 33 on page 93 of his Affidavit that the ratio of " Q float Correc" and "Q Obs." is about 0.81 and not 0.84. It was also noticed by the Tribunal that para 7.2.5.1 and 7.2.5.2 of IS 1192:2013 (ISO 748:2007) describes the method for determination of velocity. Accordingly, the witness was requested to explain the

inconsistency in his report in respect of the value being either 0.84 or 0.81, and also to inform as to whether the provisions in IS 1192:2013 in respect of coefficient of surface float had been kept in view. The explanation given by the witness was that computation of the correction factor and its application to the Float data was all built into the same Excel spread sheet, which means once the spread sheet was programmed, it calculated the factor and also applied it to the Float data without any additional intervention or command by the user. It was mentioned by the witness that he had found that CWC 2003 Report had the discharge data from 1979-1984. According to the witness he had disagreed with CWC computations, and therefore, the outcome in their study and that the disagreement continues, but that does not mean a total rejection of the entire report as if it was a monolith. The witness explained that since there were no convincing arguments for rejection of the data, he used it and further revised his computation and on inserting the 1979-1984 discharge data in the spread sheet the factor automatically changed from 0.84 to 0.81, and the spreadsheet also applied this factor without any intervention from him and completed the calculations.

A question was put to the witness as to whether he had examined the data sheet of CWC in respect of observations during the period from 1979-2000 to check whether necessary coefficient as prescribed in ISO 748:2007/IS 1192:2013 (Mark 14) had been applied as multiplication factor by CWC to convert the surface velocity observed by float measurement into the mean velocity or not. In answer to the said question, the witness categorically mentioned that he had not checked the CWC's original data sheets at the site. On examination of the data sheet of Central Water Commission in respect of daily discharge data, particularly, the statement related to velocity observation by float, it was found by the Tribunal that Central Water Commission had used suitable multiplication factor and from the data sheet of one particular date i.e. 3.7.2001, it was noticed that 0.89 had been used as multiplication factor to convert the observed surface velocity into the mean velocity, therefore the opinion of the witness was sought by the Tribunal that the exercise to correct the discharge for the period from 1979 to 2000 had been undertaken by the witness without thorough examination and was uncalled for. In answer to the said question, the witness mentioned that on the data sheet 03.07.2001, a date when he believed the observations were

already being done by the Current Meter Method but the data sheet says that a factor of 0.89 has been applied, and he had no further comments to make on that.

135. The attention of the witness was drawn to page 58 of his Affidavit and it was put to him that it was apparent that he was not at all confident about the findings presented by him in the report and therefore how did he expect the Tribunal to accept his findings and the recommendations. After denying the inference as suggestion in the question, the witness stated that comments made by him in the paragraph quoted in the question should be read together with an earlier comment made by him on page 36 of his report, whereas in third paragraph “Hydrology is an inexact science, in the sense hydrologic computation cannot be made with the same exactness as – say – computation of the trajectory of a ballistic missile, or voltage and current in a circuit”. The witness stated that the decisions are likely to be taken by appropriate authorities based on his yield study report, which will impact the lives of millions of people, impact the environment, and also involve expenditure of large sums of money. The witness stated that Thiessen Polygon, Linear Regression, are methods routinely used by the Hydrologists and he has also used

them but that does not change the fact that neither of these methods have any basis in the science of hydrology, because Thiessen Polygon concept arises from a branch of mathematics known as “Proximity Analysis” and merely divides an area into polygons in which all the points are closest to a certain point in each polygon. There is no basis to assume that the rainfall at all points in such a polygon is the same as the nodal point in that polygon. The witness mentioned that Linear Regression is a procedure from statistics and fits a straight line to a set of data of two variables by minimizing the square of errors between observed values and predicted values, without any reference to the cause and effect relationship between the two variables.

136. The witness further mentioned that the hydrologists use both these methods because at the moment nothing much better is available but the inherent deficiencies in these methods cannot be ignored. The witness further added that as regards use of hourly data, traditionally the same is used for flood studies and not for water availability study and since he has not made any flood study of Mandovi basin, he had not examined the continuity, and reliability of the hourly data.

137. The attention of the witness was drawn to the observations made by him on page 58 of his Affidavit as the Tribunal had found the same to be disturbing and a matter of serious concern. The witness was requested to inform the Tribunal as to where the problem lies - with the study programmes or with the teaching system or with the professionals' training or something else, and what measures are necessarily required to improve the situation. The witness explained that there is no lack of hydrology talent in India and many of the Indian Universities, for example, the IITs teach Hydrology at Post Graduate level, but the problems are inherent to the science of Hydrology and although in India, Hydrology is traditionally taught as a specialization in Civil Engineering, it is now recognized as a group of Sciences known as "Earth Sciences". All Earth Sciences have certain inherent limitations arising out of very large data sets; from which only a limited sample is available; spatially distributed data; inadequate understanding of how the nature behaves; having to predict the future based on the past despite being fully aware that the natural processes are not constant. It was explained by the witness that an example of limitations of Earth Sciences is our inability to predict earthquakes and that this is not due to any

inadequacy in training programmes or teaching etc. Further, he mentioned that the School of Earthquake Engineering in IIT, Roorkee is one of the finest in the world but the problem is that natural process leading to earthquakes have not yet been fully understood and it is very difficult to make observations of the causative factors which result in earthquakes. The witness expressed that Hydrology has progressed somewhat better but suffers from the inherent limitations and in the foreseeable future will continue to suffer from the inherent limitations of Earth Sciences and Hydrology requires analysis of very large data sets which was difficult without the computers, and in fact, the science of hydrology has started making some appreciable progress only after computers became available to civilian users, which in India means approximately 1975, but before that, hydrology was practiced mostly by Empirical formulae and sometime in late 1990s, the desktop computers became powerful enough to undertake hydrological analysis.

This is the sum and substance of the evidence of witness, Shri Chetan Pandit (AW-1).

Oral evidence of RW-1 Prof. A.K. Gosain for the State of Karnataka

138. Having discussed the evidence of expert witness Shri Chetan Pandit, AW-1, examined on behalf of the State of Goa regarding availability of water in Mahadayi Basin, it is time to discuss the Affidavit of Examination-in-Chief filed by Professor A.K. Gosain, RW-1, on behalf of the State of Karnataka.

139. In paragraph 1 of his Affidavit dated 15.9.2015 (Volume 166), the witness has stated that he is a Professor of Civil Engineering at the Institute of Technology, Delhi, and his expertise for three decades in the field of Water Resources Engineering is derived from his education in the subject of Civil Engineering leading to Ph.D. thesis in Hydrology, teaching experiences in the area of "Water Resources Engineering" i.e. Civil Engineering Department of the Indian Institute of Technology, Delhi, research projects, guiding the Ph.D. students in Water Resources Engineering and research publications in National and International journals. The witness has annexed his Bio Data as Annexure A to his Affidavit.

140. The witness has stated in paragraph 2 of his Affidavit that the Water Resources Department of the Government of Karnataka approached him in the month of October 2013 requesting him to study the yield of inter-State of the Mahadayi Basin, and on studying the materials given to him which included the Central Water Commission's draft report of 2001 and the final report of March 2003 and the estimations made by the National Water Development Agency in 1989, he agreed to conduct further studies in close association with Mr. Anil Kumar Goyal, who retired in 2011 as the Director (Hydrology), Central Water Commission.

141. The witness has proceeded to mention that he himself with the assistance of Shri A.K. Goyal, who was M.Tech. in Hydrology from I.I.T., Roorkee, conducted the study on the water availability in the Inter-State Mahadayi basin and estimated the yield of the Basin lying in the State of Karnataka and the entire basin spread across the States of Karnataka, Maharashtra and Goa, having a catchment area of 2032 sq.km. What is emphasized by the witness is that Shri Goyal assisted him in respect of the following aspects:-

a. Checking of the consistency of the rainfall and runoff data; and

b. Re-establishing rainfall-runoff relationship.

142. The questions considered by the witness are mentioned by him in paragraph 4 of his Affidavit. In paragraph 5, the witness claims that he had independently cross checked the various aspects on which he had sought for and had received technical computations from Shri Goyal and that his study is in the form of his report titled as “The Yield Study of Mahadayi Basin”. The witness has produced his report dated September 8, 2015 as Annexure B to his Affidavit. The witness has reproduced the conclusions of the study in paragraph 6 of his Affidavit. At page 7 of his Affidavit, the witness has stated that in Case-I, he has extended the annual gross yield series of Mahadayi basin for the period 1998-99 to 2012-13 based on CWC methodology and by adopting regression equation used in CWC’s Report of march 2003 i.e, RO = 0.87891*P – 49.6451.

At page 8 of his Affidavit the witness has stated that in Case-II, he has extended annual gross yield series of Mahadayi basin for the period from 1998-99 to 2012-13 based on CWC methodology but using a revised regression equation based on runoff data of Ganjim measured by CWC for the period 1979-2012, the revised regression equation being RO = 0.7368*P + 432.28.

143. According to the witness, since long term continuous flow data of 34 years was available at Ganjim Site, the same is used for calculating the 50% and 75% dependable gross annual yield at the Gangim and run-off data observed at Ganjim Site is the net run-off after abstracting utilizations upstream. The witness has stated that, to get the virgin run-off at G&D Site, the upstream utilization has been added, to the net run-off at site, whereas for the Karnataka catchment, the annual yield has been worked out based on catchment area proportion method with respect to the yield at Ganjim. The witness has explained that Table 11 on page 9 provides summary of 50% and 75% dependable gross annual yield for Mahadayi basin at Ganjim and

for Karnataka part of the catchment, which is reproduced hereunder.

Table-11: Annual Gross Yiled in Mahadayi, Ganjim and Karnataka part of the Basin

Depend -ability	Annual Gross Yield For entire Mahadayi Basin (1928-29 to 2012-13) – Using CWC's Regression Equation	Annual Gross Yield for entire Mahadayi Basin (1928-29 to 2012-13) – Using Revised Regression Equation	Annual Gross Yield for entire Mahadayi Basin (1928-29 to 1997-98) – As per CWC Report 2003	Annual Gross Yield At Ganjim (1979-80 to 2012-13)	Annual Gross Yield at Goa/ Karnataka Border based on catchment area propor-tionate w.r.t. Ganjim (1979- 80 to 2012-13)
	Case-I	Case-II			
50% (Mcum)	6361	6321	6234	3481	1483
75% (Mcum)	5784	5838	5652	2896	1234
50% (tmc)	224.61	223.20	220.13	122.90	52.37
75% (tmc)	204.24	206.14	199.58	102.25	43.57

What is emphasized by the witness is that 50% and 75% dependable annual gross yield of Mahadayi basin worked out by using the extended data with the old R-R model is not very

different from the one obtained by revising the R-R model after incorporating the additional run-off observations, and therefore, it is recommended to use the 50% and 75% dependable gross annual yield for Mahadayi basin as 6321 Mcum (223.20 tmc) and 5838 Mcum (206.14 tmc) respectively, since it is the outcome of a correct procedure.

144. If one refers to the yield study of Mahadayi basin Report of the witness, it becomes evident that the witness has carried out the study, which is aimed at extending the assessment of the annual gross yield of Mahadayi basin at 75% and 50% dependability, by taking into account the additional available hydrological and meteorological data and employing the procedure deployed by the CWC. In para 2 of his report, the witness has described Mahadayi basin in great detail. The witness has informed the Tribunal that a major portion of the area of river basin, i.e. 1580 sq.km. (77.76%) lies in the State of Goa, 375 sq.km. (18.46%) area of the river basin falls in Karnataka and 77 sq.km. (3.78%) area falls in Maharashtra. In para 3 of his report, the witness has mentioned about the availability of the data, whereas at page 20, which forms part of para 3(i), the witness has given Gauge and Discharge data of two existing G&D sites in

the basin, maintained by Central Water Commission. In para 3(ii), which is at page 21 of the report, the witness has provided the information relating to rainfall data. On reading the said para, it becomes evident that, the CWC (2003), after making an assessment has used the rainfall data, for the following rain-gauge stations in and around the Mahadayi basin, collected/supplied by IMD, for the respective periods, as shown in Table 2. The witness has mentioned that in his study, the rainfall stations used for the period 1964-1998, have been used for the extended period, i.e. 1999-2012. The Table No.2 provided by the witness at page 22 of his report is as under:-

Table 2: Data Availability of Rainfall in Mahadayi Basin

Period	Rainfall Stations
1928-40	Valpoi, Ponda, Panjim, Mapuca, Collem, Khanpur.
1941-63	Valpoi, Ponda, Panjim, Mapuca, Sanguem, Khanpur. Supa
1964-1998	Valpoi, Ponda, Panjim, Mapuca, Sanguem, Khanapur, Kankumbi, Castlerock, Jamagaon, Amagaon

145. In para 4 of his report, the witness has mentioned about the prevalent Methodologies for yield assessment of

catchment of river basins in India and has claimed that in the present scenario the method used by the Central Water Commission in its study of 2001 and 2003, has been relied upon since this is an accepted method. What is mentioned by the witness is that the Central Water Commission has used the rainfall-runoff relationship, for working out the long term series of the Mahadayi River Basin and in the present exercise, since the data of the additional 15 years has become available, it has been used to strengthen the CWC studies of 2001 and 2003.

