FINAL MINE FEASIBILITY STUDY

REPORT PART I

MINE PLAN & FEASIBILITY

HOMDHAR STONE QUARRY

Nangkhor Gewog, Zhemgang

NRDCL

FINAL REPORT

OCTOBER 2011

NATURAL RESOURCES DEVELOPMENT CORPORATION LIMITED

THIMPHU BHUTAN

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DEPARTMENT OF GEOLOGY AND MINES
MINISTRY OF ECONOMIC AFFAIRS
ROYAL GOVERNMENT OF BHUTAN
THIMPHU

X-77/DGM/2011/523

19th October 2011

APPROVAL of FMFS Report and EMP

The Mines Evaluation Section of the Mining Division has evaluated the Final Mine Feasibility Study (FMFS) report and the Environmental Management Plan (EMP) of the proposed **Homdhar Stone Quarry.** The background and summary of the report are specified below:

Background

Date	Activity
20th May 2011	Applicant given permission to prepare the FMFS report and EMP for the proposed quarry for submission vide letter no. X-77/DGM/2011/1495
19th July 2011	Receipt of the 1st draft FMFS report and EMP
12th August 2011	Evaluation comments on the FMFS report and EMP forwarded to the applicant vide letter no. X-77/DGM/2011/224 for corrections.
18th October 2011	Receipt of the corrected final report
12th October 2011	Receipt of environmental clearance vide letter no. NEC/ESD/DGM/2279/2011/2237

FMFS Summary

General Information

Promoter	:	Natural Resources Development Corporation Ltd.
Name of the proposed quarry	:	Homdhar Stone Quarry
Location of the proposed quarry:		Tingtibi, Nangkor Gewog, Zhemgang Dzongkhag
Rock type	:	Quartzite rock for constrction purpose
Type of operation	:	Semi-mechanized
Total leased area	:	26.658 hectares
Annual Production estimates	:	210000 MT
Geological reserve estimation:		> 1.49 million MT
Annual overburden generation:		11,500 m^3
Lease period applied	:	10 years
Market and Products	:	Aggregates and boulders for construction activities under Zhemgang Dzongkhag, Mangde Chhu and Digala Hydro power projects etc.
Manpower Requirement	:	53 personnel

Prepare file Note sheet.

29/10/11

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ROYAL GOVERNMENT OF BHUTAN
THIMPHU

Evaluation comments:

The FMFS report and EMP has been prepared by a competent mining engineer based on approved geological report after the receipt of clearances from all the relevant agencies. They have been assessed to be acceptable for implementation based on the mineability, reserve availability, economic viability and other technical and environmental considerations as addressed in the reports. Environmental clearance has also been obtained.

Compliance requirement

- The terms and conditions laid down in all the clearances should be complied with along with terms and conditions specified in the minutes of the FMFS presentation meeting with the stakeholders.
- The quarrying operation should be carried out as per the approved FMFS report and the EMP.
- Should the proponent outsource part or whole of the mining operations to a contractor, the qualification, expertise and experience (in mining) of the contractor should be given utmost importance during the selection. The selection committee should involve senior officials from the Mining Division of the Department of Geology & Mines. NRDCL should also draw up a proper terms of reference for the contractors so that each and every provisions laid down in the FMFS report and the EMP are complied with along with the terms of the lease agreements, clearances and the minutes of the FMFS presentation meeting with the stakeholders.
- The proponent should ensure that the quarrying operation is supervised by a competent mining engineer either on a part time basis or full time.

Evaluation done by:

(Lhendup Gyeltshen)
Deputy Executive Engineer / Head,
Mines Evaluation Section

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Verified by:

(Sangay Tshering)
Offtg. Head,
Mining Division

Approved by:

Director General
Department of Geology & Mines

Copy to:

1. Offtg. Head, Mining Divission, DGM, Thimphu for information
2. Head, Mines Evaluation Section, DGM, Thimphu for information
3. Head, Mines Leasing Section, DGM, Thimphu for information and necessary follow-up

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National Environment Commission

Royal Government of Bhutan

NEC/ESD/DGM/2279/2011/ ৪২৩৪ **October 12, 2011**

To

The Chief Executive Officer
Natural Resources Development Corporation Limited
Thimphu

Sub: Forwarding the Environmental Clearance

Sir,

Enclosed please find herewith the Environmental Clearance for the operation of Homdhar Stone Quarry located at Homdhar under Nangkor Gewog, Zhemgang Dzongkhag measuring a total area of 26.67 hectares.

This environmental clearance (EC) is issued as per the decision of Environmental Assessment Technical Committee (EATC) meeting held on 10th October, 2011 with the following preconditions;

1. The barriers/check dams are constructed at the approved dump yard and all necessary areas prior to quarry development and dumping of overburden materials;
2. River protection works are carried out at all necessary areas prior to actual operation of the quarry in order to avoid pollution of water due to spillage of mucks/debris;
3. Approach and haul roads are constructed by adopting Environmentally Friendly Road Construction (EFRC) techniques to minimize adverse environmental impacts;

Therefore, you may please be informed that you are required to report to National Environment Commission Secretariat (NECS) after the completion of the above mentioned preconditions following which NECS will further inspect and decide on allowing the actual operation of the quarry.

Sincerely,

Head
Environment Services Division

Copy to:

1. Hon'ble Secretary, NECS for kind information.
2. The Dzongdag, Dzongkhag Administration, Zhemgang for kind information.
3. The Head, Mining Division, DGM, MoEA, Thimphu for kind information.
4. The Dzongkhag Environment Officer, Dzongkhag Administration, Zhemgang for information and necessary compliance monitoring.

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CHAPTER ONE
INTRODUCTION

Crushed stone, sand and gravel are the foundations for the development of a nation. These resources are essential for building roads and highways, power plants and dams, houses, dzongs, monasteries, schools and hospitals and all sorts of construction activities. Construction aggregate, for instance, enables the farmer to grow crops and bring his goods to market on safe and efficient highways and provides the resources that enable a community to have construction materials. The stone aggregate and sand production plays a vital role in the nation's economy and in the quality of life for its residents. One can imagine the difference it makes in the quality of life with and without highways, medicines, bridges, and other necessities — all made possible with crushed stone. These resources are indispensable to the maintenance and development of rural and urban environments today. The relationship between available crushed stone and community development is essential for the maintenance and growth of our society. Without minerals from crushed stone, we wouldn't have the modern necessities that make our lives safe, comfortable and productive.

Sand ranges in size from 0.02mm to 2.0mm and is one of the principle elements used as aggregate in portland cement concrete, mortar, plaster and other building materials.

Even though stone is widely distributed throughout the country, its availability for exploitation is not easy. Some areas may lack the quality of stone, does not meet the physical-property requirements for certain uses, or it contains mineral constituents that react adversely when used in cement concrete. The others are covered by overburden that is too thick to allow economical surface mining. Further in some other areas there will be conflict in landuse as either the land is used for cultivation or important infrastructure are built on it or it forms the areas of religious importance.

The stone quarry site at Homdhar in Zhemgang Dzongkhag has been identified and promoted by NRDCL.

With the boom in construction industry in the area, power projects in Mangde Chhu and Digala, and the road widening projects, it is envisaged that the demand for the construction stone chips and aggregates will go up steeply. With the opening of stone quarry and setting up stone crushing plant at Homdhar by NRDCL, the shortage of the construction aggregate is expected to be filled up and the pricing will be low compared to other suppliers.

The proposed quarry and the crusher at Homdhar are expected to produce and capture at least 50% of the demand of construction material in the radius of 100km. The quarry output shall consist of hard and compact run-off-mine quartzite lumps, and the aggregates of various sizes

will be produced in the crushing plant set up by the corporation.

1.1 IMPORTANCE OF QUARRY DESIGN

It is always important to ensure the mine is correctly designed from the start. It should highlight whether there are sufficient geologic information, sound geotechnical and hydrologic information, sequential and efficient pit development and optimized haul roads and ramps. A knowledgeable mine planning is absolutely critical to a successful operation. The planning mistakes can result in very severe consequences that affect both safety and production. The knowledge of the deposit to be mined is a critical factor that can be overlooked when starting up a new project. Geological information needs to be carefully reviewed to build an accurate resource model for use in the mine design process. The collection and utilisation of accurate geotechnical data is critical in selecting the right pit slope angles. It is necessary to collect sufficient data to perform the required rock mechanics evaluation to design pit walls that remain safe and stable during operations, as the pit failures can result in buried equipment, injured employees, and lost production. Mine owners should be able to recognise issues in advance and know how to keep the mine operation going as efficiently and safely as possible.

1.2 ACCESSIBILITY

The stone quarry at Homdhar shall easily be accessible once 1.121 km of access road from existing Zhemgang-Gelephu highway to the crushing plant site is improved, and 2.84km additional quarry access is constructed. It is located about 1.5KM from Tingtibi town towards Zhemgang. The temporary road bifurcates towards Homdhar before reaching Tingtibi town. The stone quarry is located on the left bank of Dakpai river and flanked by Mangde Chhu in the south.

1.3 PHYSIOGRAPHY

The mapped area forms a part of Topo-sheet No 78/1/12 under Zhemgang Dzongkhag and the approximate geographical co-ordinates: 1042500 and 2811800 (UTM). Investigated area can be accessible from the Tingtibi as it is located on opposite of Tingtibi Township (left bank of Dakpai Chu), which is connected by approximately 2km footpath from Tingtibi township area. The topography is rugged with very steep slope on either side of the narrow ridge that runs north-south.

The perspective view of the proposed quarry site is provided in **Annexure 1.1**.

1.4 CLIMATE

The stone quarry lies under sub-tropical mountainous climate. Homdhar-Tingtibi area experiences heavy rain precipitation during monsoon and comparatively hot and windy spring. It is located next to the Gelephug-Trongsa national highway. Because of humid climatic condition it has great varieties of sub-tropical vegetations which consist of various species of broad leaves trees and bamboos/creepers with thick under growths. Homdhar ridge (Tingtibi area) lies in mid Himalayan region.

1.5 LEGAL AND REGULATORY CONSIDERATIONS

While carrying out the mining, processing, transporting and selling of the stone aggregates, the provisions of the Mines and Minerals Management Act 1995 and Mines and Minerals Management Regulations 2002 along with the environmental legislation shall be complied diligently, specifically the terms and conditions of the mining lease agreement and the proposal provided in this report.

CHAPTER TWO

MARKET

2.1 Size of market and specifications

The market for stone aggregates is growing at enormous rate with numerous development activities taking place around the country. In Zhemgang, the prospective customer for NRDCL will be the Mangde Chhu Hydropower Project, the Digala Hydropower project and associated infrastructural development projects.

2.2 Competition in the market

At present there is no any competitor in the aggregate industry and there is huge shortage of construction material.

2.3 Quality control of products

The raw material used will be quartzite rocks which is one of the good quality stone used for construction. The stone from the quarry site has been tested for its suitability and strength and the report is enclosed as **Annexure 2.1.**

2.4 Prices

Depending on the cost of mining and the demand for the stone the price of hard quartzite lumps at mine-head would be Nu 275 to Nu 300 per metric tonne. The prices for other aggregate sizes are as below. The conversion factor is taken as 25 cft per MT ***and*** the bulk density is around 1.6MT/m^3. The annual quantity is based on 100% capacity utilization.

Sl No	Specification	Quantity per year (in MT)	Quantity per year (in cft)	Rate (Nu)	Total annual sale (Nu million)
1	20-40 mm	60,000	1,500,000	19/cft	28,500,000
2	10-20mm	60,000	1,500,000	20/cft	30,000,000
3	5-10 mm	60,000	1,500,000	18/cft	27,000,000
4	<5 mm	22,500	562,500	5/cft	2,812,500
5	Boulder	5,000	125,000	11/cft	1,375,000
	TOTAL	210,000	5,250,000		89,687,500

CHAPTER THREE
GEOLOGY AND RESERVES

3.1 Geology

The geological investigation was carried out by NRDCL with the help of expertise from the Department of Geology and Mines. The geological reserve has been estimated at 1.49 million tonnes of quartzite rock. The geological investigation report is enclosed as **Annexure 3.1**.

The rock types encountered during surface geological investigation are mostly homogeneous quartzite horizon (gray-wake/arkosic) sequence with various quartz pegmatite intrusions. The minor flaggy types of interbandings are frequently observed within the massive band.

Dark-grey color quartzite exposed at the bottom line of standing cliff which is followed by ash-grey fined to medium grained massive quartzite band. Trend (attitudes) of rock NW (north-western flank) flank of ridge mainly towards cliff bottom strike N30°E-S30°W to N80°E-S80°W with dip amount ranges from 15° to 40° towards SE direction whereas on the eastern flank including ridge strike N40°W-S40°E to N85°W-S85°E with dip amount ranges from 20° to 50° towards NE direction. However, the outcrop in general appears to be homogeneous and due to presence of recumbent fold the rock attitude measured is not constant.

The geological cross sections along A-A', B-B' and C-C' are provided under Annexure 6.5(d), 6.5(e) and 6.5 (f) respectively.

3.2 MINEABLE RESERVE

The mineable reserve is calculated based on the actual quantity of quartzite and other rocks that will be excavated from the designed pit. The geological reserve has been estimated based on 20m down dip extension based on surface assessment. However, as the quartzite bedding is expected to be continuous till the extent of designed pit the mineable reserve will be higher than the geological reserve. This shall be proven through additional studies that will be undertaken.

However to get the 100% confidence level on the stripping ratio and the quantity of good quality rock the core drilling would be preferable by any mine planning engineer, which will help in overcoming the surprises encountered by many other stone quarries around the country. Alternatively geophysical methods need to be adopted to study the thickness of overburden in the down dip extension of the quartzite bed.

The pits have been designed based on the following assumptions.

Assumptions;

- The mine reserve estimation is based on the geological map and sections and the topography map.
- Litho-contact and shear zone is as provided in the geological map.
- The general dip of quartzite rock bed is 20 to 50° towards south-east and north-east as

reported by the geologist.

- The specific gravity of waste rock above and below the quartzite bed is 2.65.
- The overburden thickness is based on the geomorphology, geological map and sections.
- The absence of any fault in the geological map is interpreted such that the quartzite band continues down dip for the whole stretch of demarcation boundary following the same attitude of bedding.
- Final pit slope is 37° from the horizontal.
- Mining pit is constrained by the lease boundary and the terrain condition.

The levelwise lithological volume of quartzite and overburden waste that will be excavated from the quarry are provided in **Annexure 3.2.**

CHAPTER FOUR
MINE DEVELOPMENT PLANNING

It is always important to ensure the mine or a quarry is correctly designed from the start. It is also important to highlight sufficient geologic information, sound geotechnical and hydrologic information, sequential and efficient pit development and optimized haul roads and ramps for location, proper width, access, and quality. Bad mine planning can affect both safety and production. To know the deposit the detailed geological information is important as it helps in the correct mine design process. The collection and utilisation of accurate geotechnical data is critical in selecting the correct pit slope angles to ascertain safe and stable pitwalls during operations. Pit failures can result in buried equipment, injured employees, and lost production. Designing mine plans optimise the output of the equipment being used.

Lease area = **65.87 Acres** (26.67 hectares)

The following are considered for the selection of mining method and subsequent mine planning and design:

- Scale of operation
- Quantity of Reserve
- Quantity of waste/Thickness of overburden & interburden
- Demand in the market
- Environmental considerations
- Disposition/Spatial distribution of mineral deposit
- Physical properties of rock
- Joint spacing and massiveness
- Bench parameters
- Ultimate pit slope
- Requirement of qualified and experienced manpower
- Value of stone and profitability.

The following assumptions were made while designing the mines:

- 10% of the rock excavated will go as waste in the form of undersize and dust contaminated with reject rocks and overburden.
- The quartzite is suitable for all type of construction activity in non-wearing surfaces.
- The quality and down dip extension are persistent at depth in the absence of core drilling.
- The annual quantity of stone aggregates requirement is 210,000 metric tonnes which is sufficient to feed the crushing plant of 100TPH capacity being set up by the company.
- The mining activity will be environment friendly by taking into consideration all the statutory requirements.

The following basic facilities shall be put in place and activities completed as a part of

preliminary activities and mine development;

- Determination of pit boundary.
- Determination of the area for establishment of infra-structural facilities.
- Access road to the quarry area and the mining benches.
- Pre-production development works including jungle & bush clearance, initial cut and bench preparation to expose the deposit.
- Establishment of infrastructure that include crushing plant, machinery & equipment, office and residential buildings.
- Provision of ancillary facilities such as power, water, weighbridge, explosive magazine, transport facility etc.
- Waste dump area.

4.1 Pit Boundary

The pit boundary is based on the nature of deposit, natural slope conditions of deposit, type of mineral, general dip direction of overburden & rock bed and production schedule etc. At the proposed production target the pit boundary has been determined for the 15 years lease of the quarry. The pit boundary takes into account the orientation of ultimate pit berms, length and width of the working space for heavy machine. The design of the pit and benches is such that at any instance during mine operation the length of face is more than 50 metres and width is more than 18 metres.

4.2 Determination of area for establishment of infra-structural facilities

The crushing plant site consists of 2.78 hectares (6.87 acres) which is sufficient for construction of colony and office for both the quarry and the crushing plant, apart from the area required for crusher. There is also ample area between the proposed waste dump and the crushing plant where infrastructure can be set up both by the company and the quarrying contractor.

4.3 Access Road

From the existing highway connecting Tingtibi and Zhemgang, there exists a rough fair weather road to Homdhar terrace through the Dakpai river.

The distances of different segments of the road are as provided below:

- Highway to crushing plant = 1.121KM
- Crushing plant to quarry top = 3.5 KM

The quarry road traffic shall be as follows:

The daily output from the mine face = 700 MT

Capacity of each tipper = 10 MT

Number of tippers plying to and from the quarry and the crushing plant (two-way) = 70 round trips.

