Feasibility Study on Water Resources Development in Rural Area in the Kingdom of Morocco
Final Report
Volume IV Supporting Report (2.A)
Feasibility Study

Supporting Report X Geology And Construction Material

FEASIBILITY STUDY
ON
WATER RESOURCES DEVELOPMENT
IN
RURAL AREA
IN
THE KINGDOM OF MOROCCO

FINAL REPORT

VOLUME IV
SUPPORTING REPORT (2.A)
FEASIBILITY STUDY

SUPPORTING REPORT X

GEOLOGY AND CONSTRUCTION

MATERIAL

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X1 Introduction

In phase I, referring to existing study report for 25 project-sites on this study, first of all aiming to grasp present condition of respective sites, the Engineers has checked them at actual field situation around contemplate dam sites, and gives careful consideration to geologically and topographically dam construction suitability or problems.

The project sites are situating all over Moroccan country. Due to that, field investigation at sites has been done during one to two days respectively mainly around dam sites.

In phase II, study has been done for four sites (N'Fifikh, Taskourt, Timkit, and Azghar) selected from the result of phase I study.

The geological Engineer concentrates his attention on the area around dam sites and reservoirs in this phase for the outlook regarding dam design and construction.

The methods of study are geological field survey, core drilling and relating tests, seismic refraction prospecting. Further for construction material study, test pitting and sampling, and laboratory test for soil mechanics and concrete aggregate were carried out.

JICA Engineer did directly conduct geological field survey at selected respective dam sites and reservoir areas during around one week respectively, and soon getting them in reasonable geological shape for mapping. Mapping scale is 1/5000 around reservoir areas and 1/500 around dam sites.

Core drilling and relating test in situ, seismic refraction prospecting, test pitting and sampling, and laboratory tests were rendered to the local subcontractor (Laboratoir Public d'Etude et d'Essai = LPEE, main office in Casablanca) were worked out including tender documents. JICA Engineer made Technical Specification for these works and managed their works.

Core drilling was set along contemplate dam axes for the purpose of outline design of dam body. Five spots of drilling (50 linear meters respectively) along respective dam axis were conducted (however at Azghar site, omitted due to some logs already existing carried out by DGH). Lugeon test were conducted at every boreholes to check imperviousness of bedrock.

Seismic refraction prospecting was conducted at three dam sites except Timkit where data already exist. Prospecting lines are 6 or 7 along the direction to dam axes and perpendicular to them. Distance is 3 km each, total 9 km.

Test pitting for construction material survey was conducted at three dam sites except Timkit where data already exist. Five test pits were dug around every dam sites.

Laboratory tests were conducted for checking the suitability as embankment material or concrete aggregate using samples from test pits. Rock tests were also done by drilled cores.

Further to decide design seismic acceleration at respective dam sites, JICA Engineer collected all seismic event data around Morocco from seismic center and analyzed them.

X2 Result of the Study at Respective Dam Project Area

X2.1 N'Fifikh Dam

X2.1.1 Physiography and Geology

(1) Around Catchment Area

Location of N'Fifikh area is as follows:

around 60 km ESE from Casablanca;
around 45 km SE from Mohamedia; and
nearest town is Ben Slimane where is in around 25 km distance.

Elevation of catchment area ranges from 230 m to a little higher than 800 m. Catchment land area of reservoir is 323 km^2.

The area belongs to so-called Morocco Central Méséta where is put between Méséta Cotiere and Morocco Méséta. Méséta Cotiere consists of coastal plain and three levels of tableland bounded in lines around 200 m and 500 m elevations. Morocco Méséta is inland mountains or plateaus (elevation is in between 500 and 1000 m).

Dam site is contemplated on Oued Dalia, where is located at around 50 km upstream from the mouth of Oued N'Fifikh at Mohamedia.
The upstream length of main watercourse up to dam site is about 35 km joining many branch tributaries 10 to 15 km of length.

Catchment area characterized by hills and mountains with round peak 500 to 700 meters in elevation with high density of valleys. They are the result of long time erosion from Paleozoic.

Geological structure in the area complicates very much due to the existence of many over-folds, thrusts and faults.

According to the geological map on a scale of 1: 500,000 issued by Ministry of Mineral and Mining, the Geology around Catchment area is as shown in Figure X2.1.1.

Dam site consists of Limestone, Quartzite, Sandstone and Pelitic schist or Argillite of Lower to Middle Devonian, while the area to a certain upstream and the left bank of the catchment consists of some type of schistose rocks of Carboniferous. Faults limit the extension of these rocks, which is orienting N-S in the middle to downstream area, while NE-SW in the upstream area.

Bedrocks in the middle to upstream area consist of Limestone, Slate or Pelitic schist, Sandstone, Quartzite and Conglomerate of Devono-Carboniferous to Devonian. Granite exists widely in the eastern outside of the basin.

The continuousness of formations is very poor in any area due to folding and faults.

Probably due to relatively small and repeated folding, Middle to Upper Devonian and Devono-Carboniferous outcrop repeatedly. On the whole, they are heaved up towards the Granite exposure.

(2) Around Reservoir

Round peak hills have their peak from 330 m gradually going up to 400 m in elevations at left bank side. While, those at right bank side have a feature situating them some levels, namely around the level of 320 ~ 330m, around 370m, around 400m, and 450m, then down to around 410m. That at dam site is around 360m. Though some peaks exist independently, they generally form long and narrow ridges and then step up or down.

The largest tributary (Oued al Meish) joins from right bank side at around 1.2 km upstream of dam site. Main watercourse changes sometimes its course suddenly. It flows towards NNW in the upstream, N in the midstream and W around dam site.

Terrace plain develops along river courses on both banks, of which the width extend uniformly around 200m in the upstream area and around 300m in the downstream area. The right rear slopes of terrace plain show the triangular shape.

The average gradient of riverbed in the reservoir area along main watercourse is 1/165. Due to that gentle gradient, the distance from dam site to upstream end of reservoir is more than 5 km.

Geological condition around reservoir area is as shown in Figure X2.1.3.

The bedrock in the area consists of very folded and faulted Paleozoic formations. It is very difficult to follow their continuousness. Their rock facies are the alternation of Sandstones (or Psammitic schist) and Pelitic-stone (Argillite, Slate, Phyllite, and Pelitic schist). Sandstone dominant area and Pelitic-stone dominant area outcrops repeatedly. Limestone, massive Quartzite or Quartzitic Sandstone exist partly and irregularly.

Gray Limestone exists around the peak at right bank of dam site, and large and massive Quartzite blocks scatter on the slope. Vertical stratum of Quartzitic Sandstone or Sandy Quartzite crosses the river course perpendicularly at just downstream of dam site forming horse-bags. Surround area is covered by Colluvium probably underlain by the alternation of dominant Sandstone and Pelitic-stone.

Sandstone dominant area extends around dam site, the right bank side of Oued al Meish, the rear mountains of left bank and higher level of right bank side of main river. On the other hand, Pelitic-stone dominant area extends at the right bank side between the confluence with Oued al Meish and downstream bending point, in between area of Oued al Meish and main river course, and on both banks of the upstream side of Oued al Meish. Their tone of color is usually dark greenish to blackish probably due to mineralization of galena and/or zincblende.

The alternation of Psammitic schist and Pelitic schist suggesting the tone of bluish gray color exists along the upstream left bank side of main watercourse and the lower level of right bank.

The dark greenish and the bluish gray formations have almost horizontal boundary (probably horizontal fault and overturned fold).

According to the geological map “Mohammedia” drawn on a scale of 1:100000 adjoining in the northward of the project site including area, the bedrock in the area is of Devonian to Carboniferous. Limestone of right bank side at dam site is Lower Devonian (Formation Dhar-es-Smene), bedrock around dam site intercalated by Quartzite is Upper Devonian (Formation Ain Aliliga), the bluish gray rocks are of Upper Carboniferous (Visean) and the others' are of Devono-Carboniferous (Formation d'Al-Brijate).

Relative height of Terrace plain from present riverbed is few to ten and few meters. Terrace deposits consist of basal sand & gravel overlain by mainly fine-grained soil. Their thickness is 3 to 4 m.

Colluvial deposits on slope and at the foot of mountain consist of angular gravels bearing soil of which the thickness is sometimes more than 2 m.

(3) Dam Site

In case of right bank side, a small stream flows in the rear of horse-bag shaped hill that depresses to lean col towards the upstream side. The slope along this stream is relatively steep suggesting the inclination of around 30º with bumpy surface due to slope failure. Deep gully exists at just upstream of contemplated dam axis. The crest elevation of the col is 246m, and the peak elevation of horse-bag is around 1m higher than that. The inclination of slope is: 15 to 20º until around 235m, and 10 to 15º higher than that. Peak is 288.5m. At around 150m upstream from dam axis, a linear branch joins to main watercourse from ENE.

While in the side of left bank, it is relatively steep from riverbed to around 280m in elevation suggesting the inclination of 25 to 35º. The direction of slope strike is almost same towards downstream, however changes right angle towards upstream. Upstream slope is depressed slightly where the surface layer is sliding. A protuberance of Quartzitic rock exists at just downstream followed by talus slope (average inclination is 35 to 40º). Terrace-like gentle slope exists between 230 and 240m in elevation with inclination lower than 10º extending to upstream from dam axis. The upper slope of terrace is average 30º, while lower slope is 25º. Left bank is composed of independent hill of which peak elevation is 334m.

Main watercourse runs through at the foot of left bank and the elevation of riverbed is 213m. The width of present flow course is about 20m. Alluvial terrace of 30 to 40 m in width extends on right bank. The elevation of alluvial terrace plain is around 215m to 216m.
The gradient of riverbed around dam site is average 1/250.

Geological condition around dam site is as shown in Figure X2.1.2 and geological profile along contemplate dam axis is shown in Figure X2.1.4.

Vertical Sandy Quartzite layer of 10 m in thickness runs perpendicular to watercourse on both banks at just downstream of contemplated dam axis. Small Quartzite blocks also scatter between contemplated dam axis and the col of right bank. These outcrops continue intermittently as boudin formed by overturned fold.

The bedrock around the contemplated dam axis consists probably of Sandstone dominant alternation of Devono-Carboniferous, though they are covered by Colluviums. Partly Pelitic-stone dominant alternation exists where is more deteriorate rather than the other area.

Faults are inferred along the 240m elevation contour line on left bank orienting E-W due to its sudden geological structural change, and on the line crossing through the col of right bank orienting NW-SE from Quartzite distribution pattern. Further from Quartzite block distribution, faults located around this area are also inferred.

Strata around dam site are overfolded, then their strike and dip orient several direction (especially in the Pelitic-stone dominant area, this tendency is remarkable). As far as the area near riverbed is concerned, the strike of strata tends to orient around N-S.

Terrace of relative height 5 to 10 m from present riverbed extends to upstream along left bank from dam axis and to downstream along right bank from horse-bag shaped hill, which consists of mainly fine grained soil.
Alluvial cone deposits distributes at the outlets of deep gully and of branch streams. Alluvial terrace extends both banks with 50 to 100 m in width. The former consists of rubble and soil, and the latter mainly of silts and fine sands.
Talus deposits accumulate at the foot steep slope, which consist of Cobble and Boulder bearing fine-grained soil.

(4) Remarks

As a point to which we should pay attention around dam site, the next matter is given.

- Around dam site, faults are inferred at left abutment around the level of dam crest orienting E-W, and through the col of right bank orienting NW-SE and NE-SW.

- Pelitic-stone dominant strata at just downstream of dam axis in left bank is sheared to some extent and brittle.

- Generally in the area, the depth to sound foundation is relatively deep

- Colluvial deposits situating in the middle and at the foot of slope accumulate thick partly, and some parts are causing surface slope failure, especially the slope in the rear of right bank is the land failure area.

X2.1.2 Seismic Velocity Profile along Contemplate Dam Axis

Seismic velocity profile along contemplate dam axis is shown in Figure X2.1.5.

Largely, velocity layers can be divided into the following three.

Layer No.	Left Abut.	Riverbed	Right Abut.
I	0.6km/s (Colluvial dep.)	0.8km/s (Alluvial dep.)	0.7～0.8km/s (Colluvial dep.)
II	1.7km/s (Weathered rocks or semisolid Terrace dep.)	-	2.5～2.7km/s (Weathered rocks)
III	3.7km/s (Fresh rocks)	3.2km/s (Fresh rocks)	3.2～4.0km/s (Fresh rocks)

Low velocity zone can be recognized at left abutment and right ridge.

X2.1.3 Construction Material

Due that the depth to sound foundation is relatively deep in the area in general, concrete type of dam may be difficult to construct on the foundation. Considering fill type of dam, necessary material for embankment is impervious material, shell material and some volume of sands & gravels for concrete facilities.

Taking into consideration the above matter, borrow area and quarry site shall be checked to do the next material with an object.

・**Borrow area**

Terrace deposits: consist mainly of silts and clay with basal gravels & silts.
Colluvial deposits: weathered rock fragments in a matrix of fine-grained soil.

・**Sands & Gravels Quarry site**

River deposits or Alluvial Terrace deposits: distribute at the confluence of two tributaries, e.g. Oued Dalia and Oued al Meish.
Terrace deposits: basal portion consists of gravels and silts with some sands; thickness is around 1m.

・**Rock Quarry site**

Limestone: outcrops at the peak of right bank side at just downstream of dam site.
Quartzite: outcrops at both banks of just downstream of dam axis, and exposes as blocs or boudin at right bank of dam site.

Those location are shown in Figure X2.1.6 “Design Borrow Area & Quarry Site for N’Fifikh Dam”

(1) Survey by Test Pitting

Five pits named P1 to P5 have been carried out for the earth embankment material located in the vicinity of the N’Fifikh dam. Test pits P1, P2, and P3 are in the proposed reservoir area, while the pits P4 and P5 are downstream dam site on the left bank of Oued N’Fifikh.
It was expected to dig these pits manually, with the aid of the shovel and the pickaxe, for 5m in depth as from the natural field.

・**Logging of Test Pit**

- Pit P1 –

0.00 - 0.20 m : Top soil.
0.20 - 0.90 m : Red-color silty clay with some gravels.
0.90 - 3.70 m : Various-color silty clay.
3.70 - 4.70 m : Gravels & cobbles with boulders (ϕ> 30 cm) in sandy silt matrix.

- Pit P2 –

0.00 - 0.50 m : Top soil.
0.50 - 0.80 m : Gravels with boulders in clayey matrix.
0.80 - 2.70 m : Yellowish silty clay with some boulders.
2.70 - 3.90 m : Clay with gravely bearing angular debris.
3.90 - 5.00 m : Gravels & cobbles with boulders in sandy silt matrix.
5.00 m - : Bedrock.

- Pit P3 -

0.00 - 0.30 m : Top soil.
0.30 - 1.00 m : Rock fragments in silt & clay matrix.
1.00 m - : Rock bloc.

- Pit P4 -

0.00 - 1.60 m : Reddish clayey soil with some rock blocs.
1.60 - 4.00 m : Yellowish silty clay with some rock blocs.

- Pit P5 -

0.00 - 1.60 m : Red-color gravelly clayey soil with some rock blocs.
1.60 - 2.60 m : Yellowish silty clay.
2.60 - 4.40 m : Silty soil with angular rock fragments.
4.40 - 5.00 m : Highly weathered bedrock.

During the on site reconnaissance period (from September 8th to September 26th, 2000), any ground water was not found in the above pits.
Targeting soil for the impervious embankment of the dam is yellowish silty clay.

Thickness of the yellowish silty clay ranges between 0.8 and 2.8 m.
This yellowish silty clay is generally covered by a layer of reddish clay with gravel. The subjacent layers are generally either weathered bedrock or gravel deposits.

・**In-situ Density Test**

The yellowish silty clay has been subjected to in-situ and laboratory density tests. This is very solid. The results of the in-situ density vary between 1.80 and 1.96 t/m^3

(2) Laboratory Test on Soil Material

The laboratory tests have been carried on 4 samples taken from **the yellow silty clay** layer, namely P1 at 3.00 m, P2 at 1.50 m, P4 at 2.00 m, and P5 at 2.00 m.
Results of laboratory tests are described as follows:

・**Grain size analysis**
1) The percentage of the particle smaller than 0.08 mm is 57 to 83%.
2) The percentage of the particle between 0.08 and 2 mm is 10 to 13%.
3) The percentage of the particle larger than 2 mm is 7 to 32%.

・**Atterberg Limits**
The Atterberg limits are not very high (WL = 31 to 36 %, IP = 15 to 17 %), which enables the classification of CL (Less plastic clay).

・**Water Content**
As shown as following table, soils (yellowish silty clay) are rather low water content and saturation ratio.

Pit	*Depth (m)*	*Dry density (t/m^3)*	*Specific gravity*	*Water content (%)*	*Saturation ratio*
P1	3.00	1.91	2.720	11	70%
P2	1.50	1.93	2.708	10	64%
P4	2.00	1.82	2.711	9	47%
P5	2.00	1.92	2.716	11	71%

・**Proctor Compaction Test**
The Proctor compaction tests carried out in the laboratory has evaluated the following maximal densities and the optimal water contents:

Pit	*Depth (m)*	*Optimal water content W_{opt} (%)*	*Maximal density γ_{dmax} (t/m^3)*
P1	3.00	15	1.79
P2	1.50	14.5	1.82
P4	2.00	16	1.79
P5	2.00	14	1.86

・**Triaxial Compression Test**

Consolidated undrained triaxial compression tests to evaluate shear strength were carried out on reconstituted samples at 95% of optimum proctor density. Samples were saturated before consolidation procedure. Pore water pressure was measured during compression to shear.

The shear strength (internal friction angle and cohesion) on both the effective stress and total stress condition are summarized as following table:

		Total stress		*Effective stress*	
Pit	*Depth (m)*	*Friction angle* ϕ_{cu}	*Cohesion* C_{cu} *(KPa)*	*Friction angle* ϕ'	*Cohesion C' (KPa)*
P1	3.00	19°	20	30°	10
P2	1.50	13°	20	22°	10
P4	2.00	16°	30	25°	15
P5	2.00	16°	30	26°	15

・**Consolidation Test**

The consolidation tests have been carried out on reconstituted samples at 95% of optimum proctor density.

The characteristics (Ic: Compressibility index, Pc: Pre-consolidation pressure, Ig: Swelling index) measured are grouped in the following table:

Pit	*Depth (m)*	*Ic*	*Pc (KPa)*	*Ig*	*Pg (KPa)*
P1	3.00	0.17	60	0.02	20
P2	1.50	0.16	100	0.01	20
P4	2.00	0.20	200	0.017	20
P5	2.00	0.14	70	0.015	20

These values show on the first part that this soil is rather compressible than expectation, and on the second part it shows that this has a weak swelling potential.

・**Permeability Test**

The permeability tests were carried out on reconstituted samples at 90% and 100% of the optimum proctor density with optimum water content

The permeability K measured are as follows:

Pit	*Depth (m)*	$K_{90\%}$ *(cm/s)*	$K_{100\%}$ *(cm/s)*
P1	3.00	2×10^{-6}	6×10^{-7}
P2	1.50	3×10^{-6}	2×10^{-7}
P4	2.00	10^{-5}	10^{-7}
P5	2.00	10^{-6}	3×10^{-7}

It is noticing that the permeability obtained at 90% of the optimum density is relatively higher than that obtained at 100% of the optimum density which endows the clay with a practically impermeable characteristic.

It is noticing that the permeability obtained at 90% of the optimum density is relatively higher than that obtained at 100% of the optimum density which endows the clay with a practically impermeable characteristic.

(3) Mechanical Laboratory Test on Rock Sample

Mechanical laboratory test was carried out in the laboratory on rock samples taken from the drilling cores of the dam site. Items tested and results are as follows:

Apparent density γ and porosity ***n***.
Unconfined compression resistance ***Rc***
Young module ***E*** and Poisson coefficient ν
Ultra-sonic velocity: longitudinal (primary) wave ***Vl*** and transversal (secondary) wave ***Vt***

Sample	γ *(t/m³)*	*n (%)*	*Rc (MPa)*	*E (GPa)*	*Vl (m/s)*	*Vt (m/s)*	ν
S3(12.00–12.30 m)	2.74	0.80	27.2	40	8751	5454	0.18
S3(26.70–27.00 m)	2.70	0.67	36.1	49	8125	5000	0.20

The measured unconfined resistance of the rock is fairly high for the fill dam foundation

(4) Consideration

- **Impervious Soil Material**

Judging by the field reconnaissance around dam site and the result of the test pitting and the laboratory test, terrace and soil deposits will be proper for impervious material. They are observed on the moderate slopes along a river of downstream and upstream of dam site. Borrow pits of A1 and A2 are proposed in the proposed reservoir area. Another borrow pit about 3 km downstream of dam site is also prospective. Thickness of soil deposit is 2-3 m. Expecting volumes are (1km long x 100m wide x 2m thick =) 200,000 m^3, (300m x 100m x 2m=) 60,000 m^3 and (1km x 100 x 2m=) 200,000 m^3 for A1, A2 and B1, respectively.
Materials from every borrow pit are almost same kinds of property. Natural moisture content is about 15 %, its plastic index is about 17 % and natural density is 1.9 t/m^3.
These properties indicate that it is heavy and proper material for impervious embankment use. Actually laboratory permeability test proves its imperviousness at the condition optimum moisture content and maximum compaction density. Only problematic matter is that the natural moisture is 4-5% dryer than optimum moisture. Watering to increase moisture is necessary for actual construction stage.
Triaxial compression shearing test under consolidated and undrained (C-U) condition were performed on the impervious soils material at the density of

D=95% with optimum moisture content. Design effective shearing strength will be proposed to be 25 degrees as internal friction angle and 10 KPa as cohesion on the base of mean value of C-U shearing test.

・Semi-pervious and Filter Materials

Sand and gravel from river bed (C material) and lower layer of terrace and colluvial deposits (D material) are recommendable for filter and semi-pervious materials. They deposit on the confluence of the upstream river and the downstream riverbed and on the slopes beside of the river. As the deposit material, especially that of on the slopes contains some rate of silt content; it will show the characteristics of semi-perviousness. Excavation materials (E material) that are mostly composed of weathered or hard rocks from spillway foundation will be also proper for pervious to semi-pervious embankment use beside pervious rock embankment use. Rough expecting volumes will be about (100m x 100m x 2.5m x 2 areas=) 50,000 m^3 for C material and 700,000 m^3 for D material. Volume of E excavation material will be estimated as 430,000 m^3, of which half volume will be utilized for pervious rock material.

Concrete aggregate material can depends on two (2) kinds of material. One is sand and gravel of C or D material. The other material is of taking in or purchasing aggregate outside of project area. In the former case some washing treatment and sieving of material should be necessary as sand and gravel are considered to be not clean and not well grading by direct use. Material of latter case will give better quality but be expensive somewhat. Final selection of aggregate is proposed to be done after detailed investigation on next survey.

・ Pervious Rock Material

Relatively large amount of excavation volume from spillway foundation is prospected for the dam. It should be applied to dam embankment to make dam construction economic. Its half volume will be hard rock of quartzite that is probably suitable for pervious embankment. If the rock is bolder size such as more than 30 cm diameter, it will be also possible to rip rap use. Available volume of these rock materials will be expected around 200,000 m^3.

・ Rip Rap Material

Quarry site of riprap with high quality good for rock material is recommended on the hill near downstream of the right abutment of the dam. Rocks are limestone and quartzite. Surface of quarry shows hard, dense and durable quality rocks. They are judged to be suitable for riprap on the surface embankment of the dam.

Excavation rock materials from the spillway foundation will be probably quartzite and sandstone. Quartzite of large-size fresh material will be possible for riprap but sandstone materials may not be sure for riprap use.

X2.2 Taskourt Dam

X2.2.1 Physiography and Geology

(1) Around Catchment Area

Location of Taskourt area is as follows:
around 70 km SW of Marrakech; and
around 45 km SSE of Chechaoua.
Catchment area of reservoir is 419 km^2.

Situating in northern slope of Haute Atlas Occidental, very high mountains of 3,200 to over 3,600 m in elevation are ranging in the rear such as J.Tichka, J.Igdet, and J.Erdouz, etc.

Taskourt dam site is on Assif el Ma, which has many branches flowing from those high mountains. The highest peak of the catchment area is J.Igdet (3,615 m). The main river course rises J.Tichka (3,350m) and flows 30 and several kilometers until dam site. The elevation of riverbed at dam site is around 940m. It flows down further 10 and several kilometers in the mountain area and outflows to vast alluvial fan area and Hauz plain. Assif el Ma has perennial flow due to constant water supply from high mountains' snowmelt. Because the catchment is composed of steep mountains, then a lot of sediments are supplied forming thick and wide river deposits.

According to geological map on a scale of 1:500,000 issued by Ministry of Mineral and Mining, the Geology around Catchment area is as shown in Figure X2.2.1.

The uppermost stream area around J.Tichka and J.Igdet consist of Granite, Migmatite and Hornfels, etc. Those are surrounded by contact metamorphic rocks and continuing to regional metamorphic rocks of Paleozoic.
Metamorphosed Paleozoic formations around the area consist of Psammitic rocks and many types of Schist, and partly schistose Graywacke, Arkose, or Pyroclastics of Cambrian to Ordovician.

Though many faults and folds exist in the area, those formations are largely arranged in the NE-SW direction bounded mainly by same direction of faults.

Mesozoic (Jurassic & Cretaceous) formations composed of Gypsum, Marl, Limestone, Sandstone and Conglomerate, which are almost horizontal strata, exists around 6 to 8 km upstream from dam site and extend westwards and eastwards. Almost E-W orienting boundary of Paleozoic and Mesozoic of the mountainside is fault up heaving mountainside relatively.

(2) Around Reservoir

Average inclination of mountain slope in the upstream left bank side is 35 to 40º rising directly from riverbed to ridge with partially gentle slope portion. While in the downstream side, tableland extends between 1300 and 1500m in elevation, and suddenly going down to 1100m with average gradient 40º. Then, slope becomes a little gentle continuing to riverbed (Altitude 940m).
On the other hand in the right bank side, upstream side is rather gentle slope and downstream side is very steep from riverbed with inclination more than 40º.

The river course is obliged to meander at around the center area of reservoir due to long and narrow protruding ridge. The width of riverbed is generally wide with 150 to 200m, however become relatively narrow to several tens meters around dam site.

Assif el Ma with relatively wide river shore flows first to north meandering through very steep mountains, and change its course to NE at a little upstream of dam site. It changes course again suddenly to NW at downstream of dam site.

The branch tributaries are mainly orienting E-W around main river course of Assif el Ma and right bank side, while in the mountain area of left bank side NW-SE and NE-SW.

The reservoir shapes 500 to 600m width and 4 to 5km long.

The average gradient of riverbed in the reservoir area along mainstream is 1/80.

Geological condition around reservoir area is as shown in the Figure X2.2.3.

According to Geological Map on a scale of 1:100,000 "Imi n'Tanout" and "Amizmiz" issued by Ministry of Mineral and Mining, the bedrock in the area consists of Schists of Cambrian to Ordovician. Geological map shown in the figure is the result of detail geological field reconnaissance in this time. As a result of that, except Mesozoic formations, the bedrock in the area is largely divided into six zones arranged in rows orienting N-S to NNE-SSW. Those are Paleozoic formations. We call them here in order from west side to east as zone **i** to **vi**.

i- Quartzite, Quartzitic Schist, Quartz-Chlorite Schist, and Chlorite Schist
(Lower Cambrian)

ii- Pelitic or Biotite Schist intercalated with Psammitic Schist
(Cambro- Ordovician)

iii- Phyllitize Rocks, Graphite Schist, and Meta-Quartzite layer (boudin) with many Quartz vein, Calcite vein, and Igneous material intrusion (Silurian)

iv- Alteration zone (Brittle Graphite Schist altered by sulphate, gypsum, and other igneous material)

v- Pelitic Schist, Psammitic Schist, or Biotite or Black Schist (partly phyllitize)
(Cambro-Ordovician)

vi- Psammitic Schist or Quartz-Biotite Schist (black and hard, partly Pelitic or Biotite Schist)
(Ordovician)

Zone **i** consists of light green to green Quartzite, Quartzitic Schist, Quartz-Chlorite Schist, and Chlorite Schist (Green Schist), which is generally very hard to hard and massive. Those are correlated to Formations of Lower Cambrian shown in geological map of 1/100,000. They form the plateau of 1,300 to 1,500m in elevation and limited eastern side by some faults forming very steep slope.

Zone **iv** is tectonically alteration zone runs between zone **iii** and **v**. Schists in this zone is generally soft Graphite Schist remarkably altered by sulphide materials, gypsum, and other igneous materials. This zone extends from the depression orienting N-S in the rear of left bank of dam site through under the upstream Assif el Ma to village Assaïs and then spreads to eastwards and westwards. Probably some sheared zones are inferred to accompany along this zone.

Zone **ii** and **iii** run western (left bank) side of the alteration zone (Zone **iv**) with a little less than 1km width.

Zone **iii** is the strongly affected zone by the alteration zone (Zone **iv**) and extends equally along it with 500 to 600m widths. Probably some sheared zones exist in the side of alteration zone. The rocks are generally phyllitizate and observed many graphitic rocks and igneous material intrusion. Further so many quartz and calcite veins intrude, and partly Barite and Zinc mines exist. Characteristic one or two strata of meta-Quartzite runs through this zone folded complicatedly and as boudin. This zone may be of Silurian by correlating to geological map of 1/100,000.

Zone **ii** runs along the west side of Zone **iii** with around 200m widths. It is also regarded as the affected zone of the alteration zone to some extent. This zone consists of mainly Pelitic or Biotite Schist interbedded by Psammitic Schist. Schitosity is very clear and rock itself is platy. This zone may be of Cambro-Ordovician by correlating to geological map of 1/100,000.

The boundary between Zone **ii** and **iii** may be faults.

Zone **v** and **vi** runs eastern (right bank) side of the alteration zone (Zone **iv**).

Zone **v** is also slightly affected zone of the alteration zone and consists of Pelitic Schist, Psammitic Schist, and Biotite Schist (Black Schist), partly phyllitizate. Steep mountain slope in the rear of left bank of dam site and upstream just right bank slope of Assif el Ma are composed of this zone. Rock type and structure is almost same as Zone **iii** and correlated as Cambro-Ordovician.

Zone **vi** overlies on Zone **v**. This zone consists of blackish hard (partly very hard) Psammitic Schist or Quartz-Biotite Schist interbedded relatively soft Pelitic or Biotite Schist. This zone extends in both banks of dam site and on the right bank ridges of the upstream Assif el Ma with 1,200 to 1,300m in elevation. However, it doesn't exist in the upstream side from Assaïs village and left bank side. This zone may be of Ordovician by correlating to geological map of 1/100,000.
Zone **vi** transits from Zone **v** unconformity.

Some intrusive rocks exist in the area. There are 4 types.

One of them is Metabasite dyke greenish, basic and schistose, existing as lenticular along the boundary between zones **i** and **ii**.

Second one is slightly schistose Quartzitic or Granophyric dyke existing in the right bank between Imi-n-Erkha and Assaïs village with 1 to 2m widths forming as backbone of ridge. This dyke doesn't intrude Zone **vi**.

Third one is Aplitic sill scatteringly existing in the area of Zone **iii** and **v**. This rock is massive, with no schistosity, milky yellowish gray and intrudes into Schist relatively concordantly to its schistosity. Though it looks like arkosic sedimentary rock at a glance, it is considered as igneous material from the following reason: filling fissures at many places in Zone **iii** with no schistosity and making mother rocks a little altered.

The last one is Microdiorite dyke existing in the depression between Assaïs and Imi-n-Erkha villages. These are greenish gray, with no schistosity, hard and massive. Two dykes arrange to E-W orientation straightly with 5 to 10m and around 2m in thickness. This one intrudes also the rocks of Zone **vi** and makes it altered and sheared.

Mesozoic formations overlie unconformity on Paleozoic formations with horizontal or slightly dipping beds in both banks of uppermost stream area of reservoir. These are of Jurassic to Cretaceous.

Jurassic formations consist of mainly Conglomerates, Marly Sandstone, Sandy Limestone or Dolomite interbedded many Gypsum layers. Cretaceous formations consist of mainly Marl, Limestone and Dolomite (partly interbedded by Gypsum)

Terrace deposits are observed on both banks along present river course. Relative height from present riverbed is: 1 to 2 m to the surface of alluvial terrace composed mainly of sandy to silty deposits, and 5 to 10m to upper level of terrace composed of sands, gravels and cobbles. Some higher levels of terrace surface with thin deposits are also observed. Riverbed, which is composed of generally sands, gravels and cobbles, has relatively equal width around 300 to 400 m. However around dam site, it becomes narrower to 100 to 150m.

Thick alluvial cone deposits exist in the left bank from Tilwa to Kern village.

Talus deposits exist at the foot of both banks. Especially, those of left bank of left branch at just upstream of dam site is extent widely and thick. This is extent widely also at the foot of faults cliffs between Zone **i** and **ii**.

(3) Dam Site

Slope inclination in the right bank side from riverbed to around 1005m elevations is around 25º, and around 35º in a section higher than this elevation. Upstream side is much steeper showing average around 40º until 1030m elevations (near riverbed are nearly 50º, and higher than this level, becomes gentle).
While in the left bank side, it is vertical cliff until elevation around 1000m (riverbed 940m). However both in the upstream and downstream it becomes rather gentle inclination.

The width of present riverbed is around 100m in the upstream and downstream side, while around dam site it becomes narrower to 50 to 70 m. River course meanders suddenly at 400m downstream due to narrow ridge protruding to riverside.

The gradient of riverbed around dam site is average 1/93.

Terrace surfaces are not clear in the area.

Geological condition around dam site is as shown in Figure X2.2.2 and geological profile along contemplate dam axis is shown in Figure X2.2.4.

The bedrock around dam site is Quartz-Biotite Schist interbedded with Biotite Schist of Ordovician. Quartz-Biotite Schist is generally hard to very hard and massive. While, Biotite Schist is relatively soft. Schistosity of left bank side is N10 ~ 30ºE, 25 ~ 30ºE. Strata forming vertical cliff folds slightly, and its schistosity is generally N30 ~ 55ºW, 25 ~ 40ºE, partly becoming vertical. Those of right bank side are N10ºE ~ 30ºW, 30 ~ 50ºE. On the whole, these schistosity is almost perpendicular to river course and dipping to downstream side. However because they fold slightly, partly dipping towards riverside or mountainside. Though Quartz-Biotite Schist and Biotite Schist alternate around dam site, their distribution is not continuous between left bank and right bank. They have a structure different laterally so that faults on river course may be inferred.

Deteriorated portion or zone is very few in left bank side, however in right bank side seemed to exist a lot of weak zones orienting from upstream side to downstream side. They dip both riverside and mountainside.

One of them has their strike and dip N40ºE, 40 ~ 53ºS. Joints are usually dipping towards riverside. N65ºW35ºN orienting weak zones are also observed. Fault with 7 to 10m widths orienting N30ºE, 90º exists at just downstream of dam site. Bedrock downstream side of the fault exposes to surface, however talus deposits cover them in the upstream side.

Around 5m thick talus deposits cover the area bedded by Biotite Schist in the right bank around dam site. Likewise, very thick talus deposits distribute in the area a little downstream side in the left bank side. Talus deposits are also accumulated upstream in the left bank side due probably to dipping towards river.

Terrace deposits situate under Talus deposits. Relative height of its position from present riverbed is around 5m. Thickness is 2 to 3m composed of rounded with few boulders around ϕ 1m.

