Pre Bid Technical Clarification No.5 dtd 28.07.2025 to NIB No.477 dtd 26.02.2025 for EPC execution of EM Works of 240MW Heo HEP.

Sl. No.	Volume	Page No.	Clause No.	Tender Provision	Bidder Clarification	NEEPCO replies
1	**Volume 2 ,Section-II, M4**	**2**	**4.2.2**	Butterfly Valve House Crane: The general arrangement of the crane shall be in accordance with the BF Valve House layout drawings enclosed and as described in the specification at various places.	As per Section M7 – HVAC System, the requirements of HVAC system for BF Valve House including the associated access tunnel, is not specified in bidder's scope. Bidder requests customer to review and confirm the same. In case the HVAC system is in bidder's scope, bidder proposes the following system type and design details for your review and approval: **System Type:** Dry-type ventilation system with 100% fresh air, achieved through 2 x 100% centrifugal supply and exhaust fans. The supply air will be delivered via a ducted system, while the exhaust air will be discharged without ducts. **Capacity Design:** The ventilation system for the BF Valve House shall be designed with consideration of maximum of following: A maximum air change rate of 2.0 air changes per hour, or The heat dissipation rate of equipment, ensuring that the internal design temperature does not exceed 5.0°C above the maximum ambient temperature of 40.0°C. **Fan Location:** The centrifugal fans for both supply and exhaust will be installed near the entrance adit of the respective tunnels. Adequate space for the installation and maintenance of these fans shall be provided by customer.	This is to confirm that HVAC system for BF Valve House shall be within the scope of bidder. Dry Type Ventilation system is envisaged for the BF Valve House. Supply, Exhaust, Rate of air change per hour and other design parameters shall be as per system requirements and relevant IS/ IEC codes.
	VOLUME II SECTION II M-7 – HVAC System	**1**	**7.1**	SCOPE		
2	**VOLUME II SECTION II M-7 – HVAC System**	**1**	**7.1**	SCOPE	Bidder understands that HVAC system for acccess tunnel for surge shaft and pressure shaft is not in bidder's scope. Please confirm scope. In case same is in bidder's scope, please furnish technical specification for HVAC system along with tunnel layout drawings.	It is confirmed that HVAC system for acccess tunnel for surge shaft and pressure shaft is not in bidder's scope.
	VOLUME II SECTION II M-7 – HVAC System	**2**	**7.2.1**	……All ventilation and air-conditioned areas will be designed to maintain a positive pressure. Air changes in accordance to IS-4720, applicable for Surface Hydel Stations, will also be applicable for this Power House……	Design inside temperature condition which are to be maintained for ventilated area are not specified in technical specification. Bidder is considering maximum inside temperature in ventilation areas to be maintained by AHU system as 35.0 ^{0} C. Customer is requested to review and confirm the inside temperature condition to be maintained.	

3	**VOLUME II SECTION II M-7 – HVAC System**	**3**	**7.3 Basic Dimensions and Ratings**	**7.3.1 Design condition** The maximum and minimum ambient temperature and relative humidity for the design of the HVAC system in summer and winter shall tentatively considered as follows: Summer: 40° C & 100% max. Relative Humidity Winter: 1° C & 39% min. Relative Humidity. The maximum and minimum river water temperatures during the year shall tentatively be considered as 20° C and 8°C respectively.		The temperature of ventilated area shall be maintained at max. 5º C above ambient. Number of air changes as per specification shall be maintained.
4	**VOLUME II SECTION II M-7 – HVAC System**	**1**	**7.1**	SCOPE	Requirement of HVAC system for barrage and Tato-1 intake gate area is not specified in the scope of bidder in the tender specification. We understand that since rooms in theses ares are far & separately located wrt Heo's power house, HVAC requirement for rooms (including for bidder supplied panels) in these areas shall not be in bidder's scope. In case, any such requirement is to be considered by bidder, please specifiy the scope, system & design requirements to be considered by bidder alongwith layout drawings of barrage and Tato-1 intake gate areas. Please confirm.	Requirement of HVAC system for barrage and Tato-1 intake gate area is not in the bidder's scope.

Sr. No.	Volume	Clause No.	Clause name	Page No.	Specification as per Bid Document	Bidder Query / Clarification	NEEPCO Reply (As per Pre Bid Technical Clarification No.3 dtd 27.05.2025)	Bidder Query / Clarification	NEEPCO Reply
A. Hydraulic									
5	PTS-Mechanical, Volume II, Section-II, M-1 Turbine and MIV	1.9	1.9 Smooth, Stable and Quiet Operation and Noise Limit	11 of 83	3. The peak-to-peak pressure pulsation at any of the 4 taps located below the runner shall not exceed 3% (6% peak to peak) of the rated net head….....	Considering the project paramters and project specific speed range, the pressure pulsation requirement is stringent. We propose to modify the pressure pulsation requirement as follows: "**The peak pressure pulsations** at any of the 4 taps located below the runner shall not exceed 3 % (6% peak to peak) of the rated net head **at rated Power**." Kindly accept.	As per technical specification.	The specifed clause has ambiguity and state the two different requirement of 3% peak to peak and 6% peak to peak pressure pulsation. Hence, We propose to correct the clause and modify the pressure pulsation requirement as follows: "The peak pressure pulsations at any of the 4 taps located below the runner shall not exceed 3 % (6% peak to peak) of the rated net head at rated Power." Kindly confirm.	The Clause stands corrected as; "The peak to peak pressure pulsations at any of the taps located below the runner shall not exceed 3 % of the rated net head".
6	PTS-Mechanical, Volume II, Section-II, M-1 Turbine and MIV	1.9	1.9 Smooth, Stable and Quiet Operation and Noise Limit	11 of 83	4. The peak-to-peak power pulsations shall not exceed 1% of the rated power. (Ignoring however any isolated sharp peaks)….....	Considering the project paramters and project specific speed range, the power pulsation requirement is stringent. We propose to modify the power pulsation requirement as follows: "**The peak power pulsations shall not exceed 2% of the rated power. (Ignoring however any isolated sharp peaks)**." Kindly accept.	As per technical specification.	Based on the defined project rating and speed, the resonace is foressen in the project and which will lead to the higher power pulsation. As project rating and speed is fixed and bidder can not deviate from this, hence we propose to modify the power pulsation requirement as follows: "The peak power pulsations shall not exceed 2% of the rated power. (Ignoring however any isolated sharp peaks)." Kindly accept.	The Clause stands corrected as; "The peak to peak Power pulsations shall not exceed 1% of the rated Power (Ignoring however any isolated sharp peaks).
7	PTS-Mechanical, Volume II, Section-II, M-1 Turbine and MIV	1.19	1.19 Cavitation pitting guarantee	17 of 83	Excessive pitting shall be defined as the removal of metal from runner and other water passage components, exceeding a weight of W = 0.05 D2per 1000 hours of operation during the guarantee period, defined above where 'w' is metal weight removed due to cavitation in kilograms and D is the throat or discharge diameter of runner in metres. If the guarantee expires before 8000 hours or operation the weight loss for guarantee purpose shall be on pro-rata basis. In case of excessive cavitation the Contractor shall, at his cost, correct the condition by reshaping or resurfacing, grinding, polishing, building up by welding or by any other means and rectify/ replace the parts thus affected and carry out such modifications in design and such improvement in the manufacture and finish as may be required to minimize and contain cavitation pitting within permissible limit. The replacement shall be subject to the same guarantees as per the original equipment.	Any revolving cavitation guarantee shall not be offered. In case of excessive cavitation pitting and after modification/ repair/ replacment, cavitation guarantee shall be extended by 12 months from the time such replacement/repair subject to maximum time period of thirty-six (36) months from the date of putting plant and equipment into operation. Kindly accept.	Bid stipulation shall prevail.	We understand that cavitaion warranty period shall be limited/ capped as per clause 34 guarantee/ warranty of Sec-IIIA: General Conditions of Contract. Kindly confirm.	Cavitation Guarantee is not covered under clause 34 guarantee/ warranty of Sec-IIIA: General Conditions of Contract.
8	Volume II Section III Tender Drawings	-	Power house general arrangement cross section-A & B WAP/Heo/E& M/TD/01 & 02	-	Draft Tube dimensions : Depth, length, exist width/ height	We understand that the draft tube dimensions (bottom point elevation, length, exit height & exit width) defined in the power house cross section and plan drawing are preliminary/ tentative. However, final dimensions of draft tube shall be defined by bidder based on the selected hydraulic solution and shall be informed in bid. Kindly accept.	The power house dimensions and layout has already been freezed. No Change in these dimesions shall be accepted on the acoount of change in draft tube dimensions.	The specifed draft tube exit width of 7.0m is on very higher side which may lead to the flow seperation in draft tube. Hence, we request to allow the bidder to select draft tube exit width (less than 7.0m) as per hydraulic requirement. The other dimensions of draft tube shall be maintained as per specification/ drawings. Kindly confirm.	Bidders may adopt dimensions of flow path components as per their optimal design provided that the Power House dimensions and Layout remains unchanged.
9	PTS-Mechanical, Volume II, Section-II, M-1 Turbine and MIV	1.23	1.23 Model test report Model Acceptance	22 of 83	Model Acceptance 3. If the model fails to meet the guarantees and requirements, it shall be optional for the Engineer-of-Contract to conditionally accept the model and direct the Contractor to modify the model until it complies with the requirements. All expenses involved for the modifications and subsequent model tests shall be borne by the Contractor.			We kindly resquest you to modify the model acceptance clause in line to **clause 1.2.4 (f) of Vol-II, Sec-II of Tato-I Tender specification** "3. If the model fails to meet the guarantees and requirements, the penalty shall be imposed upto shortfall in WAE up to 1.5% as per LD defined in caluse 1.18. If the Model WAE falls below the guaranteed figure by more than 1.5%then turbine may be subjected to rejection." Kindly confirm.	Bid stipulations shall prevail.
B. Turbine									

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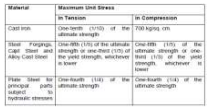
10	PTS-Mechanical, Volume II, Section-II, M-1 Turbine and MIV	1.24	Design and Construction	22 of 83	Design Stress Limits: Under the most severe operating conditions, the unit stresses in the materials shall not exceed the values shown in table  For other materials, not covered in table used in the construction of the turbine and associated equipment, the maximum stresses in tension or compression due to the most severe conditions occurring in normal operation shall exceed neither one-fifth of the yield strength of the material. Maximum stresses in shear shall not exceed 210 kg/sq. cm. in components made of cast iron and shall not exceed 60% of the allowable stresses in tension for other materials.	The design stress limit shall be followed as for the conditions occurring in normal operation shall not exceed one-half (1/2) of the yield strength of the material and for the most severe operating conditions like pressure test and runaway speed etc. the stresses shall not exceed three-fourth (3/4) of the yield strength. For other materials, not covered in table used in the construction of the turbine and associated equipment, the maximum stresses in tension or compression due to the most severe conditions occurring in normal operation shall exceed one-half (1/2) of the yield strength of the material. Please review the requirement and confirm the above mentioned stress criteria as followed for the hydro turbines world wide based on the advanced tool/ software's calculations.	Bid stipulation shall prevail.	Again it is requested to follow the bidder standard design practice with respect to stress criteria as follows below The design stress limit shall be followed as for the conditions occurring in normal operation shall not exceed one-half (1/2) of the yield strength of the material and for the most severe operating conditions like pressure test and runaway speed etc. the stresses shall not exceed three-fourth (3/4) of the yield strength. For other materials, not covered in table used in the construction of the turbine and associated equipment, the maximum stresses in tension or compression due to the most severe conditions occurring in normal operation shall exceed one-half (1/2) of the yield strength of the material. Please review the requirement and confirm the above mentioned stress criteria as followed for the hydro turbines world wide based on the advanced tool/ software's calculations.	Bid stipulations shall prevail.
11	PTS-Mechanical, Volume II, Section-II, M-1 Turbine and MIV	1.24	Design and Construction	24 of 83	Material selection and standards: Stay ring and stay vanes — Carbon steel fabricated from steel plate — ASTM A 537 class II or ASTM A 516 GR 70 Bottom ring, spiral casing, head cover, draft tube cone — Carbon steel fabricated from steel plate — ASTM A 537 class II or ASTM A 516 GR 70 Bearing housing — Carbon steel fabricated from steel plate — ASTM A 283 Grade C Guide vane servomotor body, piston and rings — Carbon steel casting/fabricated from steel plate — ASTM 286 Grade WCC ASTM A 537 Class II or ASTM A 516 Grade 70	Material IS 2062 E250/ E350, IS S235 J2/ 355 J2/ Equivalent for stay ring & Stay Vanes, Spiral Casing, Draft Tube Cone, Discharge ring, Bearing Housing, Bottom Ring, Head Cover, Servomotor Body, Piston & Rings shall also be acceptable in addition to the mentioned in tender specification as these standard materials for the similar type of Turbines are accepted worldwide also and worked successfully.	Bid stipulation shall pre	Requested to accept the below material also as these are specifically suitable for this type and size of the machine. Material IS 2062 E250/ E350, IS S235 J2/ S355 J2/ Equivalent for stay ring & Stay Vanes, Spiral Casing, Draft Tube Cone, Discharge ring, Bearing Housing, Bottom Ring, Head Cover, Servomotor Body, Piston & Rings shall also be acceptable in addition to the mentioned in tender specification as these standard materials for the similar type of Turbines are accepted worldwide also and worked successfully.	Any alternative material offered must be equivalent or better than the material specified in the Tender specification both in terms of chemical composition and material properties. However, detail comparison of chemical composition, material properties and evidence of use successfully in similar other projects must be submitted to the Purchaser for approval during detail engineering stage.
12	PTS-Mechanical, Volume II, Section-II, M-1 Turbine and MIV	1.24	Design and Construction	25 of 83	Material selection and standards: Coupling bolts — Alloy steel Ni-Cr-Mo forged — ASTM A 434 Class BD Fasteners on parts required frequent dismantling — Stainless steel	For coupling bolts/ shear element material shall also be considered as 34CrNiMo6/ 42CrMo4/ Equivalent. For other parts the bolts material shall be considered as A4-70, C3-80, 8.8 OR Equivalent. Above bolt/ coupling materials are standard materials for all type of hydro turbine and successfully accepted globally.	Bid stipulation shall pre	Requested to accept the below material as these are standard materials for all type of hydro turbine and successfully accepted globally. For coupling bolts/ shear element material shall also be considered as 34CrNiMo6/ 42CrMo4/ Equivalent. For other parts the bolts material shall be considered as A4-70, C3-80, 8.8 OR Equivalent.	Any alternative material offered must be equivalent or better than the material specified in the Tender specification both in terms of chemical composition and material properties. However, detail comparison of chemical composition, material properties and evidence of use successfully in similar other projects must be submitted to the Purchaser for approval during detail engineering stage.
13	PTS-Mechanical, Volume II, Section-II, M-1 Turbine and MIV	1.25	Fixed/embedded component	26 of 83	Spiral case: The embedding of the spiral casing in concrete is proposed to be carried out with the suitable pressure to withstand maximum possible hydraulic and other forces acting on it.	Embedment hydraulic pressure during spiral casing concreting shall be 70% of minimum static head. Please review the requirement and confirm.	Bid stipulation shall pre	Embedment hydraulic pressure during spiral casing concreting shall be mutually discussed and agreed during the contract signing stage. Please review the requirement and confirm.	Bid stipulation shall prevail.
14	PTS-Mechanical, Volume II, Section-II, M-1 Turbine and MIV	1.20	Other Guarantees	18 of 83	Cooling Water Failure Duration Withstand Capacity The turbine guide bearing shall be designed & guaranteed to withstand operation for a period of at least 15 minutes for the condition of cooling water supply getting cut off for any reason without suffering or incurring any damage after which period the turbine shall be signaled to stop and shall come down to stand still safely.	The requirement for 15 minutes on higher side. It shall be for the 10 minutes for the compact and efficient design of the turbine. Please review the requirement and confirm.	Bid stipulation shall pre	The mentioned conditions shall be as follow: • For at least (10) minutes at any speed up to 110 percent rated load , without cooling water supply. • For ten (10) minutes at any speed up to maximum runaway speed, with cooling water supply. The requirement for 15 minutes on higher side, Please review the requirement and confirm	Bid stipulation shall prevail.

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15	PTS-Mechanical, Volume II, Section-II, M-1 Turbine and MIV	1.28	Rotating parts, guide bearings and seals	37 of 83	Turbine Guide Bearing The bearing shall be capable of being operated continuously, without any damage to pads & without causing any detrimental effect on future operation of the machine under following conditions: • Continuous at any speed up to 110 percent rated load under normal operating condition. • For at least (15) minutes at any speed up to 110 percent rated load , without cooling water supply. • For fifteen (15) minutes at any speed up to maximum runaway speed, with cooling water supply. The coils shall be free from leakage when tested in the shop under a pressure of 10.0 bars for a period of 1/2 hour.	The mentioned conditions shall be as follow: • For at least (10) minutes at any speed up to 110 percent rated load , without cooling water supply. • For ten (10) minutes at any speed up to maximum runaway speed, with cooling water supply. The requirement for 15 minutes on higher side, Please review the requirement and confirm. Test pressure of the coils shall be around 5 to 6 bar. 10 bar test pressure is on higher side. Please review the requirement.	Bid stipulation shall pre	Please review the requirement and confirm. Test pressure of the coils shall be around 5 to 6 bar. 10 bar test pressure is on higher side. Please review the requirement.	Bid stipulation shall prevail. Test Pressure of the coil shall be 1.5 times of the rated pressure.
16	PTS-Mechanical, Volume II, Section-II, M-1 Turbine and MIV	1.20	Other Guarantees	18 of 83	Operating Temperature Limits The maximum guide bearing metal temperature under permissible range of turbine under 110% of full Load condition shall not exceed 70°C but during normal operation should be around 65°C to 70°C.	Seems there is a discrepancy in temperature limits for Bearings in Turbine & Generator PTS. We recommend temperature limits as per Generator PTS clause number 1.4.5.2 for Turbine Guide Bearing also, i) Maximum permissible operating temperature ≤70°C. ii) Alarm temperature 75°C iii) Trip temperature 80°C Kindly confirm the same.	Operating temperature limits mentioned in clause 1.20 shall stand ammended to figures mentioned in clause 1.28.	Values mentioned in Turbine Clause no. 1.20 and 1.28 are same. We proposed temperature limits as per "Generator PTS Clause number 1.4.5.2" for Turbine Guide Bearing also as below: i) Maximum permissible operating temperature ≤70°C. ii) Alarm temperature 75°C iii) Trip temperature 80°C Kindly confirm the same.	Temperature limits shall remain as per our earlier clarifications.
17	PTS-Mechanical, Volume II, Section-II, M-1 Turbine and MIV	1.28	Rotating parts, guide bearings and seals	38 of 83	Turbine Guide Bearing That the normal working metal pad temperature shall not exceed 65°C for turbine operating at all loads up to the permitted load. The high temperature alarm and unit trip shall be set at 70°C and 75°C respectively. The oil temperature in operation shall be relatively lower. The lubricating oils system shall be designed so that the temperature of the bearing metal and bearing oil shall not exceed 70°C and 65°C respectively under continuous operation in any operating conditions.				
18	General							Please provide the water quality report of the river.	Attached as Annexure-IV- A & IV- B
C. Quality									
19	GTS Volume-II, Section-I, G-1	5.4.11		63	**Site Test:** Measurement of polarization Index	Kindly note that only Insulation resistance is applicable. Polarization Index is not applicable as per IS 325. Please confirm.	Bid stipulation shall pre	Kindly note that Polarization Index Value is not defined in IS 325 for guarantees. Same will be provided only for information. Please accept.	Bid stipulation shall prevail. No Guarantee is required as per the Particular Clause.
20	Volume-II, Section-II, E-2 Generator Transformer	2.6.43		52	t) Measurement of no load current at 500V, 1KV, 2.5KV, 5KV and 10KV	This test is not applicable as per IEC60076-1	Bid stipulation shall prevail.	This test is not applicable as per IEC60076-1 As per IEC 60076, No load has been defined to performed at 90 % ,100 %, 110 % of LV voltage. According corresponding current shall be measured. Please review and confirm.	Bid stipulation shall prevail.
21	Volume-II, Section-II, E-3 11 kV Isolated Phase Bus Duct and Accessories	3.15.2		40 of 40	**d) SITE COMMISSIONING TESTS** • Milli-volt drop test on all joints.	This test is applicable on sample length.Test conducted on similar type of bus duct shall be submitted for review.This test is not feasible on entire length at site.	Bid stipulation shall prevail. The clause referred by the bidder is from earlier cancelled tender of Heo HEP. Bidder may refer to the specification for Bid No. 477 Dtd. 26.02.2025	This clause 3.15.2 refers to the bid specification for bid No. 477 Dtd. 26.02.2025. As per IS: 5561:1970, This test is applicable on sample conductor length, just to ensure that after weld conductor joints resistance are within the limit. This will be checked through milli-volt drop test. Since welding of joints will be done by same method, material, procedure and trained welder.Therefore, this test is not required to be performed on all the joints. Kindly accept.	Bid stipulation shall prevail.

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22	Volume-II, Section-II, E-8 DC System	8.8.2		32	All tests shall be conducted in accordance with the relevant IEC and BIS in the presence of the representatives of purchaser/ consultant. The bidder shall give 45 days notice regarding readiness of equipment for inspection.	Please note that 45 days intimation time period is more. we will notify end customer 15 days before the final inspection. Kindly accept	Bid stipulation shall prevail.	Please note that 45 days intimation time period is very long period. Bidder propose to notify end customer 15 days before the final inspection. Request to review once again and accept the proposal.	Agreed. 15 days prior intimation is acceptable.
23	Volume-II, Section-II, E-8 DC System	8.8.9.2		35	vii) Milli-volt drop test	Kindly note that Milli-Volt drop test is applicable on Breakers. In DCDB, component will be MCBs only. Therefore, this test is not applicable	Bid stipulation shall prevail.	Kindly note that Milli-Volt drop test is applicable on Breakers. In DCDB, component will be MCBs only which is being used as an electrical ON/OFF switch (Not like Circuit breaker). Therefore, this test is not applicable. Please confirm.	Agreed.
24	Volume-II, Section-II, E-8 DC System	8.8.9.3 & 8.8.9.4		35	Type Tests	In DCDB having MCBs only. Therefore, Type test will not be applicable	Bid stipulation shall prevail.	Kindly note that DCDB is having MCBs only. These are trader based items. Therefore,Type test is not feasible. Kindly accept.	Type Test Reports as per Bid stipulations shall be submitted.
25	Volume-II, Section-II, E-10 Pothead Yard Equipment	10.4.2.3		43	**Special Acceptance Test** • Thermal stability test on three sections (IEC 7.2.2) • Aging & Energy Capability test on block (procedure to be mutually agreed). • Watt loss test.	Please note that these tests are not a part of Routine test. Therefore, internal report carried out by the supplier shall be shared for review. Kindly accept.	Bid stipulation shall prevail.	Please note that as per IEC 60099-4, these tests are not a part of Routine test. Therefore, internal report carried out by the supplier shall be shared for review. Kindly accept.	Special Acceptance Test needs to be carried out and Reports to be shared for our acceptance.
D. General									
26	GTS, Volume-II, Section-I, G-1	0.3	Standards	2	Although Indian or IEC standards for workmanship material and plant have been selected generally in these specifications as a basis of reference, other standards and recommendations of standard international organisations will be acceptable provided they ensure equal or higher quality than those specified, and provided, furthermore, that the Contractor submits for approval, detailed standards which he proposes to use.	We request you to modify this Paragraph as "Although Indian or IEC standards for workmanship material and plant have been selected generally in these specifications as a basis of reference, other standards and recommendations of standard international organisations will be acceptable provided they ensure equal or higher quality than those specified, and provided, furthermore, that the Contractor submits for approval, ~~detailed standards~~ extracts of the standard which he proposes to use, as Standards are copyright products and cannot be shared". Please accept the above modification in the specification and confirm.	Bid stipulation shall pre	We request you to modify this Paragraph as "Although Indian or IEC standards for workmanship material and plant have been selected generally in these specifications as a basis of reference, other standards and recommendations of standard international organisations will be acceptable provided they ensure equal or higher quality than those specified, and provided, furthermore, that the Contractor submits for approval, ~~detailed standards~~ extracts of the standard which he proposes to use, as Standards are copyright products and cannot be shared". Please accept the above modification in the specification and confirm.	Accepted.
27	Volume-II, Section-I, G-1, General Tech. Specification	6.1.2	Standards	80	If the Contractor intends to apply Standards and Regulations other than those specified, he shall provide the Engineer with two (2) sets of such documents, which shall be complete, unabridged and written in the Contract Language.	If the Contractor intends to apply Standards and Regulations other than those specified, ~~he shall provide the Engineer with two (2) sets of such documents, which shall be complete, unabridged and written in the Contract Language.~~ He shall provide the extract of the applicable standard written in contract language. Please accept the above modification in the specification and confirm.	Bid stipulation shall pre	If the Contractor intends to apply Standards and Regulations other than those specified, ~~he shall provide the Engineer with two (2) sets of such documents, which shall be complete, unabridged and written in the Contract Language.~~ He shall provide the extract of the applicable standard written in contract language. Please accept the above modification in the specification and confirm.	Accepted.

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28	General				Transport limitation			We have conducted a detailed route survey and observed the limitation enroute. Considering the heaviest component (Pressure Shaft Valve), It is requested to please ensure to provide suitable road to transport the equipment of size at least Length 7.0 (m)X Width 6.8 (m) X Height 3.5 (m) and weight wise atleast 70 tons material without trailer must be ensured by NEEPCO. Any widening of road, chipping, strengthening and widening of bridges, cutting the trees and mountain edge, overhead wires etc. shall be in NEEPCO scope. Any delay in availability of road (including approach road) shall be to NEEPCO account.	Please Refer Pre Bid Technical Clarification No. 2 dated 02.05.2025 wherein the following has been stated: The project road from Kamba-Mechuka road to Heo Power House is being built as per the following specifications: i) Single lane carriage way width: 3.75M (ii) Minimum Formation width: 7.75M (iii) Maximum vertical gradient: 1 in 15 (iv) Vertical Ruling gradient: 1 in 20 (v) Minimum Radius of curvature: 20.0M Detail Geometric design shall be done as per IRC manual for hills road. The bailey bridge over Yarjep river shall be of 40R specifications, having a clear width of 4.25 Metres (from truss to truss). Therefore, the maximum width of the largest consignment shall be computed accordingly. The maximum weight of the consignment shall also be finalized as per the bailey bridge specifications. THe bidder is requested to visit site and carryout detail survey to ascertain transportation constraints, if any, in the Kamba Mechuka Road as well as the project roads to Power House and Valve House.
E. Balance of Plant - Electrical (BOPe)									
29	PTS, Volume-II, Section-II, E-7	E7	33kV Overhead Transmisson Line	8 of 30	Approximately 5 km long 33 kV single circuit transmission line using "ACSR DOG" conductor shall be constructed with one no. earth wire strung on steel tubular poles from powerhouse to Upstream area (HRT Intake area & Valve house location) including Tapping arrangement at Intake and Valve house area, Lightning Arrestors, Horn Gap Fuses & Air break Switches, insulators etc. and provision for stringing of ADSS cable and mounting of street Lights on pole". .....The complete scope shall include obtaining right-of-way, Survey, Line design, Right-of-way clearance and access tracks, Foundation works, Grounding & Earth wire, Erection of poles, mounting structures etc., Stringing works with polymer insulator, Testing, final inspection and commissioning and Any other work required to complete the work.			33 kV transmission line including obtaining 'Right of Way', 'Survey', 'Right-of-way clearance and access tracks' etc, is not possible for us to include in the scope being specialized job. Such requirement generally does not include in EM package scope. Reference can be drawn from various EM tender across PSU / private sector. We would like to insist and request to kindly exclude the 33 kV Line, ADSS and street lighting as mentioned in the clause from the scope of E&M contractor.	Please Refer Pre Bid Technical Clarification No.3 dated 27.05.2025, sl. no. 86 wherein the following has been stated: Refer MOM of Pre bid meeting dated 15-05-2025 on Tato-I HEP. The same shall be applicable for Heo HEP, also.
30	PTS, Volume-II, Section-II, E-7, HT and LT Switchgear	E7	33kV Board / Switchgears and 33kV XLPE Cable	4 of 30	The number of 33 kV Boards / Switchgears have been indicated in Drawings. However, the required number of Boards / Sub distribution Boards of desired specification may be provided by Bidder / Contractor at various location as per the site condition. The Boards / switchgears comprising of: • Draw out type incoming/outgoing Vacuum circuit breaker (VCB); Since the elevation is above 1000 m, necessary altitude correction factor shall be applied to the relevant			The considered Basic insulation level (rated lightning impulse & power frequency voltage) for 33kV switchgear is 70kV (rms) & 170kVpeak respectively, as per the IEC 62271 for altitude upto 1000 m. All reputed manufacturer having type test report upto altitude 1000m for the 33kV switchgear. If, altitude correction factor has to be considered, then the 33kV switchgears shall be with SF6 gas insulated. Please confirm the requirement.	Both Vacuum Ciruit Breaker or SF6 Circuit Breaker shall be acceptable.
31	PTS-Electrical, Volume II Section-II ; E-5, GIS and GIB	5.6.2	Special Spare Parts	48 of 50	The following special spare parts shall be quoted by the Tenderer and included in the total tender price: • One complete CB interrupter unit with operating mechanism • Two closing coils • Two tripping coils • One complete DS/ES with operating mechanism			Special spare part mentioned at PTS clause 5.6.2 is contradicting from the requirement mentioned at PTS-Electrical Volume II Section-II ; E21, Schedule of Requirement (Electrical). Kindly confirm which list has to be considered in bid.	SOR (Volume II Section-II ; E21) shall be considered for Mandatory Spare Parts of GIS and GIB.
32	PTS-Electrical Volume II Section-II ; E21, Schedule of Requirement (Electrical)	E21	245kV Gas Insulated System	14 of 40	S.no. iv. Three pole group operated Disconnector Switch with grounding switch single pole assembly module along with operating mechanism for VT Circuit complete in all respect			The requirement of Three pole group operated Disconnector Switch with grounding switch mentioned at s.no. iv, at PTS-Electrical Volume II Section-II ; E21, Schedule of Requirement (Electrical) is not applicable .Please confirm	Confirmed.
33	PTS-Electrical Volume II Section-II ; E21, Schedule of Requirement	9.25	List of Mandatory Spares	44 of 45	Multifunction Digital Bay Controller Unit; all BCU shall be identical 2 no.s			Spare item BCU is not applicable for protection system as the same is not part of protection system as the same is not mentioned in the technical specification requirement of protection system.	The items shall be considerd as Mandatory Spares under GIS/ GIB.

Sr. No.	Volume	Clause No.	Clause name	Page No.	Specification as per Bid Document	Bidder Query / Clarification	NEEPCO Reply (As per Pre Bid Technical Clarification No.3 dtd 27.05.2025)	Bidder Query / Clarification	NEEPCO Reply
F. Balance of Plant - Mechanical (BOPm)									
34	Volume-II, Section-II, M-2, Electro Mechanical Equipments - Pressure Shaft Valve	3.2	Pressure Oil System (Accumulator)	20 of 44	The oil volume shall be sufficient so as to perform three full operations of the Butterfly valve viz. close open close with oil pumps being out of operation.			As per clause 3.13, the servomotors shall be used for only opening the valve while the closing shall be by means of dead weights attached to the lever and may also be used in the faster closing operation of butterfly valve, considering the tender clause 3.13, please confirm that the accumulator volume shall be sufficient to compensate the leakage of oil in hydraulic system during opening of the Butterfly valve.	The Accumulator volume shall be sufficient to continuously compensate the leakage of oil during normal operation as well as close-open-close operation with pumps being out of operation.
35	Volume-II, Section-II, M-10, Electro Mechanical Equipments - Compressed Air System	10.4.3	Piping, Valve and Instrumentatio n	Page 4	All embedded and exposed air piping shall be seamless stainless steel of minimum schedule 40. Pipe size upto 25mm shall be minimum schedule 80.			As per tato-1 tender specification clause no. 5.3, page no. 3 under Volume II, Section II, Sub-Sec-05 HP & LP Compressed Air System, all brake air piping shall be of Stainless Steel & while all other piping shall be heavy duty Galvanised Carbon Steel material, ASTM A53 Gr B / A106 gr B. Please allow to use, same material as mentioned above in Heo project also & confirm.	Agreed.
36	Volume-II, Section-II, M-11, Electro Mechanical Works - Cooling water system	11.4.9	Valves and Piping	Page 5	All embedded and exposed piping 25mm and above shall be of black carbon steel of minimum schedule 40. Pipe size less than 25mm shall be of minimum schedule 80.			As the cooling water system presure shall be on lower side, pleaase allow to use pipe of medium class for all the pipes.	Bid stipulations shall prevail.
37	Volume-II, Section-II, M-12, Electro Mechanical Works - Drainage & Dewatering System	12.5.3	Valves, Piping and Floor Drains	Page 7	All embedded and exposed piping size 25 mm and above shall be of carbon steel of minimum schedule 40. Pipe size less than 25 mm shall be of minimum schedule 80.			As the drainage & dewatering system presure shall be on lower side, pleaase allow to use medium class for all the pipes.	Bid stipulations shall prevail.
G. GTS									
38	GTS, Volume-II, Section-I, G-1	3.4	Material Standards	4				Given clause includes materials from ASTM standard only. Kindly also allow bidder to offer materials from Indian Standard and EN (European standard) also.	Any alternative material offered must be equivalent or better than the material specified in the Tender specification both in terms of chemical composition and material properties. However, detail comparison of chemical composition, material properties and evidence of use successfully in similar other projects must be submitted to the Purchaser for approval during detail engineering stage.

ANNEXURE - IV A

Anyway, the works foreseen to be executed imply a limited risk both for the construction achievement and local population. Therefore, there are limited damages in case of occurrence of higher flood than the TR 25.

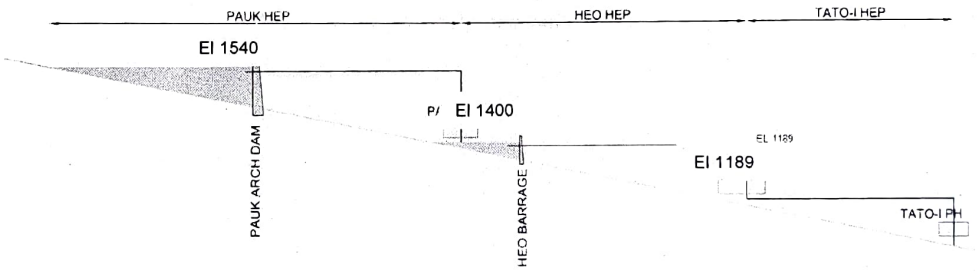
Conclusion

The construction programm has been designed so that the works at intake only occur during lean season, from November to March. The diversion flood of 1219 cumec for intake construction has hence been adoptedas per CWC approval communicated in letter No.2/ARP/22/CEA/10-PAC/3743-45 dated 3rd September 2010.

8.8 SEDIMENTATION STUDY

General

VELCAN Energy is developing Pauk (145 MW), Heo (240 MW) and Tato I (186 MW) Hydro Power Projects on Yarjep River, a tributary of Siyom River and Siang River in Arunachal Pradesh. The three projects are designed as a cascade type development with reservoir and tail water elevations as shown below.



DETAILS OF PAUK, HEO AND TATO-I HEPS				
Sr. No.	**Description**	**PAUK HEP**	**HEO HEP**	**TATO-I HEP**
1	Catchment Area	982 sq.km	1065 sq.km	1154 sq.km
2	FRL	1540 m	1400 m	1189 m
3	River level at Diversion	1445 m	1386 m	1188 m
4	Dam height	105m	16 m	From Heo tailrace
5	Gross capacity	11.5 Mcum	0.39 Mcum	nil
6	Live capacity	1.67 Mcum	0.15 Mcum	nil
7	T.W.L.	1401m	1189m	1025 m
8	Distance from origin of river	60.30 KM	63.60 KM	68.60 KM

Pauk HEP (145 MW) proposes to utilize available head between El 1540 m and El 1401 m and its headwork comprises of a 105m high arch dam (above foundation level) to provide a gross storage capacity of 11.5 mm^3 with live storage capacity of 1.67 mm^3. The reservoir spreads over an area of about 34.1 Ha and occupies 2.37km length in Yarjep River and encroaches about

0.8km length in to Sae Chu nallah, a right bank tributary of Yarjep River with its confluence about 1.2 km upstream of dam location.

Heo HEP (240 MW) proposes to utilize available head between El 1400 m and El 1189 m and its headwork comprises of a 16 m high gated barrage having a gross storage capacity of 0.39mm^{3}and live storage capacity of 0.15 mm^3. The pondage area spreads over about 8.4 Ha and occupies about 1km length in Yarjep River.

Tato-1 HEP 186 MW proposes to utilize available head between El 1189 m and El 1025 m. The tailbasinof Heo HEP directly coupled with head race channel of Tato-1 HEP. In addition, a weir is proposed across Yarjep River to divert 2.63 m^3/s of flow from intermediate catchment downstream of Heo Barrage for power generation at Tato-1 HEP.

Pauk, Heo and Tato-1 hydro power projects are designed as peaking run of the river type development with live storage of 1.67Million m^{3}being provided only at Pauk dam and a small balancing reservoir with live storage of 0.15 mm^{3}at Heo barrage.

Yarjep River is a tributary of Siyom and Siyom in turn isa major tributary in Indian territory of Siang River and forms a part of the Brahmaputra basin. Yarjep River originates from mountainous ranges along Indo Tibetborder at El ±4660 m and travels a length of about 80 km up to its confluence with Siyom River near Tato village.

A schematic diagram showing plan of Yarjep River from its origin (El ± 4660 m), location of Pauk Dam site (El 1455 m), Heo barrage site (El 1386 m) and weir of Tato-1 HEP (EL 1188 m), is presented in figure 8.25. The catchment area of Yarjep River at Pauk dam site is 982 km^2, at Heo barrage site is 1065 km^2 and at weir site for Tato I HEP is 1154 km^2. The total drainage area of Yarjep River up to its confluence with Siyom River is 1222 km^2. The longitudinal section of Yarjep River from its origin to its confluence with Siyom River is illustrated in figure 8.26.

The Yarjep River from its origin to its confluence with Siyom River has been classified into four reaches based on river bed slope for the purpose of this sedimentation study. Details are indicated in table 8.35 below.

