1.0 INTRODUCTION

A Letter of Intent had been issued by the Director General, Mine & Geology Department, Government of Haryana vide letter no. letter no DMG/Hy/Cont/Nagla Rangran Block/YNR B-14/2017/2654 dated 16.06.2017 to M/s Tirupati Earth & Project Works Pvt. Ltd. for Removal of Bajri (Minor Mineral) in revenue villages of Majri, Nagla Rangran and Sandhala over an area of 89.48 ha in district Yamunanagar, Haryana for a period of 9 years. As per the conditions of Letter of Intent, it was mandatory to obtain environmental clearance (EC) from MoEFCC, Government of India. Presentations were given in the Expert Appraisal Committee (EAC) of MoEFCC in its 31st EAC Meeting during 14-15th May, 2018 had asked for a Modified Mine Plan and had recommended the lease area be divided in to 25 m grid with the help of sections across the width of the river and along the direction of flow of river for levels so that an accurate assessment can be made on the replenishment taking place.

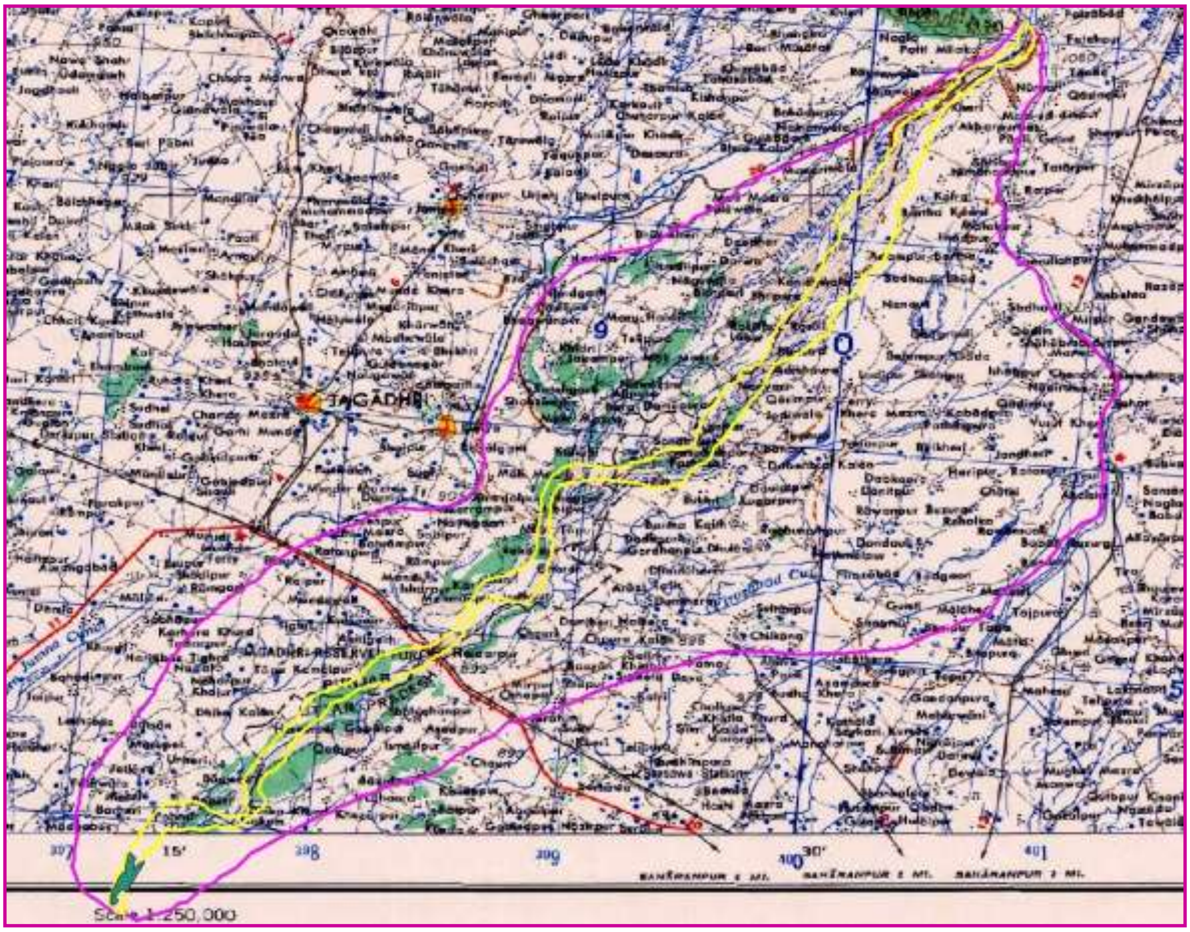
MoEFCC decided to advise all applicants to carry out scientific replenishment study and submit the report before EAC for the consideration of quantity of production for mining of Bajri/River Sand on yearly basis.

In view of the above condition, M/s Tirupati Earth & Project Works Pvt. Ltd. approached Hydro Geo Solutions (HGS) for undertaking the scientific replenishment study of his mine in the district of Yamunanagar, Haryana.

1.1 Location of the study area

The mine lease area forms part of the Yamuna river in district Yamunanagar and falls under G.T. Sheet No’s – 53G/1,5 and 53F/4,8 shown in **Figure-1**. The area is located between the following Latitude and Longitudes: 29°58’10”N to 29°59’24”N and 77°13’32”E to 77°14’19”E.

Figure-1. Part of Survey of India Toposheet Nos. 53G/1, 5 and 53F/4, 8



1.2 Methodology adopted for the sand replenishment study

River Yamuna is a perennial stream in nature. In perennial channels of the northern Haryana, sediment often moves in a continuous manner because of incessant flow. Water from storms originating in the upper reaches of a watershed is often completely absorbed in the channel before reaching the outlet. Therefore, the ability of the channel to transport sediment is dependent on varying flow as a function of distance along the channel. Sediment that is eroded, entrained, transported, and deposited by one storm may be available to subsequent storm events for transport within the channel. Thus, the transport of sediment in sub-tropical to temperate perennial channels is complicated by flow sequencing.

Therefore, the methodology adopted for the study is an integrated approach involving:

- **Field data collection** comprising of 81 cross sections taking a grid of 25 m x 25 m (Appendix-II), along the lease reach of the river showing river bed material (RBM) with present elevations which when balanced with the next deposition can be quantified as the actual deposition/replenishment for 2018. Fifteen sand samples for sieve analysis (Appendix-I) i.e. d_{10}, d_{30}, d_{50} and d_{60}, uniformity coefficient (C_u) and coefficient of curvature (C_c) was also determined as an input for estimation of bajri/sand replenishment of river reach under study. Four pits of 3 x 3 x 1.5 m were also excavated for monitoring of the future/monsoon flow sedimentation.

- **Remote sensing** was used for identification of watershed area relevant to the mine lease. The data was used is from the latest satellite imagery of CARTOSAT – 1 of ISRO having a grid of 30 metres and SRTM, NASA at grid of 80 metres and computer aided drainage analysis system.

- **Estimation of catchment yield and bed load transport**: The catchment yield has been computed using the Strange's runoff method (Strange's Monsoon runoff curves) for the runoff coefficient. The iso-pluvial maps of IMD have been used for estimation of catchment yield and peak flood discharge for the study area by various methods like Dickens, Jarvis, and Rational formula at 25, 50 and 100 years return period. The estimation of bed load transport comprises of use of analytical models namely the Einstein, Meyer Peter and Ackers & White's equation for calculation of bed load transport.