Alluvial Terrace deposits consist of mainly sand and silt and River deposits consist of sand and gravel with cobbles

(4) Remarks

As a point to which we should pay attention around dam site, the next matter is given.

- River deposits on riverbed may be relatively thick.
- In right abutment, some faults or weak zones are inferred, and Colluvial deposits on them are relatively thick.

X2.2.2 Seismic Velocity Profile along Contemplate Dam Axis

Seismic velocity profile along contemplate dam axis is shown in Figure X2.2.5.

From the analysis, velocity layers along contemplate dam axis can be divided into the following three.

Layer No.	Left Abut.	Riverbed	Right Abut.
I	1.0～1.4km/s (Colluvial dep. or Loose rocks)	1.8km/s (Alluvial dep.)	0.8～0.9km/s (Colluvial dep. partly Terrace dep.)
II	1.7～1.9km/s (Weathered rocks)	2.1km/s (Consolidated sands & gravels)	1.3 ～ 1.7km/s (Highly Weathered rocks)
III	3.0～3.6km/s (Fresh rocks)	4.8km/s (Fresh rocks)	3.5～4.1km/s (Fresh rocks)

Low velocity zone can be recognized at right abutment around 1,030-1,040 meters in elevation.

X2.2.3 Construction Material

For this project, dam is considered at present as concrete type due to topography, its scale-merit, and foundation. On account of that, construction material study in this time is concentrated on concrete aggregate.

Taking into consideration the above matter, quarry site has been checked only to do the river deposits material with an object, because enough volume of gravels accumulates on riverbed.

(1) Survey by Test Pitting

Five pits labelled P1 to P5 have been achieved for sand and gravel materials of alluvium river deposit in the vicinity of the Taskourt dam. Pit P1 is located in the downstream dam site, while other 4 pits (P2, P3, P4 and P5) are in the proposed reservoir area.
It was expected to dig these pits manually with the aid of the shovel and the pickaxe, for 1.50m in depth as from the surface.

・ **Logging of Test Pit**

- Pit P1 -

0.00 - 1.30 m: Sandy alluvium.
1.30 - 1.50 m: Hard sand of the river.

- Pit P2 -

0.00 - 1.30 m: Sandy alluvium.
1.30 - 1.50 m: Hard sand of the river.

- Pit P3 -

0.00 - 1.20 m: Sandy alluvium.
1.20 - 1.50 m: Hard sand of the river

- Pit P4 -

0.00 - 0.80 m: Sandy alluvium.
0.80 - 1.50 m: Hard sand of the river.

- Pit P5 -

0.00 - 1.20 m: Sandy alluvium.
1.20 - 1.50 m: Hard sand of the river.

It should be noticed that during the reconnaissance period (from September 14th, 2000 to September 19th, 2000), we have encountered ground water in the pits from 0.80 to 1.30m in depth.

(2) Laboratory Test on Aggregate Material

The laboratory tests on aggregate have only concerned alluvial deposits found in the pits.

・Grain Size Analysis

1) The percentage of the particle less than 0.080 mm is of: 1 to 3%.
2) The percentage of the particle between 0.08 and 2 mm is of: 12 to 20%.
3) The percentage of the particle more than 2 mm is of: 78 to 87%.
4) The percentage of the gravel more than 50 mm is of: 24 to 40%.

It should be noticed that we have encountered some large gravel with a diameter that may reach 200 mm in the samples taken.

・Los Angeles Test

Resistance of abrasion for alluvial material has been measured through Los Angeles test upon gravel of 10- 25 mm. The rate of abrasion by Los Angeles measured varies between 24 and 30. It is generally recognized that rate of abrasion should be less than 40% for coarse aggregate material. Then gravel material of the dam shows good quality.

・Density, Porosity and Absorption

The density varies between 2.64 and 2.72 t/m^3. The porosity and the absorption coefficient are relatively identical from an area to another. The porosity is of 0.59 to 1.20% and the absorption coefficient is of 0.22 to 0.46%.
It is generally recognized that gravel with density of less than 2.5 t/m3 and absorption of less than 3% is suitable for aggregate. Then gravel material of the dam shows good quality.

・**Weathering Resistance Test**

The results of the weathering resistance tests with chemical solution of sodium sulfate are as following:

Pit	*Grain size*	*Loss P*
P1	0.08 - 5 mm	3.37%
P1	5 – 80 mm	0.60%
P2	0.08 - 5 mm	2.59%
P2	5 -80 mm	1%
P3	0.08 - 5mm	3.3%
P3	5 – 80 mm	0.93%
P4	0.08 -5 mm	3.19%
P4	5 – 80 mm	1.04%
P5	0.08 - 5 mm	3.42%
P5	5 – 80 mm	0.55%

Above results show fairly good quality being less than 15%, which is general allowable limit of loss by the test.

Judging from the results of the density, the absorption, the resistance of abrasion and the weathering resistance, the gravel material in the vicinity of the dam site is suitable for concrete aggregate as well as dam embankment material.

・**Superficial Cleanness**

The superficial cleanness of the alluvium varies between 0.1 and 0.3%. This is fairly low and material may not required washing for concrete aggregate use.

・**Alkali Reactivity**

Alkali reactivity test on gravel material has been carried out and every result shows that they belong to the zone of no reaction.

(3) Laboratory Test on Rock Sample

Four drilling survey (SD1, SD2, SO and SG) for the dam foundation was carried out and core samples were taken. Among them some samples were provided to the laboratory. Items of the tests are density (γ), absorption (***n***), unconfined compression strength (***Rc***) and elastic modulus (***E***), ultra-sonic velocity of primary wave (***Vl***) and secondary wave (***Vt)*** and Poisson ratio (ν).

The results are as follows:

Sample	γ *(t/m³)*	*n (%)*	*Rc (MPa)*	*E (GPa)*	*Vl (m/s)*	*Vt (m/s)*	ν
SD2 (36.90 – 37.40 m)	2.64	2.71	30.9	45.5	5679	3750	0.13
SO (19.50 – 19.90 m)	2.70	1.74	37.4	48.5	5909	3250	0.28
SO (26.00 – 26.50 m)	2.73	1.54	34.7	52.5	6273	3286	0.31
SG (21.30 – 21.60 m)	2.55	4.66	40	42	5000	3095	0.19
SG (34.00 – 34.50 m)	2.54	5.19	38.2	37	5286	3524	0.1

The measured unconfined strength is moderate on this rock.

(4) Consideration

There observed a large amount of river sand and gravel deposits in the propose reservoir area. Also deposit of sand and gravel is observed on the riverbed of near downstream of the dam site. Prospecting volumes of deposits are estimated as (3km x 150m x 5m=) 2,250,000 m^3 for the reservoir area and (1km x 50m x 3m=) 150,000 m^3 for downstream dam site. Their boulder size content is not high. Silt content is low as less than 3%. Gravel has excellent quality such as 0.7 % of water absorption, 2.68 of specific gravity, 27 % loss of abrasion test and non-reaction of alkali reaction. Then above materials are judged to be suitable for concrete aggregate. However, it should be noted that gravels contain that of flat shape that will be causing of less consistency of mixing concrete and will sometimes require increment of cement content. To obtain a proper condition of mixing further various kinds of concrete mixing tests are necessary.

X2.3 Timkit Dam

X2.3.1 Physiography and Geology

X2.3.1.1 Around Catchment Area

Location of Timkit area is as follows:
    90 km WSW of El Rachidia; and
    25km WNW of Tinjidad.
Catchment area of reservoir is 572 km^2.

Dam site is located on the part of southern periphery of Haut Atlas Central straightly extending on the direction ENE-SWS. Due to river systems orienting same direction, its catchment shapes near rectangular elongated to direction ENE-SWS with around 45km length by 12 to 13km widths. Mountains are limited south by so-called South Atlasic Fault.

The elevation of catchment area is from 1210m at riverbed of dam site to 2921m of Ylalla Rejdet rising in northeast. At rear of the basin, many mountain chains whose peaks over 3000m run ENE-SWS directions. In the west half of the basin from Oued N'Ifer, mountains chain three abreast. Ridges elevation is around 1800m on southernmost mountain chain, 2000 to 2400m on middle one, and 2300 to 2600m on northernmost one. Two rows of depression lie among them. While in the east half of the basin, four chains of mountain align between northern and southern watershed.
These mountain chain forms generally southern side precipitous cliff, and

northern side a little gentler slope, likewise the Questa.
Downstream side of dam site is vast gravel field of alluvial fan supplied large quantities of sediments from Oued N'Ifer. Diameter of fun is more than 10 km. There are so many stream courses on this alluvial fan radiating from dam site. The largest one among them is Oued Arhbalou N'Kerdous flowing center of fan directly from Oued N'Ifer of which streambed becomes gradually narrower as proceeding to downstream. This river joins to Oued Tannguerfa, and further to Oued Todrha at Tinjidad town. Between dam site and Tinjidad, three rows of long hills elongated E-W exist forming questa-like geography.

According to geological map on a scale of 1:500,000 issued by Ministry of Mineral and Mining, geology around catchment area is as shown in Figure X2.3.1.

Mountain chains in the catchment area consist of mainly Limestone and Dolomite of Lower Jurassic (Liassic), striking generally ENE - WSW and dipping NNE. In many case, bedding plane of these Limestone-Dolomite Banc shapes northern side slope of mountains. While, their southern side cliff is due to fault planes orienting ENE - WSW. Triassic Basalt scatters partly in the area.
Depressed area between mountains consists of Limestone partly interbedded with Marl and Gypsum of Upper Liassic, red-color Sandstone (partly Conglomerate) of Upper Jurassic to Lower Cretaceous, and Silty Sandstone, Gypsum, thin-layered Limestone, Marl and Sandy Mudstone of Cretaceous. These are widely covered by Quaternary unconsolidated deposits. Thick Alluvial deposits accumulate on riverbed.
Jura-Cretaceous formations extend widely in the southern side of mountains as E-W orienting hills. Paleocene formations also exist scatteringly.
Fan deposits in the downstream area consist generally of Cobbles, Sands and Gravels with few fine-grained soil. Lower portion of fan deposits are travertinized in the area of eastern side of Alluvial Fan, covered by thin wind deposits of silts and fine sands.

X2.3.1.2 Around Reservoir

Straight mountain ranging ENE-WSW direction rises to both banks from dam site having width of 1-1.5 km, which forms torrent and develops deep gorge of maximum height 350m and length 2km. Oued N'Ifer enters to this gorge first from northeast side (flows to south west) and suddenly changes its course to southeast. After passing the gorge, it meanders largely towards downstream through Timkit village. At 350 m upstream from the bending point mentioned above, tributary Oued Oursad joins from right after flowing through the foot of mountain.

Mountain of right bank inclines toward north like undulated tilting board and falls suddenly as cliff toward south. While, left bank is that first lean ridge runs to northeast and gradually bends towards southeast becoming rather thick. Riverside of this mountain is precipitous cliff, while opposite side makes slope inclined around 30º.

The area between Oued N'Ifer and Oued Oursad is wide depression plain gently sloping among mountains, though some gullies develops in the area. Terraces extend along the bank of present river course, though it is not so clear.

High water level of reservoir is crossing to the northern gentle slope, and checked southern line by mountains.

The average gradient of riverbed in the reservoir area along mainstream is 1/75 to 1/80.

Geological condition around reservoir area is as shown in Figure X2.3.3.

Bedrock in the area is mainly of Limestone-Dolomite dipping toward upstream. Formation around dam site is mostly of Lower Liassic. Limestone interbedded with red-color Mudstone and Gypsum of Upper Liassic and Dolomitic Limestone with basal layers (red-color Sandstone, Conglomerate) of Middle Liassic lies in reservoir area. Cretaceous forms partly upstream area. Stratigraphic description hereupon is relying upon Geological Map of scale 1:100,000 "Tinjidad" issued by Ministry of Mineral and Mining.

Type of Dolomite-Limestone is various, e.g. thick strata, thin strata etc., and karsts commonly develop well. Trend shows upper layers develop more karsts.

Bedding plane is generally dipping to upstream with some folding, and the surface of upstream side of mountain slope express bedding surface itself undulating gently.

Travertine Conglomerate is relatively widely distributing along upstream side foot of mountains.

Flood deposits of sands & conglomerate, fine sands and silts extend widely on the plain between Oued N'Ifer and Oued Oursad, and on both banks of Oued N'Ifer.

Terrace gravels (partly fine-grained soil) extend mainly along right bank of Oued N'Ifer.

River deposits consist of cobbles, sands and gravels on flowing course and partly of fine sands and silts on periphery.

Talus deposits exists at the foot of terrace scarps, steep mountain slopes, etc.

(3) Dam Site

Dam site is located in gorge.
The slope inclination of right side gorge is average 35º with some vertical cliff by rock joints. A ridge protrudes to riverside at a little downstream and river course changes along this ridge.
While left bank gorge is average 40º, forming triangle-shape. Mountain of left bank side is a lean ridge gently curving from northeast to east direction. The average inclination of northern (upstream side) slope is 30 to 35º, while southern (downstream side) slope is 30 to 35º from riverbed to 1230m elevations, 15 to 20º until 1270m, and 25 to 30º at higher portions forming like step.

The width of present riverbed is between 20 and 30m even in upstream or downstream.

The gradient of riverbed around dam site is average 1/100.

Geological condition around dam site is as shown in Figure X2.3.2 and geological profile along contemplate dam axis is shown in Figure X2.3.4.

Bedrock is mainly Dolomite or Dolomitic Limestone. The upper one is thickly layered, massive, platy, while the lower one is thin to fine layered by stromatolitic lamination of the mixture of calcareous and cherty material. Black Dolomitic stratum bearing a lot of iron-manganese mineral intercalates between them.

According to Geological Map of scale 1:100,000 "Tinjidad" issued by Ministry of Mineral and Mining, all of these formations are of Lower Liassic.

The upper strata are usually gray, white, pink, or greenish gray, porous and loose developing a lot of karsts. The more upstream side, it is impressed as looser. Strike and dip of bedding plane is almost flat in the upstream and N20 ~ 40ºE, 25 ~ 35ºW in the downstream around the level of riverbed.

Black Dolomitic stratum bearing iron-manganese is very loose due to a lot of fractures and developing remarkable karsts. Step-like area in the left bank is composed of Travertine concreting the rock blocks of Limestone and Dolomite. Talus deposits cover this rock distributing area of the right bank.

The lower one consist of alternation of calcareous rocks and marly rocks, and largely divided into **a)** the part interbedded with brown iron-manganese bearing layers and **b)** the part non-interbedded with them. Both strata have two horizons. The thickness of layers is 1.0 to 1.5m respectively in **a** portion, and as proceeding to lower it becomes thin to fine layered. In **a** strata, partly cataclastic (or nodular) strata are interbedded (especially in Marl layers). This is due to sliding along relatively soft layers beds (bedding sliding). Karsts develop partly along these cataclastic layers. In **b** strata, karsts cannot be observed.

Strike and dip in this horizons is N42 ~ 50ºE, 34 ~ 38ºW in left bank side and N32 ~ 45ºE, 23 ~ 29ºW in right bank side around the level of riverbed.

As proceeding to lower of **b** strata, rocks become cherty and relatively hard forming white to whitish gray stromatolitic laminated thin to fine layers. Two partial folding are observed in left bank in these strata. The upper slope of the folding is curving largely, that is, this folding reaches the whole area. Strike and dip of upstream side of the folding at the level of riverbed is N50ºE36ºW and downstream side is N80ºW14 ~ 22ºN. Strike of downstream side is almost same direction of mountain slope. Those of right bank side is N5 ~ 28ºE, 30 ~ 38ºW. Karsts are not observed in these strata. The anticlinal axis orients NNE-SSW plunging to N.

As mentioned above, Travertine concreted with many rock blocks exists in the middle of left bank slope.

Talus deposits distribute from middle to foot of steep slope. Those around the area of partial folding are relatively consolidated so that it may be inferred to be Subrecent deposits.

River deposits consist of cobbles, sands and gravels.

(4) Remarks (About the Leakage from Dam Site)

Foundation at dam site consists of the rocks as the followings from upstream side to downstream side.

i) Limestone and Dolomite

ii) Black to brown ore (iron-manganese) mineralized Dolomite

iii) Alternation of **ii** strata intercalated with marl and **vi** strata

iv) White to bluish gray thinly layered (or laminating) stromatolitic or cherty strata.

Strata **i** are gray, white, pink, or greenish gray colored, porous and loose due to a lot of karsts. As proceeding to the upper layers, karsts are developing more and become porous and loose more.

Stratum **ii** is also very fractured and loose due to karsts developing remarkably. The left bank side slope of this stratum forms gently sloping terrace where travertine extends concreting the rubbles. The right bank side slope cannot be observed well due to the cover of debris, however it is also supposed to be fractured.

Strata **iv** exist in two levels intercalated with a Stratum **iii** in between. Strata **iii** include the layers cataclastic (or nodular) caused probably from slides along bedding plane of the relatively soft layers. Strata **iii** develop karsts along the cataclastic layers, while strata **iv** have no karsts and few fractures so that they may be impervious.

The elevation of strata **iv** is gradually going up as proceeding to downstream in the right bank side, while in the left bank side it is almost horizontal along mountain slope of which the uppermost elevation is around 1,250 m.

Contemplate height of Dam Crest is also around this elevation, so that the leakage through the foundation will be fairly checked on the condition that the loose stratum **ii** is grouted. The leakage through the rims and wings will be also checked, if the grouting line is joined with impervious strata **iv**. Cretaceous rocks cap the front slope of mountain chain, which may be impervious due to alternating with marl layers.

The stratum **iii** between the strata **iv** has also leakage problem. However due that the upper stratum **iv** consists of layers alternating with few fractured impervious marl, leakage in the vertical direction to bedding planes is seemed to be few. But to avoid any leakage possibility, plug of stratum **iii** may be necessary by grouting the section from the upper strata **iv** to the lower.

X2.3.2 Seismic Velocity Profile

Another JICA Study Team already conducted seismic refraction prospecting survey at Timkit dam site in 1990 on the study for dam construction project in Rheris Basin. Instead of omitting those investigations this time therefore existing data were obtained. Because the dam axis has been contemplated in a lower reaches side further this time, a section just on a contemplated dam axis does not exist, but a section of the just upstream is very useful for considering the foundation condition along contemplate dam axis. Existing seismic velocity profile nearest to contemplate dam axis is shown in Figure X2.3.5.

Largely, velocity layers can be divided into the following four.

Layer No.	Left Abut.	Riverbed	Right Abut.
I	0.3km/s (Colluvial dep.)	0.3km/s (Alluvial dep.)	0.3km/s (Colluvial dep.)
II	1.0km/s (Loose rocks)	1.0km/s (Alluvial dep. over water level)	1.0km/s (Loose rocks)
III	2.0km/s (Weathered rocks)	2.0km/s (Alluvial dep. under water level)	2.0km/s (Weathered rocks)
IV	3.0km/s (Fresh rocks)	3.0km/s (Fresh rocks)	3.0km/s (Fresh rocks)

X2.3.3 Construction Material

For this project, dam is considered at present as concrete type due to topography, its scale-merit, and foundation. On account of that, construction material study in this time is concentrated on concrete aggregate.

Material test was also already conducted in 1992 on detail design study for Timkit dam by C.I.D. consultant. Test was carried out for river deposit in the reservoir area.

This time, JICA Engineer checked the condition of river deposit material by watching in the field. As a result of that, Recommendable quarry sites for concrete aggregate are shown in Figure X2.3.6.

(1) Survey by Test Pitting

Three pits named PS1 to PS3 have been achieved in the downstream near Tinjidad town for checking geohydrological condition. Those results may be considered as one of reference value for construction material.
These pits have been dug at 0.60 to 1.50 m depth as from the surface.

・Grain Size Analysis

1) The percentage of the particle less than 0.08 mm is of: 2 to 3%.
2) The percentage of the particle between 0.08 and 2 mm is of: 12 to 68%.
3) The percentage of the particle more than 2 mm is of: 29 to 86%
4) The percentage of the gravel more than 50 mm is of: 0 to 15%.

It should be noticed that we have found some hard gravel with a diameter that may reach 150 mm in the samples taken.

・Permeability Test

The permeability tests have been carried on samples put in Terzaghi mould with simple pouring and slight compaction. The samples have been levelled at 20 mm.

The permeability obtained by the Terzaghi method with a constant water head is as follows:

Pit	***K** (cm/s)*
PS1	2.9×10^{-2}
PS2	7.3×10^{-2}
PS3	3.2×10^{-2}

These permeability values are high and pervious.

(2) Laboratory Test on Rock Sample

Five drilling surveys for the dam foundation were carried out and core samples were taken. Among them some samples were provided to the laboratory. Items of the tests are density (γ), absorption (***n***), unconfined compression strength (***Rc***) and elastic modulus (***E***), ultra-sonic velocity of primary wave (***Vl***) and secondary wave (***Vt***) and poisson ratio (ν).
The results are as follows:

Sample	γ *(t/m³)*	***n** (%)*	***Rc** (MPa)*	***E** (GPa)*	***Vl** (m/s)*	***Vt** (m/s)*	ν
SG3 (12.20 – 12.60 m)	2.63	5.55	18.9	22.5	5097	3098	0.21
SG3 (15.10 – 15.60 m)	2.62	3.23	13.2	12	4788	2257	0.36
SD (19.30 – 19.70 m)	2.64	7.43	49.9	52.5	6320	2981	0.36
SD (23.00 – 23.50 m)	2.58	5.48	46.4	47	4788	2633	0.28
SG1 (4.80 – 5.20 m)	2.75	3.12	30.8	44	6304	2457	0.41
SG1 (17.40 – 17.70 m)	2.74	4.00	27.5	34	533	3077	0.25
SG2 (14.75 – 15.00 m)	2.61	6.98	33.3	45.5	8125	5000	0.20
SG2 (22.70 – 23.10 m)	2.71	3.41	35.7	49	8357	5318	0.20
SO (10.80 – 11.10 m)	2.69	4.07	41.6	47.5	6300	3500	0.28
SO (23.30 – 23.60 m)	2.73	2.06	34	43	7650	4500	0.24

The measured unconfined resistance varies 13.2 to 49.9 MPa.

(3) Consideration

There observed sand and gravel deposit on the riverbed around upstream and downstream of the dam site. Prospecting volumes of deposits are estimated as 450,000 m^3. In the alluvium plain of downstream of Ifegh village a enormous volume of sand and gravel are also observed. Although no laboratory test on sand and gravel as construction material was performed, those materials considered to have hard and of high durability to be suitable from their appearance.
Natural sand and gravel have wide range of gradation, depending on the deposit condition and the depth. Using sand and gravel with the natural gradation as concrete aggregate may affect the concrete qualities, for example, showing unevenness of the concrete strength. It is important to clarify the tendency or

relation between the gradation of material and concrete qualities such as strength, workability, etc. through the survey and concrete mixing test in the next stage.

X2.4 Azghar Dam

X2.4.1 Physiography and Geology

(1) Around Catchment Area

Azghar area is located about 70 km WSW of Fès.
The nearest town is Ribat Al Kheir where dam site is at 7 km WSW.

Catchment area of reservoir is 263 km^2.

Very high peaks more than 3,000 m in elevation (J. Bou Iblane and Adar Bou Nasseur, etc.) of Moyen Atlas rise as rock walls in the rear of the basin. Oued Zloul basin is relatively rich in water flow in winter season due to snowmelt, however in summer season it is usually dried up.

The elevation of the catchment is from 820m at dam site to 2,100m. Oued Zloul flows to west joining with two tributaries from north and northeast and passes valley of dam site. Then it flows out to the downstream wide valley.

Both banks of dam site and continuing watershed of the catchment form long hills, while central area and its rear is gently sloping area.

The downstream wide valley area situates long and narrow along Oued Zloul between tablelands and hills where relative height from valley bottom is around 100m in left bank and 100 to 300m in right bank.

According to geological map on a scale of 1:500,000 issued by Ministry of Mineral and Mining, the Geology around Catchment area is as shown in Figure X2.4.1.

Central and left bank side of the catchment consist of Middle to Lower Jurassic arranging NE-SW, while right bank side and its rear is of the series of J. Tazzekka of Paleozoic. Red-color formations and Basalt of Triassic distributes long and narrow continuously between these areas in right bank, and scatteringly along faults in left bank. Alluvial deposits on riverbed are relatively few.

Jurassic formations, which are main composition of the catchment, repeat as syncline and anticline with gentle undulation without any strong deformation. Small regionally they are almost monoclinic dipping 10 to 20º.

Though large fault and sheared zones may not exist in the area, some dislocations of formations with sharp plane are observed. It is inferred a gradual blocks tilting action accompanied with upheaval of Moyen Atlas. Mainly two systems of conjugating faults are observed orienting NE-SW and NW-SE, forming weak blocks tilting action and folding. Nearer to Moyen Atlas, this kind of tectonic movement may be stronger.

(2) Around Reservoir

A hill of E-W direction from a left bank side and a hill of N-S direction from a right bank side face each other at the valley of a dam site. Oued Zloul flows to west along the foot of left bank side hill meandering a little. Oued Chara joins from N-E at 2 km upstream of dam site. A small but deep valley cuts right bank side hills.

At dam site, riverbed is around 820m in elevation, ridges of left bank side hill is from 950 to 1000m, and those of right bank side hill is 910 to 920m. Both hills have steep slope of 35 to 40º in reservoir side and gentle slope around 15º in another side. Some long and narrow ridges protrude to south from independent hill in northern side.

The area between hills is very gently undulating slope with some shallow gullies continuing to rivers. Terrace develops along riverbank.

Reservoir shapes near rectangular of around 600 m by 2 km. Full water level is crossing to gentle slope in north and checked by hills in south and west.

The gradient of riverbed in reservoir area along main river course is average 1/100 ~ 1/105.

Geological condition around reservoir area is as shown in the Figure X2.4.3.

Bedrock in the area is divided largely into two Formations.

One of them is rhythmically alternated black Limestone and laminated black Marl. They form hills around dam site and continuous watershed. Limestone is usually platy with 10 to 50 cm thickness. Marl is very fissile same like Shale. Ratio of Limestone and Marl is around 1:5 around dam site. At upstream area and the part at midstream area of reservoir along Oued Zloul, Limestone ratio becomes a little larger.

Another one is almost of Marl (with no or very few Limestone layers) forming very gentle slope area between hills.

Both Formations transit in conformity where the former overlie on the latter.

According to the geological map “Sefrou” on a scale of 1:100000 adjoining in the southwestward of the project site including area, both formations in the area are of Toarcian, Liassic (Lower Jurassic).

Structurally they are folding largely and gently where anticlinal axis orienting N-S or NNE-SSW through the point confluence of Oued Chara and Oued Zloul plunging to south and synclinal axis orienting almost same direction outside of reservoir (downstream side). Dip of bedding is generally 10 to 15º or gentler, partly 30 to 45º. Gentler slope side of hills is made mostly of this bedding plane of Limestone like a natural stone pavement.

Terrace of almost uniform widths of 100 to 150 m extends along both banks of Oued Zloul and Oued Chara. Relative height from present riverbed is 5 to 10 m. Terrace of around 50 m widths also exists along the stream confluence to Oued Zloul at just upstream of dam site. Terrace deposits consist of several meters to 10 m thick sands and gravels. Its thickness is changes very much area by area. Higher level of terrace deposits are also observed on some saddles in left bank of Oued Zloul composed of thin rounded gravel deposits. Its relative height from present riverbed is 25 to 30m.

In the upstream area of Oued Chara, rounded gravel deposits are also observed even far from river course. These are probably Flood deposits supplied from upstream mountain area.

Terrace-like surface is also extending along both banks of gullies flowing directly to rivers by probably sheet erosion composed of thin deposits of silts and fine sands.

Colluvial deposits develop at the foot and mid-slopes of hills composed of angular gravel bearing soils.

Red to yellow or gray color fine grained soils cover the gentle sloping area. These are residual soils derived from strongly weathered Marl. Transported mainly by wind, it accumulates thick partly. In case transportation is few, soils may be red due to iron-oxidized material weathered long time at the same place. The area slightly transported may be yellow, and the area transported often may be gray.

(3) Dam Site

Slope inclination in the right bank side is rather gentle showing average 22º in the mid-slope and 7 to 8º at the foot, while those of left bank side is very steep around 50º, though ridge portion inclines gently towards downstream side with 10 to 20º. Right bank ridge protrude a little towards downstream side.

Valley bottom is gently sloping from the foot of right bank hill to river course with 5 to 6º. The gradient of riverbed around dam site is average 1/175. Around the confluence of the stream from right bank and Oued Zloul at just upstream of dam site, terrace of relative height several meters from present riverbed is clear.

The widths of river course is uniformly around 10m, and valley bottom is around 160m along contemplated dam axis and become narrower towards downstream where the minimum is 75 m at the distance 300m downstream.

Geological condition around dam site is as shown in Figure X2.4.2 and geological profile along contemplate dam axis is shown in Figure X2.4.4.

Bedrock is the rhythmical alternation of black Limestone and laminated and fissile Marl. Marl is of film-sheeted aggregate less than 1 mm thickness. These formations can be correlated to Liassic.

Generally, Limestone is hard and platy with thickness of stratum 10 to 30 cm and Marl layer between two Limestone plates is usually 30 to 100cm. The ratio of both strata is Limestone 1 to Marl 3-4. Left bank side is a little higher Limestone ratio than right bank. However as far as the formation of left bank concerned, platy strata situating higher level than 860m elevation can be called completely Limestone but the one lower than that elevation is a little muddy calcareous rocks. The one of right bank side can also be called Limestone. Strike of bedding is around N30ºW (N20º-50ºW) almost perpendicular to valley, and dipping towards downstream around 10ºSW (5º-15º). Joints in this area are almost vertical orienting N-S and E-W as clear one. The steep slope of left bank may develop along E-W orienting joints. Joints orienting NW-SE are also observed frequently, one of them around downstream outlet of the valley makes fault-dislocating strata (strike N55ºW, dip 90º, intercalated with 40cm gouge). At just downstream of dam axis in left bank, some dislocation of strata can be observed (strike N30ºW, dip 65ºE).

As far as the area around dam site is concerned, bedding of strata is monoclinic without any large faults and sheared zone. Rock is contacted each other with no karsts developing.

In the steep slope of left bank, bedrock outcrop almost all and partly talus deposits accumulate at the foot. However in right bank, thick Colluvial deposits extend widely from mid-slope to the foot. Lower portion of this Colluvial deposits is concreted by calcareous material forming Travertine. Valley bottom sloping gently from right bank to river course near horizontal is covered by very fine Colluvial deposits with thickness 1 to 2m underlain by Terrace gravels of thickness around 2m. This Terrace gravels may distribute from just present riverbank to the foot of right bank slope with widths 100 to 150m on the whole. Terrace deposits distribute also along the stream joining from right at just upstream of dam site with widths around 40m. The thickness changes by a place.

(4) Remarks

Around dam site, any big faults or sheared zones are not found and the matter such as landslide also cannot be observed so far. The foundation is relatively watertight and probably strong enough for the dam base.

Some small dislocation of strata (minor fault) may be inferred between the drilling location SG2 and SG3 in left abutment.

In the reservoir area, a fault is inferred through hill of left bank side about 500 m upstream of dam site to the bend part of right bank hill about 600 m upstream of dam site. Its strike is N50～60°W. Left bank hillside slope is bumpy by thick talus deposits with no rock outcrops. Though any sheared zone cannot be observed at right bank hill, strata there are disturbed to some extent.

X2.4.2 Seismic Velocity Profile along Contemplate Dam Axis

Seismic velocity profile along contemplate dam axis is shown in Figure X2.4.5.

Largely, velocity layers can be divided into the following four.

Layer No.	Left Abut.	Valley bottom	Right Abut.
I		0.9～1.0km/s (Colluvial dep. & Terrace dep.)	1.0～1.2km/s (Colluvial dep. & Travertine)
II	1.0～1.3km/s (Highly Weathered rocks)		1.5～1.7km/s (Highly Weathered rocks)
III	2.3km/s (Weathered rocks)	2.2～2.5km/s (Weathered rocks)	2.0～2.5km/s (Weathered rocks)
IV	3.1～3.7km/s (Fresh rocks)	3.7～3.8km/s (Fresh rocks)	3.8～3.9km/s (Fresh rocks)

X2.4.3 Construction Material

From topographical condition and foundation condition, both concrete type and fill type of dam can be considered at this site. Then to get impervious and shell material for embankment and sands & gravels for concrete aggregate, borrow area and quarry site shall be checked to do the next material with an object.

・**Borrow area**

Colluvial deposits: distribute at dam site on the slope and at the foot of right bank side hill and on the valley bottom; consist of silts and clay with rock fragments; enough volume exists around dam site.

Residual soils: distribute in the reservoir area or in the plain area of upstream and downstream gently sloping; consist of silts and clay, especially reddish colored portion is cohesive; exist as thin surface layer but widely extending on the area of Marl bedrock.

・**Sands & Gravels Quarry site**

Terrace deposits: distribute along both banks of Oued Zloul and at the valley bottom of dam site with 2 to 3 m in thickness and 100 to 150 m in width overlain by 1 to 2 meter thick Colluvial deposits; consist of sands and gravel with some silts, basal portion is mainly cobbles and boulders.

Alluvial deposits on Oued Qarya: vast volume of gravels exists at the outlet from mountainous area to basin area.

Sands are not currently distributed in adequate quantities, and then we have been unable to obtain them around dam site.

As riprap material, Limestone platy blocs can be obtained from the ridge area of right bank hill. However, volume is not enough.

・**Rock Quarry site**

Limestone: as rock material, limestone of bedrock alternating with marl can be considered; the small hill in the reservoir area situating 700-800m upstream from dam site consists of relatively higher ratio of limestone against marl, then recommendable as good rock quarry site.

Those locations are shown in Figure X2.4.6.

(1) Survey by Test Pitting

Five pits named P1 to P5 have been achieved in the earth embankment material situated in the vicinity of the Azghar dam. The setting of P1 and P2 is in the proposed reservoir area, that of P3 on the dame site and that of P4 on the left bank of downstream dame site. It was expected to dig for 5 m depth as from the natural field.

Furthermore, three complementary manual pits have been achieved mainly for the research of alluvium formations. These pits are named $P5_{bis}$, $P5_1$, and $P5_2$. $P5_{bis}$ has been executed on the right bank of the Oued Zloul, while the pits $P5_1$ and $P5_2$ have been set up on the left and the right bank of Oued Qarya of adjacent basin, respectively.

・**Logging of Test Pit**

The detailed geological logging of the manual pits are as follows:

- Pit P1 -

0.00 - 0.20 m: Top soil.

0.20 - 3.00 m: Yellowish clayey soils with gravels and rock fragments (Yellow Clay).

- Pit P2 -

0.00 - 0.70 m: Top soil.

0.70 - 4.00 m: Silty sand and gravels.

The firmness, and particularly the substantial size of the alluvium elements prevented the digging of this pit more than 5m in depth from the natural field.

- Pit P3 -

0.00 - 0.90 m: Cultivated soil.

0.90 - 1.60 m: Red-color clayey soil (Red Clay).

1.60 - 2.50 m: Sand and gravel with red-color soil.

2.50 - 4.00 m: Sand & gravels, cobbles and boulders.

The firmness, and particularly the substantial size of the alluvium elements prevented the digging of this pit more than 5m in depth from the natural field.

- Pit P4 -

0.00 - 0.60 m: Red-color clayey soil with nodular stones (Red Clay).

0.60 - 2.10 m: Greenish or bluish grey, very soft and brittle rock fragments and residual soils.