146. In para 5 of his report at page 23, the witness has stated about the consistency of flow and rainfall data, whereas in para 5.1 the witness has explained the stream flow data in detail. According to the witness at the Ganjim site, the observations are being carried out, using current meter with the help of boat and cableway during monsoon at higher stages and by wading during the non-monsoon at lower stages. The witness has further mentioned that during 2005-2006, a vented weir, 2 meter high, with a provision for vertical gates up to 4.5 meters high, was constructed at about 1 km. downstream of CWC site at Ganjim, to facilitate pumping for drinking purpose to Goa and got into operation from March 2006 onwards. The witness has informed

the Tribunal that from November 2006 onwards, due to closure of the weir the discharge could not be observed during non-monsoon period as the flow velocities die down due to stagnation of water at the site. What is asserted is, that the contribution of this non-monsoon flow at the Ganjim site from December to May is insignificant, i.e. less than 3% of the annual flow and that, besides velocity, the other important factor in the discharge computation is the river cross-section at the site. The witness has stated that as a standard practice in CWC, pre-monsoon and post-monsoon cross-sections are taken every year and the Gauge and Discharge curves are updated accordingly from time to time, and since many of the times, flow data is measured directly by measuring the velocity in multiple segments, across the river cross-sections, G&D curves are used for observations made during the intervening days. The witness has pointed out that the two most common methods of discharge measurement practised by CWC are Current meter and Float methods and as per the standard practice of CWC, the data collected by both the methods is accepted by CWC for water availability studies. In para 5.1.1 the witness has mentioned about the Internal Consistency of Flow Data as well as Ganjim Flow Series – Mass Curve Analysis and has mentioned that unlike

with rainfall data, where the double mass curve is used for consistency check, in case of flow data single mass curve analysis is generally carried out. In para 5.1.1.2, which is at page 26 of his report, the witness has mentioned about T-test for testing Homogeneity of the Ganjim series and has stated that mass curve analysis and t-test analysis of Ganjim series establish that the flow data is consistent over the years.

147. In paragraph 5.1.1.3, which is at page 27 of his report, the witness has informed the Tribunal about Collem Flow Series and Mass Curve Analysis and has stated that, no appreciable kink is visible in the mass curve for Collem flow and data appears to be consistent. At para 5.1.1.4, which is at page 28 of the report, the witness has stated about the Homogeneity Test for the Collem Flow Series and has mentioned that the tests show a mixed reponse to the consistency check of the flow series of Collem, and therefore, the station has not been used further for detailed assessment of the basin water yield. Again in para 5.1.2, which is at page 29 of his report, the witness has considered the External Consistency of Flow Series and stated that there is a dip in the flow data of both the sites, between the period 2000-2004, which establishes that in case of Ganjim, change in method of

measurement from float to current meter in 2001 has not resulted in any kind of systematic error in the data. The witness in para 5.2 of his report, which is at page 30 of his report, has referred about consistency of rainfall data and has stated that the processed monsoon rainfall data for the period from 1928-29 to 2000-01 and for the period from 2001-02 to 2012-13 are given at Appendix IV and V of the report.

148. In para 6 of his report, the witness has mentioned about earlier studies for yield assessment of Mahadayi basin, made by (a) Preliminary Water Balance Study of National Water Development Agency; (b) Draft report on Yield Studies for Mahadayi basin by Central Water Commission – September 2001. While considering the above mentioned draft reports, the witness has mentioned that the length of the series to be used for building the Rainfall-Runoff relationship is an important factor and it is equally important to make appropriate selection of rain-gauge stations that should be used to get the mean average rainfall for the respective catchment and (c) Report of March 2003 by the Central Water Commission on the Yield Studies of Mahadayi basin. In para 6.3.1 of his report, at page 34, the witness has mentioned about Runoff (Discharge) data, whereas

in para 6.3.2 the witness has discussed the rainfall data and in para 6.3.3.1 of his report, at page 35, the witness has mentioned about Weighted Catchment Rainfall of Ganjim, wherein Thiessen weights obtained are mentioned in Table 6, which is at page 35. In para 6.3.3.2 at page 35 of his Affidavit, the witness has dealt with the Weighted Catchment Monsoon Rainfall of entire Mahadayi basin and has stated that Thiessen weights have been worked out for different periods for those stations as indicated in Table 7. The witness has emphasized that considering the geographical locations of the rain-gauge stations vis-a-vis catchment and availability of data, Valpoi, Amagaon, Jamagaon, Castlerock, Kankumbi, Mapuca and Panjim are, the key Stations for the computation of the basin rainfall. At page 37, in para 6.3.3.3 of his Affidavit, the witness has mentioned about Rainfall-Runoff Model, whereas in para 6.3.3.4, the witness has stated about Generation of Water Yield series for the Mahadayi Basin and in para 6.3.4 the methodology adopted by CWC has been discussed by the witness.

149. The gross annual yield series from 1928-29 to 2012-13 for Mahadayi has been mentioned by the witness in para 7, at page 38 of his report. The weighted catchment monsoon rainfall

of Ganjim is mentioned in Table 8, which forms part of para 7.3.1 at page 40 of his report, whereas the weighted monsoon rainfall for the entire Mahadayi basin is mentioned by the witness in Table 9, which is a part of para 7.3.2 at page 41 of his report. In para 7.4 at page 41, of his report, the witness has discussed the generation of the Annual Yield series for the Mahadayi basin. Under the heading, 'Case-I', Extended Gross Annual Yield Series of Mahadayi basin for the period from 1998-99 to 2012-13 based on CWC Methodology and Regression Equation used in CWC's Report of March 2003, are mentioned, whereas under the heading, 'Case-II', Extended Gross Annual Yield Series of Mahadayi basin for the period from 1928-29 to 2012-13 based on CWC Methodology and Revised Regression Equation based on Extended Runoff data of Ganjim, measured by CWC for the period 1979-2012 are given. What is mentioned in para 7.5 at page 44 of the report, is the Gross Annual Yield up to Ganjim Site and of the Karnataka Catchment, whereas in para 7.5.1 the Annual Gross Yield at Ganjim is mentioned, and the Dependable Gross Yield at Ganjim is mentioned at Table 10, which forms part of the said para. Again in para 7.5.2 at page 46 of his report, the witness has mentioned about the Annual Gross Yield in the Karnataka catchment and conclusions have been derived in para

8 of his report. At page 49 of his report, the witness has reproduced Annual Gross Yield in Mahadayi, Ganjim and Karnataka part of the Basin, in Table 11, which is already reproduced under Para 143 of this Report.

150. This witness has further filed an additional Affidavit of Examination-in-Chief on 15th November, 2016 (Volume 193). In the additional Affidavit, the witness has mentioned that, pursuant to the order dated 1.9.2016, passed by the Tribunal, he has filed, the additional Affidavit. This witness, with the additional Affidavit, has produced the copy of the supplementary study ('Supplementary study for yield assessment at project sites') along with enclosure as Annexure A to his Affidavit. The witness has mentioned that, a simple approach of using the proportional area method, with the rainfall factor of nearest observed rainfall, to the mean gauged sub-basin rainfall, has been used. The witness has categorically stated that, the yield at Bhandura dam is estimated by him as 3.7 tmc at 75% dependability, whereas the yield is estimated as 4.0 tmc at 75% dependability in the detailed project report of 2000 (Volume 20). It is further stated that if the yield is 4.0 tmc, the project will operate at 70% dependability.

151. A glance at the Supplementary Study for Yield Assessment at Project Sites, enclosed along with the Supplementary Affidavit, makes it evident that, the yield available for power generation at Kotni Dam site is augmented by the diversion of Bail Nadi and Irti streams which join Mahadayi river down stream of Kotni dam site. It further shows that, the witness has computed the monsoon yield on the basis of catchment area – rainfall proportion applied to monsoon gauged flow at Ganjim Gauge Station. In para 1.3 of his supplementary study, the witness has mentioned areas of different catchment and he has stated that weighted rainfall in the catchment of Ganjim site is taken from his Affidavit dated 15.9.2015. The witness proceeds to state that the rainfall of Chapoli and Gavali stations, available in the near vicinity of Kotni dam catchment and Bhandura catchment, are taken from the document Volume 98, whereas the monsoon rainfall at Ganjim has been taken from his Affidavit dated 15.9.2015.

152. The topic of diversion to Kali River Basin is discussed by the witness in para 2 of his Affidavit and the Kalasa Diversion Scheme is discussed by the witness in para 3 of his Affidavit. The

Irti Pick up Dam, downstream of Kotni Dam, with independent catchment, is considered by the witness in para 4 of his Affidavit. The witness has mentioned that the rainfall of Chapoli and Gavali stations, as available in the near vicinity of Irti pick up dam, catchment, is taken from document Volume 98.

153. In his supplementary study, the witness has asserted the combined flow at Kotni dam site at 50% and 75% dependability, is 23.9 tmc and 19.4 tmc, respectively, whereas the combined flow for diversion at Kali Basin at 50% and 75% dependability, is estimated by the witness to be 6.1 tmc and 5.3 tmc, respectively. The witness has further asserted that, the combined flow available at Kalasa Nala catchment including the diversion of Haltara and Surla at 50% and 75% dependability is 4.6 tmc and 3.8 tmc, respectively, whereas the flow available at Irti dam catchment, at 50% and 75% dependability is, 1.5 tmc and 1.2 tmc, respectively.

154. The witness has filed an Affidavit dated 24.3.2017 (Volume 197), wherein he has referred to the fact of his filing his Affidavit before the Tribunal on 12.9.2015. According to the witness, on 22.3.2017, the learned Counsel for the State of

Karnataka had made a statement that due to oversight, his Affidavit sworn on 12.9.2015 had not been "properly affirmed and verified" and had sought permission of the Tribunal to file a properly affirmed and verified Affidavit. Thus by filing the Affidavit, the witness has reiterated the contents of his Affidavit sworn on 12.9.2015, and Annexure A and B thereto, and has verified, the contents of paras 1 to 3, including Annexure A of the Affidavit sworn on 12.9.2015.

155. This witness has further filed an Affidavit dated 11.5.2017 (Volume 198) in support of the analysis of yield of Mahadayi basin, taking rainfall data from 1928-29 to 2012-13. After referring to the fact that he had sworn and filed the verified Affidavit on 24.3.2017, by annexing the Report authored by him and Shri A.K. Goyal in September 2015 as Annexure B, the witness has stated that, in response to question Nos.98-99, put by the learned Counsel for the State of Goa, he had offered to conduct the analysis by using rainfall data mentioned therein. The witness has claimed that, accordingly, he had prepared the analysis titled as 'Analysis of Yield of Mahadayi Basin taking Rainfall Data from 1928-29 to 2012-13', which was finalized by him, on 9th May, 2017. The said analysis has been appended as

Annexure A (Colly.) to his Affidavit. The witness has stated that the contents of Annexure A (Colly.) to his Affidavit, are based on his expertise in the field of Water Resources Engineering and that the analysis produced by him provides further credence to his study mentioned in the Report, prepared in September 2015, which was filed as Annexure B to the Affidavit sworn on 24th March, 2017.

Again paras 1 and 2 of his Analysis at Annexure A, describe Mahadayi basin. In para 3 of the Analysis, the witness has mentioned about the Gross Annual Yield Series from 1928-29 to 2012-13. In para 3.1 of his Analysis, the Runoff Data is considered, whereas in para 3.2 the Rainfall Data is considered, and in para 3.3 the Methodology adopted for working out the Long Term Annual Yield Series for Mahadayi basin is described. The estimation of Weighted Monsoon Catchment Rainfall is mentioned, in para 3.3.1 at page 4 of the Analysis, and the Weighted Catchment Monsoon Rainfall of Ganjim is mentioned, in para 3.3.1.1 at page 4 of the Analysis. The Thiessen Weights for Ganjim Site (CWC Report 2003) is re-produced at Table 1 on page 5 of the Analysis, whereas in para 3.3.1.2, the Weighted Catchment Monsoon Rainfall of entire Mahadayi basin, is

reproduced in Table 2. The witness has pointed out that, the weighted catchment monsoon rainfall, for the Mahadayi basin, for the period from 1928-29 to 2012-13 is appended at Annexure VI to his Analysis. In para 3.4 of his Analysis, the witness has referred to, Rainfall – Runoff Model and Generation of the Annual Yield series for the Mahadayi basin, and in para 3.4.1 the witness has described, the Extended Gross Annual Yield Series of Mahadayi basin for the period from 1928-29 to 2012-13, based on CWC Methodology and Revised Regression Equation, based on Runoff data of Ganjim, measured by CWC during the year 1979-2012. The witness has further mentioned the revised R-R relationship and has stated that the value of R works out to about 0.816, which is considered to be good.

156. Under the heading, 'Case-I', mentioned in para 3.4.2 of the Analysis, the witness has stated that the monsoon yield series have been obtained, by substituting the catchment rainfall in mm for the monsoon, for the period from 1928-29 to 2000-01 in the best fit R-R relation. The witness has further proceeded to state that the 50% and 75% dependable annual gross yield, for the entire Mahadayi basin, adopting this approach, works out to 6105 Mcum (215.59 tmc) and 5619 Mcum (198.42 tmc),

respectively. The Mahadayi gross annual yield series, thus worked out, has been appended at Annexure VIII to the Analysis.

157. Under the heading, 'Case-II', mentioned in para 3.4.3, on page 7 of the Analysis, the witness has mentioned that the monsoon yield series, have been obtained by substituting the catchment rainfall in mm for the monsoon period from 1928-29 to 2012-13 in the best fit R-R relation and the 50% and 75% dependable annual gross yield for the entire Mahadayi basin, from this approach, works out to 6141 Mcum (216.89 tmc) and 5736 Mcum (202.55 tmc), respectively. The Mahadayi gross annual yield series, thus worked out, is appended at Annexure IX to his Analysis. In para 4 of his Analysis, the witness has mentioned, details of Gross Annual Yield up to Ganjim site, and in the Karnataka catchment. This is found in Table 3 on page 8. As mentioned in para 4.1 on page 9 of his Analysis, the Karnataka catchment of Mahadayi basin is 375 sq. km. against the Ganjim catchment of 880 sq.km., and 50% and 75% dependable gross annual for the Karnataka catchment, by area proportion method, works out to 1460.35 Mcum (51.57 tmc) and 1223.26 Mcum (43.57 tmc) respectively.