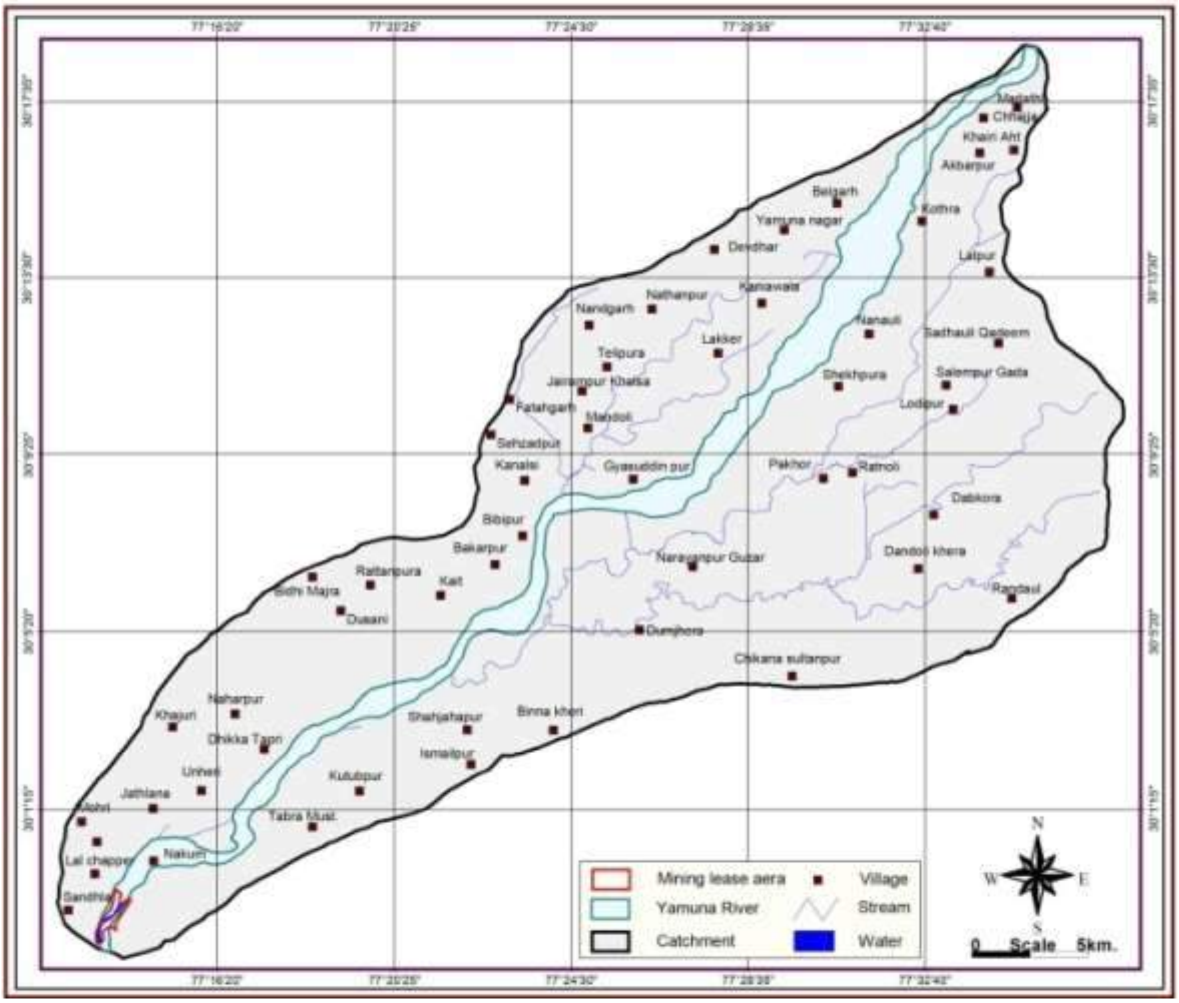
2.0 HYDROLOGY

2.1 Yamuna river basin

Study area falls in upper reaches of Yamuna river basin. Yamuna is the largest tributary of the Ganga. Originating from the Yamunotri Glacier at a height of 6,387 metres on the south western slopes of Banderpooch peaks in the Lower Himalayas in Uttarakhand, it travels a total length of 1,376 km and has a catchment area of 3,66,223 km^2 (40.2% of the entire Ganga river basin) before merging with the Ganga at Triveni Sangam, Allahabad, the site for the Kumbha Mela every twelve years.

It crosses several states, Uttarakhand, Haryana and Uttar Pradesh, passing by Himachal Pradesh and later Delhi, and meets several of its tributaries on the way, including Tons, its largest and longest tributary in Uttarakhand, Chambal, which has its own large basin, followed by Sindh, Betwa, and Ken. Most importantly, it creates the highly fertile alluvial, Yamuna-Ganges Doab region between itself and the Ganga in the Indo-Gangetic plain. Nearly 57 million people depend on the Yamuna waters.

Figure-2. Watershed map of the study area



2.2 Climate

There is no IMD meteorological station near the study area, the nearest stations being at Karnal, which are about 36 km from center of the study area. However, the climatic conditions are not much different than recorded at Karnal.

Based on Koppen classification of climatic pattern, the study area may be classified as sub-tropical to temperate. The year is divided in to four seasons. The winter season is from mid-December to February and is followed by the hot summer season from March to mid-July, including the pre-monsoon season from April to June. The period from mid July to mid-September constitutes the southwest monsoon season and the period from the later half of September to mid-December as post monsoon season.

Table-1. Meteorological data as recorded at IMD Karnal

Month	Temperature		Relative Humidity		Mean Cloudiness	
	Mean Daily Max °C	Mean Daily Min °C	08:30 %	17:30 %	08:30 Oktas	17:30 Oktas
Jan.	19.9	7.1	74	53	1.0	0.9
Feb.	22.5	9.2	70	50	1.1	0.9
Mar.	28.0	13.4	62	44	1.0	1.0
Apr.	35.1	19.3	46	29	0.6	1.1
May	38.6	23.2	45	29	0.4	0.4
Jun.	38.6	25.9	57	40	1.5	1.2
Jul.	34.2	25.5	77	64	2.8	2.2
Aug.	32.8	25.0	80	71	4.1	3.4
Sep.	32.9	23.2	74	62	1.2	1.1
Oct.	31.6	17.6	66	49	0.3	0.2
Nov.	27.3	12.0	66	50	0.3	0.3
Dec.	21.9	8.1	72	53	0.6	0.6
Annual mean	**30.3**	**17.5**	**66**	**50**	**1.2**	**1.1**

2.2.1 Temperature

The period from March to June is marked by continuous increase in the temperatures. June is the hottest months of the year with a mean daily minimum and maximum temperature of

25.9°C and 38.6°C respectively. With the onset of southwest monsoon by about mid-June, the temperatures go down considerably. From November onwards, both the day and night temperatures decrease and January, the coldest month, with daily minimum and maximum temperatures of 7.1°C and 19.9°C.

2.2.2 Rainfall

Average annual rainfall based on rainfall data recorded at Yamunanagar, the district headquarter, for last 24 years has been observed as 1054.16 mm **(Table-2)**. Rains are received almost in half of the year but rains are minimum to nil during summer months.

Table-2. Rainfall (mm) recorded at Yamunanagar district headquarter

Year	Rainfall data (mm)	Year	Rainfall data (mm)
1991	769.0	2006	831.20
1992	1035.70	2007	866.00
1993	856.70	2008	993.00
1994	1157.10	2009	750.50
1995	1432.50	2010	1433.90
1996	1758.00	2011	922.20
1997	1172.40	2012	1349.30
1998	1448.70	2013	1350.20
1999	808.30	2014	774.50
2000	1168.30	2015	893.30
2004	652.00	2016	912.60
2005	948.00	2017	1016.50
Average annual rainfall in mm			**1054.16**

2.3 Estimation of catchment yield

For estimation of surface run off coefficient, HGS has considered a particular value of peak rainfall. In absence of non-availability to HGS, peak storm water has been estimated as under:

2.3.1 Strange's run-off

The dependability has been calculated on the basis of last 24 years rainfall, as indicated in Table-2 where water availability has been considered for arriving at 50% dependability (Table-3 and 4), respectively.

Table-3. Rainfall data (arranged in descending order, mentioning serial number /order number m) of each year's rainfall

S.N., i.e. order number (m)	Rainfall in descending order in mm	S.N., i.e. order number (m)	Rainfall in descending order in mm
1.	1758.00	13.	948.00
2.	1448.70	14.	922.20
3.	1433.90	15.	912.60
4.	1432.50	16.	893.30
5.	1350.20	17.	866.00
6.	1349.30	18.	856.70
7.	1172.40	19.	831.20
8.	1168.30	20.	808.30
9.	1157.10	21.	774.50
10.	1035.70	22.	769.00
11.	1016.50	23.	750.50
12.	**993.00**	24.	652.00

Table-4. Calculation of order number (m)

	Rainfall dependability percentage
	p=50%
m =	N x p/100
	N= 24, p = 50
m =	**12**

Here, m = Order number
N = The available rainfall data of the past N years is first of all arranged in the descending order of magnitude
p = Dependability percentage

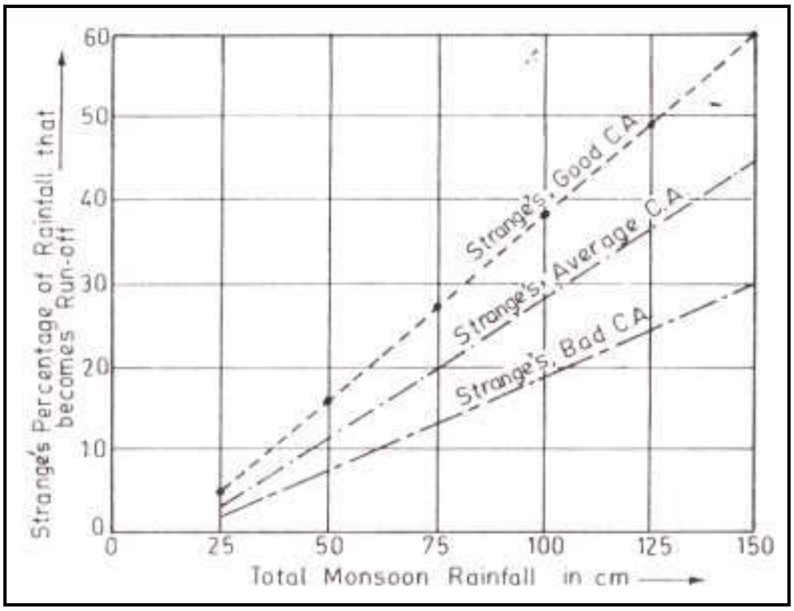
The rainfall value tabulated above in Table -3, the Order No. 12has the values of 993 mm.