2.10 - 5.00 m: Greenish or bluish grey, friable rock powder and rock fragments and some rock blocs.

- Pit $P5_{bis}$ -

0.00 - 0.30 m: Top soil.

0.30 - 3.90 m: Sands and gravels.

The firmness, and particularly the substantial size of the alluvium elements prevented the digging of this pit more than 5m in depth from the natural field.

- Pit $P5_1$ -

0.00 - 1.00 m: Gravel in a silty matrix.

- Pit $P5_2$ -

0.00 - 1.00 m: Sandy gravel.

The pits $P5_1$ and $P5_2$ have been stopped at 1.00m in depth in order to identify the alluvium formations of the riverbed of Oued Qarya.

During in-situ reconnaissance period (from October 9th, 2000 to November 3rd, 2000), no ground water was found in the pits.

We considered that three kinds of soil materials are representative. They are yellowish clay as observed in pit P1, red clay as observed in P2 and highly weathered or residual soil of marl as observed in P4.

Prospecting sand and gravel material for dam embankment and concrete aggregate is alluvium deposits on Oued Qarya. The sample was taken from $P5_1$ and $P5_2$ as representative material.

・**In-situ Density Test**

The results of the in-situ density tests, as well as the tested formation are grouped in the following table :

Pit	*Depth*	*Nature of the tested formation*	*Dry density (t/m^3)*
P1	2.40 m	Yellow clay	1.72
P1	3.00 m	Yellow clay	1.83
P2	1.50 m	Red clay	1.73
P4	2.00 m	Highly weathered marl	1.58
P4	4.30 m	Weathered marl	1.86

The red and yellow clay are very solid on site. Weathered marl is fairly to very solid.

(2) Laboratory Test on Soil Material

The laboratory tests have been carried on 5 samples taken from the yellow clay formation in the following depths: P1 at 2.40 m and 3.00 m, the red clay in the following depths: P3 at 1.50 m, and in the marl formation (P4 at 2.00 m and 4.30 m).

・**Grain size analysis - Atterberg Limit**

-Yellow clay-

1) The percentage of the particle smaller than 0.08 mm is of: 45to 65%.
2) The percentage of the particle between 0.08 and 2 mm is of: 8 to 15%.
3) The percentage of the particle more than 2 mm is of: 20 to 47%.

It should be noticed that there encountered some large gravel with a diameter that may reach 63 mm in the samples taken.
The Atterberg limits are relatively low (WL = 26 to 28 %, IP = 7 to 9 %), which enables the classification in GC-GM (less plastic) according to the international classification.

-Red Clay -

1) The percentage of the elements inferior to 0.08 mm is of: 81%.
2) The percentage of the elements contained between 0.08 and 2 mm is of: 4%.
3) The percentage of the elements superior to 2 mm is of: 15%.

It should be noticed that we have encountered some large gravel with a diameter that may reach 63 mm in the samples taken.
The Atterberg limits are relatively high (WL = 37 %, IP = 17 %), which enables the classification of this formation in CL (less plastic clay).

Highly weathered marl:

1) The percentage of the elements inferior to 0.08 mm is of: 72%.
2) The percentage of the elements contained between 0.08 and 2 mm is of: 12%.
3) The percentage of the elements superior to 2 mm is of: 16%.

It should be noticed that we have encountered some rough elements with a diameter that may reach 63 mm in the samples taken.
Atterberg limits are relatively low (WL = 29 %, IP = 8 %), which enables the classification in CL (less plastic clay).

Weathered marl:

1) The percentage of the elements inferior to 0.08 mm is of: 44%.
2) The percentage of the elements contained between 0.08 and 2 mm is of: 14%
3) The percentage of the elements superior to 2 mm is of: 42%.

The Atterberg limits are relatively low (WL = 31 %, IP = 10 %), which enables the classification of this formation in GA (less plastic aggregate).

・**Density**

The measure of the mass in the laboratory through the hydrostatic method carried out on the intact samples in the shape of clump of earth has shown the following dry densities :

Pit	*Depth (m)*	*Dry density (t/m^3)*	*Specific gravity (t/m^3)*	*Water content (%)*	*Saturation degree (%)*
P1	2.40	1.77	2.721	15	76
P1	3.00	1.73	2.711	19	91
P3	1.50	1.76	2.693	16	81
P4	2.00	1.71	2.719	16	74
P4	4.30	1.55	2.718	15	54

・**Proctor Compaction Test**

The Proctor compaction tests carried out in the laboratory has evaluated the following maximal densities and the optimal water contents :

Pit	*Depth (m)*	*Optimal water content W_{opt} (%)*	*Maximal density γ_{dmax} (t/m^3)*
P1	2.40	16	1.76
P1	3.00	16	1.75
P3	1.50	17	1.69
P4	2.00	16	1.76
P4	4.30	16	1.84

・**Triaxial Compression Test**

Consolidated undrained triaxial compression tests to evaluate shear strength were carried out on reconstituted samples at 95% of optimum proctor density. Samples were saturated before consolidation procedure. Pore water pressure was measured during compression to shear.

The shear strength (internal friction angle and cohesion) on both the effective stress and total stress condition are summarized as following table:

		Short term		*Long term*	
Pit	*Depth (m)*	*Friction angle ϕcu*	*Cohesion Ccu (KPa)*	*Friction angle ϕcu*	*Cohesion Ccu (KPa)*
P1	2.00	23°	10	33°	0
P1	3.00	24°	25	30°	10
P3	1.50	19°	15	27°	5
P4	2.00	27°	20	34°	10
P4	4.30	23°	20	31°	10

・**Consolidation Test**

The consolidation tests have been carried out on reconstituted samples at 95% of optimum proctor.

The measured characteristics (Ic: Compressibility index, Pc: Pre-consolidation pressure, Ig: Swelling index, and Pg: Swelling pressure) are grouped in the following table:

Pit	*Depth (m)*	*Ic*	*Pc (KPa)*	*Ig*	*Pg (KPa)*
P1	2.00	0.130	200	0.01	0
P1	3.00	0.125	100	0.01	0
P3	1.50	0.185	100	0.014	0
P4	2.00	0.150	140	0.010	0
P4	4.30	0.120	110	0.010	0

These values show on the first part that this soil is moderately compressible, and on the second part it shows that this has a weak swelling potential.

・**Permeability Test**

The permeability tests were carried out on reconstituted samples at 90% and 100% of the optimum proctor density with optimum water content

The permeability K measured is as follows:

Pit	*Depth*(m)	$K_{90\%}$ *(cm/s)*	$K_{100\%}$ *(cm/s)*
P1	2.00	2.2×10^{-6}	5.8×10^{-7}
P1	3.00	6.5×10^{-5}	2.1×10^{-7}
P3	1.50	6.7×10^{-5}	1.8×10^{-6}
P4	2.00	1.3×10^{-5}	8.3×10^{-7}
P4	4.30	2.5×10^{-5}	2.6×10^{-7}

It is noticing that the permeability obtained at 90% of the optimum density is relatively higher than that obtained at 100% of the optimum density which endows the clay with a practically impermeable characteristic.

(3) Laboratory Tests on Gravel

The laboratory tests on gravel for aggregate use and dam embankment use have only concerned the alluvium material taken from the pits $P5_1$ and $P5_2$ in the riverbed of Oued Qarya.

・**Grain Size Analysis**

1) The percentage of the particle less than 0.0880 mm is of: 4 to 6%.
2) The percentage of the particle between 0.08 and 2 mm is of: 10%.
3) The percentage of the particle more than 2 mm is of: 84 to 86%
4) The percentage of the gravel more than 50 mm is of: 36 to 37%.

It should be noticed that we there encountered some large gravel with a diameter that may reach 200 mm in the samples taken.

・**Specific Gravity**

The specific gravity of the particle less than 2 mm is 2.7.

・**Los Angeles Test**

Resistance of abrasion for gravel material has been measured through Los Angeles test upon the size of 10- 25 mm. The rate of abrasion by Los Angeles measured varies between 19 and 26%. It is generally recognized that rate of abrasion should be less than 40% for coarse aggregate material. Then gravel material of the dam shows good quality.

・**Density, Porosity and Absorption**

The density varies between 2.64 to 2.67 t/m^3. The porosity and the absorption coefficient are very variable from an area to another: in the pit $P5_1$, the porosity is of 1.20%, and the absorption coefficient is of 0.46. In the pit $P5_2$, the porosity is 0.59%, and the absorption coefficient is 0.22. It is generally recognized that gravel with density of less than 2.5 t/m^3 and absorption of less than 3% is suitable for aggregate. Then gravel material of the dam shows good quality.

・**Weathering Resistance Test**

The results of the weathering resistance tests with chemical solution of sodium sulfate are as following:

Pit	*Grain size*	*Loss P*
$P5_1$	0.08 - 5 mm	3.25%
$P5_1$	5 - 80 mm	0.86%
$P5_2$	0.08 - 5 mm	2.70%
$P5_2$	5 - 80 mm	0.87%

Above results show fairly good quality being less than 15%, which is general allowable limit of loss by the test.

Judging from the results of the density, the absorption, the resistance of abrasion and the weathering resistance, the gravel material of the Oued Qarya is suitable for concrete aggregate as well as dam embankment material.

・**Superficial Cleanness**

The superficial cleanness of the alluvium gravel and sand varies between 6.3 and 9.5%. This is considerably high being more than 5% so that materials tested is possibly required washing for concrete aggregate use.

・**Alkali Reactivity**

Alkali reactivity test on gravel material has been carried out and every result shows that they belong to the zone of no reaction.

(3) Consideration

・**Impervious Soil Material**

Residual soil and colluvial soil deposit, which are distributed on the moderate slopes around dam site, are judged to be proper for impervious material. Borrow pit A1 of residual soil is in the proposed reservoir area. Borrow pit A2 of residual soil is about 1 km downstream of dam site. Another borrow pit B of colluvial soil is on the dam site. Thickness of soil deposit is 2-4 m. Expecting volumes are (800m x 400m x 2m=) 640,000 m^3, (500m x 200m x 3m=) 300,000 m^3 and (400m x 100m x 2m=) 80,000 m^3 for A1, A2 and B, respectively. Residual soils from A1 and A2 borrow pits will be major materials for impervious zone although they contain more or less amount of gravel.

Natural moisture contents of the soils are 15 to 19 %, plastic index is 7 to 17, mostly about 9, and natural density is 1.6 to 1.9 t/m^3. These properties indicate that they are not even quality and somewhat low plasticity materials.

Laboratory permeability test shows imperviousness to be order of 10-7 cm/s at the condition of optimum moisture content and maximum compaction density. However, low compaction density at 90 % of maximum density with optimum moisture content does not hold enough imperviousness such as order of 10-5 to 10-6 cm/s. Sufficient compaction to attain high density and saturation ratio will be required for actual embankment.

Design effective shearing strength based on shearing test will be proposed to be 30 degrees as internal friction angle and 10 KPa as cohesion on the base of mean value of C-U shearing test.

・**Filter and Pervious Sand and Gravel Materials**

Sand and gravel from river bed of Oued Qarya are recommendable for filter and one of pervious materials. The site is located around 8 km distance along public road. Prospecting volume will be estimated as (4km x 100m x 3m=) 1,200,000 m^3.

Materials beside perennial river flow look clean without silt and clay. However, some of deposits are covered or consisted with fine sediment. Clean materials should be selected for filter material.

Gravel has excellent quality such as 0.4 % of water absorption, 2.65 of specific gravity, 23 % loss of abrasion test and non-reaction of alkali reaction. Then this material is judged to be suitable for concrete aggregate.

・**Pervious Rock Material**

Volume of excavation from spillway foundation is prospected to be 200,000 m^3. Most of excavation materials will be slightly weathered or fresh rock of marl. It should be applied to pervious dam embankment to make dam construction economic. Rock of marl itself is hard and durable quality but laminated and fissile characteristics. This will imply that shape of rock become rather flat and large size rock being suitable to rip rap cannot be expected much

・**Rip Rap Material**

Quarry site of riprap is recommended on the hill in the reservoir area where high ratio of limestone formation with less fissure can be expected. As no geological survey except sub-surface reconnaissance is not yet performed, detailed survey with drilling, sampling, laboratory testing, etc. are required in next stage of study.

X3 Earthquake Analysis

Earthquake analysis for dam design was evaluated based on earthquake records obtained from the Seismic Center of Morocco in Mohammad V University at Rabat. Those are the data of all events of earthquakes having epicenter in the area covering within 300 km of distance from the contemplated dam sites.

All events were recorded in the period almost 100 years from 1900 to 1999. However during first several tens years, due to non-systematic seismic observation facilities, data were not recorded fully.

Full record may be for about sixty years from 1930 in the northern region, and about thirty years from 1960 in the southern region.

These earthquake data were used for evaluation of seismicity (shown in Table X3.1 to X3.4).

For each earthquakes estimated was intensity that could have been felt at the contemplated dam sites by use of formulae of attenuation relationship from Cornell.

Formula according to Cornell

$$I = 8.0 + 1.5\ M - 2.5\ Ln\ r$$

Where, I : Earthquake Intensity in Modified Mercalli Scale felt at the dam site
M : Magnitude in Richter Scale
r : Focal distance in kilometer $r = (d^2 + h^2 + 400)^{0.5}$
d : Epicentral distance (km)
h : Focal depth (km)

$$\log A = 0.014 + 0.30\ I$$

Where, A : Peak horizontal acceleration (cm/sec^2 or gal)

Number of earthquake events shall be counted for each intensity step, i.e., Intensity 1 (0.5 to 1.4), Intensity 2 (1.5 to 2.4), Intensity 3 (2.5 to 3.4), etc., and then accumulated to obtain the number of events in total year exceeding the given intensity for each of the same intensity per one year exceeding the given intensity (Nc).

According to Gutenberg, the earthquake intensity (Imm) has a linear relationship with the logarithm of the number of earthquakes exceeding that intensity, that is,

$$\log Nc = p + q.I$$

where p and q are constants. The values of I and Nc were plotted on a graph, and the point where the I – logNc line intersects the horizontal line for 0.01 of Nc gives the probable maximum earthquake intensity for the return period of 100 years (and 0.005 of Nc for 200 years). Those results are shown in Figure X3.1 to X3.4.

Probable Maximum Earthquake Acceleration for Return Period 100 & 200 years felt at respective dam sites are as the followings:

Dam Site	100 years (gal)	200 years (gal)
N'Fifikh	42	70
Taskourt	102	209
Timkit	88	149
Azghar	66	103

X4 Local Subcontracting Geotechnical Works

X4.1 Core Drilling

X4.1.1 Scope of the Work

Core drilling, together with standard penetration tests and water pressure tests, are performed for the purpose of obtaining geotechnical data about the sub-surface conditions of the sites proposed for dams, material sources and other important structures.

Core drilling is made for bedrock, soil, gravel deposits, colluvial deposits and talus deposits that may contain boulders.

Standard penetration tests are for checking to evaluate the mechanical strength of foundation in the sections of the boreholes that are located within soils, uncemented deposits or intensively weathered rocks. However because that the thickness of those foundation was usually very thin at every drilling point, this test is not need to carried out actually

Water pressure tests are carried out, following the "Lugeon test" procedure of the descending stage method, for every five-meter section, in the parts of boreholes through bedrock in order to evaluate the seepage conditions of the foundation rocks.

X4.1.2 Quantity and Location of the Work

The quantity of the work was as the followings.

・**Core drilling**

Total 750 m

N'Fifikh nos.5 × 50 m = 250 m

Taskourt nos.2 × 50 m + 70 m + 80 m = 250 m

Timkit nos.5 × 50 m = 250 m

・**Water Pressure Test (Lugeon Test)**

Total 157 nos.

N'Fifikh nos.48

Taskourt nos.43

Timkit nos.66

X4.1.3 Specification

(1) Core Drilling

Core drilling is performed by use of hydraulic driven rotary machine, at the locations, in the directions and up to the depth as specified or directed by the Engineer.

The work is aim at 100 % core recovery in both rock and uncemented deposits.

The recovered core samples are placed in order in core boxes and are submitted to the Engineer. Each core box has five grooves; each groove with adequate dimensions for containing one meter of core section. Accordingly, every core box contains core samples of 5 m section.

The core samples is placed in order, in the same length of grooves of the core box as the length that has been drilled to obtain those core samples. Parts of no core recovery are left vacant in the grooves. Marks are put regularly to the grooves to indicate depths of sampling. Every core box is marked with the borehole number and depth of the section of which the core samples are put in it.

Water level in boreholes is measured and recorded every morning before commencement of the day's drilling work. This measurement is continued during the period when the hole is being drilled.

On completion of the drilling at each location, the drilling point is marked by putting an immovable post or a concrete block with description of the hole number and the elevation at the top of the hole.

(2) Water Pressure Test

Water pressure test is performed in the sections of borehole passing through bedrock by 3 to 5 m stage in descending order, by use of packer.

When a borehole has been drilled to the depth of bottom of a section to be tested in the bedrock, it is washed inside by flushing water through the drill rod inserted to the bottom of the hole. When the returning water becomes clean, a packer is installed at the top of the 3 to 5 m long test section and water is pumped into the section through the injection pipe. Under a certain water pressure, regulated constant, the water injection rate is observed during 10 minutes. Through this 10 minutes' observation period, the injected quantity of water is observed and recorded every minute. This procedure is repeated under varied pressures directed by the Engineer.

Once the above observation has been completed, the drilling is resumed for another 3 to 5 m. The new 3 to 5 m section again be tested by the same procedure as above.

In case that the pressure cannot rise up to the designated maximum at an injection rate of 100 liters per minute because of high leakage potential in the test section, the test is made only for the attainable pressures. If the insufficient rise of the water pressure is due to deficiency of the equipment, e.g., low capacity of the pump or leakage from the hose or pipe, the deficiency is rectified immediately.

X4.2 Seismic Refraction Prospecting

X4.2.1 Scope of the Work

The seismic refraction prospecting is carried out dam sites in order to obtain geological and foundation engineering by classifying the sub-surface ground on the basis of difference in velocity of seismic wave propagation. It gives overall picture of the subsurface foundation condition and detect depth of solid rock, locations of weak zones, faults, etc.

X4.2.2 Quantity and Location of the Work

The seismic refraction prospecting was performed with twenty two (22) traverse lines and for 9,600 meters of the total length, in the N'Fifikh, Taskourt, and Azghar dam sites.

X4.2.3 Specification

(1) Setting of Prospecting Traverse

A plan of arrangement of shooting (blasting) points and detector (geophone) points is prepared for every prospecting traverse line and submitted to the Engineer.

Ground surface profile of every traverse line is surveyed, and all shooting points and detector points is marked with wooden stakes and pegs numbered with distance from an end of each traverse line.

Each prospecting traverse line is divided into observation spreads, each of which is a unit of observation covered by a set of geophones in the same number as of channels of the oscillograph. The field prospecting work is made spread by spread until all the length of each traverse line is covered.

(2) Profile Survey

Ground height of every detector point is surveyed accurately by leveling to draw a topographic profile of every prospecting traverse line to the scale of 1/1000.

(3) Shooting

Shooting is made effectively and safely with subsurface explosion in hand-dug pits or auger holes, by use of dynamite and instantaneous electric detonators. Prior to blasting, adequate warning is given to all persons, whether of the project or the public, staying within a distance of 50 meters from the blasting point.

(4) Detecting

Detectors or geophones is allocated at a regular interval of 5-10 meters on part of each spread on the prospecting traverse line.

(5) Recording

Record of every shooting is reviewed at the site. When any record is not clear or questionable, the shooting and recording is made again. Ends of every spread shall overlap with ends of the adjoining spreads for continuity of the records over a prospecting traverse line.

(6) Interpretation

The record is plotted on time-distance graphs, and then interpreted into professes of seismic wave velocity layers.

The procedure of the interpretation is described in the report and any auxiliary lines utilized to interpret the time-distance curve (travel-time curve) are shown on the same graph. Abnormal or peculiar record, e.g., discontinuity in the time-distance curves and reversed velocity layers, if found, is reported.

Deduced seismic wave velocity layers are shown in profiles, using the ground surface profile prepared by the profile survey.

The seismic wave velocity layers distinguished is geologically and geotechnically interpreted in correlation with the findings in the surface geological mapping, the core drilling, the test pitting, etc.

X4.3 Investigation of Dam Construction Material

X4.3.1 Scope of the Work

Test pitting, sampling, and laboratory tests are included in these items.

The purpose of test pit is that to carry out for the investigation of earth embankment material and aggregates for concrete and sampling for laboratory tests.

Test pits are excavated in the areas of potential sources of earth core material for a dam and/or sand/gravels for aggregates of concrete. The work comprises digging 5 meters deep vertical pits in earth borrow areas and 1.5 meters deep vertical pits in sand/gravel deposit.

Soils and sand/gravels are sampled from the test pits and rock pieces are from drilling cores, then those are sent to laboratory.

X4.3.2 Quantity and Location of the Work

(1) Test Pitting

Total 15 nos.

N'Fifikh	5 nos.
Taskourt	5 nos.
Azghar	5 nos.

(2) Laboratory Testing

Earth material

Particle size analysis by sieve & hydrometer	8 samples
Liquid limit, plastic limit, plastic index	8 samples
Specific gravity of soil	8 samples
Water content of soil	8 samples
Proctor compaction test	8 samples
Triaxial compression CU	8 samples
Permeability test	8 samples
Consolidation	8 samples

Aggregates

Sieve analysis of aggregates	7 samples
Specific gravity and water absorption	7 samples
Washing test	7 samples
Soundness tests by sodium sulphate	7 samples
Abrasion test by Los Angeles machine	7 samples
Chemical (alkali) reactivity test	7 samples
Sand Equivalent test	7 samples

Rocks

Water absorption and bulk density	15 samples

Unconfined compression and Poisson's ratio	15 samples
Ultrasonic velocity	15 samples

X4.3.3 Specification

(1) Test Pitting

The test pits are dug by manpower with conventional tools of hand shovels, picks, and bucket with rope, etc.

Depth of the pits in clayey soil or intensively weathered rock is 5 meters, but shallower pit may be acceptable solely when a groundwater table or bedrock, difficult to dig even if weathered, is encountered at a depth less than 5 meters.

Depth of the pits in sand/gravel deposit is not more than 1.5 meters.

The pits are geologically sketched to be finalized as geological columns. Disturbed samples, each 50 kilograms in weight or quantity as prescribed in the standard testing method, is taken from a thickest layer in each pit or the layer of apparently the most promising quality of material.

(2) Sampling

The disturbed samples is taken at test pits. Minimum weight of the samples is 50 kg in case of soil material, and maximum 500 kg if transported all to the laboratory or necessary volume after done the field sieve analysis in case of sand/gravel material or as prescribed in the standard testing method.

The disturbed samples are packed in a watertight bag and then in a strong bag, such as a jute bag, for transportation.

Each bag is marked with sample number, sampling date, location, pit number and sampling depth, etc.

(3) Laboratory Testing by Test Pit Samples

Items and envisaged quantities of the laboratory test by test pit samples is as listed above. Test items and quantities are also described as above.

(4) Laboratory Testing by rocks

Items and envisaged quantities of the laboratory test is as listed above. The samples for the tests are selected by the Engineer mainly out of core samples of the core drilling.

Tables

Table X2.1: Classification Criteria for Rock Foundation of Dam
(by TANAKA)

Category	Characteristics
A	Very fresh rock, no weathering nor alteration observation in rock-forming minerals and particles. Fissures and joints are well closed and no weathering is observed on the planes thereof. Sound of hammering is metallic.
B	Very hard rock, well closed with no opened (even 1 mm) fissures or joints, and well closed. However, partial and slight weathering and alteration are observed. Sound of hammering is metallic.
CH	Relatively hard rock, though rock-forming minerals and particles except quarts are weathered. Generally chemically compounded with limonite, etc. Cohesive strength at joints and fissures is slightly reduced. Rock fragments are flaked at joints by strong hit with hammer, and clayey material may be observed on the stripped face. Sound of hammering is slightly dull.
CM	Rock, rock-forming minerals and particles except quartz are slightly softened by weathering. Cohesive strength at joints and fissures is slightly reduced. Rock fragments are flaked at joints by normal hit with hammer, and clayey material may be observed at the stripped face. Sound of hammering is slightly dull.
CL	Rock, rock-forming minerals and particles are softened. Cohesive strength at joints and fissures are reduced. Rock fragments are flaked at joints by light hit with hammer, and clayey material is observed at stripped face. Sound of hammering is dull.
D	Rock, rock-forming minerals and particles are remarkably softened by weathering. Cohesive strength at joints and fissures is almost completely lost. Rock is easily destroyed by slight hit with hammer, and clayey material is observed at stripped face. Sound of hammering is very dull.

Table X2.2 Summary of Soil Test for Construction Material (N'FIFIKH Dam)

No.	depth	in-situ	density		Gs	gradation		Atterberg		Proctor		peameability		shearing strength		consolidation		note
	(m)	γ_d(t/m3)	labo.			(mm)	(%)	consistency				D(%)	(cm/s)	φ'(°)	C'(Kpa)			
			Wn(%)	11		+2	7	WL	36	Wopt	15	100	6×10^{-7}	30	10	Ic	0.17	
P1	3	1.86	γ_d(t/m3)	1.91	2.72	~	10	PL	18	γ_d(t/m3)	1.79	90	2×10^{-6}	(D=95%)		Pc(KPs)	60	
						-0.08	83	PI	17									
			Wn(%)	10		+2	32	WL	32	Wopt	14.5	100	2×10^{-7}	22	10	Ic	0.16	
P2	1.5	1.96	γ_d(t/m3)	1.93	2.708	~	10	PL	15	γ_d(t/m3)	1.82	90	3×10^{-6}	(D=95%)		Pc(KPs)	100	
						-0.08	58	PI	17									
			Wn(%)			+2		WL		Wopt						Ic		
P3			γ_d(t/m3)			~		PL		γ_d(t/m3)						Pc(KPs)		
						-0.08		PI										
			Wn(%)	9		+2	15	WL	32	Wopt	16	100	1×10^{-7}	25	15	Ic	0.2	
P4	2	1.8	γ_d(t/m3)	1.82	2.711	~	11	PL	17	γ_d(t/m3)	1.79	90	1×10^{-6}	(D=95%)		Pc(KPs)	200	
						-0.08	74	PI	15									
			Wn(%)	11		+2	30	WL	31	Wopt	14	100	3×10^{-7}	25	15	Ic	0.14	
P5	2	1.92	γ_d(t/m3)	1.92	2.716	~	13	PL	16	γ_d(t/m3)	1.86	90	1×10^{-6}	(D=95%)		Pc(KPs)	70	
						-0.08	57	PI	15									

Table X2.3 Summary of Soil Test for Construction Material (AZGHAR Dam)

No.	depth	in-situ	density		Gs	gradation		Atterberg		Proctor		peameability		shearing strength		consolidation		note
	(m)	γ_d(t/m3)	labo.			(mm)	(%)	consistency				D(%)	(cm/s)	φ'(°)	c'(Kpa)			
			Wn(%)	15		+2	47	WL	26	Wopt	16	100	5.8×10^{-7}	33	0	Ic	0.13	
P1	2.4	1.72	γ_d(t/m3)	1.77	2.721	~	8	PL	19	γ_d(t/m3)	1.76	90	2.2×10^{-6}	(D=95%)		Pc(KPs)	200	
						-0.08	45	PI	7									
			Wn(%)	19		+2	20	WL	28	Wopt	16	100	2.1×10^{-7}	30	10	Ic	0.125	
P1	3	1.83	γ_d(t/m3)	1.73	2.711	~	15	PL	19	γ_d(t/m3)	1.75	90	6.5×10^{-5}	(D=95%)		Pc(KPs)	100	
						-0.08	65	PI	9									
			Wn(%)	16		+2	15	WL	37	Wopt	17	100	1.8×10^{-6}	27	5	Ic	0.185	
P2	1.5	1.73	γ_d(t/m3)	1.76	2.693	~	4	PL	20	γ_d(t/m3)	1.69	90	6.7×10^{-5}	(D=95%)		Pc(KPs)	100	
						-0.08	81	PI	17									
			Wn(%)	16		+2	16	WL	29	Wopt	16	100	8.3×10^{-7}	34	10	Ic	0.15	
P4	2	1.58	γ_d(t/m3)	1.71	2.719	~	12	PL	21	γ_d(t/m3)	1.76	90	1.3×10^{-5}	(D=95%)		Pc(KPs)	140	
						-0.08	72	PI	8									
			Wn(%)	15		+2	42	WL	31	Wopt	16	100	2.6×10^{-7}	31	10	Ic	0.12	
P4	4.3	1.86	γ_d(t/m3)	1.55	2.718	~	14	PL	21	γ_d(t/m3)	1.84	90	2.5×10^{-5}	(D=95%)		Pc(KPs)	110	
						-0.08	44	PI	10									

TableX2.4 Summary of Aggregate Material Test (TASKOURT Dam)

No.	depth (m)	sieve analysis Dmax(mm)	(mm)	(%)	washing (%)	specific gravity & water absorption		soundness	abrasion loss(%)	alkali reactivity	sand equivalent	note
P1		150	+5	35	1	Gs	2.65	(0.08-5mm)	28	non reaction		
			5〜2	52		W	0.68	3.4				
			2〜0.08	12				(5-80mm)				
			-0.08	1				0.6				
P2		200	+5	24	2	Gs	2.72	(0.08-5mm)	29	non reaction		
			5〜2	56		W	0.87	2.6				
			2〜0.08	18			2.64	(5-80mm)				
			-0.08	2				1				
P3		200	+5	24	1	Gs	2.64	(0.08-5mm)	30	non reaction		
			5〜2	55		W	0.67	3.3				
			2〜0.08	20				(5-80mm)				
			-0.08	1				1				
P4		150	+5	30	2	Gs	2.68	(0.08-5mm)	24	non reaction		
			5〜2	48		W	0/61	3.2				
			2〜0.08	20				(5-80mm)				
			-0.08	2				1				
P5		150	+5	40	3	Gs	2.7	(0.08-5mm)	24	non reaction		
			5〜2	44		W	0.99	3.4				
			2〜0.08	13				(5-80mm)				
			-0.08	3				0.6				

Table X2.5 Summary of Aggregate Material Test (AZGHAR Dam)

No.	depth (m)	sieve analysis Dmax(mm)	(mm)	(%)	washing (%)	specific gravity & water absorption		soundness	abrasion loss(%)	alkali reactivity	sand equivalent	note
P5		200	+5	37	8	Gs	2.64	(0.08-5mm)	19	non reaction		
			5〜2	47		W	0.46	3.3				
			2〜0.08	10				(5-80mm)				
			-0.08	6				0.9				
P5		200	+5	36	4	Gs	2.67	(0.08-5mm)	26	non reaction		
			5〜2	50		W	0.22	2.7				
			2〜0.08	10				(5-80mm)				
			-0.08	4				0.9				

Table X2.6

Summary of Aggregate Material Test (TIMKIT Dam)

No.	depth (m)	peameability in-situ(cm/s)	sieve analysis Dmax(mm)	(mm)	(%)	note
PS1		2.9×10^{-2}	40	+5	0	
				5〜2	29	
				2〜0.08	68	
				-0.08	3	
PS2		7.3×10^{-2}	150	+5	15	
				5〜2	71	
				2〜0.08	12	
				-0.08	2	
PS3		3.2×10^{-2}	80	+5	9	
				5〜2	56	
				2〜0.08	32	
				-0.08	3	

Table X3.1: Estimated Earthquake Intensity and Ground Acceleration Felt at N'Fifikh Dam Site (1/7)
(Latitude: 33°23'57''N, Longitude: 7°03'17''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
1	1930	8	9	18	9	38.0	34.300	-5.399	0.0	4.70	183.4	2.005	4.13
2	1930	8	13	3	20	45.0	34.300	-5.399	0.0	4.40	183.4	1.555	3.02
3	1937	8	21	23	55	16.0	35.100	-8.799	0.0	4.80	248.6	1.403	2.72
4	1938	3	30	15	6	6.0	33.500	-6.250	0.0	5.10	75.6	4.750	27.49
5	1952	5	12	19	34	36.8	35.690	-6.471	60.0	5.30	259.5	1.981	4.06
6	1954	4	23	19	55	19.0	34.699	-4.900	0.0	4.50	246.7	0.971	2.02
7	1960	12	5	21	21	47.1	35.690	-6.621	5.0	4.90	257.0	1.470	2.85
8	1963	3	31	14	58	4.9	35.266	-9.179	13.0	5.40	285.9	1.952	3.98
9	1963	8	2	10	49	17.1	34.841	-8.803	5.0	4.10	227.9	0.568	1.53
10	1963	11	2	12	45	16.5	35.053	-4.651	5.0	4.10	289.0	-0.022	1.02
11	1964	11	15	20	3	54.3	34.938	-5.470	19.0	5.00	225.3	1.938	3.94
12	1965	4	14	18	5	18.8	35.416	-6.160	5.0	3.60	238.4	-0.294	0.84
13	1965	6	29	15	26	36.1	35.751	-5.598	33.0	3.00	293.6	-1.727	0.31
14	1965	12	1	18	11	40.2	36.004	-6.586	14.0	3.50	291.8	-0.949	0.54
15	1965	12	5	3	50	13.0	34.843	-5.698	5.0	4.40	203.7	1.296	2.53
16	1966	2	23	3	16	16.3	35.443	-6.683	33.0	3.10	229.0	-0.970	0.53
17	1966	6	8	5	32	37.2	35.510	-5.130	5.0	3.00	294.4	-1.719	0.32
18	1966	12	18	10	46	28.1	35.801	-7.596	40.0	4.00	270.8	-0.037	1.01
19	1967	3	11	4	13	2.1	35.341	-9.174	14.0	3.70	291.7	-0.648	0.66
20	1967	3	17	6	13	49.7	34.936	-5.431	5.0	4.10	227.5	0.572	1.53
21	1967	8	28	21	15	0.0	31.300	-6.299	0.0	4.60	242.9	1.160	2.30
22	1967	8	30	18	21	0.0	31.499	-6.000	0.0	4.10	232.2	0.522	1.48
23	1967	9	24	17	8	0.0	32.500	-5.700	0.0	4.30	160.6	1.734	3.42
24	1968	1	22	7	19	8.1	35.136	-5.833	40.0	4.10	223.4	0.578	1.54
25	1968	4	3	5	27	33.7	35.315	-4.788	16.0	4.00	299.1	-0.261	0.86
26	1968	5	22	14	1	58.9	34.883	-4.408	26.0	4.00	295.9	-0.240	0.87
27	1968	6	15	21	37	41.9	35.191	-5.021	5.0	3.50	274.1	-0.791	0.60
28	1969	2	10	19	30	7.9	34.220	-6.651	60.0	3.10	98.4	0.746	1.73
29	1969	4	12	0	2	6.0	32.000	-6.200	0.0	4.40	174.2	1.683	3.30
30	1969	6	11	3	18	8.6	35.940	-8.051	5.0	3.70	296.3	-0.685	0.64
31	1970	1	11	2	7	6.0	35.026	-4.948	33.0	3.80	266.2	-0.286	0.85
32	1970	2	19	12	5	27.4	35.188	-6.095	33.0	3.30	217.3	-0.542	0.71
33	1970	4	25	4	7	12.6	35.986	-7.363	5.0	2.90	288.0	-1.814	0.30
34	1970	7	9	0	41	49.1	35.336	-8.311	20.0	3.70	244.3	-0.212	0.89
35	1970	11	4	19	12	38.6	35.929	-6.203	10.0	2.50	291.2	-2.443	0.19
36	1971	3	14	20	47	37.6	35.269	-5.955	10.0	4.60	231.0	1.282	2.50
37	1971	7	2	21	11	8.5	34.100	-5.200	0.0	4.60	189.1	1.780	3.53
38	1971	8	12	11	52	2.7	35.074	-5.525	5.0	3.20	233.8	-0.845	0.58
39	1971	9	24	5	33	13.9	34.913	-4.570	14.0	4.00	285.4	-0.144	0.93
40	1972	2	27	12	14	6.2	34.821	-8.818	5.0	4.70	227.3	1.474	2.86
41	1972	5	7	3	4	32.0	35.256	-6.211	13.0	3.40	220.1	-0.400	0.78
42	1972	6	25	15	45	38.0	32.430	-5.580	0.0	3.00	174.1	-0.416	0.77
43	1972	10	4	21	0	12.7	31.960	-5.960	1.0	3.60	189.1	0.280	1.25
44	1972	11	15	4	18	9.9	32.750	-5.580	2.0	3.50	154.8	0.623	1.59
45	1972	12	23	8	10	6.7	32.038	-6.000	1.0	2.90	179.9	-0.646	0.66
46	1973	2	2	21	18	14.2	34.240	-5.370	5.0	3.00	182.2	-0.529	0.72
47	1973	2	5	6	52	0.7	35.170	-4.879	26.0	3.00	281.8	-1.620	0.34
48	1973	2	16	1	36	38.6	32.150	-5.820	0.0	3.10	179.8	-0.345	0.81
49	1973	2	19	11	13	47.9	34.761	-4.615	5.0	3.10	272.4	-1.375	0.40
50	1973	2	19	11	8	49.3	34.758	-4.488	10.0	3.60	282.1	-0.714	0.63
51	1973	2	24	20	14	53.6	32.090	-5.960	2.0	3.30	177.2	-0.009	1.03
52	1973	3	1	23	20	34.3	32.170	-5.990	1.0	2.20	168.3	-1.533	0.36
53	1973	3	1	3	37	35.9	32.820	-4.289	1.0	3.00	265.0	-1.457	0.38
54	1973	3	3	15	9	59.8	32.090	-6.280	110.0	3.50	161.9	0.045	1.07
55	1973	3	5	6	52	37.0	32.150	-4.430	4.0	3.30	280.5	-1.148	0.47
56	1973	3	7	14	59	10.6	32.080	-6.160	1.0	3.30	168.2	0.120	1.12
57	1973	3	8	17	52	59.9	33.820	-5.130	17.0	3.40	184.9	0.025	1.05