Table8.35: Classification of Yarjep River based on river slope

S No	Description	Distance from origin	Elevation	River Bed Slope
1	Upper mountainous reach	0.00 km to 3.4 km	4660m to 3497m	34.2%
2	Lower mountainous reach	3.4 km to 30 km	3497m to 1978m	5.71%
3	Mechuka plains	30km to 51.9 km	1978m to 1892m	0.39%
4	Mountainous reach below Mechuka plain	51.9km to 80km	1892m to 952	3.34%

Fig. 8.25 Schematic Plan of Yarjep River

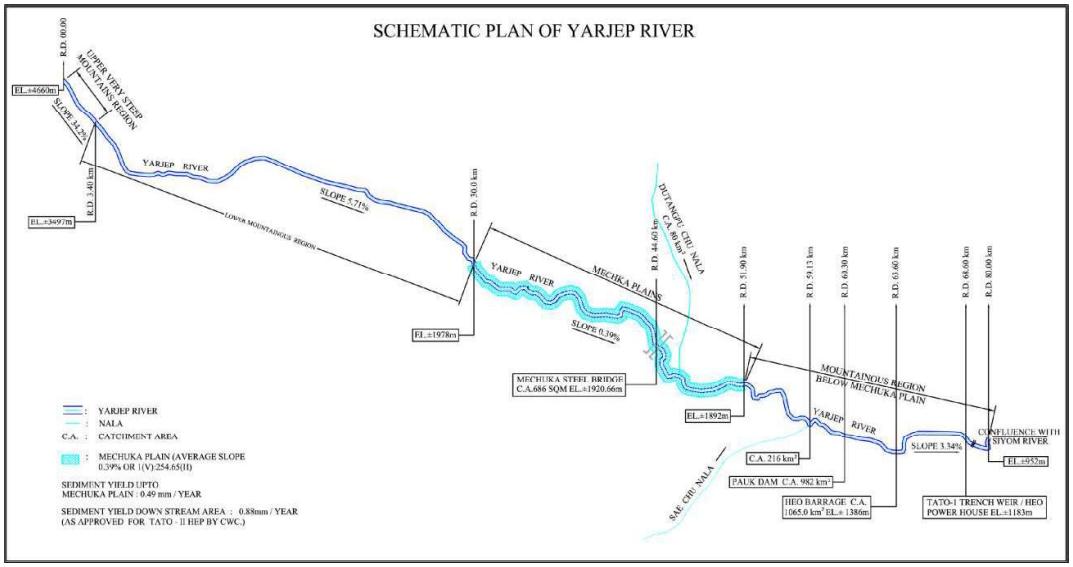
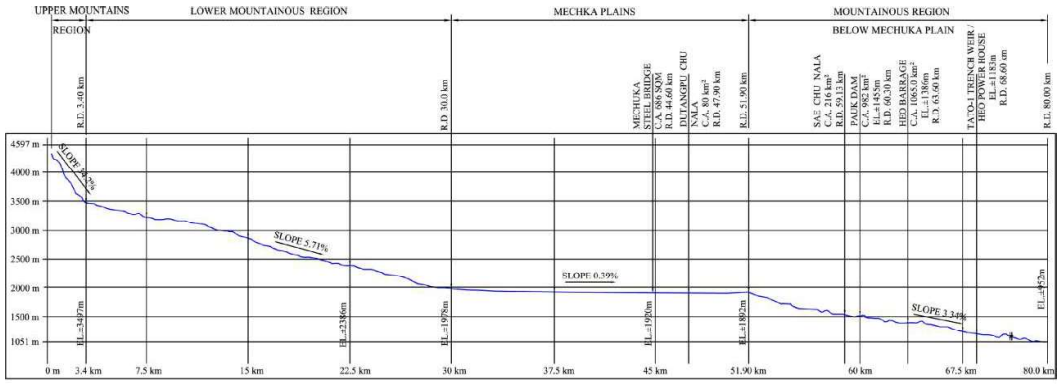


Fig. 8.26 Yarjep River Longitudinal section



LONGITUDINAL SECTION OF YARJEP RIVER

In its upper mountainous reach spread over a length of about 3.4 km, Yarjep River has a very steep average bed slope of 34.2%. Thereafter, the river follows a moderate bed slope of 5.7% for a length of 26.6 km up to RD 30 km. Yarjep River then flows in Mechuka plains for a distance of about 22 km (from RD 30km to RD 51.9km) with river slope of 0.39%. This reach is characterised by wide river section and shallow water depth thus giving the appearance of a large lake. The lower velocity of flowing water through Mechuka plains leads to settlement of sediments carried from upper mountainous river reach. A satellite image of meandering river course through Mechuka plains with sediment deposits is shown in figure 8.27. Within the Mechuka plain, Dutangphu Chu joins Yarjep River from the left bank at RD 47.9 km. The characteristics of this tributary are identical to those of Yarjep River within Mechuka plain reach. The catchment area of Yarjep River at the downstream end of Mechuka plain at RD 51.9 km including catchment area of Dutangphu Chhu is 766km^2. Satallite image of Mechuka plain is shown in figure 8.27 along with photographs of Dutangphu Chu valley. Longitudinal section of Dutangphu Chu is also presented in figure 8.27a.

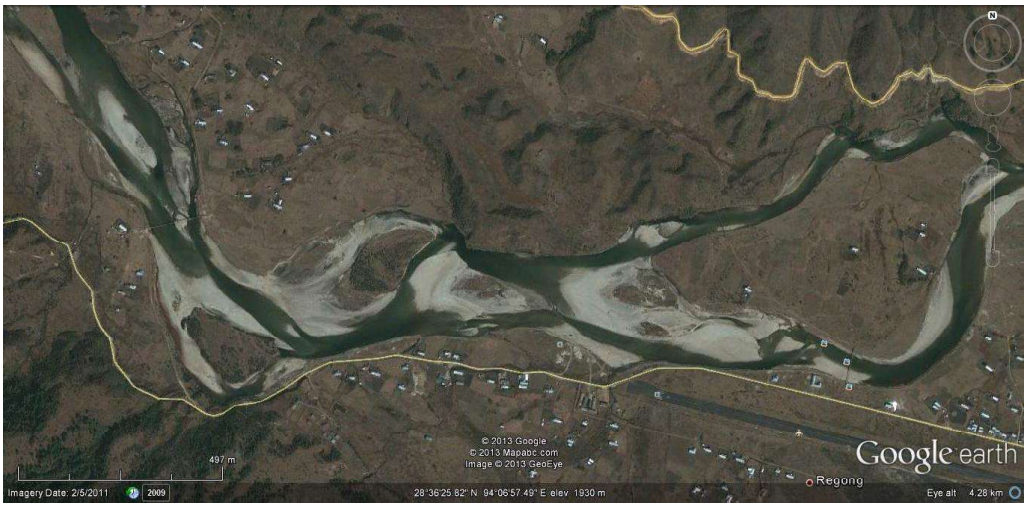
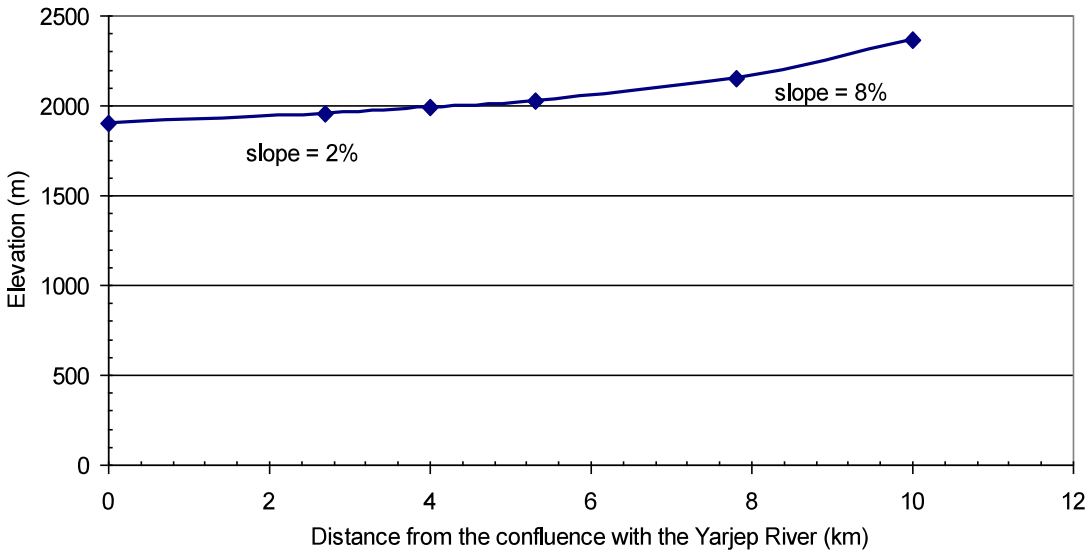


Fig. 8.27 Yarjep River passing through Mechuka plains (above) and Dutangphu Chu upstream of confluence with Yarjep River (below).

Fig 8.27a: Longitudinal profile of Dutangphu Chu



Downstream of Mechuka plain, Yarjep River flows with an average river bed slope of 3.34% for a length of 28.1 km up to its confluence with Siyom River. This reach of Yarjep River is also classified as mountainous reach for the purpose of this sedimentation study. All three projects being developed by Valcan Energy laying in this reach.

Pauk dam is located at RD 60.30 km, Heo barrage at RD 63.60 km and Tato-1 weir at RD 68.60 km along Yarjep River.

Daily discharge measurement and sedimentation data collection for design of above three projects is being done since 2009 at Mechuka steel bridge located at RD 44.6km within Mechuka plain. The catchment area of Yarjep River at Mechuka steel bridge location is about 686 km^2. Rain gauges are installed at four locations within the catchment area of Yarjep River at Mechuka, Segong located about 9 km upstream of Mechuka bridge, Hanuman camp located about 20 km upstream of Mechuka Bridge and at Gapo located downstream of Mechuka. Daily rainfall data is available since 2008 at Gapo and Mechuka and since 2010 at Segong and Hanuman camp.

Pauk HEP propose construction of a 95m high arch dam at RD 60.3km and utilises flow from a catchment area of 982km^2. Storage reservoir at Pauk dam has a gross capacity of 11.5 $mm^3$and live capacity of 1.67 mm^3. Sedimentation study at Pauk dam is carried out considering catchment area of 766 km^2 up to RD 51.90 km including Mechuka as plain area and the remaining catchment area of 216km^2 up to Pauk dam (between RD 51.9km to RD 60.3km) as mountainous region. The sedimentation studies have been carried out duly taking into consideration sediment in transportation and deposition behaviour.

Heo barrage is proposed at RD 63.6km about 3.3 km downstream of Pauk dam and utilises flow from a total catchment area of 1065km^2. Heo barrage receives flows from Pauk power house, surplus flows of Pauk dam and flow from intermediate catchment area of 83 km^2 downstream of Pauk dam up to Heo barrage. The gross storage at barrage is 0.39 mm^3 and live storage is 0.15 mm^3 providing benefit of a balancing reservoir for Heo HEP. Heo Hydro Electric Project does not have any storage over a month/year. Therefore as per IS:12182-1987 "Guidelines for determination of effects of sedimentation in planning and performance of reservoirs" as well as CBIP TR No.-19, Life of Reservoirs – 1980, design for this project does not require detail sediment study. However the impact of sediment from Pauk dam and 83km^2 intermediate catchment area is also studied and discussed in the following sections. Sedimentation study takes into consideration, periodic flushing of sediment from diversion barrage during monsoon period to avoid permanent deposition of sediments in pondage area of Heo barrage.

Tato-I receives 98% of flows directly from tailrace of Heo power house and additional 2% flow (2.7 cumec) is diverted from Yarjep River through weir constructed at RD 68.6km. The total catchment area of Yarjep River at weir site is 1154km^2 and the intermediate catchment downstream of Heo barrage is 89 km^2. As 98% of flow from Heo power house will be used for power generation at Tato-1 HEP and only 2% additional flow is added from Yarjep River, the sedimentation study for Heo HEP is valid for Tato-1 HEP. Accordingly, no separate site specific sedimentation study is carried out for Tato-1 HEP.

Sedimentation study has been carried out based on the discharge and sediment data collected since 2009 to estimate the impact of sediment problems for the entire cascade (Pauk HEP, Heo HEP, Tato-I HEP). Sedimentation study is carried out in three steps – in first step, sediment load is estimated at downstream end of Mechuka plain, in second step at Pauk dam location taking in to consideration the impact of Pauk reservoir and in the last step at Heo barrage location.

Sediment Data

No sediment flow data on Yarjep River is available prior to allotment of projects to Velcan Energy. However sediment data on Siyom / Siang River collected by Brahmaputra Board and NHPC, downstream of its confluence with Yarjep River is available at Raying site (CA = 3285 km²) for the period 2000 to 2005 and at Pangin site (CA = 5110 Km²) from 1978 to 2003. The location of above sites with reference to project location of Tato-I HEP is illustrated in Figure 8.28.

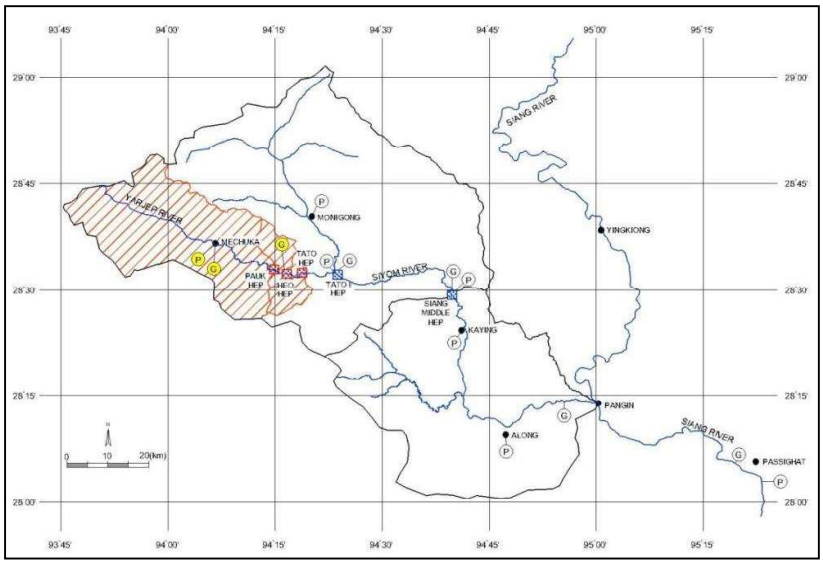


Fig. 8.28 Location of sediment measurement site on Siyom / Siang River

Sediment data collection has been started by Velcan Energy at Mechuka bridge site since 2009 and at Heo barrage site in 2012. Presently about 4 years sediment data at Mechuka site is available. At Heo HEP barrage location (at Puring), water samples for estimation of suspended sediments have been collected during 2012. Sediment concentration, grain size analysis and petrography analysis on sediments has been carried out on the water samples collected at Mechuka and Puring and the results are discussed in subsequent sections. In addition, 7 samples from river bed-at Mechuka steel bridge (3 no), Pauk dam site, confluence of Sae Chhu and Yarjep and at Heo barrage (2 no) have been collected and analysed for grain size distribution.

The above sediment data has been analyzed to assess the quantity of sediment load expected at Pauk dam site as well as at Heo barrage site.

Sediment data at Pangin and Raying Sites

Sediment concentration measurements carried out in Yarjep / Siyom River by Brahmaputra Board and NHPC are available for Pangin and Raying sites on Siyom River. The location of these two sites is illustrated in figure 8.28. Brief details of suspended sediment data are given below;

Table: 8.36 Detail of sediment concentration at Pangin site (CA = 5110 km^2)

Year	No. of sampling days in a year	No. of days having sediment concentration				
		<150 ppm	>150 ppm & < 500 ppm	> 500 ppm & < 1000 ppm	>1000 ppm & <2000 ppm	>2000 ppm
1978	290	261	27	2	0	0
1979	216	216	0	0	0	0
1980	197	192	3	2	0	0
1981	103	103	0	0	0	0
1982	92	92	0	0	0	0
1983	126	125	1	0	0	0
1984	78	76	2	0	0	0
1985	132	122	8	1	1	0
1986	158	158	0	0	0	0
1987	114	113	1	0	0	0
1990	137	136	1	0	0	0
1991	146	146	0	0	0	0
2002	341	298	36	7	0	0
2003	178	177	1	0	0	0
Total	2308	2215	80	12	1	0
Percent (%)		96	3.5	0.46	0.04	0

Table: 8.37 Sediment concentration at Raying site (CA = 3285 km^2)

Year	No. of sampling days in a year	No. of days having sediment load				
		<150 ppm	>150 ppm & <500 ppm	>500 ppm & <1000 ppm	>1000 ppm & <2000 ppm	>2000 ppm
2000	167	87	54	18	4	4
2001	344	173	94	52	23	2
2002	339	238	97	4	0	0
2003	359	59	267	33	0	0
2004	365	338	26	1	0	0
2005	299	261	36	2	0	0
Total	1873	1156	574	110	27	6
Percent (%)		61.7	30.7	5.9	1.4	0.3

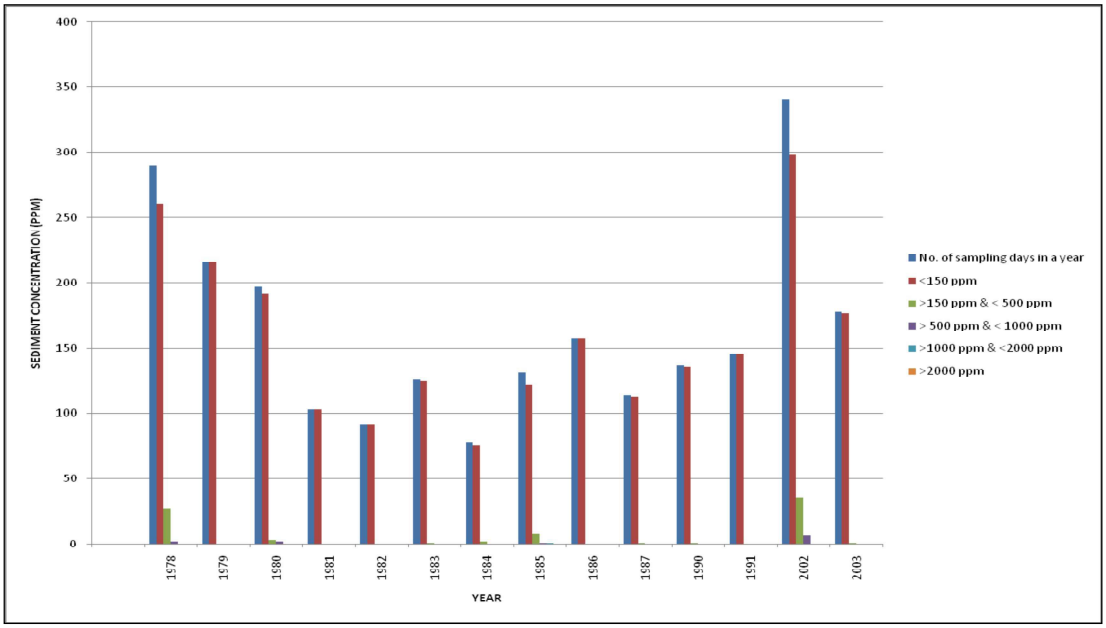


Fig.8.29 Sediment concentration at Pangin site (CA : 5110 km^2)

Sediment measurement studies carried out by the Brahmaputra Board and NHPC on Siyom / Siang River for Pangion and Raying water samples indicates that event of sediment concentration more than 500 ppm is very rare.

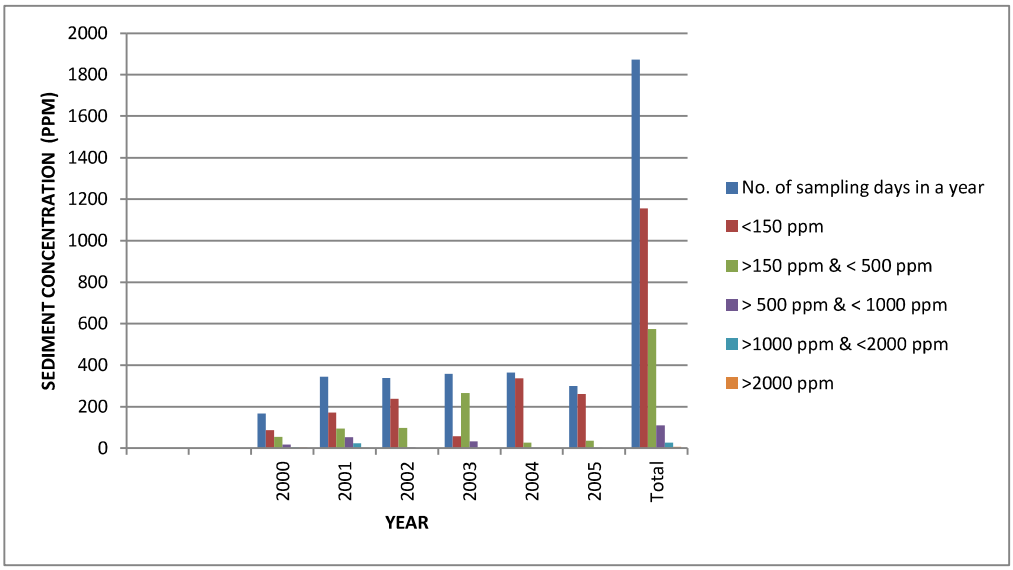


Fig: 8.30 Sediment concentration at Raying site (CA = 3285 km^2)

Sediment data in Yarjep River at Mechuka Bridge

Daily sediment observations on the Yarjep River at Mechuka Steel Bridge (catchment area 686 km^2) have been carried out during 2009 to 2012. The details of sediment concentration for this data are presented below in Table 8.38 and figure 8.31.

Table: 8.38 Sediment Concentration in Yarjep River at Mechuka Bridge

Year	No. of sampling days in a year	No. of days having sediment load					
		0.0 ppm	> 0.0 to 150 ppm	>150 ppm & < 500ppm	> 500 ppm & < 1000 ppm	> 1000ppm & < 2000ppm	>2000 ppm
2009	184	157	21	6	0	0	0
2010	365	343	6	5	7	4	0
2011	181	172	2	3	4	0	0
2012	180	134	30	8	5	3	0
Total	910	806	59	22	16	7	0
Percent (%)		88.5	6.5	2.4	1.8	0.8	0

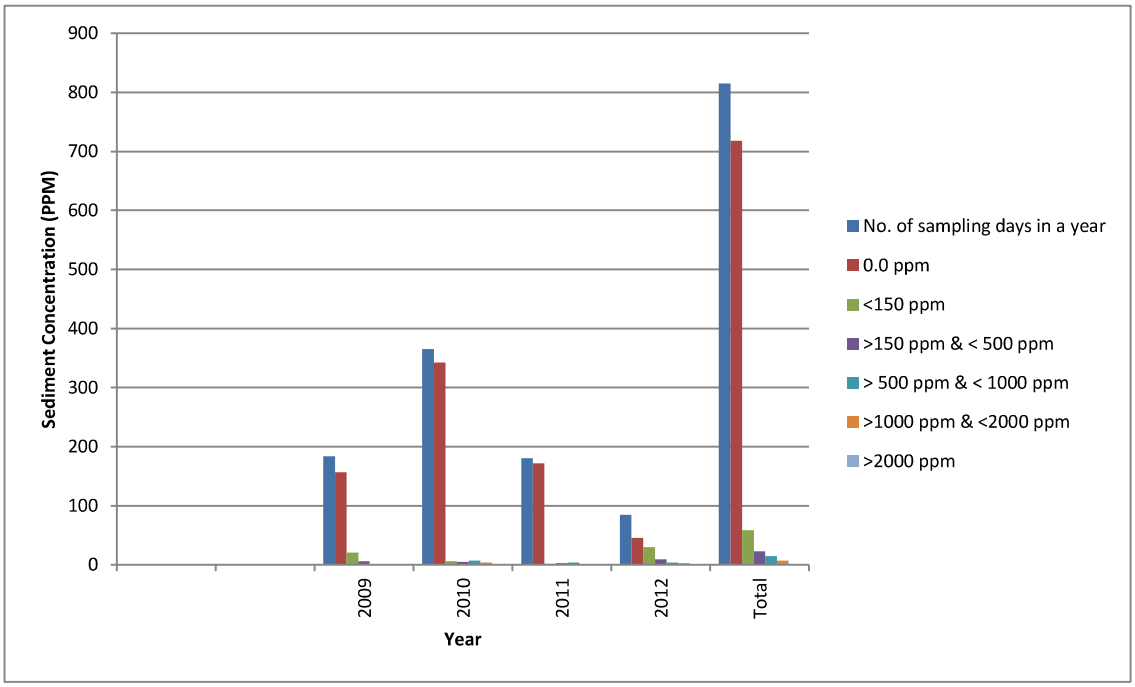


Fig: 8.31 Details of Sediment Concentration at Mechuka bridge (CA: 686 km^2)

8.8.4.1 *Grain size distribution for Suspended sediments at Mechuka Bridge*

Grain size distribution has been performed on sediments obtained from water samples at Mechuka Bridge gauging site. This testing is carried out for 10 no water samples collected during 2010 and appended in **Appendix -E**. Details of grain size distribution on sample collected during year 2010 are tabulated below.

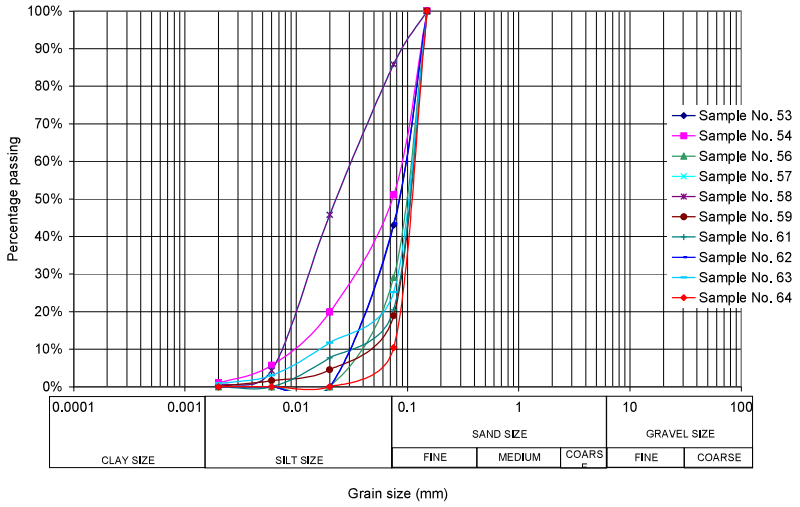
The result of grain size distribution on 10 samples for 2010 indicates that maximum size of suspended sediment at Mechuka Bridge is less than 0.15 mm or 150 microns. Grain size distribution for suspended sediments for samples collected during year 2010 is presented below in table 8.39 and figure 8.32.

About 46 number of samples containing suspended sediments were collected during 2012 and sediment concentration was obtained for each of these samples and results appended in **Appendix -E**. The sediments obtained from these 46 samples were mixed and grain size distribution was performed on this mixed sample. Details of grain size distribution on samples collected in 2012 are presented in table 8.40 and figure 8.33.

Table 8.41: Sediment Concentration and Grain size distribution of Suspended sediments in water samples for year 2010

Sample no	53	54	56	57	58	59	61	62	63	64
Date of Sample Collection	23/06/2010	24/06/2010	26/07/2010	30/07/2010	10/08/2010	11/08/2010	21/08/2010	22/08/2010	23/08/2010	24/08/2010
Sediment Concentration (ppm)	467	617	764	600	917	1600	659	433	1065	1957
GRAIN SIZE DISTRIBUTION										
IS Sieve (mm)	% of Sediments Passing (by weight)									
0.15	100	100	100	100	100	100	100	100	100	100
0.075	43	51	29.1	85.8	85.8	18.9	20.5	43.4	25.2	10.4
0.02		19.8		45.8	45.8	4.5	7.7		11.7	
0.006		5.67		4.34	4.34	1.61			3.0	
0.002		0.94		0.39	0.39	0.15			0.9	

Fig: 8.32 - Grain size distribution of suspended sediments at Mechuka Bridge for year 2010



Grain size distribution for suspended sediment observed at Mechuka steel bridge during year 2010 indicates that all suspended particles are smaller than 0.15 mm in size.

Petrographic analysis of suspended particles for the samles collected during year 2012 has been conducted by AIMIL and the results are enclosed in **Appendix E.**

Table: 8.40 Sediment Concentration and grain size distribution of Suspended sediments in water samples at Mechuka for year 2012

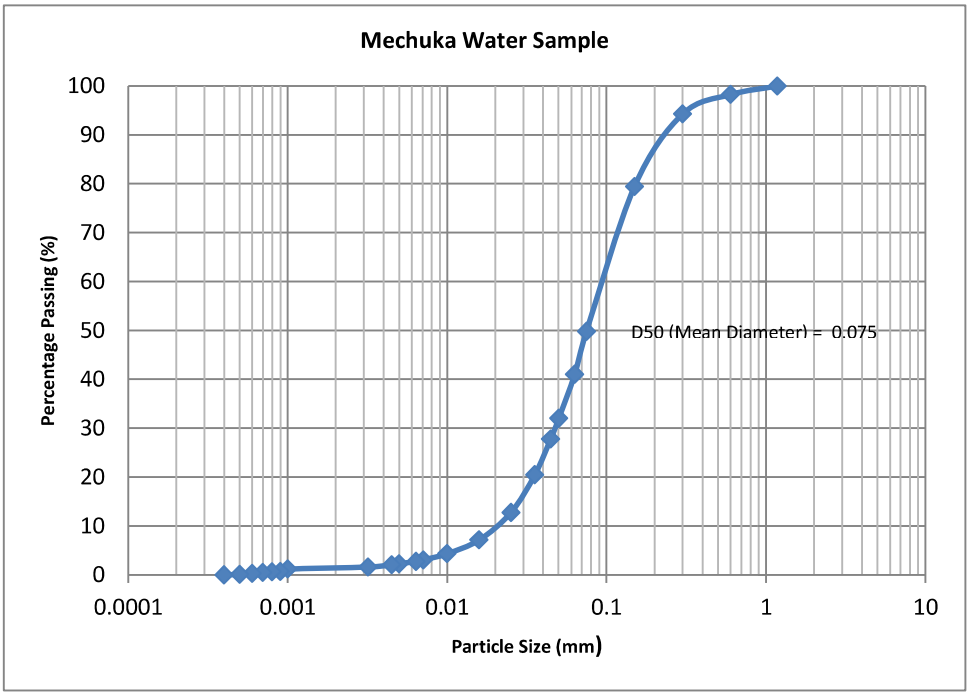
Sample no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Date of Sample Collection	24-Jul-12	25-Jul-12	26-Jul-12	27-Jul-12	28-Jul-12	29-Jul-12	30-Jul-12	31-Jul-12	7-Aug-12	8-Aug-12	9-Aug-12	10-Aug-12	11-Aug-12	12-Aug-12	13-Aug-12	14-Aug-12	15-Aug-12	16-Aug-12	22-Aug-12	23-Aug-12	24-Aug-12	25-Aug-12	29-Aug-12
Sediment Concentration (ppm)	12	656	8	8	4	10	7	2	2	669	8	29	1259	407	9	9	1	3	167	1	131	1023	1
Sample no	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
Date of Sample Collection	31-Aug-12	16-Sep-12	17-Sep-12	18-Sep-12	19-Sep-12	21-Sep-12	22-Sep-12	23-Sep-12	24-Sep-12	25-Sep-12	26-Sep-12	30-Sep-12	1-Oct-12	2-Oct-12	3-Oct-12	4-Oct-12	5-Oct-12	6-Oct-12	10-Oct-12	11-Oct-12	12-Oct-12	13-Oct-12	16-Oct-12
Sediment Concentration (ppm)	1449	217	863	228	154	310	104	18	550	171	16	8	16	10	12	12	62	8	16	470	756	15	20

GRAIN SIZE DISTRIBUTION

IS Sieve (mm)	% of Sediments Passing (by
1.180	100
0.600	98.25
0.300	94.26
0.150	79.44
0.075	49.83
0.050	32.012
0.025	12.730
0.001	4.320
0.0004	0.000

Grain size distribution of 46 samples for 2012 indicates that maximum size of suspended sediment at Mechuka Bridge is less than 1.18 mm and 80% of sediments are smaller than 0.15 mm. Graphical representation of grain size distribution for suspended sediments for year 2012 is presented below. From this graph, it is interpreted that 88% of suspended sediments are finer than 0.2 mm.

Figure 8.33 Grain size distribution of suspended sediments at Mechuka Bridge for year 2012



Sediment data in Yarjep River at Heo Barrage Site

Daily water samples have been collected at Puring Bridge near Heo Barrage during year 2012. Details of test results are presented below.

Table 8.41: Sediment Concentration at Puring near Heo Barrage (CA: 1065 km2)

Year	No. of sampling days in a year	No. of days having sediment load					
		0.0 ppm	> 0.0 to 150ppm	>150 ppm & < 500 ppm	> 500 ppm & < 1000 ppm	>1000ppm & <2000ppm	>2000 ppm
2012	180	129	31	0	4	15	1
Percent (%)		71.6	17.2	0	2.2	8.4	0.6

About 51 no. water samples containing suspended sediments were collected from Heo Barrage location during 2012 and sediment concentration was obtained for each of these samples. The sediments obtained from these 51 samples were mixed and grain size distribution was performed on this mixed sample. Details of grain size distribution on samples collected in 2012 are tabulated below in table 8.42.

Table 8.42: Grain Size Distribution

IS Sieve (mm)	% of Sediments Passing (by weight)
1.180	100.00
0.600	95.10
0.300	90.79
0.150	70.61
0.075	40.05
0.050	21.75
0.025	6.66
0.001	2.56
0.0004	0.000

Grain size distribution of 51 samples for 2012 indicates that maximum size of suspended sediment at Heo Barrage is less than 1.18 mm and 70% of sediments are smaller than 0.15 mm. Graphical representation of grain size distribution for suspended sediments for year 2012 is presented below. From this graph, it is interpreted that 80% of suspended sediments at Heo Barrage are finer than 0.2 mm.

Petrographic analysis of suspended particles for the samples collected during year 2012 has been conducted by AIMIL and the results are enclosed in **Appendix E**.

Fig: 8.34 Grain size distributions for suspended sediment at Heo HEP barrage site

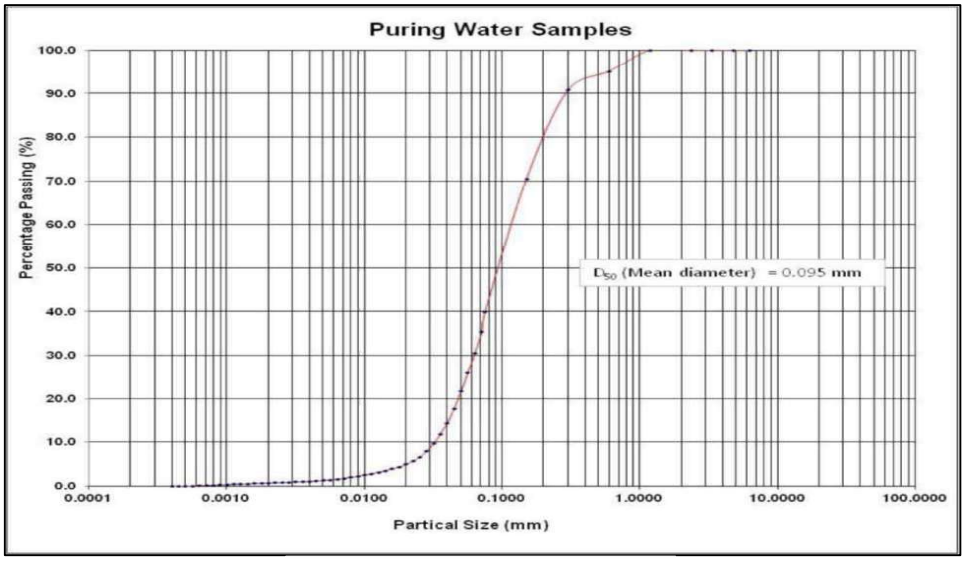


Fig. 8.11 Particle Size Distribution

Sdiment Analysis for Samples collected from River Bed

A total of seven samples were collected from Yarjep River bed as per details given in Table 8.43. These seven samples were analysed for grain size.

Table: 8.43 Table showing Location of Sample collection point for Bed Load Samples

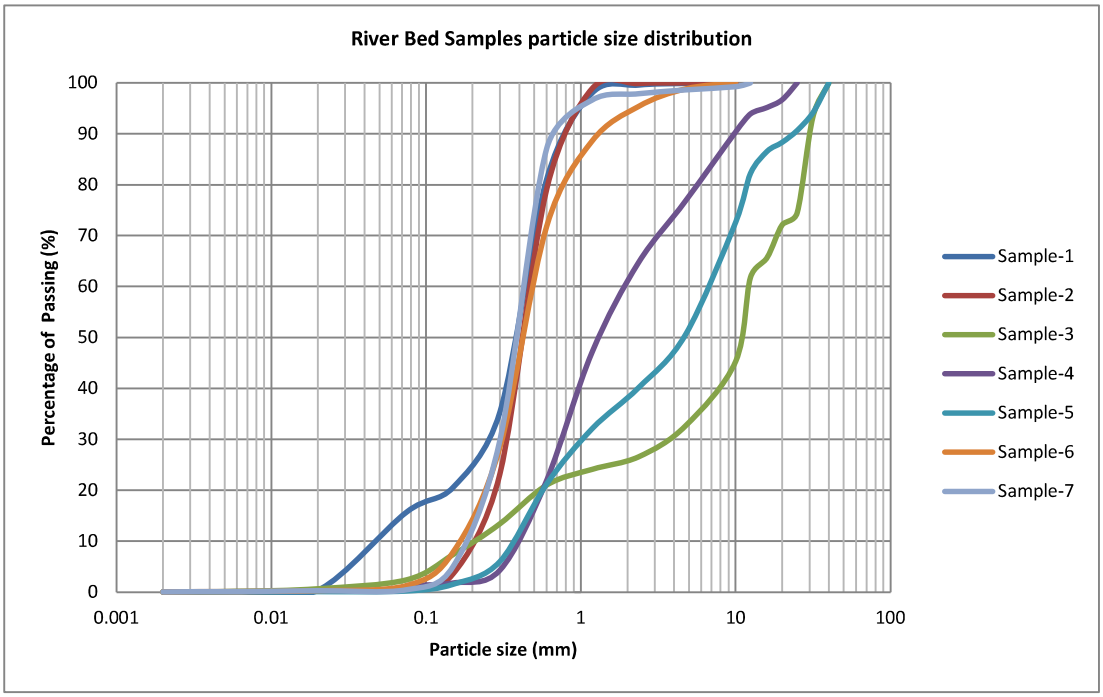
S No	Description	Location of sample collection point
1	Sample 1	Mechuka steel bridge Right bank
2	Sample 2	Mechuka steel bridge Right bank
3	Sample 3	Mechuka steel bridge Left bank
4	Sample 4	River bed Pauk dam
5	Sample 5	River bed of Sae Chu and Yarjep
6	Sample 6	Puring near Heo barrage beach Left bank
7	Sample 7	Puring near Heo barrage beach Left bank

Details of grain size distribution of above samples are presented in table-8.44below.

Table – 8.44

	MECHUKA BED SAMPLES			Sae Chu	Pauk dam	Heo Barrage	Heo Barrage
	Sample-1	Sample-2	Sample-3	Sample-4	Sample-5	Sample-6	Sample-7
IS Sieve							
40			100		100		
31.5			93.277		94.135		
25			74.531	100	90.668		
20			72.14	96.7	88.307		
16			65.676	95.2	86.536		
12.5			61.797	93.9	82.257		100
10	100	100	45.315	90.4	72.704	100	99.28
4.75	99.87	100	32.644	76.8	50.572	98.84	98.61
2.36	99.6	99.87	26.568	64.7	40.133	95.38	97.85
1.18	97.99	98.86	24.111	47.1	32.055	88.55	96.64
0.6	81.02	79.07	21.008	21.9	21.21	71.79	87.05
0.3	35.35	23.21	13.381	4.3	5.976	28.44	29.84
0.15	20.59	3.62	7.369	1.8	1.549	7.86	5.06
0.075	15.76	0.6	2.392	1.3	0.221	1.27	0.45
0.02	0.34	0.22	0.65		0.07	0.29	0.29
0.006	0.09	0.09	0.13		0.04	0.11	0.11
0.002	0.02	0	0.04		0.01	0.05	0.05

Fig: 8.35 Grain size distributions for Bed sediment at Mechuka, Sae chu nala, Pauk dam and Heo barrage



Study of river discharge vs Sediment concentration relationship

Daily discharge measurements (three times a day at 6.30am, 12.30pm and 4.30pm) are being taken at Mechuka steel bridge gauging station. Water samples for determination of sediment concentration have been collected at Mechuka bridge including monsoon season of 2009 to 2012 (**refer Appendix – D**). Observed daily river discharge and corresponding day sediment concentration for monsoon months of June, July, August and September have been plotted graphically for each of the four years and are presented in figure 8.36, 8.37, 8.38 and 8.39.