So, $\mathbf{P_{50\%} = 99.30\ cm}$

Average value of Strange's Run off percentage is calculated from Strange's monsoon rainfall-runoff curves **(Figure-3)** considering the catchment area as good and the Runoff % for the area is:

Runoff % at 50% dependability of rainfall = 38%

Figure-3. Strange's monsoon rainfall-runoff curves



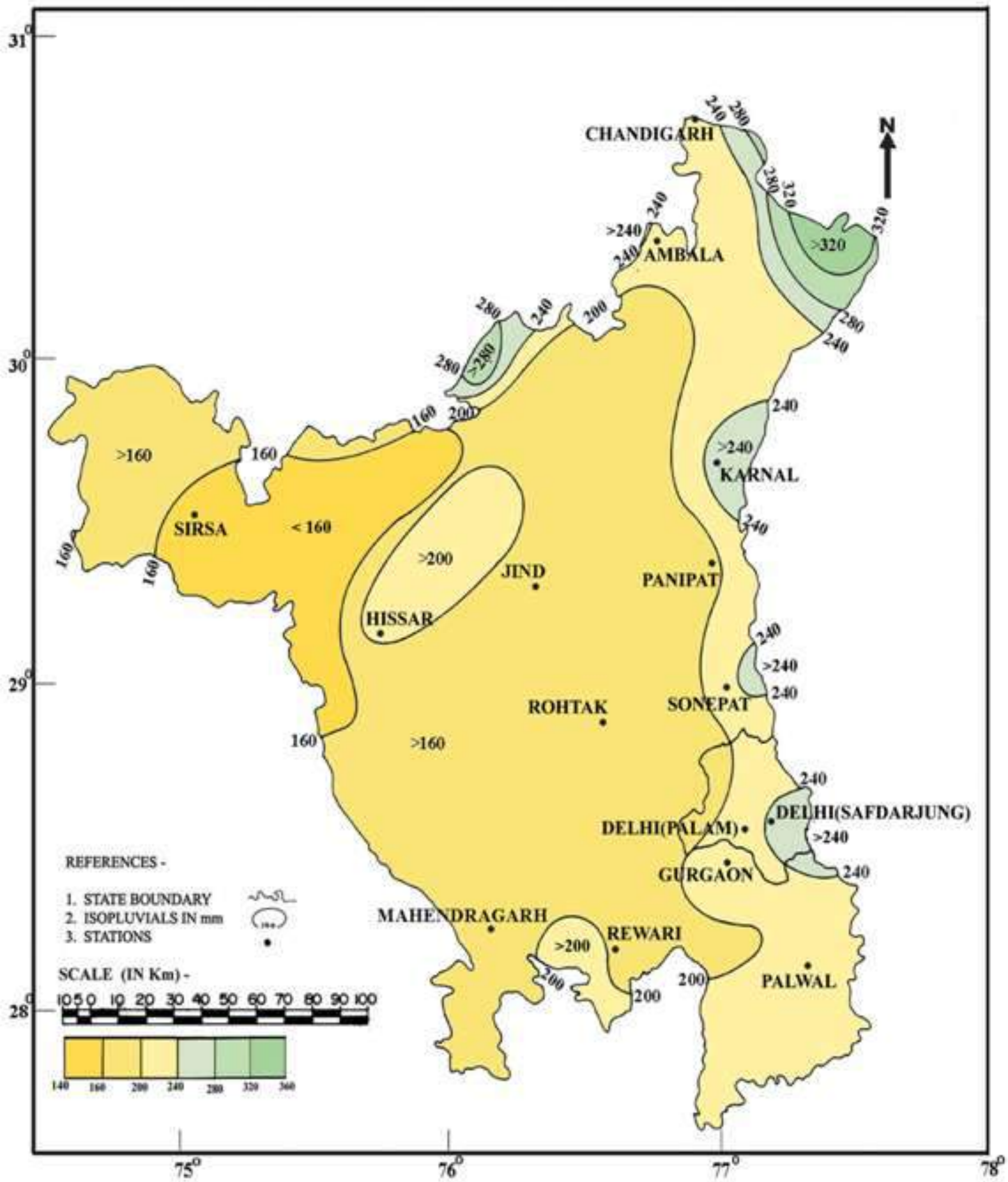
2.3.2 Isopluvial maps

Extreme point rainfall values of different durations and for different return periods have been evaluated by IMD and the iso-pluvial (lines connecting equal depths of rainfall) maps covering the entire country have been prepared. These are available for rainfall in mm in duration of 24 hr for return periods of 2, 5, 10, 25, 50 and 100 years **(Figures-4, 5 and 6).**

Isopluvial (Return Period) maps provide fairly reliable estimates of rainfall at a particular point / area. The return period is the average time in which a given magnitude of the event is equaled or exceeded.

The value of peak rainfall (Figure-1.) used for the present study based on 25 years return period for 24 hrs. = 280 mm

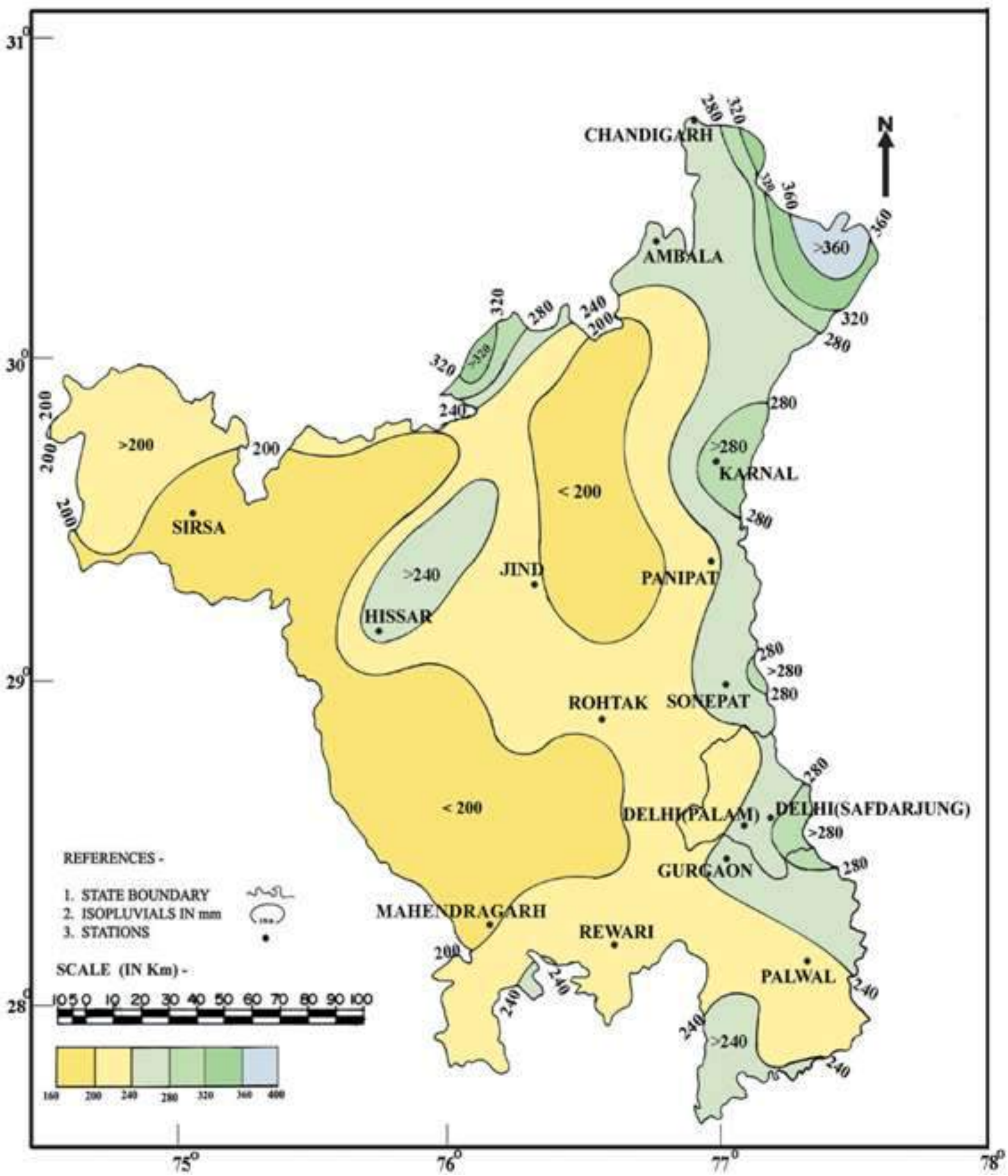
Figure-4. Haryana-25 Years - 24 Hours Isopluvial map (mm)



Source: – Atlas of state wise generalized isopluvial (return period) maps of India, Indian Meteorological Department.