Table X3.1: Estimated Earthquake Intensity and Ground Acceleration Felt at N'Fifikh Dam Site (2/7)
(Latitude: 33°23'57''N, Longitude: 7°03'17''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
58	1973	3	10	23	30	39.1	35.405	-5.493	30.0	3.30	265.4	-1.026	0.51
59	1973	3	13	20	25	43.4	34.699	-4.390	1.0	3.00	286.5	-1.651	0.33
60	1973	3	27	14	4	49.8	31.720	-4.859	33.0	3.40	276.2	-0.977	0.53
61	1973	3	29	12	4	47.8	32.290	-5.600	100.0	3.20	182.7	-0.559	0.70
62	1973	3	30	11	7	49.7	32.550	-4.240	2.0	3.50	278.1	-0.826	0.58
63	1973	4	8	15	55	7.5	33.220	-5.779	2.0	3.40	120.3	1.092	2.20
64	1973	5	19	20	49	3.5	32.470	-5.570	2.0	3.80	172.2	0.812	1.81
65	1973	6	1	18	13	30.1	33.929	-6.840	29.0	3.40	62.0	2.433	5.54
66	1973	6	3	0	45	57.7	35.550	-6.979	26.0	3.10	238.4	-1.058	0.50
67	1973	6	25	21	25	21.8	35.559	-7.399	2.0	2.80	241.4	-1.525	0.36
68	1973	7	24	8	57	15.5	33.039	-5.050	5.0	3.70	190.6	0.410	1.37
69	1973	7	31	1	25	27.8	32.100	-6.289	149.0	2.70	160.6	-1.434	0.38
70	1973	8	24	8	4	32.8	34.420	-4.840	2.0	3.20	234.9	-0.857	0.57
71	1973	9	16	12	37	39.7	34.199	-7.649	52.0	3.00	104.4	0.566	1.53
72	1973	9	23	0	6	19.8	34.120	-5.940	102.0	3.30	130.8	0.154	1.15
73	1973	10	1	16	20	31.7	35.090	-5.770	4.0	3.50	222.1	-0.269	0.86
74	1973	10	8	5	33	4.6	35.440	-6.620	5.0	2.70	229.7	-1.552	0.35
75	1973	10	9	14	47	12.8	32.408	-5.350	1.0	3.60	192.8	0.232	1.21
76	1973	10	16	11	38	56.2	34.070	-5.390	133.0	4.50	171.7	1.288	2.51
77	1973	12	11	20	58	12.8	31.939	-6.450	165.0	2.60	171.3	-1.787	0.30
78	1974	1	17	10	31	38.1	30.890	-8.048	1.0	4.00	292.9	-0.205	0.90
79	1974	2	3	23	21	54.3	34.649	-5.419	5.0	3.40	205.7	-0.228	0.88
80	1974	2	9	13	49	31.2	35.120	-4.740	14.0	2.90	287.5	-1.812	0.30
81	1974	3	9	11	33	58.0	31.230	-8.268	2.0	3.50	265.5	-0.711	0.63
82	1974	3	19	17	50	57.5	35.649	-7.470	1.0	2.90	252.2	-1.483	0.37
83	1974	3	25	13	44	43.2	34.859	-4.480	1.0	3.30	288.9	-1.221	0.44
84	1974	3	28	3	23	23.2	34.850	-4.470	0.0	3.10	289.1	-1.523	0.36
85	1974	4	6	12	16	3.4	31.880	-6.220	1.0	3.70	185.3	0.480	1.44
86	1974	4	25	8	53	1.9	33.570	-8.170	69.0	3.30	105.4	0.829	1.83
87	1974	5	31	18	51	21.4	34.850	-9.430	48.0	3.40	273.1	-0.969	0.53
88	1974	7	2	21	1	0.1	34.579	-8.639	126.0	2.80	196.9	-1.445	0.38
89	1974	7	4	4	2	53.6	33.900	-5.529	2.0	3.50	152.3	0.664	1.63
90	1974	11	3	17	18	59.6	33.110	-5.020	2.0	3.20	191.9	-0.356	0.81
91	1974	12	8	17	12	38.3	32.570	-7.470	65.0	2.70	99.6	0.068	1.08
92	1975	1	9	12	33	22.3	35.059	-5.756	51.0	3.30	220.0	-0.609	0.68
93	1975	1	23	20	27	14.0	33.100	-5.210	1.0	3.20	174.7	-0.124	0.95
94	1975	1	29	7	48	5.9	33.910	-5.010	2.0	3.50	198.3	0.012	1.04
95	1975	2	10	15	53	2.6	35.820	-7.350	4.0	2.90	269.6	-1.649	0.33
96	1975	3	27	5	21	22.8	31.640	-6.759	2.0	3.60	196.8	0.181	1.17
97	1975	5	6	15	10	52.2	35.610	-8.509	0.0	3.40	279.7	-0.991	0.52
98	1975	5	7	6	37	4.3	35.870	-7.600	1.0	3.10	278.4	-1.429	0.38
99	1975	6	20	6	45	49.6	30.720	-7.089	0.0	3.50	296.8	-0.988	0.52
100	1975	6	24	4	28	14.5	31.720	-6.440	117.0	2.60	194.6	-1.673	0.33
101	1975	6	29	8	0	40.5	33.520	-5.600	38.0	2.70	135.9	-0.349	0.81
102	1975	7	5	22	20	53.8	35.160	-5.069	91.0	3.00	268.6	-1.625	0.34
103	1975	8	3	19	11	51.4	33.070	-5.319	5.0	3.50	165.4	0.459	1.42
104	1975	8	3	0	20	58.9	33.199	-5.250	12.0	3.40	169.2	0.248	1.23
105	1975	8	15	13	26	16.0	31.359	-7.480	2.0	3.70	229.4	-0.049	1.00
106	1975	10	25	18	9	59.1	32.408	-5.270	112.0	2.70	199.0	-1.536	0.36
107	1975	10	29	22	22	14.7	31.359	-7.970	17.0	3.30	241.5	-0.782	0.60
108	1975	11	1	19	20	17.9	32.240	-5.790	153.0	2.60	174.1	-1.724	0.31
109	1975	11	3	9	35	35.4	31.640	-6.299	135.0	2.60	207.2	-1.884	0.28
110	1975	11	9	17	31	2.7	34.350	-4.280	2.0	3.50	278.6	-0.831	0.58
111	1975	11	13	6	37	42.6	32.628	-4.230	1.0	3.00	276.2	-1.559	0.35
112	1975	11	14	10	41	19.3	32.360	-4.820	103.0	3.00	237.5	-1.398	0.39
113	1975	11	17	14	46	22.9	33.540	-4.640	9.0	3.50	225.0	-0.302	0.84
114	1975	12	7	10	17	34.0	34.606	-4.668	60.0	2.60	259.0	-2.065	0.25

Table X3.1: Estimated Earthquake Intensity and Ground Acceleration Felt at N'Fifikh Dam Site (3/7)
(Latitude: 33°23'57''N, Longitude: 7°03'17''W)

No.	Year	Month	Day	Time			Hypocenter		Focal	Magnitude	Epicentral	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E	Depth (km)	in Richter Scale	Distance (km)	Intensity (Imm)	Acceleration (gal)
115	1975	12	8	19	40	16.8	34.129	-4.440	30.0	3.30	256.2	-0.939	0.54
116	1975	12	10	6	35	9.7	32.620	-5.350	126.0	2.60	180.5	-1.596	0.34
117	1975	12	10	3	37	46.5	33.520	-4.800	26.0	2.90	210.0	-1.048	0.50
118	1976	1	8	13	37	38.3	35.129	-5.730	89.0	3.40	227.8	-0.657	0.66
119	1976	1	20	3	55	19.0	31.340	-5.470	128.0	3.20	271.6	-1.467	0.37
120	1976	2	5	4	55	0.4	33.990	-5.779	13.0	3.00	135.5	0.190	1.18
121	1976	2	6	1	27	39.0	32.360	-5.170	1.0	4.00	209.7	0.625	1.59
122	1976	2	6	10	41	16.2	33.129	-4.680	55.0	3.10	222.8	-0.949	0.54
123	1976	2	13	12	0	8.5	31.429	-5.600	1.0	3.50	256.8	-0.628	0.67
124	1976	2	18	6	39	10.1	34.840	-4.340	87.0	3.40	298.6	-1.255	0.43
125	1976	3	5	20	4	5.5	32.320	-4.759	94.0	3.50	244.6	-0.679	0.65
126	1976	3	16	18	37	57.6	33.300	-4.890	23.0	4.30	201.6	1.157	2.30
127	1976	4	13	19	23	19.3	34.280	-4.920	14.0	4.20	221.1	0.788	1.78
128	1976	4	15	16	6	15.1	33.920	-6.280	5.0	3.90	92.3	2.477	5.72
129	1976	4	20	11	2	31.3	31.790	-6.130	111.0	3.50	197.9	-0.321	0.83
130	1976	8	28	4	16	28.5	35.800	-8.200	5.0	3.40	286.5	-1.051	0.50
131	1976	10	5	8	28	29.3	34.830	-7.700	5.0	3.10	169.5	-0.200	0.90
132	1976	11	8	21	14	54.7	32.129	-5.910	1.0	3.00	176.4	-0.448	0.76
133	1977	1	7	15	20	42.9	32.600	-5.770	2.0	3.60	148.7	0.873	1.89
134	1977	2	19	19	54	9.4	35.290	-6.740	1.0	3.10	211.5	-0.747	0.62
135	1977	5	2	14	43	15.9	34.950	-8.410	20.0	3.20	213.0	-0.626	0.67
136	1977	5	12	6	59	16.9	34.230	-4.820	59.0	3.30	227.2	-0.705	0.63
137	1977	6	3	11	55	2.4	32.250	-6.100	1.0	3.20	155.2	0.168	1.16
138	1977	6	26	17	2	44.5	35.310	-5.170	31.0	2.60	274.8	-2.162	0.23
139	1977	8	23	22	34	56.0	32.380	-5.040	128.0	2.80	218.7	-1.645	0.33
140	1977	8	30	6	3	38.1	31.230	-6.870	21.0	3.00	240.9	-1.229	0.44
141	1977	9	1	18	35	14.1	32.800	-5.510	125.0	3.40	158.2	-0.178	0.91
142	1977	9	9	12	20	20.0	33.170	-4.170	2.0	4.10	269.4	0.153	1.15
143	1977	10	25	13	1	41.5	31.440	-5.610	2.0	2.90	255.2	-1.513	0.36
144	1977	10	27	13	15	34.7	32.789	-5.299	107.0	3.30	176.7	-0.388	0.79
145	1977	11	6	4	37	5.3	33.929	-5.240	17.0	3.70	178.6	0.560	1.52
146	1977	11	6	17	35	3.8	33.039	-4.759	78.0	3.00	217.1	-1.112	0.48
147	1977	11	11	15	54	3.5	35.090	-7.990	16.0	3.80	206.5	0.355	1.32
148	1978	1	16	9	56	48.9	32.210	-6.020	1.0	2.40	163.1	-1.155	0.47
149	1978	2	8	21	42	50.5	31.970	-5.950	2.0	4.30	188.7	1.335	2.60
150	1978	3	2	14	25	19.0	35.900	-7.500	0.0	2.90	280.1	-1.744	0.31
151	1978	3	5	16	47	55.6	31.820	-5.970	45.0	3.40	201.9	-0.242	0.87
152	1978	3	24	12	14	26.0	35.800	-7.000	0.0	2.80	266.0	-1.766	0.30
153	1978	4	10	19	3	47.4	34.180	-6.000	52.0	3.20	130.8	0.408	1.37
154	1978	4	22	2	56	3.8	31.980	-6.850	5.0	3.50	158.4	0.567	1.53
155	1978	4	24	21	7	33.4	33.810	-5.940	15.0	3.80	113.2	1.818	3.63
156	1978	4	27	22	7	53.4	34.900	-9.130	5.0	3.50	254.7	-0.608	0.68
157	1978	5	12	6	24	40.4	33.670	-8.969	1.0	4.10	180.5	1.146	2.28
158	1978	6	12	20	11	23.8	30.869	-6.820	1.0	3.10	281.1	-1.453	0.38
159	1978	9	20	2	23	55.0	35.000	-4.900	0.0	2.90	267.5	-1.630	0.33
160	1978	9	23	1	56	37.7	36.000	-6.800	20.0	4.20	289.1	0.121	1.12
161	1978	11	6	3	20	53.6	31.099	-5.749	133.0	3.70	282.3	-0.813	0.59
162	1978	11	6	3	23	46.6	31.120	-5.629	102.0	3.70	285.2	-0.739	0.62
163	1978	11	23	7	11	40.0	35.000	-6.200	0.0	3.60	194.3	0.213	1.20
164	1978	11	23	7	12	36.0	35.000	-6.200	0.0	3.10	194.3	-0.537	0.71
165	1978	12	5	18	20	42.0	35.000	-4.800	0.0	2.70	274.6	-1.995	0.26
166	1978	12	23	5	29	6.0	34.900	-4.600	0.0	3.00	282.3	-1.614	0.34
167	1979	1	2	15	39	58.8	31.778	-4.911	96.0	3.20	268.3	-1.337	0.41
168	1979	1	4	13	9	29.2	34.091	-5.723	8.0	2.80	145.6	-0.279	0.85
169	1979	1	4	9	27	35.7	34.260	-5.636	4.0	2.90	162.8	-0.400	0.78
170	1979	1	17	17	43	27.0	33.400	-5.399	0.0	4.50	153.9	2.138	4.52
171	1979	1	19	1	9	21.2	33.461	-5.063	16.0	2.90	185.3	-0.729	0.62

Table X3.1: Estimated Earthquake Intensity and Ground Acceleration Felt at N'Fifikh Dam Site (4/7)
(Latitude: 33°23'57''N, Longitude: 7°03'17''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
172	1979	2	5	13	34	36.5	33.479	-5.028	19.0	2.90	188.6	-0.776	0.60
173	1979	2	9	3	27	48.6	35.631	-8.631	10.0	2.80	287.4	-1.960	0.27
174	1979	2	14	3	6	4.3	33.500	-6.629	68.0	2.50	41.1	0.735	1.72
175	1979	2	21	3	10	12.9	34.601	-7.015	2.0	2.90	133.2	0.093	1.10
176	1979	2	24	6	28	56.5	33.441	-4.633	6.0	2.90	225.2	-1.203	0.45
177	1979	2	24	21	19	22.6	34.906	-4.418	5.0	4.30	296.6	0.213	1.20
178	1979	2	28	4	18	0.5	35.719	-8.441	10.0	2.70	287.5	-2.110	0.24
179	1979	3	5	1	22	20.0	34.400	-6.000	0.0	2.00	148.0	-1.516	0.36
180	1979	3	7	19	21	34.0	31.099	-6.399	0.0	3.50	262.0	-0.678	0.65
181	1979	3	11	6	42	5.0	35.000	-4.500	0.0	3.10	296.4	-1.585	0.35
182	1979	3	15	14	42	2.9	32.691	-5.391	52.0	2.40	173.4	-1.412	0.39
183	1979	3	16	23	38	15.0	35.000	-4.500	0.0	3.50	296.4	-0.985	0.52
184	1979	3	17	1	25	19.0	34.800	-4.399	0.0	3.30	291.6	-1.244	0.44
185	1979	3	19	16	11	33.5	33.300	-5.500	0.0	2.70	145.0	-0.415	0.78
186	1979	3	19	15	56	2.1	33.411	-5.411	5.0	2.70	152.8	-0.546	0.71
187	1979	3	19	15	39	10.4	33.296	-5.254	4.0	3.40	167.8	0.275	1.25
188	1979	3	25	11	13	25.0	34.000	-5.200	0.0	3.30	184.8	-0.113	0.96
189	1979	3	27	23	4	7.7	32.963	-5.380	18.0	2.40	163.0	-1.168	0.46
190	1979	4	16	4	57	0.0	34.820	-4.371	0.0	2.90	295.0	-1.873	0.28
191	1979	4	17	8	20	53.0	34.400	-4.299	0.0	3.00	279.2	-1.586	0.35
192	1979	4	18	14	53	7.5	32.800	-5.700	0.0	2.20	142.4	-1.121	0.48
193	1979	4	18	0	18	45.3	36.016	-7.443	0.0	2.80	292.1	-1.999	0.26
194	1979	4	20	14	40	26.5	32.900	-4.900	0.0	2.20	207.8	-2.053	0.25
195	1979	4	24	5	50	38.5	32.300	-4.800	0.0	2.60	242.4	-1.835	0.29
196	1979	4	25	23	8	2.0	32.800	-5.700	5.0	2.00	142.4	-1.422	0.39
197	1979	4	25	23	11	55.0	32.800	-5.700	0.0	2.20	142.4	-1.121	0.48
198	1979	4	25	23	17	36.0	35.800	-8.300	0.0	3.10	290.1	-1.531	0.36
199	1979	5	11	2	27	22.0	32.100	-6.100	0.0	2.20	169.1	-1.544	0.36
200	1979	5	13	13	53	15.0	32.400	-6.100	0.0	2.80	141.9	-0.212	0.89
201	1979	5	25	7	51	6.5	32.800	-4.800	0.0	2.30	219.9	-2.043	0.25
202	1979	5	26	6	13	16.0	35.000	-4.500	0.0	3.00	296.4	-1.735	0.31
203	1979	5	29	22	28	21.0	32.800	-5.000	0.0	2.20	202.2	-1.986	0.26
204	1979	5	30	16	8	37.5	32.400	-6.600	0.0	2.20	118.5	-0.672	0.65
205	1979	6	9	13	45	40.0	32.900	-5.399	0.0	4.10	163.6	1.388	2.69
206	1979	6	9	10	3	11.0	32.800	-5.150	0.0	2.80	189.1	-0.920	0.55
207	1979	6	9	0	36	32.0	32.800	-5.100	0.0	4.40	193.5	1.424	2.76
208	1979	6	9	1	56	22.0	32.800	-5.100	0.0	2.70	193.5	-1.126	0.47
209	1979	6	9	1	11	18.0	32.900	-5.000	0.0	3.30	198.9	-0.294	0.84
210	1979	6	9	17	12	19.0	32.900	-4.900	0.0	2.80	207.8	-1.153	0.47
211	1979	6	9	21	18	34.0	32.900	-4.900	0.0	2.30	207.8	-1.903	0.28
212	1979	6	10	18	10	19.0	32.800	-5.100	0.0	3.20	193.5	-0.376	0.80
213	1979	6	10	19	25	16.0	32.800	-5.100	0.0	2.70	193.5	-1.126	0.47
214	1979	6	10	20	3	35.0	32.800	-5.100	0.0	3.30	193.5	-0.226	0.88
215	1979	6	10	0	5	21.0	32.900	-4.800	0.0	2.70	216.8	-1.408	0.39
216	1979	6	11	13	41	47.5	32.900	-4.800	0.0	2.90	216.8	-1.108	0.48
217	1979	6	13	19	26	52.5	32.800	-5.399	0.0	3.10	167.6	-0.172	0.92
218	1979	6	16	13	51	44.0	32.800	-5.299	0.0	4.00	176.2	1.055	2.14
219	1979	6	16	14	2	27.0	32.800	-5.299	0.0	3.30	176.2	0.005	1.04
220	1979	6	16	14	26	22.0	32.800	-5.299	0.0	3.90	176.2	0.905	1.93
221	1979	6	16	17	3	19.5	32.900	-5.000	0.0	2.70	198.9	-1.194	0.45
222	1979	6	16	18	48	48.0	32.900	-5.000	0.0	3.10	198.9	-0.594	0.69
223	1979	6	17	7	38	11.0	32.800	-5.299	0.0	3.10	176.2	-0.295	0.84
224	1979	6	17	23	38	36.5	32.800	-5.299	0.0	4.20	176.2	1.355	2.63
225	1979	6	18	1	18	40.0	33.000	-5.200	0.0	2.60	178.0	-1.070	0.49
226	1979	6	18	8	25	20.0	32.000	-4.900	0.0	2.50	253.3	-2.094	0.24
227	1979	6	19	14	22	44.0	33.000	-5.200	0.0	3.90	178.0	0.880	1.90
228	1979	6	19	3	39	16.0	32.900	-5.100	0.0	3.20	190.0	-0.331	0.82

Table X3.1: Estimated Earthquake Intensity and Ground Acceleration Felt at N'Fifikh Dam Site (5/7)
(Latitude: 33°23'57''N, Longitude: 7°03'17''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
229	1979	6	20	17	50	52.0	33.000	-5.000	0.0	4.20	196.1	1.091	2.19
230	1979	6	23	18	17	3.0	34.699	-5.600	0.0	3.00	197.5	-0.728	0.62
231	1979	6	24	13	32	55.5	32.500	-6.000	0.0	2.40	139.8	-0.775	0.60
232	1979	6	24	17	41	57.0	33.000	-5.000	0.0	3.00	196.1	-0.709	0.63
233	1979	6	24	18	4	22.8	34.846	-4.425	19.0	2.80	292.3	-2.006	0.26
234	1979	6	25	5	1	5.5	32.900	-5.100	0.0	3.00	190.0	-0.631	0.67
235	1979	7	4	14	24	52.1	33.996	-6.916	0.0	4.00	67.4	3.369	10.59
236	1979	7	4	4	58	1.0	32.500	-6.700	0.0	2.10	104.9	-0.528	0.72
237	1979	7	4	5	57	3.5	33.000	-5.500	0.0	2.50	151.2	-0.817	0.59
238	1979	7	5	11	46	7.0	32.698	-5.299	0.0	3.80	180.8	0.692	1.67
239	1979	7	5	5	48	6.0	32.698	-5.100	0.0	3.70	197.6	0.321	1.29
240	1979	7	5	23	32	58.5	35.086	-5.556	0.0	3.90	233.1	0.212	1.20
241	1979	7	11	2	53	37.0	32.800	-5.200	0.0	3.10	184.8	-0.412	0.78
242	1979	7	18	20	24	46.0	32.800	-5.200	0.0	2.80	184.8	-0.862	0.57
243	1979	7	22	21	31	10.0	33.000	-5.100	0.0	3.10	187.0	-0.442	0.76
244	1979	7	23	3	24	5.0	33.000	-5.000	0.0	2.40	196.1	-1.609	0.34
245	1979	7	28	2	44	43.0	31.600	-4.700	0.0	3.00	296.1	-1.732	0.31
246	1979	7	29	10	57	50.0	35.100	-5.399	0.0	2.80	243.3	-1.544	0.36
247	1979	8	2	0	40	33.4	33.000	-4.800	0.0	2.70	214.2	-1.378	0.40
248	1979	8	5	19	38	23.0	32.800	-5.100	0.0	3.30	193.5	-0.226	0.88
249	1979	8	6	22	15	18.7	33.900	-4.299	0.0	3.40	262.1	-0.829	0.58
250	1979	8	7	23	17	28.6	31.800	-6.600	0.0	3.30	182.1	-0.077	0.98
251	1979	8	9	13	57	7.6	34.900	-4.500	0.0	2.90	289.9	-1.830	0.29
252	1979	8	18	6	8	46.2	36.035	-7.576	0.0	2.60	296.0	-2.331	0.21
253	1979	9	2	4	29	18.5	35.900	-8.000	0.0	2.50	290.6	-2.436	0.19
254	1979	9	10	2	8	58.3	31.800	-5.900	0.0	3.10	207.1	-0.695	0.64
255	1979	9	10	4	24	27.0	31.700	-6.000	0.0	3.50	212.2	-0.155	0.93
256	1979	9	13	17	45	8.5	31.470	-5.785	0.0	4.60	244.1	1.147	2.28
257	1979	9	14	15	34	36.3	31.600	-5.800	0.0	3.90	230.9	0.235	1.22
258	1979	9	20	1	18	47.0	32.300	-5.299	0.0	3.50	203.6	-0.053	1.00
259	1979	9	20	22	9	45.1	31.470	-5.785	0.0	3.70	244.1	-0.203	0.90
260	1979	10	1	22	52	5.5	32.000	-6.200	0.0	2.50	174.2	-1.167	0.46
261	1979	10	6	23	48	13.5	33.100	-5.100	0.0	3.00	184.7	-0.562	0.70
262	1979	10	11	21	53	24.5	35.100	-7.100	0.0	2.90	188.5	-0.761	0.61
263	1979	10	16	17	30	40.0	35.100	-5.100	0.0	2.70	261.8	-1.876	0.28
264	1979	10	24	13	9	50.9	32.500	-7.321	0.0	3.60	102.6	1.775	3.52
265	1979	11	5	15	37	18.0	33.900	-5.299	0.0	2.40	172.4	-1.291	0.42
266	1979	11	8	4	15	9.0	35.000	-5.000	0.0	3.10	260.6	-1.265	0.43
267	1979	11	21	20	23	16.0	35.800	-7.500	0.0	2.60	269.2	-2.095	0.24
268	1979	11	22	1	42	11.0	32.000	-6.399	0.0	2.60	166.6	-0.906	0.55
269	1979	11	24	13	42	40.5	33.600	-5.500	0.0	2.80	146.2	-0.286	0.85
270	1979	11	26	17	26	54.2	31.499	-6.399	0.0	3.00	219.2	-0.985	0.52
271	1979	11	29	15	58	3.5	35.400	-9.100	0.0	3.10	292.0	-1.548	0.35
272	1979	12	26	17	46	54.6	32.500	-5.000	0.0	2.70	215.4	-1.392	0.39
273	1979	12	27	0	37	28.3	32.800	-5.299	0.0	3.50	176.2	0.305	1.27
274	1979	12	29	23	9	52.0	33.199	-6.700	0.0	2.60	39.7	2.412	5.46
275	1980	1	20	17	20	19.7	30.836	-7.688	60.0	2.30	290.0	-2.783	0.15
276	1980	1	21	12	15	33.4	34.830	-7.870	114.0	3.10	175.7	-0.722	0.63
277	1980	2	6	4	16	34.3	33.053	-4.708	30.0	2.70	221.5	-1.484	0.37
278	1980	2	10	3	39	42.5	35.290	-4.961	20.0	3.20	285.9	-1.352	0.41
279	1980	4	20	14	18	48.7	34.960	-5.008	5.0	3.50	257.1	-0.632	0.67
280	1980	8	6	23	58	11.1	35.173	-5.998	5.0	3.20	219.7	-0.691	0.64
281	1980	10	20	7	47	5.1	36.006	-6.701	10.0	3.40	290.6	-1.088	0.49
282	1983	9	20	8	39	13.1	34.864	-5.137	33.0	4.50	241.1	1.006	2.07
283	1983	11	24	20	55	41.0	34.733	-4.541	78.0	4.60	276.5	0.743	1.73
284	1986	1	28	11	13	22.2	31.996	-5.389	10.0	4.20	219.4	0.810	1.81
285	1986	1	28	20	1	28.4	31.999	-5.318	22.0	4.90	223.9	1.800	3.58

Table X3.1: Estimated Earthquake Intensity and Ground Acceleration Felt at N'Fifikh Dam Site (6/7)
(Latitude: 33°23'57''N, Longitude: 7°03'17''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
286	1986	1	29	7	50	13.3	32.079	-5.394	10.0	4.20	212.7	0.887	1.91
287	1986	4	3	22	33	13.5	35.071	-4.691	33.0	3.30	287.4	-1.224	0.44
288	1987	7	23	11	57	31.4	35.636	-5.763	86.0	3.50	275.4	-0.917	0.55
289	1987	7	31	15	45	19.3	33.488	-4.101	10.0	3.70	274.8	-0.498	0.73
290	1988	2	26	17	32	2.0	35.205	-6.242	10.0	3.20	213.8	-0.627	0.67
291	1988	4	30	3	39	33.7	34.637	-5.536	10.0	3.90	196.8	0.628	1.59
292	1988	9	22	23	44	30.3	31.442	-7.672	10.0	3.70	224.3	0.005	1.04
293	1988	10	28	22	5	39.5	34.933	-5.820	10.0	3.50	205.1	-0.073	0.98
294	1989	1	7	14	43	9.9	35.423	-5.012	33.0	3.30	293.8	-1.279	0.43
295	1989	5	7	17	45	47.9	32.911	-5.094	10.0	3.70	190.1	0.413	1.37
296	1989	8	5	10	26	3.1	34.850	-5.525	10.0	3.40	214.6	-0.335	0.82
297	1989	8	17	13	18	57.2	35.178	-9.185	10.0	3.20	279.4	-1.289	0.42
298	1989	8	23	8	9	39.3	34.510	-5.506	10.0	3.50	189.4	0.123	1.12
299	1989	8	23	6	45	50.8	34.509	-5.435	10.0	3.00	194.4	-0.691	0.64
300	1989	8	23	6	28	53.0	34.500	-5.347	10.0	3.80	200.2	0.436	1.40
301	1989	8	23	5	30	57.2	34.521	-5.199	10.0	3.00	212.6	-0.913	0.55
302	1989	9	16	16	8	44.6	34.825	-4.758	10.0	2.70	265.6	-1.914	0.28
303	1989	9	27	2	10	21.5	35.577	-5.594	89.5	3.70	276.8	-0.639	0.66
304	1989	10	17	2	26	11.2	35.501	-5.756	76.8	2.70	262.3	-1.983	0.26
305	1989	12	8	1	8	3.1	31.941	-6.292	5.0	3.80	176.4	0.751	1.73
306	1990	8	13	1	45	49.7	34.876	-5.318	81.0	3.50	229.9	-0.498	0.73
307	1991	3	4	11	44	15.8	35.072	-5.551	32.0	3.60	232.1	-0.251	0.87
308	1991	3	12	15	58	55.1	34.536	-4.590	30.0	3.50	261.5	-0.689	0.64
309	1992	12	10	23	23	54.6	32.168	-5.839	0.0	3.60	177.1	0.442	1.40
310	1993	5	1	0	22	22.6	35.288	-6.306	28.0	3.70	220.5	0.030	1.05
311	1993	5	1	4	39	25.9	31.590	-4.930		3.10	281.4	-1.456	0.38
312	1993	5	27	19	10	48.0	32.060	-6.330		2.50	162.9	-1.002	0.52
313	1993	5	31	2	24	38.1	34.680	-4.780		2.80	254.7	-1.658	0.33
314	1993	6	23	20	51	45.5	35.300	-8.870		2.70	269.8	-1.951	0.27
315	1993	6	27	13	46	11.9	33.680	-4.650		3.80	225.7	0.142	1.14
316	1993	7	16	17	12	4.9	33.500	-4.450		2.70	242.4	-1.685	0.32
317	1993	7	23	22	13	27.0	32.420	-6.150		2.90	137.3	0.019	1.05
318	1993	8	19	12	53	33.5	34.860	-4.700		3.10	272.2	-1.373	0.40
319	1993	8	29	6	6	47.3	32.960	-5.330		3.30	167.6	0.129	1.13
320	1993	10	9	21	52	55.3	31.190	-7.410		3.60	246.9	-0.381	0.79
321	1993	10	24	5	46	10.4	35.160	-4.900		2.80	279.6	-1.890	0.28
322	1993	11	9	16	51	46.4	33.640	-6.150		2.70	88.2	0.787	1.78
323	1993	11	30	13	17	31.0	32.560	-5.620		3.80	162.6	0.953	2.00
324	1993	12	9	19	28	13.8	33.970	-4.780		4.00	220.7	0.497	1.46
325	1993	12	15	10	24	11.2	35.480	-5.030	0.0	3.00	297.6	-1.745	0.31
326	1993	12	21	22	29	14.7	34.990	-4.780		2.70	275.3	-2.001	0.26
327	1993	12	30	11	34	35.1	34.550	-4.140	0.0	2.90	299.5	-1.911	0.28
328	1994	1	27	23	18	6.7	31.710	-9.457	22.0	3.70	291.4	-0.649	0.66
329	1994	11	25	5	33	17.5	34.655	-4.519	16.0	4.10	273.7	0.109	1.11
330	1995	1	29	17	43	13.3	33.205	-5.124	0.0	3.70	180.8	0.542	1.50
331	1995	3	5	23	46	20.8	35.872	-7.722	30.0	3.60	280.9	-0.715	0.63
332	1995	4	11	13	20	30.3	35.607	-8.439	18.0	3.90	276.4	-0.216	0.89
333	1995	6	21	0	36	58.6	30.776	-7.075	30.0	3.70	290.6	-0.649	0.66
334	1995	9	25	15	13	16.7	34.180	-4.871	6.0	3.60	220.7	-0.103	0.96
335	1995	9	29	5	54	31.3	34.069	-5.884	3.0	3.50	131.7	1.019	2.09
336	1996	4	3	1	24	8.3	34.189	-4.845	0.0	3.60	223.3	-0.131	0.94
337	1996	6	18	13	58	53.3	35.285	-5.819	32.0	3.70	238.4	-0.166	0.92
338	1996	7	13	9	8	4.9	34.690	-5.787	19.0	4.20	185.3	1.218	2.39
339	1997	7	14	11	25	1.3	33.561	-4.178	14.0	3.90	268.0	-0.138	0.94
340	1997	7	26	12	56	55.7	33.155	-4.990	9.0	3.50	193.9	0.066	1.08
341	1997	8	4	14	23	37.7	32.233	-5.724	13.0	4.10	178.9	1.161	2.30