Fig 8.36: Discharge and silt contents during 2009 monsoon at Mechuka steel bridge

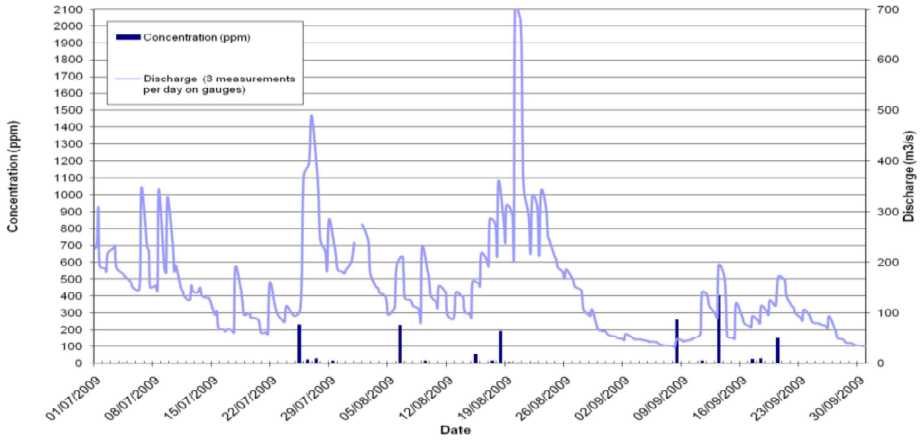


Fig 8.37: Discharge ans silt content during 2010 monsoon at Mechuka steel bridge

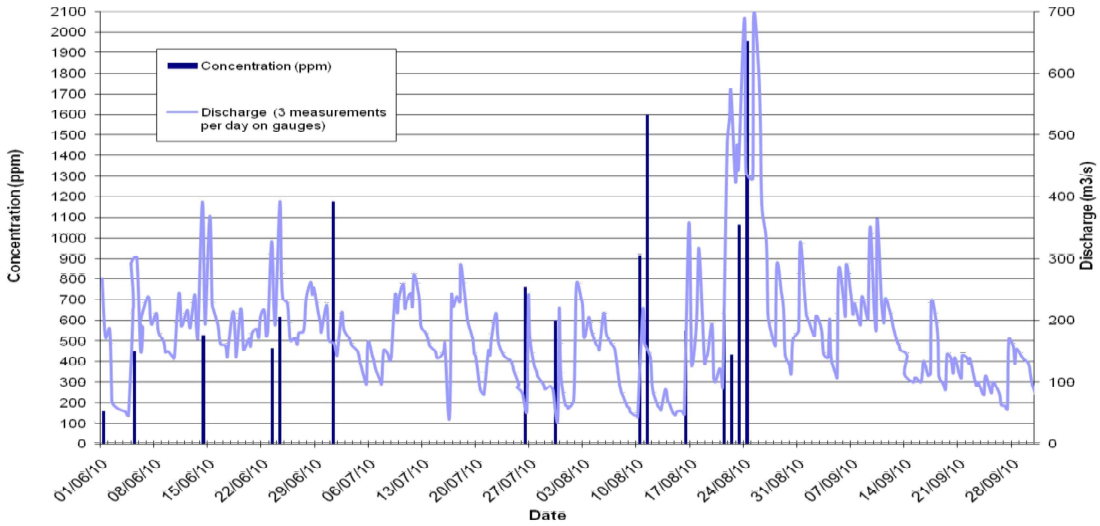


Fig 8.38: Discharge ans silt content during 2011 monsoon at Mechuka steel bridge

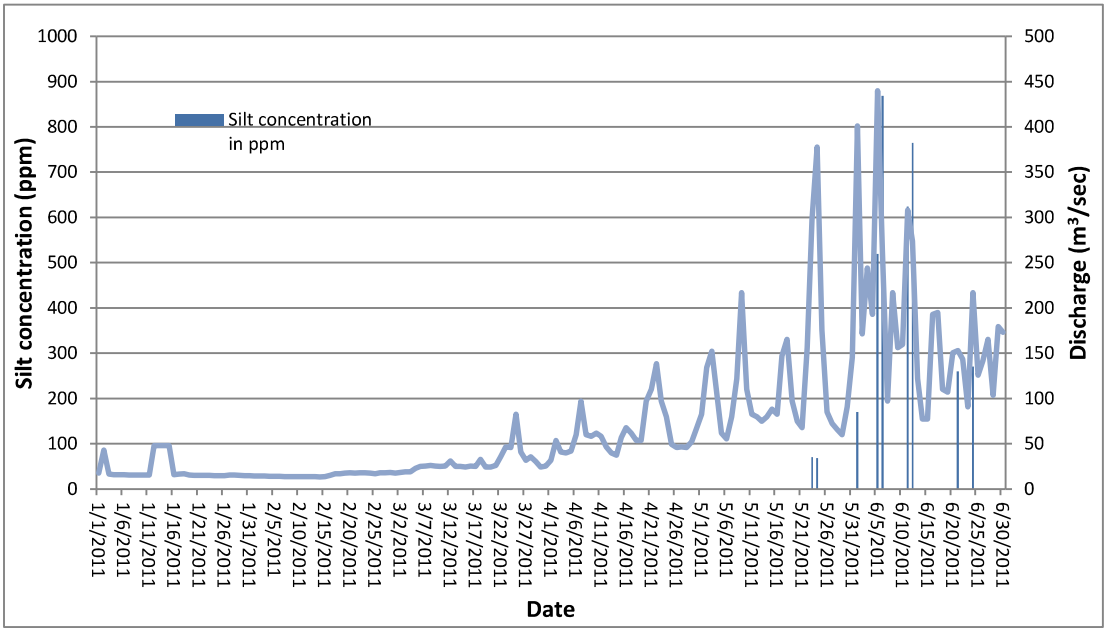
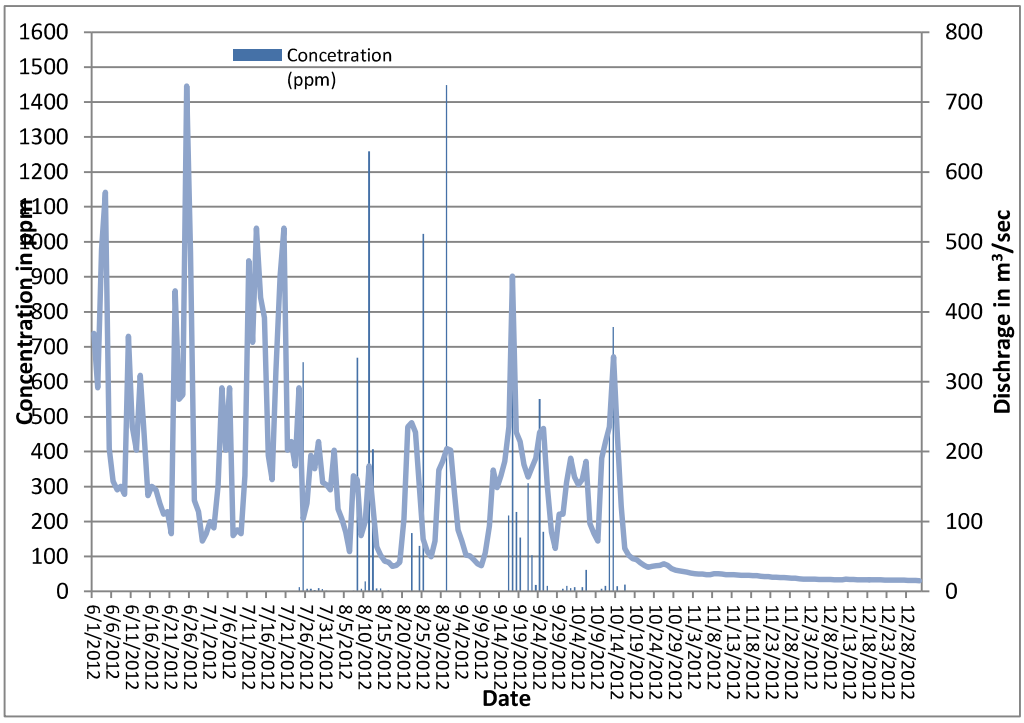


Fig 8.39: Discharge Vs sediment concentration during 2012 monsoon at Mechuka Bridge.



It is observed that river flow greater than 500 cumec is occasionally associated with higher sediment concentration. However for flows below 500 cumec, sediment concentration remains very low at almost all times.

Study of Rainfall Vs sedimentation relationship

The previous section discusses the relationship between sediment concentration and discharge. The impact of rainfall in project catchment on sedimentation concentration is discussed in this section.

Rainfall is being measured on daily basis since July 2008 at Mechuka, at Gapo since September 2007, at Segong (9 km upstream of Mechuka) and at Hanuman (20 km upstream of Mechuka) since March 2010. Relationship between rainfall and sediment concentration at Mechuka Bridge site during monsoon period for year 2010 is presented in figure 8.40.

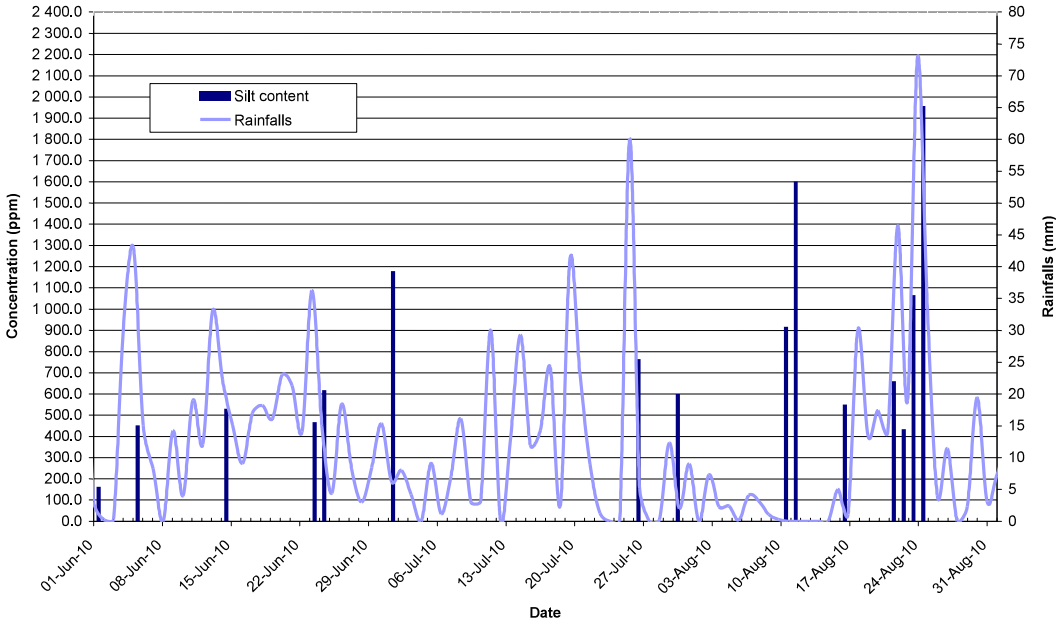


Figure 8.40: Sediment concentration and rainfall data at Mechuka for monsoon 2010

From the graph, it can be seen that the maximum rainfall occurred on August 23, 2010 and the maximum sediment concentration was observed one day later. Similar pattern is seen for high rainfall days having rainfall more than 25mm in June and July 2010.

Rainfall may not be homogeneous in the entire catchment area. The rainfall records of Hanuman, Segong and Gapo rain gauge stations also indicate this phenomenon. Therefore comparing the rainfall only at Mechuka with sediment concentration may not always present the correct picture. Therefore daily sediment concentration at Mechuka is also compared with maximum rain fall recorded at all the four rain gauge stations at Segong, Hanuman, Mechuka and Gapo during the previous 48 hours. Table 8.45 presents a summary of rainfall data at Mechuka, maximum rainfall observed in catchment area in previous 48 hours and sediment concentration for select days during monsoon period of year 2010 wherein high sediment concentration is recorded.

Table - 8.45 Summary of Rainfall data at Mechuka, Maximum Rainfall in Catchment Area and sediment concentration during monsoon period of 2010

Date	Rainfall at Mechuka (mm)	Maximum Rainfall in the CA for the last 48 hours (mm)	Sediment Concentration (ppm)
01/06/10	3.1	37.4	162.0
05/06/10	43	43	451.7
14/06/10	22.2	33.1	530.0
23/06/10	36.2	36.2	466.7
24/06/10	15	36.2	616.7
01/07/10	6.2	60	1 178.0
26/07/10	5.2	60.1	763.3
30/07/10	2	2	600.0
10/08/10	0	0	916.7
11/08/10	0	0	1 600.0
16/08/10	1.1	1.1	550.0

Date	Rainfall at Mechuka (mm)	Maximum Rainfall in the CA for the last 48 hours (mm)	Sediment Concentration (ppm)
21/08/10	46.4	48.0	658.6
22/08/10	19	55.9	433.3
23/08/10	73	73	1 065.0
24/08/10	33.3	73	1 957.0

This analysis presents a more comprehensive picture of the physical link between rainfall and sediment rate in the river. It also shows the importance of two parameters: the temporal offset and the spatial unequal distribution of the rainfall over the catchment area.

The discharge vs. sediment concentration relationship as well as the rainfall vs. sediment concentration relationship cannot be generalised and can at best be used only as a guiding factor. It is very difficult to establish a quantitative relationship between discharge or rainfall and sediment concentration. Reason for lack of a quantitative relationship can be attributed to the fact that erosion process depends not only on the importance of the rainfall, but also on the past rainfall event, on the earth saturation, on the vegetal cover as well as on human activities in the area.

A typical example is the rainfall, discharge and sediment concentration data around August, 10th and 11th 2010. During this period, discharge measurements at Mechuka are fairly low (around 200 m^3/s) and the rainfall in catchment area in preceding 48 hours is also negligible. However the sediment concentration on each of these two days exceeds 1000 ppm. The most probable explanation for this exception of very high sediment rate in spite of negligible rain and low discharge may be human activity in the form of road work excavation upstream of the gauging site (Refer figure 8.39). Another possible explanation is a landslide which could have directly reached the river (Refer figure 8.41).

Fig: 8.41 Road construction activities above Mechuka Bridge leading to soil erosion

Sediment Yield at Downstream End of Mechuka Plain

Yarjep River flows in Mechuka plains for a distance of about 22 km (from RD 30km to RD 51.9km) with average river slope of 0.39%. This reach is characterised by wide river section and shallow water depth thus giving the appearance of a large lake. Within the Mechuka plain, Dutangphu Chhu joins Yarjep River from the left bank at RD 47.9 km. Dutangphu Chhu and Yarjep River from confluence point of Dutangphu to the end of Mechuka plain have a total catchment area of 80 km^2. The characteristics of this tributary are identical to those of Yarjep River within Mechuka plain reach. The catchment area of Yarjep River at the downstream end of Mechuka plain at RD 51.9 km is 766km^2.

The mountains surrounding Mechuka plains and Dutangphu consist of very gentle hill slopes (<350) with uniform dense vegetation. These gently sloped mountains are placed about 2kms apart from meandering Yarjep River. The topography, vegetation cover and river course are very conducive for settling of suspended sediments in flows. The lower velocity of flowing water through Mechuka plains also leads to settlement of sediments carried from upper mountainous river reach.

Fig. 8.42 - Mountains surrounding Mechuka plain with gentle slopes

Yarjep River at Mechuka contains sediment laden flows for an average of around 50 days in a year during the monsoon season. Higher sediment concentration is generally associated with high river discharge. In certain instances, high concentration of silt is found during low to moderate discharges. This phenomenon may be attributed to manmade activities of road works, cultivation and other construction activities.

Fig: 8.43 - Wider, gentle river slope and shallow river course conducive for natural sedimentation.

Figure 8.44: Mechuka plain – View of upstream Mechuka village

Figure 8.45: Mechuka plain – view downstream of Mechuka village

The sediment yield is estimated based on flood events occurring within duration of 48 hours. Corresponding to sediment concentration value for a particular flow event, the maximum rainfall measured over the preceding 48 hours period is considered for computing sediment load for that particular event.

Considering the sediment concentration to be constant during the day, the amount of suspended particles carried by river during flood event can be calculated as follows:

$V_{suspended\ sediments} = V_{water} * C(ppm) / density$

Where $V_{suspended\ sediments}$ = Volume of Suspended Sediments (m^3)

V_{water} = Volume of water (m^3)

C = Sediment Concentration (ppm or mg/l)

Density of sediment = 1.3×10^6 mg/l

Daily discharge and sediment concentration data at Mechuka Bridge for the years 2009, 2010, 2011 and 2012 is used to estimate the annual sediment yield at Mechuka. Sediment concentration is recorded in water flow at Mechuka during 2009 for 27 days, during 2010 for 22 days, during 2011 for 9 days and during 2012 for 47 days. Annual sediment yield is computed by adding the sediment load for each of the sediment observations in water flow during that year. Similarly, volume of water carrying the annual sediment load is computed by adding the volume of water during the event of occurrence of sediment in water flow. This exercise is carried out separately for 2009, 2010, 2011 and 2012 as indicated in Table 8.46.

Table 8.46 Estimate of quanitity of suspended sedimensts taransported by Yarjep river in 2009, 2010, 2011 and 2012 at Mechuka

Estimation of Quantity of suspended Sediments transported by Yarjep river in 2009, 2010, 2011 and 2012 at Mechuka

2009					2010					2011					2012				
Date of sediment laden water	Discharge (m^3/sec)	Volume of water in 1 day	Sediments concentration	Amount of sediments	Date of sediment laden water	Discharge (m^3/sec)	Volume of water in 1 day	Sediments concentration	Amount of sediments	Date of sediment laden water	Discharge (m^3/sec)	Volume of water in 1 day	Sediments concentration	Amount of sediments	Date of sediment laden water	Discharge (m^3/sec)	Volume of water in 1 day	Sediments concentration	Amount of sediments
	m^3/s	$10^6 \times m^3$	ppm	tonnes		m^3/s	$10^6 \times m^3$	ppm	tonnes		m^3/s	$10^6 \times m^3$	ppm	tonnes		m^3/s	$10^6 \times m^3$	ppm	tonnes
01-07-2009	309.1	26.7	3	80.1	27-03-2010	188.3	16.3	12	195.3	23-05-2011	297.6	25.71	70	1804.1	24-07-2012	291.4	25.2	12	302.2
03-07-2009	232.9	20.1	3	60.4	23-04-2010	148.6	12.8	74	949.8	24-05-2011	377.6	32.62	68	2232.1	25-07-2012	103.5	8.9	656	5865.9
04-07-2009	232.9	20.1	4	80.5	11-05-2010	197.4	17.1	73	1245.3	01-06-2011	401.3	34.67	171	5915.5	26-07-2012	125.8	10.9	8	86.9
07-07-2009	347.9	30.1	1	30.1	12-05-2010	197.4	17.1	188	3207.0	05-06-2011	440.1	38.03	519	19742.3	27-07-2012	195.1	16.9	8	134.9
09-07-2009	343.8	29.7	1	29.7	15-05-2010	217.0	18.7	115	2156.0	06-06-2011	262.7	22.70	868	19710.1	28-07-2012	175.5	15.2	4	60.6
10-07-2009	327.9	28.3	3	85.0	21-05-2010	214.4	18.5	3	55.6	11-06-2011	308.2	26.62	624	16621.7	29-07-2012	214.4	18.5	10	185.3
18-07-2009	188.3	16.3	2	32.5	31-05-2010	207.0	17.9	5	89.4	12-06-2011	274.1	23.68	765	18114.8	30-07-2012	155.9	13.5	7	94.3
25-07-2009	489.8	42.3	232	9817.9	01-06-2010	207.0	17.9	162	2897.1	21-06-2011	152.9	13.21	259	3427.1	31-07-2012	152.3	13.2	2	26.3
26-07-2009	489.8	42.3	23	973.3	05-06-2010	219.6	19.0	452	8574.4	24-06-2011	216.4	18.69	270	5050.7	07-08-2012	165.4	14.3	2	28.6
27-07-2009	489.8	42.3	29	1227.2	14-06-2010	241.3	20.8	530	11049.4	-	-	-	-	-	08-08-2012	159.7	13.8	669	9228.4
28-07-2009	391.4	33.8	2	67.6	23-06-2010	222.2	19.2	467	8964.1	-	-	-	-	-	09-08-2012	79.8	6.9	8	55.2
29-07-2009	284.6	24.6	16	393.4	24-06-2010	235.7	20.4	617	12563.2	-	-	-	-	-	10-08-2012	100.2	8.7	29	251.0
01-08-2009	274.7	23.7	4	94.9	01-07-2010	224.8	19.4	1178	22880.3	-	-	-	-	-	11-08-2012	179.7	15.5	1259	19542.2
06-08-2009	211.9	18.3	230	4210.9	26-07-2010	238.5	20.6	763	15720.4	-	-	-	-	-	12-08-2012	121.8	10.5	407	4281.5
09-08-2009	227.5	19.7	16	314.5	30-07-2010	219.6	19.0	600	11382.0	-	-	-	-	-	13-08-2012	63.6	5.5	9	49.4
15-08-2009	284.6	24.6	54	1327.8	10-08-2010	217.0	18.7	917	17191.4	-	-	-	-	-	14-08-2012	52.3	4.5	9	40.6
17-08-2009	360.4	31.1	18	560.5	11-08-2010	217.0	18.7	1600	29995.9	-	-	-	-	-	15-08-2012	43.1	3.7	1	3.7
18-08-2009	706.1	61.0	194	11835.4	16-08-2010	356.2	30.8	550	16925.5	-	-	-	-	-	16-08-2012	41.9	3.6	3	10.9
19-08-2009	706.1	61.0	8	488.1	21-08-2010	571.0	49.3	659	32512.5	-	-	-	-	-	22-08-2012	241.3	20.8	167	3481.6
20-08-2009	706.1	61.0	6	366.0	22-08-2010	571.0	49.3	433	21362.5	-	-	-	-	-	23-08-2012	227.5	19.7	1	19.7
22-08-2009	339.8	29.4	5	146.8	23-08-2010	620.2	53.6	1065	57067.3	-	-	-	-	-	24-08-2012	150.5	13.0	131	1703.5
08-09-2009	61.6	5.3	262	1394.4	24-08-2010	620.2	53.6	1957	104864.5	-	-	-	-	-	25-08-2012	74.8	6.5	1023	6609.4
11-09-2009	192.8	16.7	16	266.5	-	-	-	-	-	-	-	-	-	-	29-08-2012	173.4	15.0	1	15.0
13-09-2009	192.8	16.7	405	6746.5	-	-	-	-	-	-	-	-	-	-	31-08-2012	204.6	17.7	1449	25608.6
17-09-2009	134.2	11.6	27	313.1	-	-	-	-	-	-	-	-	-	-	16-09-2012	235.7	20.4	217	4418.5
18-09-2009	171.4	14.8	29	429.5	-	-	-	-	-	-	-	-	-	-	17-09-2012	451.0	39.0	863	33626.5
20-09-2009	171.4	14.8	150	2221.3	-	-	-	-	-	-	-	-	-	-	18-09-2012	227.5	19.7	228	4481.0
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19-09-2012	214.4	18.5	154	2853.2
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21-09-2012	163.5	14.1	310	4378.4
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22-09-2012	177.5	15.3	104	1595.3
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	23-09-2012	190.6	16.5	18	296.4
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24-09-2012	227.5	19.7	550	10809.4
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25-09-2012	232.9	20.1	171	3441.0
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26-09-2012	150.5	13.0	16	208.1
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30-09-2012	110.4	9.5	8	76.3
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	01-10-2012	155.9	13.5	16	215.6
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	02-10-2012	190.6	16.5	10	164.7
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	03-10-2012	163.5	14.1	12	169.5
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	05-10-2012	159.7	13.8	12	165.5
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	06-10-2012	186.1	16.1	62	997.0
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10-10-2012	190.6	16.5	8	131.7
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11-10-2012	214.4	18.5	16	296.4
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12-10-2012	235.7	20.4	470	9570.0
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13-10-2012	335.8	29.0	756	21931.9
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14-10-2012	222.2	19.2	15	287.9
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16-10-2012	61.6	5.3	20	106.5
		766.3		**43594.0**			**548.7**		**381848.7**			**236.0**		**92618.4**			**690.4**		**177906.6**

Although cumulative flow of water during flood events having sediment laden water flow was lesser in terms of volume of water in 2010 than in 2009and 2012, more than 380 000 tons (293 200 m^3) of sediments were transported across Mechuka steel bridge by the Yarjep River in 2010. This is about eight times more than sediments transported in 2009 and twice as much as in 2012. As indicated earlier, reason for increase in sediment concentration during 2010 can be attributed to substantial increase in human activity related mainly to new road construction in catchment area above Mechuka. The specific conditions of 2010 will certainly be repeated more often in future because of the economic development in the area. In order not to underestimate the amount of sediment yield for the purpose of this study, the measurement for year 2010 is proposed to be considered as the basis for calculating the annual quantity of sediments carried by the Yarjep River through the Mechuka plain.

Accordingly, the annual sediment yield for Yarjep River at Mechuka Bridge (RD 44.6 km) is adopted as 293,200 m^3 of suspended sediments for the purpose of this study. The total catchment area at RD 51.9 km is 766 km^2 (CA at Mechuka Bridge 686 km^2 + CA of Dutangpu Chu 80 km^2).

In addition to the suspended sediments in flowing water, larger sediments are also transported by river flows along bed of the river. Bed load comprises mainly of larger sediment particles like pebbles, gravel and boulders and these sediment particles have a tendency to get deposited in the pondage area behind a storage dam thereby reducing its storage capacity. The bed load concentration mainly depends on the composition of riverbed material, river bed slope and to an extent on the size of suspended sediments. Bed load is thus an important source of sediment yield. However, no simple methodology exists to measure it. In absence of actual measurements for bed load, IS 12182 recommends using a percentage between 5 and 20% of the suspended load as bed load. Bulletin No. 67 of ICOLD gives a simplified table to estimate bed load in a stream based on the characteristics of the river bed and suspended sediments and the same is reproduced below.

Table – 8.47: ICOLD recommendation for determination of bed load based on river characteristics

Condition	Suspended sediment concentration (mg/L)	Streambed material	Size analysis of suspended material	Percent bed load in terms of suspended load
1	Less than 1000	Sand	20 to 50 % sand	25 to 150 %
2	between 1000 and 7500	Sand	20 to 50 % sand	10 to 35 %
3	Greater than 7500	Sand	20 to 50 % sand	5 %
4	Any concentration	Compacted clay, gravel, cobbles, or boulders	Small amount, up to 25 % sand	5 to 15 %
5	Any concentration	Clay and silt	No sand	Inferior to 2 %

The grain size analysis performed for suspended sediment particles sampled at Mechuka indicates their composition to be mainly silt and fine sand. Sand particles are very fine and almost at the limit of the category. Accordingly it is safe to assume that less than 25% of the suspended particles are sand. The streambed of the Yarjep River in the Mechuka plain comprises mainly of compacted silt with embedded gravel and pebbles of median diameter around 11 mm. In

addition, sand banks can be observed at very specific places. Condition No. 4 in the table above seems to be the most appropriate to the characteristics of the Yarjep River for estimation of bed load at Mechuka. Accordingly, the bed load is likely to be between 5 and 15% of suspended sediment load. However for the purposes of sedimentation study, bed load at Mechuka is considered as 15% of suspended sediment load. This figure is also consistent with the recommendation of IS 12 182.

$V_{bed\ load}$ = 293 200 m^3/year * 15% = **44 000 m^3/year**

Total volume of sediments carried by Yarjep River at Mechuka Bridge is estimated as:

V_{total} = 293 200 + 44 000 = 337 200 m^3/year

Catchment area at Mechuka Bridge is 686 km² and the sediment rate is computed as 0.49 mm/year (or mm of sediment/ year/ m² of CA). The catchment area at the downstream end of Mechuka plains is about 766 km² and considering the same rate of sedimentation for the balance catchment of 80 km^2 including Dutangphu Chu, the annual sediment yield at end of Mechuka plain at RD 51.9 km of Yarjep River is estimated as:

V_{total} = 337,200 + 80,000,000 * 0.49 / 1000 = 376 400 m^3/year

i.e., V_{total} = $V_{suspended}$ 327,300 + $V_{bed\ load}$ 49,100 = 376,400 m3/year

Sediment rate for Yarjep and Siyom River estimated in earlier studies

The confluence of Yarjep and Siyom River is located near Tato village; about 20 km downstream of Pauk dam location. The diversion site of Tato II HEP (700 MW) is located immediately after the confluence of Yarjep and Siyom Rivers. Sediment rate has been computed in the DPR of Tato II HEP as 0.88 mm/yr by transferring sediment yield estimated at Raying gauging site. This rate includes bed load estimated at 20% of the suspended sediment load. The sediment rate of Tato is almost twice the rate computed at Mechuka.

Tato and Mechuka are in the same river basin. The difference in computed sediment rate for the two locations can be explained by their contrasting topography and characteristics of riverbed. Mechuka is located in a long and flat plain area, in a very wide valley. The longitudinal slope at Mechuka is only 0.39% spread over nearly 22 km length and this stretch is therefore conducive to deposition of sediments. The water velocity in Yarjep River near Mechuka village during floods rarely exceeds 2 m/s and accordingly facilitates sedimentation of most particles. The Mechuka plain thus acts as a desilting basin for downstream stretch of Yarjep River. This sediment rate can be assumed to be well representative of sediment rate for the catchment area up to Mechuka plain. However, because this result is very site specific, it cannot be used for the whole catchment area of Pauk Dam and Heo barrage. For catchment area below Mechuka plain, it is proposed to adopt sediment rate of 0.88 mm/year as has been adopted for Tato II HEP.

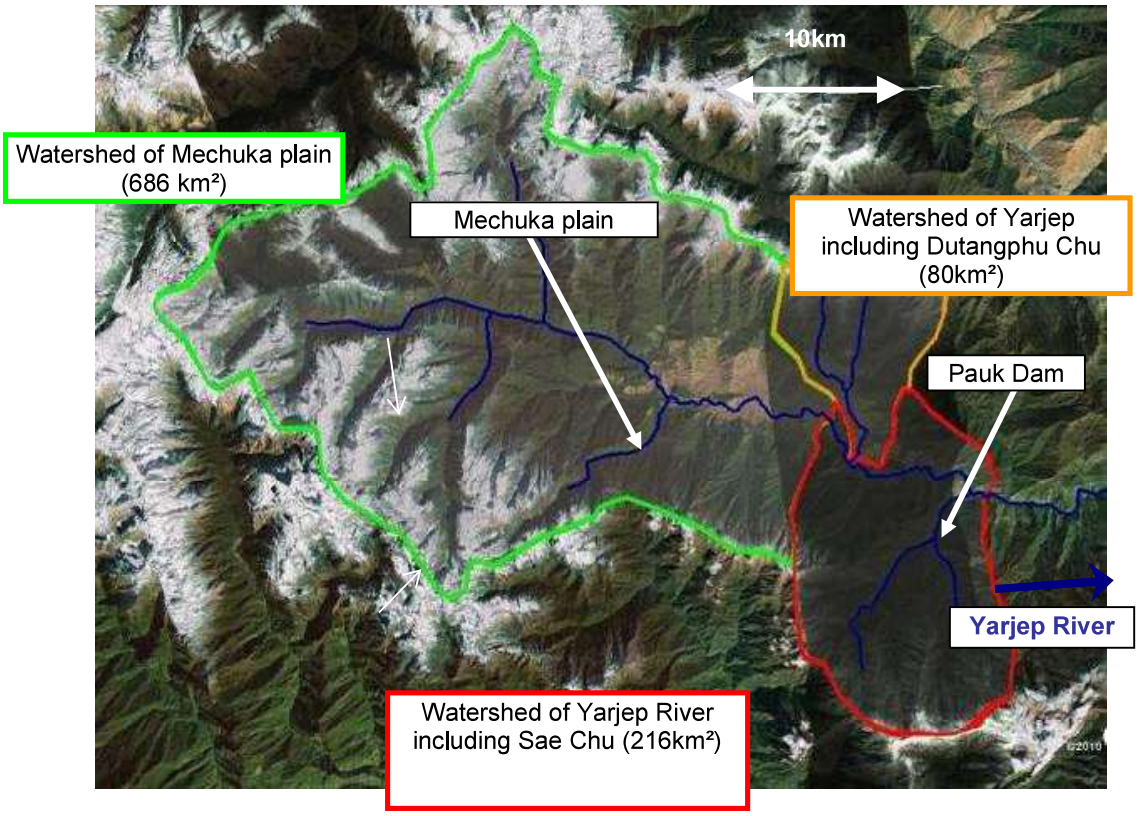
Sedimentation study at Pauk Dam Location

8.8.11.1 *Estimation of Sediment Load*

According to topographic features, the Pauk Dam catchment area of 982 km² can be divided into two distinct classifications as indicated in figure 8.26:

- Catchment area of 766 km² at end of Mechuka plain, and,
- Catchment area in mountainous reach of Yarjep River between Mechuka plain and Pauk dam location at RD 60.3 km having catchment of 216 km^2 including Sae Chu nallah. In this watershed, the valley is relatively narrow and river bed slope averages 3.34% as against a slope of 0.39% in Mechuka plain.

Figure 8.46: Division of the Yarjep River catchment area



Sediment yield at the downstream end of Mechuka is estimated as 376,400m^3/year. After Mechuka plain, the longitudinal slope of Yarjep River increases to 3.34% and the valley becomes narrow. Mountains around the valley are steep having slopes greater than 40% and vegetation is jungle type as shown in figure 8.47.

Figure 8.47: Narrow valley near Pauk Dam Axis

The watershed of Sae Chu, a right bank tributary of the Yarjep River having confluence point about 1.17 km upstream of Pauk dam, also has similar characteristics of steep banks, river bed slope of about 5% as shown in figure 8.48and jungle type vegetation (Figure 8.49).

Figure 8.48: Longitudinal profile of Sae Chu

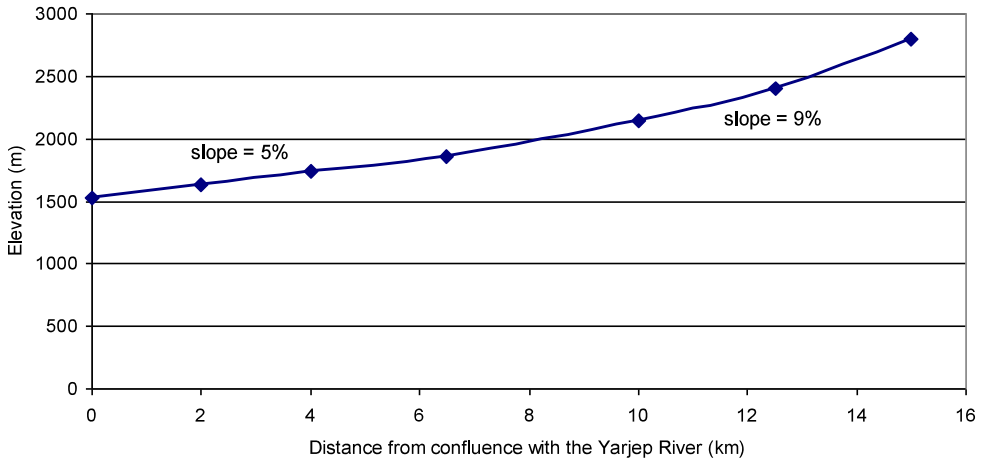


Figure 8.49: Sae Chu nallah

This part of Yarjep River watershed including Sae Chu is very classical for the Himalayan area and also similar to Siyom River catchment area. The sediment rate of Siyom River near Tato after the confluence of Yarjep and Siyom River can be considered representative of the sediment rate of hilly catchment area of Yarjep River downstream of Mechuka plain. The catchment area of Mechuka (766 km²) represents about 30% of the total catchment area at Tato (2560 km²). The impact of the low sediment rate of Mechuka on the sediment rate calculated for Tato II HEP is not expected to be significant and hence ignored.

Accordingly, sediment rate of 0.88 mm/yr adopted for Tato is used for estimating sediment yield for this part of the watershed:

$V_{sediment\ yield}$ = 0.88 mm/yr * 216 km² = **190 100 m^3/year**

The bed load has been estimated as 20% of the suspended load. The division between suspended particles and bed load for intervening catchment is given below:

$V_{suspended\ particles}$ = 190 100 m^3/yr / 1.20 = **158 400 m^3/year**

$V_{bed\ load}$ = 190 100 m^3/yr – 158 400 m^3/yr = **31 700 m^3/year.**

Total sediment yield including Mechuka plain, Dutangphu Chu and mountainous catchment area up to Pauk dam is presented in Table 8.48.

Table 8.48: Total sediment yield at Pauk Dam Location

Description	WATERSHED		
	Mechuka at RD 59.1 km	Mechuka to Pauk Dam (RD 59.1 to RD 60.3 km)	Total at Pauk Dam
CA (km^2)	766	216	982
Percentage of total CA	78%	22%	100%
Sediment yield of suspended particles (m^3)	327,300	158,400	485,700
Bed load (m^3)	49,100	31,700	80,800
% Bed load/ Suspended particles	15%	20%	17%
Total amount of sediment yield (m^3)	376,400	190,100	566,500
Percentage of total sediment yield	66%	34%	100%
Sediment rate (mm/yr)	0.49	0.88	0.58

Impact of Mechuka Plain on Sediment Concentration in case of a major flood event

The sediment rate calculated above is based on four years of measurements and during this period, peak flood intensity of 700m^3/s is observed. Based on sediment concentration study, it is proven that Mechuka plain acts like a desilting basin. This section examines the anticipated impact of Mechuka plain on sediment concentration rate in case of flood intensity corresponding to higher return period varying from 10 years to 1000 years as well as for PMF. High flows generally result in higher water velocity and this may result in erosion of deposited sediments. This process can mobilize additional sediment particles than presently anticipated and consequently change the volume of sediment carried to the Pauk reservoir.

In order to study the behaviour of sediment for various river flows, a model has been developed with HEC-RAS software. It computes the mean velocity of water in Mechuka plain corresponding to various flood discharges and is used to predict the behaviour of sediment erosion through Mechuka plain.

For this study, river cross-sections have been developed based on site topographic survey. The Yarjep River has been modelled for 11 km along the Mechuka plain - 9 km towards upstream and 2 km downstream of Mechuka Bridge. Water velocity was studied for the following return period flood discharges:

Table 8.49

Maximum flow measured at Mechuka	700 m^3/s
2 year return period flood	780 m^3/s
10 year return period flood	1330 m^3/s
25 year return period flood	1600 m^3/s
100 year return period flood	2000 m^3/s
1000 year return period flood	2670 m^3/s
PMF (Probable Maximum Flood)	2830 m^3/s

The HEC-RAS software calculates uniform flow velocity on a whole cross-section. Due to friction and viscosity, water velocity is not the same in every segment of the cross section. In May 2011, measurements were made with River Surveyor device for developing water velocity profile across Yarjep River corresponding to flow of 178m^3/s. While the mean flow velocity computed is 1.05m/s, the water velocity at different sections along the river cross section varies from 0.3 m/s on the banks to 1.6 m/s (refer figure 8.50) in the centre i.e. water velocity is higher in the middle and lower on banks and bottom of the river. As a result of this phenomenon, sediment particles deposited along river banks and river bed do not get eroded even though mean flow velocity may indicate adequate erosion potential.

To predict the erosion of deposited sediments, flow velocity on river banks and at the bottom of the riverbed, where particles are likely to be eroded needs to be determined. It is difficult to establish a link between mean flow velocity and water velocity on river bank. For this study, it is assumed that water velocity on edges and bottom evolves in the same way with respect to mean flow velocity as indicated in velocity profiles measured by river surveyor at Mechuka Bridge. The mean flow velocity is computed in HEC-RAS study at flood discharges corresponding to different return period floods. Water velocity on river banks and bottom of the river is accordingly taken as 30% of mean velocity and possibility of river bed erosion evaluated from the criteria provided by Hjulstrom (figure 8.51).

Figure 8.50: Velocity profiles measured by the River Surveyor at Mechuka Bridge. The measured mean water velocity is 1.05 m/s and flow is 178m^3/s.

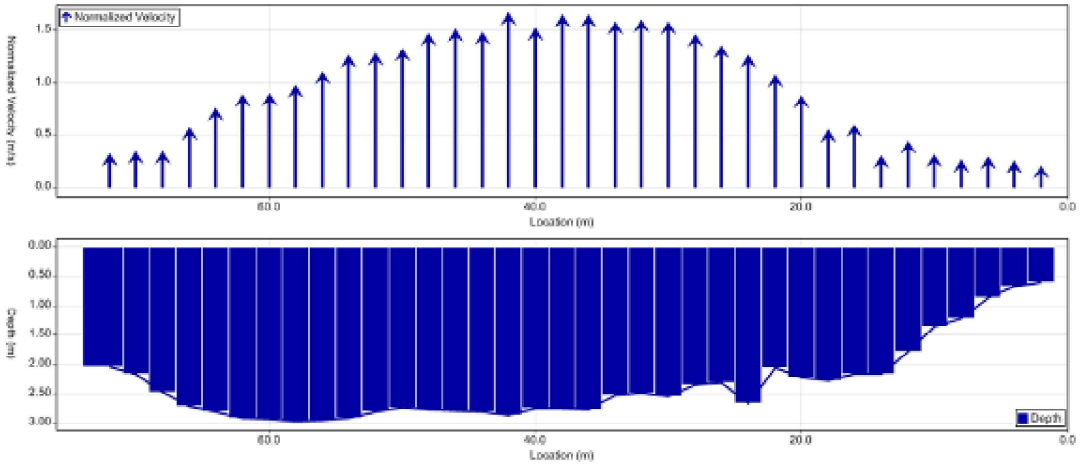


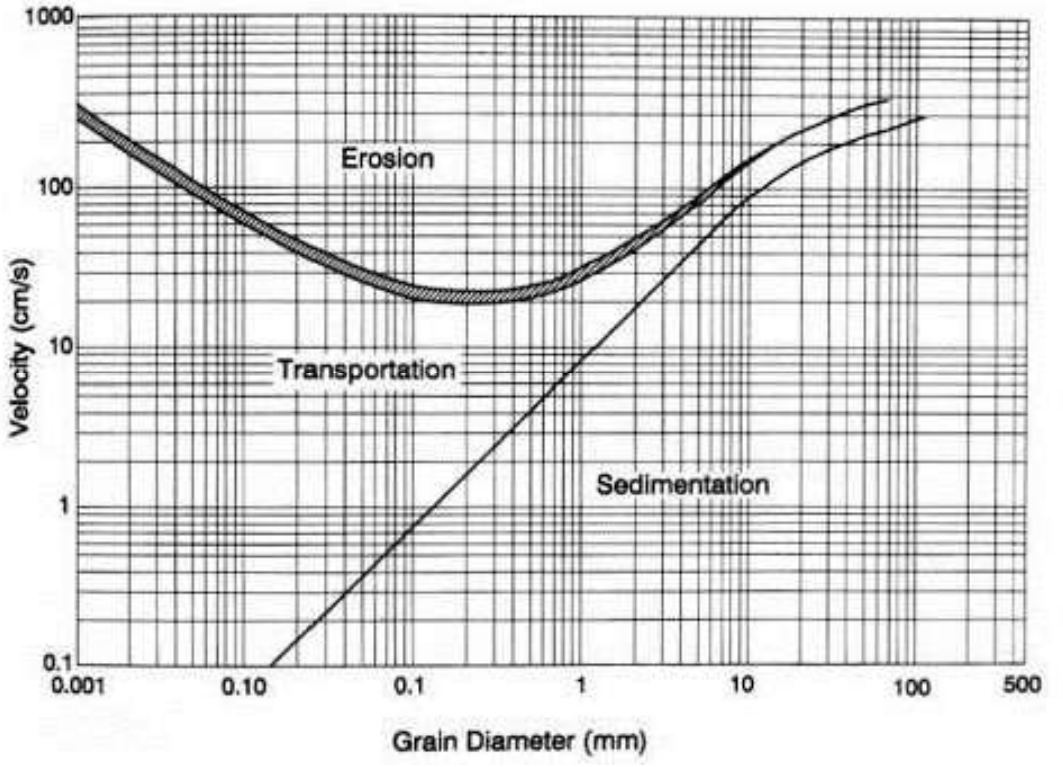
Table 8.50: Variation in mean velocity at 5 km upstream of Mechuka Bridge for discharge varying from 700 to 2830 m^3/s,

Return period of flood (yrs)	Discharge (m^3/s)	Mean velocity (m/s)	Assumed water velocity at banks and river bed (m/s)	Percentage difference in discharge	Percentage difference in velocity
-	700	2.02	0.61	-	-
2	780	2.04	0.61	11%	1%
10	1330	2.18	0.65	90%	8%
25	1600	2.19	0.66	129%	8%
100	2000	2.27	0.68	186%	12%
1000	2670	2.42	0.73	281%	20%
PMF	2830	2.45	0.74	304%	21%

Figure 8.52 and Table 8.50 show that the mean flow velocity increases very little with the flow. At five kilometres upstream from Mechuka Bridge, compared to a 700 m^3/s flow, mean velocity increases by only 12% for 100-year flood (TR100 = 2000 m3/s) and 21% for probable maximum flood (PMF = 2830 m^3/s) while the relative difference in discharge is respectively 186% and 304%. Similarly, the flow velocity along river banks and bottom of the riverbed does not change appreciably with increase in flood discharge.