Value of peak rainfall (Figure-2.4.) based on 50 years return period for 24 hrs. = 320 mm

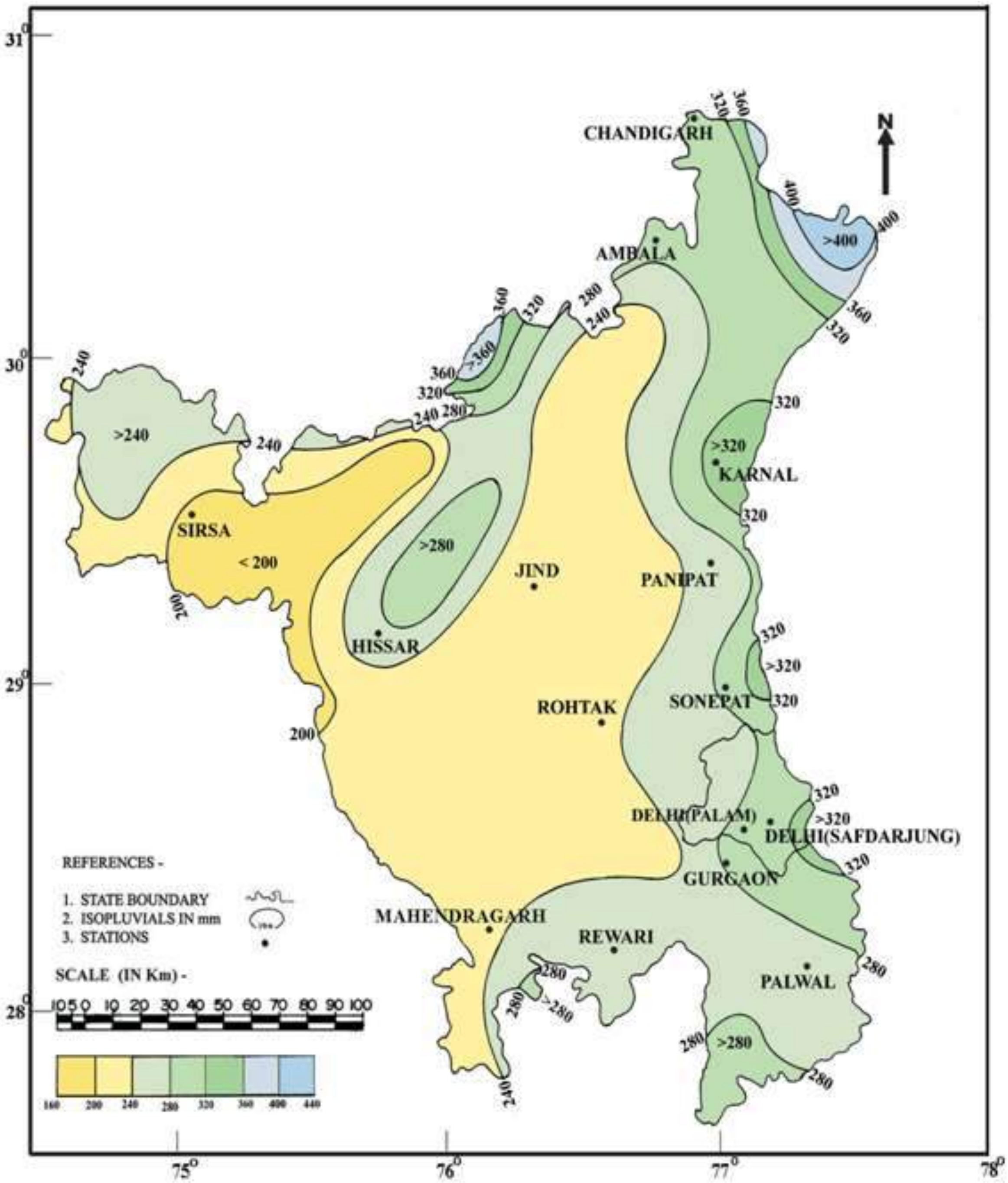
Figure-5. Haryana-50 Years - 24 Hours Isopluvial Map (mm)



Source: – Atlas of state wise generalized isopluvial (return period) maps of India, Indian Meteorological Department.

The value of peak rainfall (Figure-2.5) based on 100 years return period for 24 hrs. = 360 mm

Figure-6. Haryana-100 Years - 24 Hours Isopluvial Map (mm)



Source: – Atlas of state wise generalized isopluvial (return period) maps of India, Indian Meteorological Department.

2.4 Humidity

Relative humidity during the southwest monsoon is generally over 75%. During the rest of the year, air is normally dry. Relative humidity was observed in the range between 50% and 66%.

2.5 Cloudiness

Skies are generally moderately to heavily clouded during southwest monsoon season, being overcast on some days. During the rest of the year, the skies are normally clear to lightly clouded. During the months of August, the mean cloudiness (in Oktas) is usually more than 2.0, being generally higher in the mornings than the evenings.

2.6 Quality of surface water

The quality of surface water is good as the rocks of upper reaches are mostly consolidated sedimentaries with moderate rainfall and good drainage. The surface water therefore remains free from salinity. Water samples collected from rivers and streams during rainy season have indicated very low salt content, less than 700-900 mg/l and all constituents within permissible limits of drinking, industrial and irrigation purposes.

2.7 Geology of the area

2.7.1 Regional Geology

The North - Eastern and Central part of Haryana is Predominantly characterized by sedimentary lithology in the Sub-Himalayan zone comprising Subathus, Dagshais, Kasaulis and Siwalikas. A general Regional startigraphic sequence in the area is given in the table-5.

Table-5. A general Regional startigraphic sequence in the area

Age	Super Group	Group	Formation	Lithology
Holocene			Newer alluvium and newer Aeolian deposits	Gravel ,sand, silt, clay, limestone, gypsum
Lower to upper Pleistocene			Older alluvium and older Aeolian Deposits	Gravel, grey sand silt, clay brown sand, calcrete
Lower to middle Pleistocene	SIWALIK	Upper Siwalik	Boulder conglomerates formation	Conglomerate, sandstone, silt, clay
Upper Pliocene			Pinjore formation	Coarse grit, red sand stone and clay conglomerate
			Tatrot formation	Friable sandstone and variegated clay
		Middle Siwalik	Dhokpathan formation	Brown sandstone and orange clay
Middle Miocene			Nagri formation	Hard grey sand stone and mudstone and minor shale
		Lower Siwalik	Nahan formation	Coarse grity, clay and red sandstone often calcareous, brownish shale with lignite lenticles, greenish white quartzite
Lower Miocene	Sirmur		Kausauli Formation	Grey and greenstone, green shale and grey clay
			Dagsaj formation	Purple and green sand stone,deep red gitty, clay, whiteandstone With ferruginous concretions
Upper Eocene			Subathu formation	Sand stone with gritu clay. Impure fossiliferous limestone calcareous slate greenish shale and dark brown quartzite
Pre-proterozoic			Tundapathar	Thickly bedded , stromatolite limestone with carboniferous shale and quartzite

2.7.2 Local geology

The litho units encountered in the riverbed and surrounding areas belongs to the Siwalik Super group. The sediments are river borne and has deposited in the riverbed and the flood plains. The different formations of the area belong to Siwalik Super group and are a mixture of boulders, pebbles, sand,silt and clay. The following sequences have been observed in the area.

Soil/ Alluvium
Sand
Gravel
Boulder

There is no clear demarcation between the litho units. They have been deposit in a mixed form. The Litho- Units exposed around the riverbed belong to Siwalik Super group the mineral boulders, Gravel and Sand have formed by weathering of rocks and then deposition on the flood plains of the rivers originated from the Siwaliks, these have been washed by rainwater during rainy season and deposited in river bed in the from of boulder, gravels and sand of different sizes and shapes. These minerals are sorted by screening. The max depth of the minerals is not known.