Table X3.1: Estimated Earthquake Intensity and Ground Acceleration Felt at N'Fifikh Dam Site (7/7)
(Latitude: 33°23'57''N, Longitude: 7°03'17''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
342	1997	8	4	15	44	32.3	32.214	-5.704	7.0	3.50	181.7	0.227	1.21
343	1997	12	19	15	32	30.9	34.478	-9.770	3.0	4.00	279.3	-0.087	0.97
344	1998	4	14	7	26	50.4	32.804	-5.297	5.0	3.90	176.2	0.904	1.93
345	1998	6	16	5	30	10.3	32.655	-5.315	3.0	3.90	181.5	0.831	1.83
346	1998	6	18	19	45	34.8	32.704	-5.368	0.0	4.40	174.7	1.676	3.29
347	1998	8	3	15	25	42.7	34.720	-4.918	22.0	4.00	246.7	0.211	1.20
348	1998	9	16	7	58	2.1	32.713	-5.394	0.0	3.60	172.1	0.513	1.47
349	1999	3	16	21	41	42.2	34.414	-4.138	0.0	3.80	293.5	-0.511	0.73
350	1999	4	13	6	43	10.8	35.491	-8.771	11.0	3.80	281.3	-0.407	0.78

Table X3.2: Estimated Earthquake Intensity and Ground Acceleration Felt at Taskourt Dam Site (1/2) (Latitude: 31°11'14''N, Longitude: 8°28'20''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
1	1960	2	29	23	40	14.0	30.450	-9.616	0.0	6.00	136.1	4.690	26.36
2	1967	8	28	21	15	0.0	31.300	-6.299	0.0	4.60	207.1	1.555	3.02
3	1967	8	30	18	21	0.0	31.499	-6.000	0.0	4.10	237.7	0.464	1.42
4	1969	4	12	0	2	6.0	32.000	-6.200	0.0	4.40	234.2	0.951	1.99
5	1972	10	4	21	0	12.7	31.960	-5.960	1.0	3.60	253.9	-0.450	0.76
6	1972	12	23	8	10	6.7	32.038	-6.000	1.0	2.90	253.4	-1.495	0.37
7	1973	2	16	1	36	38.6	32.150	-5.820	0.0	3.10	273.9	-1.389	0.40
8	1973	2	24	20	14	53.6	32.090	-5.960	2.0	3.30	259.1	-0.950	0.54
9	1973	3	1	23	20	34.3	32.170	-5.990	1.0	2.20	260.0	-2.610	0.17
10	1973	3	3	15	9	59.8	32.090	-6.280	110.0	3.50	231.3	-0.622	0.67
11	1973	3	7	14	59	10.6	32.080	-6.160	1.0	3.30	241.2	-0.773	0.61
12	1973	3	29	12	4	47.8	32.290	-5.600	100.0	3.20	299.3	-1.591	0.34
13	1973	7	31	1	25	27.8	32.100	-6.289	149.0	2.70	231.0	-1.998	0.26
14	1973	12	11	20	58	12.8	31.939	-6.450	165.0	2.60	209.6	-2.073	0.25
15	1974	1	17	10	31	38.1	30.890	-8.048	1.0	4.00	52.1	3.944	15.75
16	1974	3	9	11	33	58.0	31.230	-8.268	2.0	3.50	20.0	4.888	30.23
17	1974	3	11	12	31	42.0	30.230	-10.040	82.0	3.90	183.1	0.585	1.55
18	1974	4	6	12	16	3.4	31.880	-6.220	1.0	3.70	227.6	-0.028	1.01
19	1974	4	25	8	53	1.9	33.570	-8.170	69.0	3.30	265.8	-1.095	0.48
20	1974	12	8	17	12	38.3	32.570	-7.470	65.0	2.70	180.6	-1.106	0.48
21	1975	3	27	5	21	22.8	31.640	-6.759	2.0	3.60	170.5	0.536	1.50
22	1975	6	20	6	45	49.6	30.720	-7.089	0.0	3.50	141.4	0.846	1.85
23	1975	6	24	4	28	14.5	31.720	-6.440	117.0	2.60	202.1	-1.743	0.31
24	1975	8	15	13	26	16.0	31.359	-7.480	2.0	3.70	96.3	2.078	4.34
25	1975	10	29	22	22	14.7	31.359	-7.970	17.0	3.30	51.4	2.810	7.19
26	1975	11	1	19	20	17.9	32.240	-5.790	153.0	2.60	280.6	-2.522	0.18
27	1975	11	3	9	35	35.4	31.640	-6.299	135.0	2.60	212.7	-1.931	0.27
28	1976	1	20	3	55	19.0	31.340	-5.470	128.0	3.20	286.1	-1.574	0.35
29	1976	2	13	12	0	8.5	31.429	-5.600	1.0	3.50	274.5	-0.794	0.60
30	1976	4	20	11	2	31.3	31.790	-6.130	111.0	3.50	232.6	-0.637	0.66
31	1976	11	8	21	14	54.7	32.129	-5.910	1.0	3.00	265.2	-1.458	0.38
32	1977	6	3	11	55	2.4	32.250	-6.100	1.0	3.20	254.6	-1.057	0.50
33	1977	8	30	6	3	38.1	31.230	-6.870	21.0	3.00	152.5	-0.112	0.96
34	1977	10	25	13	1	41.5	31.440	-5.610	2.0	2.90	273.7	-1.687	0.32
35	1978	1	16	9	56	48.9	32.210	-6.020	1.0	2.40	259.4	-2.303	0.21
36	1978	2	7	1	39	25.2	30.279	-7.759	3.0	4.70	121.5	3.017	8.30
37	1978	2	8	21	42	50.5	31.970	-5.950	2.0	4.30	255.1	0.588	1.55
38	1978	3	5	16	47	55.6	31.820	-5.970	45.0	3.40	248.1	-0.733	0.62
39	1978	4	22	2	56	3.8	31.980	-6.850	5.0	3.50	177.6	0.284	1.26
40	1978	5	12	6	24	40.4	33.670	-8.969	1.0	4.10	279.4	0.062	1.08
41	1978	6	12	20	11	23.8	30.869	-6.820	1.0	3.10	161.1	-0.074	0.98
42	1978	6	13	11	39	11.1	29.310	-9.360	4.0	3.80	224.7	0.153	1.15
43	1978	11	6	3	20	53.6	31.099	-5.749	133.0	3.70	259.2	-0.642	0.66
44	1978	11	6	3	23	46.6	31.120	-5.629	102.0	3.70	270.5	-0.623	0.67
45	1979	3	7	19	21	34.0	31.099	-6.399	0.0	3.50	197.4	0.024	1.05
46	1979	5	5	21	9	19.5	30.200	-8.000	0.0	3.40	118.4	1.131	2.26
47	1979	5	11	2	27	22.0	32.100	-6.100	0.0	2.20	247.3	-2.485	0.19
48	1979	5	13	13	53	15.0	32.400	-6.100	0.0	2.80	262.7	-1.735	0.31
49	1979	5	30	16	8	37.5	32.400	-6.600	0.0	2.20	223.2	-2.230	0.22
50	1979	6	24	13	32	55.5	32.500	-6.000	0.0	2.40	276.6	-2.463	0.19
51	1979	7	4	4	58	1.0	32.500	-6.700	0.0	2.10	222.7	-2.375	0.20
52	1979	8	7	23	17	28.6	31.800	-6.600	0.0	3.30	190.6	-0.189	0.91
53	1979	9	10	4	24	27.0	31.700	-6.000	0.0	3.50	241.9	-0.480	0.74
54	1979	9	10	2	8	58.3	31.800	-5.900	0.0	3.10	253.9	-1.200	0.45
55	1979	9	13	17	45	8.5	31.470	-5.785	0.0	4.60	257.5	1.015	2.08
56	1979	9	14	15	34	36.3	31.600	-5.800	0.0	3.90	258.3	-0.042	1.00
57	1979	9	20	22	9	45.1	31.470	-5.785	0.0	3.70	257.5	-0.335	0.82

Table X3.2: Estimated Earthquake Intensity and Ground Acceleration Felt at Taskourt Dam Site (2/2) (Latitude: 31°11'14''N, Longitude: 8°28'20''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
58	1979	10	1	22	52	5.5	32.000	-6.200	0.0	2.50	234.2	-1.899	0.28
59	1979	10	24	13	9	50.9	32.500	-7.321	0.0	3.60	182.2	0.373	1.34
60	1979	11	22	1	42	11.0	32.000	-6.399	0.0	2.60	216.8	-1.558	0.35
61	1979	11	26	17	26	54.2	31.499	-6.399	0.0	3.00	200.2	-0.761	0.61
62	1979	12	29	23	9	52.0	33.199	-6.700	0.0	2.60	279.6	-2.190	0.23
63	1980	1	20	17	20	19.7	30.836	-7.688	60.0	2.30	84.2	-0.191	0.90
64	1988	4	9	20	27	24.8	31.449	-9.936	10.0	4.70	142.2	2.626	6.34
65	1988	9	22	23	44	30.3	31.442	-7.672	10.0	3.70	81.2	2.467	5.67
66	1988	11	21	10	19	5.4	31.466	-9.541	10.0	4.40	106.2	2.881	7.56
67	1989	12	8	1	8	3.1	31.941	-6.292	5.0	3.80	223.6	0.165	1.16
68	1991	7	29	7	22	18.8	30.715	-6.586	30.0	4.30	186.9	1.328	2.58
69	1992	4	5	21	16	35.4	30.471	-10.003	0.0	4.20	165.9	1.504	2.92
70	1992	12	10	23	23	54.6	32.168	-5.839	0.0	3.60	273.1	-0.631	0.67
71	1993	1	8	1	43	8.7	30.634	-6.718	30.0	3.50	177.8	0.248	1.23
72	1993	5	16	1	40	29.7	30.180	-5.740		3.30	282.9	-1.169	0.46
73	1993	5	27	19	10	48.0	32.060	-6.330		2.50	225.6	-1.807	0.30
74	1993	7	23	22	13	27.0	32.420	-6.150		2.90	259.8	-1.557	0.35
75	1993	10	9	21	52	55.3	31.190	-7.410		3.60	101.0	1.813	3.61
76	1993	10	24	1	41	43.0	31.000	-9.280		3.70	79.6	2.531	5.93
77	1994	1	27	23	18	6.7	31.710	-9.457	22.0	3.70	110.2	1.707	3.36
78	1995	4	2	14	47	56.7	29.940	-9.500	30.0	3.50	169.4	0.364	1.33
79	1995	6	21	0	36	58.6	30.776	-7.075	30.0	3.70	140.5	1.107	2.22
80	1995	9	5	6	21	52.0	30.884	-10.051	31.0	3.80	153.9	1.040	2.12
81	1995	9	27	22	18	2.2	30.826	-8.133	31.0	3.60	51.4	3.030	8.37
82	1997	8	4	14	23	37.7	32.233	-5.724	13.0	4.10	286.0	0.002	1.03
83	1997	8	4	15	44	32.3	32.214	-5.704	7.0	3.50	286.9	-0.904	0.55

Table X3.3: Estimated Earthquake Intensity and Ground Acceleration Felt at Timkit Dam Site (1/5)
(Latitude: 31°38'31''N, Longitude: 5°19'15''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
1	1930	8	9	18	9	38.0	34.300	-5.399	0.0	4.70	294.9	0.828	1.83
2	1930	8	13	3	20	45.0	34.300	-5.399	0.0	4.40	294.9	0.378	1.34
3	1938	3	30	15	6	6.0	33.500	-6.250	0.0	5.10	224.0	2.111	4.44
4	1967	8	28	21	15	0.0	31.300	-6.299	0.0	4.60	99.9	3.341	10.39
5	1967	8	30	18	21	0.0	31.499	-6.000	0.0	4.10	66.1	3.564	12.11
6	1967	9	24	17	8	0.0	32.500	-5.700	0.0	4.30	101.7	2.848	7.39
7	1969	4	12	0	2	6.0	32.000	-6.200	0.0	4.40	92.0	3.237	9.66
8	1971	7	2	21	11	8.5	34.100	-5.200	0.0	4.60	272.8	0.871	1.89
9	1972	6	25	15	45	38.0	32.430	-5.580	0.0	3.00	90.7	1.171	2.32
10	1972	10	4	21	0	12.7	31.960	-5.960	1.0	3.60	69.9	2.684	6.59
11	1972	11	15	4	18	9.9	32.750	-5.580	2.0	3.50	125.3	1.142	2.27
12	1972	12	23	8	10	6.7	32.038	-6.000	1.0	2.90	77.7	1.387	2.69
13	1973	2	2	21	18	14.2	34.240	-5.370	5.0	3.00	288.2	-1.665	0.33
14	1973	2	16	1	36	38.6	32.150	-5.820	0.0	3.10	73.5	1.819	3.63
15	1973	2	24	20	14	53.6	32.090	-5.960	2.0	3.30	78.2	1.973	4.03
16	1973	3	1	23	20	34.3	32.170	-5.990	1.0	2.20	86.1	0.094	1.10
17	1973	3	1	3	37	35.9	32.820	-4.289	1.0	3.00	163.0	-0.253	0.87
18	1973	3	3	15	9	59.8	32.090	-6.280	110.0	3.50	103.3	0.687	1.66
19	1973	3	5	6	52	37.0	32.150	-4.430	4.0	3.30	101.3	1.356	2.63
20	1973	3	7	14	59	10.6	32.080	-6.160	1.0	3.30	93.0	1.563	3.04
21	1973	3	8	17	52	59.9	33.820	-5.130	17.0	3.40	242.2	-0.639	0.66
22	1973	3	27	14	4	49.8	31.720	-4.859	33.0	3.40	44.5	2.911	7.71
23	1973	3	29	12	4	47.8	32.290	-5.600	100.0	3.20	76.5	0.680	1.65
24	1973	3	30	11	7	49.7	32.550	-4.240	2.0	3.50	143.4	0.811	1.81
25	1973	4	8	15	55	7.5	33.220	-5.779	2.0	3.40	180.3	0.098	1.11
26	1973	5	19	20	49	3.5	32.470	-5.570	2.0	3.80	94.8	2.266	4.94
27	1973	6	1	18	13	30.1	33.929	-6.840	29.0	3.40	291.4	-1.105	0.48
28	1973	7	24	8	57	15.5	33.039	-5.050	5.0	3.70	157.0	0.888	1.91
29	1973	7	31	1	25	27.8	32.100	-6.289	149.0	2.70	104.6	-0.976	0.53
30	1973	9	23	0	6	19.8	34.120	-5.940	102.0	3.30	281.0	-1.306	0.42
31	1973	10	9	14	47	12.8	32.408	-5.350	1.0	3.60	85.0	2.226	4.81
32	1973	10	16	11	38	56.2	34.070	-5.390	133.0	4.50	269.3	0.482	1.44
33	1973	12	11	20	58	12.8	31.939	-6.450	165.0	2.60	111.6	-1.348	0.41
34	1974	1	17	10	31	38.1	30.890	-8.048	1.0	4.00	270.8	-0.010	1.03
35	1974	3	9	11	33	58.0	31.230	-8.268	2.0	3.50	282.1	-0.862	0.57
36	1974	4	6	12	16	3.4	31.880	-6.220	1.0	3.70	88.9	2.269	4.95
37	1974	6	10	4	23	28.3	33.649	-3.840	2.0	4.50	262.9	0.813	1.81
38	1974	7	4	4	2	53.6	33.900	-5.529	2.0	3.50	251.2	-0.573	0.69
39	1974	11	3	17	18	59.6	33.110	-5.020	2.0	3.20	165.3	0.013	1.04
40	1974	11	26	0	10	26.9	32.070	-3.920	47.0	3.20	140.6	0.280	1.25
41	1974	12	8	17	12	38.3	32.570	-7.470	65.0	2.70	227.6	-1.626	0.34
42	1975	1	23	20	27	14.0	33.100	-5.210	1.0	3.20	162.0	0.062	1.08
43	1975	1	29	7	48	5.9	33.910	-5.010	2.0	3.50	253.2	-0.594	0.69
44	1975	3	27	5	21	22.8	31.640	-6.759	2.0	3.60	135.8	1.094	2.20
45	1975	6	20	6	45	49.6	30.720	-7.089	0.0	3.50	195.8	0.044	1.06
46	1975	6	24	4	28	14.5	31.720	-6.440	117.0	2.60	106.1	-0.775	0.60
47	1975	6	29	8	0	40.5	33.520	-5.600	38.0	2.70	209.9	-1.368	0.40
48	1975	8	3	19	11	51.4	33.070	-5.319	5.0	3.50	158.4	0.567	1.53
49	1975	8	3	0	20	58.9	33.199	-5.250	12.0	3.40	172.8	0.197	1.18
50	1975	8	15	13	26	16.0	31.359	-7.480	2.0	3.70	206.3	0.214	1.20
51	1975	10	25	18	9	59.1	32.408	-5.270	112.0	2.70	85.1	-0.341	0.82
52	1975	10	29	22	22	14.7	31.359	-7.970	17.0	3.30	252.2	-0.889	0.56
53	1975	11	1	19	20	17.9	32.240	-5.790	153.0	2.60	79.8	-0.993	0.52
54	1975	11	3	9	35	35.4	31.640	-6.299	135.0	2.60	92.4	-0.862	0.57
55	1975	11	13	6	37	42.6	32.628	-4.230	1.0	3.00	150.3	-0.053	1.00
56	1975	11	14	10	41	19.3	32.360	-4.820	103.0	3.00	92.6	0.147	1.14
57	1975	11	17	14	46	22.9	33.540	-4.640	9.0	3.50	220.1	-0.248	0.87

Table X3.3: Estimated Earthquake Intensity and Ground Acceleration Felt at Timkit Dam Site (2/5)
(Latitude: 31°38'31''N, Longitude: 5°19'15''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
58	1975	12	8	19	40	16.8	34.129	-4.440	30.0	3.30	288.1	-1.228	0.44
59	1975	12	10	6	35	9.7	32.620	-5.350	126.0	2.60	108.5	-0.902	0.55
60	1975	12	10	3	37	46.5	33.520	-4.800	26.0	2.90	214.0	-1.094	0.49
61	1976	1	20	3	55	19.0	31.340	-5.470	128.0	3.20	36.3	0.545	1.51
62	1976	2	5	4	55	0.4	33.990	-5.779	13.0	3.00	264.0	-1.450	0.38
63	1976	2	6	1	27	39.0	32.360	-5.170	1.0	4.00	80.9	2.943	7.89
64	1976	2	6	10	41	16.2	33.129	-4.680	55.0	3.10	175.7	-0.403	0.78
65	1976	2	13	12	0	8.5	31.429	-5.600	1.0	3.50	35.4	3.987	16.22
66	1976	3	5	20	4	5.5	32.320	-4.759	94.0	3.50	92.0	1.023	2.09
67	1976	3	16	18	37	57.6	33.300	-4.890	23.0	4.30	188.3	1.322	2.57
68	1976	4	13	19	23	19.3	34.280	-4.920	14.0	4.20	295.0	0.074	1.09
69	1976	4	15	16	6	15.1	33.920	-6.280	5.0	3.90	268.4	-0.138	0.94
70	1976	4	20	11	2	31.3	31.790	-6.130	111.0	3.50	78.2	0.946	1.99
71	1976	11	8	21	14	54.7	32.129	-5.910	1.0	3.00	77.5	1.542	3.00
72	1977	1	7	15	20	42.9	32.600	-5.770	2.0	3.60	114.4	1.513	2.94
73	1977	1	8	10	36	16.4	32.090	-4.170	44.0	2.70	119.5	-0.098	0.96
74	1977	1	15	23	58	47.0	33.750	-3.620	2.0	4.40	283.7	0.474	1.43
75	1977	5	12	6	59	16.9	34.230	-4.820	59.0	3.30	290.9	-1.288	0.42
76	1977	6	3	11	55	2.4	32.250	-6.100	1.0	3.20	99.8	1.243	2.44
77	1977	8	23	22	34	56.0	32.380	-5.040	128.0	2.80	86.0	-0.417	0.77
78	1977	8	30	6	3	38.1	31.230	-6.870	21.0	3.00	153.3	-0.125	0.95
79	1977	9	1	18	35	14.1	32.800	-5.510	125.0	3.40	129.7	0.101	1.11
80	1977	9	9	12	20	20.0	33.170	-4.170	2.0	4.10	201.3	0.875	1.89
81	1977	10	25	13	1	41.5	31.440	-5.610	2.0	2.90	35.3	3.089	8.72
82	1977	10	27	13	15	34.7	32.789	-5.299	107.0	3.30	127.2	0.149	1.14
83	1977	11	6	17	35	3.8	33.039	-4.759	78.0	3.00	163.8	-0.517	0.72
84	1977	11	6	4	37	5.3	33.929	-5.240	17.0	3.70	253.7	-0.304	0.84
85	1978	1	16	9	56	48.9	32.210	-6.020	1.0	2.40	91.3	0.257	1.23
86	1978	2	7	1	39	25.2	30.279	-7.759	3.0	4.70	275.5	0.997	2.06
87	1978	2	8	21	42	50.5	31.970	-5.950	2.0	4.30	69.7	3.741	13.69
88	1978	3	5	16	47	55.6	31.820	-5.970	45.0	3.40	64.4	2.112	4.44
89	1978	4	10	19	3	47.4	34.180	-6.000	52.0	3.20	288.7	-1.409	0.39
90	1978	4	22	2	56	3.8	31.980	-6.850	5.0	3.50	149.2	0.713	1.69
91	1978	4	24	21	7	33.4	33.810	-5.940	15.0	3.80	247.4	-0.091	0.97
92	1978	6	12	20	11	23.8	30.869	-6.820	1.0	3.10	165.5	-0.141	0.94
93	1978	11	6	3	23	46.6	31.120	-5.629	102.0	3.70	64.8	1.530	2.97
94	1978	11	6	3	20	53.6	31.099	-5.749	133.0	3.70	72.5	0.977	2.03
95	1979	1	2	15	39	58.8	31.778	-4.911	96.0	3.20	41.6	1.129	2.25
96	1979	1	4	13	9	29.2	34.091	-5.723	8.0	2.80	274.2	-1.843	0.29
97	1979	1	4	9	27	35.7	34.260	-5.636	4.0	2.90	291.9	-1.847	0.29
98	1979	1	17	17	43	27.0	33.400	-5.399	0.0	4.50	195.1	1.553	3.02
99	1979	1	19	1	9	21.2	33.461	-5.063	16.0	2.90	203.2	-0.955	0.53
100	1979	2	5	13	34	36.5	33.479	-5.028	19.0	2.90	205.6	-0.987	0.52
101	1979	2	14	3	6	4.3	33.500	-6.629	68.0	2.50	240.3	-2.059	0.25
102	1979	2	24	6	28	56.5	33.441	-4.633	6.0	2.90	209.8	-1.028	0.51
103	1979	3	7	19	21	34.0	31.099	-6.399	0.0	3.50	118.3	1.282	2.50
104	1979	3	15	14	42	2.9	32.691	-5.391	52.0	2.40	116.5	-0.553	0.71
105	1979	3	19	15	39	10.4	33.296	-5.254	4.0	3.40	183.5	0.054	1.07
106	1979	3	19	16	11	33.5	33.300	-5.500	0.0	2.70	184.6	-1.011	0.51
107	1979	3	19	15	56	2.1	33.411	-5.411	5.0	2.70	196.4	-1.164	0.46
108	1979	3	25	11	13	25.0	34.000	-5.200	0.0	3.30	261.7	-0.976	0.53
109	1979	3	27	23	4	7.7	32.963	-5.380	18.0	2.40	146.6	-0.911	0.55
110	1979	4	18	14	53	7.5	32.800	-5.700	0.0	2.20	133.3	-0.960	0.53
111	1979	4	20	14	40	26.5	32.900	-4.900	0.0	2.20	145.1	-1.167	0.46
112	1979	4	24	5	50	38.5	32.300	-4.800	0.0	2.60	88.0	0.643	1.61
113	1979	4	25	23	8	2.0	32.800	-5.700	5.0	2.00	133.3	-1.261	0.43
114	1979	4	25	23	11	55.0	32.800	-5.700	0.0	2.20	133.3	-0.960	0.53

Table X3.3: Estimated Earthquake Intensity and Ground Acceleration Felt at Timkit Dam Site (3/5)
(Latitude: 31°38'31''N, Longitude: 5°19'15''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth	Magnitude in	Epicentral Distance	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E	(km)	Richter Scale	(km)	Intensity (Imm)	Acceleration (gal)
115	1979	5	5	21	9	19.5	30.200	-8.000	0.0	3.40	299.4	-1.160	0.46
116	1979	5	11	2	27	22.0	32.100	-6.100	0.0	2.20	89.4	0.006	1.04
117	1979	5	13	13	53	15.0	32.400	-6.100	0.0	2.80	111.7	0.371	1.33
118	1979	5	25	7	51	6.5	32.800	-4.800	0.0	2.30	137.5	-0.886	0.56
119	1979	5	29	22	28	21.0	32.800	-5.000	0.0	2.20	132.0	-0.934	0.54
120	1979	5	30	16	8	37.5	32.400	-6.600	0.0	2.20	147.2	-1.202	0.45
121	1979	6	9	10	3	11.0	32.800	-5.150	0.0	2.80	129.4	0.013	1.04
122	1979	6	9	0	36	32.0	32.800	-5.100	0.0	4.40	130.1	2.400	5.42
123	1979	6	9	1	56	22.0	32.800	-5.100	0.0	2.70	130.1	-0.150	0.93
124	1979	6	9	13	45	40.0	32.900	-5.399	0.0	4.10	139.7	1.776	3.52
125	1979	6	9	1	11	18.0	32.900	-5.000	0.0	3.30	142.8	0.523	1.48
126	1979	6	9	17	12	19.0	32.900	-4.900	0.0	2.80	145.1	-0.267	0.86
127	1979	6	9	21	18	34.0	32.900	-4.900	0.0	2.30	145.1	-1.017	0.51
128	1979	6	10	18	10	19.0	32.800	-5.100	0.0	3.20	130.1	0.600	1.56
129	1979	6	10	19	25	16.0	32.800	-5.100	0.0	2.70	130.1	-0.150	0.93
130	1979	6	10	20	3	35.0	32.800	-5.100	0.0	3.30	130.1	0.750	1.73
131	1979	6	10	0	5	21.0	32.900	-4.800	0.0	2.70	147.9	-0.465	0.75
132	1979	6	11	13	41	47.5	32.900	-4.800	0.0	2.90	147.9	-0.165	0.92
133	1979	6	13	19	26	52.5	32.800	-5.399	0.0	3.10	128.6	0.478	1.44
134	1979	6	16	13	51	44.0	32.800	-5.299	0.0	4.00	128.4	1.831	3.66
135	1979	6	16	14	2	27.0	32.800	-5.299	0.0	3.30	128.4	0.781	1.77
136	1979	6	16	14	26	22.0	32.800	-5.299	0.0	3.90	128.4	1.681	3.30
137	1979	6	16	17	3	19.5	32.900	-5.000	0.0	2.70	142.8	-0.377	0.80
138	1979	6	16	18	48	48.0	32.900	-5.000	0.0	3.10	142.8	0.223	1.20
139	1979	6	17	7	38	11.0	32.800	-5.299	0.0	3.10	128.4	0.481	1.44
140	1979	6	17	23	38	36.5	32.800	-5.299	0.0	4.20	128.4	2.131	4.50
141	1979	6	18	8	25	20.0	32.000	-4.900	0.0	2.50	56.2	1.529	2.97
142	1979	6	18	1	18	40.0	33.000	-5.200	0.0	2.60	151.0	-0.665	0.65
143	1979	6	19	3	39	16.0	32.900	-5.100	0.0	3.20	141.1	0.402	1.36
144	1979	6	19	14	22	44.0	33.000	-5.200	0.0	3.90	151.0	1.285	2.51
145	1979	6	20	17	50	52.0	33.000	-5.000	0.0	4.20	153.6	1.693	3.33
146	1979	6	24	13	32	55.5	32.500	-6.000	0.0	2.40	114.7	-0.294	0.84
147	1979	6	24	17	41	57.0	33.000	-5.000	0.0	3.00	153.6	-0.107	0.96
148	1979	6	25	5	1	5.5	32.900	-5.100	0.0	3.00	141.1	0.102	1.11
149	1979	7	4	5	57	3.5	33.000	-5.500	0.0	2.50	151.5	-0.824	0.58
150	1979	7	4	4	58	1.0	32.500	-6.700	0.0	2.10	161.3	-1.577	0.35
151	1979	7	5	11	46	7.0	32.698	-5.299	0.0	3.80	117.1	1.756	3.47
152	1979	7	5	5	48	6.0	32.698	-5.100	0.0	3.70	119.0	1.568	3.05
153	1979	7	11	2	53	37.0	32.800	-5.200	0.0	3.10	128.9	0.472	1.43
154	1979	7	18	20	24	46.0	32.800	-5.200	0.0	2.80	128.9	0.022	1.05
155	1979	7	22	21	31	10.0	33.000	-5.100	0.0	3.10	152.0	0.068	1.08
156	1979	7	23	3	24	5.0	33.000	-5.000	0.0	2.40	153.6	-1.007	0.52
157	1979	7	26	9	21	51.0	31.600	-4.600	0.0	4.60	68.3	4.238	19.30
158	1979	7	28	2	44	43.0	31.600	-4.700	0.0	3.00	58.8	2.176	4.64
159	1979	8	2	0	40	33.4	33.000	-4.800	0.0	2.70	158.4	-0.633	0.67
160	1979	8	5	19	38	23.0	32.800	-5.100	0.0	3.30	130.1	0.750	1.73
161	1979	8	6	22	15	18.7	33.900	-4.299	0.0	3.40	268.4	-0.888	0.56
162	1979	8	7	23	17	28.6	31.800	-6.600	0.0	3.30	122.1	0.905	1.93
163	1979	8	17	18	48	25.8	31.400	-4.700	0.0	3.50	64.5	2.718	6.75
164	1979	9	10	2	8	58.3	31.800	-5.900	0.0	3.10	57.4	2.381	5.35
165	1979	9	10	4	24	27.0	31.700	-6.000	0.0	3.50	64.5	2.720	6.76
166	1979	9	13	17	45	8.5	31.470	-5.785	0.0	4.60	47.8	5.031	33.36
167	1979	9	14	15	34	36.3	31.600	-5.800	0.0	3.90	45.5	4.086	17.37
168	1979	9	20	22	9	45.1	31.470	-5.785	0.0	3.70	47.8	3.681	13.13
169	1979	9	20	1	18	47.0	32.300	-5.299	0.0	3.50	73.0	2.433	5.55
170	1979	9	25	19	6	55.3	33.496	-3.774	0.0	3.00	252.2	-1.334	0.41
171	1979	10	1	22	52	5.5	32.000	-6.200	0.0	2.50	92.0	0.387	1.35

Table X3.3: Estimated Earthquake Intensity and Ground Acceleration Felt at Timkit Dam Site (4/5)
(Latitude: 31°38'31''N, Longitude: 5°19'15''W)

No.	Year	Month	Day	Time			Hypocenter		Focal	Magnitude	Epicentral	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E	Depth (km)	in Richter Scale	Distance (km)	Intensity (Imm)	Acceleration (gal)
172	1979	10	6	23	48	13.5	33.100	-5.100	0.0	3.00	163.0	-0.254	0.87
173	1979	10	24	13	9	50.9	32.500	-7.321	0.0	3.60	211.5	0.003	1.03
174	1979	11	5	15	37	18.0	33.900	-5.299	0.0	2.40	250.4	-2.216	0.22
175	1979	11	22	1	42	11.0	32.000	-6.399	0.0	2.60	109.3	0.124	1.12
176	1979	11	24	13	42	40.5	33.600	-5.500	0.0	2.80	217.8	-1.269	0.43
177	1979	11	26	17	26	54.2	31.499	-6.399	0.0	3.00	103.1	0.866	1.88
178	1979	12	26	17	46	54.6	32.500	-5.000	0.0	2.70	99.9	0.491	1.45
179	1979	12	27	0	37	28.3	32.800	-5.299	0.0	3.50	128.4	1.081	2.18
180	1979	12	29	23	9	52.0	33.199	-6.700	0.0	2.60	216.3	-1.552	0.35
181	1980	1	20	17	20	19.7	30.836	-7.688	60.0	2.30	240.8	-2.343	0.20
182	1980	2	6	4	16	34.3	33.053	-4.708	30.0	2.70	166.8	-0.800	0.59
183	1986	1	28	20	1	28.4	31.999	-5.318	22.0	4.90	39.6	5.594	49.24
184	1986	1	28	11	13	22.2	31.996	-5.389	10.0	4.20	39.8	4.748	27.45
185	1986	1	29	7	50	13.3	32.079	-5.394	10.0	4.20	48.9	4.336	20.65
186	1987	7	31	15	45	19.3	33.488	-4.101	10.0	3.70	234.9	-0.109	0.96
187	1988	9	22	23	44	30.3	31.442	-7.672	10.0	3.70	223.2	0.018	1.05
188	1989	5	7	17	45	47.9	32.911	-5.094	10.0	3.70	142.4	1.124	2.24
189	1989	12	8	1	8	3.1	31.941	-6.292	5.0	3.80	97.5	2.195	4.70
190	1991	7	29	7	22	18.8	30.715	-6.586	30.0	4.30	157.6	1.736	3.43
191	1992	9	29	5	45	30.4	31.471	-3.441	0.0	3.60	178.6	0.422	1.38
192	1992	10	23	9	11	12.5	31.513	-4.233	22.0	5.20	103.8	4.096	17.49
193	1992	10	30	10	44	1.6	31.506	-4.617	0.0	5.00	68.2	4.841	29.26
194	1992	10	30	22	59	21.3	31.061	-4.480	30.0	3.50	102.3	1.534	2.98
195	1992	10	31	0	58	46.4	31.119	-4.269	30.0	4.10	115.1	2.169	4.62
196	1992	12	10	23	23	54.6	32.168	-5.839	0.0	3.60	76.1	2.485	5.75
197	1993	1	8	1	43	8.7	30.634	-6.718	30.0	3.50	172.9	0.314	1.28
198	1993	5	1	4	39	25.9	31.590	-4.930		3.10	37.4	3.282	9.97
199	1993	5	16	1	40	29.7	30.180	-5.740		3.30	166.9	0.139	1.14
200	1993	5	27	19	10	48.0	32.060	-6.330		2.50	106.0	0.048	1.07
201	1993	6	5	6	47	25.2	32.310	-3.750		3.00	165.9	-0.296	0.84
202	1993	6	27	13	46	11.9	33.680	-4.650		3.80	234.7	0.045	1.07
203	1993	7	16	17	12	4.9	33.500	-4.450		2.70	221.9	-1.465	0.38
204	1993	7	23	22	13	27.0	32.420	-6.150		2.90	116.5	0.419	1.38
205	1993	8	29	6	6	47.3	32.960	-5.330		3.30	146.2	0.465	1.42
206	1993	9	29	5	45	34.0	31.860	-3.720		3.90	153.2	1.250	2.45
207	1993	9	29	5	45	30.6	31.485	-3.468	30.0	3.60	175.9	0.424	1.38
208	1993	10	9	21	52	55.3	31.190	-7.410		3.60	203.6	0.098	1.10
209	1993	11	9	16	51	46.4	33.640	-6.150		2.70	235.0	-1.608	0.34
210	1993	11	30	13	17	31.0	32.560	-5.620		3.80	105.6	2.006	4.13
211	1993	12	9	19	28	13.8	33.970	-4.780		4.00	263.2	0.061	1.08
212	1994	5	7	8	49	54.1	31.544	-3.433	26.0	4.00	178.7	0.995	2.05
213	1994	5	12	23	58	11.1	31.503	-3.379	23.0	3.80	184.1	0.628	1.59
214	1995	1	29	17	43	13.3	33.205	-5.124	0.0	3.70	174.3	0.631	1.60
215	1995	6	21	0	36	58.6	30.776	-7.075	30.0	3.70	191.5	0.369	1.33
216	1995	9	3	22	34	55.3	33.153	-2.928	30.0	4.30	281.4	0.330	1.30
217	1995	9	25	15	13	16.7	34.180	-4.871	6.0	3.60	284.7	-0.735	0.62
218	1995	9	27	22	18	2.2	30.826	-8.133	31.0	3.60	280.6	-0.714	0.63
219	1995	9	29	5	54	31.3	34.069	-5.884	3.0	3.50	274.4	-0.793	0.60
220	1995	11	25	18	31	41.9	33.216	-3.252	0.0	3.60	262.0	-0.529	0.72
221	1996	4	3	1	24	8.3	34.189	-4.845	0.0	3.60	286.0	-0.746	0.62
222	1997	7	14	11	25	1.3	33.561	-4.178	14.0	3.90	238.6	0.150	1.15
223	1997	7	26	12	56	55.7	33.155	-4.990	9.0	3.50	170.7	0.380	1.34
224	1997	8	4	15	44	32.3	32.214	-5.704	7.0	3.50	73.0	2.422	5.50
225	1997	8	4	14	23	37.7	32.233	-5.724	13.0	4.10	75.8	3.212	9.50
226	1997	10	12	21	29	22.4	32.445	-3.004	8.0	3.70	236.3	-0.123	0.95
227	1997	10	17	7	15	51.0	32.469	-2.848	5.0	3.80	0.0	6.135	71.53
228	1997	11	14	19	14	17.0	32.435	-2.891	9.0	3.90	0.0	6.130	71.29