This small change of velocity can be explained by the topography of the Mechuka plain. In this plain, Yarjep River streambed is quite wide and a small increase of the water level can absorb a large increase in discharge. Thus, the impact on velocity profiles is low. The increase in discharge is absorbed by flooding of the wide plain and does not result in significant increase in water velocity.

Figure 8.51: Velocity criterion of erosion and deposition for uniform particles (Hjulstrom, 1935).

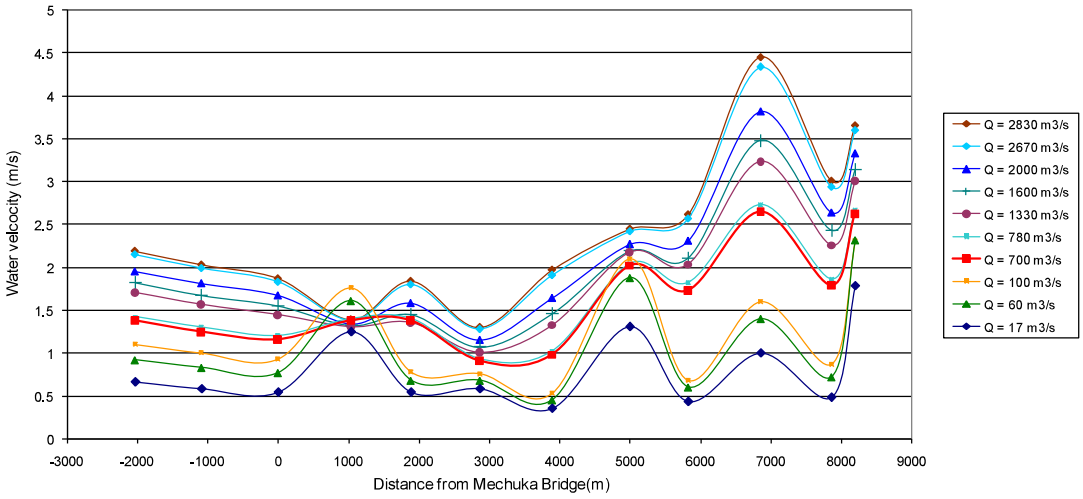


Hjulstrom has developed a relationship between flow velocity in a stream and sediment particles comprising river bed material and the same is presented in figure 8.51. Depending on flow velocity, the graph can be used to predict the behaviour of river bed in terms of erosion or sedimentation depending on grain size of river bed material. A higher flow velocity is more likely to erode the river beds whereas bigger size particles are less likely to be eroded even at higher velocity.

As can be seen from Figure 8.52, a 12% increase in water velocity does not result in any increase in the size of particles that can be eroded. It demonstrates that as velocity profiles are little changed by variations in flow and sediment erosion being dependent on water velocity, it is safe to assume that no significant increase in sediment concentration would occur in case of increase in river discharge beyond 700m^3/s.

Major floods will therefore play no specific role in the amount of sediment carried in the plain of Mechuka and the sediment rate of 0.49 mm/yr can be assumed as correct for this part of the watershed, even in case of a major flood. Further in case of a flood of even 700m^3/s, the storage capacity available at Pauk dam will be filled up only in a couple of hours and the surplus water along with suspended and bed load sediments will be passed downstream through the spillway and will not result in reduction in live storage capacity at Pauk dam.

Figure 8.52: Graphical Representation of mean velocity versus river flow in Mechuka plain



Sedimentation study after construction of Pauk Dam

8.8.12.1 *Assumptions for sedimentation study*

It is assumed that the operations of turbines of Heo HEP and Tato-I HEP will be synchronized with operation of Pauk HEP operations. Heo dam receives flows from Pauk tail race, surplus water after sedimentation at Mechuka plain and in Pauk reservoir in addition to flows from intermediate catchment area of 83km^2. Tato-I receives **flow directly from Heo tail race** and additional 2.7 m^3/s flow from intermediate catchment area of 89km^2. Sedimentation study for Heo Barrage is considered as applicable for Tato-I HEP also.During flushing operations from Pauk dam, Heo powerhouse and Tato-I powerhouse shall also have to be shut down.

8.8.12.2 *Sedimentation in Pauk reservoir*

Pauk HEP envisages construction of a 95 m high arch dam at RD 69.30.km of Yarjep River. A live storage capacity of 1.67 Mcum is available in Pauk reservoir between FRL of 1540m and MDDL of 1520 m. A gated spillway with crest at El 1490 m is provided to pass a design flood of 3200 m^3/s. Pauk reservoir spreads over a length of 2370 m into Yarjep River and about 800 m into Sae Chu nallah. Sae Chu nallah joins Yarjep about 1170m upstream of dam location. Area capacity curve for Pauk reservoir is shown in **Fig 8.55**. Cross sections of Yarjep River at a distance of 100m upstream of dam axis to a distance of 900 m upstream of dam axis are generated at a spacing of 100m for study of sedimentation process in Pauk reservoir.

The maximum discharge of 50% dependable year (2003-2004) is 295m^3/s and the peak discharge in past 4 years observed at Mechuka steel bridge gauging station is 700 m^3/s. Sedimentation study is carried out for river flow varying from 200m^3/s to 1000m^3/s with incremental step of 100m^3/s. Results are shown in Annexures.

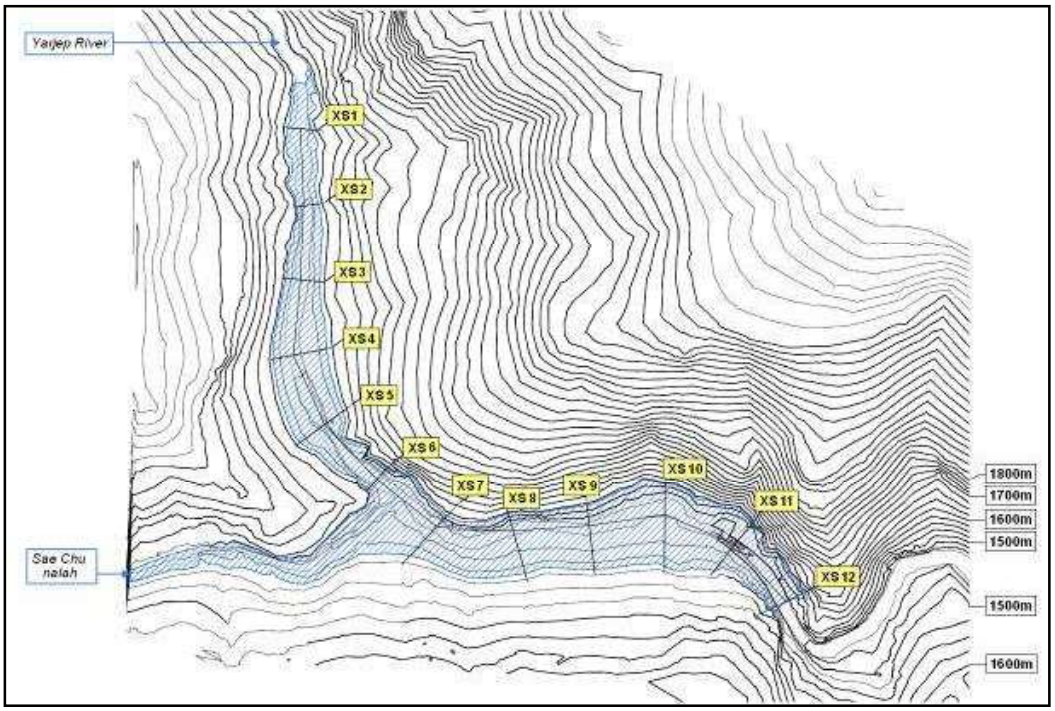


Figure 8.53: Plan showing spread of Pauk reservoir

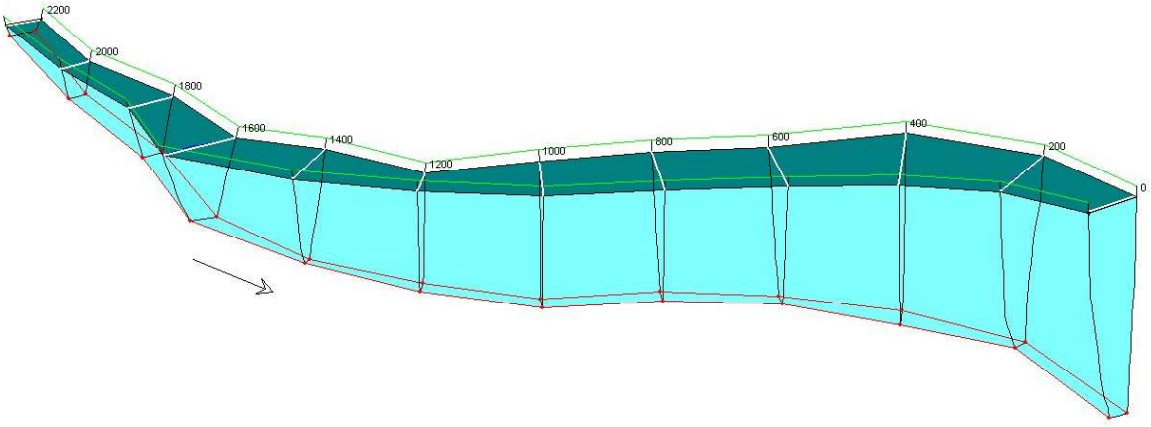


Figure 8.54: 3D Sectional View of Pauk reservoir

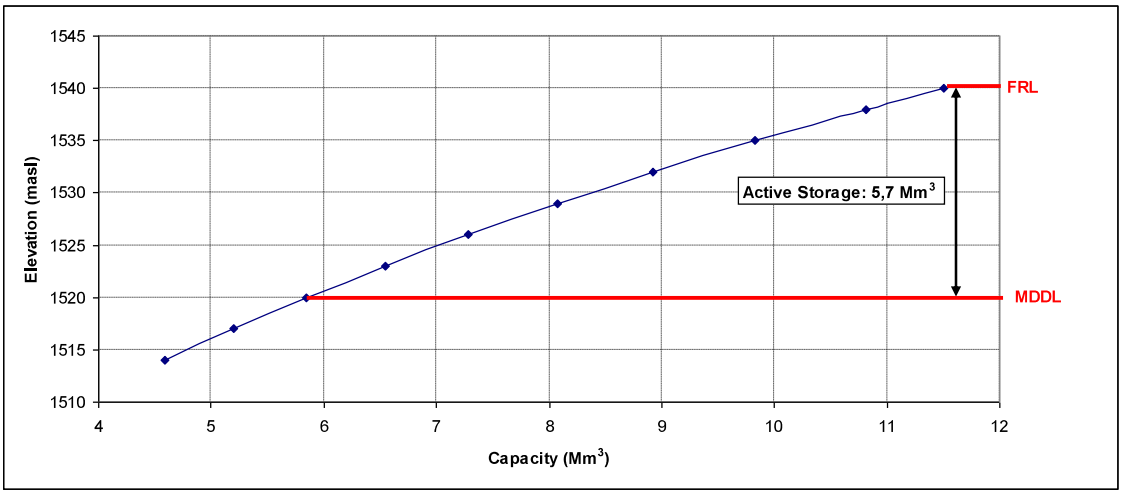


Fig: 8.55: Pauk Area Capacity Curve

Reservoir FRL i.e. 1540.0 m is considered for hydraulic calculations. For this study, it is assumed that river bed upstream of dam is silted up to crest elevation of sluice gates at EL 1490.0 m (about 35 m above river bed level at dam site) and attains a bed slope of 0.2% as per Lacey's slope formula.

Lacey's slope formula = $f^{5/3} / (3340\ Q^{1/6})$ (in mks units)

Considering Lacey's silt factor 1.5 for coarse sand

Flood Discharge = 3200 m^3/s

Sediment deposited bed slope = $1.5^{5/3} / (3340 \times 3200^{1/6})$ = 1/6523 =0.0001533 (0.015 % say 0.02%

Therefore bed slope of deposited sediments of 0.02%is adopted for computation of cross section area for flow velocity computations.

In the analysis, flow velocity at each river cross section is computed and the distance travelled by various size particles in suspension before settling on river bed is computed. Water velocity at a particular cross section may marginally increase with the passage of time, as the siltation process will reduce the area of cross sections. However flushing of sediments deposited in live storage area of Pauk reservoir shall be done on annual basis.

Sae Chu nallah confluences with Yarjep at 1170m upstream from Pauk dam. Hence cross sections of Yarjep River about 900m upstream of Pauk dam have been considered as representative section for this study. Distance travelled by suspended particles of size 0.15 mm and above before settling is studied.

Table 8.51: River section details on upstream of Pauk arch dam

Cross section U/s (Pauk Dam)	400	500	600	700	800	900
Discharge in m^3/s	1000	1000	1000	1000	1000	1000
FRL	1540	1540	1540	1540	1540	1540
Bed Level after siltation up to crest of spillway gates at +1490	1490.08	1490.1	1490.12	1490.14	1490.16	1490.18
Depth of flow in m	49.20	49.00	48.80	48.60	48.40	48.20
Area m^2	8357	7669	6062	5200.3	5613	5514
Velocity = Q / A (m/s)	0.120	0.130	0.165	0.192	0.178	0.181

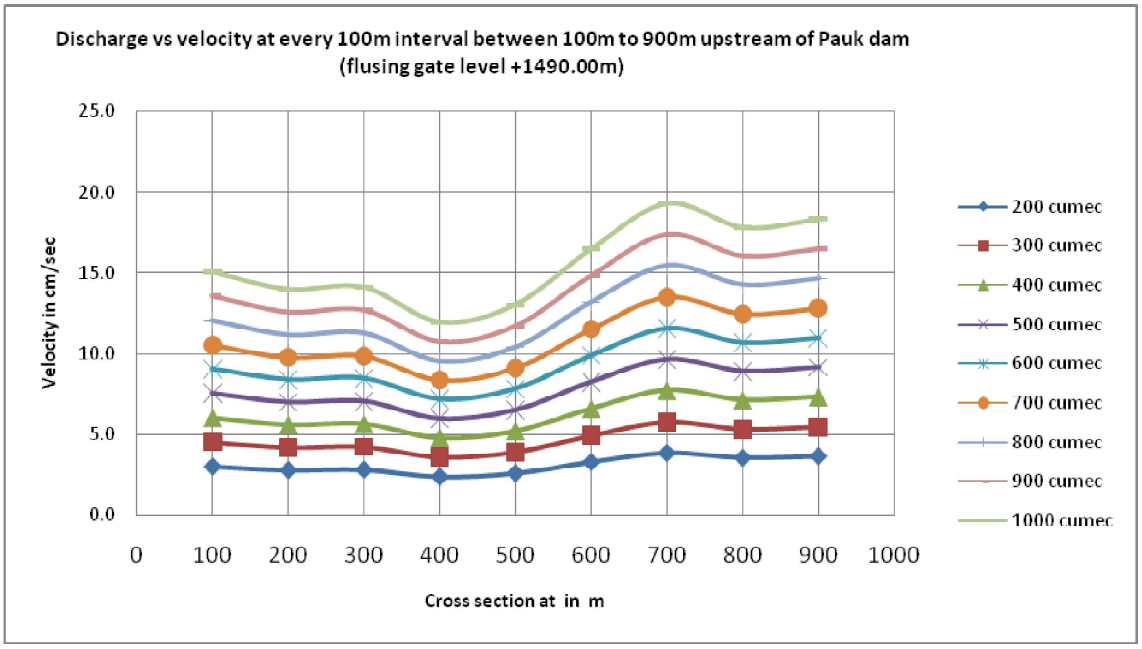


Fig: 8.56 Graph of Discharge vs velocity at every 100m interval between 100m to 900m upstream of Pauk dam

With reservoir silted up to EL 1490.00m, flow velocity up to a distance of 900m upstream of dam for discharge of 1000 m^3/s does not exceed 20 cm/s. This flow velocity is conducive for settlement of sediment particles in Pauk reservoir.

Indicative settling distances of varied size particles reaching bed level of 1490.00 for a discharge of 1000 m^3/s are shown in table 8.52 below.

Effect of turbulence in flow on deposition of sediment particles is also considered in the calculations. A correction factor on account of turbulence on falling velocity of particle is applied as per Mosonyi.

Falling velocity" w_{flow}" in flowing water = w -w'

w' =alpha U ; alpha = 0.132/ sqrt(D) where D = size of particle.

Table 8.52: Section at 900m upstream of dam

Particle size in mm	Falling velocity (cm/s)	Corrected falling velocity in flowing water (cm/s)	Velocity of flow cm/s	Depth (m)	Settling Time (s)	Settling Distance (m)	Settling Distance from dam face (m)
0.15	1.5	1.156	18.1	48.2	4170	754.8	145.2
0.2	2.1	1.756	18.1	48.2	2745	496.9	403.1
0.25	3	2.656	18.1	48.2	1815	328.5	571.5
0.3	4	3.656	18.1	48.2	1318	238.6	661.4
0.4	5.3	4.956	18.1	48.2	973	176.0	724.0
0.6	9	8.656	18.1	48.2	557	100.8	799.2
0.8	12	11.656	18.1	48.2	414	74.8	825.2
1	15	14.656	18.1	48.2	329	59.5	840.5
2	27.5	27.156	18.1	48.2	177	32.1	867.9
4	43	42.656	18.1	48.2	113	20.5	879.5
7	60	59.656	18.1	48.2	81	14.6	885.4
10	72.5	72.156	18.1	48.2	67	12.1	887.9

As per this study, duly considering the turbulence created by infall of Sae chu nala at 1170m upstream of dam, particle size of 0.150 mm and above get settled in Pauk reservoir at a maximum distance of about 755m (145m upstream of Pauk dam). Similarly, particles of size 0.2mm get settled in Pauk reservoir at a maximum distance of 497(403m upstream of Pauk dam). As the total length of reservoir extends for 2370 m from dam, particles of size 0.2 mm and above are not likely to be eroded in to suspension even due to gradual siltation during project operation. It is therefore considered that particles of maximum size 0.15 shall flow through intake and along with surplus water released from Pauk dam. As no grain size distribution of suspended sediments at Pauk dam site has been carried out, the grain size distribution of suspended sediments at Heo barrage location is considered to be applicable at Pauk dam site. Accordingly, it is considered that 70.61% (Table:8.32) of concentration of silt presence in downstream of dam surplus and tail race channel from Pauk power house will be having particle size 0.15 mm and below.

Conclusions

Based on four years of sediment observations at Mechuka, it is observed that particles of size less than 600 microns are present in suspended form in water samples but majority of suspended sediments are less than 150 microns.

Suspended sediments of size 150 micron and below are likely to remain in suspension even after storage at Pauk reservoir and may flow downstream of Pauk dam either through the turbine or through the spillway.

Volume of sediment inflowing into Pauk reservoir is about 566,500 m^3/year (Table:8.48) comprising of 485,700m^3 of suspended sediment and 80,800 m^3 of bed load. Sedimentation in

Pauk reservoir is about 29.39% (142,800m^3) of suspended sediment and 100% (80,800 m^3) of bed load, considering particle size more than 0.15 mm will be settled. Sediment volume flowing downstream of Pauk reservoir is about 342,900m^3 per year.

Annual average flow at Pauk dam annual yield is 2649. Average annual sediment concentration downstream of Pauk dam is about 126 ppm-

All sediment particles of size 200 microns and above are expected to settle in Pauk reservoir and therefore there is no impact of sediment particles is expected on design of Pauk powerhouse.

Heo Sedimentation Studies

Heo barrage is proposed about 3.5 km downstream of Pauk Dam. The catchment area at Heo barrage location is about 1065 km^2. Downstream of Pauk dam, the contribution to flow at Heo barrage is from additional catchment area of about 83 km^2. For sedimentation study at Heo barrage, it is presumed that Pauk dam is in place and accordingly, the total sediments are contributed by following flows:

- Flow from Pauk dam comprising of:
  - Flows from Pauk Power house tail race
  - Surplus flows from spillway in Pauk Dam
- Intermediate catchment flows from an area of about 83 km^2

Based on sedimentation study at Pauk dam site as discussed above, it can be concluded that particles of size 150 micron and above are expected to settle in the Pauk reservoir and only particles below 150 micron are passed downstream either through Pauk HEP or in the surplus water through the spillway at Pauk dam. Flow from intermediate catchment is however likely to carry sediments even bigger than 150 microns.

8.8.14.1 *Quantifying sediment load*

As discussed in Pauk reservoir siltation process only particles size 0.15mm and below flow in the form of surplus and Tail race channel flows. The percentage of 0.15mm and below contained is only 59.2% of concentration.

- Total sediment yield per annum at Pauk reservoir =566 500 cum
- Sediment volume having particle size 0.15mm and below = 342,900 cum

Considering intermediate Yarjep and Sae Chu nallah catchment area similar to mountainous catchment and attributing rate of sedimentation as 0.88mm /year including 20% bed load,

Annual sediment load from intermediate catchment = 83 x 10^6 x 0.88/1000 = 73 040 cum

Annual Sediment load in suspension from intermediate catchment = 73 040/1.20= 60867 cum

- Annual bed load sediments at 20% of suspended loadfrom intermediate catchment = 12173 cum
- Total annual average sediment yield at Heo Barrage site =342900+73040 = 416,000 cum
- Catchment area at Heo HEP barrage = 1065 km^2
- Annual average sediment rate at Heo HEP Barrage site =416000/1065x 10^6 = **0.39mm/year**

8.8.14.2 *Sediment Concentration at Heo Barrage location*

A total of 51 water samples containing suspended sediments were collected at Heo barrage location in the year 2012 for determining sediment concentration and for grain size distribution of suspended sediments.

Table 8.54

Description	Days	%
Total sampling days	180	
No. of days with zero ppm	129	71.6
ppm <150	31	17.2
ppm >150 and <500	0	0
ppm >500 and <1000	4	2.2
ppm >1000 and <2000	15	8.4
ppm >2000 and <3000	1	0.6
ppm >3000	0	0

It is observed that Yarjep River at Heo Barrage has suspended sediment for about 51 days in a year. Yarjep River carries sediment concentration greater than 150 ppm for a maximum period of 20 days per year. Maximum observedconcentration of suspended particles is 2300 ppm. As seen from table 8.54, (from AIMIL results), about 80 % of suspended sediments observed at Heo Barrage location are smaller than 0.2 mm.

From results of grain size distribution at Mechuka and Heo barrage, it can be concluded that the intermediate catchment between Pauk dam location and Puring (near Heo barrage) carries sediment particles only marginally bigger than sediment particles of Mechuka. The total amount of sediment yield at Heo barrage with particle size 0.2 mm and above is computed considering water released from Pauk reservoir has sediments particle of size 150 micron and below. Thus the entire sediment load having particles of size above 200 microns is contributed by intermediate catchment.

Sediment yield of suspended sediments from intermediate catchment	=	60867cum
% of sediments from intermediate catchment having particle size 200 micron and above	=	20%
Sediment yield at Heo barrage, having particle size 200 microns and above	=	12,200 cum

The sediment yield at Heo barrage for particles of size 0.2 mm and above for year 2012 is thus estimated as 12,200 cum. As per study for sediment yield at Mechuka, sediment yield in 2010 is about 2 times more than sediment yield during 2012. The maximum amount of sediment yield at Heo barrage for particle size 0.2 mm and above can therefore be expected as 25000 cum and is not likely to have any significant impact on design of Heo and Tato 1 HEP.

Conclusions

- Heo HEP Barrage site receives discharges with low concentration of suspended particles during normal operation of Pauk HEP.
- Annual sediment yield at Heo barrage site is estimated as 416,000 cum comprising of 343,000 cum of suspended sediments and 73,000 cum of bed load sediments.
- As per grain size distribution study undertaken in 2012, the suspended load contains about 80% of sediments of size smaller than 0.20mm.
- It is evident that the presence of Pauk reservoir will further deplete the presence of suspended sediments of particle size 0.15 mm and above and also result in lower percentage of sediment concentration.
- Maximum annual sediment yield at Heo barrage for particles having particle size of 0.2 mm and above is expected as 25000 cum and is not likely to have any significant impact on design of Heo and Tato-1 powerhouse.
- However as a precautionary measure spare runners with protective coat of tungsten carbide will be provided to counter unforeseen erosion.

Appendices

- Appendix-A = CWC Approved Flow Series
- Appendix-B = Design Flood Computation
- Appendix-C = IMD Report
- Appendix-D = Silt Measurements
- Appendix-E = Sedimentation Reports
- Appendix-F = List of References

APPENDIX D

Silt measurement at Menchuka Bridge from July 1st 2009 until June 30th 2011 and from June 1st 2012 until December 31st 2012

Date	Water	Silt concentration (ppm)
01/07/2009	Muddy	3.3
02/07/2009	Clear	0.0
03/07/2009	Muddy	2.9
04/07/2009	Muddy	4.0
05/07/2009	Clear	0.0
06/07/2009	Clear	0.0
07/07/2009	Muddy	1.4
08/07/2009	Clear	0.0
09/07/2009	Muddy	1.3
10/07/2009	Muddy	3.3
11/07/2009	Clear	0.0
12/07/2009	Clear	0.0
13/07/2009	Clear	0.0
14/07/2009	Clear	0.0
15/07/2009	Clear	0.0
16/07/2009	Clear	0.0
17/07/2009	Clear	0.0
18/07/2009	Muddy	1.7
19/07/2009	Clear	0.0
20/07/2009	Clear	0.0
21/07/2009	Clear	0.0
22/07/2009	Clear	0.0
23/07/2009	Clear	0.0
24/07/2009	Clear	0.0
25/07/2009	Muddy	231.7
26/07/2009	Muddy	22.9
27/07/2009	Muddy	28.6
28/07/2009	Muddy	1.7
29/07/2009	Muddy	16.3
30/07/2009	Clear	0.0
31/07/2009	Clear	0.0
01/08/2009	Muddy	4.0
02/08/2009	Clear	0.0
03/08/2009	Clear	0.0
04/08/2009	Clear	0.0
05/08/2009	Clear	0.0
06/08/2009	Muddy	230.0
07/08/2009	Clear	0.0
08/08/2009	Clear	0.0
09/08/2009	Muddy	15.7
10/08/2009	Clear	0.0
11/08/2009	Clear	0.0
12/08/2009	Clear	0.0
13/08/2009	Clear	0.0
14/08/2009	Clear	0.0
15/08/2009	Muddy	54.0

16/08/2009	Clear	0.0
17/08/2009	Muddy	18.3
18/08/2009	Muddy	194.0
19/08/2009	Muddy	8.3
20/08/2009	Muddy	5.7
21/08/2009	Clear	0.0
22/08/2009	Muddy	5.0
23/08/2009	Clear	0.0
24/08/2009	Clear	0.0
25/08/2009	Clear	0.0
26/08/2009	Clear	0.0
27/08/2009	Clear	0.0
28/08/2009	Clear	0.0
29/08/2009	Clear	0.0
30/08/2009	Clear	0.0
31/08/2009	Clear	0.0
01/09/2009	Clear	0.0
02/09/2009	Clear	0.0
03/09/2009	Clear	0.0
04/09/2009	Clear	0.0
05/09/2009	Clear	0.0
06/09/2009	Clear	0.0
07/09/2009	Clear	0.0
08/09/2009	Muddy	261.7
09/09/2009	Clear	0.0
10/09/2009	Clear	0.0
11/09/2009	Muddy	15.7
12/09/2009	Clear	0.0
13/09/2009	Muddy	405.0
14/09/2009	Clear	0.0
15/09/2009	Clear	0.0
16/09/2009	Clear	0.0
17/09/2009	Muddy	26.7
18/09/2009	Muddy	28.6
19/09/2009	Clear	0.0
20/09/2009	Muddy	150.0
21/09/2009	Clear	0.0
22/09/2009	Clear	0.0
23/09/2009	Clear	0.0
24/09/2009	Clear	0.0
25/09/2009	Clear	0.0
26/09/2009	Clear	0.0
27/09/2009	Clear	0.0
28/09/2009	Clear	0.0
29/09/2009	Clear	0.0
30/09/2009	Clear	0.0
01/10/2009	Clear	0.0
02/10/2009	Clear	0.0
03/10/2009	Clear	0.0
04/10/2009	Clear	0.0
05/10/2009	Clear	0.0

06/10/2009	Clear	0.0
07/10/2009	Clear	0.0
08/10/2009	Clear	0.0
09/10/2009	Clear	0.0
10/10/2009	Clear	0.0
11/10/2009	Clear	0.0
12/10/2009	Clear	0.0
13/10/2009	Clear	0.0
14/10/2009	Clear	0.0
15/10/2009	Clear	0.0
16/10/2009	Clear	0.0
17/10/2009	Clear	0.0
18/10/2009	Clear	0.0
19/10/2009	Clear	0.0
20/10/2009	Clear	0.0
21/10/2009	Clear	0.0
22/10/2009	Clear	0.0
23/10/2009	Clear	0.0
24/10/2009	Clear	0.0
25/10/2009	Clear	0.0
26/10/2009	Clear	0.0
27/10/2009	Clear	0.0
28/10/2009	Clear	0.0
29/10/2009	Clear	0.0
30/10/2009	Clear	0.0
31/10/2009	Clear	0.0
01/11/2009	Clear	0.0
02/11/2009	Clear	0.0
03/11/2009	Clear	0.0
04/11/2009	Clear	0.0
05/11/2009	Clear	0.0
06/11/2009	Clear	0.0
07/11/2009	Clear	0.0
08/11/2009	Clear	0.0
09/11/2009	Clear	0.0
10/11/2009	Clear	0.0
11/11/2009	Clear	0.0
12/11/2009	Clear	0.0
13/11/2009	Clear	0.0
14/11/2009	Clear	0.0
15/11/2009	Clear	0.0
16/11/2009	Clear	0.0
17/11/2009	Clear	0.0
18/11/2009	Clear	0.0
19/11/2009	Clear	0.0
20/11/2009	Clear	0.0
21/11/2009	Clear	0.0
22/11/2009	Clear	0.0
23/11/2009	Clear	0.0
24/11/2009	Clear	0.0
25/11/2009	Clear	0.0

26/11/2009	Clear	0.0
27/11/2009	Clear	0.0
28/11/2009	Clear	0.0
29/11/2009	Clear	0.0
30/11/2009	Clear	0.0
01/12/2009	Clear	0.0
02/12/2009	Clear	0.0
03/12/2009	Clear	0.0
04/12/2009	Clear	0.0
05/12/2009	Clear	0.0
06/12/2009	Clear	0.0
07/12/2009	Clear	0.0
08/12/2009	Clear	0.0
09/12/2009	Clear	0.0
10/12/2009	Clear	0.0
11/12/2009	Clear	0.0
12/12/2009	Clear	0.0
13/12/2009	Clear	0.0
14/12/2009	Clear	0.0
15/12/2009	Clear	0.0
16/12/2009	Clear	0.0
17/12/2009	Clear	0.0
18/12/2009	Clear	0.0
19/12/2009	Clear	0.0
20/12/2009	Clear	0.0
21/12/2009	Clear	0.0
22/12/2009	Clear	0.0
23/12/2009	Clear	0.0
24/12/2009	Clear	0.0
25/12/2009	Clear	0.0
26/12/2009	Clear	0.0
27/12/2009	Clear	0.0
28/12/2009	Clear	0.0
29/12/2009	Clear	0.0
30/12/2009	Clear	0.0
31/12/2009	Clear	0.0
01/01/2010	Clear	0.0
02/01/2010	Clear	0.0
03/01/2010	Clear	0.0
04/01/2010	Clear	0.0
05/01/2010	Clear	0.0
06/01/2010	Clear	0.0
07/01/2010	Clear	0.0
08/01/2010	Clear	0.0
09/01/2010	Clear	0.0
10/01/2010	Clear	0.0
11/01/2010	Clear	0.0
12/01/2010	Clear	0.0
13/01/2010	Clear	0.0
14/01/2010	Clear	0.0
15/01/2010	Clear	0.0

16/01/2010	Clear	0.0
17/01/2010	Clear	0.0
18/01/2010	Clear	0.0
19/01/2010	Clear	0.0
20/01/2010	Clear	0.0
21/01/2010	Clear	0.0
22/01/2010	Clear	0.0
23/01/2010	Clear	0.0
24/01/2010	Clear	0.0
25/01/2010	Clear	0.0
26/01/2010	Clear	0.0
27/01/2010	Clear	0.0
28/01/2010	Clear	0.0
29/01/2010	Clear	0.0
30/01/2010	Clear	0.0
31/01/2010	Clear	0.0
01/02/2010	Clear	0.0
02/02/2010	Clear	0.0
03/02/2010	Clear	0.0
04/02/2010	Clear	0.0
05/02/2010	Clear	0.0
06/02/2010	Clear	0.0
07/02/2010	Clear	0.0
08/02/2010	Clear	0.0
09/02/2010	Clear	0.0
10/02/2010	Clear	0.0
11/02/2010	Clear	0.0
12/02/2010	Clear	0.0
13/02/2010	Clear	0.0
14/02/2010	Clear	0.0
15/02/2010	Clear	0.0
16/02/2010	Clear	0.0
17/02/2010	Clear	0.0
18/02/2010	Clear	0.0
19/02/2010	Clear	0.0
20/02/2010	Clear	0.0
21/02/2010	Clear	0.0
22/02/2010	Clear	0.0
23/02/2010	Clear	0.0
24/02/2010	Clear	0.0
25/02/2010	Clear	0.0
26/02/2010	Clear	0.0
27/02/2010	Clear	0.0
28/02/2010	Clear	0.0
01/03/2010	Clear	0.0
02/03/2010	Clear	0.0
03/03/2010	Clear	0.0
04/03/2010	Clear	0.0
05/03/2010	Clear	0.0
06/03/2010	Clear	0.0
07/03/2010	Clear	0.0

08/03/2010	Clear	0.0
09/03/2010	Clear	0.0
10/03/2010	Clear	0.0
11/03/2010	Clear	0.0
12/03/2010	Clear	0.0
13/03/2010	Clear	0.0
14/03/2010	Clear	0.0
15/03/2010	Clear	0.0
16/03/2010	Clear	0.0
17/03/2010	Clear	0.0
18/03/2010	Clear	0.0
19/03/2010	Clear	0.0
20/03/2010	Clear	0.0
21/03/2010	Clear	0.0
22/03/2010	Clear	0.0
23/03/2010	Clear	0.0
24/03/2010	Clear	0.0
25/03/2010	Clear	0.0
26/03/2010	Clear	0.0
27/03/2010	Muddy	11.7
28/03/2010	Clear	0.0
29/03/2010	Clear	0.0
30/03/2010	Clear	0.0
31/03/2010	Clear	0.0
01/04/2010	Clear	0.0
02/04/2010	Clear	0.0
03/04/2010	Clear	0.0
04/04/2010	Clear	0.0
05/04/2010	Clear	0.0
06/04/2010	Clear	0.0
07/04/2010	Clear	0.0
08/04/2010	Clear	0.0
09/04/2010	Clear	0.0
10/04/2010	Clear	0.0
11/04/2010	Clear	0.0
12/04/2010	Clear	0.0
13/04/2010	Clear	0.0
14/04/2010	Clear	0.0
15/04/2010	Clear	0.0
16/04/2010	Clear	0.0
17/04/2010	Clear	0.0
18/04/2010	Clear	0.0
19/04/2010	Clear	0.0
20/04/2010	Clear	0.0
21/04/2010	Clear	0.0
22/04/2010	Clear	0.0
23/04/2010	Muddy	74.0
24/04/2010	Clear	0.0
25/04/2010	Clear	0.0
26/04/2010	Clear	0.0
27/04/2010	Clear	0.0

28/04/2010	Clear	0.0
29/04/2010	Clear	0.0
30/04/2010	Clear	0.0
01/05/2010	Clear	0.0
02/05/2010	Clear	0.0
03/05/2010	Clear	0.0
04/05/2010	Clear	0.0
05/05/2010	Clear	0.0
06/05/2010	Clear	0.0
07/05/2010	Clear	0.0
08/05/2010	Clear	0.0
09/05/2010	Clear	0.0
10/05/2010	Clear	0.0
11/05/2010	Muddy	73.3
12/05/2010	Muddy	188.0
13/05/2010	Clear	0.0
14/05/2010	Clear	0.0
15/05/2010	Muddy	115.0
16/05/2010	Clear	0.0
17/05/2010	Clear	0.0
18/05/2010	Clear	0.0
19/05/2010	Clear	0.0
20/05/2010	Clear	0.0
21/05/2010	Muddy	3.3
22/05/2010	Clear	0.0
23/05/2010	Clear	0.0
24/05/2010	Clear	0.0
25/05/2010	Clear	0.0
26/05/2010	Clear	0.0
27/05/2010	Clear	0.0
28/05/2010	Clear	0.0
29/05/2010	Clear	0.0
30/05/2010	Clear	0.0
31/05/2010	Muddy	5.0
01/06/2010	Muddy	162.0
02/06/2010	Clear	0.0
03/06/2010	Clear	0.0
04/06/2010	Clear	0.0
05/06/2010	Muddy	451.7
06/06/2010	Clear	0.0
07/06/2010	Clear	0.0
08/06/2010	Clear	0.0
09/06/2010	Clear	0.0
10/06/2010	Clear	0.0
11/06/2010	Clear	0.0
12/06/2010	Clear	0.0
13/06/2010	Clear	0.0
14/06/2010	Muddy	530.0
15/06/2010	Clear	0.0
16/06/2010	Clear	0.0
17/06/2010	Clear	0.0