Soil /alluvium varying in thickness from 2-4 constitute the top horizons in the area suitable for agriculture. Yamuna river meanders through the area exposing the alluvium and soil at the banks. Boulders, gravel and sand is found in the river bed. Boulder, gravel and sand is deposited up to great depths. this bed is presently dry and water flows only during the rainy season the sand exposed in the river bed of Yamuna and surrounding area is the product of the deposition of the sediments brought and deposited in flood plains river of the river Yamuna these sediments area of recent geological formation . The litho units exposed within the river and surrounding areas have formed as water borne sediments brought by flood water during rainy season every year and deposited in river bed Geological map section are enclosed.

2.7.3 Description of formation

The description of sand found in the lease area as minor mineral has been as under:

2.7.4 (Sand-minor mineral)

Sediments of various sizes and in mixed from are predominantly deposited in the river bed and outside the river bed as well in the central part there is no perfect classification between boulders, cobbles pebbles and sand. They are deposited in a mixed state. The classification is done by grab mining and the sediments are passed through different sieves in the screening plants.

Sediments of various sizes and in mixed from are predominantly deposited in the river bed and there is no perfect classification between sediments these may be called as coarse sand, medium sand and fine sand.

2.7.5 Grade 7& use of boulder, Gravel & sand

Most Boulder, Gravel & sand is made of quartz of quartzite / its microcrystalline cousin chalcedony, because that common mineral is resistant to weathering. River Boulder, Gravel & sands contain quartz feldspar grains, tiny bits of the rocks (lithics) or dark mineral like illuminate and magnetite.

The size of the sediments is variable. The grains whether small or large are rounded in shape gravel & sand is yellow brown in color, coarse to fine grained, the present deposits are the good quality and can be used for the building industries. There is no other use of the material

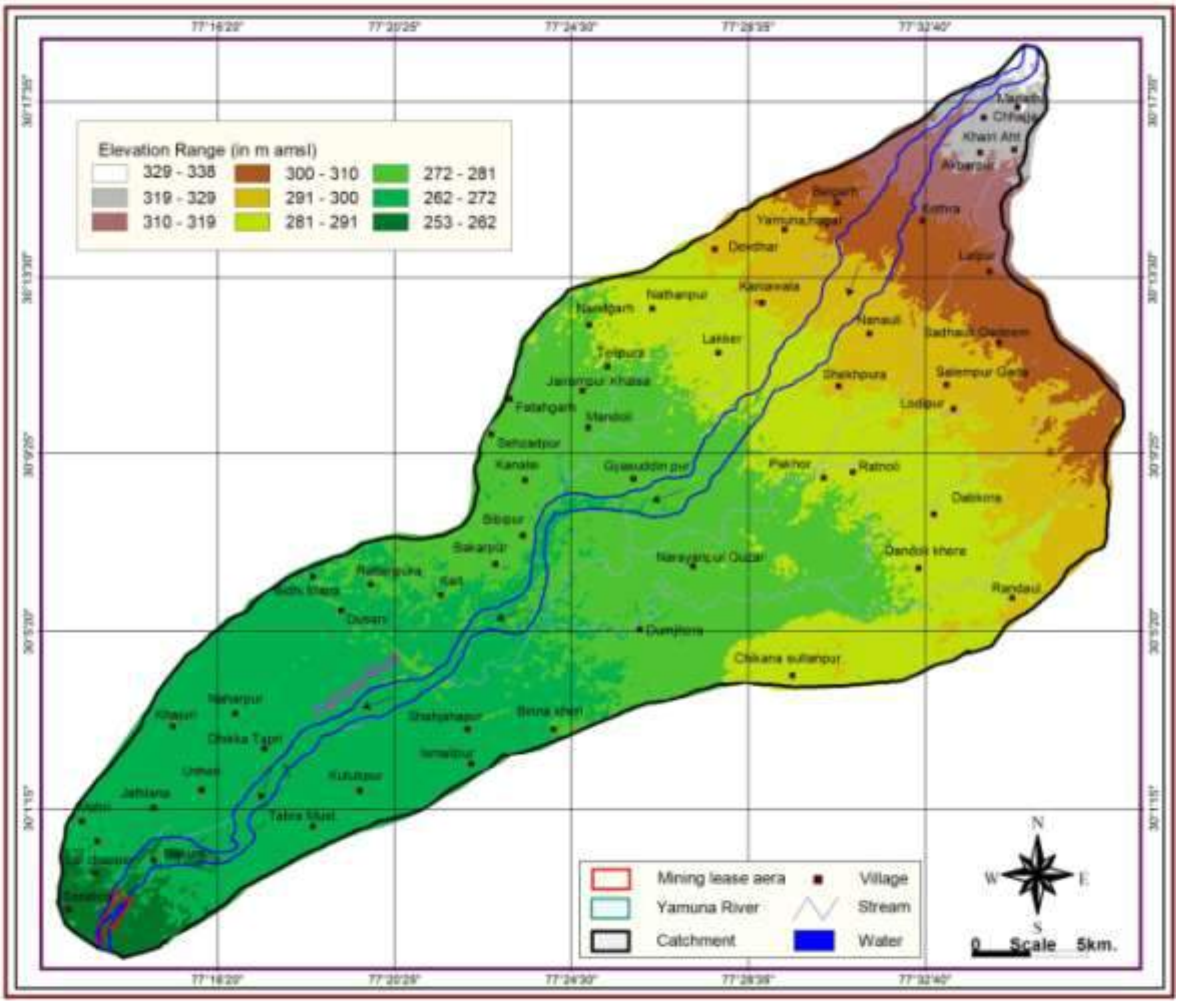
2.8 Quality of ground water

Quality of ground water in general is fresh and potable in all the formations with total dissolved salts ranges from 500-700 mg/l in the study area. The ground water therefore is suitable for drinking and irrigation purposes. All the constituents like chloride, sulphate, fluoride, nitrate etc. are within permissible limits of drinking water standards as per IS. 10500–1991 and ICMR 1975.

2.9 Delineation of watershed area

Watershed area of Yamuna is mapped in the study area on the basis of Survey of India toposheet Nos. 53G/1,5 and 53F/4,8 and also used latest satellite imagery of CARTOSAT – 1 of ISRO having a grid of 30 metres and SRTM, NASA at grid of 80 metres and computer aided drainage analysis system **(Figure-7).**

Figure-7. Digital Elevation Model (DEM) of Yamuna watershed



2.9.1 Yamuna watershed

In the study area Yamuna watershed covers an area of 617.07 km^2 with average gradient of 1.27 m/km towards south west. The catchment yield of Yamuna (within study area) is estimated as 65.66 mcm, 75.04 mcm and 84.42 mcm (Table-6) taking 280 mm, 320 mm and 360 mm, respectively as the **peak rainfall**; value based on 25 years, 50 years and 100 years return period and 24 hrs peak rainfall, respectively; and value of good surface run off coefficient of 38% for this catchment mostly rocky area.

Using formula

Catchment yield (m^3) = Catchment area (m^2) * runoff coefficient (%) * rainfall (m)

Table-6. Catchment yield at different return period of rainfall

Catchment yield at different return periods	Catchment area (m^2)	Runoff coefficient (%)	Rainfall (m)	Catchment yield (m^3)
	(A)	(B)	(C)	=A*B*C
Catchment yield (m^3) at 25 years return period	617070000	0.38	0.28	65656248
Catchment yield (m^3) at 50 years return period	617070000	0.38	0.32	75035712
Catchment yield (m^3) at 100 years return period	617070000	0.38	0.36	84415176

2.10 Determination of peak flood discharge for Yamuna watershed by means of empirical formulae

a. Dicken's formula

Dicken's formula states that: $\mathbf{Q_P = CA^{3/4}}$

Where Q_P = High flood or peak discharge in cumec
A = Catchment area in sq. km
C = A constant, taken c = 6 for the study area

b. Jarvis formula

Jarvis formula states that:

$$\mathbf{Q_P = C\sqrt{A}}$$

Where Q_p = High flood or peak discharge in cumec
C = a constant, having a value of 30 as low
A = Catchment area in sq. km

c. Rational formula

Rational formula states that:

$$Q_P = \frac{1}{36}(K.P_c.A)$$

Where Qp = High flood or peak discharge in cumec
K = Runoff coefficient
Pc = Critical rainfall intensity in cm/hr
A = Catchment area in hectares

Findings of the peak flood discharge based on above methods are given in **Table-7.**

Table-7. Peak flood discharges (Q_P) in cumec as calculated

Watershed	Dicken's	Jarvis	Rational formula		
			At 25 years return period	At 50 years return period	At 100 years return period
Yamuna watershed	742.85	745.23	762.69	866.99	977.81

3.0 PROPOSED MINING PROGRAMME

The total sand mining lease area covering parts of Yamuna river and her flood plains embrace an area of 89.48 ha (Figure-1). Mining lease area is located in revenue villages of Majri, NaglaRangran and Sandhala of district - Yamunanagar. Mining area consists of 89.48 ha area in NaglaRangran Block/YNR B-14, out of which about 23.40 ha area falls under restricted zone. About 66.08 ha area is free from restriction and the mining is proposed in this area only.