158. The conclusions have been arrived at by the witness in para 5 of his Analysis, which are to be found on page 9 of the Analysis and they are in Table No. 4 which read as under:-

Table 4: Annual Gross Yield in Mahadayi Basin by Different Approaches

Dependa-bility	Annual Gross Yield for entire Mahadayi Basin (1928-29 to 2000-01) Using Revised Regre-ssion Equation	Annual Gross Yield for entire Mahadayi Basin (1928-29 to 2012-13) Using Revised Regre-ssion Equation	Annual Gross Yield for entire Mahadayi Basin (1928-29 to 1997-98) As per CWC Report 2003	Annual Gross Yield at Ganjim (1979-80 to 2012-13)	Annual Gross Yield at Goa/ Karna-taka Border based on catchme nt area propor-tion w.r.t. Ganjim (1979-80 to 2012-13)
50% (Mcum)	6105	6141	6234	3427	1460
75% (Mcum)	5619	5736	5652	2871	1223
50% (tmc)	215.59	216.89	220.13	121.02	51.57
75% (tmc)	198.42	202.55	199.58	101.37	43.20

159. After reproducing the Annual Gross Yield in Mahadayi Basin, by different approaches in Table No.4, the witness has

stated that the 50% and 75% dependable annual gross yield, of Mahadayi basin worked out by different approaches, is very near to each other, and therefore, the witness has recommended to use the 50% and 75% dependable gross annual yield for Mahadayi Basin as 6141 Mcum (216.89 tmc) and 57.36 Mcum (202.55 tmc).

160. The witness was cross-examined by the learned counsel for the State of Goa at length and in great detail. Further to elicit the best information relating to availability of water, the Tribunal had also put certain questions to the witness. Under the circumstances, the Tribunal proposes to deal with, only those questions and answers, which are found to be relevant.

161. The learned Cross Examiner for the State of Goa wanted to know from the witness as to whether the Science of Hydrology, and particularly the computations like yield study, design flood study, etc. require the Hydrologist to make a judgment based on his experience, or is it an exact science, where given the same data set, all Hydrologists could reach the same conclusions.

The answer given by the witness was that the judgment of the Hydrologist is very important in terms of assessing, what are the conditions which are prevailing including the data availability in making a judgment as to which procedure or method is most appropriate under the circumstances. The witness has further stated that the Hydrology is not an exact science mainly on account of the high complexity of the nature and very high variability of the influencing characteristics as well as weather conditions. The witness has further clarified that, given the same data and having defined the procedure to be used, different Hydrologists should come out with the same answer.

At that stage, the attention of the witness was drawn to what is stated by him in para 5 on page 5 of his Affidavit dated 12.9.2015, where the witness has stated that “He independently cross checked the various aspects on which he had sought for and had received technical computation from Mr. Goyal”. After drawing his attention to above mentioned statement, a question was put to the witness as to whether he had accepted the technical computation, which he had received from Shri Goyal, at the face of it or had he differed with him on occasions, by carrying out his own corrections. The witness has categorically

replied that he had not taken the computation given by Shri Goyal, on the face value and he had, at times, observed some of the things and had informed Shri Goyal for corrections, but it is not so stated in his report, nor had it been so mentioned in his Affidavit.

162. The learned Cross Examiner wanted to know from the witness as to what are the main differences, if any, between his yield study and CWC study of 2003. In answer thereto, the witness has mentioned that there is no difference between the procedure adopted by CWC study of 2003, and even study of 2001, and his study. The witness has stated that, in Hydrology, when one uses the method of co-relation, it is always preferable, to use as long a length of observed flow data, as possible and it is also preferable that the length and data should be at least of 30 years. Responding to the question, as to why length of such data should be at least 30 years, the witness has stated that the nature will exhibit all the variability in terms of good monsoon years, bad monsoon years and average monsoon years, with the result, the correlation functions data derived at, shall be more appropriate, for any extension of flow series, using the long-term rainfall data. According to the witness, this is the reason that,

when he looked at CWC (2003) Report it was found by him that, the data used was till around 2001, and at least another 15 years of flow data had become available, and it was advisable to update that study, to have a more reliable outcome, on the yields of the basin. The learned counsel for the State of Goa drew the attention of the witness to the answer given by him to question No.66 wherein the witness was specifically asked that the CWC report does not anywhere, state that the study had been examined, and approved by the CWC and since the witness had not chosen to answer this part of the question, whether the witness would wish to say, as regards that part of the question No. 66, which had remained unanswered. In answer to this question, the witness categorically mentioned that he could not find the word “approved” in the Report of CWC (2003). The witness further stated that as far as examination is concerned, the Committee has all along been examining the Report, and therefore, the term “examined” used in the question, is irrelevant. The witness further claimed that he had never seen in any study being mentioned, that the study is approved, and proceeded to state that he has no knowledge of what was the fate of the Report, and whether it was placed before the CWC authorities or not.

The witness was asked as to whether he was able to state very categorically that the document titled “Reporting State of Karnataka’s Compliance of the Order dated 30.9.2014” (Volume 98), filed by the State of Karnataka before this Tribunal on 1.12.2014, was in compliance to the Order dated 03.09.2014 passed by the Tribunal, and whether that document was ever seen by him, while undertaking, carrying out, or before completion of his study. The categorical answer given by the witness to this question was that this document (Volume 98), as a whole, was not shared with him, by the State of Karnataka, and some pages thereof, where his name had appeared, were handed over to him. The learned Cross Examiner for the State of Goa wanted to know from the witness that, when rainfall data is available at many stations, in and close to a catchment, he should explain as to how the decision is taken, to either use or not to use the data of each Station, and also to explain as to what criteria or tests are applied, to select the Stations, whose data is to be used. The response given by the witness was that this is where the judgment of a Hydrologist comes into picture and it is very difficult to make generic rules, to cover all circumstances, because there are many issues, which will have to be looked into,

while making such decisions, so as to select a specific Rain Gauge Station, for a specific area. The witness gave an example and stated that if there is a station very close to the boundary of a basin, but is lying on a leeward side, it will not be a good representative Station, to be taken for that basin, whereas in other situations, a rain gauge station might be considered, even if it is not falling within the basin, but is the only one available in the near vicinity. The witness has asserted that as he had mentioned earlier, the quality of data and length of data etc., can play a role in the selection of a Station.

The learned Cross Examiner wanted to know from the witness as to whether while selecting the rainfall Station, whose data he had used, was the Station being an IMD or non-IMD, a criterion and was there any occasion for him to reject data of any Station, because it was a non-IMD Station. The answer given by the witness was that he would first give the priority to an IMD Station, but if a situation arises, where a non-IMD Station is the only data available, then he would consider that data also, with due verifications. The witness informed the Tribunal that he was not remembering any specific instance, where he had rejected a Station only because it was a non-IMD Station, and has stated

that a non-IMD Station would have been ruled out for consideration, if adequate number of IMD Stations, were available, for those respective studies. The learned Cross Examiner for the State of Goa put to the witness that the difference between conducting an yield study of a river which ends as a tributary of another river, vis-à-vis a river which outfalls into the ocean/sea, is that as the river nears the coast, the land becomes flat and a part of the catchment may drain directly into the ocean/sea, and therefore, the water resource accruing from the rainfall from this area cannot be put to beneficial use, and therefore, this area should be excluded from the computation of yield study. In answer to this suggestion, the witness stated that he would not agree to this suggestion. The witness further stated that if any area is directly contributing to the sea, then while delineating the area of the basin, such area shall not become part of the basin and as far as some part of the riverine system becoming affected by the tides and storm surges, it is a part of the natural performance of the system and is playing many important roles which one keeps on aspiring for, and therefore, it is not meaningful to take off that part of the basin for the yield computation.

It was put to the witness that when a yield study is conducted for a basin, which is an inter-State basin, then, since water resource, if at all, are to be allocated, amongst the party States, it would be necessary to compute the yield from only that catchment area, from where the water resource can be captured, and put to beneficial use. In answer, the witness did not agree with the suggestion and proceeded to state that one cannot imply that the water, which is being used by the human beings, is the only beneficial use and even if it is assumed that, any such portion, which the State wants to exclude, on account of any given reason, shall also change the proportion of the yield of the State, within the remaining basin, and therefore, any way one looks at, the proportion of the State, out of the total yield, should remain the same.

It was brought to the notice of the witness that he had derived the Runoff Equation as: Runoff = 0.7368*Rainfall + 432.28, but on verification of the table containing weighted rainfall at Ganjim, and also the observed runoff at Ganjim in mm for the years 1979 to 2012, extracted from his Report, the State of Goa was unable to get the same equation and that the State of Goa got the equation as: Runoff = 0.4802*Rainfall + 1751.737,

and therefore, the learned Cross Examiner wanted to know from the witness as to how he had got the regression equation: Runoff = 0.7368*Rainfall + 432.28.The answer given by the witness was that while deriving the regression equation, it is always important to understand the other conditions also and he further stated that he was told that the State of Goa had achieved the equation as: Runoff = 0.625*Rainfall + 1278.113.

The witness further stated that he had used this equation to derive the Mahadayi yield, as per the procedure and data used in CWC (2003) Report and he had got the yield of 238.69 tmc at 50% dependability, which is drastically different from the yield obtained by CWC (2003) Report. The witness mentioned that he believed that the State of Goa had ignored a very important line provided in CWC (2003) Report at pages 9-10, to the effect that "Regression analysis has been carried out using the monsoon catchment rainfall and concurrent runoff and best fit R-R relation obtained, ignoring inconsistent data of monsoon rainfall/runoff points as per standard practice" and thereafter, the witness proceeded to state that if the Govt. of Goa had not used the proper information while deriving the R-R relation, then the Govt. of Goa was bound to get a different equation, but as far as the

above referred equation is concerned, it is derived by ignoring all the years, with the runoff factor of more than 1.0.

The learned counsel for the State of Goa put to the witness that the intercept indicated in question No.190 was positive, which means, even if the rainfall was zero, there would be some runoff and for a catchment area of 2032 sq.km., for zero rainfall, his equation had given the runoff as 31.02 tmc, which was not proper. In answer to the said suggestion, the witness stated that the regression equation relationship, is derived using the range of observed rainfall and observed runoff and it is assumed that the relationship is linear, which may be an approximation in itself and these relationships are not supposed to be extrapolated, beyond the normal ranges of these two entities, and therefore, relationship would not be valid, if one extrapolates to the level of zero rainfall.

163. The attention of the witness was drawn to the answer given by him in question No.193, wherein it was stated by the witness as under:-

> "It is correct, the way it is put. But at the same time, as I have explained earlier, that the validity of this

> regression equation has to be within the range of the values which have been used while deriving the equation. If you refer to my September, 2015 Report at pages 68-69, Appendix-VIII, you will not find even a single value for all the years beginning from 1928 to 1997 where the yield has been more than the rainfall by using the same equation." (Underlining supplied by me).

The witness was asked as to whether still he stood by the underlined portion of his statement and the answer given by the witness was that he was standing by the underlined portion of his statement.

The attention of the witness was drawn to Appendix XII of his Report dated 12th September, 2015, more particularly, at pages 76 and 77 thereto. The witness was asked to look to the year 1971 where the rainfall was 1331 mm, and the runoff was 1413 mm and it was pointed out to the witness that the runoff was more than the rainfall, which was completely contrary to his assertion made by him in answers to questions No. 193 as well as 201, wherein he had categorically stated that not even in a single year, the runoff had exceeded the rainfall. After bringing the above facts to the notice of the witness, the learned Cross

Examiner for the State of Goa wanted to have the response of the witness.

In response, the witness stated that his answer to question No.193 must be looked into its proper perspective and the witness reproduced the relevant portion of the answer given by him to question No.193, which is as under:-

> "…that the validity of this regression equation has to be within the range of the values which have been used while deriving the equation. If you refer to my September, 2015 Report at pages 68-69, Appendix-VIII, you will not find even a single value for all the years beginning from 1928 to 1997 where the yield has been more than the rainfall by using the same equation. (Underlining supplied by me to emphasize.)"

164. The witness stressed that in the above explanation, it is very categorically mentioned that the range of values used, while deriving the R-R relationship, is an important aspect of the equation and that one would find that, the equation remains true, to the aspect of not having any single value, as is indicated in Appendix VIII of his Report of September, 2015, which pertains to the range of values which are quite similar to the ones used while deriving the R-R relationship. The witness proceeded to

state that there can be one odd value, which in Hydrological terms is termed as “Outlier”, which is out of range, and that is why it has emerged and the main question is that how much impact it has on the final outcome.

165. A question was put to the witness to the effect that actually, and factually, the data used for his study of September, 2015, and that used for the study in May, 2017, were different and distinct and that if the witness had not changed it purposely, then how the different and distinct data were found. In answer to the said question, the witness mentioned that his September, 2015 Report is extension of the CWC (2003) Report, and the processed data of CWC (2003) Report is taken for working of that Report. The witness mentioned that this is also apparent from Annex. II, page 13 of May, 2017 Report, and Table 10, Page 45 of his September, 2015 Report, from which, it can be observed that the observed monsoon runoff for Ganjim is exactly the same from the year 1998 to the year 2012, and that, the minor differences, between the two Reports, are because of the reason that in one (Report of September, 2015), the data has been taken as such for the period from 1979 to 1997, and in the Report of

May, 2017, the data has been processed, using the detailed daily data.

166. A question was put to the witness that in his opinion what should be the value of regression equation factor to be used at Ganjim site, for Mandovi river, and the answer given by the witness is that usual value of regression equation applied is in the near vicinity of 0.85, but the exact value used at Ganjim site should be known to the CWC.

167. The witness has stated in paragraph 6.3.2 of his report at page 34 that the rainfall data of some whole years/some months in a particular year are found missing for some of the Stations and the same is filled by using the standard method of Normals, and therefore, a question was put to the witness as to what is the basis on which the witness has made the said statement. In answer thereto the witness mentioned that in filling of rainfall data, using the method of Normals is a standard procedure in Hydrology for filling of the missing rainfall data.