For easy mobility of the heavy traffic there is need for a double lane road from the quarry to the crushing plant or the provision of passing places at 150m interval.

4.4 Pre Production Development

The demarcated areas are thickly vegetated that need to be cleared off during mine development stage. Bench preparation for mining operation will begin with the initial cut at the highest elevation at Homdhar quarry where the overburden is minimum and topography very steep on either side of the ridge line. The check-dam for stabilisation of waste disposal will be constructed as per the dimension provided in the mine plan drawings.

4.5 Establishment of Infrastructure

Infrastructure development is a prerequisite for start of a mining activity. The following are the infrastructure proposed for the company:

i. An office for company officials as per organisation chart
ii. Office for DGM inspector at despatch checkpoint close to weighbridge.
iii. Store for spare parts and tools
iv. Explosive magazine: The monthly requirement of explosive is 2.1 metric tonnes. So suitably sized explosive magazine, possibly 5MT capacity, shall be constructed so that the stock last for at least two months. The location of the magazine shall be next to waste dump area within the lease boundary.
v. Residential hut for the security personnel guarding the explosive magazine
vi. Residential quarters for officials and hutments for mine officials, DGM inspector(s), operators and other workers. The residential buildings will have kitchen space, cooking and drinking water provisions, toilet and proper sanitation facility.

4.6 Provision of ancillary facilities (such as power, water, weighbridge, telecommunication facility, medical facility, school facility, transport facility within and beyond the mine, etc.)

i. *Power*: For the proposed scale of operation the establishment at mine area would be sizeable. The supply is required for crushing plant, office and colony. So the power supply needs to be provided. The crushing plant will run with electrical energy.
ii. *Water*: The water requirement would be for cooking, drinking, washing, and for spray along the road for suppression of fugitive dust. The supply line shall be drawn from perennial Dakpai river close to the crushing plant.
iii. *Transport facility*: The light vehicle for the use of quarry manager which will also serve as a utility vehicle for other purposes and a bus for use by school children and staff need to be provided.
iv. *Medical facility*: The quarry site is 5 KM from the Yebilaptsa hospital so the medical facility is not proposed except the first aid facility.
v. *Survey and mapping*: To ascertain the correctness in the progress of mining the mining area has to be mapped and topography updated on a regular basis. Survey instrument, manpower and plotting facility would be necessary which shall be serviced from head quarter in Thimphu where the facility is in place.

vi. *A telecommunication facility* (walkie-talkie) shall be provided to the quarry officials and operators for easy communication which is highly essential and is used by large mines in the country.

4.7 Preparation of waste dump area

The overburden waste dump site will be prepared at the specified location shown on the maps. At the lower end of the proposed dump site a retaining barricade wall will be constructed which will be embedded into the ground for anchorage. The length of construction is provided on the map and it is 120 metres with total volume of 470 cubic metres.

CHAPTER 5
MINE DESIGN PARAMETERS

5.1 Bench dimensions:

Considering the provisions of the Mines and Minerals Management Regulations 2002 and the geotechnical characteristics of the area, the ***working and final*** mining benches will be 5m high with back-slope angle of 60°. The mine is designed based on the topography and the pit will advance perpendicular to the dip direction. The working benches will have width of at least 15m at the top bench. By maintaining the above bench parameters the final pit slope shall be 37° or less. In this manner it is possible to get optimum recovery of the hard rock with due consideration towards slope stability and environment protection.

5.2 Blast hole drilling:

The daily quartzite rock production capacity is 700 MT. In the first year about 14545 cubic metres of overburden will be excavated and disposed off. The drilling and blasting shall be done with deep hole drilling with bench height of 5.0 metres. The burden and spacing of the holes is proposed at 3.5 m and 4.0 m respectively and may deviate slightly based on site condition so as to prevent ground vibration and fly-rocks. Directional drilling and blasting shall be carried out so that no fly-rock or rolling boulders fall towards the crushing plant site at the base of the quarry. The direction of quarry benches is planned accordingly.

5.3 Blasting:

Blasting will be done with nitroglycerin based explosive in conjunction with ANFO, initiated by ordinary detonator and detonating fuse. As the quarry is located at least 1 km from public facilities, the effect of air blast due to use of detonating fuse is not expected to be significant on the settlement. When need arises, the short delay firing technique will be adopted.

5.4 Haul road and ramp:

The haul road from the quarry face to the crushing plant shall be constructed at a gradient of 1 in 13 as the tipper trucks do not need to negotiate any uphill gradient. In order to maintain access to the mined out benches and operating benches, the narrow ramp with a gradient of not more than 1 in 10 will be maintained for people to climb up for restoration and plantation monitoring works. Such ramp is not shown on the drawings, however during actual implementation it shall be maintained.

5.5 Waste dump:

The dumping of waste rock and overburden will be done at the specified dumpsite. Barricade wall to arrest the undue erosion and maintain the stability of dump slope will be constructed. The dump will rest at the angle of repose. However where the dump

height exceeds 10m there will be break in slope with width of 4 metres after every 10m vertical height.

CHAPTER SIX
MINE PRODUCTION PLANNING

The output capacity from the two quarries is 700 MT per day or 210000 MT annually. It is relatively large scale of production under the local context.

The rock deposit is not proven to high confidence level, hence the risk of getting higher quantity of reject rocks exists, which can be confirmed after the rocks are exposed.

The stone production will commence at 890m level as this forms the ideal point from the development can start for optimum recovery of rock. There is minimum development and overburden removal. The development and removal of overburden will commence at the top portion of excavation area. The schedule of operation and production quantity during individual years from the first to the tenth year is provided in **Annexure 6.1**. The working bench levels are given for each year and the excavation will take place using top slicing method. The amount of area to be disturbed and cleared off vegetation for quarry works excluding the approach road construction is provided in **Annexure 6.2**. The index map of the area is provided in **Annexure 6.3**.

The mining benches are designed as shown on the maps provided under **Annexure 6.4 (I to VII)**. Mine plan drawings are attached at the end of this document. The sections have been provided along the Profile Line M-M' at the end of first year, fifth year and tenth year of quarry operation and are attached as **Annexure 6.5a to 6.5c**. The map has been plotted in 1:1000 scale and it becomes very easy for measurement to confirm the level difference and the slope.

Approximately 2% of the mine output of hard quartzite shall be despatched in the form of lumps directly from the quarry to the consumers. The rest of the stone shall be first transported to crushing plant, crushed to planned size ranges and despatched. The size ranges of the crushed aggregates are 20 to 40 mm, 10 to 20mm, 5 to 10 mm and below 5mm. The final output shall be despatched using public trucks.

CHAPTER SEVEN
MACHINERY AND EQUIPMENT SELECTION

7.1 The major operations in the proposed quarry include;

a) Drilling
b) Blasting
c) Excavation and loading
d) Hauling to crusher
e) Despatch to destination

a) Drilling and blasting:

The method of drilling and blasting, bench parameters has been discussed in the earlier chapter. The requirement of drilling equipment and its accessories have been computed based on the parameters provided.

Medium diameter shot holes (104mmΦ)

Number of integrated wagon drill used	=	1
Number of holes to be drilled per day based on production capacity	=	4
Total meterage drilling per day	=	22m
Yield per hole	=	183 MT

b) Blasting:

Daily explosive charge required	=	85 kg
Annual explosive requirement	=	26 MT
Number of ordinary detonators	=	300
Length of safety fuse required annually, in metres	=	500 m
Length of Detonating cord, in metres	=	11,800
Powder factor obtained	=	8.25

c) Excavation and loading:

The standard excavator used in Bhutan is with 1 cubic metre bucket capacity. The calculations have been done accordingly.

Bucket capacity, cubic metres	=	1.0
Total time for loading of dumper/tipper, minutes	=	12
Excavator capacity per year	=	87000 MT
Material to be loaded per year	=	210000 MT
Number of excavators/loaders required , including waste handling	=	4

d) Hauling to crusher:

This consists of transport of quartzite from quarry face to crushing plant

Distance to be hauled between quarry face to crusher, KM	=	2.85
Payload of tipper, MT	=	10

Quantity to be hauled per day, MT	=	700	
Number of tipper loads per day	=	70	
Tipper cycle time, min	=	40	
Quantity hauled per day per tipper, MT	=	99	
Number of tippers required,	=	10	including

requirement for disposal of overburden waste to the dump site.

The hard quartzite broken rock shall be transported from the mining faces with the help of tippers having 10MT capacity.

e) Despatch to destination:

The transport of lumps and aggregates shall be done totally by public trucks.

f) The auxiliary equipment & facility required shall include:

- Diesel tank (12000 litres capacity)
- Explosive magazine (5 MT capacity)
- Weigh-bridge
- Water supply
- Communication set
- Light vehicle
- Water sprinkler truck
- Bus

CHAPTER EIGHT
WASTE DISPOSAL PLANNING

The important aspects to be considered in waste dump management are the selection of site for dumping rejects from the mine. The waste dumpsite has been selected based on the following criteria:

- Topography of the dump site
- Extent of the quartzite band
- Output of waste and final product from the mine
- Access road to the quarries
- Method of excavation and haulage
- Drainage system at the dumpsite
- Natural drainage system and perennial water flow
- Existing land use and vegetation cover
- Stability of the area

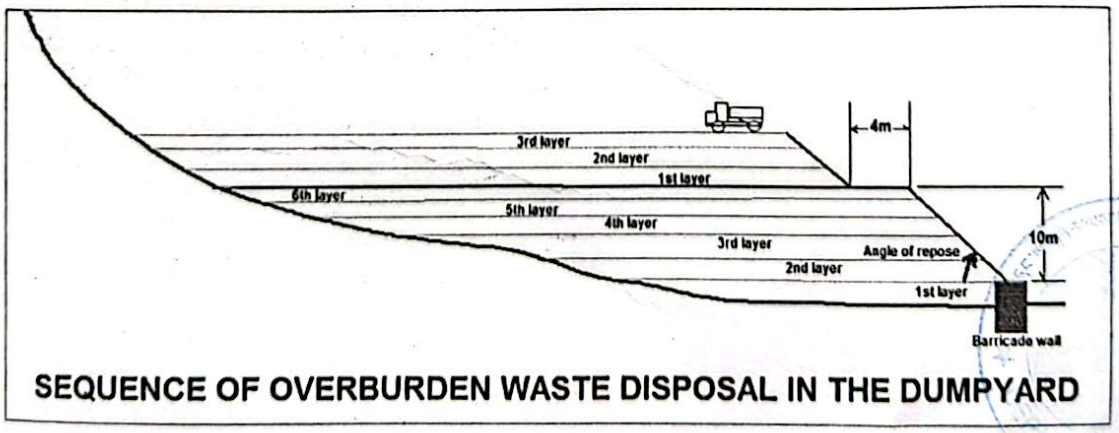
8.1 Method of overburden and waste dumping

The topography is moderately sloping in the proposed waste-dump site. The existing excavators and fleet of tippers will be used for hauling and dumping of overburden and waste to the dump site. The dumping will be done in horizontal layers and after each dumping layer the dump will be compacted with heavy equipment.

8.2 Configuration of waste dump

The waste dump shall develop like terrace with side slope resting at the angle of repose. Every after 10m high dump a terrace of width 4m shall be left to break the flow of rainwater and debris due to erosion of dumps, and for the ease of reclamation.

The top soil shall not be stored separately as there does not exist any top soil. The sites for waste dump are shown on the plans.



SEQUENCE OF OVERBURDEN WASTE DISPOSAL IN THE DUMPYARD

CHAPTER NINE

MANPOWER DEPLOYMENT AND MINE MANAGEMENT

The NRDCL management has decided that the quarry operation shall be outsourced to qualified and competent mining contractors. The contractors shall be made to operate the quarry in line with plans as provided in this report.

The main manpower to be recruited for environment friendly and scientific quarry operation include suitably qualified and experienced manager, foremen, supervisors and surveyor. The mines manager shall have the degree of Bachelor in Mining Engineering with practical field experience of at least three years. Other posts shall be held by the relevantly certified and experienced personnel. The helpers and casual workers shall be initially unskilled workers either employed in the regular payroll or on daily wage basis. The quarry shall be monitored periodically by the Mining Section at the company headquarters in Thimphu.

Administration (Head quarters)		Number
1	Mining Specialist/Mining Engineer	1
Management & Supervision (Mines)		
2	Quarry Manager (Mining Engineer)	1
3	Assistant Manager/Foreman (certificate +10 years experience)	2
4	Surveyor (Diploma in surveying)	1
5	Mine Supervisor (Certified)	4
6	Mechanical Foreman/Sr Mechanic	1
7	Stores Incharge	1
8	Accounts Officer/Accountant	1
9	Office Assistant (Despatch/Time Office)	2
10	Security guards	6
11	Messenger	1
Environment Monitoring and Management		
12	Environment Supervisor/Botanist	1
13	Helpers	3
Operators		
14	Blaster	1
15	Excavator operator	4
16	Drill operator	1
17	Tipper Operator	11
18	Mechanic	1
19	Excavator helpers	4
20	Blaster helper	1
21	Drill helper	1
22	Drivers	3
23	Weigh bridge clerk	1
24	Casual Workers (National), road maintenance crew	5
	Quarry total	**58**

The NRDCL shall ensure that the qualification, expertise and quarrying experience of the contractor shall be given due importance during the selection of the contractor. **The selection committee shall involve senior officials of Mining Division under the Department of Geology and Mines, Ministry of Economic Affairs, Royal Government of Bhutan.**

During the contractor selection process the NRDCL shall draw up a proper terms of reference for the contractors. As the scale of operation is huge the NRDCL management shall also ensure that **the quarrying works is continuously supervised by a qualified and competent mining engineer** recruited by the contractor in order to operate the quarry in environmentally friendly manner, as per the approved Final Mine Feasibility Study report and in accordance with the terms and conditions of the environmental clearance issued by the National Environment Commission on 12th October 2011 – a copy enclosed at the beginning of this document.

CHAPTER TEN
CAPTIAL INVESTMENT

10.1 Summary of Project Cost:

Sl. No.	Details	Amount (Nu)
1	Preliminary Expenses	1,034,987.00
2	Mine Development	1,987,000.00
3	Approach Road	4,167,710.00
4	Infrastructure	1,500,000.00
5	Machinery and Equipment	41,950,000.00
6	Ancillary	3,850,000.00
7	Working capital	7,411,953.00
	TOTAL	65,201,650.00

Capital expenses excluding working capital = Nu. 57,789,697.00
Equity capital = Nu. 23,115,879.00
Long term Loan = Nu. 34,673,818.00
Debt to Equity ratio = 3:2

10.2 Break-up of Project Cost

10.2.1. Preliminary Expenses: ~ **Nu. 1,034,987**

a. Geological survey and preparing geological report = Nu 55,000.00
b. Topographic mapping = Nu 759,987.00
c. Physical testing of rock quality = Nu 20,000.00
d. Quarry design/plans (Software cost up-loading) = Nu 150,000.00
e. Miscellaneous expenses = Nu 50,000.00

10.2.2. Mine Development: **Nu. 1,987,000.00**

The costs that are incurred at the quarry prior to start of actual quarry operation are incorporated as the mine-development cost. This shall include jungle clearance, overburden removal and disposal, barricade wall construction and diversion drain construction.

a) Jungle cutting and clearance, Area of 10500 m^2 Nu. 15,000
b) Overburden earth excavation and disposal, 23272m^3, over a lead distance of 3.5 km, Nu. 1,757,000
c) Construction of waste dump barricade gabion wall, 120 m long X 2m height X 2m width, [height above ground = 1m and below ground level= 1m] Nu. 200,000
d) Construction of catch drains (garland drains) : Digging the trench and lining with stone slabs, 30cm X 30 cm X 200m long, Nu 15,000

10.2.3. Approach Road: **Nu. 4,167,710.00**

Construction of 3.491 km road to quarry top including formation cutting, widening, drains, Nu. 4,167,710.00

10.2.4 Infrastructure cost: **Nu. 1,500,000**

Offices spaces	Nu 450,000.00
Stores	Nu 150,000.00
Residential	Nu 900,000

10.2.5. Mining Equipment

Sl. No.	Particulars	No	Rate (Nu)	Cost (Nu)
1	Excavators	4	5,500,000	22,000,000
2	Tipper/Dumper 10 tonnes capacity	10	1,400,000	14,000,000
3	Wagon drill machine	1	6,000,000	6,000,000
4	Water Sprinkler tanker	1	1,500,000	1,500,000
5	Light Vehicle	1	650,000	650,000
6	Rock breaker	1	1,100,000	1,100,000
	Total			**45,250,000**

10.2.6 Ancillary facilities

Sl. No.	Particulars	Cost (Nu)
1	Explosive magazine	1,000,000
2	Water supply	200,000
3	Office, IT equipment & Furniture	300,000
4	Bus for children	1,800,000
5	Communication equipment	300,000
6	Fuel tank	250,000
	Total	**3,850,000**

The capital cost for crusher and its accessories and infrastructure is excluded from this report. The quarry will supply the raw material at the crushing plant site.

CHAPTER ELEVEN

PRODUCTION COST

This is the operating cost of the quarry for production of stone boulders for supply to crushing plant. It has been computed based on the scenario where the quarry is fully outsourced, with periodic monitoring by the company officials.

The details of the annual operating costs are estimated below.