Table X3.3: Estimated Earthquake Intensity and Ground Acceleration Felt at Timkit Dam Site (5/5)
(Latitude: 31°38'31''N, Longitude: 5°19'15''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
229	1997	11	15	3	29	26.5	32.534	-2.849	4.0	3.50	0.0	5.712	53.39
230	1997	11	15	6	15	32.6	32.584	-2.805	4.0	3.50	0.0	5.712	53.39
231	1998	1	7	13	22	57.7	32.906	-2.777	30.0	3.60	0.0	4.437	22.14
232	1998	4	14	7	26	50.4	32.804	-5.297	5.0	3.90	0.0	6.285	79.34
233	1998	6	16	5	30	10.3	32.655	-5.315	3.0	3.90	0.0	6.333	82.01
234	1998	6	18	19	45	34.8	32.704	-5.368	0.0	4.40	0.0	7.111	140.35
235	1998	9	16	7	58	2.1	32.713	-5.394	0.0	3.60	0.0	5.911	61.26

Table X3.4: Estimated Earthquake Intensity and Ground Acceleration Felt at Azghar Dam Site (1/13)
(Latitude: 33°47'19''N, Longitude: 4°20'55''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
1	1926	10	11	6	39	18.0	35.699	-2.783	0.0	4.50	256.6	0.873	1.89
2	1926	10	15	6	48	20.0	35.699	-2.783	0.0	4.40	256.6	0.723	1.70
3	1926	10	15	7	53	56.0	35.699	-2.783	0.0	3.50	256.6	-0.627	0.67
4	1926	10	19	4	35	8.0	35.699	-2.783	0.0	4.10	256.6	0.273	1.25
5	1926	11	6	21	0	32.0	35.266	-3.583	0.0	3.90	178.5	0.873	1.89
6	1926	11	13	8	46	58.0	35.450	-3.366	0.0	3.80	205.5	0.375	1.34
7	1926	11	17	21	21	31.0	35.683	-3.366	0.0	4.50	229.0	1.157	2.30
8	1927	4	7	19	52	25.0	36.333	-3.533	0.0	3.40	292.2	-1.099	0.48
9	1927	9	8	8	52	50.0	35.333	-3.666	0.0	4.60	182.6	1.867	3.75
10	1927	9	12	16	48	27.0	35.333	-3.666	0.0	4.10	182.6	1.117	2.23
11	1927	9	30	6	42	21.0	35.333	-3.666	0.0	3.80	182.6	0.667	1.64
12	1927	12	3	10	9	8.0	35.733	-3.583	0.0	4.20	227.0	0.728	1.71
13	1929	8	14	6	38	36.0	35.750	-3.666	0.0	4.40	226.6	1.033	2.11
14	1930	8	9	18	9	38.0	34.300	-5.399	0.0	4.70	112.4	3.205	9.45
15	1930	8	13	3	20	45.0	34.300	-5.399	0.0	4.40	112.4	2.755	6.93
16	1930	12	24	14	27	43.0	34.500	-4.000	0.0	4.30	85.2	3.269	9.88
17	1931	9	10	21	19	44.0	35.616	-2.883	0.0	4.20	243.8	0.551	1.51
18	1932	2	13	0	3	1.0	36.000	-4.000	0.0	3.80	247.5	-0.086	0.97
19	1933	7	18	6	4	58.0	36.033	-4.766	0.0	4.60	252.0	1.069	2.16
20	1935	10	18	7	54	20.0	34.833	-4.000	0.0	4.20	120.3	2.292	5.03
21	1935	11	15	6	58	2.0	35.416	-4.000	0.0	4.20	183.4	1.256	2.46
22	1936	3	16	10	5	1.0	36.116	-5.183	0.0	4.40	269.5	0.602	1.57
23	1936	9	17	1	12	6.0	36.000	-4.250	0.0	3.90	245.5	0.083	1.09
24	1938	3	30	15	6	6.0	33.500	-6.250	0.0	5.10	178.6	2.672	6.54
25	1940	8	17	3	33	27.0	35.433	-4.000	0.0	4.10	185.3	1.081	2.18
26	1941	6	12	13	55	30.0	36.300	-3.183	0.0	4.80	298.7	0.946	1.98
27	1941	6	26	10	8	59.0	36.416	-4.416	0.0	3.50	291.6	-0.944	0.54
28	1941	12	6	0	33	56.0	35.583	-3.250	0.0	4.50	223.5	1.217	2.39
29	1942	5	13	13	30	2.0	36.000	-4.083	0.0	3.00	246.6	-1.277	0.43
30	1942	7	20	9	43	47.0	35.300	-4.100	0.0	4.20	169.2	1.454	2.82
31	1943	12	3	20	44	54.0	35.583	-4.166	0.0	3.80	199.8	0.444	1.40
32	1944	3	23	11	17	8.0	35.000	-3.300	0.0	3.90	165.7	1.057	2.14
33	1944	4	16	22	11	11.0	34.900	-3.500	0.0	4.00	146.1	1.516	2.94
34	1945	5	6	18	24	38.0	35.400	-2.899	0.0	4.00	223.4	0.468	1.43
35	1945	6	3	0	44	25.0	35.750	-2.700	0.0	4.30	265.6	0.488	1.45
36	1947	5	30	22	25	31.0	35.800	-2.300	0.0	4.20	292.6	0.097	1.10
37	1947	9	20	8	18	22.0	35.283	-2.916	0.0	3.90	212.2	0.446	1.40
38	1948	1	6	12	0	45.0	36.116	-3.199	0.0	3.80	279.2	-0.386	0.79
39	1948	2	16	2	46	28.0	36.300	-4.350	0.0	3.90	278.6	-0.231	0.88
40	1950	4	24	3	19	24.0	35.600	-2.700	0.0	4.30	252.2	0.617	1.58
41	1950	5	18	20	37	49.0	35.866	-2.400	0.0	3.90	292.5	-0.352	0.81
42	1951	1	17	15	56	0.0	36.000	-4.000	0.0	3.50	247.5	-0.536	0.71
43	1951	12	6	14	12	52.0	35.500	-2.000	0.0	4.00	288.4	-0.167	0.92
44	1952	5	12	19	34	36.8	35.690	-6.471	60.0	5.30	288.0	1.733	3.42
45	1952	8	31	15	45	22.0	35.500	-2.199	0.0	4.00	274.8	-0.047	1.00
46	1954	2	24	22	47	51.0	36.416	-4.416	0.0	3.70	291.6	-0.644	0.66
47	1954	2	25	9	26	15.0	36.416	-4.416	0.0	3.90	291.6	-0.344	0.81
48	1954	4	23	19	55	19.0	34.699	-4.900	0.0	4.50	113.1	2.890	7.61
49	1955	4	11	13	7	18.0	36.000	-3.500	0.0	3.50	257.6	-0.636	0.67
50	1955	5	12	0	10	11.0	35.699	-3.000	0.0	4.00	245.9	0.230	1.21
51	1956	1	21	14	8	18.2	36.281	-4.241	5.0	4.30	276.7	0.386	1.35
52	1956	1	26	5	2	22.0	36.086	-4.768	5.0	3.50	257.8	-0.639	0.66
53	1956	8	23	21	23	54.0	36.158	-3.245	5.0	3.80	282.0	-0.411	0.78
54	1957	4	1	13	58	8.3	35.248	-3.613	60.0	4.10	175.6	1.077	2.17
55	1957	8	25	6	59	15.8	36.138	-2.956	5.0	3.90	290.7	-0.337	0.82
56	1957	12	20	18	29	51.8	36.343	-4.178	10.0	4.00	283.8	-0.129	0.94
57	1959	8	4	7	12	7.0	35.500	-3.000	0.0	3.70	227.1	-0.023	1.02

Table X3.4: Estimated Earthquake Intensity and Ground Acceleration Felt at Azghar Dam Site (2/13)
(Latitude: 33°47'19''N, Longitude: 4°20'55''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
58	1959	8	23	13	46	6.0	35.516	-3.233	0.0	4.40	217.6	1.133	2.26
59	1959	8	23	22	21	30.8	35.513	-3.226	20.0	4.80	217.6	1.722	3.39
60	1959	8	24	0	33	56.0	35.516	-3.233	0.0	4.30	217.6	0.983	2.04
61	1959	8	29	13	31	36.0	35.800	-3.133	0.0	4.40	249.8	0.790	1.78
62	1959	8	29	13	51	51.0	35.800	-3.133	0.0	4.50	249.8	0.940	1.98
63	1959	8	29	15	33	0.0	35.800	-3.133	0.0	4.30	249.8	0.640	1.61
64	1959	8	29	20	45	59.0	35.800	-3.133	0.0	4.50	249.8	0.940	1.98
65	1959	8	30	4	30	19.0	35.688	-3.205	140.0	4.00	235.7	-0.041	1.00
66	1959	8	30	3	24	56.2	35.670	-3.080	5.0	4.80	239.4	1.495	2.90
67	1959	9	17	21	49	2.0	36.216	-3.216	0.0	4.60	288.9	0.729	1.71
68	1959	9	17	21	55	53.0	36.216	-3.216	0.0	4.60	288.9	0.729	1.71
69	1959	9	18	2	5	6.8	36.216	-3.225	5.0	4.60	288.6	0.731	1.71
70	1959	9	30	16	57	45.7	36.341	-3.283	5.0	4.80	299.8	0.936	1.97
71	1960	12	5	21	21	47.1	35.690	-6.621	5.0	4.90	297.6	1.104	2.21
72	1960	12	20	3	47	35.2	36.310	-3.298	5.0	4.00	296.1	-0.233	0.88
73	1960	12	24	20	24	11.7	35.353	-3.581	5.0	4.10	187.5	1.051	2.13
74	1962	1	13	9	36	18.8	35.660	-3.571	5.0	4.00	219.7	0.508	1.47
75	1962	2	14	13	48	15.1	35.290	-3.429	5.0	4.10	187.0	1.057	2.14
76	1962	2	21	9	2	41.0	35.500	-3.400	0.0	3.80	209.1	0.331	1.30
77	1962	3	1	22	19	57.9	35.911	-3.611	5.0	4.50	245.1	0.987	2.04
78	1962	6	1	19	59	15.9	36.246	-3.153	5.0	4.00	294.2	-0.217	0.89
79	1963	1	26	13	47	6.0	35.900	-3.800	0.0	3.00	239.7	-1.207	0.45
80	1963	3	28	4	29	25.0	35.800	-4.900	0.0	3.60	228.9	-0.193	0.90
81	1963	4	21	5	31	58.0	35.800	-4.200	0.0	3.50	223.6	-0.284	0.85
82	1963	6	20	19	47	29.0	34.750	-3.871	60.0	4.50	115.4	2.550	6.01
83	1963	6	26	10	27	7.0	36.008	-3.439	5.0	4.60	260.2	0.989	2.04
84	1963	6	27	18	46	4.8	36.370	-3.436	5.0	2.60	298.6	-2.353	0.20
85	1963	6	30	12	42	18.1	35.735	-3.553	5.0	3.10	228.1	-0.935	0.54
86	1963	7	25	1	42	11.4	35.633	-3.650	5.0	3.00	214.6	-0.933	0.54
87	1963	8	24	1	24	17.0	35.526	-3.590	5.0	2.70	205.1	-1.271	0.43
88	1963	9	8	0	44	17.0	36.441	-4.001	20.0	3.60	296.0	-0.837	0.58
89	1963	9	29	12	31	45.6	35.923	-4.156	5.0	3.40	237.5	-0.585	0.69
90	1963	11	2	12	45	16.5	35.053	-4.651	5.0	4.10	143.0	1.717	3.38
91	1964	2	19	2	44	48.0	35.699	-3.300	0.0	3.40	233.1	-0.537	0.71
92	1964	4	9	22	29	55.2	35.810	-4.308	5.0	3.70	224.3	0.007	1.04
93	1964	4	26	10	15	55.0	35.800	-4.900	0.0	3.40	228.9	-0.493	0.73
94	1964	4	26	20	28	51.4	36.205	-4.273	5.0	3.60	268.2	-0.587	0.69
95	1964	5	13	17	32	25.5	35.706	-4.963	120.0	3.90	220.2	0.031	1.06
96	1964	11	15	20	3	54.3	34.938	-5.470	19.0	5.00	164.3	2.711	6.72
97	1965	4	14	18	5	18.8	35.416	-6.160	5.0	3.60	246.2	-0.374	0.80
98	1965	4	19	3	8	3.0	35.579	-3.755	5.0	4.20	206.1	0.967	2.01
99	1965	5	30	11	59	58.0	36.100	-3.199	0.0	3.00	277.6	-1.572	0.35
100	1965	6	29	15	26	36.1	35.751	-5.598	33.0	3.00	246.4	-1.298	0.42
101	1965	11	3	15	12	6.0	35.500	-3.500	0.0	3.00	205.4	-0.825	0.58
102	1965	11	9	14	22	5.0	35.100	-3.500	0.0	2.70	165.3	-0.737	0.62
103	1965	12	5	3	50	13.0	34.843	-5.698	5.0	4.40	171.0	1.728	3.41
104	1966	1	19	10	20	2.0	36.199	-4.200	0.0	3.60	267.8	-0.582	0.69
105	1966	1	26	21	5	1.7	35.611	-4.885	5.0	3.70	208.2	0.192	1.18
106	1966	1	29	11	36	34.5	35.400	-3.400	0.0	2.60	199.1	-1.347	0.41
107	1966	1	29	12	33	25.6	35.614	-3.686	5.0	2.60	211.6	-1.498	0.37
108	1966	2	23	3	16	16.3	35.443	-6.683	33.0	3.10	283.2	-1.489	0.37
109	1966	3	19	20	30	59.0	35.400	-3.700	0.0	3.20	188.6	-0.312	0.83
110	1966	5	17	21	1	53.8	36.148	-4.410	5.0	3.70	261.8	-0.377	0.80
111	1966	5	24	10	47	2.2	35.475	-3.939	5.0	3.20	190.9	-0.344	0.81
112	1966	5	29	14	30	28.8	36.413	-3.603	5.0	4.10	299.2	-0.109	0.96
113	1966	5	30	20	53	52.5	35.371	-3.728	5.0	3.10	184.7	-0.412	0.78
114	1966	6	1	0	1	33.5	35.400	-4.200	0.0	2.90	179.3	-0.638	0.66

Table X3.4: Estimated Earthquake Intensity and Ground Acceleration Felt at Azghar Dam Site (3/13)
(Latitude: 33°47'19''N, Longitude: 4°20'55''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
115	1966	6	8	5	32	37.2	35.510	-5.130	5.0	3.00	204.2	-0.810	0.59
116	1966	7	3	9	35	41.2	36.160	-3.343	5.0	2.60	279.0	-2.185	0.23
117	1966	8	27	21	4	29.0	35.199	-4.399	0.0	3.40	156.5	0.446	1.41
118	1966	9	19	20	20	0.5	35.780	-3.528	10.0	3.00	233.6	-1.145	0.47
119	1966	9	21	14	50	18.5	35.971	-3.255	5.0	3.20	262.4	-1.132	0.47
120	1966	9	24	11	52	7.6	36.080	-3.411	5.0	3.50	268.6	-0.740	0.62
121	1966	9	28	11	0	12.2	35.735	-4.440	5.0	3.50	216.1	-0.201	0.90
122	1966	10	22	9	4	17.9	35.660	-3.245	5.0	2.80	231.3	-1.419	0.39
123	1966	11	26	21	22	0.5	35.699	-4.200	0.0	3.40	212.4	-0.307	0.84
124	1966	12	15	16	8	55.6	35.524	-3.970	5.0	2.60	195.7	-1.305	0.42
125	1967	1	30	13	58	8.7	35.288	-3.525	5.0	2.90	182.9	-0.689	0.64
126	1967	3	17	6	13	49.7	34.936	-5.431	5.0	4.10	161.9	1.413	2.74
127	1967	5	30	12	56	21.0	36.250	-4.200	0.0	2.70	273.4	-1.984	0.26
128	1967	7	1	10	35	36.9	36.381	-3.488	5.0	3.20	298.4	-1.452	0.38
129	1967	8	30	18	21	0.0	31.499	-6.000	0.0	4.10	296.4	-0.085	0.97
130	1967	9	24	17	8	0.0	32.500	-5.700	0.0	4.30	189.8	1.321	2.57
131	1967	10	6	22	1	47.2	35.135	-4.111	5.0	3.60	151.0	0.834	1.84
132	1967	11	1	19	47	42.3	35.693	-3.730	12.0	3.30	218.9	-0.535	0.71
133	1967	11	7	14	34	0.7	34.713	-3.098	23.0	3.00	154.5	-0.148	0.93
134	1967	11	14	7	20	22.5	35.425	-3.801	20.0	4.00	188.5	0.875	1.89
135	1967	11	14	2	53	40.2	35.411	-3.560	5.0	3.10	194.2	-0.536	0.71
136	1967	11	16	21	5	32.5	35.350	-3.501	13.0	3.80	190.1	0.561	1.52
137	1968	1	19	20	23	42.5	35.900	-3.650	0.0	2.70	243.0	-1.691	0.32
138	1968	1	22	7	19	8.1	35.136	-5.833	40.0	4.10	202.9	0.809	1.81
139	1968	2	5	5	40	32.9	36.041	-5.040	18.0	3.40	257.9	-0.795	0.60
140	1968	2	13	18	57	33.4	36.479	-4.565	91.0	4.30	299.2	0.082	1.09
141	1968	2	16	2	50	45.7	35.110	-4.161	20.0	3.60	147.6	0.868	1.88
142	1968	2	17	6	17	48.0	35.935	-3.396	9.0	3.10	253.9	-1.202	0.45
143	1968	2	26	6	7	56.0	36.066	-3.133	0.0	3.30	276.5	-1.112	0.48
144	1968	2	27	14	42	32.0	36.076	-3.140	5.0	3.40	277.3	-0.969	0.53
145	1968	2	28	1	41	52.0	35.933	-3.723	9.0	2.90	244.8	-1.411	0.39
146	1968	2	28	2	17	3.0	35.933	-3.716	0.0	2.90	245.0	-1.411	0.39
147	1968	3	31	21	25	12.6	35.374	-2.296	10.0	3.40	258.7	-0.798	0.60
148	1968	4	3	5	27	33.7	35.315	-4.788	16.0	4.00	174.1	1.074	2.17
149	1968	4	17	9	12	6.9	35.285	-3.746	22.0	5.00	175.1	2.551	6.02
150	1968	4	17	10	18	24.0	35.283	-3.733	0.0	3.40	175.3	0.168	1.16
151	1968	4	17	10	24	53.1	35.283	-3.733	0.0	2.60	175.3	-1.032	0.51
152	1968	4	17	9	43	41.5	35.401	-3.980	5.0	4.00	182.1	0.973	2.02
153	1968	4	18	0	58	5.5	35.283	-3.733	0.0	3.30	175.3	0.018	1.05
154	1968	4	19	4	29	44.6	35.283	-3.733	0.0	3.10	175.3	-0.282	0.85
155	1968	4	30	3	23	38.0	35.629	-4.508	5.0	3.90	204.7	0.533	1.49
156	1968	5	1	3	10	48.0	35.283	-3.733	0.0	2.50	175.3	-1.182	0.46
157	1968	5	10	2	50	22.5	36.346	-3.736	5.0	3.40	289.3	-1.075	0.49
158	1968	5	22	14	1	58.9	34.883	-4.408	26.0	4.00	121.5	1.912	3.87
159	1968	6	15	21	37	41.9	35.191	-5.021	5.0	3.50	167.5	0.428	1.39
160	1968	7	4	21	59	29.4	35.728	-3.836	10.0	3.90	220.3	0.349	1.31
161	1968	7	5	2	27	56.5	35.716	-3.833	0.0	3.50	219.1	-0.234	0.88
162	1968	7	29	18	10	41.5	35.185	-2.298	10.0	3.90	244.8	0.089	1.10
163	1968	8	5	2	18	3.4	35.016	-4.043	20.0	3.30	139.1	0.562	1.52
164	1968	8	5	2	34	32.0	35.016	-4.033	0.0	3.10	139.3	0.284	1.26
165	1968	8	10	1	0	27.4	34.621	-3.540	20.0	3.90	118.8	1.838	3.68
166	1968	8	30	18	56	41.1	35.196	-4.408	5.0	2.70	156.2	-0.600	0.68
167	1968	9	2	14	37	56.0	35.066	-2.783	0.0	4.00	202.5	0.711	1.69
168	1968	9	2	12	38	24.7	35.076	-2.788	5.0	4.00	203.0	0.705	1.68
169	1968	9	5	13	22	39.5	34.893	-2.586	5.0	3.50	203.8	-0.056	0.99
170	1968	9	13	3	5	35.0	35.066	-2.783	0.0	3.10	202.5	-0.639	0.66
171	1968	10	5	8	2	53.0	36.350	-3.850	0.0	3.10	287.9	-1.512	0.36

Table X3.4: Estimated Earthquake Intensity and Ground Acceleration Felt at Azghar Dam Site (4/13)
(Latitude: 33°47'19''N, Longitude: 4°20'55''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
172	1968	10	12	18	21	40.1	36.176	-4.278	10.0	3.60	265.0	-0.558	0.70
173	1968	10	18	23	5	35.6	35.898	-2.688	5.0	2.90	279.9	-1.742	0.31
174	1968	10	30	11	41	55.7	35.281	-3.756	5.0	4.60	174.4	1.979	4.05
175	1968	11	1	8	50	11.8	35.111	-2.946	5.0	3.70	195.8	0.344	1.31
176	1968	11	7	2	8	47.5	35.896	-4.875	80.0	3.90	238.8	0.020	1.05
177	1969	1	22	17	55	37.9	35.626	-3.958	14.0	3.00	207.0	-0.849	0.57
178	1969	1	27	23	15	16.6	36.460	-4.458	60.0	2.70	296.6	-2.236	0.22
179	1969	2	10	19	30	7.9	34.220	-6.651	60.0	3.10	218.1	-0.913	0.55
180	1969	2	20	4	54	32.5	35.088	-3.808	20.0	3.10	152.6	0.039	1.06
181	1969	2	22	8	14	11.6	35.183	-4.000	20.0	3.20	158.0	0.104	1.11
182	1969	2	22	8	9	36.9	35.198	-4.001	10.0	2.90	159.6	-0.356	0.81
183	1969	3	3	8	7	27.4	34.948	-4.303	40.0	3.50	128.7	0.964	2.01
184	1969	4	8	7	31	20.2	34.725	-3.604	10.0	3.30	124.6	0.848	1.85
185	1969	4	12	0	2	6.0	32.000	-6.200	0.0	4.40	262.0	0.672	1.64
186	1969	4	17	2	31	5.1	35.136	-3.948	5.0	3.40	154.0	0.485	1.44
187	1969	5	2	4	44	0.0	35.800	-5.200	0.0	2.00	236.6	-2.675	0.16
188	1969	6	18	0	5	14.9	35.699	-3.080	10.0	3.50	242.2	-0.485	0.74
189	1969	8	8	7	22	33.0	35.000	-3.400	0.0	4.10	160.5	1.436	2.78
190	1969	12	16	17	38	18.5	36.268	-3.248	40.0	3.50	293.3	-0.982	0.52
191	1970	1	11	2	7	6.0	35.026	-4.948	33.0	3.80	148.0	1.124	2.25
192	1970	1	11	15	42	8.1	36.246	-4.171	10.0	3.40	273.1	-0.933	0.54
193	1970	1	16	13	16	33.8	36.218	-4.765	10.0	4.20	272.3	0.275	1.25
194	1970	1	28	22	54	32.8	35.135	-4.410	40.0	3.90	149.5	1.225	2.41
195	1970	2	4	17	45	57.8	35.590	-4.708	20.0	3.60	202.6	0.098	1.10
196	1970	2	19	12	5	27.4	35.188	-6.095	33.0	3.30	223.9	-0.615	0.68
197	1970	3	3	5	53	29.9	36.328	-5.066	10.0	3.30	289.4	-1.227	0.44
198	1970	3	3	6	7	24.4	36.335	-5.238	5.0	3.70	294.2	-0.667	0.65
199	1970	3	12	1	10	55.7	36.378	-3.543	10.0	4.10	296.8	-0.090	0.97
200	1970	4	7	5	29	26.0	35.000	-3.700	15.0	3.30	147.2	0.436	1.40
201	1970	4	16	7	6	27.5	34.820	-3.705	10.0	3.60	129.0	1.214	2.39
202	1970	8	10	1	12	39.1	34.928	-3.813	20.0	3.20	135.8	0.470	1.43
203	1970	8	28	10	35	15.7	36.015	-6.088	40.0	3.50	294.7	-0.993	0.52
204	1970	8	31	12	55	56.0	36.238	-4.410	5.0	3.60	271.8	-0.620	0.67
205	1970	10	5	10	26	27.9	34.585	-4.111	5.0	4.00	91.0	2.659	6.48
206	1970	10	12	19	44	16.8	34.651	-2.960	20.0	3.20	160.1	0.073	1.09
207	1970	11	4	19	12	38.6	35.929	-6.203	10.0	2.50	292.8	-2.456	0.19
208	1970	11	6	16	52	19.5	35.531	-4.995	20.0	3.90	202.3	0.551	1.51
209	1970	12	14	16	48	52.1	35.366	-3.416	0.0	4.10	195.1	0.953	2.00
210	1971	2	4	21	38	51.2	36.248	-3.851	20.0	3.20	276.7	-1.270	0.43
211	1971	3	10	21	47	11.8	35.730	-3.360	5.0	3.40	234.0	-0.548	0.71
212	1971	3	14	20	47	37.6	35.269	-5.955	10.0	4.60	221.4	1.388	2.69
213	1971	3	26	6	25	38.0	35.699	-2.400	0.0	3.30	278.1	-1.127	0.47
214	1971	4	5	13	51	40.0	36.468	-4.516	60.0	4.10	297.7	-0.145	0.93
215	1971	7	2	21	11	8.5	34.100	-5.200	0.0	4.60	85.9	3.701	13.31
216	1971	7	22	0	23	43.9	36.336	-4.721	10.0	3.90	284.7	-0.286	0.85
217	1971	8	12	11	52	2.7	35.074	-5.525	5.0	3.20	179.3	-0.189	0.91
218	1971	9	24	5	33	13.9	34.913	-4.570	14.0	4.00	126.4	1.855	3.72
219	1971	10	4	8	30	13.8	36.175	-5.786	60.0	3.50	296.2	-1.033	0.51
220	1971	11	1	3	44	41.4	35.070	-3.445	28.0	3.00	164.9	-0.316	0.83
221	1972	2	1	11	42	22.3	35.444	-4.713	5.0	4.10	186.7	1.061	2.15
222	1972	2	7	0	59	59.7	35.188	-3.563	24.0	3.40	171.4	0.199	1.19
223	1972	2	25	20	34	27.9	35.735	-4.700	5.0	2.60	218.4	-1.577	0.35
224	1972	4	2	1	15	58.3	36.225	-5.136	5.0	3.60	279.9	-0.693	0.64
225	1972	4	26	1	52	10.0	36.183	-5.353	20.0	3.80	281.4	-0.412	0.78
226	1972	4	29	20	9	58.6	36.328	-3.811	19.0	3.70	286.1	-0.602	0.68
227	1972	5	7	3	4	32.0	35.256	-6.211	13.0	3.40	236.9	-0.582	0.69
228	1972	5	8	4	12	8.2	35.190	-3.351	5.0	2.70	180.8	-0.959	0.53

Table X3.4: Estimated Earthquake Intensity and Ground Acceleration Felt at Azghar Dam Site (5/13)
(Latitude: 33°47'19''N, Longitude: 4°20'55''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
229	1972	6	9	17	14	5.9	36.426	-3.726	5.0	3.60	298.2	-0.851	0.57
230	1972	6	10	17	40	48.5	35.585	-3.305	5.0	3.20	221.4	-0.711	0.63
231	1972	6	25	15	45	38.0	32.430	-5.580	0.0	3.00	188.9	-0.617	0.67
232	1972	7	2	3	11	24.5	36.061	-4.625	80.0	3.60	253.4	-0.563	0.70
233	1972	7	20	2	49	57.6	34.754	-3.015	5.0	3.90	163.3	1.092	2.20
234	1972	8	14	14	6	31.6	34.990	-2.815	5.0	4.20	194.5	1.109	2.22
235	1972	10	3	23	34	39.8	36.195	-4.924	5.0	3.70	272.2	-0.474	0.74
236	1972	10	4	21	0	12.7	31.960	-5.960	1.0	3.60	251.7	-0.428	0.77
237	1972	11	2	7	45	21.9	35.053	-3.548	5.0	3.30	158.6	0.263	1.24
238	1972	11	15	4	18	9.9	32.750	-5.580	2.0	3.50	162.0	0.513	1.47
239	1972	11	22	20	45	31.7	36.078	-4.100	5.0	4.20	255.0	0.438	1.40
240	1972	11	26	12	56	38.7	36.140	-4.578	5.0	3.40	261.7	-0.826	0.58
241	1972	12	6	23	41	22.8	36.138	-4.721	5.0	3.20	262.9	-1.137	0.47
242	1972	12	17	19	6	56.4	34.911	-2.956	5.0	3.70	179.1	0.564	1.52
243	1972	12	17	17	14	25.5	34.830	-2.710	34.0	3.50	190.5	0.074	1.09
244	1972	12	23	8	10	6.7	32.038	-6.000	1.0	2.90	247.0	-1.432	0.38
245	1973	2	2	21	18	14.2	34.240	-5.370	5.0	3.00	106.8	0.776	1.77
246	1973	2	5	6	52	0.7	35.170	-4.879	26.0	3.00	160.9	-0.253	0.87
247	1973	2	8	21	12	23.4	34.905	-4.178	5.0	3.30	124.9	0.849	1.86
248	1973	2	16	1	36	38.6	32.150	-5.820	0.0	3.10	227.0	-0.922	0.55
249	1973	2	19	11	8	49.3	34.758	-4.488	10.0	3.60	108.3	1.635	3.20
250	1973	2	19	11	13	47.9	34.761	-4.615	5.0	3.10	110.6	0.841	1.85
251	1973	2	24	14	20	49.4	35.050	-4.140	104.0	2.70	141.3	-0.884	0.56
252	1973	2	24	20	14	53.6	32.090	-5.960	2.0	3.30	240.2	-0.762	0.61
253	1973	3	1	3	37	35.9	32.820	-4.289	1.0	3.00	107.6	0.761	1.75
254	1973	3	1	2	26	57.0	34.831	-4.301	20.0	3.60	115.7	1.449	2.81
255	1973	3	1	23	20	34.3	32.170	-5.990	1.0	2.20	235.1	-2.359	0.20
256	1973	3	3	15	9	59.8	32.090	-6.280	110.0	3.50	259.6	-0.860	0.57
257	1973	3	5	6	25	50.0	34.850	-4.210	16.0	3.20	118.4	0.807	1.80
258	1973	3	5	6	52	37.0	32.150	-4.430	4.0	3.30	182.0	-0.075	0.98
259	1973	3	7	14	59	10.6	32.080	-6.160	1.0	3.30	252.9	-0.890	0.56
260	1973	3	8	17	52	59.9	33.820	-5.130	17.0	3.40	72.3	2.244	4.87
261	1973	3	10	23	30	39.1	35.405	-5.493	30.0	3.30	208.2	-0.433	0.77
262	1973	3	13	20	25	43.4	34.699	-4.390	1.0	3.00	101.1	0.912	1.94
263	1973	3	26	17	21	44.6	35.199	-3.889	2.0	3.50	162.1	0.510	1.47
264	1973	3	27	14	4	49.8	31.720	-4.859	33.0	3.40	234.3	-0.575	0.69
265	1973	3	29	12	4	47.8	32.290	-5.600	100.0	3.20	202.5	-0.760	0.61
266	1973	3	30	11	7	49.7	32.550	-4.240	2.0	3.50	137.8	0.909	1.94
267	1973	4	8	15	55	7.5	33.220	-5.779	2.0	3.40	146.5	0.610	1.57
268	1973	4	10	12	43	47.5	34.901	-2.726	20.0	4.00	194.2	0.802	1.80
269	1973	4	15	2	48	12.2	34.926	-2.791	5.0	3.90	191.4	0.699	1.67
270	1973	4	29	14	37	55.2	34.563	-3.988	10.0	4.60	92.1	3.520	11.75
271	1973	4	30	2	40	47.7	34.540	-4.020	2.0	3.80	88.7	2.424	5.51
272	1973	5	19	20	49	3.5	32.470	-5.570	2.0	3.80	184.8	0.637	1.60
273	1973	6	1	18	13	30.1	33.929	-6.840	29.0	3.40	230.7	-0.532	0.72
274	1973	6	24	20	7	35.9	35.850	-4.600	90.0	3.20	229.9	-0.980	0.52
275	1973	7	24	8	57	15.5	33.039	-5.050	5.0	3.70	105.5	1.857	3.73
276	1973	7	28	1	13	58.3	34.690	-4.100	27.0	3.30	102.6	1.245	2.44
277	1973	7	31	1	25	27.8	32.100	-6.289	149.0	2.70	259.3	-2.207	0.22
278	1973	8	24	8	4	32.8	34.420	-4.840	2.0	3.20	83.5	1.668	3.27
279	1973	9	23	0	6	19.8	34.120	-5.940	102.0	3.30	151.6	-0.084	0.97
280	1973	10	1	16	20	31.7	35.090	-5.770	4.0	3.50	195.2	0.052	1.07
281	1973	10	8	5	33	4.6	35.440	-6.620	5.0	2.70	278.6	-2.031	0.25
282	1973	10	9	14	47	12.8	32.408	-5.350	1.0	3.60	179.0	0.416	1.38
283	1973	10	16	11	38	56.2	34.070	-5.390	133.0	4.50	101.2	1.936	3.93
284	1973	12	11	20	58	12.8	31.939	-6.450	165.0	2.60	282.5	-2.581	0.17
285	1973	12	17	10	43	22.0	36.100	-4.700	0.0	3.10	258.5	-1.245	0.44