168. The attention of the witness was drawn to Appendix IV at page 61 of his Report, wherein in 34th column, data of

Mapuca for the year 1961 was mentioned and the rainfall indicated was 2874 mm. It was pointed out to the witness that this continued for the years 1962, 1963, 1970, 1971, 1972, 1976, 1977, 1978, 1979, 1980, 1988, 1989 and 1998, whereas in the case of Sanguem in the same Appendix IV at page 61 the rainfall was stated to be 3638 mm for 10 years i.e. for the years 1961, 1962, 1963, 1967, 1972, 1974, 1977, 1978, 1980 and 1998 and in case of Valpoi the rainfall was shown as 3934 for the 9 years, namely 1972, 1976, 1977, 1978, 1980, 1988, 1992, 1993, 1994 and 1995. The witness was asked to explain why the data of Mapuca, Sanguem and Valpoi were exactly the same as the last mm for the aforesaid several years. The answer given by the witness was that he was not the right person to tell why the values were the same for many years, because he was not a party to the process of processing the data.

169. After referring to the errors pointed out to the witness in question No.86, the attention of the witness was invited to pages 19 and 33 of Volume 15, wherein in the Table at page 29, unprocessed data and in the Table at page 33, the processed data, were mentioned, which made it clear that not only the missing data have been filled, but the data that was not missing

was also modified, which is apparent from the data relating to the year 1978. It was also brought to the notice of the witness that the observed data at page 29 was 2884.6 mm and the processed data at page 33 was 4905 mm, which was, thus increased by as much as by 70%, and similarly the data for 1979 for the same station has been increased by 37%; for 1981 by 67%; and for 1989 by 52%, and therefore, the witness was called upon to explain by which method known to the science of Hydrology were these increases made.

170. Again in answer to the said question, the witness stated that he was not party to the process. He also mentioned that it was very difficult for him to say as to what was the real reason of the difference and he believed that all these valid questions must have been resolved by the learned and experienced water resources personnel of the three participating States, and by the lead i.e. CWC at the appropriate time. At this stage a question was put to the witness as to whether he had compared the data given on two pages, i.e. on page 29 and page 33 of CWC Report (2003) (Volume 15), before undertaking his study and whether did he find any improvement in Appendix VI at page 33 over the data given at Appendix V at page 29 of the

said report. The response of the witness was that he had not checked each station with respect to the data, which was the outcome of processing for that station, as he was not having the complete information of what steps of processing had gone in between the figures appearing in Appendix V and Appendix VI. The witness mentioned that when the raw data were not made available, he had adopted the other option of using the processed data after due verification through the consistency check.

171. The question was put to the witness that whether while preparing three different Reports within a span of less than 20 months, namely his Report dated 12th September, 2015, his another report dated 15th November, 2016 and his still another report dated 11th May, 2017, whether he had considered taking into account the factors – reliable yield of the State of Goa on the water coming from the upstream of Mahadayi region, presence of thick and thin Stations, the fact that the river passes through Mhadei Wildlife Sanctuary, Bhagwan Mahabir Wildlife Sanctuary, Mallew National Park, Dr. Salim Ali Bird Sanctuary, requirement of maintaining the level of water in river Madei for navigation purposes and highly pristine eco-sanctuaries of the

coastal eco-system. The answer given by the witness was that he had not taken into consideration those factors and all the factors mentioned in the question were not required to be considered while finding out the yield of the basin.

It was brought to the notice of the witness by the learned Cross Examiner for the State of Goa that the State of Karnataka has not done any yield study of its own, whereas in his Report dated 12th September 2015, the witness has extended the series prepared by CWC in the so called 2003 Report. It was also brought to the notice of the witness that the CWC had worked out the yield of Mahadayi basin at 75% dependability as 1958 tmc, whereas in his study dated 12th September, 2015 the witness had worked out the yield of Mahadayi basin at 50% dependability as 204.24 tmc and 206.14 tmc, whereas in his study dated 11th May, 2017, the witness has worked out the yield of Mahadayi basin at 75% dependability as 198.42 tmc and 202.55 tmc.

172. It was also brought to the notice of the witness that when he had prepared the second and third Report dated 15th November, 2016 and 11th May, 2017, respectively, for computing

the yield at the project locations at different places of Karantaka and for giving so called credence to his Report dated 12th September, 2015, he was a Member of the NGT Committee, which had been appointed under the auspices of MOEFCC to determine, the carrying capacity of Western Ghat. The question was put to the witness as to whether being a Member of the aforesaid Committee, had he considered the provisions of Wildlife (Protection) Act, 1972 and more particularly section 29, which prohibits any person to interfere with the water coming into the sanctuary or otherwise diverting or by any act, whatsoever diverting, subjecting or enhancing the flow of water of the sanctuary. The answer given by the witness was that for the yield assessment periods, these factors were not required to be considered.

After drawing the attention of the witness to the answers given by him to question Nos.57, 60, 65 and 96 that the CWC is an apex organization of the country, it was put to him that he dreaded to think of the situation when on the data being collected by the apex organization, if a challenge was thrown to it, it would give rise to inter-State dispute about water, which would not be good for the society and the witness was called

upon to explain as to why, while making report of November 2015 for determining the yield at 8 locations in the State of Karnataka, he had not followed the methods indicated and used by CWC for computing the yield on the project sites. The answer given was that he had used the method which was most appropriate with respect to the data availability.

173. After the cross-examination of the witness by the State of Goa was over, the learned counsel for the State of Maharashtra was called upon to cross-examine the witness, but the learned counsel Shri D.M. Nargolkar representing the State of Maharashtra had stated that he had no question to ask to this witness by way of cross-examination. Thereafter, the witness was put several questions by the Tribunal but it is proposed to refer to only the relevant questions put to the witness by the Tribunal.

174. It para 5.1.1.3 on page 27, relating to Collem Flow Series – Mass Curve Analysis of his Report of September 2015, it is stated by the witness that there was some falling trend observed in the later part of the series, whereas from Table 4: t-Test: Paired Two Sample for Means-Collem on page 28, it is noted that the mean of first 16 years of data was about 25% higher than

the mean of the later 16 years of data. Therefore, the Tribunal wanted to know as to what could be possible reasons for such falling trend and why such reasons should not be taken into consideration, while assessing the water availability for the Mahadayi catchment as a whole. The answer given by the witness was that it is very difficult to assign specific reasons for such behavior, without thorough examination of all the data, pertaining to the basin, and one possible reason could be less rainfall in those years. According to him, in the present case because of another gauged basin namely Ganjim, which is much bigger in size, being available having consistent data, there was no requirement of exploring this small basin further.

175. It was noticed by the Tribunal that pursuant to the average monsoon rainfall for the catchment area of Mahadayi upto Ganjim, as assessed by the Expert Witness of the State of Goa, and that, by the witness indicated considerable variations. It was found that the mean of the average monsoon rainfall estimated by the Expert Witness of the State of Goa during the period from 1979 to 2005 was 4685.5 mm, whereas, on the other hand, the mean of the average monsoon rainfall estimated by this witness for the same period was only 4072.2 mm and thus

the mean of the average monsoon rainfall estimated by Expert Witness of the State of Goa was about 15% more, than the mean of the average monsoon rainfall, estimated by this witness. It was also noticed that for the year 1998, the average monsoon rainfall assessed by the Expert Witness of Goa was about 59% more than that assessed by this witness. Therefore, the Tribunal wanted to know from the witness as to whether such considerable variations are possible only due to selection of different groups of rain gauge Stations by two Experts and what could be other possible reasons for such variations. In answer, the witness stated that one possible reason, as mentioned, could be the selection of rain gauge Stations, but the selection of Stations could not have made huge differences. The witness further proceeded to state that the other possible reason for such variation could be application versus non-application of prescribed consistency checks, as part of the data processing.

176. It was noticed by the Tribunal that in his Report titled “Analysis to Check the Consistency of Rainfall Data in and around Mahadayi River Basin”, [Annexure A of “Further Response of the State of Karnataka to the Brief Note handed over to the Hon’ble Tribunal at the Hearing on 11.2.2015 (read with Orders dated

3.9.2014 and 12.2.2015)" filed by the State of Karnataka on 15.4.2015] (Volume 122), it is stated that recently a new product of India Meteorological Department, in the form of high resolution gridded daily rainfall data (0.25°x0.25° resolution), derived using quality controlled Station data (http://www.imd.gov.in/ doc/nccraindata.pdf) has come into being, which is supposed to be a much better product, which has been used here for consistency analysis. It was also stated that the location of these grid points in and around the Mahadayi basin have been shown in Figure 2, and therefore, under present situation, it is decided to use a recent product of India Meteorological Department, in the form of high resolution gridded daily rainfall data (0.25°x0.25° resolution), derived using quality controlled Station data, but, in the Report titled "The Yield Study of Mahadayi Basin" submitted as Annexure-B of the Affidavit of the witness, he had not used the data contained in the new product of India Meteorological Department, in the form of high resolution gridded daily rainfall data which in his opinion was, much better product. Therefore, the witness was called upon to explain the reasons for not using a much better product. The witness was further asked also to tell, whether the high resolution gridded daily rainfall data included in the new product

of India Meteorological Department, which in his opinion is much better product, should be invariably used for development of rainfall runoff models and if not, the reasons therefor.

In answer to the said question, the witness stated that personally he felt that the gridded daily rain fall data as provided by the IMD was more suitable for the end users, since it was a processed rainfall data, checked for most of the possible errors, but in the present case, since it was a matter of difference of opinion between the parties, he did not want to bring in another parameter i.e. the authenticity of the gridded data itself, since he knew that it was an end product of interpolation of the available actually observed rainfall and transformed on a uniform grid of 0.25°x 0.25° by IMD, and having started in that direction and having submitted one Report of consistency of the gridded data, he had decided to use the actual rain-gauge Stations for his analysis.

177. It was noticed by the Tribunal that the witness had carried out, the detailed analysis in respect of homogeneity and consistency of flow data, observed at Ganjim and the results of the same have been presented at Para 5.1.1.1, Para 5.1.1.2 and

Para 5.1.2 at pages 26 to 30 of his September, 2015 Report. It was further noticed that the witness had asserted at page 39 that the "observed series at Ganjim had been found consistent". Further it was noticed that while carrying out the analysis for development of linear regression equation, Central Water Commission had ignored, the data set of, as many as 9 years out of 19 years, and therefore, the Tribunal wanted to know from the witness that how can such data be considered as consistent and reliable. In answer to the said question the witness mentioned that by excluding these 9 years out of 19 years, for the process of formulating the R-R equation, does not imply that there is something wrong with the observed flow of these 9 years. The witness proceeded to state that those have been ignored by CWC as well as by him, as part of the stipulated process, to ensure that there is no unnecessary bias on account of such extreme events, in the R-R equation, since the equation is required to be used for extrapolation of runoff using the rainfall. What is important to notice is that the witness has admitted that this implicit explanation was not mentioned in CWC (2003) Report as well as in his September, 2015 Report.

178. In para 4 at page 3 of the additional Affidavit dated 15.11.2016 (Volume 193), the witness has mentioned that “the methods deployed by the respective departments to estimate the water yield have been variable since there is no unique approach that is universally used”. Therefore, the witness was called upon to name the various respective departments and the methods deployed by each of them, to estimate the water yield. In answer to the said question, the witness has mentioned that he did not have the record as to which Department had used which method of estimating water yield. The witness has proceeded to state that he was able to tell the methods employed by the various Departments ranging from empirical relationships, such as Inglis Formula, and Rational method to approaches such as Area Proportion method.

179. In para 2.2, on page 8 of the additional Affidavit of November, 2016 (Volume 193), the witness has stated that “the monsoon measured yield at Collem G&D site and Ganjim G&D site is adopted for the study”. It was noticed by the Tribunal that from para 2.3 and para 2.4, on page 8 for the purpose of estimation of yield for the Katla-Palna diversion and Diggi diversion sites, the witness had used the gauged data of Collem

G&D site, whereas in Para 5.1.1.4, on page 29 of the Report dated 15.9.2015 (Volume 166), he has concluded that “the tests show a mixed response to the consistency check of the flow series of Collem, therefore, the Station has not been used further for any detailed assessment of the basin water yield”. Under the circumstances, the witness was called upon to explain as to why the data of Collem G&D site was now used, although he had decided earlier not to use the same any further for assessment of basin water yield. The answer given by the witness was that the data of Collem G&D site was not rejected altogether, and only, it was not used for the extrapolation using the R-R method. The witness has emphasized that it is important to understand that in Hydrology, whatever has been recorded through observations, is the truth and it is not possible to go back in time, to re-observe it, and any segment of data that is available, must be re-looked at, for appropriateness of its use, after checking it from various angles, under different situations. What is claimed by the witness was that in any case, the Collem data only failed the t-Test, which means that it had shown two parts of the flow time series, which were different in mean value and this could have happened, on many different accounts, such as the area getting low rainfall consistently for some years. According to the

witness, the same Station of Collem passed the F-Test for variance, and therefore, the station was never discarded in true sense, because there was nothing grossly wrong found.

180. It was found by the Tribunal that from Table under para 7, page 4 of the additional Affidavit dated 15.11.2016, the witness has estimated the yield at 10 sites for 50% dependability, 60% dependability, 70% dependability and 75% dependability, but in his Report of September, 2015, he has estimated the yield at 50% dependability and 75% dependability only. Therefore, a question was asked to the witness as to why has he estimated, the yield at the 10 sites for 60% dependability and 70% dependability in addition to 50% dependability and 75% dependability and what is the utility of estimated value of yield at 60% dependability and 70% dependability, for the 10 sites? The answer given by the witness was that while estimating the yields for various projects, the dependability computations were also made for other values beyond 50% and 75%, such as 60% and 70%, since the worked yields of these projects by the respective organisations, were available, and he was trying to find out, by how much per cent of dependability, the various earlier computed yields by different Departments, would be different

from the present value. The witness gave the example that on page 4 of his November, 2016 Report, it is mentioned that "The yield at Bhandura dam is estimated by him as 3.7 tmc at 75% dependability, whereas the yield is estimated as 4.0 tmc at 75% dependability", and therefore, the idea was to arrive at more clarity in the results.