11.1 Salary and Wages:

The total monthly salary and wages are computed below-

Management & Supervision		Number	Salary per head (Nu)	Total salary per month (Nu)
1	Quarry Manager (Mining Engineer)	1	40000	40000
2	Assistant Manager/Foreman (certificate +10 years experience)	2	20000	40000
3	Foreman (Mechanical)	1	20000	20000
4	Mine Supervisor (Certified)	4	15000	60000
5	Stores Incharge	1	15000	15000
6	Accounts Officer/Accountant	1	15000	15000
7	Office Assistant (Despatch/ Time Office)	2	7500	15000
8	Security guards	6	6000	36000
9	Messenger	1	5000	5000
Environment Monitoring and Management				
10	Environment Supervisor	1	15000	15000
11	Helpers	3	4500	13500
Operators & helpers				
12	Excavator operators	4	9000	36000
13	Excavator helpers	4	4500	18000
14	Tipper operators	9	7500	67500
15	Blaster	1	12000	12000
16	Drill operator	1	12000	12000
17	Drivers	3	6000	18000
18	Mechanic	1	9000	9000
19	Drill helper	1	5000	5000
20	Blaster helper	1	5000	5000
21	Weigh bridge clerk	1	5000	5000
22	Casual Workers	5	4500	22500
	Total Manpower requirement	53		499,500

Annual salary and wage = Nu. 5,994,000
Allowances, overtime, incentives, travel, 45% = Nu. 2,349,300
Total salary & allowance for 1st year = Nu. **8,343,300**

11.2 Fuel and spares

Nu 15,779,823.00

Sl. No.	Particulars	No	Total work / month	Fuel consumed (Litres)	Fuel cost (Nu)	Spare & Lub. Cost (Nu)	Total monthly Cost (Nu)
1	Excavator	4	700	11200	459,200	229,600	688,800
2	Tipper	10	15720	6,288	257,804	128,902	386,706
3	Wagon drill	1	125	2,500	102,500	76,875	179,375
4	Jeep Bolero	1	1500	250	10,250	5,125	15,375
5	Water Sprinkler	1	1000	444	18,222	9,111	27,333
6	Bus	1	1250	500	20,500	10,250	30,750
7	Rock Breaker	1	200	-	-	25,000	25,000
8	Drill rod	1	525	-	-	12,000	12,000
9	Drill bit	1	525	-	-	15,000	15,000
	Total			19,644	746,461	421,980	1,380,340

Add 10% variation – contingency, per month 138,034.00
Total monthly cost of fuel & spares 1,518,374.00

11.3 Repair and maintenance: Machines

This cost involves the repair and maintenance of different machinery and vehicles deployed in the mine. Assuming that the equipment cost is Nu 44 million, the estimated repair and maintenance cost per year is 0.1*44,000,000 ~ **Nu 440,000.00**

11.4 Repair and maintenance-Road:

For the initial 2 years the repair and maintenance of access road to the quarries has been estimated at **Nu 150,000** and increases progressively reaching **Nu 500,000** on 10th year.

11.5 Mineral levy:

The mineral levy will consist of royalty, mineral rent and surface rent. The calculations will be as follows:

Levy type	Rate	Annual Amount (Nu)
Surface rent	640	41,687
Royalty	2.2	462,000
Mineral rent	0.55	115,500
TOTAL		**619,187**

11.6 Environment management and re-vegetation:

A sum of Nu 1,600,000 is proposed for carrying out progressive environment management and revegetation of mined out areas and stabilised waste dumps on annual basis.

11.7 Environmental restoration fund:

An annual sum of Nu **500,000** shall be set aside as environmental restoration bond as per requirement of regulations under Mines and Minerals Management Act 1995. This sum will be deposited in the account for environmental restoration bond fund for the first 5 years of *10 years'* mining lease. In total Nu **2,500,000** shall be reserved for future mine reclamation and closure *within the lease period.* This total amount has been calculated and is provided in Volume II- Environment Management Plan. The additional amount is not required.

11.8 Depreciation and amortisation:

The fixed assets procured or constructed by the company will be depreciated over a period of 5-10 years. Item-wise and year-wise depreciation amount is provided in the **Annexure 11.1**. The first year depreciation amount is Nu 8.846 million.

11.9 Overhead (administrative and general) & other costs:

The monthly overhead on administrative and other overhead have been estimated to Nu. 250,000. Thus, the annual overhead cost = **Nu. 3,000,000**

11.10 Explosives

Sl. No	Explosive material	Quantity	Amount (Nu)
1	High explosive, Kg	3183	161,904.00
2	Ammonium Nitrate, Kg	22282	1,054,250.00
3	Detonators required per year, Nos	300	2,000.00
4	Detonating Cord, m	11805	96,000.00
5	Safety fuse required per year, metres	500	3,645.00
6	Fuel oil	-	19,000.00
	TOTAL (Annual)		**1,336,799.00**

Summary

The cost per MT of stone from the quarry delivered at the crushing plant for a year 90% capacity utilisation = Nu 44735251/189,000 MT = Nu 236.69

Profit, 5% = Nu 11.83

Sub-total landed (price) per MT at crushing plant = Nu 248.52

Cost per cubic feet of rock landed at C.P. = Nu 9.94

Profit of nominal 5% has been included to provide for profit of the contractor when the quarrying activity is outsourced. The material from the quarry shall be supplied to the crushing

plant. The financial analysis is carried out separately for the quarry considering it to be operated as separate activity which supplies raw material to crushing plant at **Nu 10.00** per cubic feet. The lumps shall be sold to the market at a rate of Nu 250 per metric tonne (Nu 2500 per truckload) with 5% margin of profit over the cost of production.

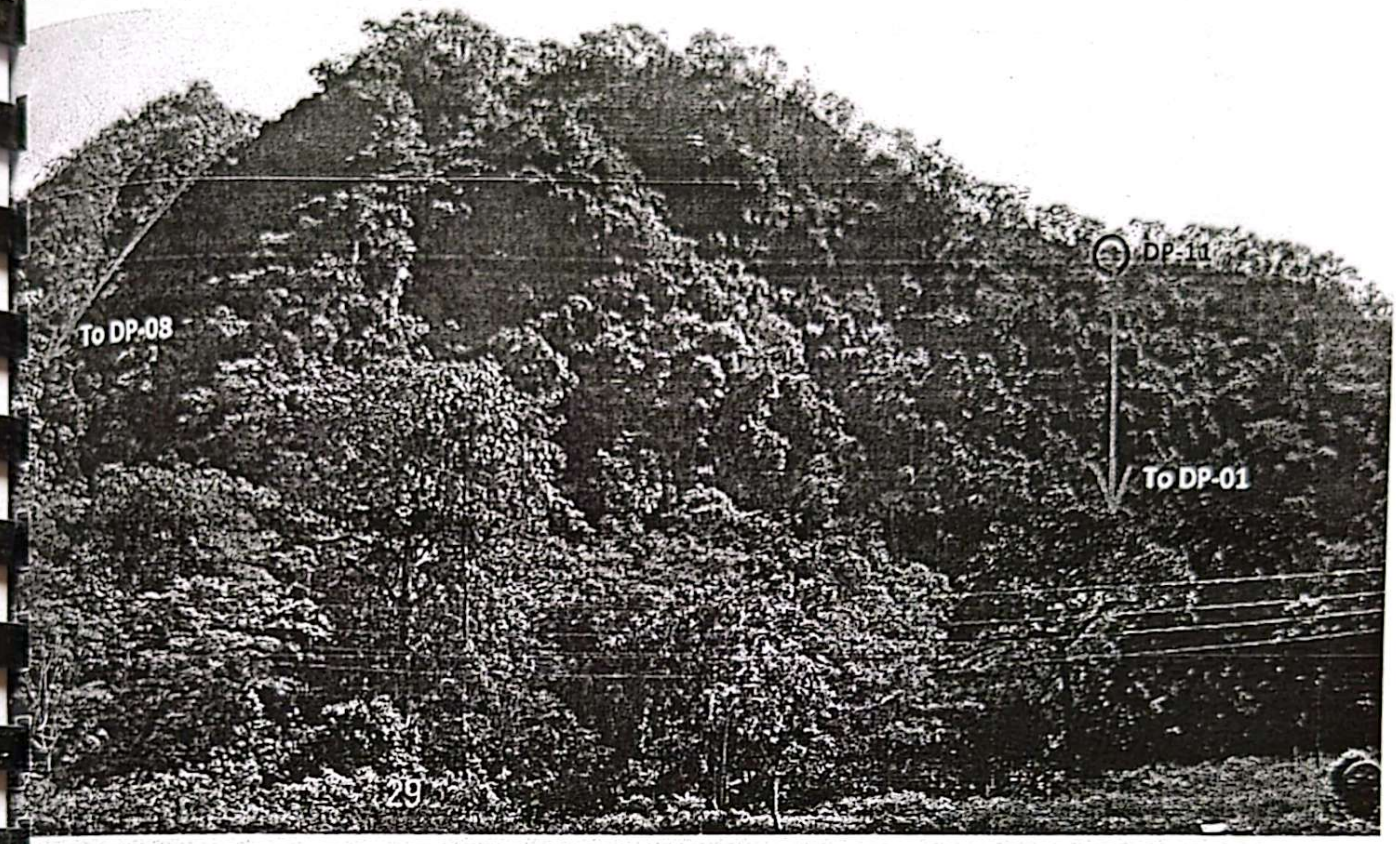
CHAPTER 12
PROFITABILITY AND CASH FLOW

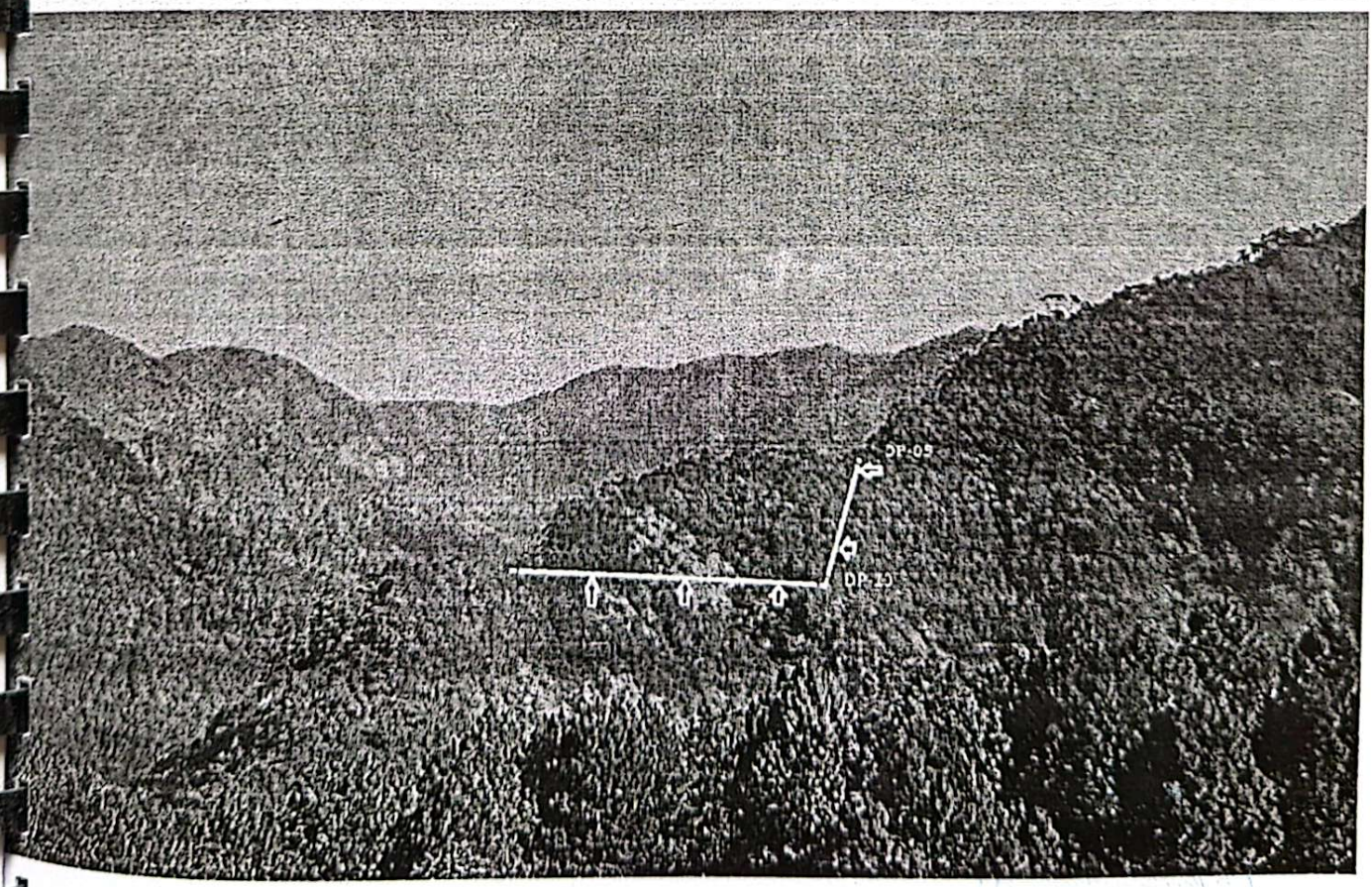
The profitability statement has been generated to assess the financial viability of the quarrying project. The statement has been prepared for 10 years operation. From the attached **Annexure 12.1,** it can be noticed that the venture is profitable from the 5th year of operation. During 2012 (1st year) the target production and sale is expected to be minimum at 60% of target capacity. The cash-flow statement is provided in **Annexure 12.2.** The Loan and its repayment and the interest are computed in **Annexure 12.3.**

The summary of financial performance is as follows:

1. Internal Rate of Return = 41.46%
2. Net present value = Nu 80.61 million
3. Return on equity = 349%
4. Return on investment = 139%

ANNEXURE 1.1: PERSPECTIVE VIEW OF PROPOSED QUARRY SITE





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ROYAL GOVERNMENT OF BHUTAN
MINISTRY OF WORKS & HUMAN SETTLEMENT
STANDARD & QUALITY CONTROL AUTHORITY
THIMPHU: BHUTAN

SQCA
Ensuring Quality Construction
MATERIAL TESTING & RESEARCH DIVISION

Date: 21/12/2010

TEST RESULT

A. CLIENT/CUSTOMERS DETAILS:

1. Name of Client / Organization/Contractor: NRDCL
2. Name of works/project: Testing of Aggregate
3. Location of works/project: -

B. SAMPLE DETAILS:

1. Sample type/No.: Aggregate
2. Source of sample: Homdor Tingtibi, Zhemgang
3. Collected /Inspected /delivered by: Client
4. Date collected/inspected/delivered: 9/11/2010

C. TEST DETAILS:

1. Test conducted by: Tandin Choden
2. Date of field test: 14/12/2010

Sl. No.	Tests type	Results obtained	Specification as per IS codes
1	Aggregate Crushing Value	25.95%	◦ Not exceed 45% for cement concrete other than wearing courses ◦ Should be less than 30% for cement concrete wearing course such as runways, roads and pavements
2	Aggregate Impact Value	16.54%	• Surface<10 % Exceptionally strong • 10 - 20 % Strong, • 10 - 30 % Satisfactory for road surfacing, • 30-35% suitability to be decided in conjunction with other test parameters, >35% weak for road s

Pema Wangmo
(Junior Engineer)

Lotay Tenzin
(Exe. Engineer)

Thimphu, Bhutan. Tel: +975-2-326843/325104; Telefax: 323712/327759; E-mail: stdunit@sqcd.gov.bt; qaulab@sqcd.gov.bt; sqca@druknet.net.bt; Website: http://www.sqca.gov.bt

Phunatsangchhu-I Hydroelectric Project.
Quality Control Wing,
Statement showing the test result of rock samples received from NRDC.

Sl. No.	Test result						Remarks
	Samples Designation	Specific Gravity	Water Absorption	Aggregate Impact Value	Aggregate Crushing Value	Aggregate Abrasion Value	
1	NRDCL/1/J-3	2059	0.80	31.75	32.01	50.62	Unsuitable for use as coarse aggregate in concrete. However, may be used in masonry works
2	NRDCL/4/H-3	2.64	0.50	26.98	Could not be tested due to less materials	39.71	Suitable for non wearing surface only
3	NRDCL/11/P-1	2.66	0.40	26.35	27.87	29.86	Suitable for wearing as well as non wearing surface
4	NRDCL/12/A-1	2.65	0.30	24.25	Could not be tested due to less materials	29.72	Suitable for wearing as well as non wearing surface
5	NRDCL/13/S-1	2.72	.040	23.27	-do-	32.00	Suitable for non wearing surface only
6	NRDCL/14/H-3/2	2.64	0.50	24.05	-do-	42.86	Suitable for non wearing surface only (this samples was not mentioned in the letter but given in the main laboratory of PHPA)

Attention to GM, mining
From Rama, Mgr. Sand.
22.7.15

BRAHMAPUTRA CONSULTANTS AND TECHNOCRATS

FATASIL AMBARI, GUWAHATI-781 025
(Regd. No.:RF/KM/143/514 of 1997-98)
94353-03112, 94355-52579 (M)

REF NO.: BCT/BHU/10-11/01 Date. 12/03/2011

Sub:- Physical tests of stone sample.

Name of Client:- M.K. Pradhan, Mining Specialist, National Resource Development Corporation Ltd., Royal Government of Bhutan, Thimphu, Bhutan.