Table-8. Lease Area (Ha.)

Name of Block	Name of village	Details of Khasraa no/ Kila nos	Area Block in Ha
Naglarangran Block / YNR B-14	Majri	31min, 34, 35, 36, 32min, 33, 37, 38, 70min ,71min, 42min, 43, 133, 134, 135, 136min, 142min, 143, 145, 152, 156, 157, 158min, 153, 154, 155min, 165min, 166min, 16, 169, 180, 184, 185min, 177, 181, 182, 183, 206, 207, 208, 209, 210, 215, 219, 220, 221, 216, 218, 230, 231, 217, 229, 232, 233, 234, 238, 44, 36, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 146, 147, 148, 149, 150	**89.48**
	Nagla Rangran	1//17 min, 18, 19, 21, 22/1, 23/1, 23/2, 24min, 5//1, 2, 3, 4min, 8min, 9, 10, 12, 13/1min, 19min, 22/2min, 6/5, 6, 7, 8, 13, 14/1, 14/2, 19, 20, 21, 22, 23, 24, 7/25, 8//4/1, 4/2, 5/1, 5/2, 6, 7, 13, 14/1, 14/2, 15, 16, 17, 18, 22, 23/1, 23/2, 23/3, 24, 25, 9//1, 2, 3, 4/1, 4/2, 5, 6, 7, 8, 9/1, 9/2, 10, 11/1, 11/2, 12, 13, 14, 15min, 16min, 17, 18, 19/1, 19/2, 20, 21, 22, 23, 24min, 17/1 ,2 ,3, 4min, 7min, 9, 10, 11, 12, 13min, 18min, 19, 20/1, 20/2, 21, 22min, 18/2, 3, 4, 5, 6, 7, 8, 9, 12/1, 12/2, 13, 14, 15, 16, 17, 18, 22, 23, 24, 25/1, 25/2, 19//2, 3, 4, 5, 6, 7, 8, 9, 12 ,13, 14, 15/1, 15/2, 16, 19,20//1, 2min, 9min, 10, 11, 20, 35	
Sandhla		9//12min, 13, 19, 20min, 21min, 22, 18//5min, 6, 7min, 14min, 15, 16, 17, 18min, 23min, 24/1, 24/2, 25, 19//1, 10, 11, 21//2min, 3, 4, 5/1, 5, 2, 6, 7, 8, 9min, 12, 13, 14, 15, 16, 17, 18, 19, 20min, 21min, 22, 23, 24, 25, 20//1, 10, 11, 34//1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 18, 19, 20, 21, 22, 23, 33/6min, 15min, 16min, 25min, 37//5min, 6, 15, 16, 25,36//1, 2, 3, 8/1, 8/2, 13, 12/1, 12/2, 11, 20, 19/1, 19/2, 18, 21, 22, 45//5, 46//1, 2.	

As per the Mining Scheme prepared by Mr. S.N. Sharma (RQP/DDN/0135/2001-A valid up to 29-03-2021) of House No. 282, Sector 11D, Faridabad the relevant details are given below.

a) **Location map of the mining lease showing the details of the approach roads up to the mine**

The area is approachable from various nearest towns as detailed below. Village Nagla Rangran is very well connected with metaled road. Yamunanagar railway terminus is about 25 km from the mines area. Delhi ISBT is about 240 km and Yamunanagar is about 25 km NW from the mines area. State headquarter Chandigarh is about 100 km in the NW from the mining area.

Proposed Lease area forms a part of G. T. Sheet No’s –53G/1,5 and 53F/4,8. Toposheet is enclosed as Figure 1. Area is located between following Latitude and Longitudes:

Location Details

Latitude	Longitude
29°58'10" N to 29°59'24" N	77°13'32" E to 77°14'19" E

3.1 Reserve

3.2 Proved Reserves

- Survey was conducted in the proposed area of Yamuna river bed and area outside river bed as per the area allocated by DMG, Haryana a document provided by the authorities to the contractor. The khasra plan was provided by the applicant.

- Following special conditions those are applicable for excavations of minor mineral(s) from river beds in the order to ensure safety of river – beds, structures and adjoining areas are considered while reserves of the area:

  1. No mining would be permissible in a river-bed up to a distance of five times of the span of a bridge on up-stream side and ten times the span of such bridge on down-stream side, subject to a minimum of 250 meters on the up-stream side and 500 meters on the down-stream side;

  2. There shall be maintained an un-mined block of 50 meters width after every block of 1000 meters over which mining is undertaken or at such distance as may be directed by the director or any officer authorized by him;

  3. The maximum depth of mining in the river-bed shall not exceed three meter from the un-mined bed level at any point in time with proper bench formation;

  4. Mining shall be restricted within the central ¾ th width of the river / rivulet;

  5. In case of areas permitted for excavation outside river/rivulet i.e. areas adjoining to river/rivulets, no mining shall be permissible in an area up to a width of 500 meters from the active edges of embankments in case of river

Yamuna, 250 meters in case of Tangri , and Ghaggar river and 100 meters on either side of all other rivers/rivulets;

6. Any other condition(s), as may be required by the irrigation department of the state from time to time for river-bed mining in consultation with the mines & Geology, a safety margin of two meters (2m) shall be maintained above the ground water table while undertaking mining and no mining operations shall be permissible below this level unless a specific permission obtained from the competent authority in this behalf.

7. The contractor shall not undertake any mining operations in the area granted on mining contract without obtaining requisite permission from the compact authority as required undertaking mining operations under relevant laws.

8. A barrier of 7.5 m width will be left from the mining area boundary, in case of area outside the river bed.

3.3 Sections

Survey was conducted of the entire patch and sections were drawn at 25 m intervals. This has been considered as influence length for the sections. Detailed calculations, location of sections, sectional area with 3.0 m depth of excavation from surface river bed for the allotted lease area has been carried out. Total reserves/ quantity thus calculated are given below:

A. **Proved Reserves As Per UNFC Code (111) = 53,68,800 MT**
B. **Total blocked reserves as per UNFC Code (211 & 222) = 8,04,000 MT**
C. **Total mineable reserves = A-B = 45,64,800 MT**
D. **Targeted Production = 39,00,000 MT/year**

3.4 Details of production & dispatches of five years

This is a new mining area allotted to the applicant. Future production programmer has bees planned as per the details given below:

Production Programme

Mining contract has been allotted for a period of 09 year only. Mining area consist of 89.49 ha area in NaglaRangran Block/YNR B-14, out of which about 23.40 hectares area is falls under restricted zone. About 66.08 hectares area is free from restriction and mining is proposed in this area only.

Daily production proposed = 14,553 MT/day

Production programme is 582 trips/ day @ 25 ton per trip

Working days have been taken as 268 days per annum for the purpose of projection of production. However, this can be increased depending on the conditions prevailing at the time of execution.

Projected Production per Year =268 x 14,553 = 39,00,204 Tons

= 3.9 MMTA

Specific Density = 2.0 ton/ m^3

Annual Volumetric Production = 1.95, Million meter m^3

Table-9: Five Years Proposed Production Details

Total (All Blocks)

Year	*Total Trips /Day*	*MTPA*	*MCM*
I	*582*	*3.9*	*1.95*
II	*582*	*3.9*	*1.95*
III	*582*	*3.9*	*1.95*
IV	*582*	*3.9*	*1.95*
V	*582*	*3.9*	*1.95*
Total	***2910***	***19.50***	***9.75***

3.5 Physical and geological characteristics of the deposit

Deposit is moderate to good quality sand. It is widely used in construction, buildings, bridges and other infrastructure. It is free from clay and is non sticky in nature.

3.6 Method of mining

Mining is proposed up to 3.0m depth in river bed.

River bed mining is proposed for extracting sand from Yamuna river bed. As per Haryana minor mineral concession rules, 2012 extraction is limited to 3.0 m depth only in river bed, mining area allotted is 89.48 ha in district – Yamunanagar . Mining activity will be carried out in allocated areas only.