Table X3.4: Estimated Earthquake Intensity and Ground Acceleration Felt at Azghar Dam Site (6/13)
(Latitude: 33°47'19''N, Longitude: 4°20'55''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
286	1974	1	11	3	11	38.6	35.406	-4.835	6.0	3.40	185.0	0.034	1.06
287	1974	2	3	23	21	54.3	34.649	-5.419	5.0	3.40	137.5	0.764	1.75
288	1974	2	6	10	51	55.8	36.360	-4.540	75.0	2.90	285.8	-1.878	0.28
289	1974	2	8	17	18	0.0	35.633	-4.748	5.0	3.70	207.9	0.195	1.18
290	1974	2	9	13	49	31.2	35.120	-4.740	14.0	2.90	152.1	-0.243	0.87
291	1974	2	21	23	51	30.3	35.295	-3.645	5.0	3.20	179.3	-0.189	0.91
292	1974	3	6	22	44	51.6	35.210	-2.700	61.0	3.90	219.3	0.272	1.25
293	1974	3	25	13	44	43.2	34.859	-4.480	1.0	3.30	119.4	0.960	2.00
294	1974	3	28	3	23	23.2	34.850	-4.470	0.0	3.10	118.3	0.682	1.65
295	1974	4	6	12	16	3.4	31.880	-6.220	1.0	3.70	273.4	-0.484	0.74
296	1974	4	7	4	22	24.3	35.400	-3.590	83.0	3.10	192.0	-0.720	0.63
297	1974	4	21	1	24	51.6	36.331	-3.783	5.0	3.50	286.9	-0.904	0.55
298	1974	6	10	4	23	28.3	33.649	-3.840	2.0	4.50	49.5	4.805	28.53
299	1974	7	4	4	2	53.6	33.900	-5.529	2.0	3.50	109.8	1.463	2.84
300	1974	7	14	2	55	26.0	35.558	-3.683	5.0	4.40	205.7	1.271	2.49
301	1974	7	18	8	32	15.3	35.598	-3.588	5.0	4.00	212.7	0.589	1.55
302	1974	9	27	9	39	26.2	35.710	-4.666	13.0	3.60	215.2	-0.044	1.00
303	1974	10	30	14	37	44.8	35.110	-3.149	44.0	4.00	183.8	0.882	1.90
304	1974	10	31	12	36	18.9	35.136	-3.266	5.0	3.20	179.9	-0.197	0.90
305	1974	10	31	8	18	57.3	35.118	-3.191	18.0	3.70	182.2	0.510	1.47
306	1974	10	31	10	8	52.0	35.116	-3.183	0.0	3.10	182.5	-0.381	0.79
307	1974	11	2	6	6	32.3	35.110	-3.439	79.0	3.10	169.0	-0.436	0.76
308	1974	11	3	17	18	59.6	33.110	-5.020	2.0	3.20	97.6	1.297	2.53
309	1974	11	12	1	24	22.8	35.958	-4.900	5.0	3.10	246.0	-1.122	0.48
310	1974	11	16	0	59	23.3	35.080	-2.720	51.0	3.50	207.8	-0.175	0.91
311	1974	11	26	0	10	26.9	32.070	-3.920	47.0	3.20	194.8	-0.463	0.75
312	1974	12	8	13	9	38.6	36.409	-4.843	22.0	3.10	294.3	-1.574	0.35
313	1975	1	9	13	20	36.1	35.436	-3.788	5.0	3.50	190.0	0.118	1.12
314	1975	1	9	12	33	22.3	35.059	-5.756	51.0	3.30	191.8	-0.289	0.85
315	1975	1	11	16	35	16.0	35.320	-3.725	9.0	3.00	179.4	-0.493	0.73
316	1975	1	11	20	51	19.5	35.444	-3.598	5.0	2.80	196.3	-1.013	0.51
317	1975	1	17	1	52	43.0	35.400	-3.600	27.0	3.10	191.7	-0.528	0.72
318	1975	1	23	20	27	14.0	33.100	-5.210	1.0	3.20	110.3	1.001	2.06
319	1975	1	29	7	48	5.9	33.910	-5.010	2.0	3.50	62.6	2.786	7.08
320	1975	3	16	2	24	53.0	36.300	-3.199	0.0	3.20	298.2	-1.450	0.38
321	1975	3	29	1	53	36.8	35.961	-3.266	5.0	4.50	261.0	0.831	1.83
322	1975	4	5	11	25	50.1	36.188	-3.324	5.0	3.50	282.5	-0.866	0.57
323	1975	5	4	19	58	49.9	34.840	-2.010	0.0	3.70	245.6	-0.217	0.89
324	1975	6	29	8	0	40.5	33.520	-5.600	38.0	2.70	119.4	-0.058	0.99
325	1975	7	5	22	20	53.8	35.160	-5.069	91.0	3.00	166.1	-0.623	0.67
326	1975	8	3	0	20	58.9	33.199	-5.250	12.0	3.40	105.9	1.384	2.69
327	1975	8	3	19	11	51.4	33.070	-5.319	5.0	3.50	120.0	1.245	2.44
328	1975	8	7	15	30	24.3	36.415	-4.591	28.0	5.20	292.3	1.589	3.09
329	1975	10	7	11	53	49.0	34.980	-4.399	131.0	3.40	132.3	0.019	1.05
330	1975	10	25	18	9	59.1	32.408	-5.270	112.0	2.70	175.3	-1.305	0.42
331	1975	11	1	19	20	17.9	32.240	-5.790	153.0	2.60	217.4	-2.064	0.25
332	1975	11	3	9	35	35.4	31.640	-6.299	135.0	2.60	298.9	-2.587	0.17
333	1975	11	5	2	1	47.7	35.730	-2.230	5.0	3.40	291.1	-1.090	0.49
334	1975	11	9	17	31	2.7	34.350	-4.280	2.0	3.50	62.6	2.786	7.07
335	1975	11	13	6	37	42.6	32.628	-4.230	1.0	3.00	129.3	0.316	1.28
336	1975	11	14	10	41	19.3	32.360	-4.820	103.0	3.00	164.4	-0.683	0.64
337	1975	11	17	14	46	22.9	33.540	-4.640	9.0	3.50	38.6	3.769	13.96
338	1975	11	18	11	19	13.2	35.150	-3.640	2.0	3.30	164.6	0.172	1.16
339	1975	11	27	11	0	42.5	35.699	-2.280	1.0	3.70	285.4	-0.591	0.69
340	1975	12	2	15	24	3.4	35.180	-3.540	16.0	3.50	171.5	0.361	1.33
341	1975	12	2	5	19	0.0	36.000	-2.700	0.0	2.80	288.8	-1.970	0.26

Table X3.4: Estimated Earthquake Intensity and Ground Acceleration Felt at Azghar Dam Site (7/13)
(Latitude: 33°47'19''N, Longitude: 4°20'55''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
342	1975	12	2	19	32	37.0	36.400	-4.200	0.0	2.90	290.1	-1.831	0.29
343	1975	12	3	12	25	0.6	35.150	-3.600	27.0	3.40	166.1	0.268	1.24
344	1975	12	3	7	10	27.4	35.170	-3.590	5.0	3.20	168.5	-0.036	1.01
345	1975	12	3	19	24	2.0	35.140	-3.500	79.0	3.50	169.2	0.162	1.15
346	1975	12	3	7	2	29.9	35.240	-3.570	51.0	3.20	176.4	-0.247	0.87
347	1975	12	7	10	17	34.0	34.606	-4.668	60.0	2.60	95.4	0.050	1.07
348	1975	12	8	19	40	16.8	34.129	-4.440	30.0	3.30	38.7	3.030	8.37
349	1975	12	10	3	37	46.5	33.520	-4.800	26.0	2.90	51.3	2.078	4.34
350	1975	12	10	6	35	9.7	32.620	-5.350	126.0	2.60	159.3	-1.396	0.39
351	1976	1	5	1	27	12.1	34.780	-3.480	78.0	4.10	136.2	1.491	2.89
352	1976	1	8	13	37	38.3	35.129	-5.730	89.0	3.40	196.0	-0.340	0.82
353	1976	1	20	3	55	19.0	31.340	-5.470	128.0	3.20	290.8	-1.608	0.34
354	1976	2	5	4	55	0.4	33.990	-5.779	13.0	3.00	134.0	0.216	1.20
355	1976	2	6	10	41	16.2	33.129	-4.680	55.0	3.10	79.3	1.172	2.32
356	1976	2	6	1	27	39.0	32.360	-5.170	1.0	4.00	175.8	1.061	2.15
357	1976	2	8	19	51	13.1	35.039	-3.939	3.0	3.80	143.8	1.255	2.46
358	1976	2	13	12	0	8.5	31.429	-5.600	1.0	3.50	286.2	-0.898	0.56
359	1976	2	18	6	39	10.1	34.840	-4.340	87.0	3.40	116.6	0.626	1.59
360	1976	3	2	8	42	28.0	35.018	-3.836	5.0	3.20	144.4	0.344	1.31
361	1976	3	5	20	4	5.5	32.320	-4.759	94.0	3.50	167.3	0.094	1.10
362	1976	3	16	18	37	57.6	33.300	-4.890	23.0	4.30	73.8	3.500	11.59
363	1976	3	16	18	34	44.2	35.448	-4.570	5.0	2.70	185.2	-1.019	0.51
364	1976	3	30	22	57	3.2	35.269	-3.630	126.0	3.70	177.2	0.085	1.10
365	1976	4	13	19	23	19.3	34.280	-4.920	14.0	4.20	75.9	3.354	10.48
366	1976	4	15	16	6	15.1	33.920	-6.280	5.0	3.90	179.1	0.864	1.88
367	1976	4	20	11	2	31.3	31.790	-6.130	111.0	3.50	276.2	-0.995	0.52
368	1976	6	3	0	36	59.4	36.020	-4.740	75.0	3.20	250.2	-1.120	0.48
369	1976	6	14	8	35	11.2	34.620	-3.439	5.0	3.50	124.8	1.150	2.29
370	1976	11	8	21	14	54.7	32.129	-5.910	1.0	3.00	233.9	-1.147	0.47
371	1977	1	7	15	20	42.9	32.600	-5.770	2.0	3.60	186.1	0.319	1.29
372	1977	1	8	10	36	16.4	32.090	-4.170	44.0	2.70	189.2	-1.136	0.47
373	1977	1	15	23	58	47.0	33.750	-3.620	2.0	4.40	67.5	3.965	15.97
374	1977	1	16	21	5	53.6	36.381	-4.820	76.0	3.40	290.9	-1.171	0.46
375	1977	2	19	19	54	9.4	35.290	-6.740	1.0	3.10	276.7	-1.414	0.39
376	1977	3	23	11	19	30.2	36.020	-5.410	54.0	3.60	266.3	-0.619	0.67
377	1977	5	12	6	59	16.9	34.230	-4.820	59.0	3.30	65.5	1.689	3.32
378	1977	5	28	7	59	40.9	34.570	-3.489	11.0	3.80	117.6	1.736	3.43
379	1977	5	29	23	3	55.9	36.000	-2.800	0.0	3.40	284.0	-1.029	0.51
380	1977	6	3	11	55	2.4	32.250	-6.100	1.0	3.20	235.2	-0.861	0.57
381	1977	6	14	4	49	52.6	34.880	-4.220	79.0	3.00	121.7	0.034	1.06
382	1977	6	26	17	2	44.5	35.310	-5.170	31.0	2.60	185.1	-1.201	0.45
383	1977	6	30	14	19	44.9	34.950	-3.960	1.0	2.50	133.8	-0.518	0.72
384	1977	7	15	5	41	51.3	35.193	-3.760	13.0	3.80	165.0	0.909	1.93
385	1977	8	23	22	34	56.0	32.380	-5.040	128.0	2.80	168.9	-1.201	0.45
386	1977	9	1	18	35	14.1	32.800	-5.510	125.0	3.40	153.5	-0.132	0.94
387	1977	9	9	12	20	20.0	33.170	-4.170	2.0	4.10	70.6	3.410	10.89
388	1977	10	25	13	1	41.5	31.440	-5.610	2.0	2.90	285.5	-1.792	0.30
389	1977	10	27	13	15	34.7	32.789	-5.299	107.0	3.30	141.5	-0.012	1.02
390	1977	11	6	4	37	5.3	33.929	-5.240	17.0	3.70	83.8	2.361	5.28
391	1977	11	6	17	35	3.8	33.039	-4.759	78.0	3.00	91.4	0.493	1.45
392	1978	1	16	9	56	48.9	32.210	-6.020	1.0	2.40	233.5	-2.042	0.25
393	1978	1	28	22	55	4.8	35.381	-1.858	0.0	3.90	290.1	-0.332	0.82
394	1978	2	8	21	42	50.5	31.970	-5.950	2.0	4.30	250.2	0.636	1.60
395	1978	2	9	14	52	56.0	35.600	-3.100	0.0	3.20	231.7	-0.823	0.58
396	1978	2	10	7	20	29.0	35.400	-3.149	0.0	2.70	210.4	-1.333	0.41
397	1978	2	12	13	12	21.4	34.964	-3.130	5.0	3.20	172.3	-0.091	0.97
398	1978	2	12	9	33	42.0	34.815	-2.946	5.0	3.00	172.5	-0.394	0.79

Table X3.4: Estimated Earthquake Intensity and Ground Acceleration Felt at Azghar Dam Site (8/13)
(Latitude: 33°47'19''N, Longitude: 4°20'55''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
399	1978	3	5	16	47	55.6	31.820	-5.970	45.0	3.40	264.9	-0.891	0.56
400	1978	3	6	18	51	13.5	35.083	-4.033	2.0	3.40	146.5	0.609	1.57
401	1978	3	13	5	28	44.0	35.500	-3.199	0.0	3.10	217.6	-0.817	0.59
402	1978	3	28	1	37	8.5	35.666	-3.665	5.0	3.90	217.7	0.382	1.34
403	1978	4	10	19	3	47.4	34.180	-6.000	52.0	3.20	158.6	-0.012	1.02
404	1978	4	24	21	7	33.4	33.810	-5.940	15.0	3.80	147.1	1.187	2.35
405	1978	5	11	16	18	50.0	35.068	-2.473	5.0	3.70	224.0	0.010	1.04
406	1978	5	23	18	27	36.0	35.411	-4.326	5.0	3.20	180.0	-0.199	0.90
407	1978	6	29	15	23	28.0	35.300	-4.100	0.0	3.00	169.2	-0.346	0.81
408	1978	9	20	2	23	55.0	35.000	-4.900	0.0	2.90	143.7	-0.094	0.97
409	1978	10	14	16	21	58.0	35.300	-3.400	0.0	4.10	189.2	1.029	2.10
410	1978	10	28	21	12	35.9	36.008	-2.501	13.0	3.00	299.6	-1.764	0.31
411	1978	11	23	7	11	40.0	35.000	-6.200	0.0	3.60	217.5	-0.067	0.99
412	1978	11	23	7	12	36.0	35.000	-6.200	0.0	3.10	217.5	-0.817	0.59
413	1978	12	2	14	49	1.0	34.830	-4.299	1.0	3.10	115.6	0.737	1.72
414	1978	12	5	18	20	42.0	35.000	-4.800	0.0	2.70	140.7	-0.342	0.82
415	1978	12	9	14	15	18.0	35.000	-4.000	0.0	3.30	138.2	0.602	1.57
416	1978	12	23	5	29	6.0	34.900	-4.600	0.0	3.00	125.5	0.389	1.35
417	1979	1	2	15	39	58.8	31.778	-4.911	96.0	3.20	229.1	-0.995	0.52
418	1979	1	4	9	27	35.7	34.260	-5.636	4.0	2.90	129.9	0.152	1.15
419	1979	1	4	13	9	29.2	34.091	-5.723	8.0	2.80	131.3	-0.028	1.01
420	1979	1	5	22	16	0.0	35.300	-4.500	0.0	2.70	168.3	-0.781	0.60
421	1979	1	6	16	1	17.2	35.346	-2.379	8.0	2.70	251.0	-1.772	0.30
422	1979	1	14	21	9	12.8	34.866	-4.286	7.0	3.70	119.7	1.550	3.01
423	1979	1	17	17	43	27.0	33.400	-5.399	0.0	4.50	106.2	3.043	8.45
424	1979	1	19	1	9	21.2	33.461	-5.063	16.0	2.90	75.4	1.408	2.73
425	1979	1	26	6	10	46.5	34.981	-4.370	14.0	3.10	132.3	0.395	1.36
426	1979	2	5	13	34	36.5	33.479	-5.028	19.0	2.90	71.6	1.500	2.91
427	1979	2	5	16	35	48.0	35.318	-2.606	73.0	2.80	233.9	-1.562	0.35
428	1979	2	14	3	6	4.3	33.500	-6.629	68.0	2.50	213.1	-1.786	0.30
429	1979	2	20	12	14	25.7	35.226	-3.703	8.0	2.80	170.3	-0.663	0.65
430	1979	2	21	19	2	34.1	35.656	-3.700	10.0	2.90	215.7	-1.098	0.48
431	1979	2	21	3	10	12.9	34.601	-7.015	2.0	2.90	262.3	-1.582	0.35
432	1979	2	24	6	28	56.5	33.441	-4.633	6.0	2.90	46.7	2.514	5.86
433	1979	2	24	16	46	29.4	34.903	-4.275	5.0	3.20	123.8	0.719	1.70
434	1979	2	24	21	19	22.6	34.906	-4.418	5.0	4.30	124.1	2.363	5.28
435	1979	2	24	19	31	22.6	34.911	-4.331	5.0	3.00	124.5	0.405	1.37
436	1979	2	25	17	46	32.4	35.118	-4.375	30.0	3.50	147.5	0.693	1.67
437	1979	2	26	22	10	34.8	34.673	-4.133	1.0	3.10	100.1	1.085	2.19
438	1979	2	27	1	4	42.0	34.649	-4.154	4.0	3.30	97.1	1.456	2.82
439	1979	2	27	12	57	10.0	36.286	-3.700	8.0	3.20	283.5	-1.325	0.41
440	1979	2	28	8	10	45.3	34.796	-3.643	5.0	2.90	129.4	0.162	1.15
441	1979	3	5	1	22	20.0	34.400	-6.000	0.0	2.00	167.0	-1.813	0.30
442	1979	3	9	22	40	35.1	34.911	-4.251	5.0	3.40	124.8	0.999	2.06
443	1979	3	10	4	1	2.0	34.900	-4.100	0.0	2.80	125.4	0.089	1.10
444	1979	3	10	3	32	7.0	35.400	-4.000	0.0	2.60	181.7	-1.120	0.48
445	1979	3	11	6	42	5.0	35.000	-4.500	0.0	3.10	135.1	0.358	1.32
446	1979	3	12	8	29	0.0	34.500	-3.000	0.0	3.20	147.5	0.293	1.26
447	1979	3	12	3	18	49.7	35.513	-3.635	9.0	3.10	202.4	-0.640	0.66
448	1979	3	15	14	42	2.9	32.691	-5.391	52.0	2.40	155.3	-1.164	0.46
449	1979	3	15	4	45	14.4	35.510	-3.835	55.0	3.40	196.8	-0.211	0.89
450	1979	3	16	23	31	53.1	34.928	-4.266	10.0	3.30	126.6	0.808	1.81
451	1979	3	16	23	38	15.0	35.000	-4.500	0.0	3.50	135.1	0.958	2.00
452	1979	3	17	1	25	19.0	34.800	-4.399	0.0	3.30	112.3	1.108	2.22
453	1979	3	18	6	46	55.0	35.400	-3.800	0.0	2.50	185.8	-1.326	0.41
454	1979	3	19	15	39	10.4	33.296	-5.254	4.0	3.40	99.9	1.538	2.99
455	1979	3	19	15	56	2.1	33.411	-5.411	5.0	2.70	106.7	0.328	1.30

Table X3.4: Estimated Earthquake Intensity and Ground Acceleration Felt at Azghar Dam Site (9/13)
(Latitude: 33°47'19''N, Longitude: 4°20'55''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
456	1979	3	19	16	11	33.5	33.300	-5.500	0.0	2.70	119.4	0.059	1.08
457	1979	3	19	13	54	30.0	32.698	-2.000	0.0	3.40	248.5	-0.697	0.64
458	1979	3	25	11	13	25.0	34.000	-5.200	0.0	3.30	82.1	1.859	3.73
459	1979	3	27	23	4	7.7	32.963	-5.380	18.0	2.40	132.2	-0.662	0.65
460	1979	3	30	6	25	44.9	36.078	-4.811	60.0	3.50	257.6	-0.701	0.64
461	1979	4	2	1	10	39.1	35.423	-3.613	0.0	2.90	193.7	-0.828	0.58
462	1979	4	5	15	14	49.0	35.533	-3.675	5.0	3.20	203.3	-0.499	0.73
463	1979	4	7	6	41	19.0	34.096	-3.691	0.0	3.20	69.7	2.091	4.38
464	1979	4	16	4	57	0.0	34.820	-4.371	0.0	2.90	114.4	0.462	1.42
465	1979	4	17	8	20	53.0	34.400	-4.299	0.0	3.00	68.0	1.848	3.70
466	1979	4	18	14	53	7.5	32.800	-5.700	0.0	2.20	166.2	-1.501	0.37
467	1979	4	20	14	40	26.5	32.900	-4.900	0.0	2.20	111.0	-0.514	0.72
468	1979	4	21	20	5	37.6	34.843	-4.208	0.0	2.90	117.7	0.394	1.36
469	1979	4	21	19	52	6.0	35.090	-4.376	5.0	3.30	144.4	0.493	1.45
470	1979	4	23	22	19	27.6	35.028	-2.841	0.0	3.20	195.7	-0.405	0.78
471	1979	4	24	5	50	38.5	32.300	-4.800	0.0	2.60	170.4	-0.962	0.53
472	1979	4	25	23	8	2.0	32.800	-5.700	5.0	2.00	166.2	-1.802	0.30
473	1979	4	25	23	11	55.0	32.800	-5.700	0.0	2.20	166.2	-1.501	0.37
474	1979	4	26	21	12	42.5	35.300	-3.400	0.0	2.40	189.2	-1.521	0.36
475	1979	4	26	20	46	42.5	35.300	-3.199	0.0	2.80	198.5	-1.040	0.50
476	1979	5	1	12	56	41.8	36.370	-5.089	5.0	3.20	294.5	-1.419	0.39
477	1979	5	11	2	27	22.0	32.100	-6.100	0.0	2.20	247.6	-2.488	0.19
478	1979	5	13	13	53	15.0	32.400	-6.100	0.0	2.80	223.5	-1.333	0.41
479	1979	5	14	21	35	42.0	36.400	-4.100	0.0	2.80	290.6	-1.986	0.26
480	1979	5	25	7	51	6.5	32.800	-4.800	0.0	2.30	117.4	-0.499	0.73
481	1979	5	26	6	13	16.0	35.000	-4.500	0.0	3.00	135.1	0.208	1.19
482	1979	5	29	22	28	21.0	32.800	-5.000	0.0	2.20	125.1	-0.805	0.59
483	1979	5	30	1	25	28.0	35.199	-4.399	0.0	3.20	156.5	0.146	1.14
484	1979	5	30	16	8	37.5	32.400	-6.600	0.0	2.20	258.9	-2.598	0.17
485	1979	6	4	22	29	28.8	36.441	-4.156	9.0	3.00	294.8	-1.723	0.31
486	1979	6	7	15	43	10.0	34.900	-4.200	0.0	3.70	124.1	1.466	2.84
487	1979	6	9	17	12	19.0	32.900	-4.900	0.0	2.80	111.0	0.386	1.35
488	1979	6	9	21	18	34.0	32.900	-4.900	0.0	2.30	111.0	-0.364	0.80
489	1979	6	9	1	11	18.0	32.900	-5.000	0.0	3.30	115.5	1.039	2.12
490	1979	6	9	0	36	32.0	32.800	-5.100	0.0	4.40	129.8	2.405	5.44
491	1979	6	9	1	56	22.0	32.800	-5.100	0.0	2.70	129.8	-0.145	0.93
492	1979	6	9	10	3	11.0	32.800	-5.150	0.0	2.80	132.4	-0.042	1.00
493	1979	6	9	13	45	40.0	32.900	-5.399	0.0	4.10	138.4	1.799	3.58
494	1979	6	10	0	5	21.0	32.900	-4.800	0.0	2.70	107.1	0.323	1.29
495	1979	6	10	18	10	19.0	32.800	-5.100	0.0	3.20	129.8	0.605	1.57
496	1979	6	10	19	25	16.0	32.800	-5.100	0.0	2.70	129.8	-0.145	0.93
497	1979	6	10	20	3	35.0	32.800	-5.100	0.0	3.30	129.8	0.755	1.74
498	1979	6	11	13	41	47.5	32.900	-4.800	0.0	2.90	107.1	0.623	1.59
499	1979	6	13	19	26	52.5	32.800	-5.399	0.0	3.10	146.5	0.160	1.15
500	1979	6	16	17	3	19.5	32.900	-5.000	0.0	2.70	115.5	0.139	1.14
501	1979	6	16	18	48	48.0	32.900	-5.000	0.0	3.10	115.5	0.739	1.72
502	1979	6	16	13	51	44.0	32.800	-5.299	0.0	4.00	140.5	1.611	3.14
503	1979	6	16	14	2	27.0	32.800	-5.299	0.0	3.30	140.5	0.561	1.52
504	1979	6	16	14	26	22.0	32.800	-5.299	0.0	3.90	140.5	1.461	2.83
505	1979	6	17	7	38	11.0	32.800	-5.299	0.0	3.10	140.5	0.261	1.24
506	1979	6	17	23	38	36.5	32.800	-5.299	0.0	4.20	140.5	1.911	3.87
507	1979	6	18	1	18	40.0	33.000	-5.200	0.0	2.60	117.7	-0.055	0.99
508	1979	6	18	8	25	20.0	32.000	-4.900	0.0	2.50	204.9	-1.568	0.35
509	1979	6	19	14	22	44.0	33.000	-5.200	0.0	3.90	117.7	1.895	3.82
510	1979	6	19	3	39	16.0	32.900	-5.100	0.0	3.20	120.6	0.785	1.78
511	1979	6	20	17	50	52.0	33.000	-5.000	0.0	4.20	106.2	2.593	6.19
512	1979	6	23	18	17	3.0	34.699	-5.600	0.0	3.00	153.5	-0.106	0.96

Table X3.4: Estimated Earthquake Intensity and Ground Acceleration Felt at Azghar Dam Site (10/13)
(Latitude: 33°47'19''N, Longitude: 4°20'55''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
513	1979	6	24	17	41	57.0	33.000	-5.000	0.0	3.00	106.2	0.793	1.79
514	1979	6	24	18	4	22.8	34.846	-4.425	19.0	2.80	117.5	0.216	1.20
515	1979	6	24	13	32	55.5	32.500	-6.000	0.0	2.40	209.1	-1.769	0.30
516	1979	6	25	5	1	5.5	32.900	-5.100	0.0	3.00	120.6	0.485	1.44
517	1979	7	4	5	57	3.5	33.000	-5.500	0.0	2.50	137.8	-0.590	0.69
518	1979	7	4	14	24	52.1	33.996	-6.916	0.0	4.00	238.3	0.307	1.28
519	1979	7	4	4	58	1.0	32.500	-6.700	0.0	2.10	260.1	-2.760	0.15
520	1979	7	5	5	48	6.0	32.698	-5.100	0.0	3.70	139.5	1.179	2.33
521	1979	7	5	11	46	7.0	32.698	-5.299	0.0	3.80	149.5	1.159	2.30
522	1979	7	5	23	32	58.5	35.086	-5.556	0.0	3.90	182.1	0.823	1.82
523	1979	7	11	2	53	37.0	32.800	-5.200	0.0	3.10	135.0	0.360	1.32
524	1979	7	18	20	24	46.0	32.800	-5.200	0.0	2.80	135.0	-0.090	0.97
525	1979	7	22	21	31	10.0	33.000	-5.100	0.0	3.10	111.7	0.821	1.82
526	1979	7	23	3	24	5.0	33.000	-5.000	0.0	2.40	106.2	-0.107	0.96
527	1979	7	26	9	21	51.0	31.600	-4.600	0.0	4.60	244.0	1.149	2.28
528	1979	7	28	2	44	43.0	31.600	-4.700	0.0	3.00	245.0	-1.262	0.43
529	1979	7	29	10	57	50.0	35.100	-5.399	0.0	2.80	174.9	-0.727	0.63
530	1979	8	2	0	40	33.4	33.000	-4.800	0.0	2.70	96.9	0.563	1.52
531	1979	8	5	19	38	23.0	32.800	-5.100	0.0	3.30	129.8	0.755	1.74
532	1979	8	6	22	15	18.7	33.900	-4.299	0.0	3.40	13.2	5.160	36.49
533	1979	8	9	13	57	7.6	34.900	-4.500	0.0	2.90	124.1	0.265	1.24
534	1979	8	17	18	48	25.8	31.400	-4.700	0.0	3.50	267.0	-0.725	0.63
535	1979	9	10	2	8	58.3	31.800	-5.900	0.0	3.10	263.1	-1.289	0.42
536	1979	9	10	4	24	27.0	31.700	-6.000	0.0	3.50	277.5	-0.821	0.59
537	1979	9	13	17	45	8.5	31.470	-5.785	0.0	4.60	289.5	0.724	1.70
538	1979	9	14	15	34	36.3	31.600	-5.800	0.0	3.90	277.4	-0.220	0.89
539	1979	9	20	1	18	47.0	32.300	-5.299	0.0	3.50	187.1	0.157	1.15
540	1979	9	20	23	14	56.2	32.335	-1.908	0.0	3.70	277.3	-0.519	0.72
541	1979	9	20	22	9	45.1	31.470	-5.785	0.0	3.70	289.5	-0.626	0.67
542	1979	9	25	19	6	55.3	33.496	-3.774	0.0	3.00	62.2	2.049	4.25
543	1979	10	1	22	52	5.5	32.000	-6.200	0.0	2.50	262.0	-2.178	0.23
544	1979	10	6	23	48	13.5	33.100	-5.100	0.0	3.00	103.2	0.861	1.87
545	1979	10	11	21	53	24.5	35.100	-7.100	0.0	2.90	292.9	-1.856	0.29
546	1979	10	16	17	30	40.0	35.100	-5.100	0.0	2.70	161.2	-0.676	0.65
547	1979	11	5	15	37	18.0	33.900	-5.299	0.0	2.40	88.7	0.325	1.29
548	1979	11	8	3	1	0.0	35.000	-4.299	0.0	2.90	134.5	0.069	1.08
549	1979	11	8	4	15	9.0	35.000	-5.000	0.0	3.10	147.3	0.147	1.14
550	1979	11	22	1	42	11.0	32.000	-6.399	0.0	2.60	274.4	-2.143	0.24
551	1979	11	24	13	42	40.5	33.600	-5.500	0.0	2.80	108.4	0.443	1.40
552	1979	12	2	11	4	4.3	36.240	-4.410	40.0	3.00	272.0	-1.548	0.35
553	1979	12	9	9	57	40.0	34.500	-3.700	0.0	3.00	99.1	0.960	2.00
554	1979	12	9	8	11	56.5	35.000	-4.399	0.0	3.00	134.5	0.219	1.20
555	1979	12	23	12	9	45.5	35.000	-4.399	0.0	2.60	134.5	-0.381	0.79
556	1979	12	26	17	46	54.6	32.500	-5.000	0.0	2.70	155.1	-0.581	0.69
557	1979	12	27	0	37	28.3	32.800	-5.299	0.0	3.50	140.5	0.861	1.87
558	1979	12	29	23	9	52.0	33.199	-6.700	0.0	2.60	226.9	-1.671	0.33
559	1980	1	18	19	15	2.6	35.588	-4.406	100.0	3.30	199.7	-0.582	0.69
560	1980	2	6	4	16	34.3	33.053	-4.708	30.0	2.70	88.1	0.660	1.63
561	1980	2	10	3	39	42.5	35.290	-4.961	20.0	3.20	175.9	-0.157	0.93
562	1980	3	21	2	11	10.1	35.866	-4.251	5.0	2.60	230.7	-1.712	0.32
563	1980	4	20	14	18	48.7	34.960	-5.008	5.0	3.50	143.5	0.808	1.80
564	1980	6	1	20	18	28.4	35.368	-3.784	5.0	3.20	182.8	-0.237	0.88
565	1980	6	14	10	54	44.0	35.383	-3.826	5.0	3.00	183.4	-0.544	0.71
566	1980	6	16	6	7	8.7	36.325	-3.341	5.0	3.40	296.4	-1.135	0.47
567	1980	6	22	7	22	59.4	35.425	-4.034	5.0	3.20	183.9	-0.251	0.87
568	1980	6	22	23	18	33.9	35.986	-5.321	80.0	4.70	259.8	1.030	2.10
569	1980	8	6	23	58	11.1	35.173	-5.998	5.0	3.20	216.4	-0.654	0.66