18/06/2010	Clear	0.0
19/06/2010	Clear	0.0
20/06/2010	Clear	0.0
21/06/2010	Clear	0.0
22/06/2010	Clear	0.0
23/06/2010	Muddy	466.7
24/06/2010	Muddy	616.7
25/06/2010	Clear	0.0
26/06/2010	Clear	0.0
27/06/2010	Clear	0.0
28/06/2010	Clear	0.0
29/06/2010	Clear	0.0
30/06/2010	Clear	0.0
01/07/2010	Muddy	1 178.0
02/07/2010	Clear	0.0
03/07/2010	Clear	0.0
04/07/2010	Clear	0.0
05/07/2010	Clear	0.0
06/07/2010	Clear	0.0
07/07/2010	Clear	0.0
08/07/2010	Clear	0.0
09/07/2010	Clear	0.0
10/07/2010	Clear	0.0
11/07/2010	Clear	0.0
12/07/2010	Clear	0.0
13/07/2010	Clear	0.0
14/07/2010	Clear	0.0
15/07/2010	Clear	0.0
16/07/2010	Clear	0.0
17/07/2010	Clear	0.0
18/07/2010	Clear	0.0
19/07/2010	Clear	0.0
20/07/2010	Clear	0.0
21/07/2010	Clear	0.0
22/07/2010	Clear	0.0
23/07/2010	Clear	0.0
24/07/2010	Clear	0.0
25/07/2010	Clear	0.0
26/07/2010	Muddy	763.3
27/07/2010	Clear	0.0
28/07/2010	Clear	0.0
29/07/2010	Clear	0.0
30/07/2010	Muddy	600.0
31/07/2010	Clear	0.0
01/08/2010	Clear	0.0
02/08/2010	Clear	0.0
03/08/2010	Clear	0.0
04/08/2010	Clear	0.0
05/08/2010	Clear	0.0
06/08/2010	Clear	0.0
07/08/2010	Clear	0.0

08/08/2010	Clear	0.0
09/08/2010	Clear	0.0
10/08/2010	Muddy	916.7
11/08/2010	Muddy	1 600.0
12/08/2010	Clear	0.0
13/08/2010	Clear	0.0
14/08/2010	Clear	0.0
15/08/2010	Clear	0.0
16/08/2010	Muddy	550.0
17/08/2010	Clear	0.0
18/08/2010	Clear	0.0
19/08/2010	Clear	0.0
20/08/2010	Clear	0.0
21/08/2010	Muddy	658.6
22/08/2010	Muddy	433.3
23/08/2010	Muddy	1 065.0
24/08/2010	Muddy	1 957.0
25/08/2010	Clear	0.0
26/08/2010	Clear	0.0
27/08/2010	Clear	0.0
28/08/2010	Clear	0.0
29/08/2010	Clear	0.0
30/08/2010	Clear	0.0
31/08/2010	Clear	0.0
01/09/2010	Clear	0.0
02/09/2010	Clear	0.0
03/09/2010	Clear	0.0
04/09/2010	Clear	0.0
05/09/2010	Clear	0.0
06/09/2010	Clear	0.0
07/09/2010	Clear	0.0
08/09/2010	Clear	0.0
09/09/2010	Clear	0.0
10/09/2010	Clear	0.0
11/09/2010	Clear	0.0
12/09/2010	Clear	0.0
13/09/2010	Clear	0.0
14/09/2010	Clear	0.0
15/09/2010	Clear	0.0
16/09/2010	Clear	0.0
17/09/2010	Clear	0.0
18/09/2010	Clear	0.0
19/09/2010	Clear	0.0
20/09/2010	Clear	0.0
21/09/2010	Clear	0.0
22/09/2010	Clear	0.0
23/09/2010	Clear	0.0
24/09/2010	Clear	0.0
25/09/2010	Clear	0.0
26/09/2010	Clear	0.0
27/09/2010	Clear	0.0

28/09/2010	Clear	0.0
29/09/2010	Clear	0.0
30/09/2010	Clear	0.0
01/10/2010	Clear	0.0
02/10/2010	Clear	0.0
03/10/2010	Clear	0.0
04/10/2010	Clear	0.0
05/10/2010	Clear	0.0
06/10/2010	Clear	0.0
07/10/2010	Clear	0.0
08/10/2010	Clear	0.0
09/10/2010	Clear	0.0
10/10/2010	Clear	0.0
11/10/2010	Clear	0.0
12/10/2010	Clear	0.0
13/10/2010	Clear	0.0
14/10/2010	Clear	0.0
15/10/2010	Clear	0.0
16/10/2010	Clear	0.0
17/10/2010	Clear	0.0
18/10/2010	Clear	0.0
19/10/2010	Clear	0.0
20/10/2010	Clear	0.0
21/10/2010	Clear	0.0
22/10/2010	Clear	0.0
23/10/2010	Clear	0.0
24/10/2010	Clear	0.0
25/10/2010	Clear	0.0
26/10/2010	Clear	0.0
27/10/2010	Clear	0.0
28/10/2010	Clear	0.0
29/10/2010	Clear	0.0
30/10/2010	Clear	0.0
31/10/2010	Clear	0.0
01/11/2010	Clear	0.0
02/11/2010	Clear	0.0
03/11/2010	Clear	0.0
04/11/2010	Clear	0.0
05/11/2010	Clear	0.0
06/11/2010	Clear	0.0
07/11/2010	Clear	0.0
08/11/2010	Clear	0.0
09/11/2010	Clear	0.0
10/11/2010	Clear	0.0
11/11/2010	Clear	0.0
12/11/2010	Clear	0.0
13/11/2010	Clear	0.0
14/11/2010	Clear	0.0
15/11/2010	Clear	0.0
16/11/2010	Clear	0.0
17/11/2010	Clear	0.0

18/11/2010	Clear	0.0
19/11/2010	Clear	0.0
20/11/2010	Clear	0.0
21/11/2010	Clear	0.0
22/11/2010	Clear	0.0
23/11/2010	Clear	0.0
24/11/2010	Clear	0.0
25/11/2010	Clear	0.0
26/11/2010	Clear	0.0
27/11/2010	Clear	0.0
28/11/2010	Clear	0.0
29/11/2010	Clear	0.0
30/11/2010	Clear	0.0
01/12/2010	Clear	0.0
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15/12/2010	Clear	0.0
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07/01/2011	Clear	0.0

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18/01/2011	Clear	0.0
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23/01/2011	Clear	0.0
24/01/2011	Clear	0.0
25/01/2011	Clear	0.0
26/01/2011	Clear	0.0
27/01/2011	Clear	0.0
28/01/2011	Clear	0.0
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21/03/2011	Clear	0.0
22/03/2011	Clear	0.0
23/03/2011	Clear	0.0
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19/04/2011	Clear	0.0

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28/04/2011	Clear	0.0
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12/05/2011	clear	0.0
13/05/2011	clear	0.0
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15/05/2011	clear	0.0
16/05/2011	clear	0.0
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21/05/2011	clear	0.0
22/05/2011	clear	0.0
23/05/2011	muddy	70.17
24/05/2011	muddy	68.42
25/05/2011	clear	0.0
26/05/2011	clear	0.0
27/05/2011	clear	0.0
28/05/2011	clear	0.0
29/05/2011	clear	0.0
30/05/2011	clear	0.0
31/05/2011	clear	0.0
01/06/2011	muddy	170.60
02/06/2011	clear	0.0
03/06/2011	clear	0.0
04/06/2011	clear	0.0
05/06/2011	muddy	519.14
06/06/2011	muddy	868.33
07/06/2011	clear	0.0
08/06/2011	clear	0.0
09/06/2011	clear	0.0

10/06/2011	clear	0.0
11/06/2011	muddy	624.29
12/06/2011	muddy	764.83
13/06/2011	clear	0.0
14/06/2011	clear	0.0
15/06/2011	clear	0.0
16/06/2011	clear	0.0
17/06/2011	clear	0.0
18/06/2011	clear	0.0
19/06/2011	clear	0.0
20/06/2011	clear	0.0
21/06/2011	muddy	259.43
22/06/2011	clear	0.0
23/06/2011	clear	0.0
24/06/2011	muddy	270.17
25/06/2011	clear	0.0
26/06/2011	clear	0.0
27/06/2011	clear	0.0
28/06/2011	clear	0.0
29/06/2011	clear	0.0
30/06/2011	clear	0.0

Date	Water	Concetration (ppm)
01-06-2012	Clear	
02-06-2012	Clear	
03-06-2012	Clear	
04-06-2012	Clear	
05-06-2012	Clear	
06-06-2012	Clear	
07-06-2012	Clear	
08-06-2012	Clear	
09-06-2012	Clear	
10-06-2012	Clear	
11-06-2012	Clear	
12-06-2012	Clear	
13-06-2012	Clear	
14-06-2012	Clear	
15-06-2012	Clear	
16-06-2012	Clear	
17-06-2012	Clear	
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19-06-2012	Clear	
20-06-2012	Clear	
21-06-2012	Clear	
22-06-2012	Clear	
23-06-2012	Clear	
24-06-2012	Clear	
25-06-2012	Clear	
26-06-2012	Clear	
27-06-2012	Clear	
28-06-2012	Clear	
29-06-2012	Clear	
30-06-2012	Clear	
01-07-2012	Clear	
02-07-2012	Clear	
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04-07-2012	Clear	
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06-07-2012	Clear	
07-07-2012	Clear	
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09-07-2012	Clear	
10-07-2012	Clear	
11-07-2012	Clear	
12-07-2012	Clear	
13-07-2012	Clear	
14-07-2012	Clear	
15-07-2012	Clear	
16-07-2012	Clear	
17-07-2012	Clear	
18-07-2012	Clear	
19-07-2012	Clear	

20-07-2012	Clear	
21-07-2012	Clear	
22-07-2012	Clear	
23-07-2012	Clear	
24-07-2012	Muddy	12
25-07-2012	Muddy	656
26-07-2012	Muddy	8
27-07-2012	Muddy	8
28-07-2012	Muddy	4
29-07-2012	Muddy	10
30-07-2012	Muddy	7
31-07-2012	Muddy	2
01-08-2012	Clear	
02-08-2012	Clear	
03-08-2012	Clear	
04-08-2012	Clear	
05-08-2012	Clear	
06-08-2012	Clear	
07-08-2012	Muddy	2
08-08-2012	Muddy	669
09-08-2012	Muddy	8
10-08-2012	Muddy	29
11-08-2012	Muddy	1259
12-08-2012	Muddy	407
13-08-2012	Muddy	9
14-08-2012	Muddy	9
15-08-2012	Muddy	1
16-08-2012	Muddy	3
17-08-2012	Clear	
18-08-2012	Clear	
19-08-2012	Clear	
20-08-2012	Clear	
21-08-2012	Clear	
22-08-2012	Muddy	167
23-08-2012	Muddy	1
24-08-2012	Muddy	131
25-08-2012	Muddy	1023
26-08-2012	Clear	
27-08-2012	Clear	
28-08-2012	Clear	
29-08-2012	Muddy	1
30-08-2012	Clear	
31-08-2012	Muddy	1449
01-09-2012	Clear	
02-09-2012	Clear	
03-09-2012	Clear	
04-09-2012	Clear	
05-09-2012	Clear	
06-09-2012	Clear	

07-09-2012	Clear	
08-09-2012	Clear	
09-09-2012	Clear	
10-09-2012	Clear	
11-09-2012	Clear	
12-09-2012	Clear	
13-09-2012	Clear	
14-09-2012	Clear	
15-09-2012	Clear	
16-09-2012	Muddy	217
17-09-2012	Muddy	863
18-09-2012	Muddy	228
19-09-2012	Muddy	154
20-09-2012	Clear	
21-09-2012	Muddy	310
22-09-2012	Muddy	104
23-09-2012	Muddy	18
24-09-2012	Muddy	550
25-09-2012	Muddy	171
26-09-2012	Muddy	16
27-09-2012	Clear	
28-09-2012	Clear	
29-09-2012	Clear	
30-09-2012	Muddy	8
01-10-2012	Muddy	16
02-10-2012	Muddy	10
03-10-2012	Muddy	12
04-10-2012	Clear	
05-10-2012	Muddy	12
06-10-2012	Muddy	62
07-10-2012	Clear	
08-10-2012	Clear	
09-10-2012	Clear	
10-10-2012	Muddy	8
11-10-2012	Muddy	16
12-10-2012	Muddy	470
13-10-2012	Muddy	756
14-10-2012	Muddy	15
15-10-2012	Clear	
16-10-2012	Muddy	20
17-10-2012	Clear	
18-10-2012	Clear	
19-10-2012	Clear	
20-10-2012	Clear	
21-10-2012	Clear	
22-10-2012	Clear	
23-10-2012	Clear	
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25-10-2012	Clear	

26-10-2012	Clear	
27-10-2012	Clear	
28-10-2012	Clear	
29-10-2012	Clear	
30-10-2012	Clear	
31-10-2012	Clear	
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02-11-2012	Clear	
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09-12-2012	Clear	
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11-12-2012	Clear	
12-12-2012	Clear	
13-12-2012	Clear	
14-12-2012	Clear	

15-12-2012	Clear	
16-12-2012	Clear	
17-12-2012	Clear	
18-12-2012	Clear	
19-12-2012	Clear	
20-12-2012	Clear	
21-12-2012	Clear	
22-12-2012	Clear	
23-12-2012	Clear	
24-12-2012	Clear	
25-12-2012	Clear	
26-12-2012	Clear	
27-12-2012	Clear	
28-12-2012	Clear	
29-12-2012	Clear	
30-12-2012	Clear	
31-12-2012	Clear	

APPENDIX E

Sedimentation Reports

ADVANCED TECHNOLOGY & ENGINEERING SERVICES
A Division of Aimil Ltd

Aimil Ltd.

Report on Sedimentometric Study on Samples from Yarjep River HEP in West Siang District in Arunachal Pradesh

1.0 Introduction

The client Velcan Energy India (VE) Pvt. Ltd., G-77, Sujan Singh Park, New Delhi-110003 entrusted the assignment to undertake the sedimentometric study on the river load samples from Yarjep river, HEP in West Siang District in Arunachal Pradesh to Advanced Technology and Engineering Services (ATES) (a division of AIMIL Ltd.), A8, Naimex House, Mohan Cooperative Industrial Estate, Mathura Road, New Delhi-110044 vide Work order 2: Sedimentological tests on samples from Yarjep river HEP in West Siang district in Arunachal Pradesh dated 17th March, 2011.

2.0 Scope of work

The following are the scope of work mutually agreed to undertake sedimentometric study on samples from Yarjep river in Arunachal Pradesh.

- Grain size analysis
  - Sieve analysis-Particle size distribution
- Sedimentometric study (Wet Analysis)
  - Silt and clay contents
  - Mean diameter (D_{50} in mm)
- To carry out test on smaples
- Compilation of test results
- Analysis on test results
- Concluding remarks

3.0 Supply of samples for testing in ATES Laboratory

The client (VE) delivered 18 samples collected from various locations of Yarjep river, HEP in West Siang district in Arunachal Pradesh instead of 20 samples on 22nd March, 2011. The list is reproduced with the weight of samples received from the party and are given in Table1.

Table1: List of samples received

Sample	Location/Project	Date	Bank	Additional Information	Wt. of samples received in lab.
1	Mechukha	25-02-2011	Right	Under the bridge interior meander 50 cm above water level	745.5 gm
2	Mechukha	25-02-2011	Right	Under the bridge interior meander 30 cm below water level Speed: 0 m/s	745.5 gm
3	Mechukha	25-02-2011	Left	Under the bridge exterior meander outside the river Speed: 22 cm/s	773.5 gm
4	Pauk Dam Beach	25-02-2011	Right	50 cm above water level behind a boulder Speed: approx 1 m/s	1355.5 gm
5	Heo Dam Beach	26-02-2011	Left	Upstream axis exterior meander 30 cm below water level Speed: approx 1 m/s	432.5 gm
6	Hoo Dam Beach	26-02-2011	Left	Upstream axis exterior meander 20 cm below water level Speed: approx 1 m/s	1116.0 gm
7	Tato I Intake	27-02-2011	Left	Upstream small sample in very small pond beside the river 50 cm above the river Speed: approx 1.5 m/s	286.5 gm
8	Tato I Intake	27-02-2011	Right	Downstream 50 cm above water level	1015.5 gm
53		23-06-2010	n/a	Concentration: 467 ppm	0.12 gm
54		24-06-2010	n/a	Concentration: 617 ppm	1.07 gm
55		01-07-2010	n/a	Concentration: 1178 ppm	Samples not delivered
56		26-07-2010	n/a	Concentration: 764 ppm	0.18 gm
57		30-07-2010	n/a	Concentration: 600 ppm	2.542 gm
58		10-08-2010	n/a	Concentration: 917 ppm	1.826 gm
59		11-08-2010	n/a	Concentration: 1600 ppm	6.844 gm
60		16-08-2010	n/a	Concentration: 550 ppm	Samples not delivered
61		21-08-2010	n/a	Concentration: 659 ppm	1.958 gm
62		22-08-2010	n/a	Concentration: 433 ppm	0.438 gm
63		23-08-2010	n/a	Concentration: 1065 ppm	2.312 gm
64		24-08-2010	n/a	Concentration: 1957 ppm	0.434 gm

4.0 Sedimentometric Study

The theory of sedimentation is based on the fact that large particles in suspension in liquid settle more

quickly than small particles assuming all particles have similar densities and shapes. The velocity which a falling particle eventually reaches is known as its terminal velocity. If the particles are approximately spherical, velocity (V) and particle diameter (D) is given by Stokes Law. This states that the terminal velocity is proportional to the square of the diameter. The relationship is given below

$$V \text{ a } D^2$$

All sedimentology methods like the pipette method, hydrometer method and laser particle size analyser are based on stokes equation and laser diffraction method respectively. The results of sedimentometric study are dependable on spherical shape and density. It is mentioned that the particles finer than 75 micron were studied using pipette method followed internationally.

5.0 Test on Samples for Sedimentometric Study

5.1 Coarse samples

Eight numbers of samples (Sample nos. 1-8) were taken to carry out grain size analysis by dry sieving method according to IS:2720 (Part 4)1985: Methods of test for soils Part 4 Grains size analysis and the percentage passing through 75 micron IS sieve were separately taken to determine the percentage of silt and clay fractions using pipette method as per IS: 2720-Part 4-1985. The results on particle size distribution along with sedimentometric study (Wet analysis) as obtained are tabulated in Tables 2 to 9. Similarly on the basis of grain size analysis, the particle size distribution plots alongwith mean diameter (D_{50}-mm) are shown in Figs 1 to 8.

5.2 Finer Samples

Ten samples (Sample nos. 53, 54, 56, 57, 58, 59, 61, 62, 63 and 64) collected from various locations by the client mentioning concentration were received in small quantities (Table 1) and all were found finer than 150 micron. Accordingly grain size analysis were first carried out using IS sieves 150 micron and 75 micron as per IS: 2720-Part 4-1985. Thereafter sedimentometric studies were carried out using pipette method for determining silt and clay contents.

The results on particle size distribution by dry sieve analysis and wet analysis (pipette method) are tabulated in Tables 10 to 19. The particle size distribution plots indicating silt and clay fractions along with mean diameter (D_{56}-mm) are shown in Figs 9 to 18).

6.0 Test results

The sedimentometric study carried out in the ATES laboratory were compiled and tabulated in Tables 2 to 19 and the particle size distribution plots are shown in Figs. 1 to 18 and are self explanatory.

7.0 Concluding Remarks

Based on experimental results for sedimentometric study carried out, the following concluding remarks are offered:

- For coarser samples (Sample nos. 1-8) the silt content passing 75 micron which also contain minor percentage of clay fraction vary from 0.22 percent to 15.76 percent (Tables 2-9 and Figs. 1-8)
- The mean diame ters (D_{50}-mm) as evaluated are also found in the range of 0.41 mm to 10.71 mm (Figs. 1-8). The D_{50} are varying from location to location.
- In case of finer samples the silt contents were found varying from 10.4 percent to 85.8 percent with low content of cl ay fractions (Tables 9 to 18 and Figs. 8 to 18)
- The mean diameter (D_{50}-mm) were found in the range of 0.03 mm – 0.11 mm indicating variation from location to location.
- The sedimentometric study provides an insight into sedimentological characterstics of samples collected from Yarjep river would prove useful database to the client.
- The report relates to 18 samples delivered to ATES Laboratory. Any change in location will require fresh study.

Grain Size Analysis

Project: Yarjep River HE Project
Location/ Sample ID: 1, Mechukha: Right bank
Weight of Sample received : 745.5 g

Table No. 2: Result of Grain size Analysis of sample no. 1, Mechukha: Right bank

IS Sieve Designation	% Passing	Remarks
10mm	100.00	Dry Sieve Analysis
4.75 mm	99.87	
2.36 mm	99.60	
1.18 mm	97.99	
600 µm	81.02	
300 µm	35.35	
150 µm	20.59	
75 µm	15.76	
20 µm	0.34	Wet Analysis (Pipette Method)
6 µm	0.09	
2 µm	0.02	

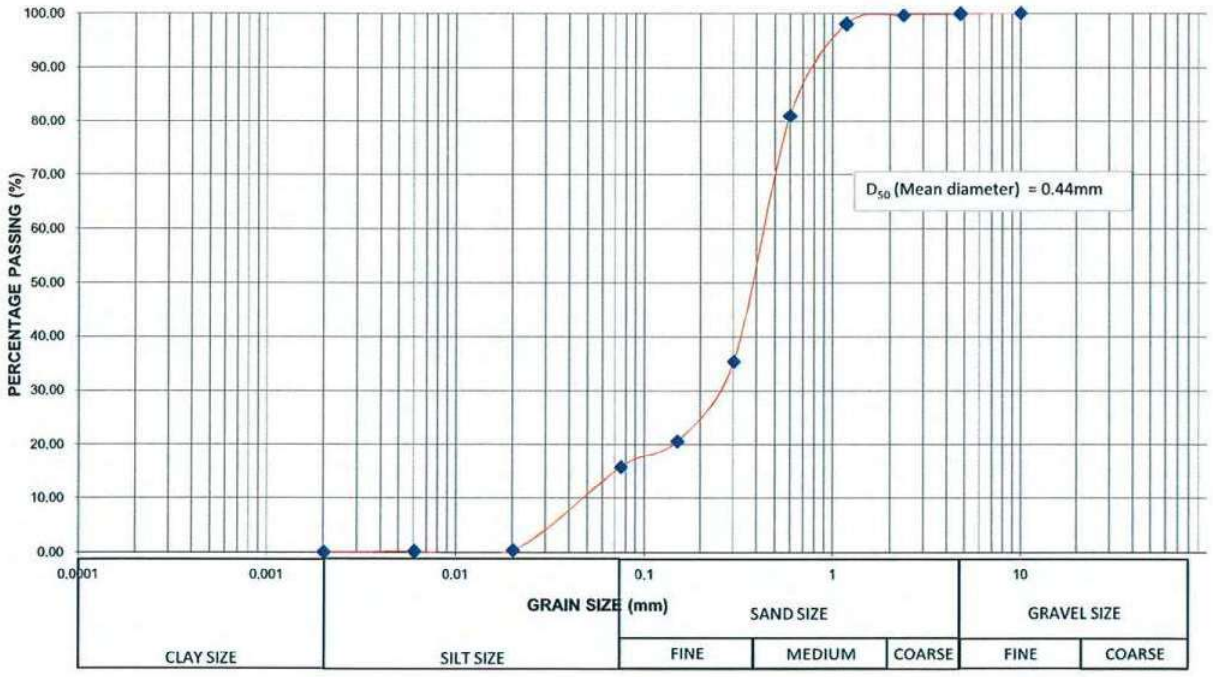

Fig. No.01: Particle size distribution curve of sample no.1, Mechukha: Right bank

Grain Size Analysis

Project: Yarjep River HE Project
Location/ Sample ID: 2, Mechukha: Right bank
Weight of Sample received : 745.5 g

Table No. 3: Result of Grain size Analysis of sample no. 2, Mechukha: Right bank

IS Sieve Designation	% Passing	Remarks
10mm	100.00	Dry Sieve Analysis
4.75 mm	100.00	
2.36 mm	99.87	
1.18 mm	98.86	
600 µm	79.07	
300 µm	23.21	
150 µm	3.62	
75 µm	0.60	
20 µm	0.22	Wet Analysis (Pipette Method)
6 µm	0.09	
2 µm	0.00	

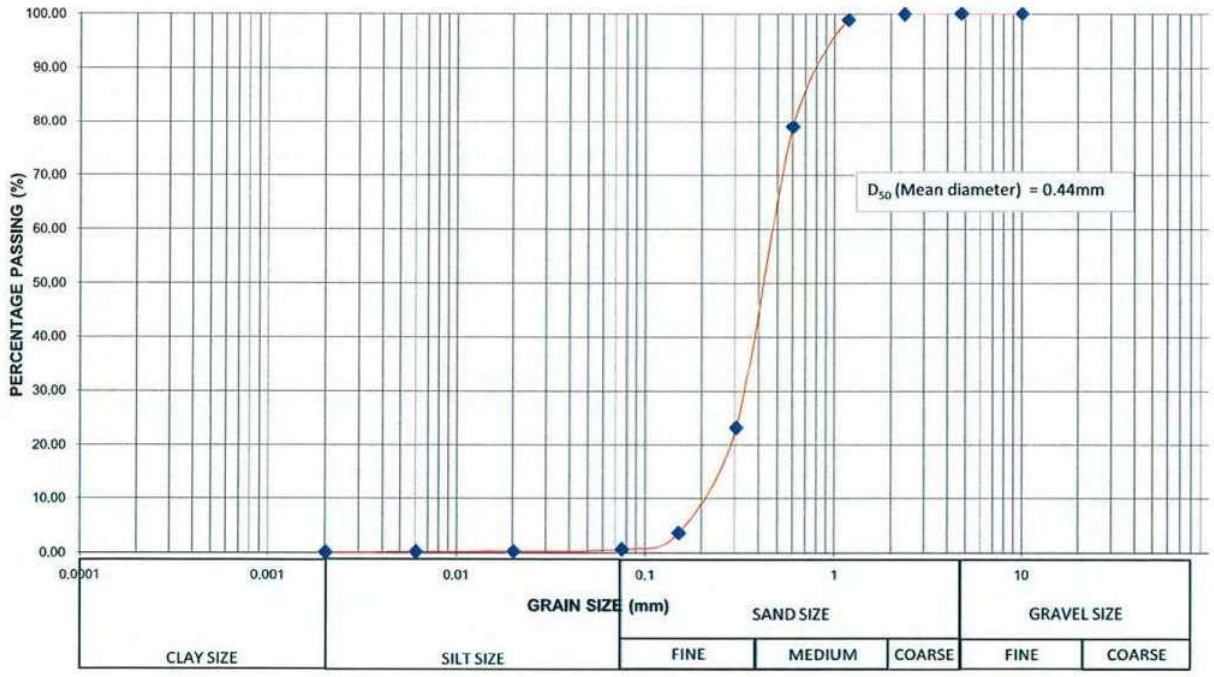

Fig. No.02: Particle size distribution curve sample no. 2, Mechukha: Right bank

Grain Size Analysis

Project: Yarjep River HE Project
Location/ Sample ID: 3, Mechukha: Left bank
Weight of Sample received : 773.5 g

Table No. 4: Result of Grain size Analysis of sample no. 3, Mechukha: Left bank

IS Sieve Designation	% Passing	Remarks
40mm	100.000	Dry Sieve Analysis
31.5mm	93.277	
25mm	74.531	
20mm	72.140	
16mm	65.676	
12.5mm	61.797	
10mm	45.314	
4.75 mm	32.644	
2.36 mm	26.568	
1.18 mm	24.111	
600 µm	21.008	
300 µm	13.381	
150 µm	7.369	
75 µm	2.392	
20 µm	0.850	Wet Analysis (Pipette Method)
6 µm	0.130	
2 µm	0.040	

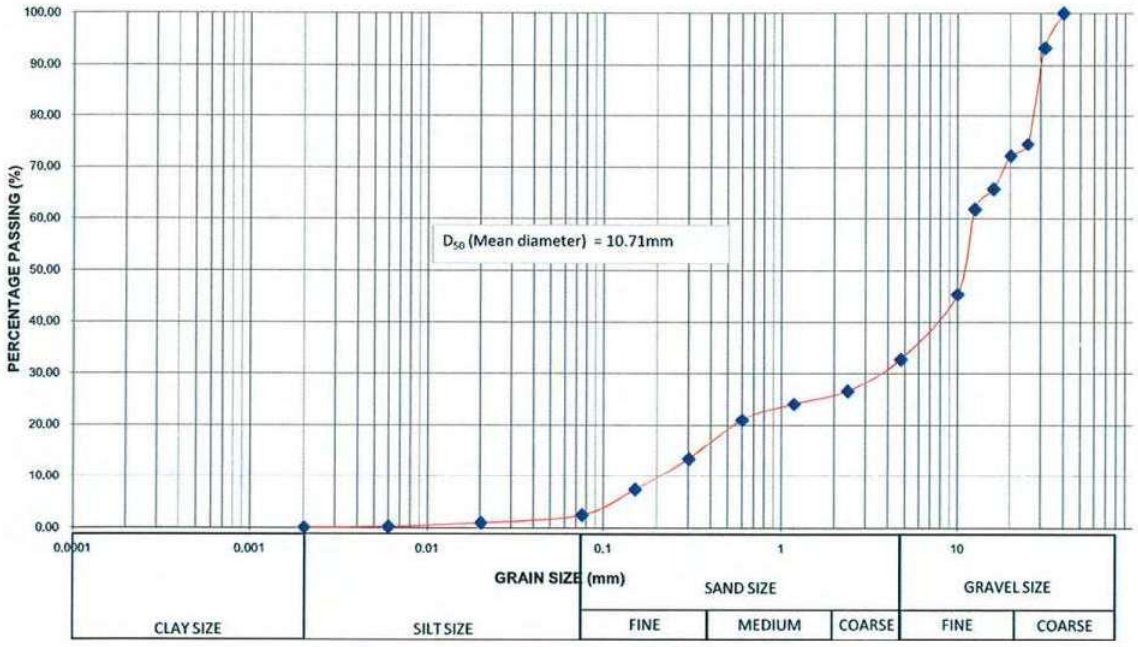

Fig. No.03: Particle size distribution curve of sample no. 3, Mechukha: Left bank

Grain Size Analysis

Project: Yarjep River HE Project
Location/ Sample ID: 4, Pauk Dam Beach: Rght bank
Weight of Sample received : 1355.5 g

Table No. 5: Result of Grain size Analysis of sample no. 4, Pauk Dam Beach: Rght bank

IS Sieve Designation	% Passing	Remarks
40mm	100.000	Dry Sieve Analysis
31.5mm	94.135	
25mm	90.668	
20mm	88.307	
16mm	86.536	
12.5mm	82.257	
10mm	72.704	
4.75 mm	50.572	
2.36 mm	40.133	
1.18 mm	32.055	
600 µm	21.210	
300 µm	5.976	
150 µm	1.549	
75 µm	0.221	
20 µm	0.070	Wet Analysis (Pipette Method)
6 µm	0.040	
2 µm	0.010	

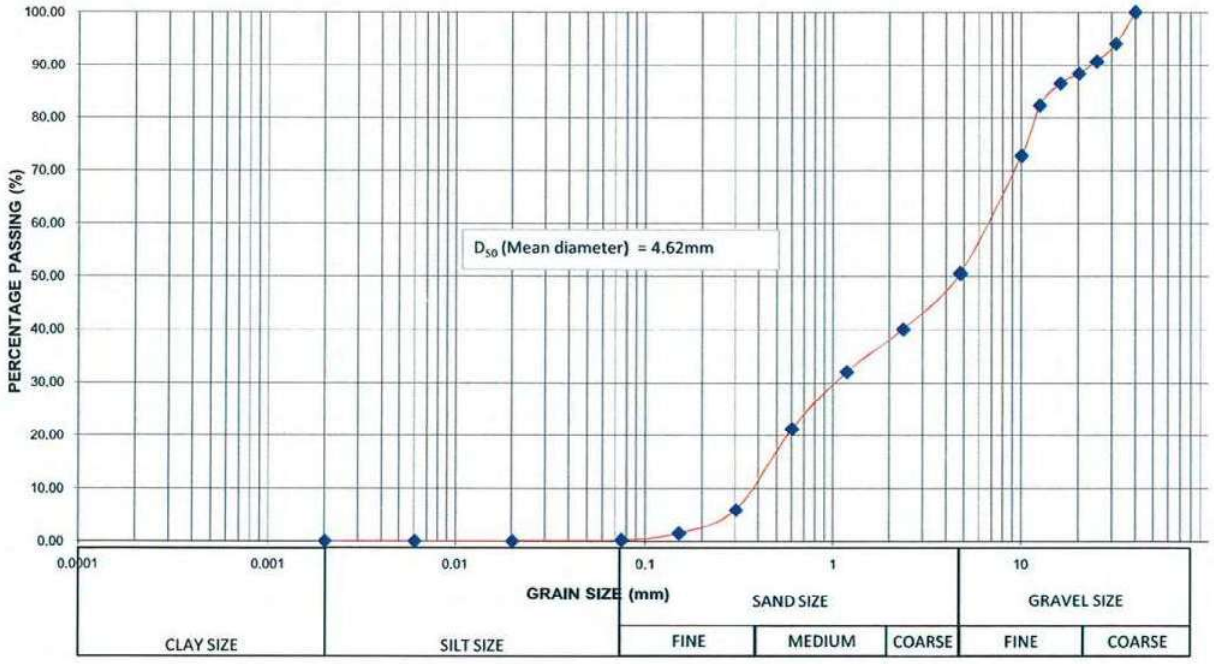

Fig. No.04: Particle size distribution curve of sample no. 4, Pauk Dam Beach: Rght bank

Grain Size Analysis

Project: Yarjep River HE Project
Location/ Sample ID: 5, Heo Dam Beach: Left bank
Weight of Sample received : 432.5 g

Table No. 6: Result of Grain size Analysis of sample no. 5, Heo Dam Beach: Left bank

IS Sieve Designation	% Passing	Remarks
10mm	100.00	Dry Sieve Analysis
4.75 mm	98.84	
2.36 mm	95.38	
1.18 mm	88.55	
600 µm	71.79	
300 µm	28.44	
150 µm	7.86	
75 µm	1.27	
20 µm	0.29	Wet Analysis (Pipette Method)
6 µm	0.11	
2 µm	0.05	

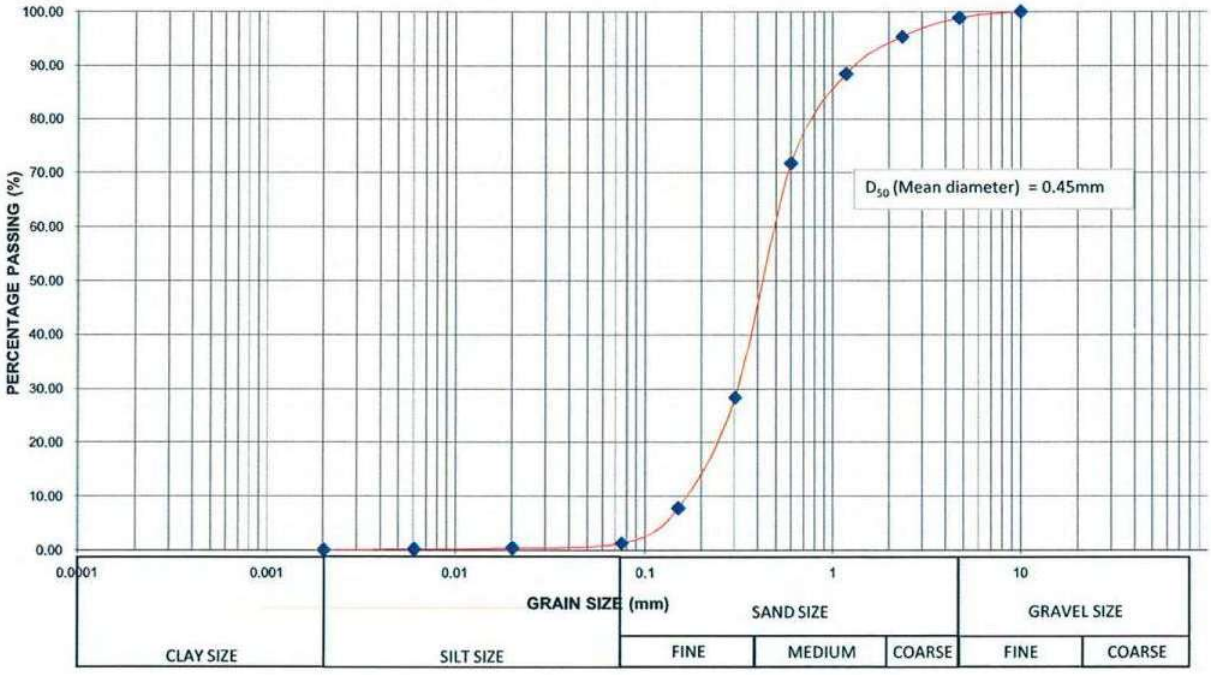

Fig. No.05: Particle size distribution curve of sample no. 5, Heo Dam Beach: Left bank

Grain Size Analysis

Project: Yarjep River HE Project
Location/ Sample ID: 6, Heo Dam Beach: Left bank
Weight of Sample received : 1116 g

Table No. 7: Result of Grain size Analysis of sample no. 6, Heo Dam Beach: Left bank

IS Sieve Designation	% Passing	Remarks
12.5mm	100.00	Dry Sieve Analysis
10mm	99.28	
4.75 mm	98.61	
2.36 mm	97.85	
1.18 mm	96.64	
600 µm	87.05	
300 µm	29.84	
150 µm	5.06	
75 µm	0.45	
20 µm	0.29	Wet Analysis (Pipette Method)
6 µm	0.11	
2 µm	0.05	

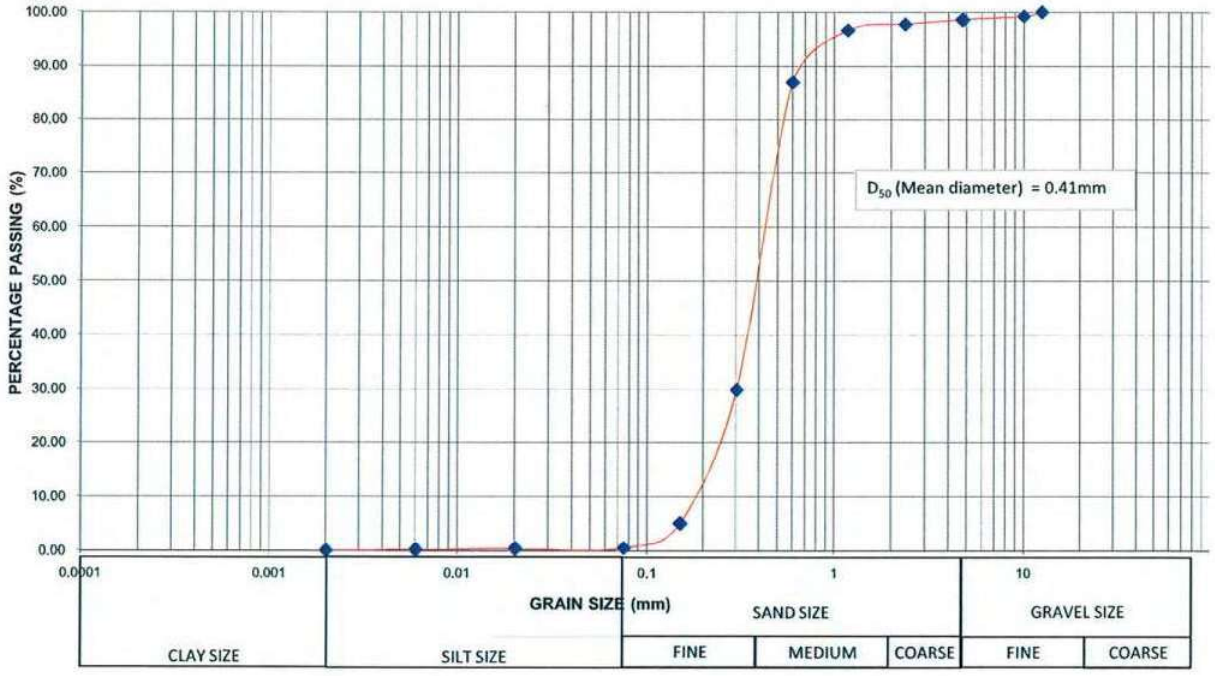

Fig. No.06: Particle size distribution curve of sample no. 6, Heo Dam Beach: Left bank

Grain Size Analysis

Project: Yarjep River HE Project
Location/ Sample ID: 7, Tato 1 Intake: Left bank
Weight of Sample received : 286.5 g

Table No. 8: Result of Grain size Analysis of sample no. 7, Tato 1 Intake: Left bank

IS Sieve Designation	% Passing	Remarks
12.5mm	100.00	Dry Sieve Analysis
10mm	89.01	
4.75 mm	59.86	
2.36 mm	39.97	
1.18 mm	28.10	
600 µm	20.42	
300 µm	12.04	
150 µm	4.71	
75 µm	1.05	
20 µm	0.29	Wet Analysis (Pipette Method)
6 µm	0.11	
2 µm	0.05	