181. In para 8 at page Nos. 4 and 5 of the additional Affidavit of November, 2016, the witness has stated that the yield at Bhandura dam was estimated by him as 3.7 tmc at 75% dependability, whereas the yield was estimated as 4.0 tmc at 75% dependability, in the Detailed Project Report of 2000 (Volume 20), and if the yield was 4.0 tmc, the project would have operated at 70% dependability. Therefore, a question was put to the witness as to whether had he gone through the Detailed Project Report of 2000 (Volume 20) of the Bhandura dam and had critically examined the procedure for estimating the yield at 75% dependability. The answer given by the witness was that he had looked at the hydrology part of the Detailed Project Report of 2000 (Volume 20), of the Bhandura Dam, but he was not remembering at the juncture, all the details regarding the procedure for estimating the yield at 75% dependablility.

Thereafter, a copy of the page 9 of the Detailed Project Report of Bhandura Water Diversion Scheme prepared in 2000 (Volume 20) was handed over to Prof. Gosain and he was asked to tell whether he agreed with the procedure adopted for estimation of 75% dependable yield and that whther the rainfall can be taken as yield. The witness stated that he did not agree with the procedure adopted in the DPR (Volume 20).

182. With the objective to ascertain, the extent of variations in the data, of a rain-gauge Station in the Report of the witness of May 2017 (Volume 198) with respect to the data of same rain-gauge Station included in his Report of September 2015 (Volume 166), the rainfall data for the period from 1979 to 2012 was examined by the Tribunal and a Statement was prepared. The Table showing comparison of rainfall data in mm and percentages in Reports of the witness of 2015 and 2017 was prepared and the same was handed over to the witness and was taken on record and marked as MARK-26. It was found by the Tribunal that for Valpoi, the average value of monsoon rainfall included in the Report of the witness of May 2017 (Volume 198) was about 2% less than the average monsoon rainfall indicated in his Report of September 2015 (Volume 166) and in several years,

there were considerable variations ranging from 52% more to 28% less. For Ponda, it was found that the average value of monsoon rainfall included in the Report of the witness of May 2017 (Volume 198) was about 3% more than the average monsoon rainfall indicated in his Report of September 2015 (Volume 166), but, in many years, there were considerable variations ranging from 70% more to 12% less. For Panjim, the average value of monsoon rainfall included in the Report of the witness of May 2017 (Volume 198) was about 3% less than the average monsoon rainfall indicated in his Report of September 2015 (Volume 166). It was noticed by the Tribunal that in few years, there were considerable variations ranging from 8% more to 43% less. For Mapuca, the average value of monsoon rainfall included in the Report of the witness of May 2017 (Volume 198) was about 2% less than the average monsoon rainfall indicated in his Report of September 2015 (Volume 166), and in few years, there were considerable variations, ranging from 12% more to 45% less. For Sanguem, the average value of monsoon rainfall included in the report of the witness of May 2017 (Volume 198) was about 8% less than the average monsoon rainfall indicated in his report of September 2015 (Volume 166), whereas in several years, there were considerable variations ranging from 18% more

to 50% less. For Khanapur, the average value of monsoon rainfall included in the Report of the witness of May 2017 (Volume 198) was found to be about 4% less than the average monsoon rainfall indicated in his Report of September 2015 (Volume 166), whereas in several years, there were considerable variations ranging from 60% more to 33% less. For Kanakumbi, the average value of monsoon rainfall included in the Report of the witness of May 2017 (Volume 198) was about 11% less than the average monsoon rainfall indicated in his Report of September 2015 (Volume 166), but in many years, there were considerable variations ranging from 44% more to 44% less. For Jamagaon, the average value of monsoon rainfall included in the Report of the witness of May 2017 (Volume 198) was about 3% less than the average monsoon rainfall indicated in his Report of September 2015 (Volume 166), but in many years, there were considerable variations ranging from 56% more to 42% less. For Amagaon, the average value of monsoon rainfall included in the Report of the witness of May 2017 (Volume 198) was about 37% more than the average monsoon rainfall indicated in his Report of September 2015 (Volume 166), whereas in most of the years, the rainfall included in Volume 198 was relatively much higher than that

mentioned in Volume 166 with maximum variation being of the order of 130% for the year 1999.

For Castlerock, the average value of monsoon rainfall included by the witness in his Report of May 2017 (Volume 198) is about 60% more than the average monsoon rainfall indicated in his Report of September 2015 and in most of the years, the rainfall included in his Report of May 2017 is relatively much higher than that indicated in his Report of September, 2015, with maximum variation being of the order of 226% for the year 1982.

The Tribunal was of the prima facie opinion that the variations in data of different rain-gauge Stations included by the witness in his two Reports were erroneous, and therefore, a question was put as to whether the witness had thoroughly checked the data that was made available to him from time to time and which had been used by him for his two Reports and why such major variations were not noticed and/or ignored by him. The answer of the witness was that he had thoroughly checked all the values that had been used in his analysis of May, 2017 and the variations between his Report of September, 2015 and Report of May, 2017, as depicted in MARK-26, were on

account of the additional data, that was earlier missing and which had become available from IMD. According to the witness the other reason for these variations could have been the result of the application of consistency check.

183. It was noticed by the Tribunal that rainfall data of the rain-gauge station of Castlerock was used for assessment of yield of Mahadayi basin in various Reports namely;

a. CWC Report of 2003 (Volume 15),
b. Report of Mr. Gosain of September 2015 (Volume 166), and
c. Report of Mr. Gosain of May 2017 Volume (198).

184. The rainfall data of the rain-gauge Station at Castlerock was furnished to the witness by the State of Karnataka, vide Volume 98 filed on 1.12.2014. On examination of the above stated data the Tribunal had prepared a Table of comparison of rainfall data of Castlerock in mm used for analysis in different Reports and the said Table was given MARK-27, a copy of which was handed over to the witness. A similar exercise was undertaken by the Tribunal in case of Ponda, Mapuca, Sanguem, Khanapur, Kankumbi, Jamagaon, Amagaon and

Castlerock, and the variations found in Table MARK-26 were pointed out to the witness.

The observed rainfall data as well as the processed rainfall data of the rain-gauge Station at Castlerock as available in different documents and Reports were examined by the Tribunal and a Table of Comparison of Rainfall Data of Castlerock in mm, used for Analysis in different Reports, was taken on record and was marked as MARK-27. A copy of the aforesaid document was also handed over to the witness. From MARK-27, it was evident that Annexure V(xv), page 32 of CWC Report of 2003 provided the observed rainfall data of IMD rain-gauge Station at Castlerock for the period from 1964 to 2001 and it was found that the data of three years, namely 1980, 1982 and 1987 were missing and using the available data, the average monsoon rainfall of IMD rain-gauge Station at Castlerock was found to be 2307 mm. Similar such discrepancies found by the Tribunal, were brought to the notice of the witness and it was put to the witness that: (i) there are considerable considerable variations in the values of rainfall data of rain-gauge station at Castlerock from one Report to the other; (ii) the data were inconsistent; and (iii) the approach

used for finalizing the data to be used for further analysis, was not at all rationale.

It was further noticed by the Tribunal that no care had been taken by the witness to verify whether the values of rainfall of Castlerock furnished by the State of Karnataka were authentic, correct and reliable, and therefore, he was called upon to offer his response. In reply, the witness mentioned that variations in the Comparison Table (MARK-27) are on account of the fact that due to some reason the data of this Station was not consistent, as it could be made out from the averages provided for various periods as part 'c' of the question. The witness mentioned that while preparing the September 2015 Report, since the decision was taken to use the processed data prior to 2001, for all the Stations, as was done in CWC (2003) Report, reprocessing of this data would not have been meaningful. The witness stated that while preparing the May 2017 study, re-processing of the whole rainfall data sets with respect to infilling and consistency analysis was done. According to the witness, as it can be observed from column 4 of MARK-27, the data prior to 1981 was appreciably different from the data after 1981, as has been indicated by the averages of this period in the last two rows of column 4 of MARK-

27. The witness informed the Tribunal that one could not afford to make any corrections without doing the proper analysis, and it was possible that all these years, before 1980, could have been drought years, but such inference can only be drawn, by performing consistency check, wherein the double mass curve is plotted between the Station in question and a group of adjoining Stations. The witness further asserted that it was through this analysis that in his study of May 2017, this Station of Castlerock was found to be violating the consistency, and correction for consistency was made as per the details given in spread sheet 'Consistency RF 1964-12'of Volume 199. The witness admitted that there were variations of values in Castlerock from one report to other, but there were reasons for the same, which have been enumerated by him in his reply. The witness stated that the data can be inconsistent in the raw form, but proper consistency check had been applied and the consistency of the final processed data had been ascertained. According to the witness, the approach used for finalizing the data series for the Mahadayi basin yield analysis was rational and every care had been taken to ensure that he was using the most correct and reliable values.

This is the sum and substance of the evidence of Prof. A.K. Gosain (RW-1).

Oral evidence of RW-2 Shri A.K. Bajaj for the State of Karnataka

185. Having discussed the evidence of Professor A.K. Gosain, the Tribunal feels it proper to discuss the evidence of Shri A.K. Bajaj, RW-2, deposing as an expert witness on behalf of the State of Karnataka on the subject of Hydrological Analysis of the Diversions and Utilization by the Upstream States in Mahadayi Basin.

186. Affidavit in evidence of Shri A.K. Bajaj, deposing as an expert witness, on behalf of the State of Karnataka, was filed on 30.12.2016 (Volume 194). In Para 1 of his Affidavit the witness has referred to his educational qualifications, posts held by him as well as his experience in the field.

187. In Paragraph 2 of his affidavit the witness has stated that the Govt. of Karnataka through its Chief Engineer (ISW), Water Resources Development Organization requested him to carry out Hydrological Analysis of Diversion by the Upstream States in Mahadayi Basin, which would also include a water balance analysis in the context of trans-basin diversions of the

Mahadayi waters to Malaprabha Reservoir and Kali Reservoir as planned by the Govt. of Karnataka. The witness has proceeded to state that he had gone through the complaints (the complaints filed by three States to the Central Government), amended Statement of Claims, submissions and other relevant documents filed before the Tribunal by the three States of Goa, Karnataka and Maharashtra, besides other related technical reports and available data, and after studying these submissions and other materials, he had prepared his study titled 'Hydrological Analysis of Diversions and Utilizations by Upstream States in Mahadayi Basin which was annexed by him to his affidavit as Annexure-A (colly). In Paragraph 4 of his affidavit the witness has mentioned conclusions of his Analysis as under:

> "(i) There is a large quantity of water in Mahadayi Basin as estimated at around 200 TMC by both the CWC and Prof. A.K. Gosain of IIT Delhi. Out of this water, the present utilisations of Goa are only 9.395 TMC and the planned utilisations being only 38.53 TMC inclusive of the present utilisations (Reply of Goa to interrogatories of Maharashtra and Karnataka at Volumes 102 and 103).
>
> (ii) Even after considering Maharashtra's proposed diversion of 180 Mcum (6.35 TMC), the diversions and utilisations claimed by Karnataka are

not incompatible with the planned utilisations by Goa, in particular the 10 projects in Goa (namely Sonal , Surla, Surla II, Derode I, Mandovi Nanoda, Surla III, Kharmol, Mayada, Khadki weir and Ganjim weir) which are in the shared catchment for utilisation of 10.59 TMC are not likely to suffer hydrologically.

(iii) As against the originally estimated inflows which were the basis for the planning of both Malaprabha Reservoir and Supa Reservoir across Kali river, they have suffered acute shortage of inflows as discussed above and therefore augmentation of inflows into these reservoirs from Mahadayi which is in surplus as discussed above becomes necessary in the larger interests of the inhabitants of the State of Karnataka.

(iv) The non-utilisation by Karnataka or Maharashtra as planned would only result in surplus going to sea.

(v) The maintenance of natural equilibrium of Mahadayi River in Goa would be wholly inconsistent with the principles of water utilisation and management of the Mahadayi basin."

188. In Para 1 of Hydrological Analysis, the witness has mentioned about scope of the study, whereas in Paragraph 2 of Hydrological Analysis, the witness has mentioned about Hydrology of Mahadayi Basin. According to the witness in March

2003, CWC had done an estimation of the total water availability in the Basin and this estimation made by CWC was based on the regression analysis developed from the gauge data at Ganjim G & D site maintained by CWC (in the territory of State of Goa) for the years 1979-80 to 1997-98; and the rainfall data available with the Indian Meteorological Department, and according to this study, the total available water in the Basin as a whole was:

(i) 5652 Mcum (199.6 tmc) at 75% dependability; and
(ii) 6234 Mcum (220 tmc) at 50% dependability.

189. The witness further stated that Professor Ashwani Kumar Gosain of IIT, Delhi had also estimated the yield in Mahadayi Basin and his study shows that 5838 Mcum (206.14 tmc) was available at 75% dependability and 6321 Mcum (223.20 tmc) was available at 50% dependability. The witness has mentioned that in the CWC study, non-monsoon flows were about 2.67% of the gross monsoon flows which came to about 147.50 Mcum (5.21 tmc) and 162 Mcum (5.72 tmc) corresponding to 75% and 50% dependable flows respectively. The witness pointed out that Govt. of Karnataka has planned diversion of 7.56 tmc from the monsoon flows to Malaprabha

Dam for meeting drinking water and other needs of that area, and besides, at Kotni reservoir, as per the study done on yield figures from 1980 to 2009, the surplus water available is varying from nil in some years to 23.787 tmc. The witness informed in his affidavit that, out of this surplus water, the State of Karnataka had planned to divert about 7 tmc of water by using carryover capacity of Malaprabha reservoir during the monsoon months for meeting the agricultural and drinking water needs in the drought prone areas of the Malaprabha command and adjoining areas and that in addition, 5.527 tmc is planned to be diverted to the Kali Basin. The witness further informed in his affidavit that Karnataka is proposing to consumptively utilize, a total of 24.15 tmc from the Mahadayi Basin, which inter-alia includes in-basin utilisations, evaporation losses etc. in addition to afore-stated diversions.