A. The production plan for each year is suggested to be 39,00,000 MT but for second year onward the same shall be dependent upon the rate of replenishment of the mineral during proceeding year. In case due to any reason the replenishment of mineral (sand is not taken place up to depth the of mined out area (which would not be more then 3 meter of existing level of bed) in that case the working replenishment. for example – in case during any year only 2.5 m or 1.5 m, of the mined out area is refilled after rainy season – the production for said year shall be accordingly adjusted and mining depth will be reduced accordingly.

B. The same will also act as annual replenishment study of the mine as compared to the prevailing status of river bed.

C. Sequence of working has been shown in the plate No 4. The proposed rate of production has been shown at chapter 7.2 for the 5 year plan period. If the depth of mineral replacement is less than 3.0 m then proposed production shall be reduced proportionately.

3.7 Proposed year wise development for five years

Sand mining lease is proposed to be granted for a period of five years only. Calendar plan has already been made and details have been given. Sequence of operation has been depicted in Working Plan and Sections.

Ultimate extraction limit will be 3.0 m below existing bed level as indicated in the working section.

3.8 Proposed rate of production when the mine is fully developed

Year wise production during the plan period will be as follows:

Table-10. Proposed Production

Year	Targeted Production (in MMTA)	Targeted Production (in MCM)	OB/ Waste (M^3)
1	*3.9*	*1.95*	-
2	*3.9*	*1.95*	-
3	*3.9*	*1.95*	-
4	*3.9*	*1.95*	-
5	*3.9*	*1.95*	-
Total	***19.50***	***9.75***	-

Conversion factor is 2.0 ton/ m^3

3.9 Mineable reserves and anticipated life of the mine

It is presumed that the mineral will be replenished every year in river year in river bed during the rainy season. New mineral will be added every year in the river bed. However the present reserves are sufficient for 1 year in "river bed" and thereafter will be replenishment every year.

3.10 Proposed method of mining

- Mining activity will be carried out by open cast semi-mechanized method.
- No overburden / waste material will be produced in river bed. No drilling / blasting are required as the material is loose in nature.
- Light weight excavators/JCB will be used for loading of mineral in tippers.
- Proper benching of 3.0 m height will be maintained and width of the bench will be around 20 m. The benches shall be maintained in the form of slices / strips parallel to the banks of river.
- Mining activates will be carried out in a manner so that there is no obstruction to the movement of water flow, if any, during rainy season.
- Roads will be properly made and sprayed by water for suppression of dust.
- Roads in the mining area for the movement of loaded trippers/ trucks will not have slopes more than 1 in 20.
- Extraction activities will start in the blocks from the upstream side to downstream side. This will not obstruct the movement of water, if any, during monsoon period in the river course.

3.11 Conceptual Mining Plan

River bed: mine area will be worked in block for case of operation. However, as the digging depth will be restricted to 3.0 m only in river bed and material will still be available below. This will be further replenished during rainy season. Blocks will be worked systematically as the width is limited while length is much more. The mining area will be worked in blocks for ease of operation. The depth would be restricted to 3.0 m only from th exiting level of the river bed. Regular monitoring of the bed level would be ensured by taking the bed level after fixed intervals, including after the rainy season. The mined out area would be refilled by the mineral (sand) after every rainy. Hence even after completion of the five year period of contact or even on expiry of the period of contract the status of the contracted area / are to be used for mining in the river bed would remain unchanged.

Hence the conceptual plan of the mine after the period of contracts shall be as is on the present day.

Sequence of working has been shown on plate no. 4. As the mining contract period is only 9 years, some of the area will be left un-worked at the end of contract period.

Final slope angle to be adopted

Thickness of the bench is limited to 3.0 m only in river bed and width will be more than the height of the bench, river bank side will be protected by working in ¾ part of middle of the river. Bank side natural slop will not be disturbed. This will prevent collapse of bank and erosion. However, the height of the bank with respect to river bed is varying from 2-3m only.

During plan period workings will be carried out in the designated villages at a time of the mining area simultaneously. Scattered working will ensure safety, remove congestion of vehicles and will have better control and management.

Capacity of dumps

There will be no over bur den generation and hence no separate dump yard is required.

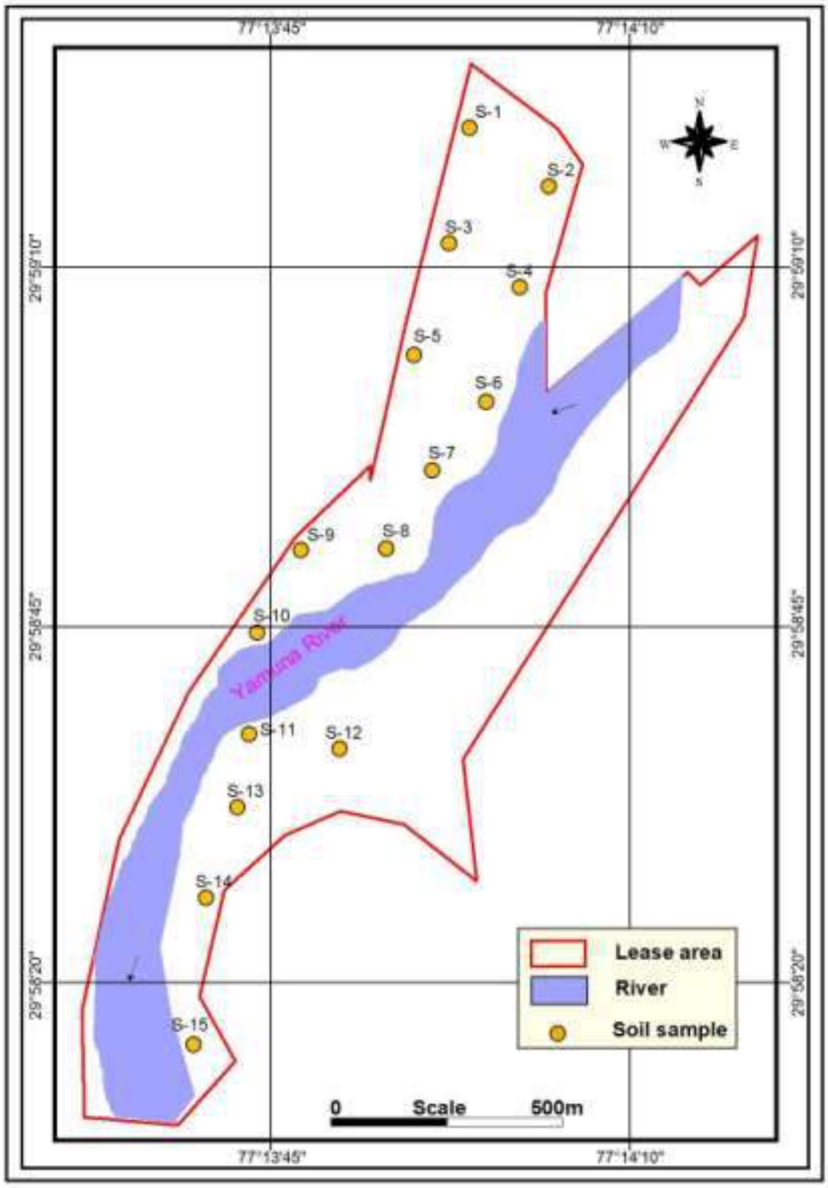
4.0 SEDIMENT TRANSPORT ANALYSIS

4.1 Sediment Data

Sieve Analysis results

The sediment samples were collected from the bed of the Yamuna over the entire length of the study reach. Sampling sites were located in the flood plains of the channel and were taken approximately 100 metre apart. Sediment samples were obtained from soil pits excavated in the channel, with the sediment sample material integrated over the one to two metre depth of the pit. The locations of the sediment sampling sites were shown in **Figure-8.**

Figure-8. Sediment sampling sites



Sieve analyses of the sediment samples were performed to obtain the sediment gradation curves shown in Inspection of the data revealed a consistent trend in sediment size by reach or with distance along the study reach. Table-11 shows that the variation from the mean is not significant and D_{50} which is used extensively in the analysis is **2.82 mm**. Therefore, the sediment gradation curves for all samples were averaged together to obtain a composite reach-averaged curve for the Yamuna lease reach.

Sediment sample gradation data and plots showing the sediment distribution curves for each reach are provided in Appendix-I. The uniformity coefficient Cu is defined as the ratio of D_{60} by D_{10}. So when Cu is greater than 4 to 6, it is understood as a well graded soil and when the Cu is less than 4, they are considered to be poorly graded or uniformly graded. Uniformly graded in the sense, the soils have got identical size of the particles. Another coefficient to measure gradation is: Cc is equal to (D_{30} square)/(D_{60} into D_{10}) where coefficient of gradation or coefficient of curvature. For the soil to be uniformly graded the value of coefficient of uniformity Cu has to be less than 4 and Cc should be in the range of 1 to 3. So higher the value of Cu the larger the range of the particle sizes in the RBM. So if the Cu value is high it indicates that the RBM mass consists of different ranges of particle sizes.