Ref. Your Letter No. NRDCL/HQ/Prod/Min/2011/619 dt. 07/03/2011

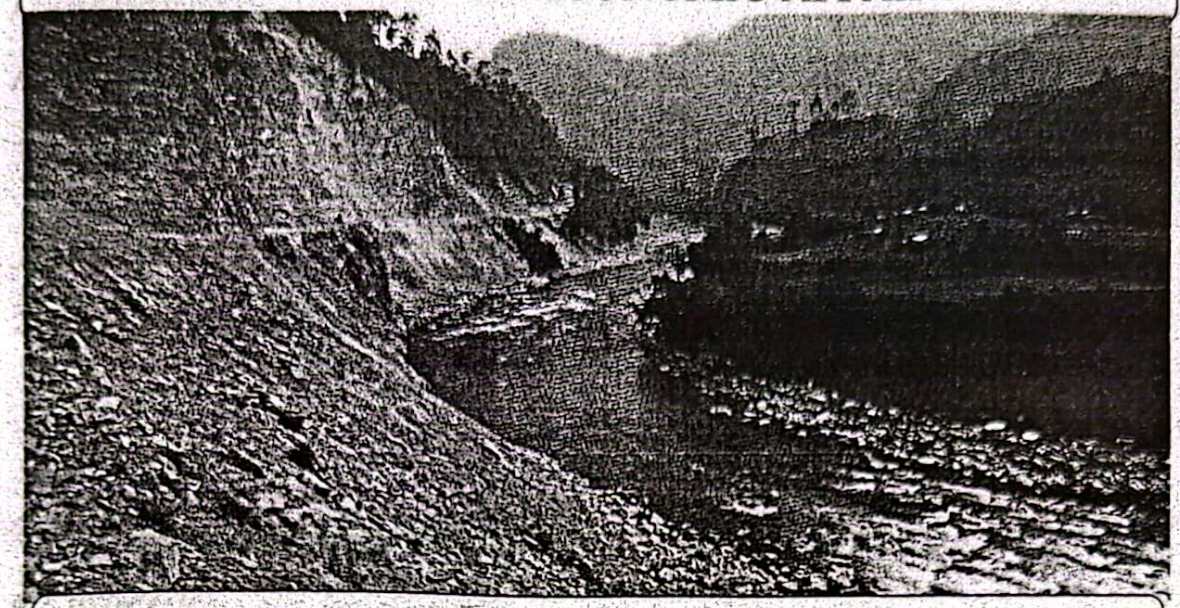
Sl No.	Identity Mark	Obtained Results				Specification	Remarks
		Los-Angeles Abration %	Aggr. Impact Value %	Aggr. Crushing Value %	Specific Gravity Test		
6	NRDCL-4a	-	25.00	-	-	Relevent Test done as per IS 2386 Pt. IV	Sample supplied by the clients in sealed condition
7	NRDCL-4b	18.20	-	28.66	-		
8	NRDCL-5a	30.90	-	-	-		
9	NRDCL-5b	-	-	31.20	-		
10	NRDCL-6a	25.81	27.63	24.73	-		

For M/s. BRAHMAPUTRA CONSULTANTS AND TECHNOCRATS

Scientist/Director (Tech.)

M/s Brahmaputra Consultants and Technocrats Sevi Bari Path

ROYAL GOVERNMENT OF BHUTAN
MINISTRY OF ECONOMIC AFFAIRS



Report on the Geological Studies carried out on stone quarry (construction material) at Homdar area Tingtibi Geog under

Kharka. S Ghalley (Sr. Geologist)
Glaciology Division.
Department of Geology and Mines

Edited:
Ugyen Wangda (Head/Chief Geologist)
GSB, Department of Geology and Mines.

Table of Content

Acknowledgement

Author thankfully acknowledged his sincere gratitude to Head/Chief Geologist, GSB, Department of Geology and Mines, for constant technical guidance with supportive suggestions on both in field as well as editing the report in presentable form for Homdar stone quarry. The author would like to extend his sincere gratitude to Director General, Department of Geology and Mines. Secondly, author also would like to thank the Kalchakra Consultency for taking care all logistic related to present assignment and making possible to complete geo. & Topo-survey work in stipulated time.

Abstract

Department of Geology and Mines carried out geological study on stone quarry (construction material) at Homdar area Tingtibi Geog under Zhamgang Dzongkhag. The studied area falls within geographical co-ordinates: 1042600 to 2811800 in the part of Topo-sheet No. 78I/12 of National Land Commission.

Homdar stone quarry where study was conducted falls within the undifferentiated meta-sediment of Black Mountain Group (Tethyan meta-quartzite).This litho sequence is exposed from the south of Tingtibi and remains continues up to Dakpai feeder road bifurcation point exhibiting variation sedimentary facies including the intra-formational conglomerate band towards the lower part of this sediment.

The assignment was carried out on deposit work basis and initiated the field work since last week of December 2010 and continues up to Jan, Feb 2011 vides their letter no. NNRDCL/HQ/MIN/2/2010 of dated 02 October 2010. Geological -mapping and topographical survey were carried out simultaneously on the **scale of 1: 1500** with **5m contour interval** covering an area approximately **34.13 hectares** inclusive of **10%** of adjacent areas including **dumped yard and staff colony** in the proposed stone quarry.

The rock types encountered during investigation are bedded to massive quartzite exhibiting fined to medium grained dirty-white ash-grey colored; the same quartzite horizon at time shows the colored variation with gritty nature, except minor laminations, quartz veins and pegmatite intrusions the rest appears to be more or less homogeneous strata thorough out the proposed stone quarry site.

In-situ geo-reserve has been estimated as 1.49 **million tones** based on surface geo-field data collected during the investigation using the geological cross sectional method.

1.0 Introduction

Department of Geology and Mines carried out geological investigation on stone quarry (construction material) at Homdar area Tingtibi Geog under Zhamgang Dzongkhag. The assignment was carried out on deposit-work basis and field work initiated since last week of December 2010 and remains continues till the completion of work vide letter no. NNRDCL/HQ/MIN/2/2010/797 dated 2nd December 2010. The office of NRDCL approached to Department of Geology and Mines for geological and topographical study on identified stone quarry for construction material. As such client has several stone quarry sites in various regions including the present site. Accordingly NRDCL selected the identified sites on priority basis.

The geological and Topo--mapping carried out simultaneously on **scale 1: 1500** with **5m contour interval** covering an area **34.13 Hectares** inclusive of **10%** adjacent area including **dumped yard and staff colony** in the proposed stone quarry.

The rock types encountered during investigation are mostly homogeneous quartzite horizon (gray-wake/arkosic) sequence with various quartz pegmatite intrusions. The minor flaggy types of interbandings are frequently observed within the massive band. Dark-grey color quartzite exposed at the bottom line of standing cliff which is followed by ash-grey fined to medium grained massive quartzite band.

Prior to the initiation the detail work in targeted site, a wider area scanning have been conducted to establish the regional geological set-up on scale 1:50,000 based map (Topo-sheet 78M/4) and set up the litho succession in the area besides local geology, and other aspects on stone quarry: material types with susceptibility to weathering quality and quantity of economically workable material are also studied. The geological cross-sections across the strata were drawn keeping equal interval to calculate the in-situ geo-reserve. A few photographs attached for ready reference with the report.

Trend (attitudes) of rock NW (north-western flank) flank of ridge mainly towards cliff bottom strike N30°E-S30°W to N80°E-S80°W with dip amount ranges from 15° to 40° towards SE direction whereas on the eastern flank including ridge strike N40°W –S40°E to N85°W-S85°E with dip amount ranges from 20° to 50° towards NE direction. However, the outcrop in general appears to be homogeneous and due to presence of recumbent fold the rock attitude measured is not constant.
In-situ geo-reserve has been worked-out based on the interpretation of surface geological data using the geological cross sectional method.

1.1: Location and Accessibility:

The mapped area forms a part of Topo-sheet No 78/I/12 under Zhamgang Dzongkhag and the approximate geographical co-ordinates: 1042500 and 2811800 (UTM) in the National Land Commission.

Investigated area can be accessible from the Tingtibi as it is located on opposite of Tingtibi Township (left bank of Dakpai Chu), which is connected by approximately 2km footpath from Tingtibi township area.

1.2: Climate and Vegetation:

Studied stone quarry lies under sub-tropical mountainous climate. Homdar Tingtibi area experiences heavy rain precipitation during monsoon and comparatively hot and windy spring. It is located next to the Geylephug-Trongsa national highway. Because of humid climatic condition it has great varieties of sub-tropical vegetations which consist of various species of broad leaves trees and bamboos/creepers with thick under growths.

Homdar ridge (Tingtibi area) lies in mid Himalayan region. Due to geographical location and nearness of major river valley forms a comfortable home of large varieties of poisonous/allergic grasses, insects, and wild animals like wild-bores, barking deer, rain-deer, wild-cats and leopards with large verities of bird species.

1.3: Method& objectives:

Before to initiate fieldwork the team had to gathered required literatures pertaining to assigned work and trying to find out the exact location on topo-sheet (1:50,000). Beside that extensive desktop study had been carried out and prepared the working sheets on convinces scale and sizes. Lastly team left for camp with necessary equipments to Homdar Tingtibi Geog, under Zhamgang Dzongkhag.

In order to find out geologic set-up in region, team took several geo-traverses studying the rock types as well as measuring the orientation of beddings foliations. The environment impacts on surrounding areas have been taken into due account from the geological point of view while finalizing this report.

The objective is to locate the suitable stone quarry and field verification on quality which is considered for suitable material for the construction purposes. And it is also suggested to conduct technical tests for suitability and find out whether or not they fulfill the required specification from construction agencies and availability of sufficient quantity.

1.4: Geomorphology.

Bhutan is a small part of higher Himalayas which has the continuous chain of younger mountain ranges of south-eastern portion of Himalayas. Landscape pattern is mostly controlled by erosion activities, geo-structural phenomena including the frazzled litho succession. The prominent ridges are frequently dissected by the perennial river systems with deep gorges and valleys.

2.0: Geology:

Higher ranges that are made up of various tectonic set-up along major geo-sections and express themselves, as Lower (Lesser) Higher (Greater) Himalayan sequence under three major physiographic sub-divisions and those tectonic divisions are separated from each other by the low angle fault/Thrust (B.S.Jangpangi 1983-84).

The geology of the Maokhola Group has been broadly divided into the following divisions (formation) based on its depositional history: Nake-chu Formation, Tirkhola Formation and Hara-chu Formation

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Nake-chu Formation: (Lower Ordovician) — White thickly bedded fine to medium grained ortho-quartzites with thin phyllitic bands, stretched pebbled-conglomerate and basal conglomerate (bigger pebbles) in southern part.

----------UNCONFORMITY----------

Tirkhola Formation (Cambrian)

Member D: Dark-grey carbonaceous phyllites and slates with grey quartz-sericite-phyllite.

Member C: Greyish–green thickly bedded sub gray-wacke, arkosic quartzites and grey micaceous quartzite with development of poor foliation. Thin argillaceous interbands with development of biotite porphyroblasts.

Member B: Brown and buff calcareous quartzites with thin limestone bands and greenish white quartzites.

Member A: Thickly bedded greenish grey sub greywacke, arkosic quartzite and micaceous quartzites with thin interbands of phyllites quartz biotite schists, intrusive basic sills, amphibolites and tourmaline granites.

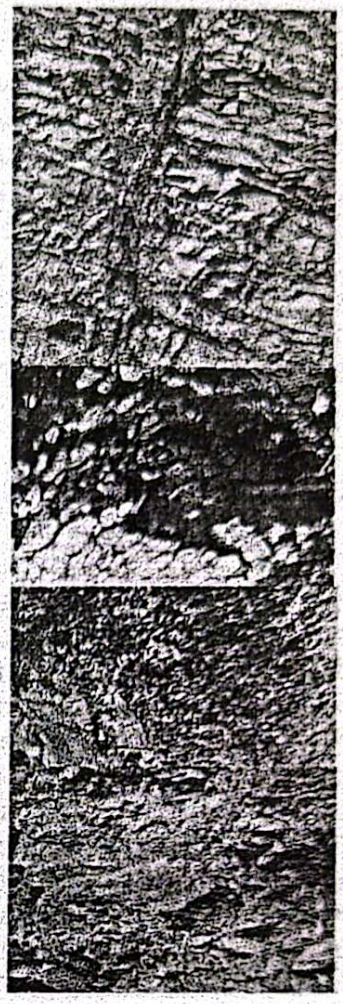
----------GRADATIONAL CONTACT----------

Hara-chu Formation: — Grey, greenish grey, pale, buff and grayish brown calc-phyllites impure crystalline limestone,marble etc. Thin argillaceous and arrenaceous (sub greywacke) bands present. Essentially calcareous, Intrusive tourmaline granites present.

----------GRADATIONAL METAMORPHIC CONTACT----------

2.1: Regional:

Tethyan basement is believed to be High Grade Crystalline Complex and as well as Chekha Sequence. The litho succession encountered in the investigated area belongs the rocks of higher stratigraphic level under Chekha Group, exhibiting the various stages of structural complication. Some of the upper most litho packages under the same sequence are fossiliferous-crystalline-limestone, black-slate, carbonaceous-shale at the higher level. Normally towards the basal part of Chekha sequence expressed the fresh water sediments in its depositional environment. And at certain geo-sections these meta-sediments exhibits inverted metamorphism because of the presence of out of sequence structure below the STDS. The quartzite horizon exhibits the persistent strike extension with intra-formational stretched pebbles conglomerate band at basal part.



2.2: Homdar area Tingtibi:

Homdar ridge lies along left bank of a small tributary of Mangdue chu (Dakpai river) forming small ridge with approximate elevation ranges from 574 to 875 m. from msl. The working team had conducted several geo-traverses in order to understand the local as well as regional geology of the area for the final interpretation of geological map.

The main constitutes of this litho-package is thin to thickly bedded and massive types find to medium grained_ash-grey quartzite, intercalated chlorite/sericitic phyllite common in the horizon. The thin laminations of the arrenaceous/arkosic layers expressed the pronounced orientation of the bedding and foliation planes. Medium to wide spaced joint sets and deep fractures zones appears to be quite penetrative as result, lot of fallen scree pilled up along slope bottom on both sides of the ridge.

General trend (attitudes) of rock shows strike N25°E-S25°W to N80°W-S80°E with dip amount ranges from 20° to 50° towards SE and NW direction. However the strike and dip of these quartzite horizons are not constant, varies frequently specially on northern flank of mapped area dip noted reversed direction it is because of folding (recumbent) The quartzite band exhibits gritty types, brittle nature and very friable on the exposed outcrop.

2.3: Weathering

The proposed stone quarry is covered-up by lots of loose boulder rubble of various sizes as overburden with organic decayed. There are sporadic high standing trees of pine-species with small undergrowth. Huge boulders of various sizes are scattered all over the ridge including the either slopes. These rocks are highly susceptible on atmospheric weathering as it is cropping out vertical to near vertical cliff on adjacent area. The sets of joint, fractures and sheared zones shows comparatively wide spaced with lot of infill materials, and those materials (rubbles/boulders and organic decayed) blanketed over the whole ridge are seems to be loosely packed in nature. The shearing, undulations and wrapping are some of the common phenomena observed in the field.

2.4: Construction material

Since the hard-stone were used throughout human civilization history as tools, decorative items and as raw material for industrial manufacturing. Materials of value that man extracts from earth in order to carry out their development activities are some of the industrial rock and mineral, on other hand rock which has high value and having high weathering resistance or can withstand prolong atmospheric condition are good construction material and can be considered as construction material deposit, thus they have their own commercial rank in manufacturing industries. And to meet the other geo-technical parameters on certain standardization for construction purposes depends on the individual project specification published by user organization.

Mining engineer also associated with visiting team to carry out related issues like mines-viability, instability of access road and to demarcate the leasing area for stone quarry. The exposed outcrops are physically checked on the spot to find out the material suitability for construction purposes, and to assess the total workable material available with some effective recommendation on environment impact posed by mining activities.

3.0: In-situ geological reserve

Rocks in Homdar hillock (ridge) are more or less homogeneous exposed continuous strike extension and approximately hundred m. thicknesses. In-situ geo-reserve has been estimated using cross sectional method. The geological cross sections were drawn sequentially from west to east across the geo-strata at regular interval.

Area of effective influence has been taken as half distance on either side of each section line. The dip direction as measured from field is against the ridge line; obviously the overburden ratio becomes the minimum. The depth persistence 25m.for this band has been assumed based on exposures on either side of ridge to estimate the geo-reserve. The total extractable construction material within demarcated area has been worked out with an average density of rock (quartzite) 2650kg/m without any sub-surface geological-data.

In-situ geological-reserve table

SL No	Geo/ section	Strike Length (meters)	Thickness (meters)	D/Persistence (meters)	Sp.Gr.for Quartzite	Metric tones
1	A-A'	85.00	90.00	20.00	2.65	**381600**
2	B-B'	100.00	125.00	20.00	2.65	**636000**
3	C-C'	100.00	130.00	20.00	2.65	**662500**
1756950						

Total geo-reserve figure without any deduction is of **1756950** as construction material estimated from three geo-cross sections drawn across strata.

The total extractable geo-reserve worked-out 1.49 **million tones** after allowing **15%** deduction. Geological-reserve figure as mentioned in column is estimated based on the interpretation only on surface geological-data from field; therefore author is not responsible for any major variation that might occur during actual excavation.

4.0: Conclusion

Homdar stone quarry under Tingtibi Geog can be reached by approximately 2km. footpath from Tingtibi township on the left bank of Dakpai River which is located along the Geylegphug Trongsa national highway before Zhamgang Dzong.

Low grade undifferentiated meta-sedimentary series of quartzite occurrence at Homdar ridge physically appears to be strong enough on local and as well as other civil engineering structures for construction purposes. The ash-grey quartzite exhibits high hardness/toughness/gritty and brittle types, commonly compact in nature, as a result rock seems to be resistance to withstand longer enough duration on atmospheric weathering.

The construction material produced from any stone quarry may contain a variable amount of unwanted materials (fines particles) which depends upon various reasons on source rock.

To meet wider range of standard specification of building material it has to conduct a series of geo-technical tests to determine the required specification by the consuming organization which depends upon type of civil engineering structures with their own standard specifications.