190. In Paragraph 5 of his Hydrological Analysis, the witness has mentioned that there were no measurements at the Malaprabha Dam site during the planning stage in 1970 when, the project was being formulated, and the yield at the dam site was estimated on the basis of 30 years rainfall records and gauge data of 12 years of a downstream site (Kolchi Weir). The

witness has stated that this was cross verified by using isohyetal methods, and on the basis of records of hydrologically similar catchments. The witness, in clear terms, has stated that the yield at 75% dependability, on the basis of rainfall record, was adopted as 47.25 tmc, but during the performance of the project after construction, the inflows started to be recorded giving yield figures at the dam site, and the yield on the basis of the measured series of the 34 years for the period from 1972-73 to 2005-2006, at 75% dependability was 26.76 tmc only. The witness has proceeded to state in his hydrological analysis that, thus, the project report which contemplated an utilization of 44 tmc had to be modified for the revised actual water available and the report titled "Modified Detailed Project Report of Malaprabha Project" was prepared by the office of the Chief Engineer, Karnataka Neeravari Nigam Ltd., in the year 2009, for utilization of 27 tmc.

191. The witness has mentioned in his hydrological analysis that the revised DPR of Malaprabha Project of 2009 was posed to the CWC and the Ministry of Water Resources, Govt. of India for clearance, and in the 100th meeting of the Advisory Committee of Ministry of Water Resources, held on 9.10.2009,

the Malaprabha DPR 2009 was considered and was accepted. By stating the above facts the witness has attempted to show that Malaprabha Reservoir is a deficit reservoir.

192. In Paragraph 8 of his hydrological analysis, the witness has referred to hydrology of Kali Reservoir and has mentioned that the catchment area at Supa Dam site across river Kali, which is a west flowing river, is 408 sq. miles (1057 sq.km.), and the average yield estimated on the basis of rainfall was 119.84 tmc (3394 Mcum). According to the witness the construction of the project was started in 1971 and was completed in 1987 and the gross storage capacity at full reservoir level and maximum water level is 147.54 tmc (4178 Mcum = 5605 Meters and 151.96 tmc (4303 Mcum), respectively, whereas the live storage capacity is 132.73 tmc (3758.4 Mcum). The witness has stated in his analysis that the main components of the project are the Supa Dam with a designed capacity of 147.54 tmc and a power house for hydel generation, and as in the case of Malaprabha Dam, the water yield at the time of planning the project was over-estimated, and the Supa Dam was filled only twice out of 29 years i.e. in 1994 and in 2006, since the start of filling in 1984. The witness has mentioned that the

recorded average yield is only 95.66 tmc, whereas the power potential with the originally estimated yield and storage created in the Supa Dam was 1255 Mw with a head of 488 Mtrs. The witness claimed in his analysis that the maximum annual energy that could be generated is 5605 Mu, but due to shortage of yield, the average annual energy generated is of the order of 3600 Mu only, by the planned diversion of water from Malaprabha Basin to Kali Dam, and the total generation could be augmented by 182 Mu.

193. In Paragraph 9 of his aforesaid analysis, the witness has dealt with the water needs as claimed by three co-basin States of Karnataka, Goa and Maharashtra, and stated that Kalasa Project Report of 2000 as well as the revised Report of 2010, and Bhandura project report of 2000 and revised report of 2012, indicate that the Government of Karnataka had planned the diversion of about 7.56 tmc of waters from the monsoon flows of River Mahadayi to the Malaprabha sub-basin of the Krishna basin for meeting the drinking water requirements of the twin city of Hubli-Dharwad, which has the highest priority amongst the uses of water, as per the National Water Policy. What is emphasized by the witness is that the Govt. of Karnataka, in its

amended Statement of Claims dated 17.4.2015, has also mentioned that it had plans to divert some of the monsoon flows of the Mahadayi to the Kali River for augmenting the generation of electricity under the existing Kalinadi Hydro Power Project. The witness has further mentioned that Karnataka Govt. had also proposed a run-of-the-river scheme on the main river Mahadayi for power generation which would not entail any consumptive use of water. It is also mentioned by the witness that besides this, at Kotni Reservoir, the surplus water varying from nil in some years to 23.787 tmc is available, and out of this surplus water, the State of Karnataka had planned to divert about 7 tmc of water to Malaprabha Reservoir for meeting the agricultural and drinking water needs, in the drought prone areas.

194. In Paragraph 10 of his analysis the witness has mentioned about water needs, as claimed by Goa. According to the witness the State of Goa in its amended Statement of Claims dated 23.04.2015 has submitted its long term needs in the Mahadayi river basin, and in Para 189, the State of Goa has listed the water requirement upto 2051 AD, which are: (a) Domestic water supply 208 Mcum; (b) Industrial Water Supply 208 Mcum;

(c) Irrigation 2050 Mcum (d) Salinity Control 158 Mcum and (e) Forest Management 50 Mcum, totalling 2674 Mcum by 2051 AD which is equal to 94.4 tmc, but the Govt. of Goa has submitted the project report/preliminary reports in respect of 63 projects in answer given to the interrogatories issued by the States of Karnataka and Maharashtra. The witness proceed to state that the total water requirement for these projects added upto only 37.22 tmc as per Annexure 1-1 of Volume 102 and 38.53 tmc, as per the so titled 'Detailed Project Reports' of 63 projects, and lift irrigation schemes, bhandhuras, tanks, drinking water requirement and industrial use. According to the witness, out of these 63 projects only 18 projects for utilization of 17.04 tmc fell in the shared catchment of the Mahadayi basin and even out of these 18 projects only 8 projects are on streams, where Karnataka has not proposed any of its projects, which are: (1) Kodal HEP; (2) Golali; (3) Iverkhud; (4) Ragada II; (5) Avarda; (6) Nandran; (7) Derode II; and (8) Khandepar.

195. According to the witness, the utilization by Goa from the balance 10 projects in the shared catchment would be only 10.59 tmc. It has been stated that out of the 10 projects in the shared catchment, only 7 projects were upto Ganjim and the

utilisation from these would be only 8.14 tmc and the remaining 53 projects fell in the catchment of Mahadayi, which would not depend on the flows coming from Karnataka.

196. The witness has emphasized that the Mahadayi River has little utilization, and at the present, utilisation in Goa is 9.395 tmc, whereas at the present, utilisation in Karnataka and Maharashtra was negligible, and therefore the entire water of 199.6 tmc at 75% dependability, excluding 9.395 TMC of the present utilisation by the Goa is going unused to Sea. What is emphasized is that wastage to Sea has not found favour with Krishna Narmada Tribunals in the past, and even the public policy of India is to avoid wastage.

197. In Para 11 of his hydrological analysis, the witness has mentioned about plan of the State of Maharashtra at the Virdi Project and several other projects. According to the witness the requirements of the State of Maharashtra are: Irrigation, 132.27 Mcum, Drinking Water needs, 3.65 Mcum (1.65 M.cum in Mandovi Basin + 2.0 Mcum in Tillari basin), Industrial Water Supply 2.10 Mcum and provision for future development 25.0 Mcum and Evaporation losses 16.30 Mcum, totalling 179.32

Mcum which is equal to 6.35 tmc. It is also mentioned by the witness that Maharashtra, has so far filed information on 4 projects and one DPR of Virdi Project, which proposes utilisation of only 43.396 Mcum.

198. In Para 12 of his hydrological analysis, the witness has referred to Water Balance Analysis and stated that even if one takes the entire claim made by the State of Goa at its face value, the total water claims of the three States of Goa, Maharashtra and Karnataka add upto 124.90 tmc annually, but the available water as estimated by CWC in Mahadayi basin is much larger being 199.60 tmc annually at 75% dependability and 220 tmc annually at 50% dependability. According to the witness, even if the yield of 199.60 tmc at 75% dependability is considered, there will be a surplus water of 74.70 tmc annually, and therefore, the claims of the three riparian States of Goa, Maharashtra and Karnataka are not incompatible to each other, and there is enough surplus water and potential in Mahadayi basin for all the co-basin States.

199. This witness was cross- examined at length by the learned counsel for the State of Goa, and was also put several

questions by the Tribunal, for eliciting the information relating to availability of water. Therefore, the Tribunal propose to deal with only relevant questions put to the witness and answers given to those questions by him. A question was put to the witness by the learned counsel for the State of Goa as to what are the upper and lower limits of run off factor, for the catchment upto Ganjim, beyond which the data for that year would be considered as an outlier.

The answer given by the witness was that there can be no specific two values of upper and lower limits of runoff factors, which can be termed as outlier, and this depends upon the judgment of the Hydrologist carrying out the study, and the final data set arrived at, before deciding the regression equation. The witness categorically stated that he was not aware of the values which were treated as outlier by the Hydrologists, carrying out the study. It was put to the witness by the Tribunal that if he was not knowing even the data details which Prof. Gosain had used in his studies/Report, or even CWC used in 2003 Report, then how and on what basis and on which principles he had agreed with the Report of the study conducted by Prof. Gosain and/or the CWC (2003) Report.

The response of the witness was that he had gone through the CWC (2003) Report, and examined the data available therein, and the procedure used in calculating the yield. According to the witness the Report contained all material data relevant for the study, but they did not contain some of the minor details like the specific values of runoff factor etc., but the general contents of the Report were to his satisfaction, and it is for this reason that he had taken the values of yield derived in the study.

200. The witness was asked as to whether he was able to show the learned cross-examiner of the State of Goa from his Report or from his affidavit, having stated that the environmental studies should be first conducted or that the necessary permission and clearances ought to be first secured and if not, would it not mean that the support the witness proposed to lend to the projects of the State of Karnataka, proposed in the midst of Western Ghats, would be undermining the implication and the likely adverse effects on the ecological system.

The answer given by the witness was that he had not talked about the environmental clearances required, or even other clearances required, before taking up these projects. The witness

stated that this was a standard requirement with Government of Karnataka, taking the clearances in the course of proceedings, and going ahead with the construction of these projects. The witness mentioned that his study is regarding the available water being sufficient to meet the requirements of the three States, and is not in support of any specific project. The witness clarified that whether the project proposed to be undertaken by the Government of Karnataka would or would not, and how much it would affect the environment, can only be determined by carrying out a proper Environmental Impact Assessment of the project proposed. The witness proceeded to state that he presumed that proper process of obtaining all clearances from various agencies of the Govt. of Karnataka for the project to be undertaken, would have been taken.

201. In his affidavit in evidence, as well as in his Report dated 30.12.2016 (Volume 194), Page 14, Para 9, the witness has stated that as per the National Water Policy, the drinking water needs has the highest priority, and similarly in answer to Question No.74, the witness has stated that drinking water needs have the highest priority as per the National Water Policy. Attention of the witness was drawn to Volume 33 (B), i.e

Modified Detailed Project Report of Malaprabha Project submitted by the State of Karnataka on 18.3.2013, more particularly, at Page 17, wherein allocation is made for water supply and for industrial purpose as per the revised Project Report. Having drawn the attention to the above stated facts, the learned cross-examiner deduced that it was evident that as per the revised Project Report, the total allocation of water for industrial and drinking water taken together was 0.216 tmc, and a question was put to the witness as to whether this allocation of only 0.216 tmc, was in accordance with the National Water Policy, which the witness had claimed giving highest priority to the drinking water.

The answer given by the witness was that at the time of preparing a revised Project Report of an already ongoing project, generally the existing usages have to be protected and it is probably on this basis that the allocation have been apportioned. The witness categorically admitted that he was not in a position to say as to why or what were the conditions in the command areas due to which, the Govt. of Karnataka has given the quantities for the purpose as mentioned in Volume 33 (B) at

Page 17, and he was not in a position to say whether the allocations were justified or not.

202. The attention of the witness was drawn to the following facts, by the learned Cross-examiner of the State of Goa:

(a) At the time of initial estimation of yield in the Malaprabha Reservoir, cultivation of sugar crop, was on the rise in the Northern Karnataka Region. In Volume No. 86 which are answers on behalf of the State of Karnataka to the interrogatories of State of Goa, at Annexure-1 thereof at Page 11, the State of Karnataka has given the figures of area irrigated under Malaprabha Reservoir from 1979-80 to 2012-13. At Col. 1 in Sl. No.1, the figure for 1979-80 for sugarcane crop is 224 Ha., but, for the year 2009-10, the sugarcane cultivation figure has risen upto 3038 Ha. and in the years 2010-11, it has gone upto 3421 Ha.

(b) The figures given by the office of the Cane Development Commissioner and Director of Sugar are reflected in Annexure 2 at Sl. No.3 at Page 12 of Volume 86. The sugarcane demarcated/allocated, Taluka-wise/District wise for sugarcane development for each of the existing

and proposed sugarcane factories in command of Malaprabha Reservoir are given vide Annexure-1 and Annexure-2 thereof, at Page 13 of the said document, namely, Volume 86. In respect of the five factories the area allocated for sugarcane development of the existing factories works out to 24827 Ha., and in the Table on the same page, another five proposed sugarcane factories are reflected.