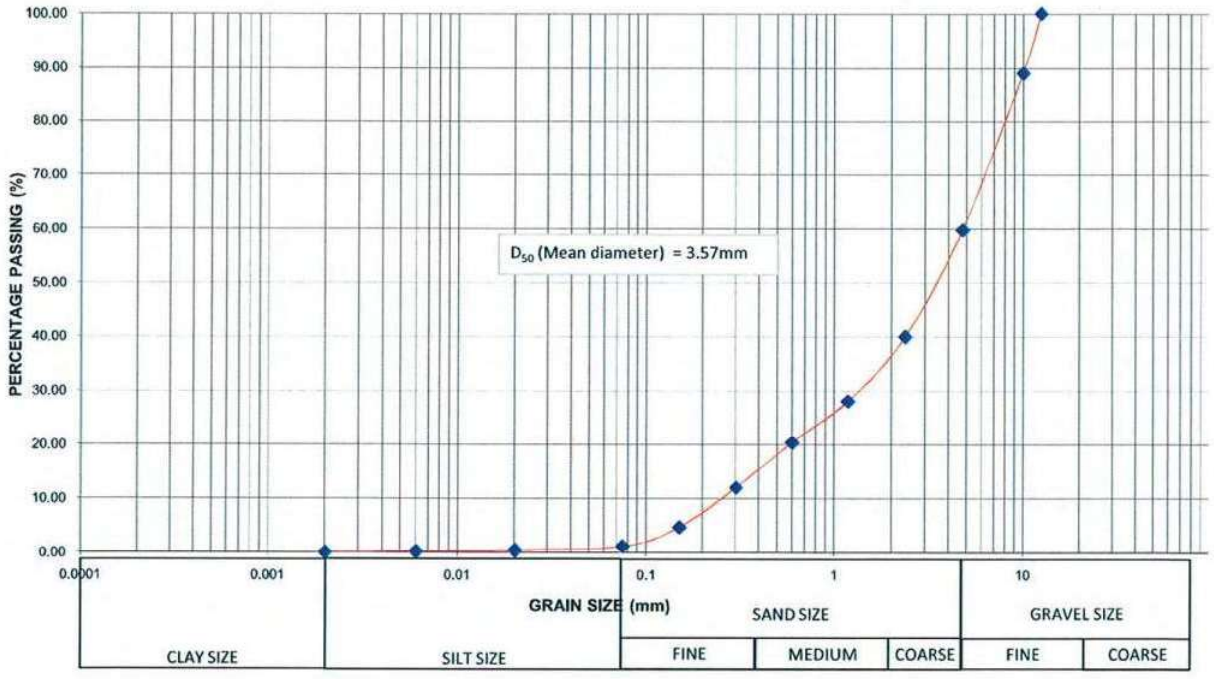

Fig. No.07: Particle size distribution curve of sample no. 7, Tato 1 Intake: Left bank

Grain Size Analysis

Project: Yarjep River HE Project
Location/ Sample ID: 8, Tato 1 Intake: Right bank
Weight of Sample received : 1015.5 g

Table No. 9: Result of Grain size Analysis of sample no. 8, Tato 1 Intake: Right bank

IS Sieve Designation	% Passing	Remarks
16mm	100.000	Dry Sieve Analysis
12.5mm	93.944	
10mm	89.069	
4.75 mm	74.495	
2.36 mm	59.478	
1.18 mm	43.476	
600 µm	26.194	
300 µm	14.279	
150 µm	6.844	
75 µm	1.182	
20 µm	0.060	Wet Analysis (Pipette Method)
6 µm	0.030	
2 µm	0.010	

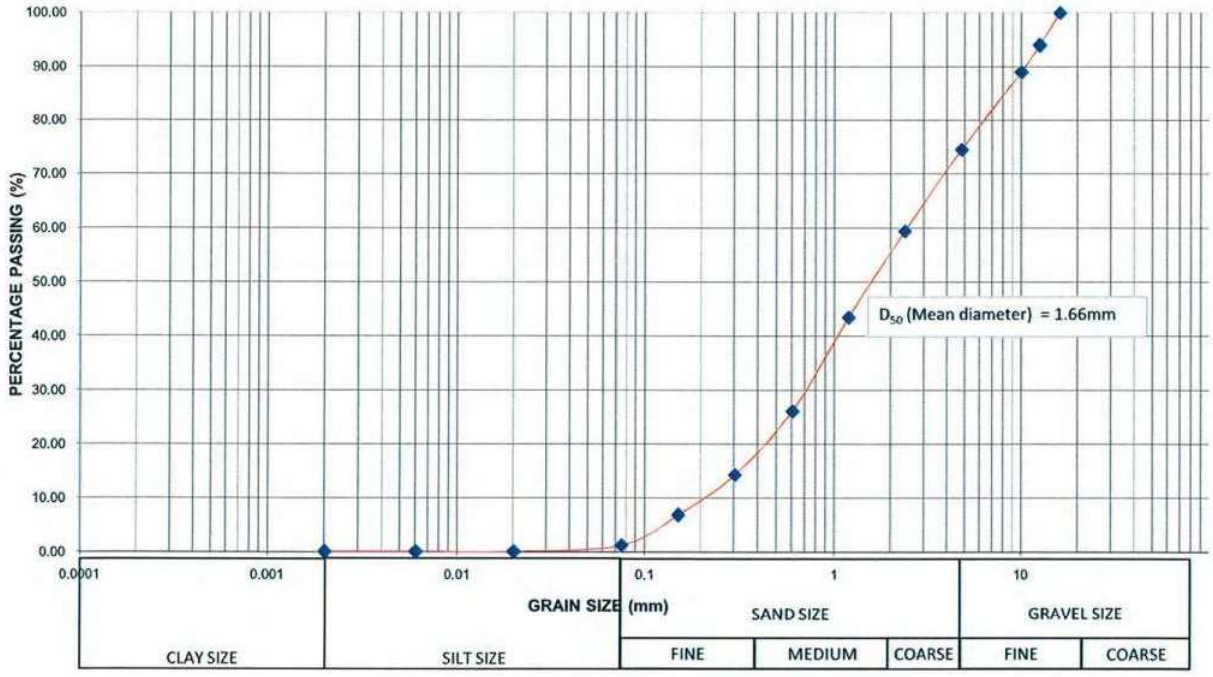

Fig. No.08: Grain size Analysis of sample no.8,Tato 1 Intake: Right bank

Grain Size Analysis

Project: Yarjep River HE Project
Location/ Sample ID: 53,
Weight of Sample received : 0.12 g

Table No. 10: Result of Grain size Analysis of sample no.53

IS Sieve Designation	% Passing	Remarks
150 µm	100.00	Dry Sieve Analysis
75 µm	43.00	
20 µm	0.00	Wet Analysis (Pipette Method)
6 µm	0.00	
2 µm	0.00	

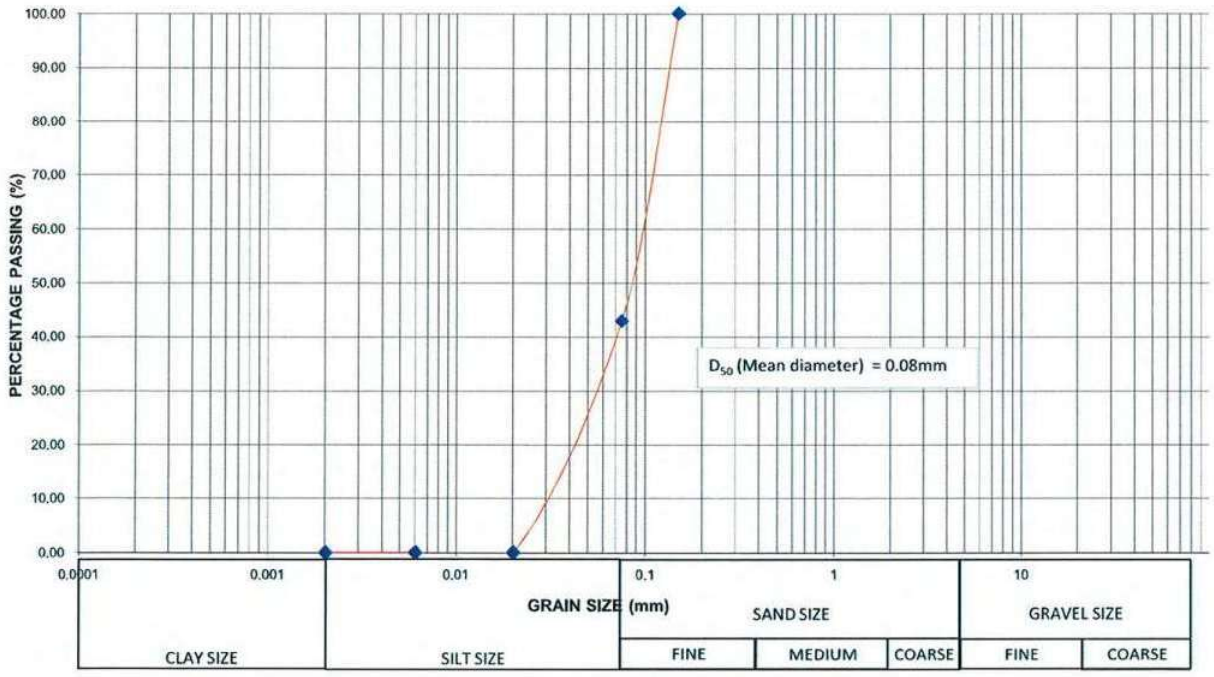

Fig. No.09: Particle size distribution curve of sample no.53

Grain Size Analysis

Project: Yarjep River HE Project
Location/ Sample ID: 54,
Weight of Sample received : 1.079 g

Table No. 11: Result of Grain size Analysis of sample no.54

IS Sieve Designation	% Passing	Remarks
150 µm	100.00	Dry Sieve Analysis
75 µm	51.00	
20 µm	19.83	Wet Analysis (Pipette Method)
6 µm	5.67	
2 µm	0.94	

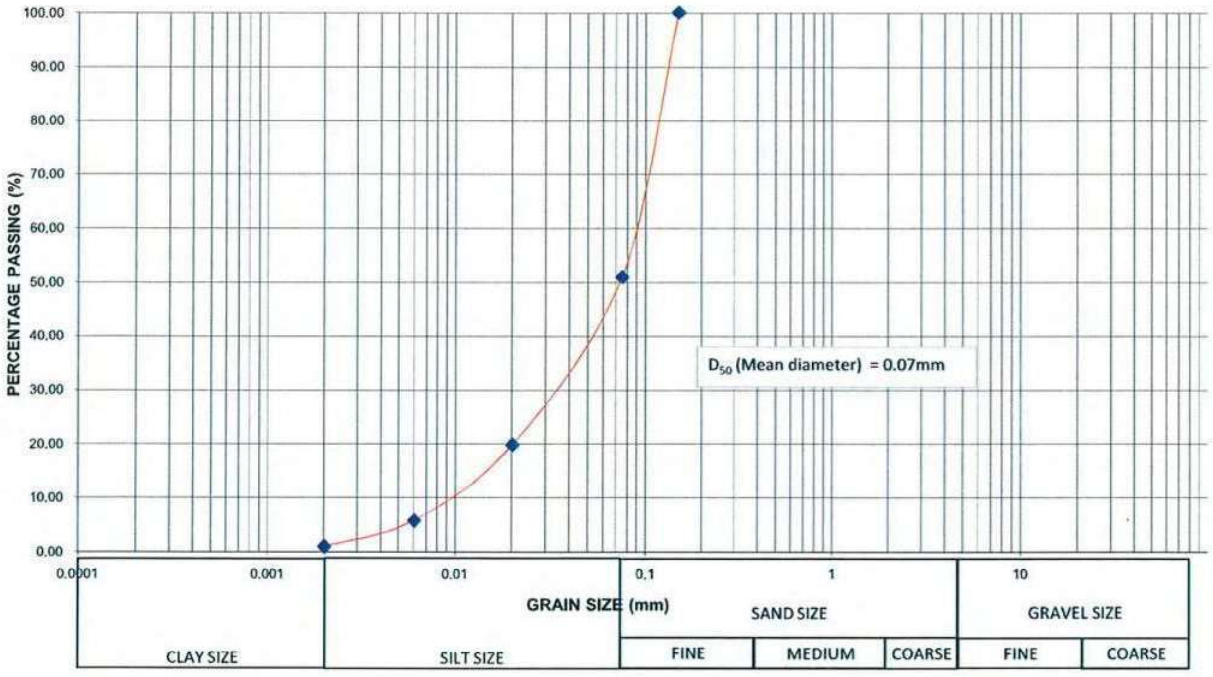

Fig. No.10: Particle size distribution curve sample no.54

Grain Size Analysis

Project: Yarjep River HE Project
Location/ Sample ID: 56,
Weight of Sample received : 0.183 g

Table No. 12: Result of Grain size Analysis of sample no.56

IS Sieve Designation	% Passing	Remarks
150 µm	100.00	Dry Sieve Analysis
75 µm	29.10	
20 µm	0.00	Wet Analysis (Pipette Method)
6 µm	0.00	
2 µm	0.00	

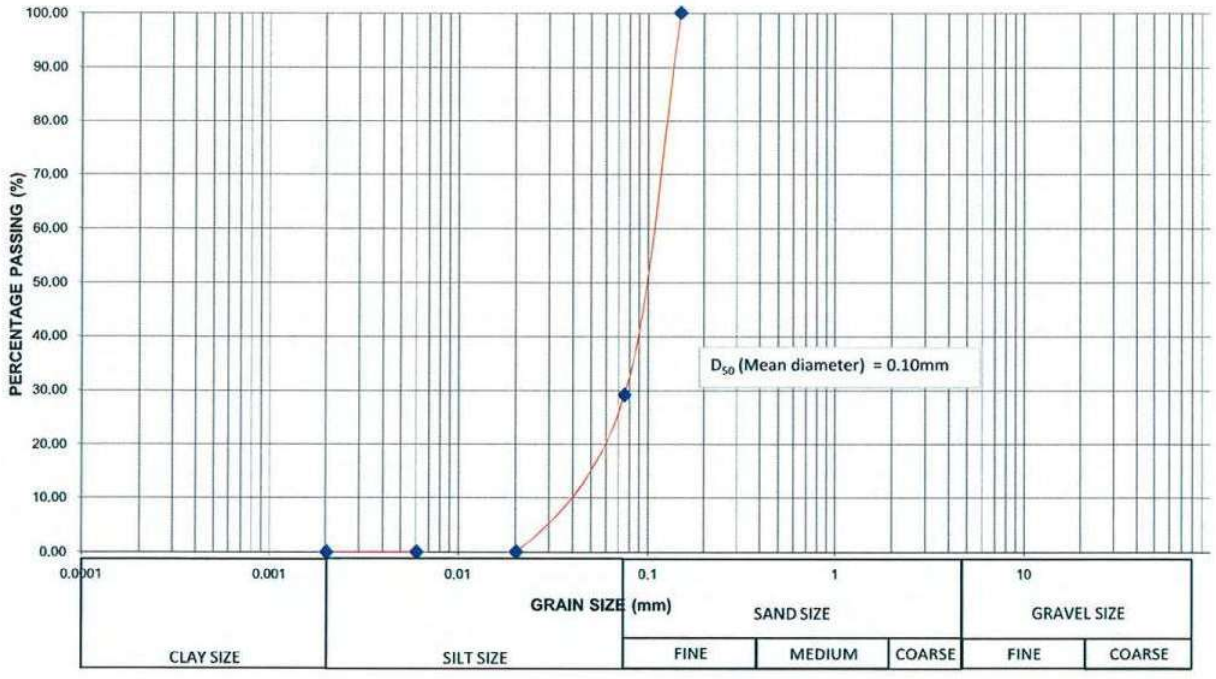

Fig. No.11: Particle size distribution curve of sample no.56

Grain Size Analysis

Project: Yarjep River HE Project
Location/ Sample ID: 57,
Weight of Sample received : 2.542 g

Table No. 13: Result of Grain size Analysis of sample no.57

IS Sieve Designation	% Passing	Remarks
150 µm	100.00	Dry Sieve Analysis
75 µm	85.80	
20 µm	45.77	Wet Analysis (Pipette Method)
6 µm	4.34	
2 µm	0.39	

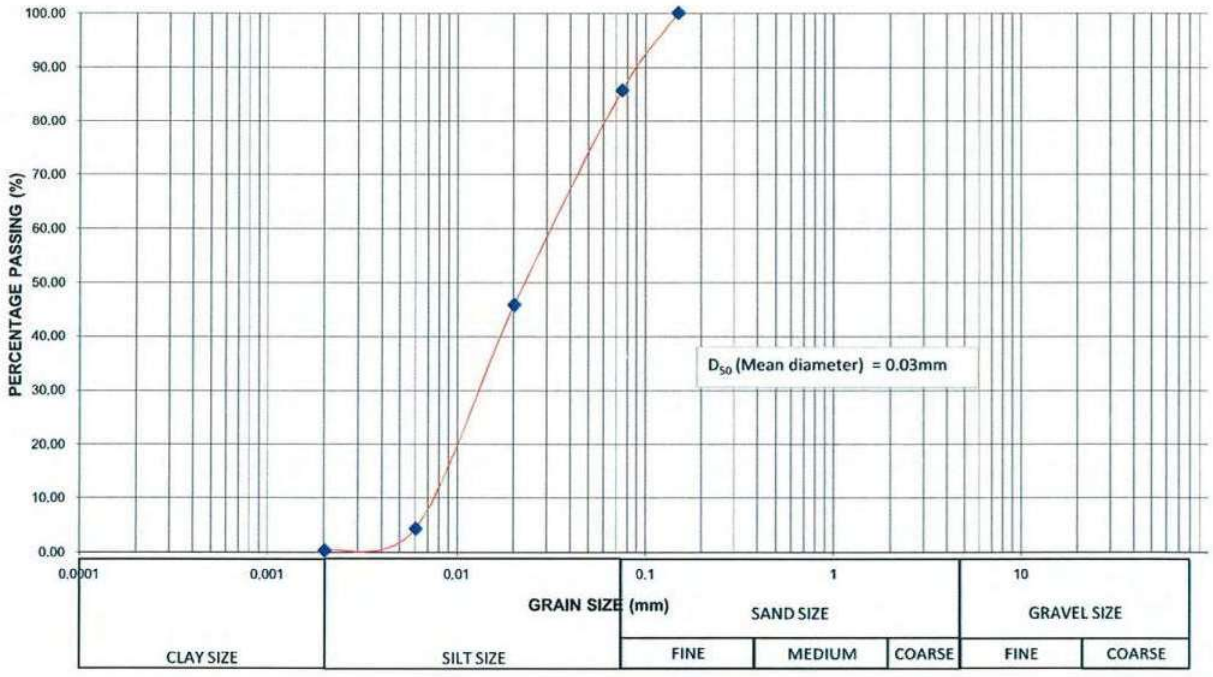

Fig. No.12: Particle size distribution curve of sample no.57

Grain Size Analysis

Project: Yarjep River HE Project
Location/ Sample ID: 58,
Weight of Sample received : 1.826 g

Table No. 14: Result of Grain size Analysis of sample no.58

IS Sieve Designation	% Passing	Remarks
150 µm	100.00	Dry Sieve Analysis
75 µm	85.80	
20 µm	45.77	Wet Analysis (Pipette Method)
6 µm	4.34	
2 µm	0.39	

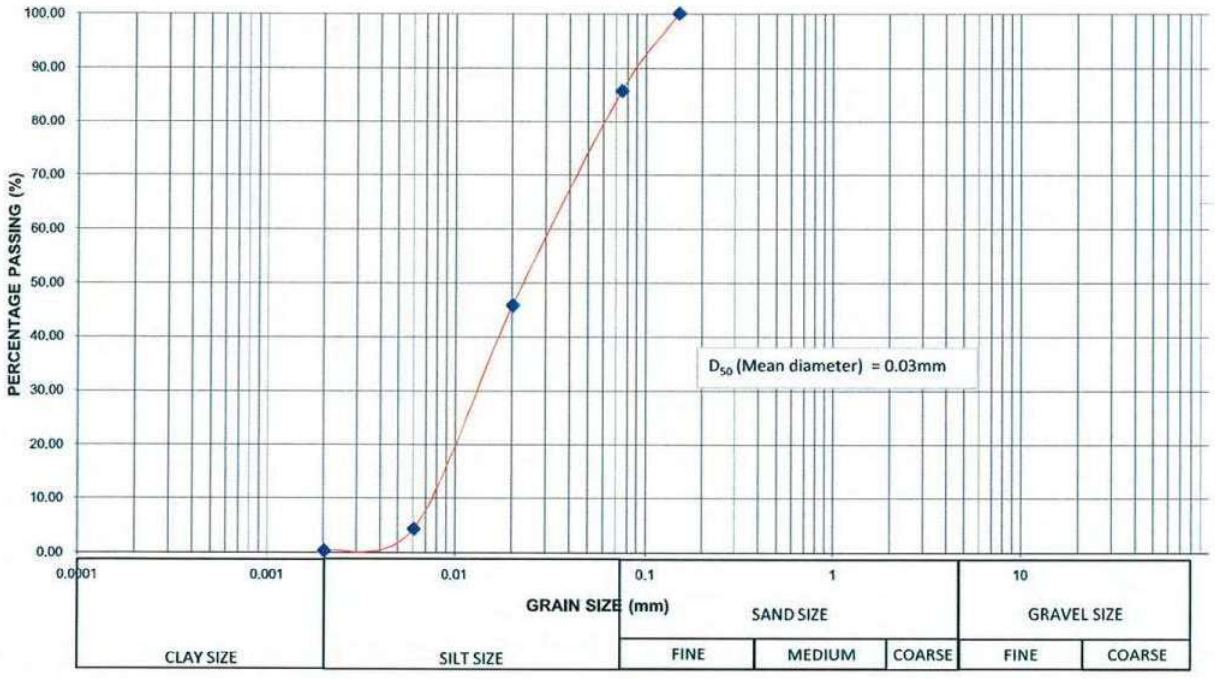

Fig. No.13: Particle size distribution curve of sample no.58

Grain Size Analysis

Project: Yarjep River HE Project
Location/ Sample ID: 59,
Weight of Sample received : 6.844 g

Table No. 15: Result of Grain size Analysis of sample no. 59

IS Sieve Designation	% Passing	Remarks
150 µm	100.00	Dry Sieve Analysis
75 µm	18.90	
20 µm	4.54	Wet Analysis (Pipette Method)
6 µm	1.61	
2 µm	0.15	

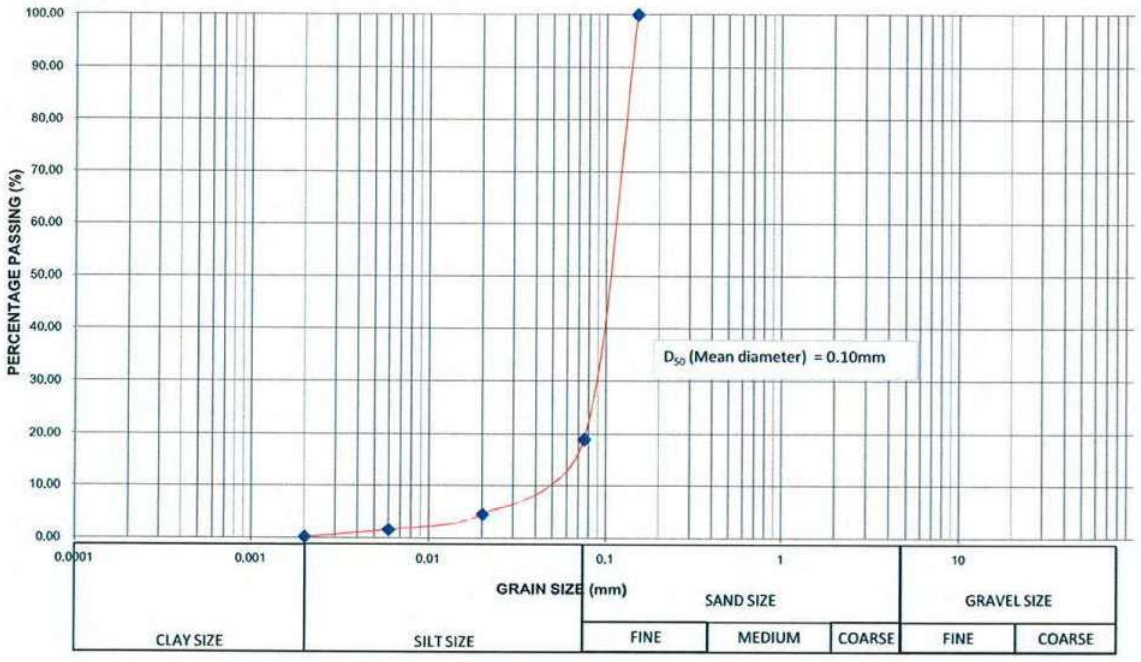

Fig. No.14: Particle size distribution curve of sample no. 59

Grain Size Analysis

Project: Yarjep River HE Project
Location/ Sample ID: 61,
Weight of Sample received : 1.758 g

Table No. 16: Result of Grain size Analysis of sample no. 61

IS Sieve Designation	% Passing	Remarks
150 µm	100.00	Dry Sieve Analysis
75 µm	20.50	
20 µm	7.69	Wet Analysis (Pipette Method)
6 µm	0.00	
2 µm	0.00	

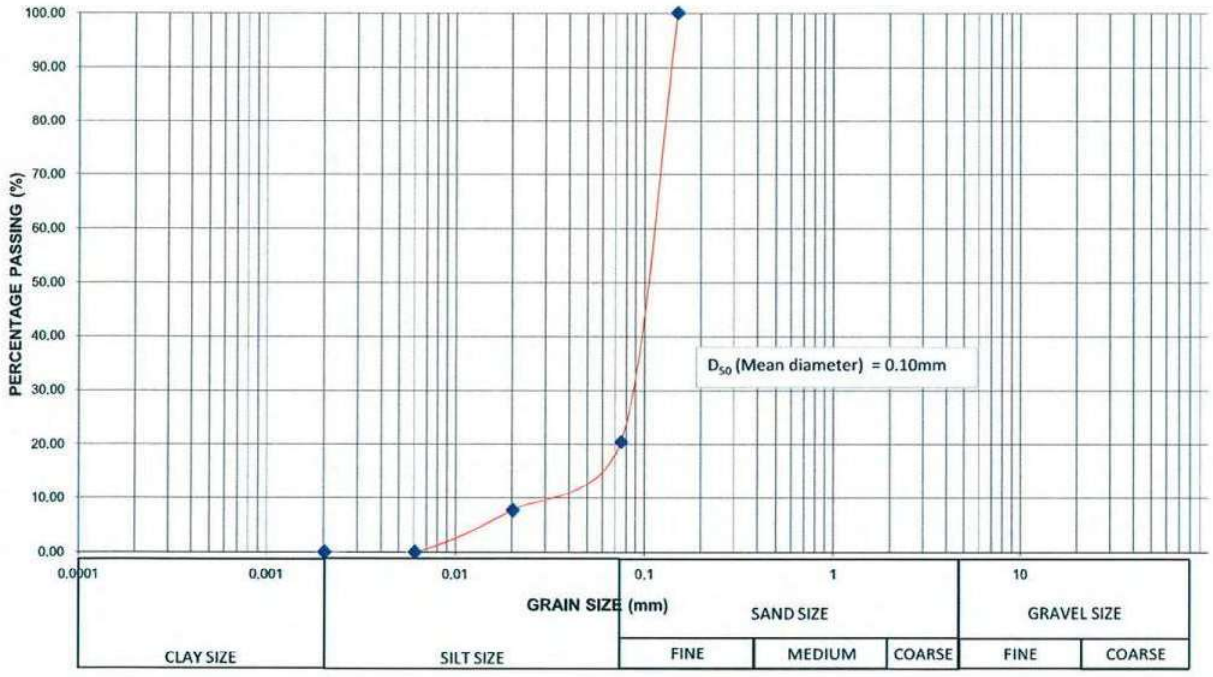

Fig. No.15: Particle size distribution curve of sample no. 61

Grain Size Analysis

Project: Yarjep River HE Project
Location/ Sample ID: 62,
Weight of Sample received : 0.438 g

Table No. 17: Result of Grain size Analysis of sample no. 62

IS Sieve Designation	% Passing	Remarks
150 µm	100.00	Dry Sieve Analysis
75 µm	43.40	
20 µm	0.00	Wet Analysis (Pipette Method)
6 µm	0.00	
2 µm	0.00	

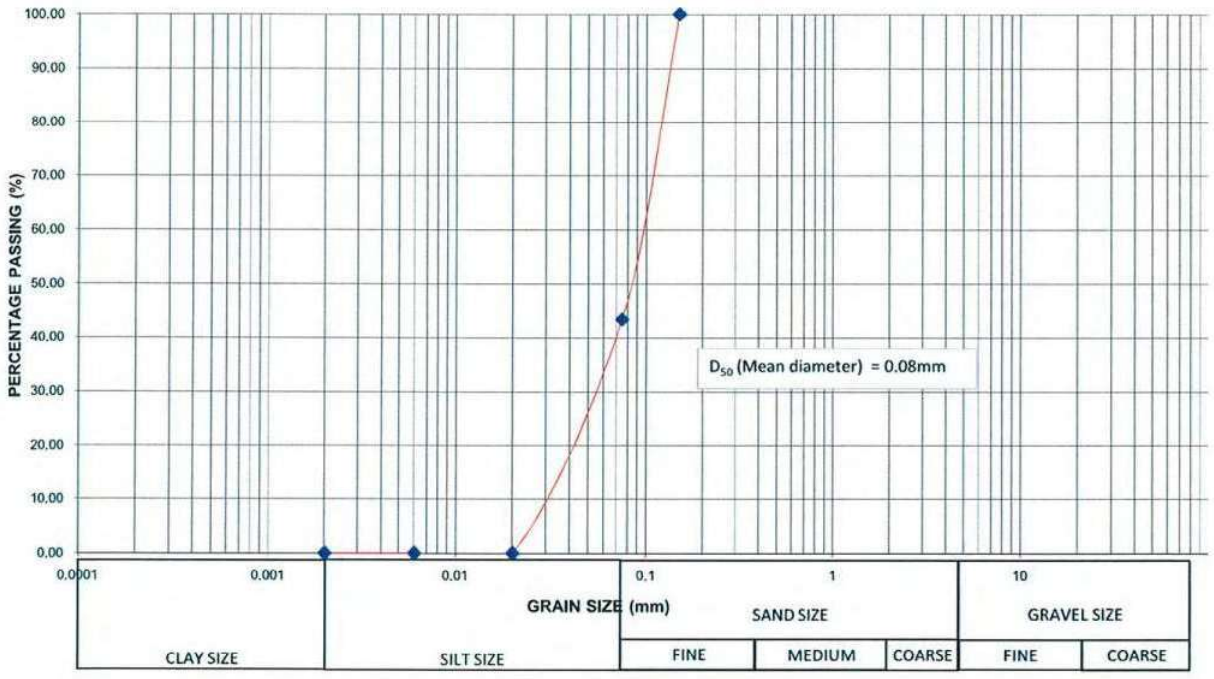

Fig. No.16: Particle size distribution curve of sample no. 62

Grain Size Analysis

Project: Yarjep River HE Project
Location/ Sample ID: 63,
Weight of Sample received : 2.312 g

Table No. 18: Result of Grain size Analysis of sample no. 63

IS Sieve Designation	% Passing	Remarks
150 µm	100.00	Dry Sieve Analysis
75 µm	25.20	
20 µm	11.73	Wet Analysis (Pipette Method)
6 µm	3.04	
2 µm	0.87	

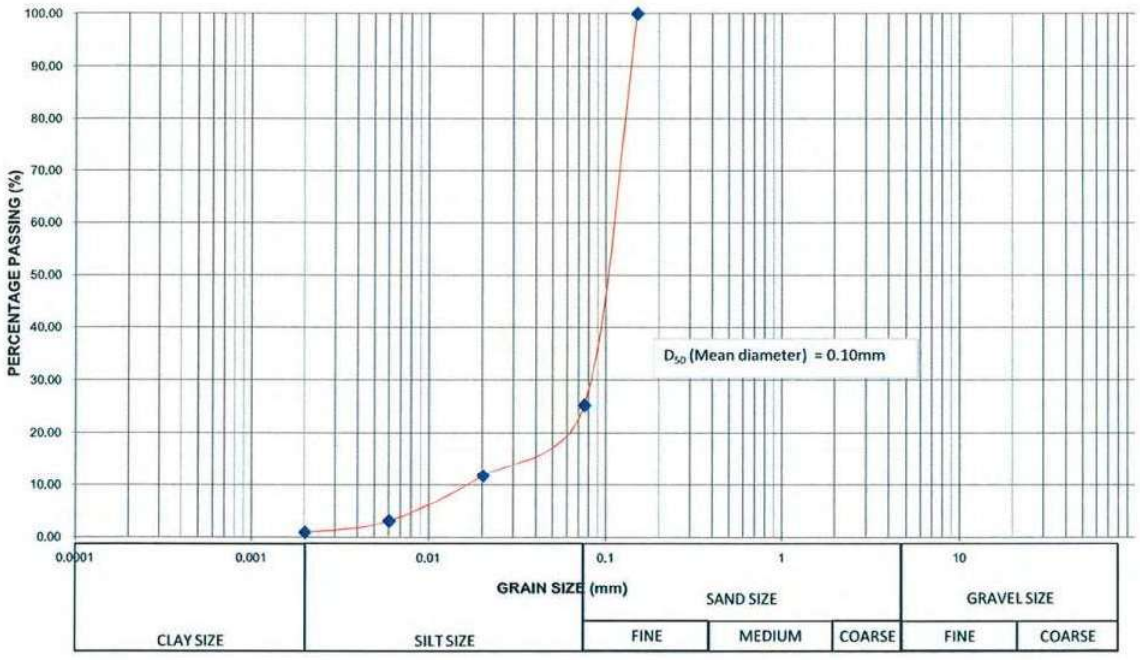

Fig. No.17: Particle size distribution curve of sample no. 63

Grain Size Analysis

Project: Yarjep River HE Project
Location/ Sample ID: 64,
Weight of Sample received : 0.434 g

Table No. 19: Result of Grain size Analysis of sample no. 64

IS Sieve Designation	% Passing	Remarks
150 µm	100.00	Dry Sieve Analysis
75 µm	10.40	
20 µm	0.00	Wet Analysis (Pipette Method)
6 µm	0.00	
2 µm	0.00	

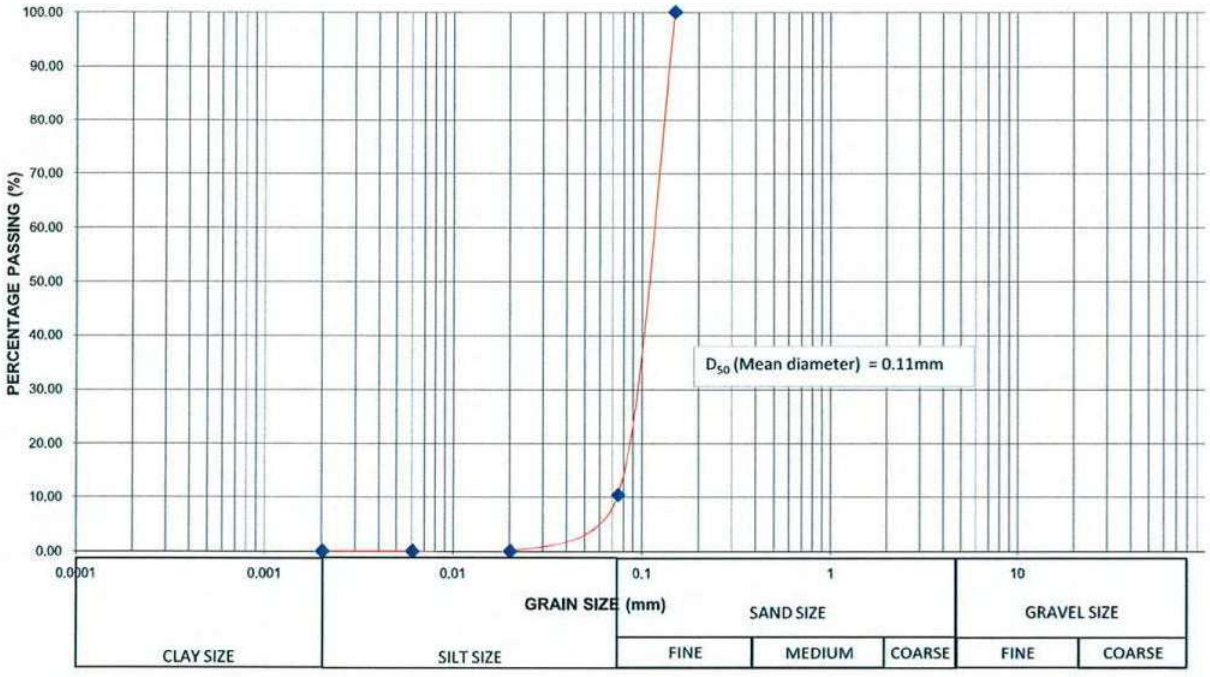

Fig. No.18: Particle size distribution curve of sample 64

Table-1: Grain Size Analysis

IS Sieve Designation	% Passing				
	Sample-1	Sample-2	Sample-3	Sample-4	Sample-5
25 mm	100.0	100.0	100.0	100.0	100.0
20 mm	100.0	96.7	100.0	100.0	100.0
16 mm	100.0	95.2	100.0	100.0	100.0
12.5 mm	100.0	94.0	100.0	100.0	100.0
10 mm	97.0	90.4	82.3	93.1	100.0
4.75 mm	87.5	76.8	55.1	77.0	98.7
2.36 mm	81.4	64.7	42.2	67.7	98.3
1.18 mm	77.9	47.1	31.6	62.5	97.0
600 µm	75.3	21.9	18.6	52.0	84.9
300 µm	53.2	4.3	6.3	21.4	35.6
150 µm	21.6	1.8	3.3	8.5	8.7
75 µm	5.6	1.3	2.2	4.0	2.4
Silt Content %	**5.6**	**1.3**	**2.2**	**4.0**	**2.4**

The sand samples did not contain clay fraction.