Plate no 1: Location map of the stone quarry (C/material) at Homdar area Tingtibi geog, under Zhamgang Dzongkhag. (1:50,000)

ANNEXURE 3.2: LEVELWISE RECOVERY OF STONE AND WASTE

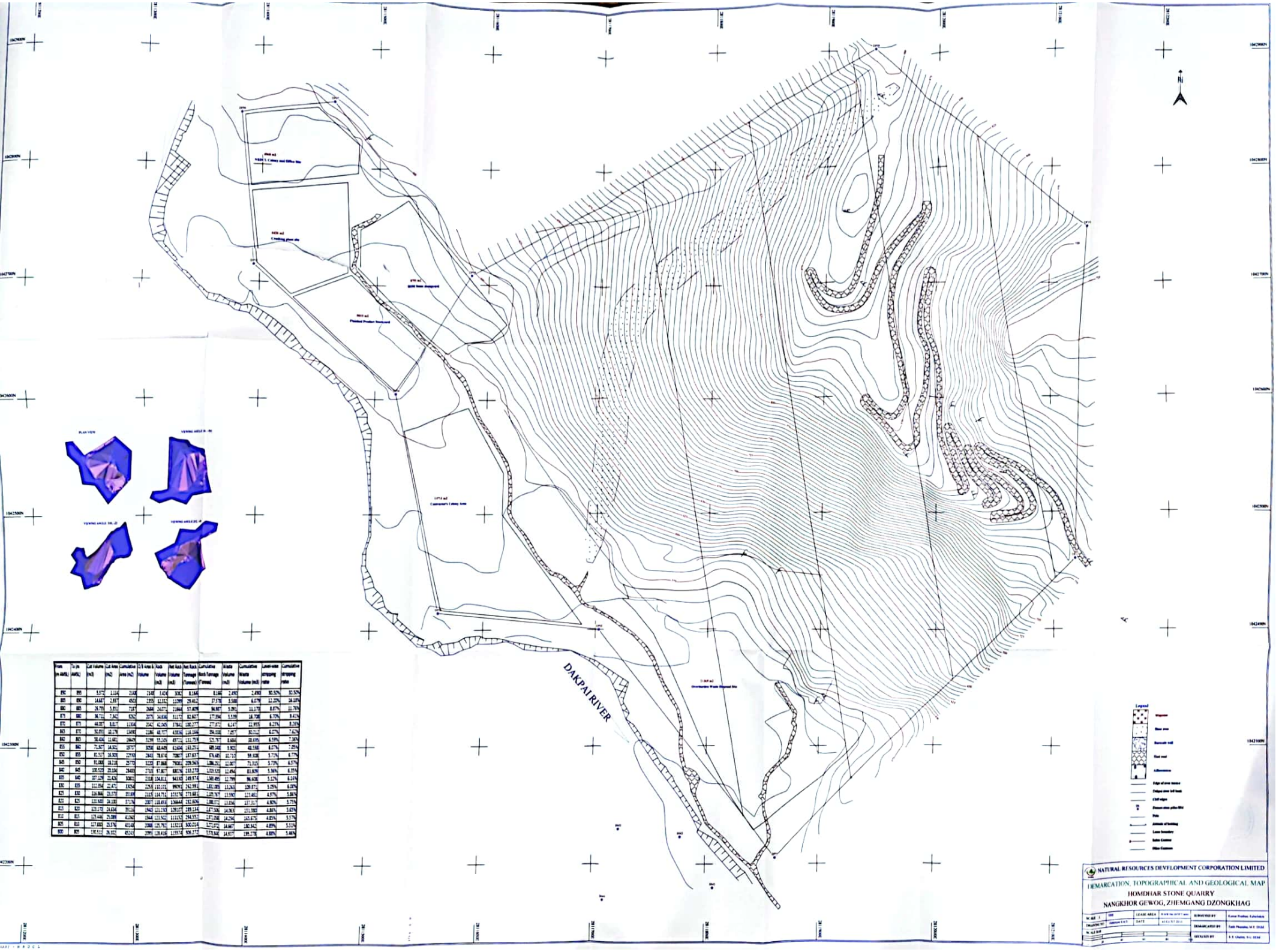
From (m AMSL)	To (m AMSL)	Cut Volume (m3)	Cut Area (m2)	Cumulative Area (m2)	O/B Area & Volume	Rock Volume (m3)	Net Rock Volume (m3)	Net Rock Tonnage (Tonnes)	Cumulative Rock Tonnage (Tonnes)	Waste Volume (m3)	Cumulative Waste Volume (m3)	Level-wise stripping ratio	Cumulative stripping ratio
890	895	5,572	1,114	2148	2148	3,424	3082	8,166	8,166	2,490	2,490	30.50%	30.50%
885	890	14,687	2,937	4503	2355	12,332	11099	29,412	37,578	3,588	6,079	12.20%	16.18%
880	885	26,755	5,351	7187	2684	24,071	21664	57,409	94,987	5,091	11,170	8.87%	11.76%
875	880	36,711	7,342	9262	2075	34,636	31172	82,607	177,594	5,539	16,708	6.70%	9.41%
870	875	44,087	8,817	11304	2042	42,045	37841	100,277	277,872	6,247	22,955	6.23%	8.26%
865	870	50,893	10,179	13490	2186	48,707	43836	116,166	394,038	7,057	30,012	6.07%	7.62%
860	865	58,404	11,681	16649	3159	55,245	49721	131,759	525,797	8,684	38,695	6.59%	7.36%
855	860	71,507	14,301	19707	3058	68,449	61604	163,251	689,048	9,903	48,598	6.07%	7.05%
850	855	81,517	16,303	22550	2843	78,674	70807	187,637	876,685	10,710	59,308	5.71%	6.77%
845	850	91,088	18,218	25770	3220	87,868	79081	209,565	1,086,251	12,007	71,315	5.73%	6.57%
840	845	100,520	20,104	28483	2713	97,807	88026	233,270	1,319,520	12,494	83,809	5.36%	6.35%
835	840	107,129	21,426	30801	2318	104,811	94330	249,974	1,569,495	12,799	96,608	5.12%	6.16%
830	835	112,354	22,471	33054	2253	110,101	99091	262,591	1,832,085	13,263	109,871	5.05%	6.00%
825	830	116,866	23,373	35169	2115	114,751	103276	273,681	2,105,767	13,590	123,461	4.97%	5.86%
820	825	120,500	24,100	37176	2007	118,493	106644	282,606	2,388,372	13,856	137,317	4.90%	5.75%
815	820	123,170	24,634	39116	1940	121,230	109107	289,134	2,677,506	14,063	151,380	4.86%	5.65%
810	815	125,446	25,089	41060	1944	123,502	111152	294,552	2,972,058	14,294	165,675	4.85%	5.57%
805	810	127,880	25,576	43148	2088	125,792	113213	300,014	3,272,072	14,667	180,342	4.89%	5.51%
800	805	130,511	26,102	45243	2095	128,416	115574	306,272	3,578,344	14,937	195,278	4.88%	5.46%

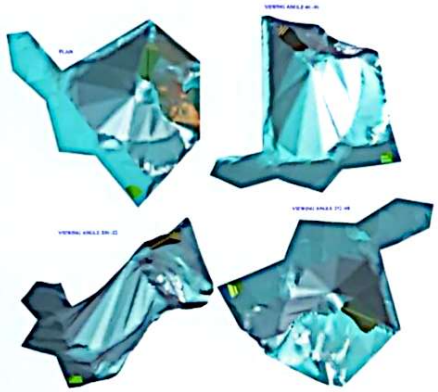
ANNEXURE 6.1: YEARWISE PRODUCTION SCHEDULING FOR 10 YEARS

Year	From (m AMSL)	To (m AMSL)	Cut Volume (m3)	Cut Area (m2)	Cumulative Area (m2)	O/B Area & Volume	Rock Volume (m3)	Net Rock Volume (m3)	Net Rock Tonnage (Tonnes)	Cumulative Rock Tonnage (Tonnes)	Waste Volume (m3)	Cumulative Waste Volume (m3)	Level-wise stripping ratio	Cumulative stripping ratio
I	890	895	5,572	1,114	2148	2148	3,424	3082	8,166	8,166	2,490	2,490	30.50%	30.50%
	885	890	14,687	2,937	4503	2355	12,332	11099	29,412	37,578	3,588	6,079	12.20%	16.18%
	880	885	26,755	5,351	7187	2684	24,071	21664	57,409	94,987	5,091	11,170	8.87%	11.76%
	875	880	15,078	3,016	9262	2075	13,003	11703	31,012	126,000	3,375	14,545	10.88%	11.54%
II	875	880	21,633	4,326	9262	0	21,633	19470	51,595	51,595	2,163	2,163	4.19%	4.19%
	870	875	44,087	8,817	11304	2042	42,045	37841	100,277	151,872	6,247	8,410	6.23%	5.54%
	865	870	4,546	909	13490	2186	2,360	2124	5,628	157,500	2,422	10,832	43.04%	6.88%
III	865	870	46,347	9,270	13490	0	46,347	41713	110,539	110,539	4,635	4,635	4.19%	4.19%
	860	865	36,057	7,212	16649	3159	32,898	29608	78,462	189,000	6,449	11,084	8.22%	5.86%
IV	860	865	22,347	4,469	16649	0	22,347	20112	53,298	53,298	2,235	2,235	4.19%	4.19%
	855	860	59,956	11,991	19707	3058	56,898	51208	135,702	189,000	8,748	10,983	6.45%	5.81%
V	855	860	11,551	2,310	19707	0	11,551	10396	27,549	27,549	1,155	1,155	4.19%	4.19%
	850	855	79,342	15,868	22550	2843	76,499	68849	182,451	210,000	10,493	11,648	5.75%	5.55%
VI	850	855	2,175	435	22550	0	2,175	1957	5,186	5,186	217	217	4.19%	4.19%
	845	850	89,096	17,820	25770	3220	85,876	77288	204,813	210,000	11,808	12,025	5.77%	5.73%
VII	845	850	1,992	398	25770	0	1,992	1793	4,752	4,752	199	199	4.19%	4.19%
	840	845	88,771	17,754	28483	2713	86,058	77452	205,248	210,000	11,319	11,518	5.51%	5.48%
VIII	840	845	11,749	2,350	28483	0	11,749	10574	28,021	28,021	1,175	1,175	4.19%	4.19%
	835	840	78,620	15,724	30801	2318	76,302	68671	181,979	210,000	9,948	11,123	5.47%	5.30%
IX	835	840	28,510	5,702	30801	0	28,510	25659	67,995	67,995	2,851	2,851	4.19%	4.19%
	830	835	61,794	12,359	33054	2253	59,541	53587	142,005	210,000	8,207	11,058	5.78%	5.27%
X	830	835	50,560	10,112	33054	0	50,560	45504	120,586	120,586	5,056	5,056	4.19%	4.19%
	825	830	39,606	7,921	35169	2115	37,491	33741	89,415	210,000	5,864	10,920	6.56%	5.20%

Annexure 6.2: Yearly area opened for quarry operation

Year	Area used for Quarry Operation, in Sq.m.			
	Waste dump area (m^2)	Cumulative dump area (m^2)	Excavation area (m^2)	Cumulative Area m^2)
1	2,187	2,187	8,306.66	8,306.66
2	1,629	3,816	3,457.31	11,763.97
3	1,667	5,483	4,131.95	15,895.92
4	1,652	7,134	3,150.64	19,046.56
5	1,752	8,886	3,314.35	22,360.91
6	1,808	10,694	3,231.02	25,591.93
7	1,732	12,426	2,302.66	27,894.59
8	1,673	14,099	2,152.85	30,047.44
9	1,663	15,762	2,147.67	32,195.11
10	1,642	17,404	1,995.79	34,190.90


DAKPAI RIVER
NATURAL RESOURCES DEVELOPMENT CORPORATION LIMITED
DEMARCATION, TOPOGRAPHICAL AND GEOLOGICAL MAP
HOMDHAR STONE QUARRY
NANGKHOR GEWOG, ZHEMGANG DZONGKHAG



Year	From (m AMSL)	To (m AMSL)	Cut Volume (m3)	Cut Area (m2)	Cumulative Area (m2)	O/B Area & Volume	Rock Volume (m3)	Net Rock Volume (m3)	Net Rock Tonnage (Tonnes)	Cumulative Rock Tonnage (Tonnes)	Waste Volume (m3)	Cumulative Waste Volume (m3)	Level-wise stripping ratio	Cumulative stripping ratio
1	890	895	5,572	1,114	2148	2148	3,424	3082	8,166	8,166	2,490	2,490	30.50%	30.50%
	885	890	14,687	2,937	4503	2355	12,332	11099	29,412	37,578	3,588	6,079	12.20%	16.18%
	880	885	26,755	5,351	7187	2684	24,071	21664	57,409	94,987	5,091	11,170	8.87%	11.76%
	875	880	15,078	3,016	9262	2075	13,003	11703	31,012	126,000	3,375	14,545	10.88%	11.54%

DAKPAI RIVER

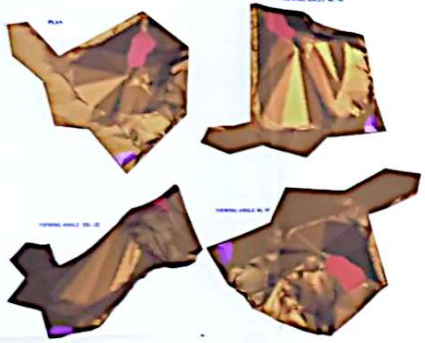
Legend

NATURAL RESOURCES DEVELOPMENT CORPORATION LIMITED

TENTATIVE PIT PLAN AT THE END OF FIRST YEAR

HOMDHAR STONE QUARRY

NANGKHOR GEWOG, ZHEMGANG DZONGKHAG



Year	From (m AMSL)	To (m AMSL)	Cut Volume (m3)	Cut Area (m2)	Cumulative Area (m2)	O/B Area & Volume	Rock Volume (m3)	Net Rock Volume (m3)	Net Rock Tonnage (Tonnes)	Cumulative Rock Tonnage (Tonnes)	Waste Volume (m3)	Cumulative Waste Volume (m3)	Level-wise stripping ratio	Cumulative stripping ratio
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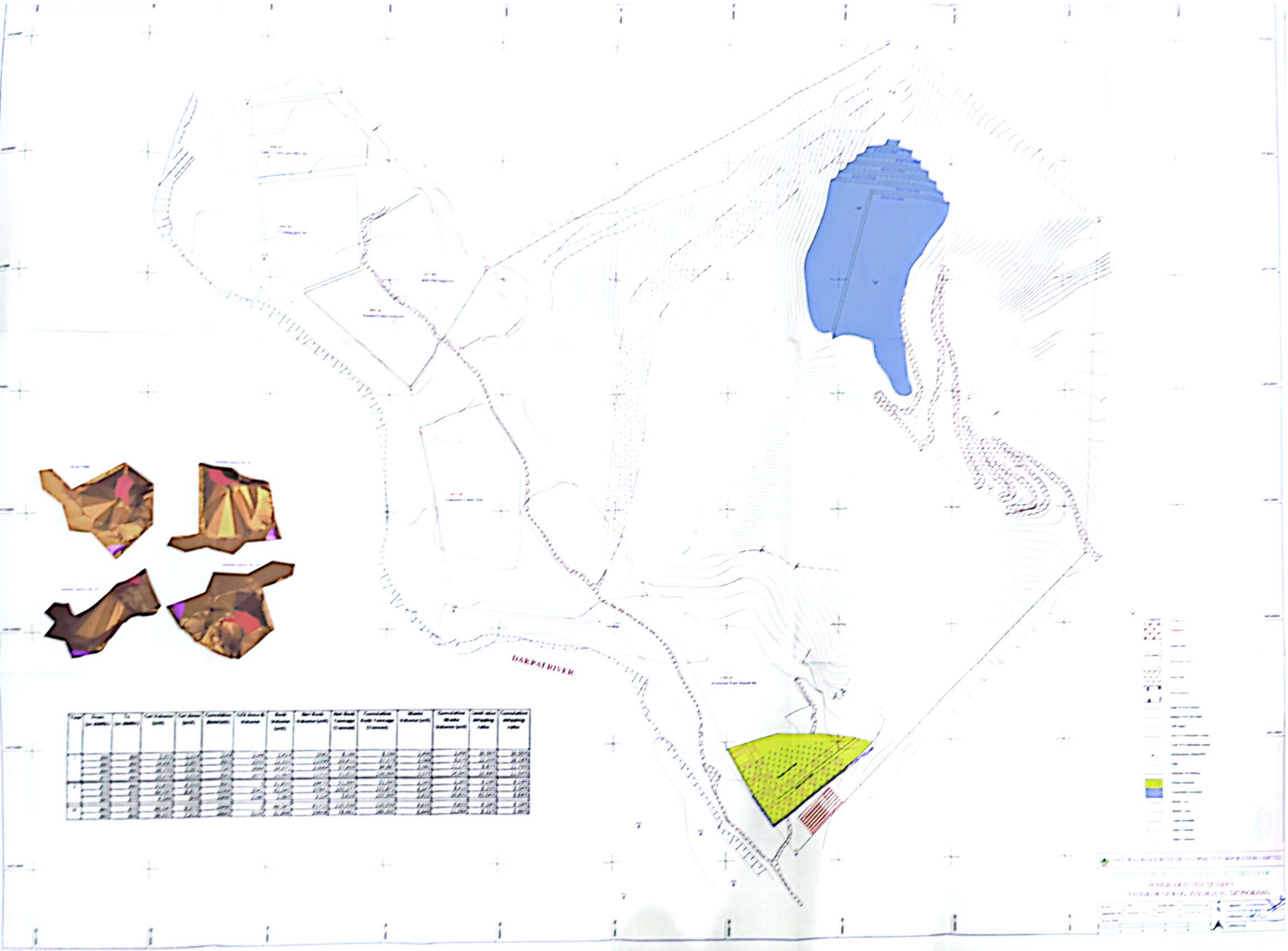
II	875	880	21.633	4.326	9262	0	21.633	19470	51.595	51.595	2.163	2.163	4.19%	4.19%
	870	875	44.087	8.817	21304	2042	42.045	37841	100.277	151.872	6.247	8.410	6.23%	5.54%
	865	870	4.566	909	13490	2186	2.380	2124	5.628	157.500	2.422	10.832	43.04%	6.88%