(c) The modified DPR of Malaprbha Project [Volume 33(B)] there is no whisper about sugar cultivation or the area allocated for the same, but in his Report annexed to the affidavit dated 30.12.2016 (Volume 194), the witness has dealt at Page 11 therein with the hydrology of Malaprabha Reservoir and that the witness had deliberately avoided any reference to Malaprabha Basin as such or its tributaries.

(d) In Para 7 of his Report on Page 12, the witness had concluded, based on the revised DPR of 2009, that Malaprabha Reservoir is a deficit reservoir.

After pointing out the above mentioned facts to the witness, the learned Cross-examiner had put questions as to why

the witness had, instead and in place of dealing with Malaprabha Basin and its tributaries dealt with only the reservoir, conveniently leaving out a large portion to the extent of 80% of the water in the Malaprabha basin. The witness was also asked as to why he had not dealt with or addressed the issue of large scale untamed and uncontrolled rise in sugarcane cultivation, which consumes the water from the Malaprabha reservoir in his Report, and whether the Witness had, before undertaking or carrying out the study which had culminated in the Report, undertaken an enquiry as regards 2009 modified DPR vis-à-vis the answer given in Vol.86 by the State of Karnataka, which display figures from 224 Ha. in 1979-80 to 3038 Ha. in 2009-10, as also the other figure of 24827 Ha. as mentioned earlier.

In answer to the said question, the witness stated that he had dealt with the water available in the Malaprabha Dam Reservoir, as this was the utilisable water, and for harnessing the water flowing in the rest of the basin, proper infrastructure would have to be provided. According to the witness he was discussing the limited issue of reduction in the flows to the reservoir in his Report and not the cropping pattern in the

command, and as such he had not addressed the issue of cultivation of sugarcane in the command, in his Report.

The witness candidly admitted that he had not undertaken the detailed study of sugarcane figures ranging from 224 Ha. In 1979-80 to 3038 Ha. In 2009-10 or the worked out figure of 24827 Ha mentioned by the Cane Development Commissioner allocated to the five factories.

203. The witness was made aware of the fact by the learned cross-examiner that the total catchment area of Malaprabha Basin is 11549 sq.km., whereas the total catchment area of Malaprabha Dam Reservoir is only 2204 sq.km. and from the perusal of his Report, it appeared that he had restricted his study to only Malaprabha Dam Reservoir, catchment of which constituted approximately 20% of the total catchment area of Malaprabha basin. Having been so aware about the ratio of catchment area of Malaprabha Dam Reservoir, question was put to the witness as to why he had restricted his study to only Malaprabha Dam Reservoir and not extended it to the whole of the basin.

In answer, the witness stated that he had considered the water availability upto the Malaprabha Dam site only, as this was the utilisable water available to the Project Authorities for meeting the various requirements in the command of Malaprabha Project, and for meeting the drinking water requirements being fed from the reservoir. The witness mentioned that he did not consider the water available in the balance Malaprabha basin, as, in order to utilise the water available in the balance catchment, further infrastructure projects would have to be taken up.

204. In view of the above stated answer, a question was put to the witness as to whether he meant that based on his Report dated 30.12.2016, it could not be deduced or found out as to whether the Malaprabha basin, as a whole, is deficient basin or not and the witness answered that it was correct.

205. The attention of the witness was drawn to the document MARK-GOA/12, which was the interview given by the witness, and more particularly to a question and an answer

given by the witness to the said question. The aforesaid question and answer from the interview were reproduced:

> "**Give an insight into the CAD&WM programme launched by the Government**.
>
> *Government of India has launched the Command Area Development and Water Management (CAD&WM) programme with the objective of developing the last mile irrigation infrastructure for delivering the water to the fields. This addresses the issue of micro level infrastructure development and efficient water management at the farm level. The programme also includes actions required for correction of system deficiencies besides the development and management activities below the outlet. Efficient water management cannot be achieved unless the infrastructure for water conveyance and delivery system is in good condition to retain its operational efficiency"*.

206. Thereafter a question was put to the witness to the effect that whether from his report dated 30.12.2016 (Volume 194), he was in a position to show that before commenting on the fact that Malaprabha reservoir is a deficit reservoir, all the requirements for correction of the system for efficient water management had been carried out by the State of Karnataka, with respect to the infrastructure for water conveyance.

The answer given by the witness was that he was not in a position to show from his Report dated 31.12.2016 whether before commenting on the fact that Malaprabha Reservoir is a deficient Reservoir, all the requirements for correction of the system for efficient water management had been carried out by the State of Karnataka with respect to the infrastructure for water conveyance.

207. It was brought to the notice of the witness that the total catchment area of Kali Basin is 4843.3 sq.km., whereas the total catchment area of Supa Dam Reservoir is only 1056.72 sq. km. but from the perusal of his Report it appeared that he had restricted his study to only Supa Dam Reservoir, catchment of which constituted approximately 25% of the total catchment area of Kali Basin, and therefore, a question was put to the witness as to what was the reason to restrict his study, only to Supa Dam reservoir and not to extend it to the whole of the basin.

The answer given by the witness was that it was correct that he had considered the catchment up to the Supa Dam Project site only, as it was the only water that is utilisable for generating power.

208. Another question that was put by the learned counsel for the State of Goa was that based on his Report dated 31.12.2016, it could not be deduced or found out as to whether Kali Basin as a whole was a deficit basin or not and the response given by the witness was that he agreed that based on his report dated 31.12.2016, it could not be deduced or found out as to whether Kali Basin as a whole, was deficit basin or not.

209. The learned Cross-examiner wanted to know from the witness as to whether he had personally verified and checked the facts and figures, data and its application, as well as the choice of rainfall stations and the Thiessen Polygon done in the Report dated 12th September 2015, by Prof. A. K. Gosain, (Volume 166), before agreeing with the same, and if not, why had he not done so when he was knowing that his report would be presented as evidence by one of the parties to the dispute before the Tribunal. In response, the witness stated that he had not done a detailed analysis of Professor Gosain's Report regarding the facts and figures, data and its application, as well as the choice of rainfall stations, and the Theissen Polygon done in the Report. The witness however, claimed that he had verified the contents and facts and noticed that it was basically

an extension, with subsequent data, of the CWC (2003) Report, and the final yield figures were also more or less matching with the results of the CWC (2003) Report.

210. The witness was informed by the learned cross examiner that there were two major tributaries on the right bank of Malaprabha River i.e. Joul Nala and Bennehalla Nalla and that Joul Nalla has a catchment area of 224 sq.km., whereas the Bennehalla Nalla had a catchment area of around 5048 sq.km., which is more than twice the entire Mahadayi basin area, and a proposal to utilise the water of Bennehalla Nalla was prepared by Shri Sudheer Sajjan, who is/was an Engineer with the Water Resources Department of Government of Karnataka and that while answering a question put by the Tribunal he had admitted that he had been provided with the Report submitted by Shri Chetan Pandit, the expert witness for the State of Goa. It was further brought to the notice of the witness that in his proposal Mr. Sajjan had estimated the yield of Bennehalla Nala as 10.92 tmc on 75% dependability of which, as per the same proposal, hardly 1.5 tmc had been put to use. Having pointed out the above stated relevant facts, the witness was asked as to why in his Report, while considering the availability of water for

Malaprabha Reservoir, he had not considered this important aspect. The witness responded that the document Annexure-D at Page 146 of Volume 192 of Additional Affidavit of Examination-in-Chief, Shri Chetan Pandit was mentioned as a Flood Control Scheme, and as such he did not consider it for the purpose of water availability. He further stated that he was not in a position to say as to whether it was technically feasible or not to divert this water to the Malaprbha Reservoir.

211. It was brought to the notice of the witness by the learned counsel for the State of Goa that Annexure-D mentioned in Question No.108 dealt with, and was cited as "Flood Control and Utilization of Water in Bennehalla Basin – a Scientific Proposal", and that the very first line mentions Bennehalla Basin is the biggest tributary of the Malaprabha river. Therefore, it was put to the witness that Annexure-D was not a Flood Control document, as mentioned by the witness, but indeed it spoke of utilization of water also. The cross-examiner put to the witness that he had not considered this important document annexed to the Affidavit of Shri Chetan Pndit, wherein the study made, an attempt to propose a major diversion scheme for its utilisation, and that having not adverted to this

important document, which would have thrown much light on the reasons for the deficiency of water, if any, in Malaprabha reservoir, as well as the remedy which was available within the Malaprabha basin, the report of the witness fell short of the required level of a study to be presented as an expert evidence before the Tribunal and his response was sought.

In answer thereto, the witness stated that there was no techno-economical feasibility study for diversion of this water from Bennihalla tributary and it was for this reason that he had not included in his study the possibility of whether or not this quantity of water or any lesser quantity therefrom, could be diverted to the Malaprabha Reservoir. The witness further explained that it is definitely possible to divert water from both the sources, the present proposal of Govt. of Karnataka from Mahadayi, as well as from Behhihalla, after making a detailed study and D.P.R. for this diversion.

212. In view of the above stated answers given by the witness it was noticed by the Tribunal that while answering Question No. 108 put to the witness by the learned cross-examiner for the State of Goa, the witness had stated that the

document Annexure-D at Page 146 of Volume 192 was mentioned as a Flood Control Scheme, and as such he had not considered it for the purpose of its water availability, whereas while answering Question No. 109, the witness had attempted to provide some other justification for ruling out the said document. The Tribunal had, therefore, put to the witness that once as admitted by him earlier, he had even chosen not to take into consideration the said document, the question of providing some other justifications for not considering the same as being not the proper solution to the problem posed a question would not even arise and, therefore, the witness was required to offer his explanation. The witness gave following reply:

> "I wish to apologize if answers to the two questions are contradictory to each other and seek indulgence of the Hon'ble Tribunal".

213. The attention of the witness was drawn to document MARK-GOA/12 i.e. his own interview and the question and answer to the said question at Page 1 wherein the witness had stated that "few large rivers like Brahmaputra and Ganga (particularly their northern tributaries), Mahanadi, Godavari and rivers originating from the Western Ghat, have been found to be

surplus in water resources. India can capitalise on the surplus water by diverting water from these rivers to other parts of the country which are deficient in water. This will help to reduce the regional imbalance and benefit will accrue in terms of additional water for irrigation, domestic and industrial water supply, hydro power generation and navigational facilities. A Master Plan for this has been prepared after a proper technical examination under the overall scheme of inter linking of rivers." Having brought necessary facts to the notice of the witness, the learned Cross-examiner put it to the witness as to why river Mahadayi, though originating from Western Ghats, has not been mentioned therein to be a river of surplus in water resources, and further whether a technical examination of the diversion of waters of Mahadayi outside the basin being carried out by any Central Agency, namely, NWDA, Planning Commission or Ministry of Water Resources.

The response given by the witness was that during his aforesaid interview, he had mentioned a few rivers like Brahmaputra, Ganga, Godavari, Mahanadi and a general term "rivers of Western Ghats" as an example of some of the rivers with surplus water. According to the witness as it was not an

exhaustive list of the rivers having surplus waters, the name of Mahadayi was not appearing in his aforesaid answer in the interview. The witness further stated that he was not in a position to say as to whether any Central Agency, named in the question, had carried out any proper technical examination of the water diversion of waters of Mahadayi outside the basin.

214. After the cross-examination of the witness by the learned counsel for the State of Goa was over, Shri D.M. Nargolkar, learned counsel for the State of Maharashtra was requested to examine the witness, but he stated that he had no questions to ask this witness. Shri Brijesh Kalappa, the learned counsel for the State of Karnataka also stated that no opportunity for any re-examination of the witness was required.

215. Thereafter the Tribunal had put certain questions to the witness, to elicit best information relating to the availability of water in Mahadayi Basin. It was brought to the notice of the witness by the Tribunal by putting Question No.6 that the contents of Para 4 on Pages 9-10 of his affidavit are based on the information and data included in the Statement of Claims of the State of Karnataka, and other related documents filed by the

State of Karnataka, from time to time. Therefore, the witness was asked as to whether he had undertaken any studies with additional data and information to review, and/or update the findings of earlier studies and if so, the results thereof. The witness stated that that the Govt. of Karnataka had planned diversion of 7.56 tmc from the monsoon flows to Malaprabha Dam for meeting drinking water and other needs of that area and the witness was required to inform the Tribunal regarding:

(i) The quantum of water planned to be utilized for drinking purpose; and

(ii) The quantum of water planned to be utilized for meeting other needs and to clearly specify the various needs and water planned to be used for each and specific needs.

216. It was noticed by the Tribunal that the witness had mentioned that at Kotni Reservoir, as per the study done on yield figure from 1980 to 2009, the surplus water available was varying from nil in some years to 23.78 tmc, and therefore, a question was put to the witness as to which was the said study and whether it is on record of this case or is it reflected in a study and

why the data after the year 2009 had not been used to update this study.

217. It was also noticed that the witness had stated that Karnataka was proposing to consumptively utilise a total of 24.15 tmc from the Mahadayi basin, which inter alia includes in-basin utilisation, evaporation losses etc. in addition to diversions. Therefore, the witness was required to inform the Tribunal about complete break-up of 24.15 tmc of water including (i) Quantum of water proposed to be diverted out of Mahadayi basin for irrigation; (ii) Quantum of water proposed to be diverted out of Mahadayi basin for irrigation (iii) Quantum of water proposed to be diverted out of Mahadayi basin for hydro-power generation; (iv) Quantum of water proposed to be diverted out of Mahadayi basin for any other purpose; (v) Quantum of water to be used within Mahadayi basin for drinking purposes; (vi) Quantum of water to be used within Mahadayi basin for irrigation; (vii) Quantum of water to be used within Mahadayi basin for hydro-power generation; (viii) Quantum of water to be used within Mahadayi basin for any other purpose; (ix) Quantum of water earmarked towards evaporation from

reservoir; (x) Quantum of water earmarked for any other losses through the planned projects.