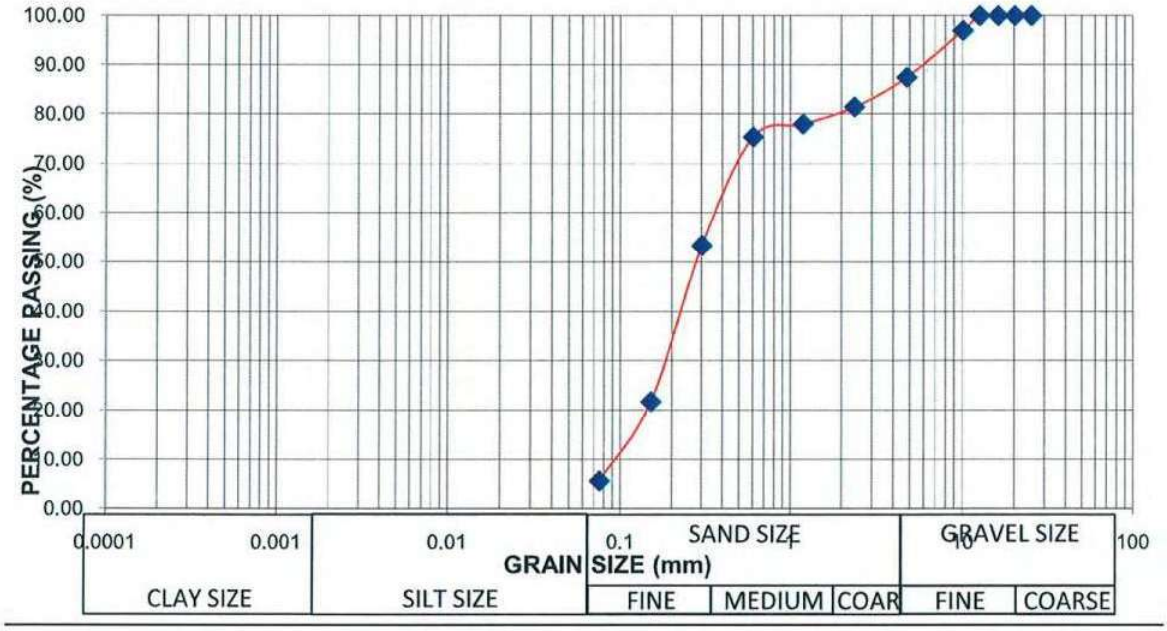

Fig.-1: Particle Size Distribution Curve of Sample-1

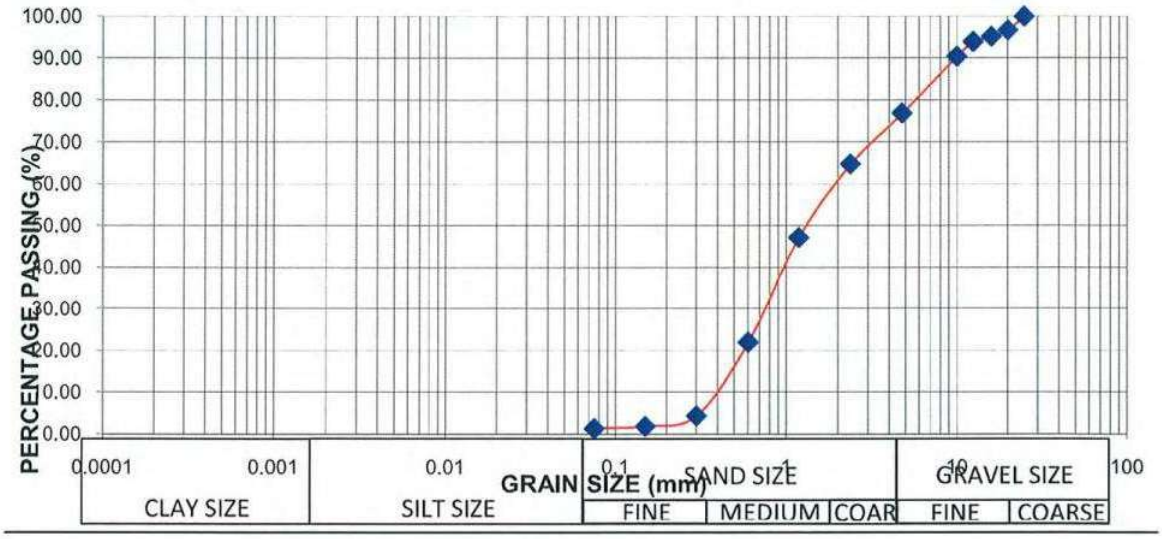

Fig.-2: Particle Size Distribution Curve of Sample-2

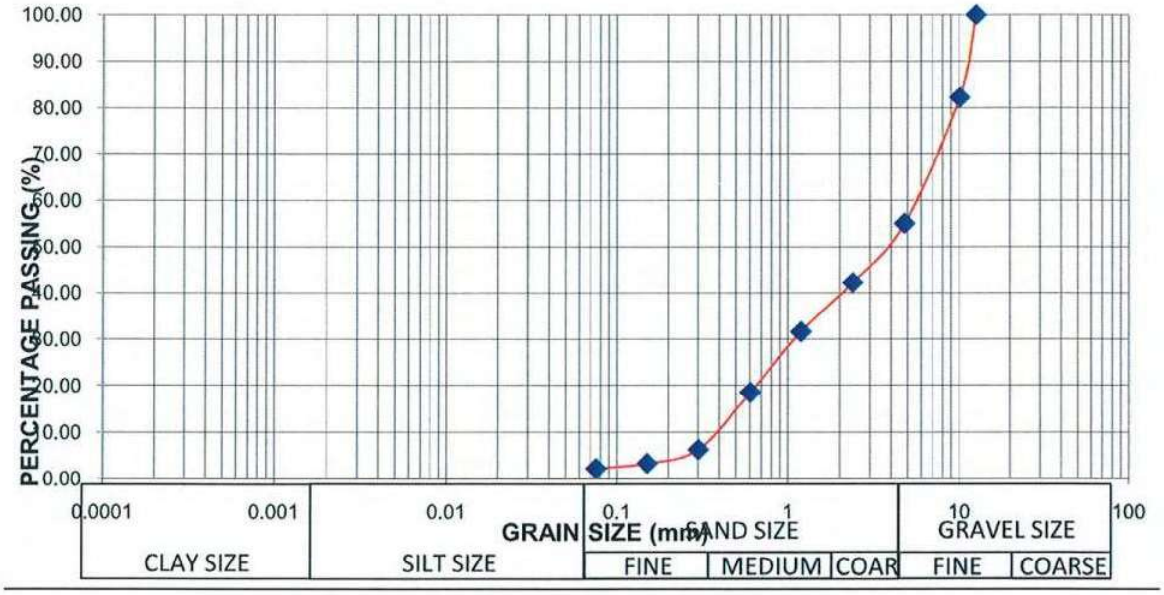

Fig.-3: Particle Size Distribution Curve of Sample-3

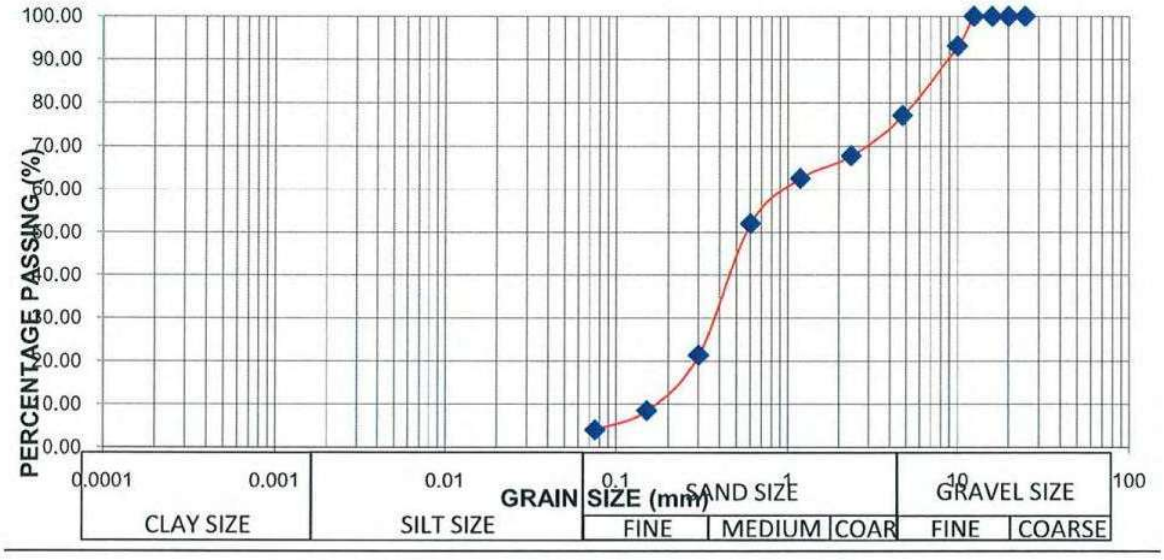

Fig.-4: Particle Size Distribution Curve of Sample-4

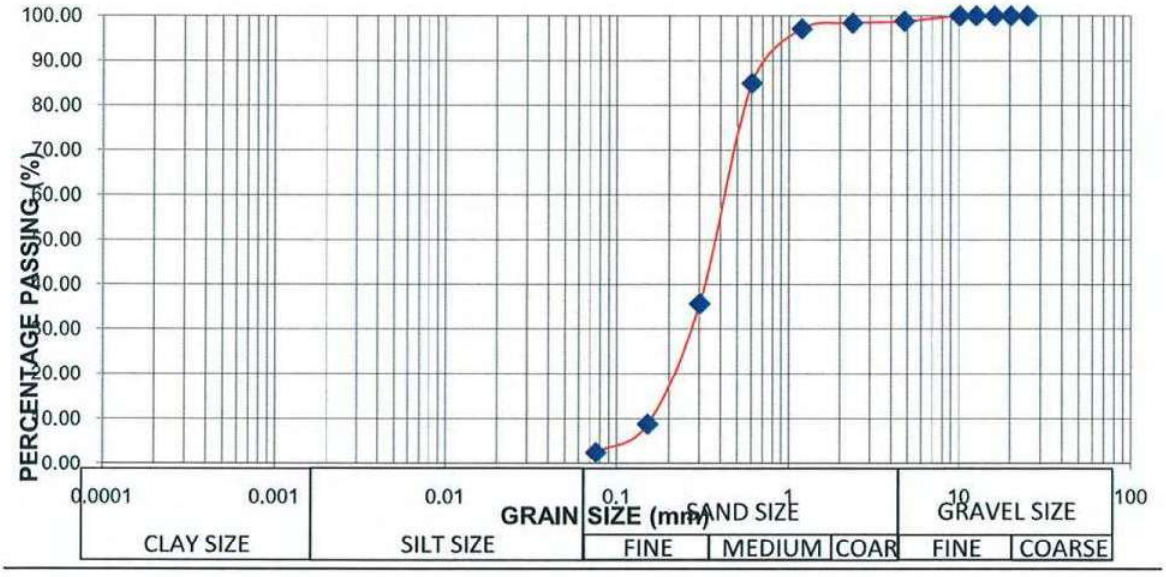

Fig.-5: Particle Size Distribution Curve of Sample-5

Aimil Testing Laboratory

Advanced Technology & Engineering Services

Corporate Office: Naimex House, A-8, Mohan Co-operative Industrial Estate, Mathura Road, New Delhi 110044, INDIA
Phone: 91-11-30810277/259, Fax: 91-11-26950011, Email: testinglab@aimil.com, atesdel@aimil.com, Website: www.aimil.com

Report No.: W-106
Date: 04/02/13

TEST REPORT

1.	**Material Tested**	:	Said to be Water (Lab Code: W/09-12/85/06/01 to 65)
2.	**Name of Client**	:	Velcan Energy India Pvt. Ltd. G-77, Sujan Singh Park, New Delhi-110003, India
3.	**Date of Receipt**	:	27/09/12
4.	**Condition of Sample**	:	ok
5.	**Date of Testing**	:	01/09/12-09/09/12
6.	**Environment Condition**	:	Temp. 27 ± 2° C; RH 60 ± 10%
7.	**Tested as per**	:	-
8.	**Results**	:	

A. Silt Concentration

Sl. No.	Sample ID (Puring)	Silt Concentration (ppm)
1	02/08/2012	2.0
2	03/08/2012	4.0
3	04/08/2012	1.0
4	05/08/2012	23.0
5	06/08/2012	12.0
6	07/08/2012	29.0
7	08/08/2012	112.0
8	09/08/2012	34.0
9	10/08/2012	28.0
10	11/08/2012	2311.0
11	12/08/2012	142.0
12	13/08/2012	100.0
13	14/08/2012	14.0
14	15/08/2012	17.0
15	16/08/2012	17.0
16	17/08/2012	37.0
17	18/08/2012	26.0
18	19/08/2012	15.0
19	20/08/2012	77.0
20	21/08/2012	64.0
21	22/08/2012	97.0
22	23/08/2012	102.0
23	24/08/2012	55.0
24	25/08/2012	114.0
25	26/08/2012	20.0
26	27/08/2012	7.0
27	28/08/2012	7.0
28	29/08/2012	1872.0
29	30/08/2012	1305.0
30	31/08/2012	1375.0

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Phone: 91-11-30810277/259, Fax: 91-11-26950011, Email: testinglab@aimil.com, atesdel@aimil.com, Website: www.aimil.com

Report No.: W-106
Date: 04/02/13

TEST REPORT

1. **Material Tested** : Said to be Water (Lab Code: W/09-12/85/06/01 to 65)

Sl. No.	Sample ID (Mechuka)	Silt Concentration (ppm)
1	24/07/2012	12.0
2	25/07/2012	656.0
3	26/07/2012	8.0
4	27/07/2012	8.0
5	28/07/2012	4.0
6	29/07/2012	10.0
7	30/07/2012	7.0
8	31/07/2012	2.0
9	07/08/2012	2.0
10	08/08/2012	669.0
11	09/08/2012	8.0
12	10/08/2012	29.0
13	11/08/2012	1259.0
14	12/08/2012	407.0
15	13/08/2012	9.0
16	14/08/2012	9.0
17	15/08/2012	1.0
18	16/08/2012	3.0
19	22/08/2012	167.0
20	23/08/2012	1.0
21	24/08/2012	131.0
22	25/08/2012	1023.0
23	29/08/2012	1.0
24	31/08/2012	1449.0

Tested By

Checked By

Approved By

Name: NITIN KOSHTA
Designation: Dy. Assignment Manager

P.T.O.: Terms & Conditions

Corporate **Office:** Naimex House, A-8, Mohan Co-operative Industrial Estate, Mathura Road, New Delhi 110044, INDIA
Phone: 91-11-30810277/259, Fax: 91-11-26950011, Email: testinglab@aimil.com, atesdel@aimil.com, Website: www.aimil.com

Report No.: W-108
Date: 04/01/13

TEST REPORT

1.	**Material Tested**	:	Said to be Water (Lab Code: W/12-12/124/08/01 to 57)
2.	**Name of Client**	:	Velcan Energy India Pvt. Ltd. G-77, Sujan Singh Park, New Delhi-110003, India
3.	**Date of Receipt**	:	6/12/12
4.	**Condition of Sample**	:	ok
5.	**Date of Testing**	:	12/12/12 – 21/12/12
6.	**Environment Condition**	:	Temp. 27 ± 2° C; RH 60 ± 10%
7.	**Tested as per**	:	IS 2386-Part-1-1963, IS 2386-Part-8-1963
8.	**Results**	:	

A. Silt Concentration

Sl. No.	Sample ID (Mechuka)	Silt Concentration (ppm)
1	16/09/2012	217.0
2	17/09/2012	863.0
3	18/09/2012	228.0
4	19/09/2012	154.0
5	21/09/2012	310.0
6	22/09/2012	104.0
7	23/09/2012	18.0
8	24/09/2012	550.0
9	25/09/2012	171.0
10	26/09/2012	16.0
11	30/09/2012	8.0
12	01/10/2012	16.0
13	02/10/2012	10.0
14	03/10/2012	12.0
15	05/10/2012	12.0
16	06/10/2012	62.0
17	10/10/2012	8.0
18	11/10/2012	16.0
19	12/10/2012	470.0
20	13/10/2012	756.0
21	14/10/2012	15.0
22	16/10/2012	20.0

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Phone: 91-11-30810277/259, Fax: 91-11-26950011, Email: testinglab@aimil.com, atesdel@aimil.com, Website: www.aimil.com

Report No.: W-108
Date: 04/01/13

TEST REPORT

1. **Material Tested** : Said to be Water (Lab Code: W/12-12/124/08/01 to 57)

Sl. No.	Sample ID (Puring)	Silt Concentration (ppm)
1	16/09/2012	75.0
2	17/09/2012	75.0
3	18/09/2012	135.0
4	19/09/2012	1100.0
5	20/09/2012	1897.0
6	21/09/2012	1243.0
7	22/09/2012	799.0
8	23/09/2012	113.0
9	24/09/2012	77.0
10	25/09/2012	1880.0
11	26/09/2012	1081.0
12	27/09/2012	1926.0
13	28/09/2012	1954.0
14	29/09/2012	1080.0
15	30/09/2012	1744.0
16	01/10/2012	1261.0
17	02/10/2012	1205.0
18	03/10/2012	977.0
19	04/10/2012	667.0
20	05/10/2012	1520.0
21	06/10/2012	570.0

B. For grain size analysis result please sees annexure A.
C. For petrographic analysis result please see annexure B.

Tested By **Checked By** **Approved By**

Name: NITIN KOSHTA
Designation: Dy. Assignment Manager

P.T.O.: Terms & Conditions

ANNEXURE-A

(Grain Size Distribution)

Sample ID	IS Sieve Designation	% Passing
Mechuka Water Samples	10 mm	100.000
	6.3 mm	100.000
	4.75 mm	100.000
	2.36 mm	100.000
	1.18 mm	100.000
	600 µm	98.249
	300 µm	94.261
	150 µm	79.435
	75 µm	49.825
	63.2 µm	41.043
	50.2 µm	32.012
	44.7 µm	27.794
	35.5 µm	20.474
	25.2 µm	12.730
	15.9 µm	7.141
	10.0 µm	4.320
	7.1 µm	3.064
	6.4 µm	2.750
	5.0 µm	2.244
	4.5 µm	2.045
	3.2 µm	1.583
	2.0 µm	1.179
	1.0 µm	0.673
	0.9 µm	0.577
	0.8 µm	0.468
	0.7 µm	0.359
	0.6 µm	0.256
	0.5 µm	0.083
	0.4 µm	0.000

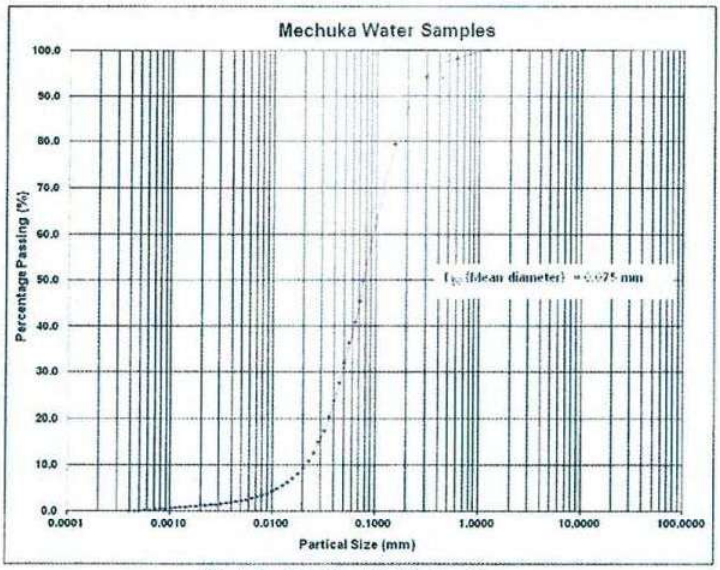


Fig. 1 Particle Size Distribution Curve

Sample ID	IS Sieve Designation	% Passing
Puring Water Samples	10 mm	100.000
	6.3 mm	100.000
	4.75 mm	100.000
	3.35 mm	100.000
	2.36 mm	100.000
	1.18 mm	100.000
	600 µm	95.101
	300 µm	90.786
	150 µm	70.608
	75 µm	40.050
	63.2 µm	30.661
	50.2 µm	21.753
	44.7 µm	17.907
	35.5 µm	11.854
	25.2 µm	6.655
	15.9 µm	3.932
	10.0 µm	2.557
	7.1 µm	1.806
	6.4 µm	1.616
	5.0 µm	1.318
	4.5 µm	1.209
	3.2 µm	0.974
	2.0 µm	0.745
	1.0 µm	0.396
	0.9 µm	0.327
	0.8 µm	0.252
	0.7 µm	0.183
	0.6 µm	0.120
	0.5 µm	0.011
	0.4 µm	0.000

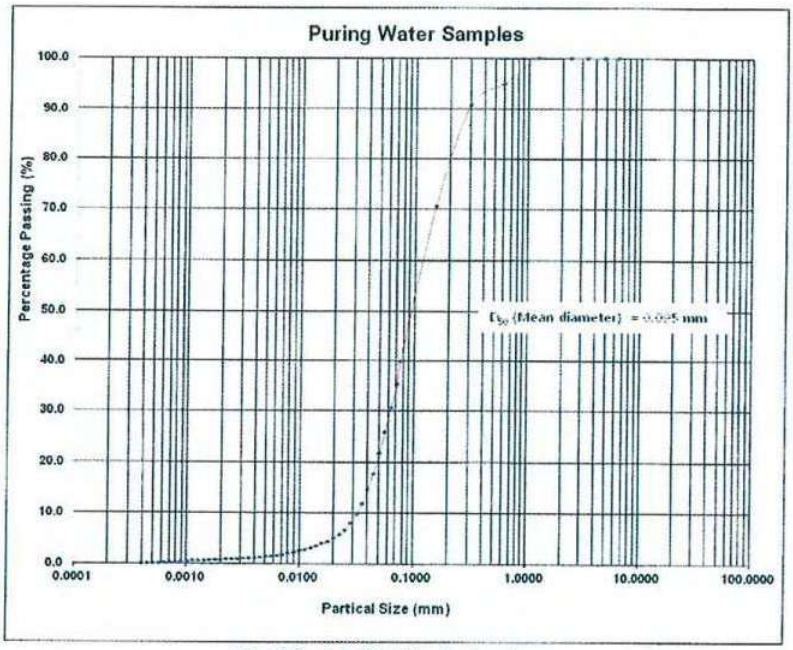


Fig. 2 Particle Size Distribution Curve

ANNEXURE- B
(Petrographic Analysis)

1. **Sender's sample no.** : Mechuka Water Samples
2. **Field name of sample, if any (assigned by the sender)** : Silt
3. **Nature of the sample** : River borne sediments
4. **Location of the sample** : Mechuka Site
5. **Lab code** : W/12-12/124/08/01-57
6. **Laboratory name of the sample (assigned by the present study)** : Silt (river borne sediments)

Grain Size Analysis:

Table-1 shows grain size analysis of the sample. From this table it is clear that the grain size varies from 0.600 mm to -0.075 mm (pan). It is evident from the suspended material at above location; the fractions (i.e. 0.150 mm & 0.075 mm) constitute a major part of the sample that is about 44.44% of the suspended sediments. For microscopic studies two fractions namely 0.150 mm & 0.075 mm have been selected as they are most appropriate for textural studies. Graphical representation clearly brings out the weight % and grain size fraction relationship.

Table –1 Grain Size Analyses – Mechuka Water Samples

Weight of Total Sample taken: 11.709 g

IS Sieve Designation	Sediment Grain Size Classification (Wentworth 1922)	% Retained	Cumulative % Retained	% Passing
4.75 mm	Pebble	0.0	0.0	100.000
3.35 mm	Granule	0.0	0.0	100.00
2.36 mm	Granule	0.0	0.0	100.000
1.18 mm	Very Coarse Sand	0.0	0.0	100.000
600 µm	Coarse Sand	1.75	1.75	98.249
300 µm	Medium Sand	3.99	5.74	94.261
150 µm	Fine Sand	14.83	20.57	79.435
75 µm	Silt	29.61	50.18	49.825
-75 µm	Silt + Clay	49.82	100.00	0.000

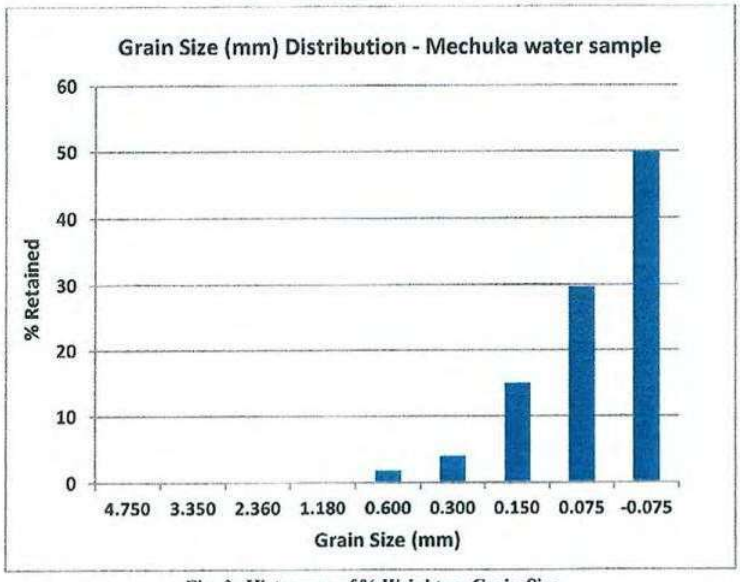


Fig. 3: Histogram of % Weight vs. Grain Size

Petrographic Analysis:

Megascopic Study of the sample (Study aid –naked eye & hand lens)

It is composed of loose grains of fine sand to fine silt. It is brown sand with white sheen imparted by the presence of white mica and black specks due to presence of biotite and other ferro-magnesium minerals. The given sample is river borne sediment.

Microscopic Study of the sample (Study aids – Computer interfaced high resolution polarizing microscope with photographic attachment)

Under microscope the grain mounts comprise of quartz, feldspar, mica (muscovite & biotite), hornblende, magnetite, kyanite and lithic fragments. Most of the quartz grains and lithic fragments are angular to sub angular in shape while feldspar grains appear sub rounded. Some of the grains of quartz have thin veins of ferruginous material. Hornblende grains are pleochroic in shades of light green and are sub-angular. The extinction angle of the quartz grains cannot be determined due to unnatural orientation. Biotite mica flakes are pleochroic in shades of yellowish brown and have broken edges. A few grains of kyanite are present only in +150μ size fraction and are angular to sub-angular in shape. Opaque minerals are sub angular to sub rounded. Grain morphometry is quite explicit from the photomicrographs.

Table -2 represents the different minerals identified, their hardness (H, as per Moh's scale) and modal percentage (VE).

* ***It is suggested that the suspended sediments samples should be collected periodically i.e. pre-monsoon, monsoon and post monsoon, so as to get the actual nature and content of suspended load of sediments during the year.***

Table - 2 Mineralogical composition (in %) of sediments of suspended material

Sample No.	Grain Size (μ)	Quartz/ Lithic fragments (H*=7) (Sp** 2.65)	Feldspar, (H*=6-6.5) (Sp**2.57-2.76)	Hornblende (H*=5.5) (Sp** 3.05-3.47)	Mica (H*=2.5-4) (Sp** 2.7-3.0)	Magnetite (H*=5.5-6.5) (Sp** 4.9 - 5.2)	Kyanite (H*=4.5-6.5) (Sp** 3.58)
1	+150	69-71	6-8	2-4	15-16	2-4	1-2
2	+75	62-64	8-10	4-6	20-22	1-3	-

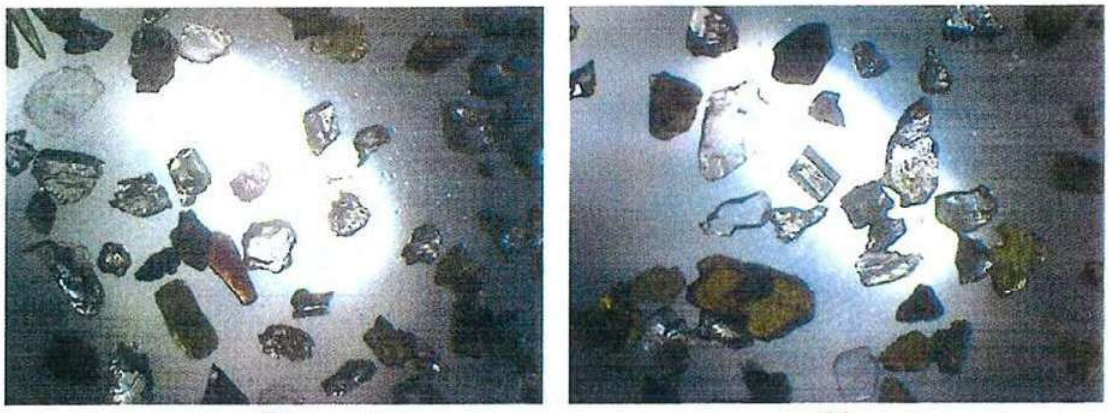
Abbreviations used:

H*: Hardness & Sp** Specific gravity: given values are standard for the minerals, and not the measured ones.

PHOTMICROGRAPHS

(i) *(ii)*

Fig. 4 Mgf X40 (+150 microns): Angular to sub-Angular grains of quartz, mica flakes and lithic fragments. Note some of the grains are coated with iron oxides.



(iii) *(iv)*

Fig. 5 Mgf: X40 (+75 microns): Angular to sub-angular grains of quartz, feldspar and mica flake. Note some of the grains are coated with iron oxides.

1. **Sender's sample no.** : Puring Water Samples
2. **Field name of sample, if any (assigned by the sender)** : Silt
3. **Nature of the sample** : River borne sediments
4. **Location of the sample** : Puring Site
5. **Lab code** : W/12-12/124/08/01-57
6. **Laboratory name of the sample (assigned by the present study)** : Silt (river borne sediments)

Grain Size Analysis:

Table-3 shows grain size analysis of the sample. From this table it is clear that the grain size varies from 0.600 mm to -0.075 mm (pan). It is evident from the suspended material at above location; the fractions (i.e. 0.150 mm & 0.075 mm) constitute a major part of the sample that is about 50.74% of the suspended sediments. For microscopic studies two fractions namely 0.150 mm & 0.075 mm have been selected as they are most appropriate for textural studies for the suspended sediments. Graphical representation clearly brings out the weight % and grain size fraction relationship. The grain size analysis suggests that the sample collected is quiet heterogeneous which is evident from the histogram plot as well.

Table - 3 Grain Size Analyses

Weight of Total Sample taken: 60.017 g

IS Sieve Designation	Sediment Grain Size Classification (Wentworth 1922)	% Retained	Cumulative % Retained	% Passing
4.75mm	Pebble	0.00	0.00	100.000
3.35mm	Granule	0.00	0.00	100.000
2.36mm	Granule	0.00	0.00	100.000
1.18mm	Very Coarse Sand	0.00	0.00	100.000
600µm	Coarse Sand	4.90	4.90	95.101
300µm	Medium Sand	4.32	9.21	90.786
150µm	Fine Sand	20.18	29.39	70.608
75µm	Silt	30.56	59.95	40.050
-75µm	Silt + Clay	40.04	100.00	0.000

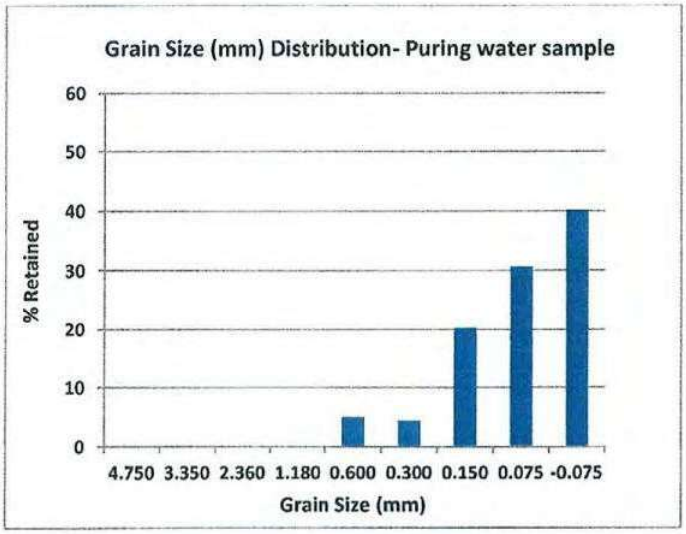


Fig. 6: Histogram of Weight % vs. Grain Size

Petrographic Analysis:

Megascopic Study of the sample (Study aid –naked eye & hand lens)

It is composed of loose grains of fine sand to fine silt along with a few grains of granule size. It is brown sand with white sheen imparted by the presence of white mica and black specks due to presence of biotite and other ferro-magnesium minerals. The given sample is river borne sediment. Most of the grains are sub angular to sub rounded as identified with the help of hand lens.

Microscopic Study of the sample (Study aids – Computer interfaced high resolution polarizing microscope with photographic attachment)

Under the microscope the minerals identified in the 0.150mm & 0.075mm fractions are quartz, feldspar, mica (biotite and muscovite), magnetite, lithic fragments and hornblende, however kyanite and garnet are reported in addition in 0.150mm fraction. Kyanite occurs in the form of blades with angular to sub-angular margin. Garnet grains are angular to sub-angular. Biotite mica flakes are pleochroic in shades of yellowish brown and have broken edges. Hornblende grains are prismatic in shape. Most of the grains of quartz, feldspar and lithic fragments are angular to sub angular, whereas opaque minerals are sub angular to sub rounded. The extinction angle of the quartz grains cannot be determined due to unnatural orientation. Some of the grains of quartz have thin veins of ferruginous material. Grain morphometry is quite explicit from the photomicrographs.

Table -2 represents the different minerals identified, their hardness (H, as per Moh's scale) and modal percentage (VE).

* ***It is suggested that the suspended sediments samples should be collected periodically i.e. pre-monsoon, monsoon and post monsoon, so as to get the actual nature and content of suspended load of sediments during the year.***

Table - 4 Mineralogical composition (in %) of sediments of suspended material

Sample No.	Grain Size (μ)	Quartz/ Lithic fragments (H*=7) (Sp** 2.65)	Feldspar, (H*=6-6.5) (Sp**2.57-2.76)	Hornblende (H*=5.5) (Sp** 3.05-3.47)	Mica (H*=2.5-4) (Sp** 2.7-3.0)	Magnetite (H*=5.5-6.5) (Sp** 4.9 - 5.2)	Kyanite (H*=4.5-6.5) (Sp** 3.58)	Garnet (H*=6.5-7.5) (Sp** 3.1-4.3)
1	+150	65-67	5-7	2-4	18-20	2-4	1-2	1-2
2	+75	66-68	8-10	4-6	16-18	1-3	-	-

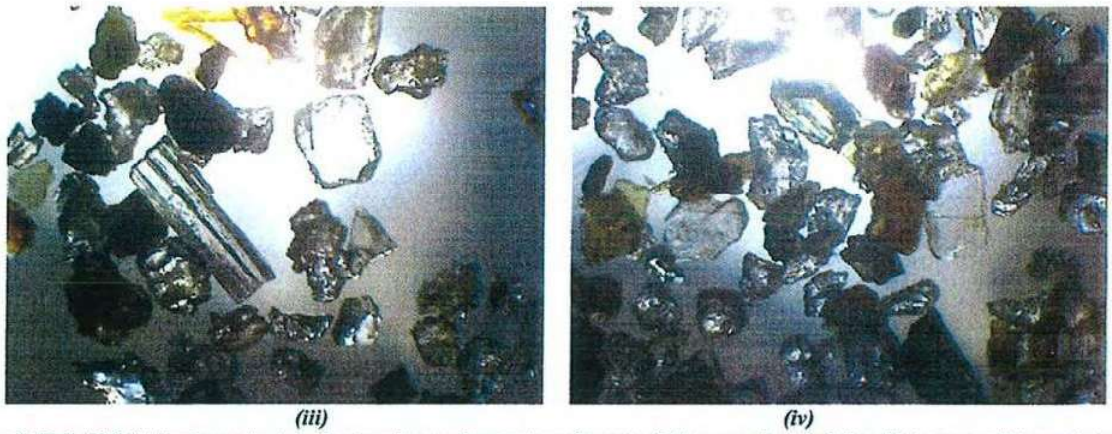
Abbreviations used:

H*: Hardness & Sp** Specific gravity: given values are standard for the minerals, and not the measured ones.

PHOTMICROGRAPHS

(i) *(ii)*

Fig. 7 Mgf X40 (+150 microns): Angular to sub-Angular grains of quartz, mica flakes and lithic fragments. Note some of the grains are coated with iron oxides.



(iii) *(iv)*

Fig. 8 Mgf: X40 (+75 microns): Angular to sub-angular grains of quartz, feldspar and mica flake. Note some of the grains are coated with iron oxides.

ANNEXURE-IV B

Report on

Petrography of suspended slit Sediments collected from Yarjep River for Heo HE Project, Arunachal Pradesh

Submitted by,

Dept. of Applied Geology

Dibrugarh University

Dibrugarh, Assam

1. PARTICLE SIZE ANALYSIS:

The statistical parameter grain size plays a crucial role in characterizing cumulative curves and facilitating numerical comparisons related to grain size and depositional conditions. These parameters can be computed using the moment method (Krumbein and Pettijohn, 1938) or the graphic method (Folk and Ward, 1957; Folk, 1961). In this study, graphic method is primarily employed to describe the grain size distribution of the sample name Heo Hap 1 [HH1(a), HH1(b), HH1(c)] & Heo Hap 2 [HH2(a), HH2(b), HH2(c)] within the context of Yarjep River sediments. (in Table 1 & 2 and Figure 1)

Granulometric analysis was conducted on each sample three times, with the average of these measurements taken as the definitive result; each analysis used identical samples, each weighting 50 grams.

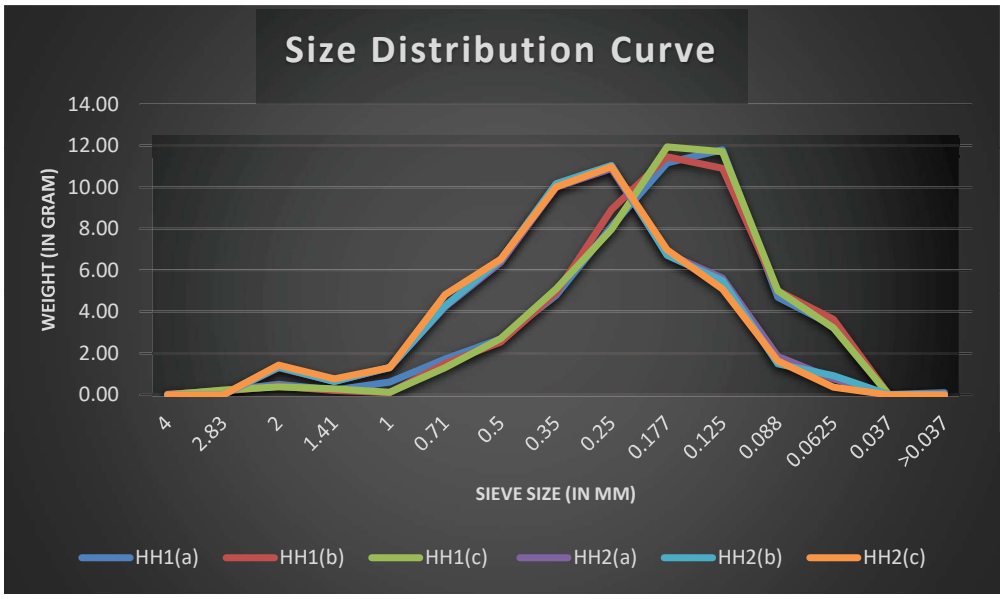


Figure 1: Size Distribution Curve

Sieve Size	5	7	10	14	18	25	35	45	60	80	120	170	230	325	PAN	TOTAL
in mm	4.000	2.830	2.000	1.410	1.000	0.710	0.500	0.350	0.250	0.177	0.125	0.088	0.063	0.037	>0.037	(-)
HH1(a)	0.016	0.200	0.500	0.225	0.625	1.725	2.691	4.793	8.100	11.172	11.805	4.695	3.338	0.006	0.100	49.990
HH1(b)	0.022	0.192	0.420	0.210	0.105	1.498	2.540	4.913	8.930	11.465	10.915	5.002	3.643	0.001	0.003	49.857
HH1(c)	0.000	0.228	0.395	0.289	0.110	1.305	2.705	5.094	7.975	11.935	11.705	5.007	3.212	0.000	0.002	49.960
Average	0.013	0.207	0.438	0.241	0.280	1.509	2.645	4.933	8.335	11.524	11.475	4.901	3.397	0.002	0.035	49.936

Table no. 1: Sieve Analysis of Heo Hap 1

Sieve Size	5	7	10	14	18	25	35	45	60	80	120	170	230	325	PAN	TOTAL
in mm	4.000	2.830	2.000	1.410	1.000	0.710	0.500	0.350	0.250	0.177	0.125	0.088	0.063	0.037	>0.037	(-)
HH2(a)	0.000	0.000	1.301	0.645	1.299	4.225	6.373	10.000	10.901	6.815	5.628	1.850	0.768	0.002	0.000	49.807
HH2(b)	0.000	0.000	1.325	0.650	1.312	4.290	6.500	10.180	11.045	6.703	5.491	1.492	0.925	0.007	0.000	49.919
HH2(c)	0.000	0.000	1.428	0.758	1.295	4.829	6.540	10.009	10.991	6.987	5.100	1.635	0.356	0.000	0.000	49.926
Average	0.000	0.000	1.351	0.684	1.302	4.448	6.471	10.063	10.979	6.835	5.406	1.659	0.683	0.003	0.000	49.884

Table no. 2: Sieve Analysis of Heo Hap 2

INTERPRETATION:

A. for the sample no. Heo Hap 1 [Average of HH1(a), HH1(b), HH1(c)]

1. The provided sample consists of granular grains restrained in sieve mesh number 5-10, corresponding to 2-4 mm is 1.32%.
2. The provided sample consists of very coarse sand grains restrained in sieve mesh number 14-18, corresponding to 1.41- 1 mmi s 1.04%.
3. The provided sample consists of coarse sand grains restrained in sieve mesh number 25-35, corresponding to 0.71- 0.5 mm is 8.33%.
4. The provided sample includes medium-sized sand grains restrained in sieve mesh number 45-60, corresponding to 0.35-0.25 mm is 26.57%.
5. Additionally, the sample comprises fine-sized sand grains restrained in sieve mesh numbers 80-120, corresponding to 0.177- 0.125 mm is 46.035%.
6. In sieve mesh numbers 170-230, corresponding to 0.088- 0.0625 mm, there are 16.6% of very fine sand grains restrained, respectively.
7. In sieve mesh number 325 and less, corresponding to 0.044 mm and less, there are 0.1% of silt restrained, respectively.

B. for the sample no. Heo Hap 2 [Average of HH2(a), HH2(b), HH2(c)]

1. The provided sample consists of granular grains restrained in sieve mesh number 5-10, corresponding to 2-4 mm is 2.71%.
2. The provided sample consists of very coarse sand grains restrained in sieve mesh number 14-18, corresponding to 1.41- 1 mm is 3.97%.
3. The provided sample consists of coarse sand grains restrained in sieve mesh number 25-35, corresponding to 0.71- 0.5 mm is 21.89%.
4. The provided sample includes medium-sized sand grains restrained in sieve mesh number 45-60, corresponding to 0.35-0.25 mm is 42.18%.
5. Additionally, the sample comprises fine-sized sand grains restrained in sieve mesh numbers 80-120, corresponding to 0.177- 0.125 mm is 24.54%.
6. In sieve mesh numbers 170-230, corresponding to 0.088- 0.0625 mm, there are 4.69% of very fine sand grains restrained, respectively.
7. In sieve mesh number 325 and less, corresponding to 0.044 mm and less, there are no grains of silt restrained.