NATURAL RESOURCES DEVELOPMENT CORPORATION LIMITED

TENTATIVE PIT PLAN AT THE END OF SECOND YEAR

HOMDHAR STONE QUARRY

NANGKHOR GEWOG, ZHEMGANG DZONGKHAG



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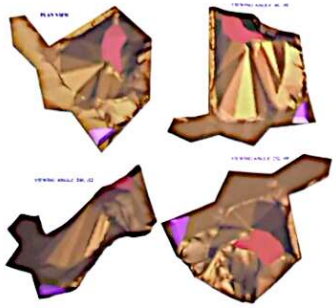

DAKPAI RIVER

Year	From (m AMSL)	To (m AMSL)	Cut Volume (m3)	Cut Area (m2)	Cumulative Area (m2)	O/B Area & Volume	Rock Volume (m3)	Net Rock Volume (m3)	Net Rock Tonnage (Tonnes)	Cumulative Rock Tonnage (Tonnes)	Waste Volume (m3)	Cumulative Waste Volume (m3)	Level-wise stripping ratio	Cumulative stripping ratio
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	875	880	15,078	3,016	9262	2075	13,003	11703	31,012	126,000	3,375	14,545	10.88%	11.54%
II	875	880	21,633	4,326	9262	0	21,633	19470	51,595	51,595	2,163	2,163	4.19%	4.19%
	870	875	44,087	8,817	11304	2042	42,045	37841	100,277	151,872	6,247	8,410	6.23%	5.54%
	865	870	4,546	909	13490	2186	2,360	2124	5,628	157,500	2,422	10,831	43.04%	6.88%
III	865	870	46,347	9,270	13490	0	46,347	41713	110,539	110,539	4,635	4,635	4.19%	4.19%
	860	865	36,057	7,212	16649	3159	32,898	29608	78,462	189,000	6,445	11,080	8.22%	5.86%
IV	860	865	22,347	4,469	16649	0	22,347	20112	53,298	53,298	2,235	2,235	4.19%	4.19%
	855	860	59,956	11,991	19707	3058	56,958	51208	135,702	189,000	8,748	10,983	6.45%	5.81%

Legend

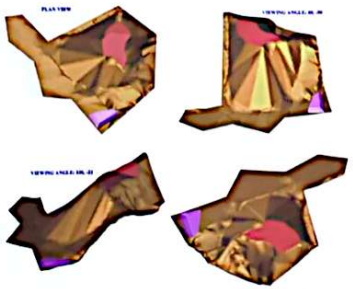
- Magazine
- Stone store
- Barricade wall
- Haul road
- Afforestation
- Edge of river terrace
- Deepest river soft basin
- Cliff edges
- Toe of Overburden Dump
- Crest of Overburden dump
- Demarcation pillar BM
- Trees
- Attitude of bedding
- Dump boundary
- Excavation boundary
- Bench Toe
- Bench Crest
- Lease boundary
- Stakes Common
- Other Common

NATURAL RESOURCES DEVELOPMENT CORPORATION LIMITED

TENTATIVE PEP PLAN AT THE END OF FOURTH YEAR

HOMDHAR STONE QUARRY

NANGKHOR GEWOG, ZHEMGANG DZONGKHAG



Year	From (m AMSL)	To (m AMSL)	Cut Volume (m3)	Cut Area (m2)	Cumulative Area (m2)	O/B Area & Volume	Rock Volume (m3)	Net Rock Volume (m3)	Net Rock Tonnage (Tonnes)	Cumulative Rock Tonnage (Tonnes)	Waste Volume (m3)	Cumulative Waste Volume (m3)	Level-wise stripping ratio	Cumulative stripping ratio
I	890	885	5,572	1,114	2148	2148	3,424	3082	8,166	8,166	2,490	2,490	30.50%	30.50%
	885	880	14,687	2,937	4503	2355	12,332	11099	29,412	37,578	3,548	6,078	12.20%	16.18%
	880	875	26,755	5,351	7187	2684	24,071	21664	57,409	94,987	5,095	11,170	8.87%	11.76%
	875	880	15,078	3,016	9262	2075	13,003	11703	31,012	126,000	3,373	14,545	10.88%	11.54%
II	875	880	21,633	4,326	9262	0	21,633	19470	51,595	51,595	2,165	2,165	4.19%	4.19%
	870	875	44,087	8,817	11304	2042	42,045	37841	100,277	151,872	6,247	8,410	8.23%	5.54%
	865	870	4,546	909	13490	2186	2,360	2124	5,628	157,500	2,422	10,832	43.04%	6.88%
III	865	870	46,347	9,270	13490	0	46,347	41713	110,539	110,539	4,635	4,635	4.19%	4.19%
	860	865	36,057	7,212	16649	3159	32,898	29608	78,462	189,000	6,449	11,084	8.22%	5.86%
IV	860	865	22,347	4,469	16649	0	22,347	20112	53,298	53,298	2,235	2,235	4.19%	4.19%
	855	860	39,956	11,991	19707	3058	36,898	33208	88,004	141,302	3,992	6,227	4.19%	4.22%
V	855	860	11,551	2,310	19707	0	11,551	10396	27,549	27,549	1,155	1,155	4.19%	4.19%
	850	855	79,342	15,868	22550	2843	76,499	66849	182,451	210,000	10,493	11,648	5.75%	5.55%

DAKPAI RIVER

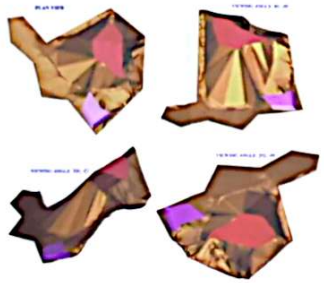
Legend

NATURAL RESOURCES DEVELOPMENT CORPORATION LIMITED

TENETATIVE PIT PLAN AT THE END OF FIFTH YEAR

HOMDHAR STONE QUARRY

NANGKHOR GEWOG, ZHEMGANG DZONGKHAG



Year	From (in AMSL)	To (in AMSL)	Cut Volume (m3)	Cut Area (m2)	Cumulative Area (m2)	O/B Area & Volume	Rock Volume (m3)	Net Rock Volume (m3)	Net Rock Tonnage (Tonnes)	Cumulative Rock Tonnage (Tonnes)	Waste Volume (m3)	Cumulative Waste Volume (m3)	Level-wise stripping ratio	Cumulative stripping ratio
I	890	885	5,572	1,114	2148	2148	3,424	3082	8,166	8,166	2,490	2,490	30.50%	30.50%
	885	880	14,687	2,937	4503	2355	12,332	11099	29,412	37,578	3,588	6,078	12.20%	16.18%
	880	875	26,755	5,351	7187	2684	24,071	21664	57,409	94,987	5,091	11,170	8.87%	11.76%
	875	880	15,078	3,016	9262	2075	13,003	11703	31,012	126,000	3,375	14,545	10.88%	11.54%
II	875	880	21,633	4,326	9262	0	21,633	19470	51,595	51,595	2,163	2,163	4.19%	4.19%
	870	875	44,087	8,817	11304	2042	42,045	37841	100,277	151,872	6,247	8,410	6.23%	5.54%
	865	870	4,546	909	13490	2186	2,360	2124	5,628	157,500	2,422	10,832	43.04%	6.86%
III	865	870	46,347	9,270	13490	0	46,347	41713	110,539	110,539	4,635	4,635	4.19%	4.19%
	860	865	36,057	7,212	16649	3158	32,898	29608	78,462	189,000	6,449	11,084	8.22%	5.86%
IV	860	865	22,347	4,469	16649	0	22,347	20112	53,298	53,298	2,235	2,235	4.19%	4.19%
	855	860	58,956	11,991	19707	3058	56,898	51208	135,702	189,000	8,748	10,983	6.45%	5.81%
V	855	860	11,551	2,310	19707	0	11,551	10396	27,549	27,549	1,155	1,155	4.19%	4.19%
	850	855	79,342	15,868	22550	2843	76,499	68849	182,451	210,000	10,493	11,648	5.75%	5.55%
VI	850	855	2,175	435	22550	0	2,175	1957	5,186	5,186	217	217	4.19%	4.19%
	845	850	89,096	17,820	25770	3220	85,876	77288	204,813	210,000	11,808	12,025	5.77%	5.73%
VII	843	850	1,992	398	25770	0	1,992	1793	4,752	4,752	199	199	4.19%	4.19%
	840	845	88,773	17,754	28483	2713	86,058	77452	205,248	210,000	11,319	11,518	5.51%	5.48%
VIII	840	845	11,749	2,350	28483	0	11,749	10574	28,021	28,021	1,175	1,175	4.19%	4.19%
	835	840	78,620	15,724	30801	2318	76,302	68671	181,979	210,000	9,948	11,123	5.47%	5.30%
IX	835	840	28,510	5,702	30801	0	28,510	25659	67,995	67,995	2,851	2,851	4.19%	4.19%
	830	835	61,794	12,359	33054	2253	59,541	53587	142,005	210,000	8,207	11,058	5.78%	5.27%
X	830	835	50,560	10,112	33054	0	50,560	45504	120,586	120,586	5,056	5,056	4.19%	4.19%
	825	830	39,606	7,921	35149	2133	37,491	33741	89,415	210,000	5,864	10,920	6.56%	5.20%

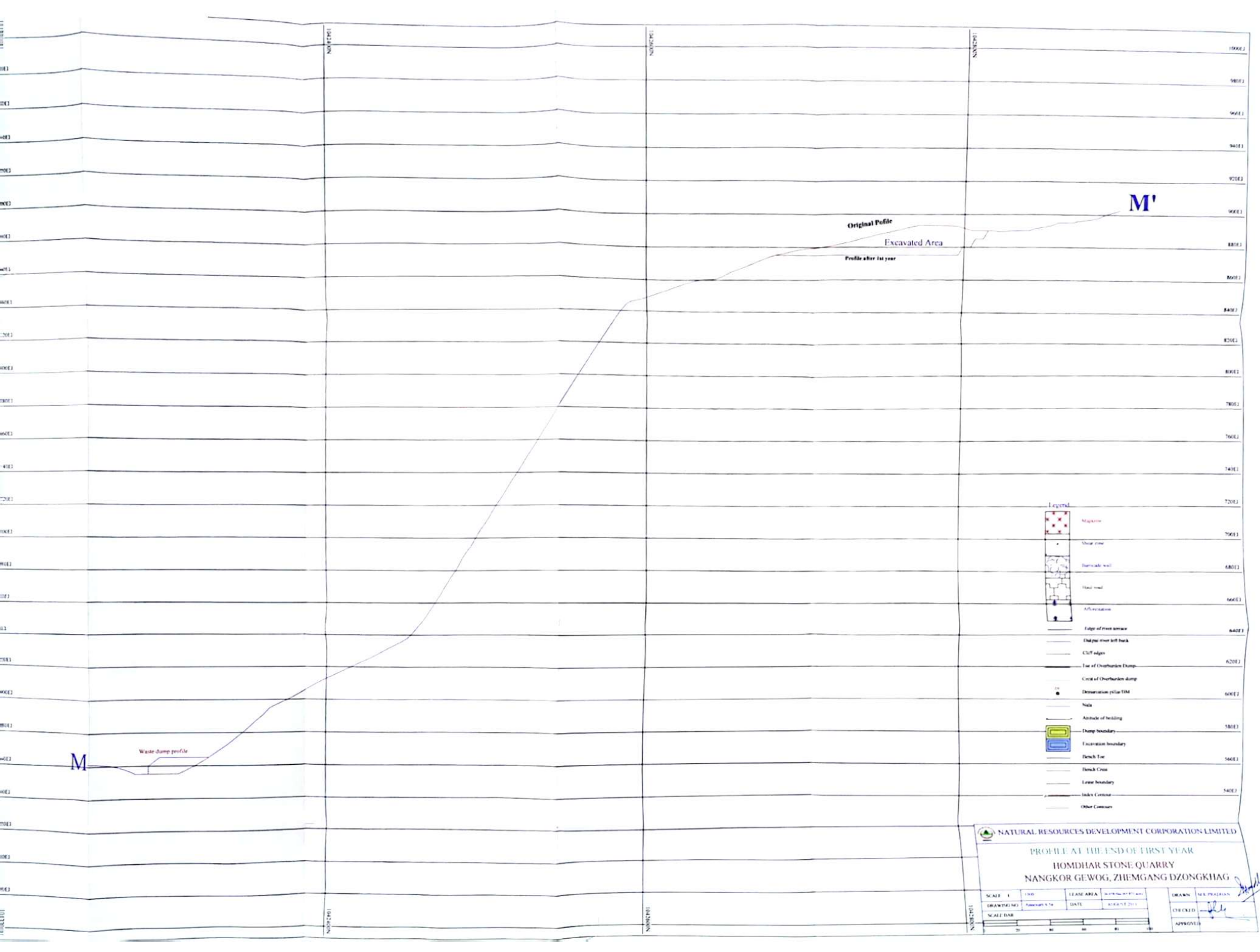
DAKPAI RIVER

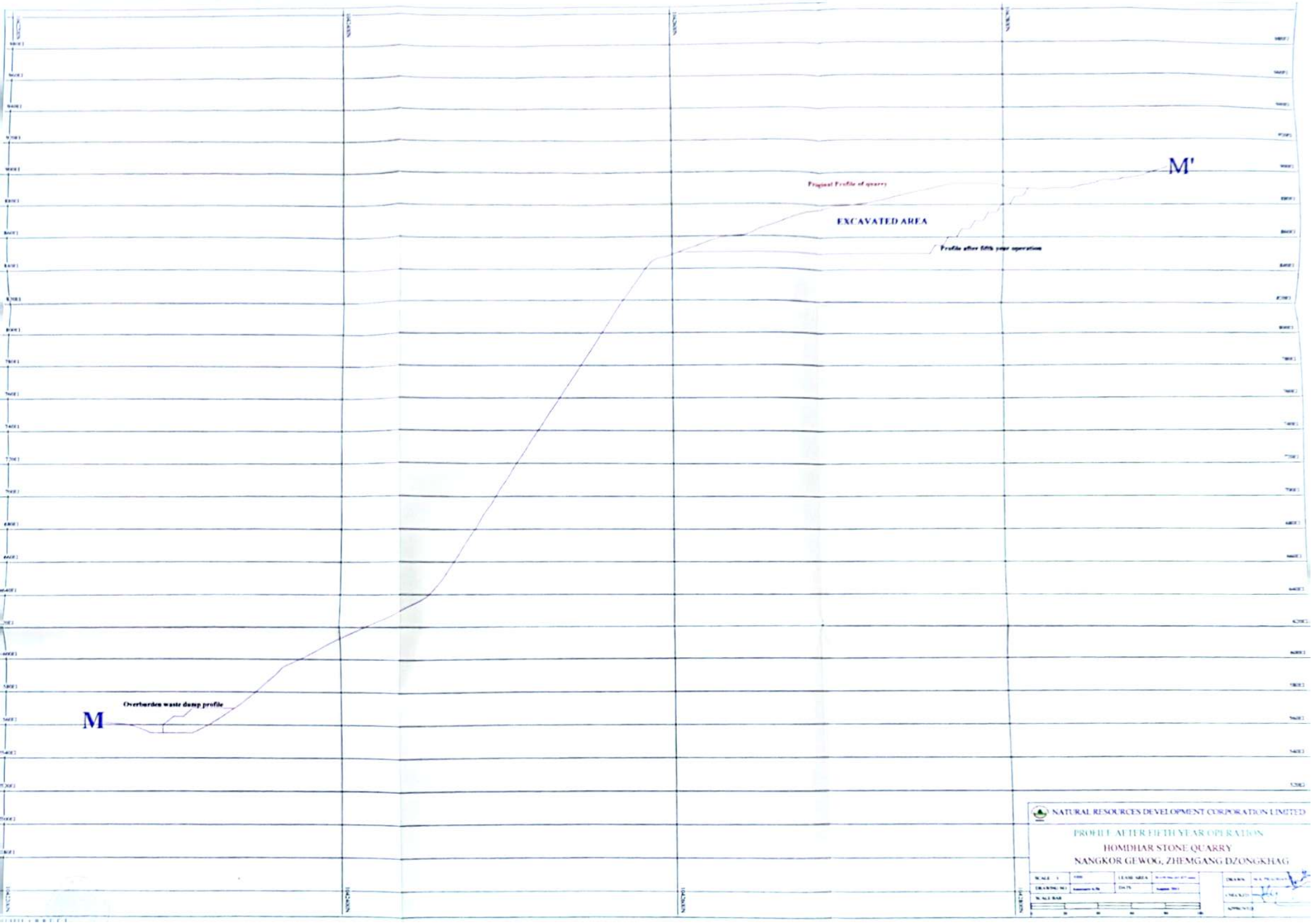
NATURAL RESOURCES DEVELOPMENT CORPORATION LIMITED