The response given by the witness was that he had not undertaken any study with additional data in order to review and/or update the findings of earlier studies. The witness expressed his inability to give a specific break up of the diversion of 7.56 tmc for drinking water purposes and for meeting other needs. The witness stated that as per the proposal of Govt. of Karnataka, the quantity of water is proposed to be transferred to Malaprabha Dam to augment the water availability and then the utilisation will be according to various needs. The witness further mentioned that water is planned to be used for augmenting water supply to the twin city of Hubli-Dharwad and some other nearby areas which are not being provided with water from the Dam, and there is also a reference to some small quantities of water being utilized for irrigation also. The witness stated that he was not in a position to say as to why the data after 2009 had not been used to update his study and that he was not aware of the detailed break-up of 24.15 tmc uses referred to in Question.

218. The attention of the witness was drawn to Para 14 on Page 10 of his affidavit, as well as Para 13.2 on Page 93 of the amended Statement of Claims by the State of Karnataka (Volume 129). It was also brought to the notice of the witness that the availability of water at (i) Bhandura Dam site and (ii) Kalasa Dam site, including portion of Haltara Nalla and Surla Nalla had been assessed by Prof. A.K. Gosain, expert witness of the State of Karnataka in his Report of November 2016 (Volume 193), and relevant information in respect of Bhandura Dam site were culled out from Table 4 at Page 15, Volume 193 and water availability at 75% dependability was computed by the Tribunal, and the witness was confronted with the results thereof.

219. It was brought to the notice of the witness that the available water at Bhandura Dam site at 75% dependability, assessed by Prof. Gosain, was only 3.675 tmc, against the proposal of diverting 4 tmc from Bhandura Dam site, and thus the diversion of 4 tmc from Bhandura Dam site was not feasible, and as a result, the proposal for diversion of 7.56 tmc from Kalasa Nalla diversion and Bhandura Nalla, taken together would also be not feasible. It was noticed by the Tribunal that Shri Chetan Pandit, an expert witness of the State of Goa had

also assessed the water availability at 75% dependability at Bhandura Dam site and Kalasa Nalla site and were indicated as 1.4961 tmc and 1.9767 tmc, respectively, in Table 1 at Page 4 of the additional affidavit of Shri Chetan Pandit (Volume 196). It was further noticed by the Tribunal that the quantum of water available for diversion would get further reduced after taking into consideration the demand of water, for various purposes and mandatory environmental requirements, particularly by those for Karnataka region in the down stream reaches of proposed Kalasa Dam, Haltara Dam and Bhandura Dam. Under the circumstances the witness was called upon by the Tribunal to inform as to whether he was endorsing a proposal which was apparently not feasible in its present form.

The answer given by the witness was that the earlier studies conducted by the Govt. of Karnataka did not indicate 4 tmc of water available for diversion at Bhandura pick up point, but the studies by Professor Gosain indicated the lesser amount of water of 3.675 tmc at Bhandura Dam site and this meant that the dependability of the proposal would reduce from 75% to a lesser percentage of 70%, as indicated in the Table 4 referred to in the question. The witness further stated that regarding the

diversion of 3.56 tmc from Haltara Kalasa sites, the water availability figure as per the Table No.4 was indicated as 3.8 tmc at 75% dependability, whereas regarding the figures of water availability worked out in the Report of Shri Chetan Pandit, he had not taken those figures into consideration, as the Report suffered from some inconsistencies and the figures were not reliable. The witness also explained that the mandatory releases for environmental requirements and various other purposes, if any, would have to be made at the time of operation of these projects and these releases would further reduce the water available for diversion from the Bhandura point.

220. Further, the attention of the witness was drawn to Para 5 on Page 11 of his affidavit wherein he has stated that initially the yield of Malaprabha Reservoir was estimated to be 47.25 tmc at 75% dependability on the basis of observed gauge data of 12 years at Kolichi Weir site and 30 years of rainfall, and after cross verification with the records of hydrologically similar basin, the figure of 47.25 tmc was adopted. However, it was also noticed by the Tribunal that in Para 6 at Page 11, the witness has stated that the yield on the basis of measured series of 34 years for the period from 1972-73 to 2005-06 at 75%

dependability, was 26.76 tmc only, and thus the estimated yield of 47.25 tmc at the time of planning was on a very high side. The Tribunal was of a prima facie view that these two figures did not match and therefore there was an error somewhere in the assessment. Under the circumstances a question was put to the witness as to whether he had examined as to what led to such erroneous assessment and what measures he would suggest for ensuring that such errors are avoided during the course of planning in future.

The witness responded that, he did not feel that the hydrology of the project, as worked out in the earlier Project Report as 47.25 tmc, was erroneous and hydrology was based on the available hydrological data and was checked by CWC before approval being granted by the Planning Commission to the Project Report in 1963. According to the witness the figure of 26.76 tmc in the revised DPR was on the basis of annual inflows into the reservoir from 1972-73 to 2005-06. The witness further mentioned that hydrology of any proposed project, to be taken up in future, should be done only after long term data is available, which could avoid such type of over or under estimation, besides observing due care in processing of the data.

221. The attention of the witness was drawn to what he had stated in Para 8 on Page 13 of his affidavit and it was pointed out to him that the information included in the said Para was limited to average yield and no information related to yield at 75% dependability, was provided. Similarly, it was brought to the notice of the witness that he had not provided any information relating to yield at 90% dependability which is generally taken into consideration while planning hydropower projects. Under the circumstances, three questions were put to the witness, namely: (a) as to why the live storage capacity of 132.73 tmc i.e. about 10% more than the then assessed average yield of 119.84 tmc at the Project site was considered necessary; (b) whether he had examined the relevant data and information to identify the possible reasons for erroneous assessment of yield on higher side at the time of planning and what measures he was suggesting to ensure that such errors were avoided during the course of planning of future projects; and (c) as to whether he did not agree that average yield estimated at 119.84 TMC and the live storage capacity estimated at 132.73 tmc were wrong and erroneous because the yield was only 95.66 tmc.

The witness answered that he was not in a position to comment on the reason why the live storage capacity was fixed at 10% more than the average yield as that decision was taken by the officers of Karnataka Government framing the Project Report. The witness further stated that he had gone through the hydrology of the Project as it appeared in Volume 100 (b) but it was not appropriate to say that this was an erroneous assessment of yield on higher side at the time of planning. The witness maintained that the Project Report prepared by Government of Karnataka officials must have been prepared with due care, and it had been checked by the Central Agencies for its correctness, before being accorded an approval. The witness referred to his answers given to Question No.12, and stated that generally the Hydrology for any project should be worked out on the basis of long term data which then takes care of any abnormal figure for a few years in the data set and that he did not agree with the suggestion that the average yield estimated at 119.84 tmc and the live storage capacity estimated at 132.73 tmc, were wrong and erroneous.

222. The answers given by the witness to Question No.74 and Question No.75, put by the learned Sr. Counsel for the State of Goa on 14.9.2017, were brought to the notice of the witness and apprehension was expressed on behalf of the Tribunal that the reply raised serious issues relating to sanctity of provisions of National Water Policy as well as State Water Policy of the Govt. of Karnataka, in respect of the first priority assigned to drinking water needs. The witness was informed that the aforesaid issue becomes more severe and worrisome in respect of Malaprabha Dam, in view of the reported changes in the cropping pattern, in accordance with the areas of sugarcane crop requiring more waters. It was noticed by the Tribunal that the witness had chosen not to reply those queries, stating that he had not undertaken the detailed study of the sugarcane figures ranging from 224 Ha. in 1979-80 to 3038 Ha. in 2009-10 or the worked out figures of 24827 Ha. mentioned by Cane Development Commissioner. Further it was noticed by the Tribunal that the State of Goa had highlighted the issue of supply of Malaprabha water to Pepsico unit of Dharwad by the Karnataka Water Board, which also raises the issue of priority of allocation of water for commercial purposes, while the twin city

of Hubli-Dharwad were facing reported serious crisis of drinking water for local population.

Under the circumstances a question was put as to why the witness did not examine all these issues at the time of preparation of his affidavit and Report of December 2016, as most of the related information, were available in the documents filed by the party State. Another question which was put to the witness was as to why did he not feel that his Report was deficient on account of many important aspects, not having been examined in proper perspective.

The answer given by the witness was that he had not discussed the issue of water allocation from Malaprabha Dam Project with the Project Engineers and the reasons for not withdrawing water from the existing agricultural uses and diverting it to drinking needs of the twin city of Hubli-Dharwad. According to him, he was informed that there was severe stress in the existing command and in fact there was a demand for more water. The witness mentioned that it was not possible to divert water from the existing agricultural uses to drinking purposes at the time of framing the revised DPR, and regarding

the sugarcane areas under cultivation, the figures indicated in the allocation letter of the Cane Development Commissioner he was informed that although this land had been allocated for sugarcane cultivation, the actual area under sugarcane cultivation was a very small percentage of the allocated area because of severe shortage of water. The witness proceeded to mention that regarding allocation of water for industrial purposes to the Pepsico Factory, he was not in a position to say with surety about the reasons for doing so, more particularly, since the quantity allocation had not been indicated and he had not come across the same while preparing his study. The witness denied the suggestion that his Report was deficient on account of many important aspects not having been examined by him in proper perspective.

223. The attention of the witness was drawn to Question No.71 put by the learned Senior Counsel for the State of Goa on 13.9.2017 and his reply thereto, and it was pointed out to him that the witness on referring to both the National Water Policy 2012 (MARK KA/4), as well as National Water Policy of 2002 (MARK KA/13) and a prima facie view was expressed by the Tribunal that it was felt that once NWP 2012 was in place, all

previous versions of National Water Policy stood replaced, and that the provisions of latest version i.e. NWP-2012 should have guided actions for planning and management of water resources. From the Report given by the witness, a prima facie impression was gathered by the Tribunal that he had looked at relatively very complex water related issues in a highly simplistic manner by selectively citing specific provisions of the NWP-2012, which itself was against the basic principles identified in Para 1.3 of NWP-2012 and that the witness had not taken into consideration the contents of said Para 1.3, which identifies the basic principles to be borne in mind, while looking at relatively complex water related issues. Under the circumstances, a question was put to the witness that as to whether he felt the need for considering the provisions of NWP-2002, when the same was replaced by NWP-2012. Another question put as to whether the basic principles listed at Para 1.3 of NWP-2012, and all related provisions of NWP-2012, were considered during the process of techno-economic appraisal of the water resources projects in the Central Water Commission and if so, in what manner.

The answer given by the witness was that basically he had relied on the provisions contained in NWP-2012 only, and his statement on 14.9.2017 referring to the NWP-2002 was only to say that the drinking water had always been a priority. The witness further informed that he had retired from Central Water Commission in 2011, whereas the provisions relating to latest NWP are of the year 2012, and therefore, he was not in a position to indicate whether or not, the basic principles listed in Para 1.3 of NWP-2012, and all related provisions of NWP-2012, were being duly considered during the process of techno economic appraisal of the water resources projects in the Central Water Commission.

224. It was noticed by the Tribunal that National Water Policy 2002 was in place at the time of preparation of "Modified Detailed Project Report of Malaprabha Project" prepared by the Government of Karnataka, and its techno-economic appraisal by the CWC. It was brought to the notice of the witness that NWP-2002 provided for collection of reliable data regarding water availability and actual water use, collection of information relating to ground water resources and its consumptive use, and planning of water resources, development and management, for

a hydrological unit, such as drainage basin as a whole or for a sub-basin, multi-sectorally, taking into account surface and ground water for sustainable use incorporating quantity and quality aspects as well as environmental consideration etc. It was further noticed by the Tribunal that all individual and developmental projects and proposals should have been formulated and considered within the framework of such an overall plan, keeping in view the existing agreement/award for a basin so that the best possible combination of opinions can be selected and sustained.

225. Therefore, the Tribunal had asked a question to the witness as to whether reliable data regarding water availability and actual water use including that for respective water needs for twin city of Hubli-Dharwad were collected and considered for Malaprabha Sub-basin as a whole before planning for Malaprabha Project and whether these aspects were considered during the course of techno-economic appraisal of the Malaprabha Project. It was further asked by the Tribunal, as to whether the future water needs for various purposes, including that for twin city of Hubli-Dharwad were scientifically assessed and examined with reference to Allocation Priorities.

Yet another question put to the witness was as to whether ground water potential was assessed on a scientific basis and duly considered for incorporating and carrying development of surface and ground water in respect of Malaprabha Project, and if yes, particulars be provided. The last question which was put by the Tribunal was as to what was the total water availability for Malaprabha Sub-basin and what was the percentage of usable water.

The witness answered that as per his information data for drinking water requirements of Hubli-Dharwad were considered at the time of preparing DPR. The witness further stated that he was not able to state regarding up to what future date the requirements were projected in the revised DPR. The witness also expressed his inability to provide particulars regarding the ground water potential assessed and the provisions made for integrated use of surface as well as ground water and that, he was not able to give the figure of total water availability of the Malaprabha sub-basin whereas the percentage of utilisable water was not readily available with him. It was brought to the notice of the witness that National Water Policy 2002 accorded highest priority to drinking water, and calls for providing

adequate safe drinking water, both in urban and rural areas, and therefore a question was put to the witness as to why necessary provisions were not made to meet the full requirements of drinking water of the region including that of the twin city of Hubli-Darwad before allocating water for irrigation and other purposes in "Modified Detailed Project Report". The witness was further asked as to on what basis the allocations of 0.201 tmc water only was made for drinking and industrial purposes, in the Modified Detailed Project Report of Malaprabha Project.

The answer given by the witness was that the existing water uses for irrigation etc. had to be protected while framing revised DPR, and it was not possible to divert water from there for the drinking water requirements. The witness further stated that he was not in a position to say why only 0.201 tmc had been provided for drinking water, as this decision was taken by the Project Engineer, while framing the revised DPR.

This is the sum and substance of the evidence of Shri A.K. Bajaj, (RW-2).