Table X3.4: Estimated Earthquake Intensity and Ground Acceleration Felt at Azghar Dam Site (11/13)
(Latitude: 33°47'19''N, Longitude: 4°20'55''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
570	1980	10	13	20	13	44.3	35.803	-4.561	100.0	4.20	224.3	0.532	1.49
571	1983	9	20	8	39	13.1	34.864	-5.137	33.0	4.50	139.8	2.308	5.09
572	1983	11	24	20	55	41.0	34.733	-4.541	78.0	4.60	106.3	2.668	6.52
573	1986	1	24	18	37	48.4	35.127	-4.292	10.0	3.20	148.6	0.269	1.24
574	1986	1	28	20	1	28.4	31.999	-5.318	22.0	4.90	217.8	1.867	3.75
575	1986	1	28	11	13	22.2	31.996	-5.389	10.0	4.20	220.9	0.793	1.79
576	1986	1	29	7	50	13.3	32.079	-5.394	10.0	4.20	212.9	0.884	1.90
577	1986	4	3	22	33	13.5	35.071	-4.691	33.0	3.30	145.7	0.411	1.37
578	1986	12	24	16	11	35.4	35.651	-3.932	10.0	3.30	210.2	-0.434	0.77
579	1986	12	28	21	23	25.9	35.384	-3.543	10.0	3.40	192.0	-0.061	0.99
580	1986	12	28	14	13	44.6	35.757	-5.122	10.0	3.20	229.8	-0.805	0.59
581	1987	1	2	8	14	48.6	35.373	-3.691	10.0	3.70	186.0	0.468	1.43
582	1987	1	4	6	41	56.2	35.408	-3.520	10.0	3.80	195.3	0.497	1.46
583	1987	1	8	23	10	12.7	35.403	-3.618	15.0	4.30	191.4	1.293	2.52
584	1987	3	1	14	10	29.8	35.384	-3.622	10.0	3.10	189.3	-0.476	0.74
585	1987	7	23	11	57	31.4	35.636	-5.763	86.0	3.50	243.1	-0.638	0.66
586	1987	7	31	15	45	19.3	33.488	-4.101	10.0	3.70	40.5	3.966	15.99
587	1987	8	15	3	57	11.8	36.184	-4.312	10.0	3.00	265.8	-1.466	0.38
588	1987	12	9	15	40	34.2	35.484	-3.785	30.0	4.60	195.2	1.673	3.28
589	1987	12	10	0	20	26.7	35.440	-3.820	33.0	3.80	189.6	0.537	1.50
590	1987	12	10	0	2	16.2	35.426	-3.760	33.0	3.20	189.6	-0.363	0.80
591	1987	12	24	0	45	40.8	35.430	-3.789	33.0	3.50	189.3	0.091	1.10
592	1987	12	25	18	45	51.6	35.932	-4.568	100.0	3.30	238.7	-0.947	0.54
593	1988	2	26	17	32	2.0	35.205	-6.242	10.0	3.20	235.2	-0.862	0.57
594	1988	3	4	1	49	34.0	36.245	-5.573	10.0	2.60	295.1	-2.325	0.21
595	1988	3	17	0	1	17.7	36.035	-5.792	10.0	2.70	282.7	-2.069	0.25
596	1988	4	9	9	50	45.7	34.999	-3.413	27.0	4.30	159.7	1.712	3.37
597	1988	4	30	3	39	33.7	34.637	-5.536	10.0	3.90	144.6	1.386	2.69
598	1988	5	8	19	59	33.2	35.458	-4.902	10.0	2.70	192.1	-1.112	0.48
599	1988	5	30	10	44	4.5	36.347	-4.584	121.0	3.20	284.7	-1.541	0.36
600	1988	6	26	21	21	31.9	35.979	-4.279	18.0	3.40	243.1	-0.649	0.66
601	1988	7	8	23	31	11.1	36.213	-5.419	15.0	3.80	286.6	-0.455	0.75
602	1988	7	9	2	19	30.3	36.222	-5.453	9.0	2.80	288.6	-1.970	0.26
603	1988	7	24	0	47	22.5	35.443	-3.678	10.0	3.30	193.7	-0.233	0.88
604	1988	7	28	17	37	53.5	35.361	-4.824	116.0	3.60	179.9	-0.026	1.01
605	1988	9	10	10	27	12.9	36.347	-4.364	93.0	3.00	283.9	-1.754	0.31
606	1988	10	5	0	42	11.0	35.505	-3.858	32.0	3.80	195.7	0.462	1.42
607	1988	10	13	6	32	46.4	35.758	-4.639	133.0	3.00	220.1	-1.382	0.40
608	1988	10	14	14	58	38.3	36.445	-4.503	10.0	2.80	295.1	-2.025	0.25
609	1988	10	20	22	51	58.9	35.490	-3.844	10.0	3.70	194.4	0.358	1.32
610	1988	10	28	22	5	39.5	34.933	-5.820	10.0	3.50	186.0	0.167	1.16
611	1988	10	31	6	51	9.5	36.180	-5.721	73.0	4.20	294.1	0.010	1.04
612	1988	11	28	19	54	28.2	36.268	-4.547	100.0	3.30	275.7	-1.259	0.43
613	1988	12	12	6	40	41.7	36.300	-4.512	92.0	4.90	279.0	1.137	2.26
614	1989	1	7	14	43	9.9	35.423	-5.012	33.0	3.30	191.4	-0.236	0.88
615	1989	1	27	23	48	57.4	36.327	-4.768	10.0	2.70	284.3	-2.083	0.25
616	1989	3	8	0	26	8.1	35.353	-4.200	10.0	3.00	174.1	-0.420	0.77
617	1989	5	7	17	45	47.9	32.911	-5.094	10.0	3.70	119.3	1.553	3.02
618	1989	6	30	10	7	57.8	35.294	-3.711	10.0	3.00	177.1	-0.462	0.75
619	1989	8	5	10	26	3.1	34.850	-5.525	10.0	3.40	160.3	0.384	1.35
620	1989	8	6	4	32	57.9	35.064	-3.528	10.0	3.70	160.5	0.830	1.83
621	1989	8	12	4	12	52.4	35.260	-3.789	10.0	3.30	171.2	0.071	1.08
622	1989	8	18	11	6	22.9	35.597	-3.889	10.0	3.10	205.1	-0.673	0.65
623	1989	8	22	7	6	36.6	35.186	-3.829	10.0	3.40	162.3	0.353	1.32
624	1989	8	23	5	30	57.2	34.521	-5.199	10.0	3.00	113.0	0.633	1.60
625	1989	8	23	6	28	53.0	34.500	-5.347	10.0	3.80	121.4	1.661	3.25
626	1989	8	23	6	45	50.8	34.509	-5.435	10.0	3.00	128.3	0.326	1.29

Table X3.4: Estimated Earthquake Intensity and Ground Acceleration Felt at Azghar Dam Site (12/13)
(Latitude: 33°47'19''N, Longitude: 4°20'55''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
627	1989	8	23	8	9	39.3	34.510	-5.506	10.0	3.50	133.6	0.979	2.03
628	1989	8	30	8	52	11.6	35.192	-3.791	14.9	3.40	164.0	0.322	1.29
629	1989	9	9	4	17	58.7	35.206	-3.907	10.0	3.40	162.5	0.350	1.32
630	1989	9	16	16	8	44.6	34.825	-4.758	10.0	2.70	121.0	0.018	1.05
631	1989	9	16	4	17	58.2	35.199	-3.894	10.0	3.40	162.0	0.357	1.32
632	1989	9	27	2	10	21.5	35.577	-5.594	89.5	3.70	229.4	-0.224	0.88
633	1989	10	11	17	14	19.3	34.976	-3.808	10.0	3.00	140.9	0.099	1.11
634	1989	10	17	2	26	11.2	35.501	-5.756	76.8	2.70	230.2	-1.688	0.32
635	1989	11	8	19	22	5.5	36.159	-4.372	10.0	3.20	263.0	-1.139	0.47
636	1989	12	8	1	8	3.1	31.941	-6.292	5.0	3.80	272.5	-0.327	0.82
637	1990	2	6	7	41	32.2	36.183	-4.064	20.0	3.50	267.0	-0.732	0.62
638	1990	4	13	22	17	13.9	35.576	-4.756	93.0	3.90	201.8	0.331	1.30
639	1990	4	18	9	44	29.0	35.349	-4.017	0.0	3.70	175.8	0.610	1.57
640	1990	5	2	16	40	27.2	36.461	-4.490	87.0	4.20	296.8	-0.041	1.00
641	1990	5	15	23	32	17.6	35.071	-4.476	0.0	3.50	142.8	0.823	1.82
642	1990	8	13	1	45	49.7	34.876	-5.318	81.0	3.50	150.3	0.383	1.35
643	1990	8	15	1	6	52.6	35.830	-3.166	20.0	3.90	251.5	0.016	1.04
644	1990	9	28	2	7	58.3	35.872	-4.485	109.0	3.50	231.5	-0.619	0.67
645	1991	3	4	11	44	15.8	35.072	-5.551	32.0	3.60	180.6	0.356	1.32
646	1991	3	12	15	58	55.1	34.536	-4.590	30.0	3.50	85.9	1.915	3.88
647	1992	5	12	23	18	7.0	35.113	-2.505	16.0	3.80	225.0	0.144	1.14
648	1992	5	14	15	0	56.7	35.052	-2.501	12.0	3.90	220.9	0.342	1.31
649	1992	5	14	15	48	10.5	35.218	-2.392	0.0	3.70	240.5	-0.165	0.92
650	1992	9	29	5	45	30.4	31.471	-3.441	0.0	3.60	270.5	-0.607	0.68
651	1992	10	23	9	11	12.5	31.513	-4.233	22.0	5.20	252.7	1.952	3.98
652	1992	10	30	10	44	1.6	31.506	-4.617	0.0	5.00	254.5	1.644	3.22
653	1992	10	31	10	33	2.5	35.624	-3.481	30.0	3.60	218.8	-0.104	0.96
654	1992	10	31	0	58	46.4	31.119	-4.269	30.0	4.10	296.3	-0.097	0.97
655	1992	12	10	23	23	54.6	32.168	-5.839	0.0	3.60	226.5	-0.167	0.92
656	1992	12	21	9	2	58.6	35.246	-2.275	12.0	4.10	250.7	0.328	1.30
657	1993	5	1	0	22	22.6	35.288	-6.306	28.0	3.70	245.7	-0.235	0.88
658	1993	5	1	4	39	25.9	31.590	-4.930		3.10	249.8	-1.160	0.46
659	1993	5	23	7	40	56.0	35.223	-2.406	7.0	4.00	239.9	0.290	1.26
660	1993	5	23	7	40	55.3	35.330	-2.460		5.10	244.3	1.895	3.82
661	1993	5	27	19	10	48.0	32.060	-6.330		2.50	265.2	-2.208	0.22
662	1993	5	31	2	24	38.1	34.680	-4.780		2.80	106.6	0.484	1.44
663	1993	6	5	6	47	25.2	32.310	-3.750		3.00	173.1	-0.402	0.78
664	1993	6	9	22	45	3.7	35.290	-2.420		4.00	243.9	0.249	1.23
665	1993	6	27	13	46	11.9	33.680	-4.650		3.80	30.3	4.717	26.87
666	1993	7	12	2	53	15.9	35.228	-2.277	3.0	3.60	249.3	-0.405	0.78
667	1993	7	16	17	12	4.9	33.500	-4.450		2.70	33.4	2.897	7.64
668	1993	7	23	22	13	27.0	32.420	-6.150		2.90	225.3	-1.204	0.45
669	1993	8	19	12	53	33.5	34.860	-4.700		3.10	123.2	0.583	1.54
670	1993	8	20	21	10	35.1	34.540	-3.970		3.10	90.4	1.330	2.59
671	1993	8	29	6	6	47.3	32.960	-5.330		3.30	129.1	0.768	1.76
672	1993	9	13	3	20	39.5	35.770	-4.890		3.20	225.4	-0.755	0.61
673	1993	9	29	5	45	34.0	31.860	-3.720		3.90	221.7	0.336	1.30
674	1993	9	29	5	45	30.6	31.485	-3.468	30.0	3.60	268.3	-0.602	0.68
675	1993	10	24	5	46	10.4	35.160	-4.900		2.80	160.4	-0.514	0.72
676	1993	11	7	13	1	57.4	34.250	-3.160		3.70	121.2	1.523	2.96
677	1993	11	9	10	24	58.8	34.270	-3.190		3.60	119.6	1.404	2.72
678	1993	11	9	16	51	46.4	33.640	-6.150		2.70	167.3	-0.767	0.61
679	1993	11	9	0	22	31.4	36.400	-4.500		3.40	290.1	-1.081	0.49
680	1993	11	25	18	28	23.4	34.410	-1.760		3.30	248.9	-0.851	0.57
681	1993	11	30	13	17	31.0	32.560	-5.620		3.80	180.0	0.703	1.68
682	1993	12	9	19	28	13.8	33.970	-4.780		4.00	44.6	4.275	19.79
683	1993	12	11	0	18	32.1	35.640	-4.760		3.00	208.9	-0.866	0.57

Table X3.4: Estimated Earthquake Intensity and Ground Acceleration Felt at Azghar Dam Site (13/13)
(Latitude: 33°47'19''N, Longitude: 4°20'55''W)

No.	Year	Month	Day	Time			Hypocenter		Focal Depth (km)	Magnitude in Richter Scale	Epicentral Distance (km)	Cornell's Analysis	
				Hour	Min	Sec	Latitude N	Longitude E				Intensity (Imm)	Acceleration (gal)
684	1993	12	15	10	24	11.2	35.480	-5.030		3.00	197.9	-0.733	0.62
685	1993	12	21	22	29	14.7	34.990	-4.780		2.70	139.1	-0.314	0.83
686	1993	12	21	16	58	3.9	35.030	-3.840		2.80	145.5	-0.274	0.85
687	1993	12	30	11	34	35.1	34.550	-4.140		2.90	86.6	1.131	2.26
688	1994	3	25	21	24	31.2	35.347	-2.673	4.0	3.50	232.1	-0.377	0.80
689	1994	5	7	8	49	54.1	31.544	-3.433	26.0	4.00	263.0	0.050	1.07
690	1994	5	12	23	58	11.1	31.503	-3.379	23.0	3.80	269.0	-0.303	0.84
691	1994	5	26	8	26	55.5	35.139	-3.908	21.0	5.50	155.3	3.595	12.37
692	1994	5	26	12	27	55.2	35.184	-3.979	7.0	3.50	158.5	0.563	1.52
693	1994	6	3	8	57	40.3	35.213	-3.998	5.0	4.00	161.3	1.271	2.49
694	1994	8	15	6	28	34.9	35.325	-3.931	0.0	3.90	174.8	0.925	1.96
695	1994	8	20	4	55	27.2	35.230	-3.985	0.0	3.70	163.4	0.791	1.78
696	1994	11	25	5	33	17.5	34.655	-4.519	16.0	4.10	97.4	2.619	6.31
697	1995	1	29	17	43	13.3	33.205	-5.124	0.0	3.70	96.6	2.072	4.32
698	1995	3	31	8	57	55.3	35.884	-3.195	19.0	3.50	255.8	-0.625	0.67
699	1995	9	3	22	34	55.3	33.153	-2.928	30.0	4.30	149.0	1.869	3.75
700	1995	9	25	15	13	16.7	34.180	-4.871	6.0	3.60	64.9	2.844	7.37
701	1995	9	29	5	54	31.3	34.069	-5.884	3.0	3.50	145.2	0.780	1.77
702	1995	10	15	1	43	11.6	35.187	-4.076	0.0	3.80	157.2	1.037	2.11
703	1995	11	10	17	49	55.9	36.131	-2.916	0.0	3.50	291.7	-0.945	0.54
704	1995	11	25	18	31	41.9	33.216	-3.252	0.0	3.60	119.6	1.405	2.73
705	1995	12	23	21	24	1.4	35.192	-3.989	7.0	3.80	159.2	1.003	2.06
706	1996	4	3	1	24	8.3	34.189	-4.845	0.0	3.60	63.8	2.892	7.61
707	1996	4	24	19	36	12.5	35.150	-4.068	0.0	4.00	153.2	1.399	2.71
708	1996	6	8	21	16	17.3	35.320	-4.059	3.0	3.70	172.0	0.664	1.63
709	1996	6	18	13	58	53.3	35.285	-5.819	32.0	3.70	214.5	0.091	1.10
710	1996	7	13	9	8	4.9	34.690	-5.787	19.0	4.20	166.3	1.481	2.87
711	1996	9	16	1	38	15.5	34.995	-4.250	10.0	4.10	134.1	1.868	3.75
712	1996	11	16	1	38	15.5	34.995	-4.250	10.0	4.10	134.1	1.868	3.75
713	1997	7	2	9	38	59.3	35.737	-4.182	12.0	4.00	216.7	0.539	1.50
714	1997	7	2	12	53	20.6	35.803	-4.381	9.0	4.00	223.5	0.464	1.42
715	1997	7	2	17	33	21.7	35.808	-4.205	7.0	3.70	224.4	0.005	1.04
716	1997	7	4	5	29	28.5	35.276	-4.540	9.0	3.50	166.0	0.449	1.41
717	1997	7	14	11	25	1.3	33.561	-4.178	14.0	3.90	29.8	4.722	26.96
718	1997	7	26	12	56	55.7	33.155	-4.990	9.0	3.50	92.0	1.877	3.78
719	1997	8	4	14	23	37.7	32.233	-5.724	13.0	4.10	214.4	0.716	1.69
720	1997	8	4	15	44	32.3	32.214	-5.704	7.0	3.50	215.0	-0.188	0.91
721	1997	8	7	19	17	32.1	35.951	-3.053	5.0	3.50	268.1	-0.736	0.62
722	1997	8	20	2	44	3.4	36.397	-4.899	9.0	3.70	293.8	-0.664	0.65
723	1997	10	12	21	29	22.4	32.445	-3.004	8.0	3.70	194.1	0.364	1.33
724	1997	10	13	21	50	18.7	36.211	-3.218	5.0	3.60	288.4	-0.767	0.61
725	1997	10	17	7	15	51.0	32.469	-2.848	5.0	3.80	201.7	0.420	1.38
726	1997	11	14	19	14	17.0	32.435	-2.891	9.0	3.90	201.8	0.568	1.53
727	1997	11	15	6	15	32.6	32.584	-2.805	4.0	3.50	195.5	0.048	1.07
728	1997	11	15	3	29	26.5	32.534	-2.849	4.0	3.50	196.4	0.036	1.06
729	1998	1	7	13	22	57.7	32.906	-2.777	30.0	3.60	175.2	0.434	1.39
730	1998	3	25	10	26	8.7	35.578	-4.920	21.0	3.50	205.4	-0.087	0.97
731	1998	4	14	7	26	50.4	32.804	-5.297	5.0	3.90	140.1	1.468	2.85
732	1998	6	16	5	30	10.3	32.655	-5.315	3.0	3.90	154.3	1.232	2.42
733	1998	6	18	19	45	34.8	32.704	-5.368	0.0	4.40	152.8	2.005	4.13
734	1998	8	3	15	25	42.7	34.720	-4.918	22.0	4.00	115.9	2.038	4.22
735	1998	9	16	7	58	2.1	32.713	-5.394	0.0	3.60	153.5	0.794	1.79
736	1998	10	20	23	47	18.3	34.908	-3.790	0.0	3.60	134.5	1.119	2.24
737	1999	3	16	21	41	42.2	34.414	-4.138	0.0	3.80	72.1	2.914	7.73
738	1999	3	26	20	13	33.2	35.569	-3.650	3.0	3.60	207.8	0.047	1.07
739	1999	5	29	11	30	53.1	35.852	-2.932	10.0	3.90	263.7	-0.096	0.97

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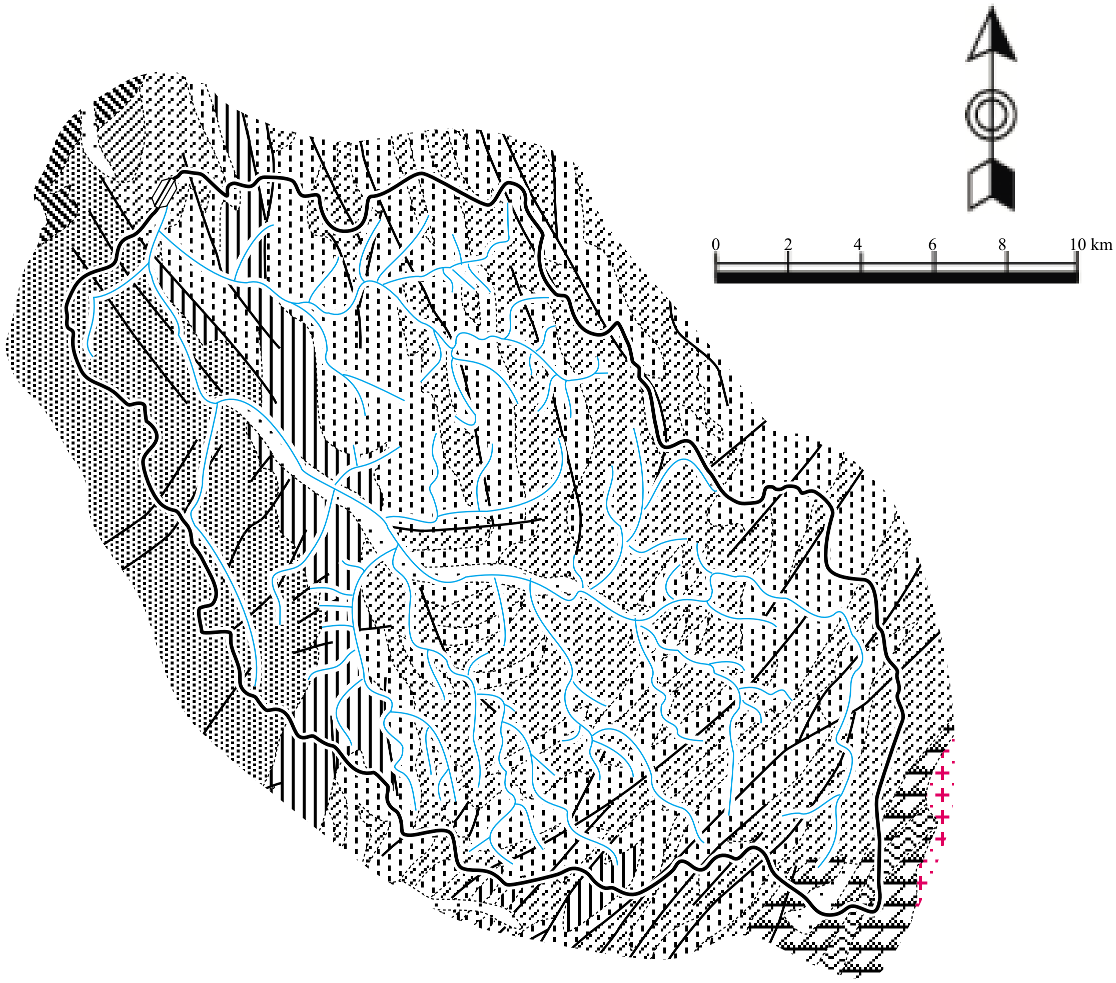
Figures



L e g e n d

Quarternary	Schist (Upper Silurian)
Hercynian Granite	Sandstone & Quartzite (Lower Silurian)
Red Mudstone & Basalt (Triassic)	Contemplate Dam site
Sandstone & Pelitic stone (Carboniferous)	Fault
Sandstone & Pelitic or sandy pelitic stone (Devonian-Carboniferous)	Geologic Boundary
Quartzite & Sandstone with Pelitic stone (Upper Devonian)	Catchment Area
Silty Argillite, Limestone interbedded with Argillite (Middle Devonian)	Tributaries
Argillite with some Limestone (Lower Devonian)	

FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure X2.1.1** **Geological Map around Catchment Area of N'Fifikh Dam**
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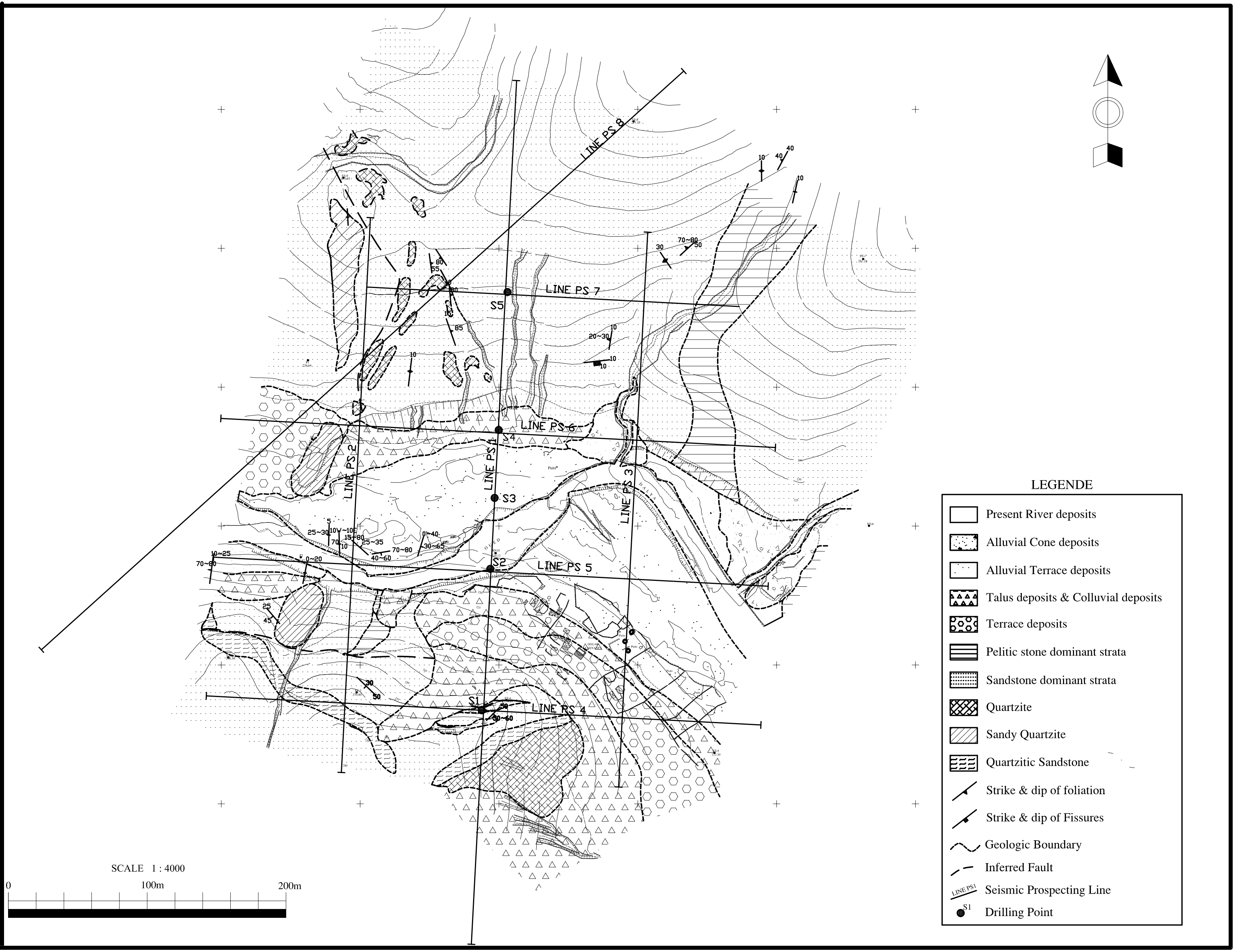
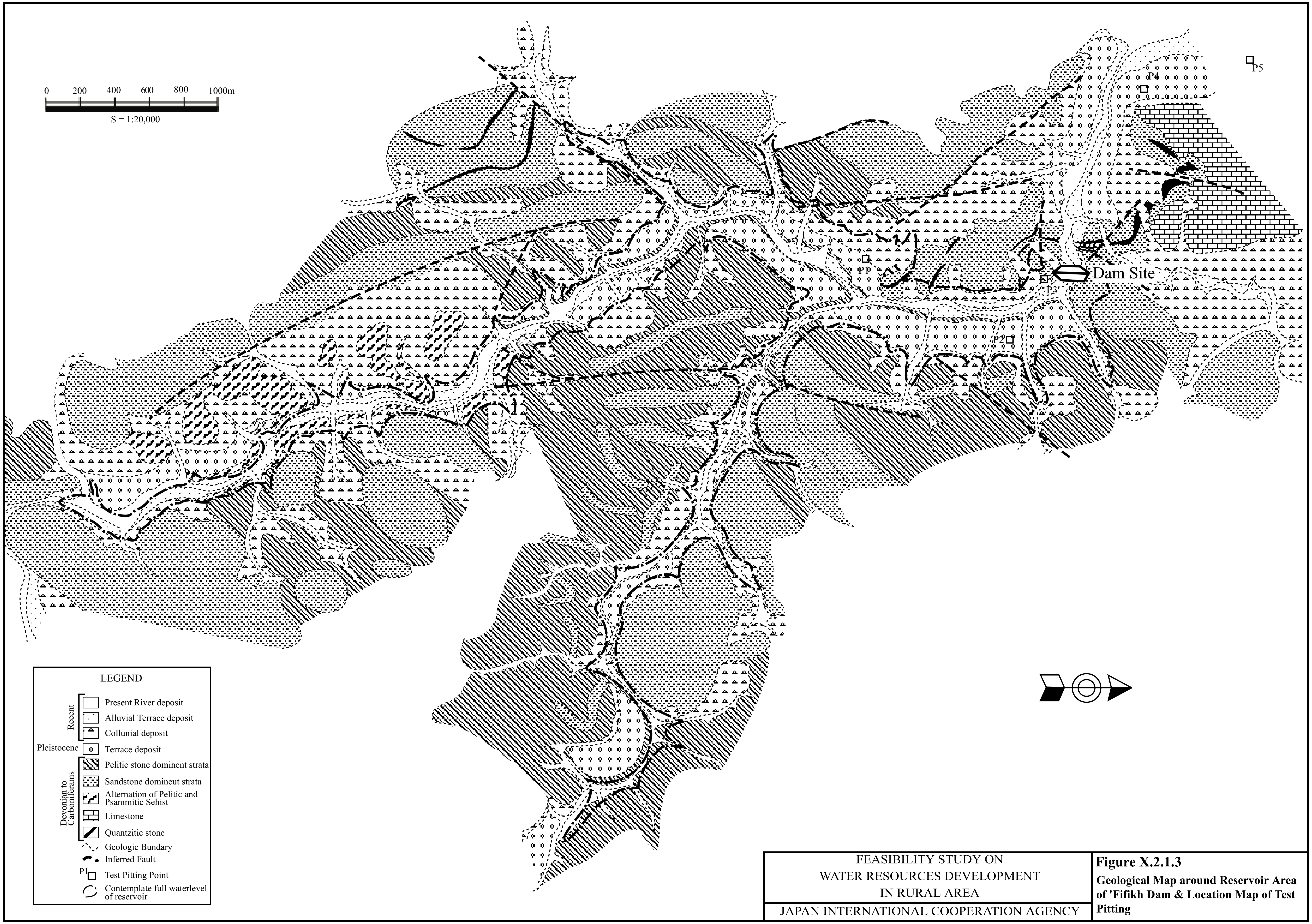
FEASIBILITY STUDY ON
WATER RESOURCES DEVELOPMENT
IN RURAL AERA

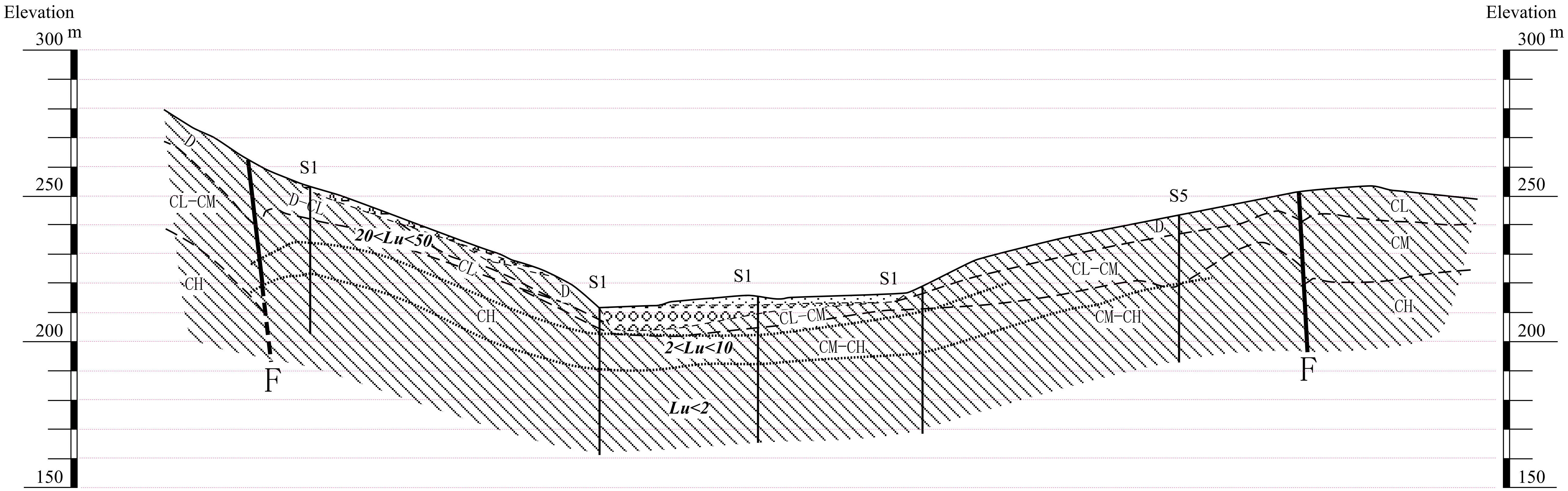
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure X2.1.2
Geological Map around N'Fifikh Dam Site & Location Map of Drilling and Seismic Prospecting





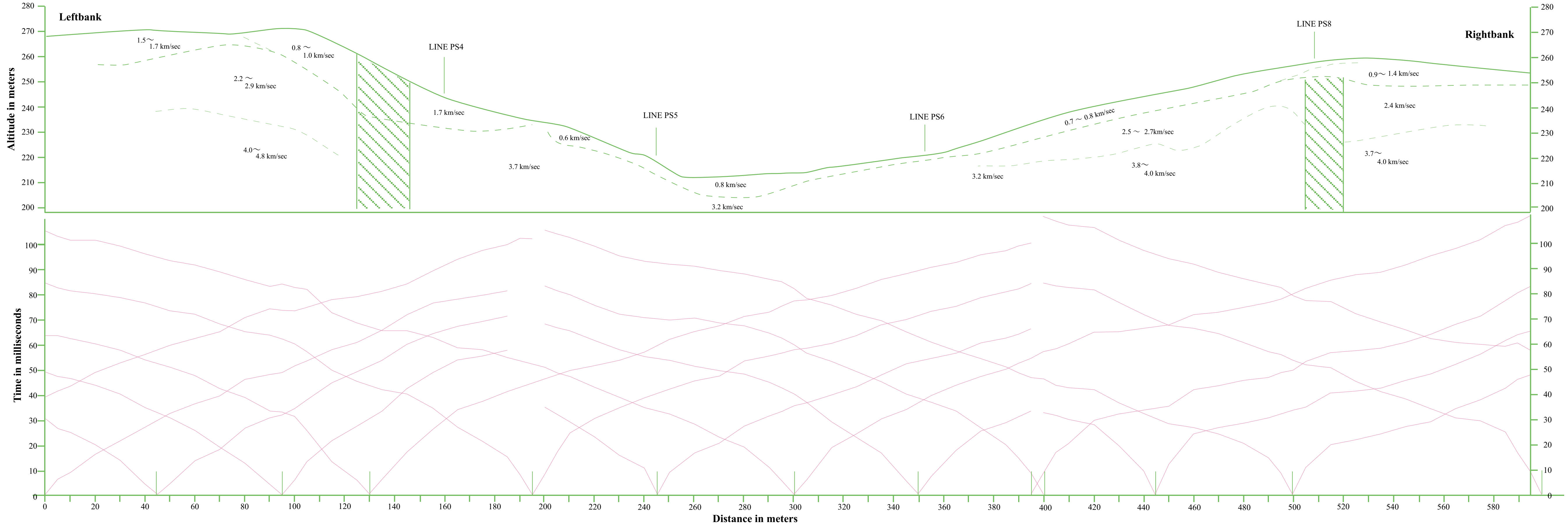
FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure X.2.1.3**
JAPAN INTERNATIONAL COOPERATION AGENCY	**Geological Map around Reservoir Area of 'Fifikh Dam & Location Map of Test Pitting**



LEGEND

- Alluvial Terrace deposits
- River deposits
- Terrace deposits
- Colluvial deposits
- Sandstone Dominant Bedrock
- Faults
- Geological Boundary
- **CM-CH** Rock Classes
- Boundary of Rock Classes
- **S1** Drilling Location and their Numbers
- *Lu<2* Lugeon Units of Bedrock
- Boundary of Lugeon Units

FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure X2.1.4** **Geological Profile along Contemplate N'Fifikh Dam Axis**
JAPAN INTERNATIONAL COOPERATION AGENCY	



FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**FigureX2.1.5** **Profile of Seismic Velocity Distribution along Contemplate N'Fifikh Dam Axis**
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