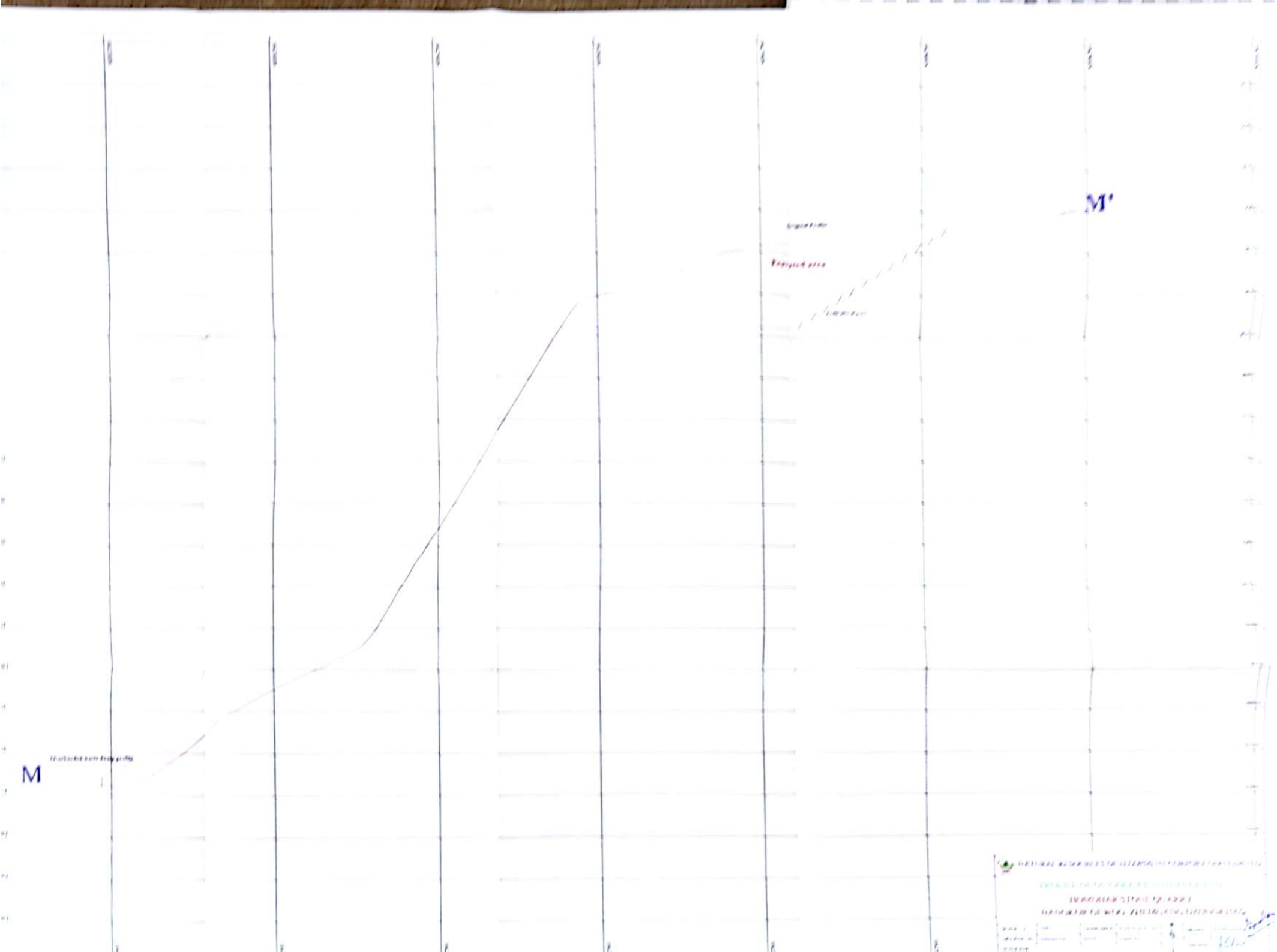
TENTATIVE PIT PLAN AT THE END OF TENTH YEAR

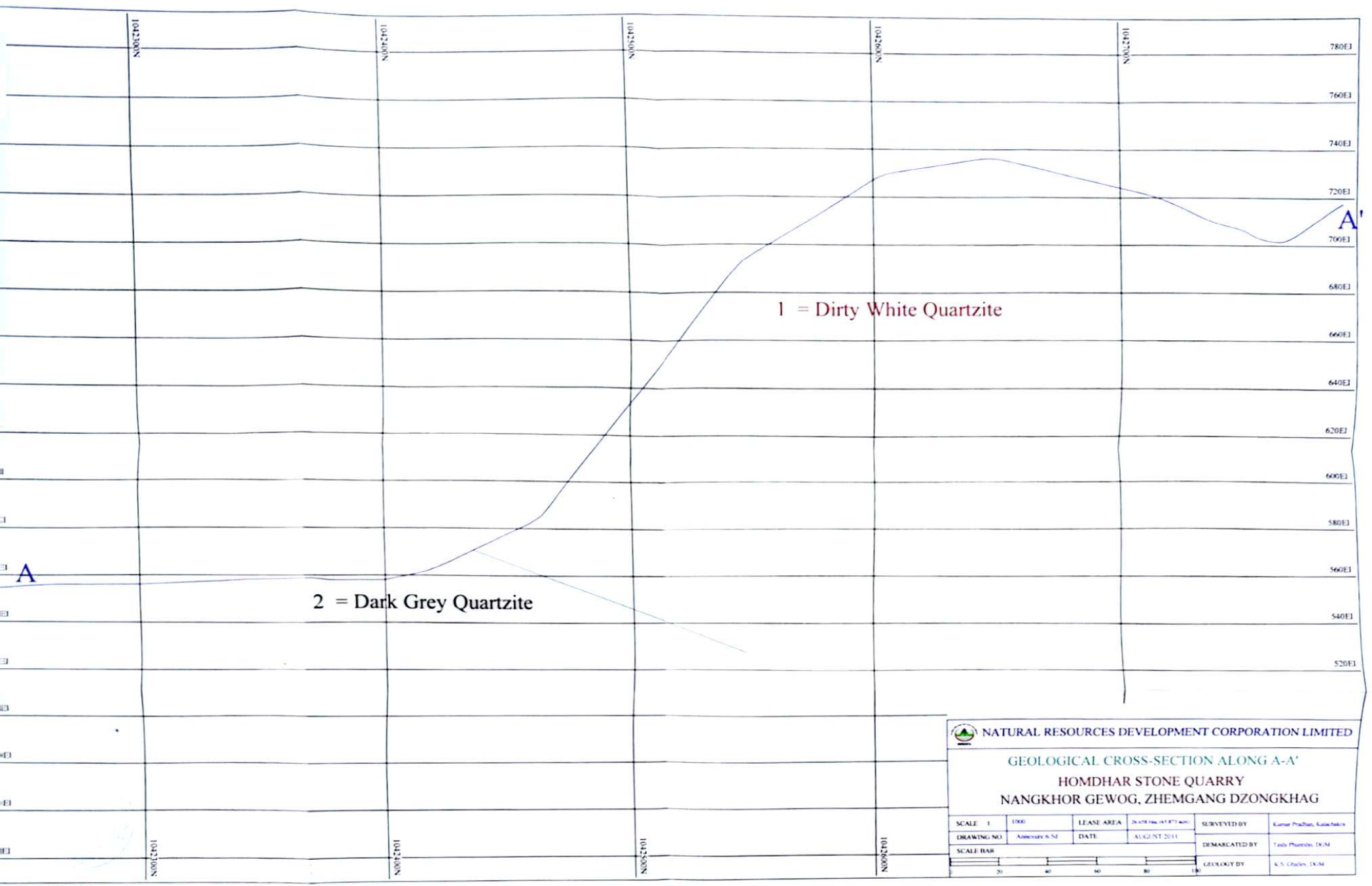
HOMDHAR STONE QUARRY

NANGKHOR GEWOG, ZHEMGANG DZONGKHAG


M
M'
Waste dump profile
Original Pofile
Excavated Area
Profile after 1st year
Legend
Magazine
Shear zone
Barricade wall
Haul road
Afforestation
Edge of river terrace
Dakpai river left bank
Cliff edges
Toe of Overburden Dump
Crest of Overburden dump
Demarcation pillar/BM
Nala
Attitude of bedding
Dump boundary
Excavation boundary
Bench Toe
Bench Crest
Lease boundary
Index Contour
Other Contours
NATURAL RESOURCES DEVELOPMENT CORPORATION LIMITED
PROFILE AT THE END OF FIRST YEAR
HOMDHAR STONE QUARRY
NANGKOR GEWOG, ZHEMGANG DZONGKHAG
SCALE 1:
LEASE AREA
DRAWING NO
DATE
SCALE BAR
DRAWN
CHECKED
APPROVED


M'
Proposed Profile of quarry
EXCAVATED AREA
Profile after fifth year operation
M
Overburden waste dump profile
NATURAL RESOURCES DEVELOPMENT CORPORATION LIMITED
PROFILE AFTER FIFTH YEAR OPERATION
HOMDHAR STONE QUARRY
NANGKOR GEWOG, ZHEMGANG DZONGKHAG





NATURAL RESOURCES DEVELOPMENT CORPORATION LIMITED

GEOLOGICAL CROSS-SECTION ALONG A-A'

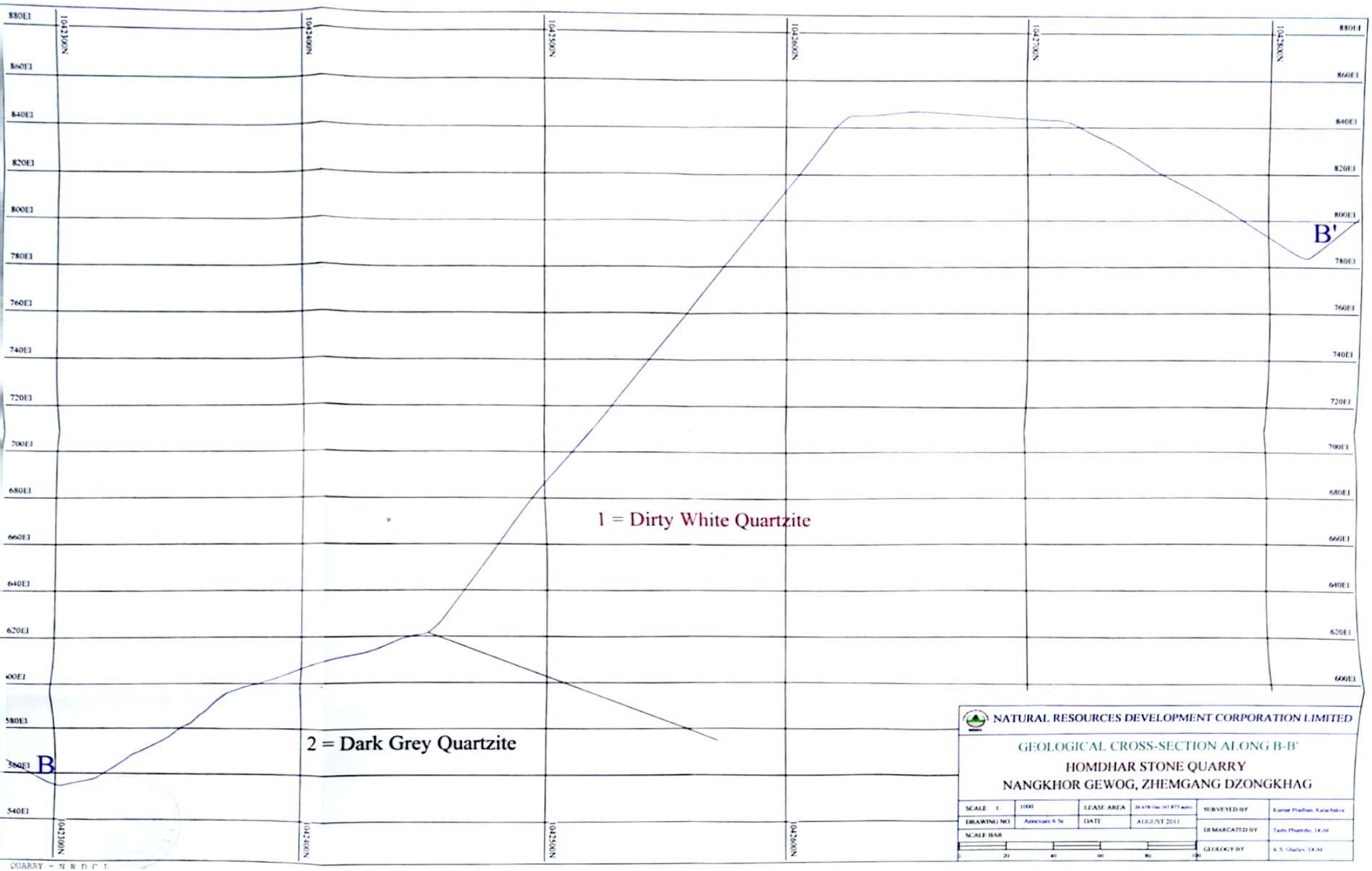
HOMDHAR STONE QUARRY

NANGKHOR GEWOG, ZHEMGANG DZONGKHAG

SCALE 1:	1000	LEASE AREA	26.678 Ha. (65.873 acres)	SURVEYED BY	Kumar Pradhan, Kalachakra
DRAWING NO.	Annexure 6.5d	DATE	AUGUST 2011	DEMARCATED BY	Tashi Phuntsho, DOM
SCALE BAR				GEOLOGY BY	K.S. Gurung, DOM

0 20 40 60 80 100

QUARRY - N R D C L



NATURAL RESOURCES DEVELOPMENT CORPORATION LIMITED

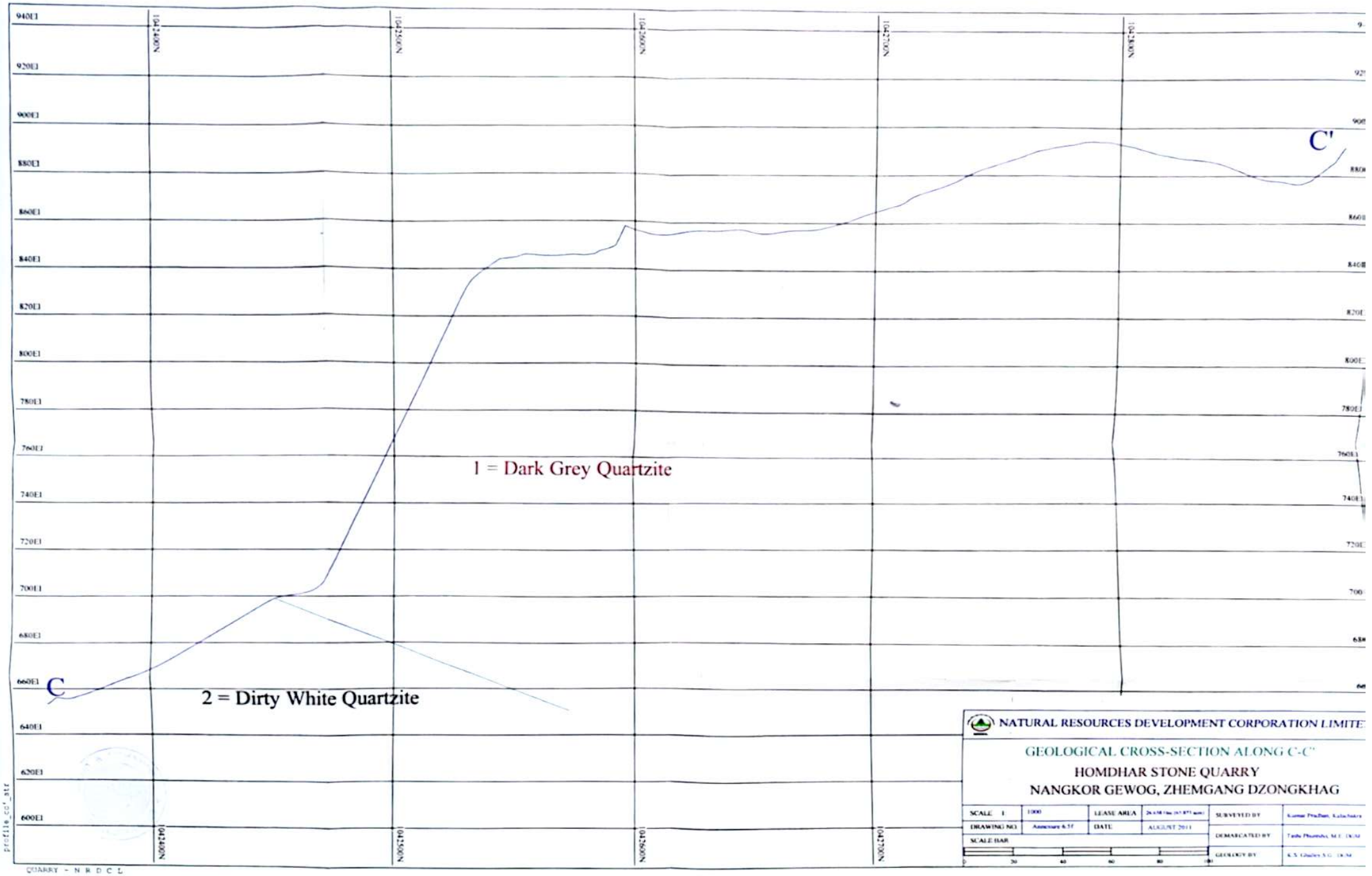
GEOLOGICAL CROSS-SECTION ALONG B-B'

HOMDHAR STONE QUARRY

NANGKHOR GEWOG, ZHEMGANG DZONGKHAG

SCALE 1:	1000	LEASE AREA	26.670 Hac (65.875 acres)	SURVEYED BY	Kumar Pradhan, Kaichakra
DRAWING NO	Annexure 6.5c	DATE	AUGUST 2011	DEMARCATED BY	Tashi Phuntsho, DGM
SCALE BAR				GEOLOGY BY	K.S. Ghalley, DGM

0 20 40 60 80 100



NATURAL RESOURCES DEVELOPMENT CORPORATION LIMITE

GEOLOGICAL CROSS-SECTION ALONG C-C'