CONCLUSION:

In conclusion, the granulometric analysis of the Heo Hap 1 and Heo Hap 2 samples reveals distinct sediment characteristics within the Yarjep River system, illustrating variations in grain size distribution and depositional environment. Heo Hap 1 is predominantly composed of fine to medium sand grains, while Heo Hap 2 exhibits a relatively higher content of coarser to medium sand grains, indicating differing hydrodynamic conditions at their respective depositional sites. The use of the graphic method has provided a detailed understanding of the particle size distribution, enabling insights into the sedimentological processes shaping these river sediments. Given that a considerable amount of granular, very coarse sand, along with coarse sand grains, has been detected in the samples, there is substantial doubt regarding their classification as suspended load. Additionally, the silt content appears very low in both the samples, further intensifying this scepticism. The fine sand found in both samples indicates the presence of sediments derived from the suspended load sediments, while the granular and coarser sands observed in both samples suggest sediments associated with the bedding load sediments.

2. PETROGRAPHIC ANALYSIS (Total Silt content in percentage):

For petrographic studies, samples were collected from the Yarjep River section of Arunachal Pradesh.

Analysis: To prepare thin sections of river sediments, one must initially select a representative portion of the samples using the coning and quartering method. Subsequently, the samples are subjected to sieving in a machine to separate grain sizes and eliminate unwanted materials intertwined with the samples. For the purpose of analysis, samples were meticulously chosen to ensure the consistent and representative nature of each constituent. In this analysis concentrated on examining distribution of predominant mineral types against the grain size distributions. To achieve this, slides were prepared for each sample, from coarse grains to finer grains. From the given each sample, three (03) thin section slides are prepared and studies under the Petrographic Microscope. Each sample were named as HH1(X), HH1(Y), HH1(Z) for sample Heo Hap 1 and HH2(X), HH2(Y), HH2(Z) for sample Heo Hap 2. Upon successful verification, the slides are deemed suitable for petrographic analysis.

From the provided samples, a total of three (03) thin section slides are meticulously crafted and subjected to examination beneath the Petrographic Microscope. Employing the Model Counting method as delineated by Carver (Robert E., 1971) in "Procedures in Sedimentary Petrology" (pp. 79-88, Published by John Wiley & Sons, Inc., New York), a systematic point counting approach is adopted. This method facilitates the acquisition of statistical measurements pertaining to the constituent minerals, namely Quartz, Mica, Feldspar and other Minerals. These measurements are quantified as percentages and meticulously documented in Table 3 & 4 and Figure 2.

Slide No.	Quartz	Mica Minerals	Feldspar Minerals	Other Minerals	Total
HH1X	51.85	37.20	5.25	5.70	100.00
HH1Y	50.94	37.78	4.98	6.30	100.00
HH1Z	53.06	35.74	4.70	6.50	100.00
Average	51.95	36.91	4.98	6.17	100.00

Table 3: Point counting of Slides of Heo Hap 1

Slide No.	Quartz	Mica Minerals	Feldspar Minerals	Other Minerals	Total
HH2X	55.38	38.35	2.94	3.33	100.00
HH2Y	56.21	38.65	2.50	2.64	100.00
HH2Z	55.95	37.98	1.92	4.15	100.00
Average	55.85	38.33	2.45	3.37	100.00

Table 4: Point counting of Slides of Heo Hap 2

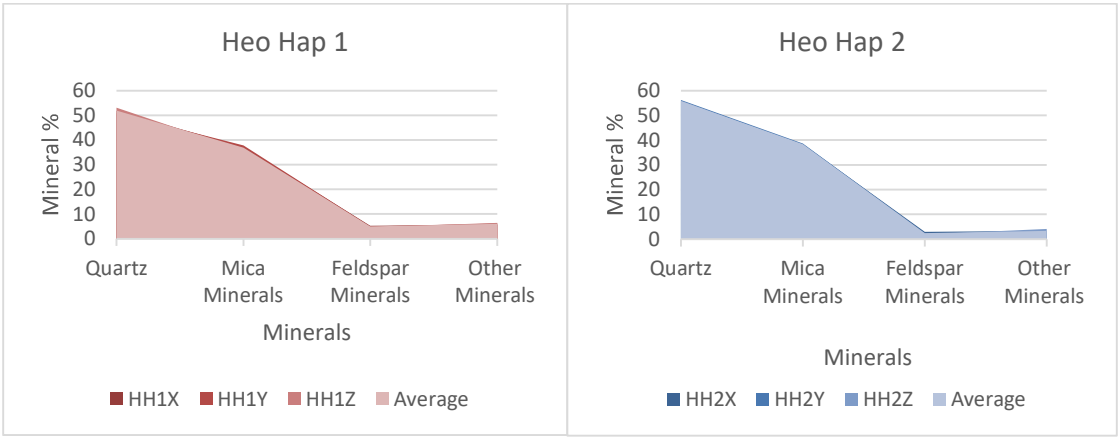


Figure 2: Gain Distribution Diagram

INTERPRETATION FOR TABLE NO. 1:

This table provides a summary of mineral composition across three slides (HH1X, HH1Y, and HH1Z) from a rock sample, showing the percentage of each mineral type (Quartz, Mica, Feldspar, and Other Minerals) in the sample.

1. Quartz: Quartz is the dominant mineral, averaging around 51.95%.

2. Mica Minerals: Mica minerals, which make up an average of 36.91%, are the second most abundant group.

3. Feldspar Minerals: The feldspar content averages at 4.98%, which is relatively low.

4. Other Minerals: This category, averaging 6.17%, likely includes accessory minerals and potentially heavy minerals. Here, Hornblende and pyroxene are observed in little greater

abundance, while rutile, chlorite, tourmaline, and amphibole are present in comparatively lower quantities. The percentage of heavy minerals found in this samples is significantly lower compared to the abundance of quartz and mica minerals.

INTERPRETATION FOR TABLE NO. 2:

This table details the mineral composition across three slides (HH2X, HH2Y, and HH2Z) from a rock sample, indicating the percentage distribution of Quartz, Mica, Feldspar, and Other Minerals.

1. Quartz: Quartz is the most abundant mineral, with an average of 55.85%.
2. Mica Minerals: Mica minerals are the second most prominent component, averaging 38.33%.
3. Feldspar Minerals: Feldspar content is relatively low, averaging only 2.45%.
4. Other Minerals: The 'Other Minerals' category averages at 3.37%, which includes minor or accessory minerals. In this sample, hornblende, Rutile and pyroxene are present in slightly higher amounts, while rutile, chlorite, tourmaline, and amphibole appear in comparatively smaller quantities. As like as table no. 1, the percentage of heavy minerals is notably lower than the abundance of quartz and mica minerals.

CONCLUSION:

The petrographic analysis of the Yarjep River sediments from samples HH1 and HH2 reveals little distinct mineralogical compositions and textural differences. HH2 displays a higher quartz content (average 55.85%) compared to HH1 (average 51.95%), suggesting a more mature or quartz-enriched sedimentary source in HH2. Mica content remains relatively consistent across both sample sets, indicating stable depositional condition or metamorphic provenance favoring mica retention. The greater feldspar abundance in HH1 (average 4.98%), specifically of microcline and plagioclase, suggests a closer proximity to a feldspathic source, potentially less weathered than HH2, which shows signs of more advanced alteration with reduced feldspar levels. Furthermore, HH1 contains slightly more accessory minerals, with hornblende and pyroxene prevalent, whereas HH2 has fewer accessory phases. These observations imply varying weathering history and metamorphic provenance for each sample.

PHOTOMICROGRAPH OF THE THIN SECTION OF SLIDES

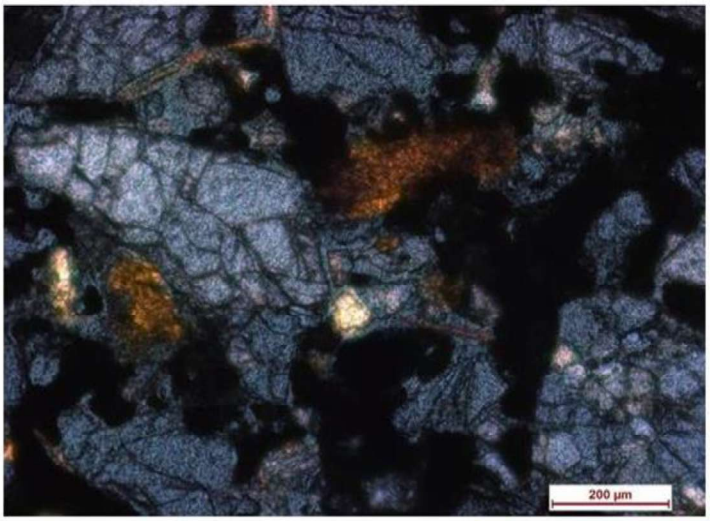


Figure 3: Polycrystalline quartz and Mica Minerals

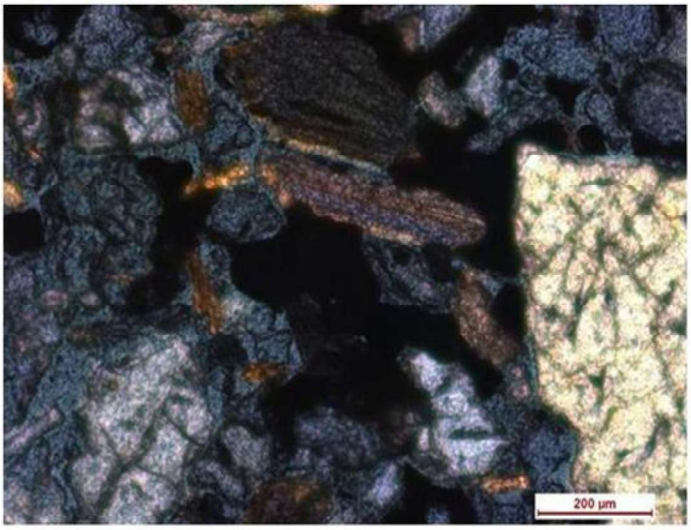


Figure 4: Quartz, Feldspar and Mica Grains

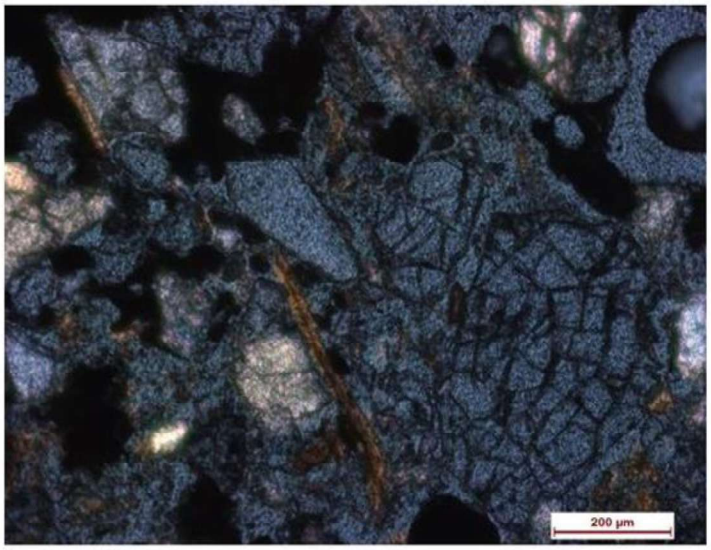
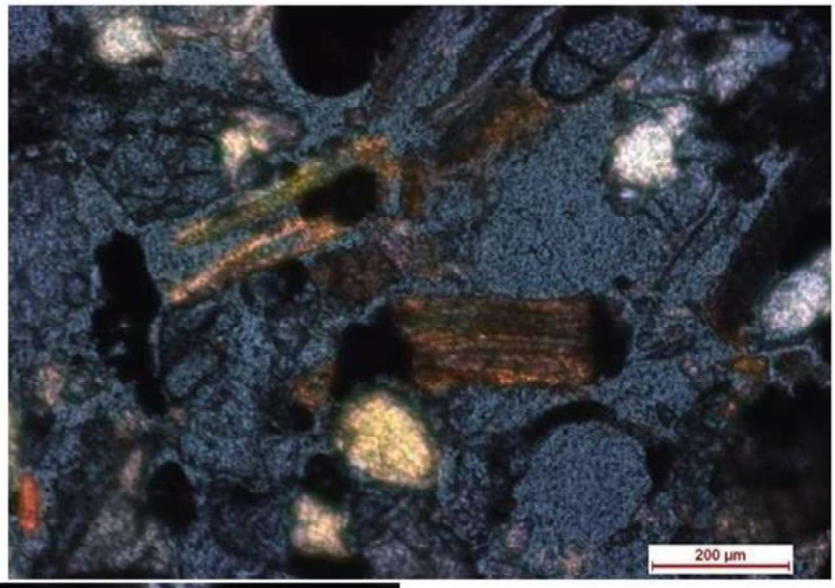


Figure 5: Quartz, Mica and Heavy Minerals Grains

Figure 6: Quartz, Mica and Hornblende Grains



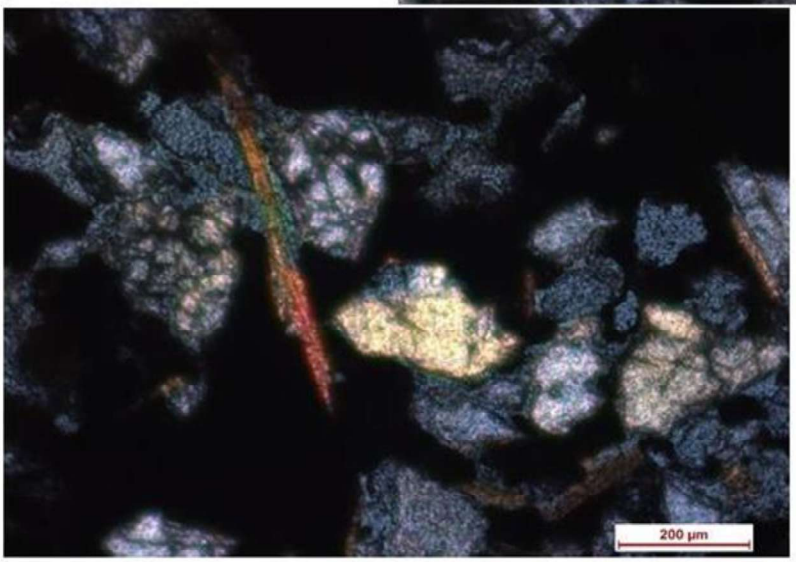
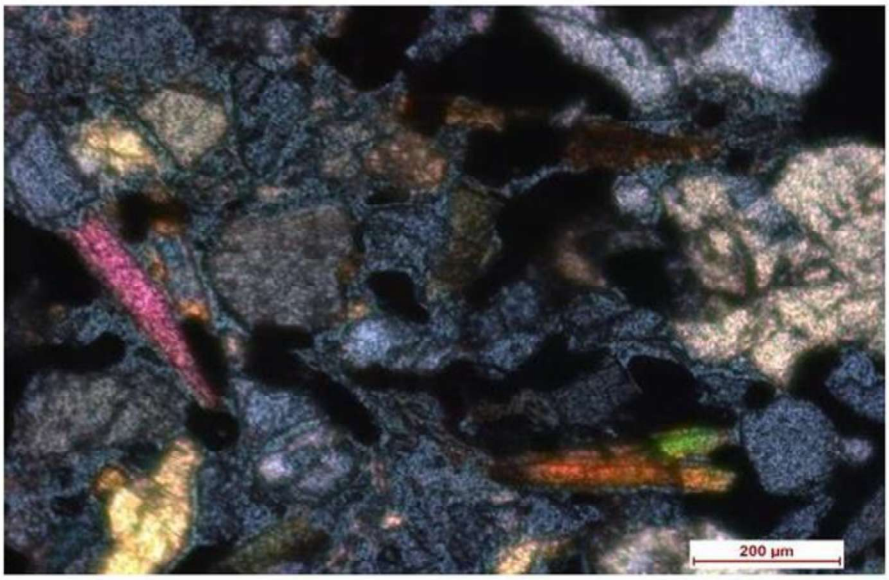


Figure 7: Quartz and Mica Grains

Figure 8: Quartz and Mica Grains



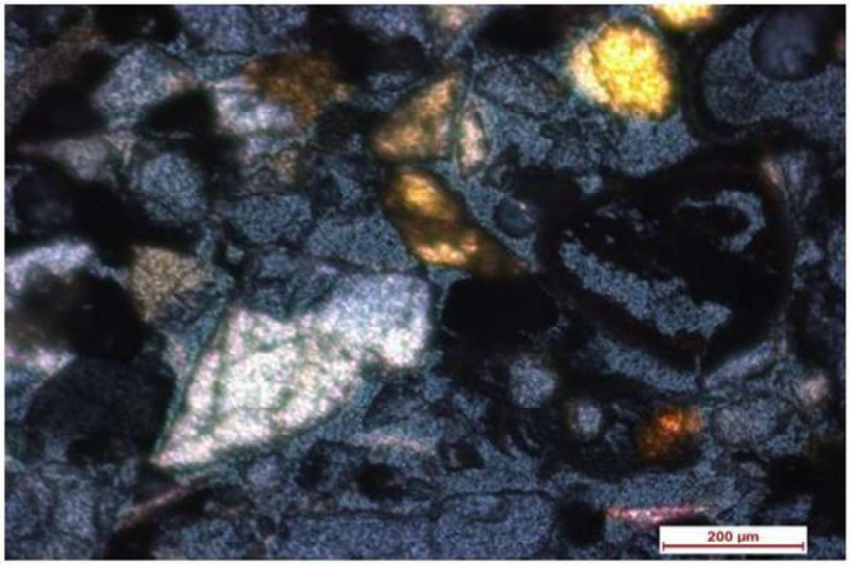


Figure 9: Quartz, Mica, Pyroxene Grains

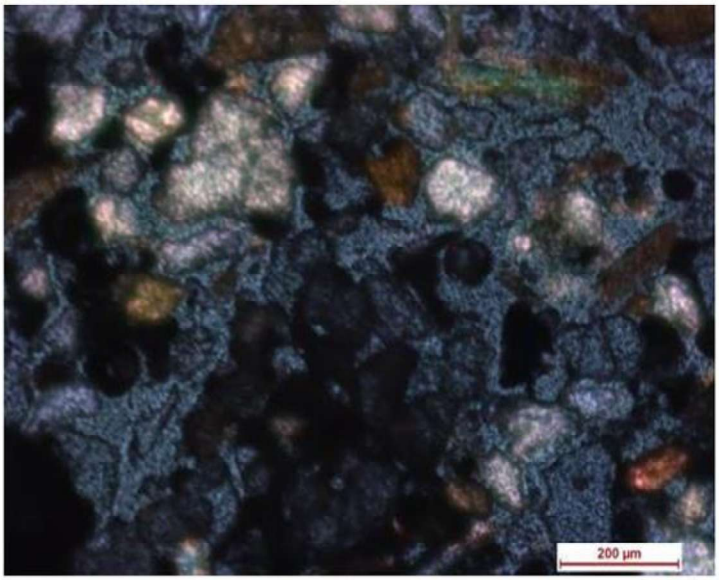


Figure 10: Quartz, Mica, Rutile, Pyroxene and Amphibole Grains

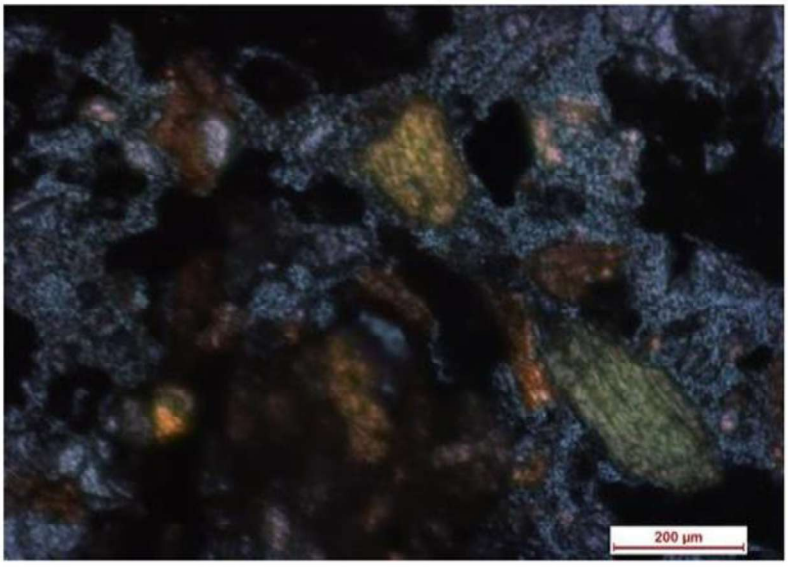


Figure 11: Quartz, Rutile and Chlorite Grains

Figure 12: Quartz, Feldspar and Mica Grains

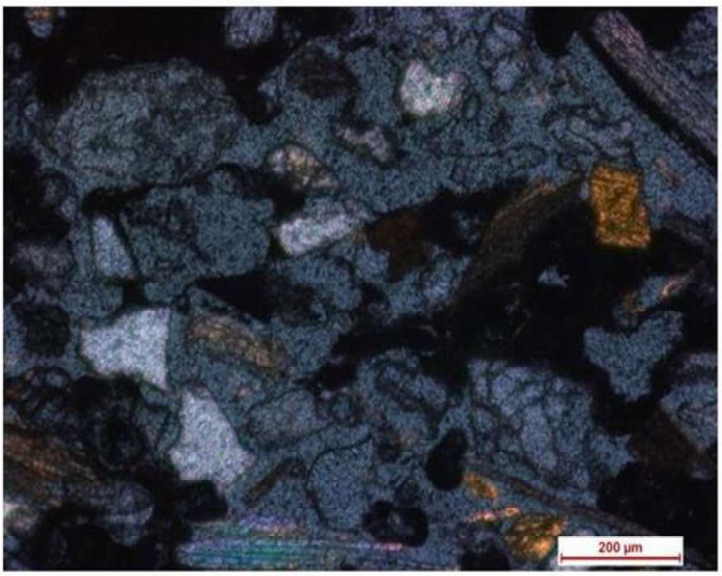


Figure 13: Monocrystalline and polycrystalline Quartz, Feldspar and Mica Grains

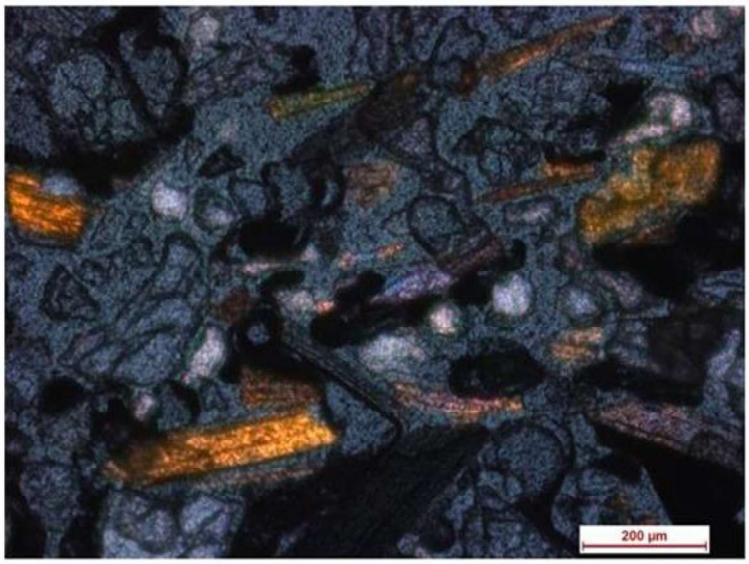


Figure 14: Quartz, Mica Feldspar and tourmaline Grains

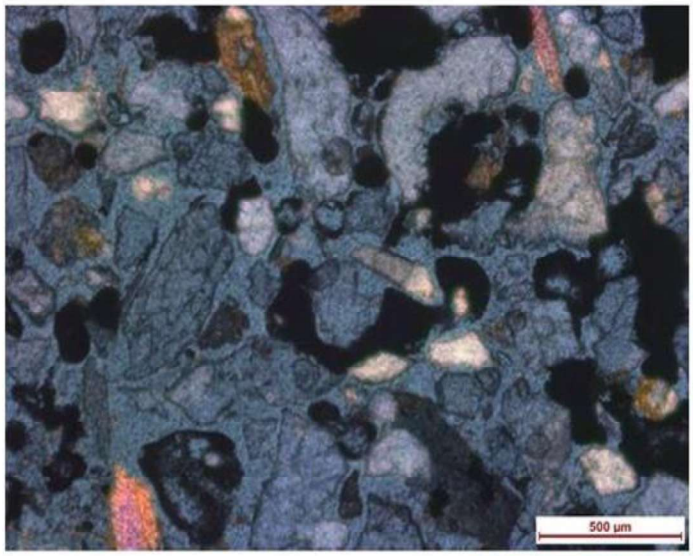


Figure 15: Quartz, Heavy Minerals and Mica Grains

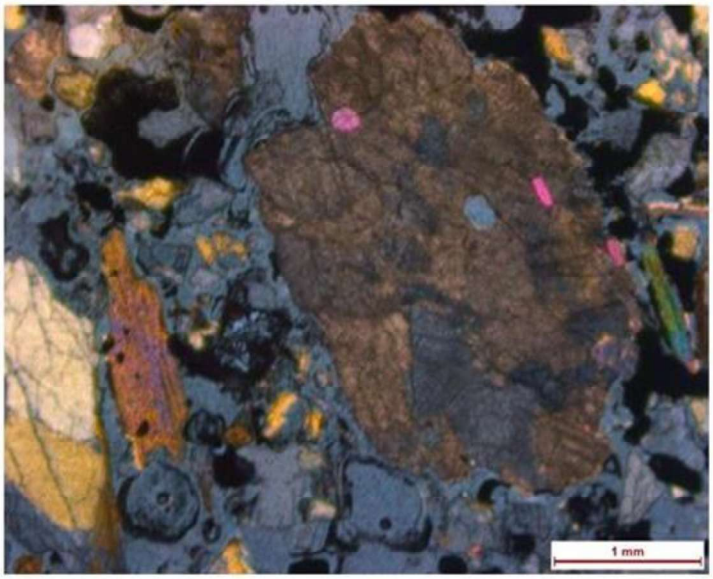


Figure 16: Quartz, Microcline, Amphibole and Mica Grains

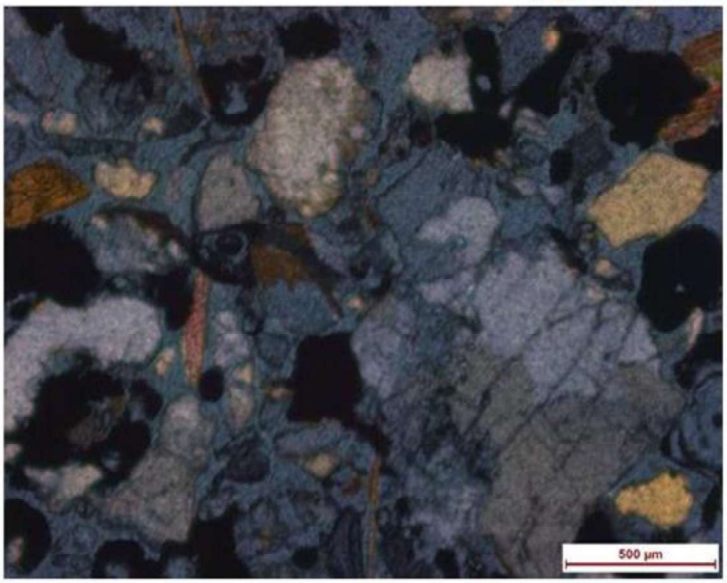


Figure 17: Fractured Quartz and Mica Grains, Feldspar Grains

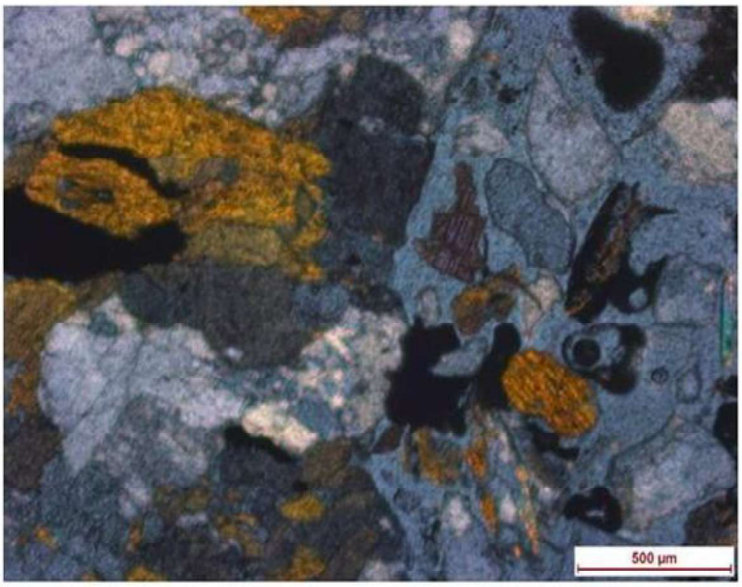


Figure 18: Quartz, Mica Grains and Feldspar Grains

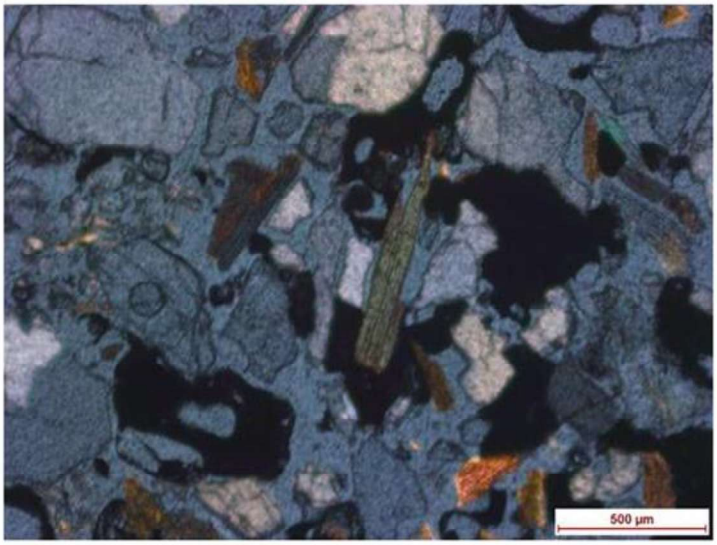


Figure 19: Quartz and Mica Grains, Tourmaline and Rutile Grains

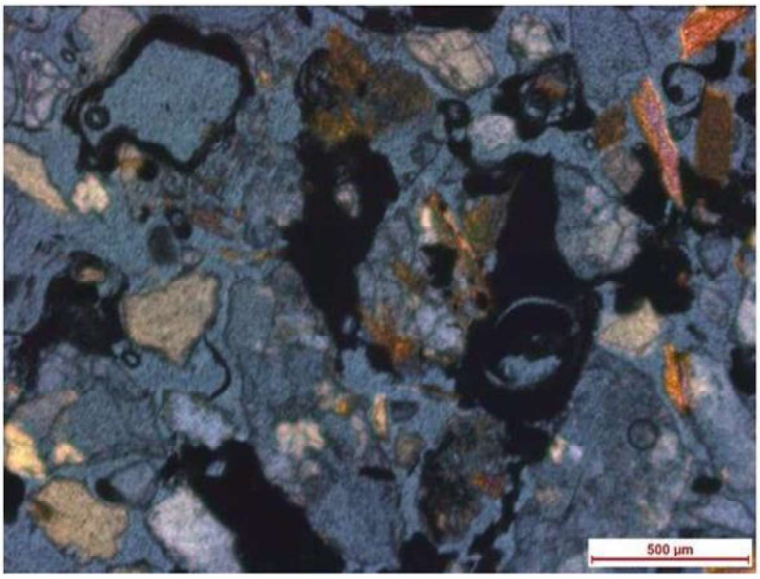


Figure 20: Quartz and Mica Grains, Feldspar Grains

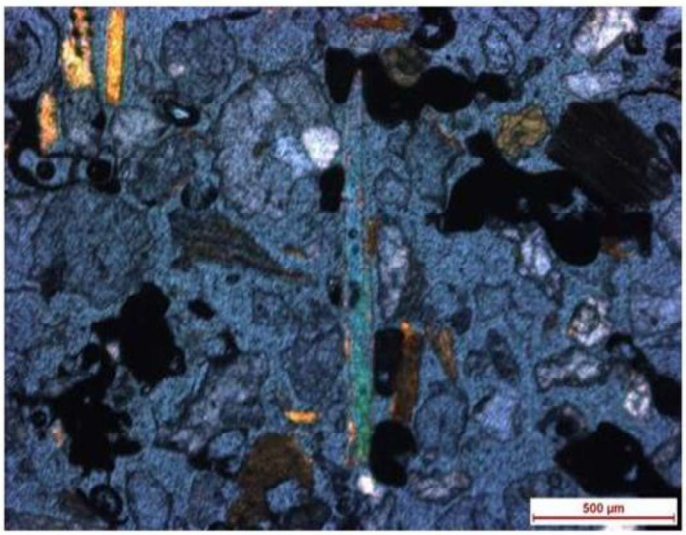


Figure 21: Quartz and Mica Grains, Feldspar, Plagioclase Grains

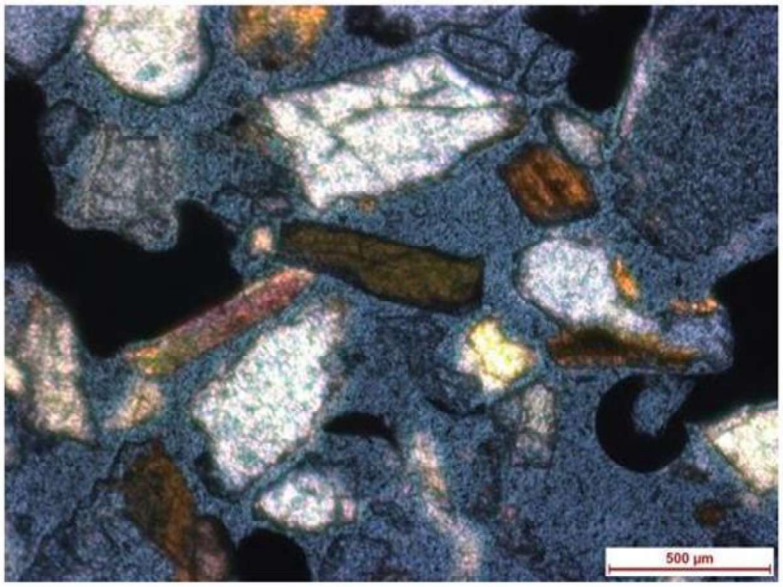


Figure 22: Quartz and Mica Grains, Hornblende, Rutile Grains

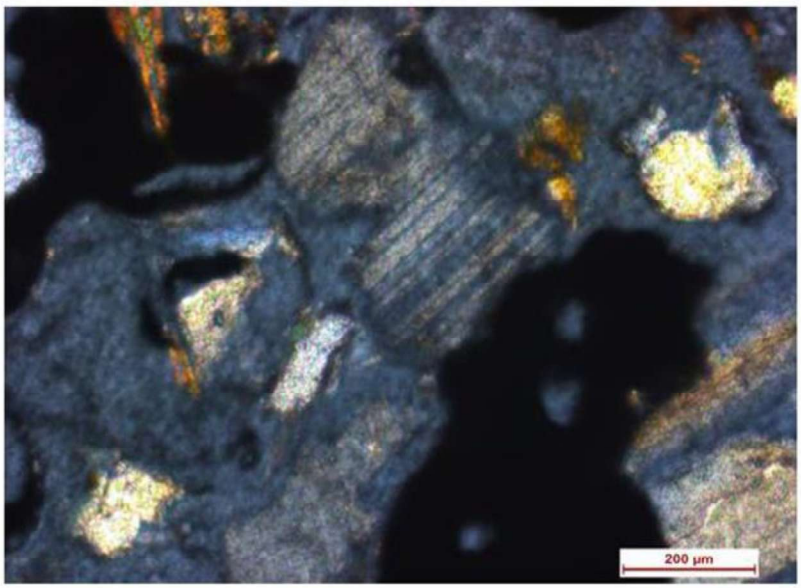


Figure 23: Quartz and Mica Grains, Feldspar, Plagioclase and Pyroxene Grains

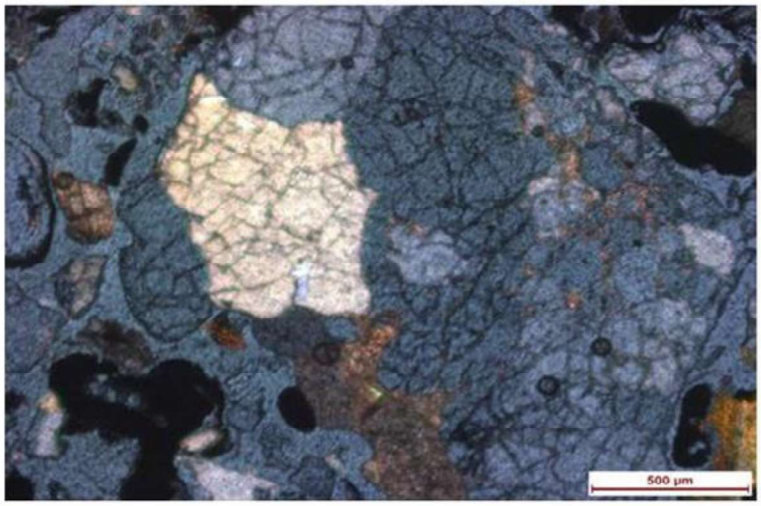


Figure 24: Fractured Quartz and Mica Grains

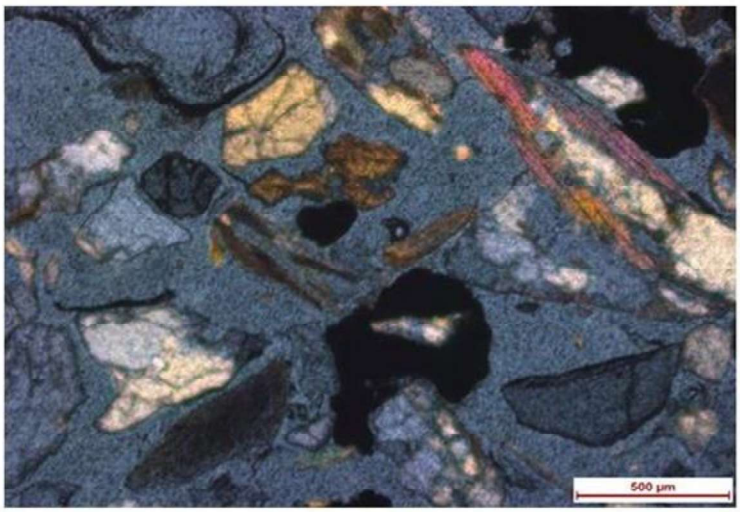


Figure 25: Quartz and Mica Grains

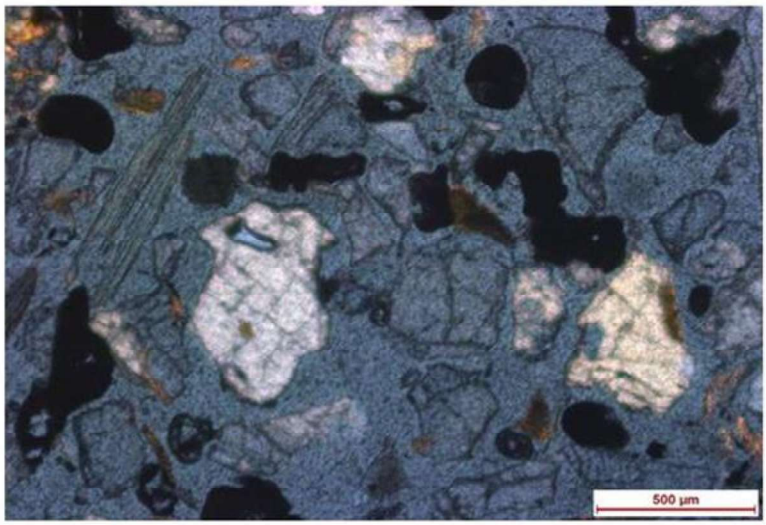


Figure 26: Quartz, Pyroxene and Mica Grains

Figure 3-14: From Slides of Heo Hap 1 & Figure 15-26: From Slides of Heo Hap 2

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