HOMDHAR STONE QUARRY

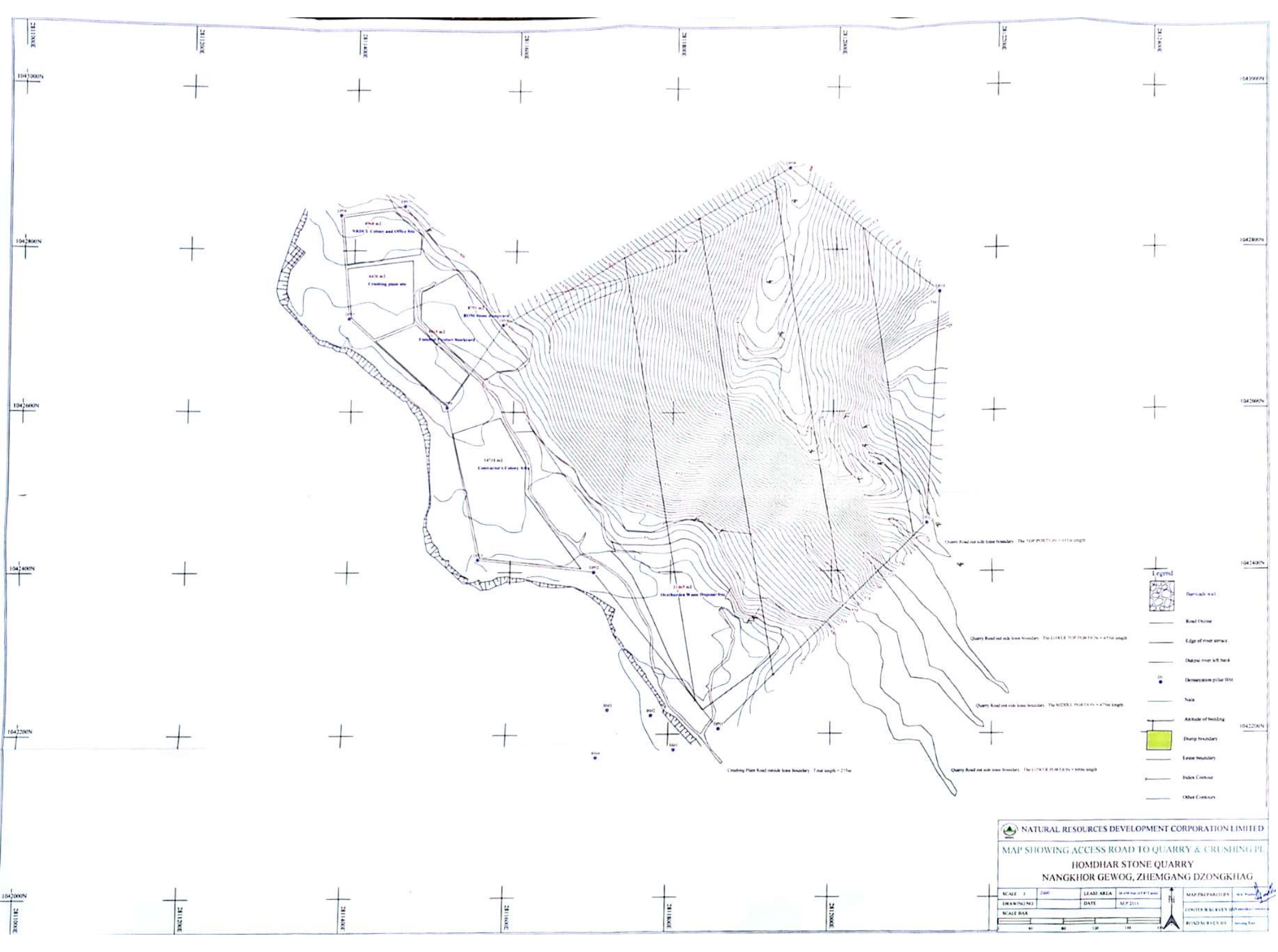
NANGKOR GEWOG, ZHEMGANG DZONGKHAG

SCALE 1:	1000	LEASE AREA	26.638 Hac (65.871 acres)	SURVEYED BY	Kumar Pradhan, Kalachakra
DRAWING NO.	Annexure 6.5f	DATE	AUGUST 2011	DEMARCATED BY	Tashi Phuntsho, M.E. DGM
SCALE BAR				GEOLOGY BY	K.S. Ghalley M.Sc. DGM

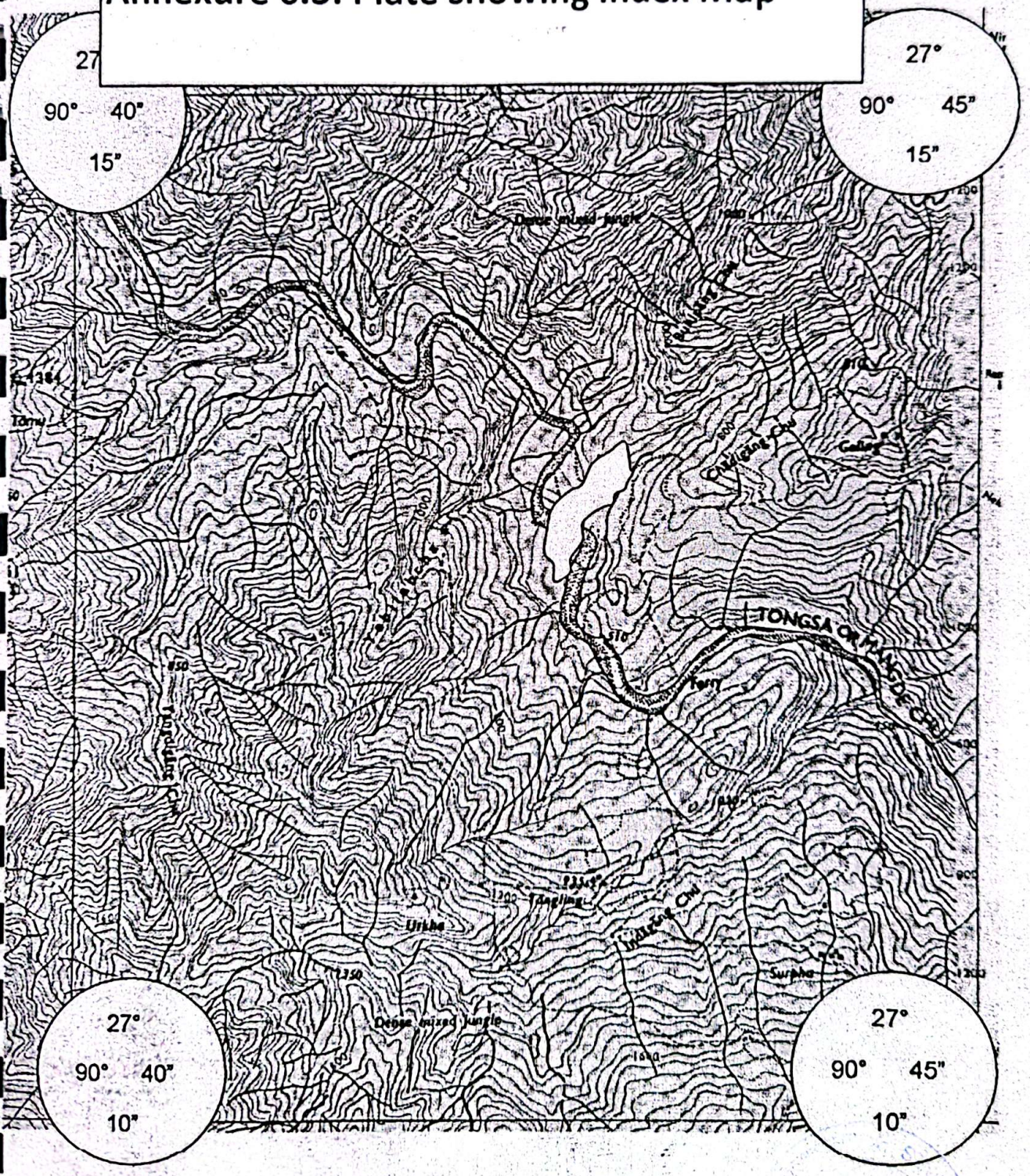
0 20 40 60 80 100

profile_cc'.str

QUARRY - N R D C L


Legend
Barricade wall
Road Outline
Edge of river terrace
Dakpai river left bank
Demarcation pillar BM
Nala
Attitude of bedding
Dump boundary
Lease boundary
Index Contour
Other Contours
NATURAL RESOURCES DEVELOPMENT CORPORATION LIMITED
MAP SHOWING ACCESS ROAD TO QUARRY & CRUSHING PL
HOMDHAR STONE QUARRY
NANGKHOR GEWOG, ZHEMGANG DZONGKHAG
SCALE
DRAWING NO.
DATE
SCALE BAR
LEASE AREA
MAP PREPARED BY
CONTOUR SURVEY BY
ROAD SURVEY BY

Annexure 6.3: Plate showing Index Map



ANNEXURE 11.1: DEPRECIATION & AMORTISATION STATEMENT

FIXED ASSETS	TOTAL VALUE	DEPRECIATION & AMORTISATION RATE %	DEPRECIATION AMOUNT (Nu) in different years									
			2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Preliminary expenses	1,034,987	10.00%	103,499	103,499	103,499	103,499	103,499	103,499	103,499	103,499	103,499	103,499
Mine development	1,987,000	20.00%	397,400	397,400	397,400	397,400	397,400	0	0	0	0	0
Approach road	4,167,710	20.00%	833,542	833,542	833,542	833,542	833,542	0	0	0	0	0
Infrastructure	1,500,000	20.00%	300,000	300,000	300,000	300,000	300,000	0	0	0	0	0
Excavator	23,100,000	15.00%	3,465,000	3,465,000	3,465,000	3,465,000	3,465,000	3,465,000	3,984,750	3,984,750	3,984,750	3,984,750
Compressor + drill	6,000,000	15.00%	900,000	900,000	900,000	900,000	900,000	900,000	1,035,000	1,035,000	1,035,000	1,035,000
Tippers	14,000,000	15.00%	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000	2,100,000	2,415,000	2,415,000	2,415,000	2,415,000
Vehicles	3,950,000	15.00%	592,500	592,500	592,500	592,500	592,500	592,500	681,375	681,375	681,375	681,375
Water supply	200,000	10.00%	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Fuel tank	250,000	15.00%	37,500	37,500	37,500	37,500	37,500	37,500	43,125	43,125	43,125	43,125
Magazine	1,000,000	10.00%	37,500	37,500	37,500	37,500	37,500	37,500	37,500	37,500	37,500	37,500
Other ancillary equipments	600,000	10.00%	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000
TOTAL	57,789,697		8,846,941	8,846,941	8,846,941	8,846,941	8,846,941	7,315,999	8,380,249	8,380,249	8,380,249	8,380,249

ANNEXURE 12.1: PROFITABILITY STATEMENT

Return from Sales

Product size	Quantity	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
All	210,000	28,350,000	37,209,375	46,883,813	49,228,003	57,432,670	60,304,304	63,319,519	66,485,495	69,809,770	73,300,258
Total of sales	210,000	28,350,000	37,209,375	46,883,813	49,228,003	57,432,670	60,304,304	63,319,519	66,485,495	69,809,770	73,300,258
Capacity utilisation		60%	75%	90%	90%	100%	100%	100%	100%	100%	100%
	Total yearly quantity	*126000*	*157500*	*189000*	*189000*	*210000*	*210000*	*210000*	*210000*	*210000*	*210000*
Expenditure											
Salary & wages		8,604,300	8,862,429	9,128,302	9,402,151	9,684,215	9,974,742	10,273,984	10,582,204	10,899,670	11,226,660
Fuel and spares		9,938,446	13,044,210	16,435,704	17,257,490	20,133,738	21,140,425	22,197,446	23,307,318	24,472,684	25,696,318
Explosive		922,364	1,187,544	1,467,804	1,511,838	1,730,215	1,782,121	1,835,585	1,890,653	1,947,372	2,005,793
Repair & maintenance		354,000	442,500	531,000	557,550	585,428	614,699	645,434	677,706	711,591	747,170
Administrative expenses		1,800,000	2,250,000	2,700,000	2,700,000	3,000,000	3,000,000	3,000,000	3,000,000	3,000,000	3,000,000
Mineral Levy		388,677	475,302	587,915	587,915	648,552	678,871	678,871	678,871	710,705	710,705
Environment Management		600,000	750,000	900,000	900,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Environment Restoration fund		0	500,000	500,000	500,000	500,000	500,000	0	0	0	0
Depreciation		8,846,941	8,846,941	8,846,941	8,846,941	8,846,941	7,315,999	8,380,249	8,380,249	8,380,249	8,380,249
Interest on long term loan	12%	4,004,826	3,588,740	3,172,654	2,756,569	2,340,483	1,924,397	1,508,311	1,092,225	676,139	260,054
Interest on W.C loan	13%	722,665	0	0	0	0	0	0	0	0	0
Sub-Total of expenses		36,182,219	39,947,666	44,270,320	45,020,453	48,469,571	47,931,253	49,519,880	50,609,225	51,798,411	53,026,950
Gross Profit		-7,832,219	-2,738,291	2,613,493	4,207,551	8,963,099	12,373,051	13,799,640	15,876,270	18,011,359	20,273,308
Provision for tax	30%	0	0	0	0	1,564,090	3,711,915	4,139,892	4,762,881	5,403,408	6,081,993
Net profit after tax	-57,789,697	-7,832,219	-2,738,291	2,613,493	4,207,551	7,399,009	8,661,135	9,659,748	11,113,389	12,607,951	14,191,316

ANNEXURE 12.2: CASHFLOW STATEMENT (Figures in Ngultrums)

Outflow

Particulars/Year	0	1	2	3	4	5	6	7	8	9	10
Machinery & Structure	57,789,697	0	0	0	0	0	0	0	0	0	0
Interest on long term loan	0	4,004,826	3,588,740	3,172,654	2,756,569	2,340,483	1,924,397	1,508,311	1,092,225	676,139	260,054
Interest on W.C loan	0	722,665	0	0	0	0	0	0	0	0	0
Loan repayment	0	9,026,347	3,467,382	3,467,382	3,467,382	3,467,382	3,467,382	3,467,382	3,467,382	3,467,382	3,467,382
Production cost	0	22,607,787	27,511,985	32,250,725	33,416,943	37,282,148	38,690,858	39,631,320	41,136,751	42,742,022	44,386,647
Provision for tax	0	0	0	0	0	1,564,090	3,711,915	4,139,892	4,762,881	5,403,408	6,081,993
Working capital	7,411,953	0	0	0	0	0	0	0	0	0	0
Total outflow	**65,201,650**	**36,361,625**	**34,568,107**	**38,890,761**	**39,640,894**	**44,654,102**	**47,794,552**	**48,746,905**	**50,459,239**	**52,288,951**	**54,196,075**

Inflow

Sales return	0	28,350,000	37,209,375	46,883,813	49,228,003	57,432,670	60,304,304	63,319,519	66,485,495	69,809,770	73,300,258
Sale of assets	0	0	0	0	0	0	3,545,000	0	0	0	21,758,000
Loan	34,673,818	0	0	0	0	0	0	0	0	0	0
Equity capital	23,115,879	0	0	0	0	0	0	0	0	0	0
Depreciation	0	8,846,941	8,846,941	8,846,941	8,846,941	8,846,941	7,315,999	8,380,249	8,380,249	8,380,249	8,380,249
Total inflow	**57,789,697**	**37,196,941**	**46,056,316**	**55,730,753**	**58,074,944**	**66,279,611**	**71,165,302**	**71,699,768**	**74,865,744**	**78,190,018**	**103,438,507**

Net cash flow	-7,411,953	835,316	11,488,209	16,839,992	18,434,050	21,625,509	23,370,751	22,952,863	24,406,505	25,901,067	49,242,431

ANNEXURE12.3: LOAN REPAYMENT SCHEDULE (in Ngultrum)

Term Loan	34,673,818	Total	57,789,697
Equity	23,115,879		

Quarter	Principal Year start	Interest	Repayment	Principal Year end
1	34,673,818	1,040,215	866,845	33,806,973
2	33,806,973	1,014,209	866,845	32,940,127
3	32,940,127	988,204	866,845	32,073,282
4	32,073,282	962,198	866,845	31,206,436
5	31,206,436	936,193	866,845	30,339,591
6	30,339,591	910,188	866,845	29,472,745
7	29,472,745	884,182	866,845	28,605,900
8	28,605,900	858,177	866,845	27,739,055
9	27,739,055	832,172	866,845	26,872,209
10	26,872,209	806,166	866,845	26,005,364
11	26,005,364	780,161	866,845	25,138,518
12	25,138,518	754,156	866,845	24,271,673
13	24,271,673	728,150	866,845	23,404,827
14	23,404,827	702,145	866,845	22,537,982
15	22,537,982	676,139	866,845	21,671,136
16	21,671,136	650,134	866,845	20,804,291
17	20,804,291	624,129	866,845	19,937,445
18	19,937,445	598,123	866,845	19,070,600
19	19,070,600	572,118	866,845	18,203,755
20	18,203,755	546,113	866,845	17,336,909
21	17,336,909	520,107	866,845	16,470,064
22	16,470,064	494,102	866,845	15,603,218
23	15,603,218	468,097	866,845	14,736,373
24	14,736,373	442,091	866,845	13,869,527
25	13,869,527	416,086	866,845	13,002,682
26	13,002,682	390,080	866,845	12,135,836
27	12,135,836	364,075	866,845	11,268,991
28	11,268,991	338,070	866,845	10,402,145
29	10,402,145	312,064	866,845	9,535,300
30	9,535,300	286,059	866,845	8,668,455
31	8,668,455	260,054	866,845	7,801,609
32	7,801,609	234,048	866,845	6,934,764
33	6,934,764	208,043	866,845	6,067,918
34	6,067,918	182,038	866,845	5,201,073
35	5,201,073	156,032	866,845	4,334,227
36	4,334,227	130,027	866,845	3,467,382
37	3,467,382	104,021	866,845	2,600,536
38	2,600,536	78,016	866,845	1,733,691
39	1,733,691	52,011	866,845	866,845
40	866,845	26,005	866,845	0

Working capital 7,411,953

Year	Principal Year start	Interest	Repayment	Principal Year end
1	5,558,965	722,665	5,558,965	0
2	0	0	0	0

Salvage value at the end of 10 years 21,758,000