Table-11. Sieve analysis results

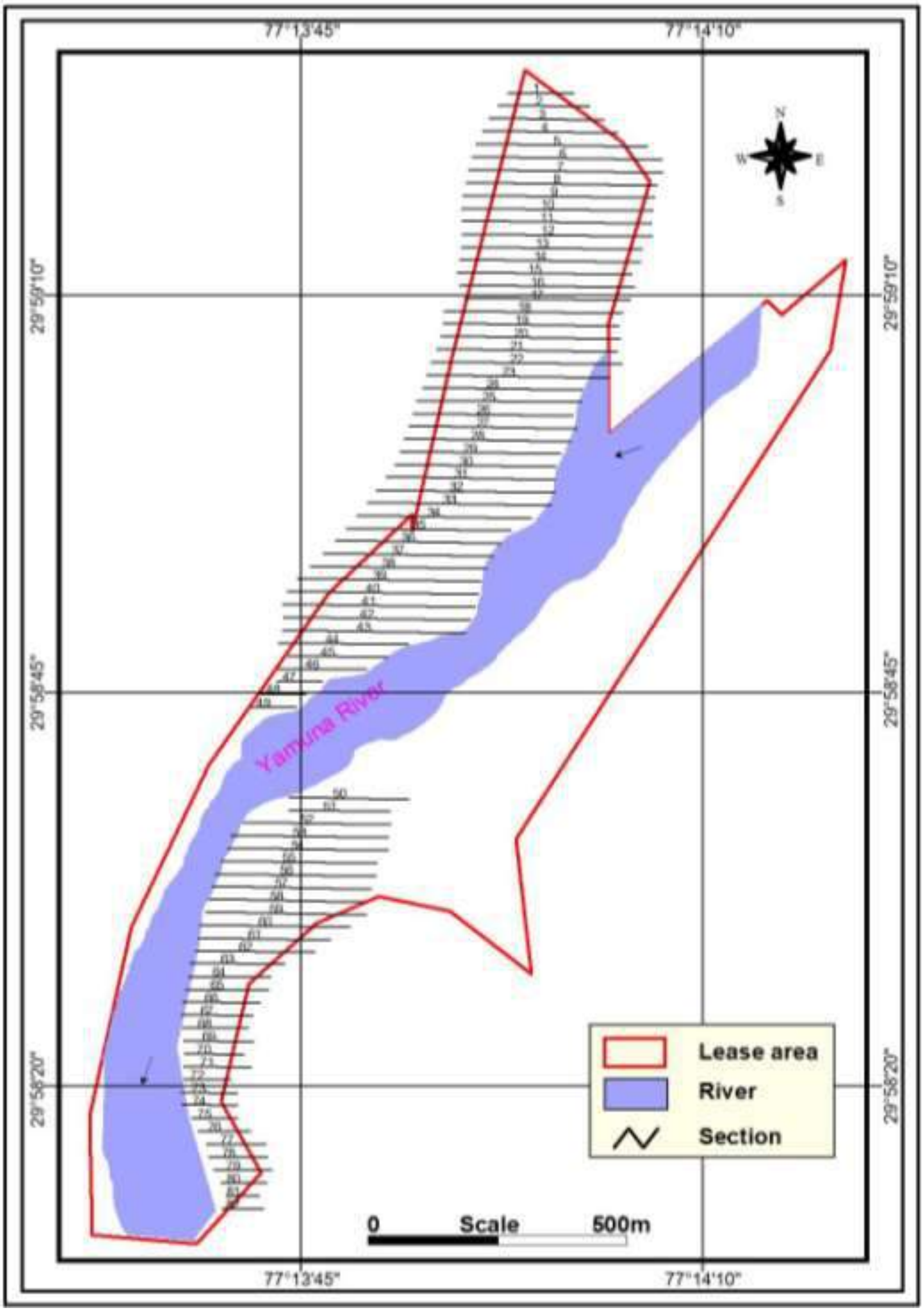
Sample	D_{10}	D_{30}	D_{50}	D_{60}	C_u	C_c
1	1.204	2.236	3.450	4.411	03.66	00.94
2	0.911	2.208	3.320	4.486	04.92	01.19
3	0.512	1.923	3.020	3.901	07.62	01.85
4	0.361	0.815	2.850	2.721	07.55	00.68
5	0.274	1.022	2.470	2.524	09.23	01.51
6	0.340	1.130	3.180	3.209	09.43	01.17
7	0.352	1.378	2.810	3.284	09.34	01.64
8	0.313	1.301	3.160	3.196	10.21	01.69
9	0.308	1.226	2.520	3.192	10.37	01.53
10	0.224	0.971	3.160	3.050	13.60	01.38
11	0.221	0.937	2.400	2.899	13.11	01.37
12	0.221	0.937	2.820	2.899	13.11	01.37
13	0.257	0.767	2.730	2.392	09.30	00.96
14	0.254	0.733	2.215	2.490	11.12	00.96
15	0.192	0.957	2.180	2.309	12.01	02.06

4.2 River bed elevation divided into vertical sections for measurement of replenishment

Eighty two cross-sections on a spacing of 25 metres were surveyed using a Total Station and river bed profiles plotted (Appendix-II) and four benchmarks were established in the lease area (Photoplate-1). The location of the section lines are given below in **Figure-9.**

The objective of the survey is to observe the difference in elevation post-monsoon, 2018 and quantify the actual sand deposition taking place.

Figure-9. Location of section lines in the in the river



Photoplate-1. Survey using TS and benchmark under construction

4.3 Sediment Transport Analysis

The sediment transport analysis is based on three different steps with various equations pertaining to stream process, one dealing with critical dimensionless shear, another on relative roughness and boundary resistance and the last on bed load equations.

4.3.1 Flow Resistance from Relative Roughness

Colebrook-White equation, of which a number of variations exist, has the general form

U/U* = A log(B*relative roughness)

Resistance Factor = velocity / shear velocity = U/U*

Where:

U = velocity

U* = shear velocity

Value varies from about 2 for rough streambeds to 16 for smooth.

U/U* is related to common resistance equations as follows:

Manning's roughness coefficient (n):

$U/U^* = R(^{1/6)/(ng0.5)}$

D'Arcy-Weisbach friction factor (f):

$U/U^* = (8/f)^{0.5}$

Because the Colebrook-White equation is a function of measurable values; depth and particle size, other roughness coefficients can be made functions of depth and particle size in generally straight uniform gravel-bed streams where resistance is dominated by boundary roughness

4.3.2 Shield's Threshold of Motion Equation.

$D_s = \tau / ((\rho_s - \rho)\ g\ 0.06)(304.8)$

D_s=diameter sediment particle (mm)

τ=shear stress=(ρg)(depth)(slope) (lb/ft^2) (N/m^2)

ρ_s=density of sediment (5.15 $slugs/ft^3$) or (2560 kg/m^3)

ρ=density of water (1.94 $slugs/ft^3$) (1000 kg/m^3)

g=gravitational acceleration (32.2 ft/s^2) (9.81 m/s^2)

0.06 = Shield's parameter typically in the range of 0.04 to 0.07

Conversion Constant 304.8 mm/ft or 1000 mm/m

In gravel-bed streams at bankfull flow the particle at the threshold of motion is often near in size to the D_{50} of mobile bed surface material.

4.3.3 Bedload Sediment Rate

Three common bed load equations are Ackers and White, Meyer-Peter and Einstein. Many more equations exist, some of which are more appropriate for different conditions. The most appropriate for perennial streams applicable to this study is the Meyer-Peter equation, although calculations have been done for all three. Out of the 3 methods considered, the Meyer-Peter equation gives the reliable value for bed load sediment rate calculation. Considering it has the most suitable equation for perennial stream of Haryana.

4.4 Results

The sediment transport analysis was performed using "Sediment Equations, version 4.0" software developed by Department of Natural Resources, Ohio University, USA.

The parameters used with units and analysis results (Tables-12 to 13) are presented below:

Table-12. Analysis result using Threshold of Motion

		metric units	
Depth	d	**0.75**	m
Slope	S	**0.00127**	m/m
Diameter sediment	d_s	**0.00282**	m
Gravitational acceleration	g	9.81	m/sec^2
Density fluid	ρ_f	1000	kg/m^3
Density sediment	ρ_s	2650	kg/m^3
Specific weight of water	γ	9810	N/m^3
		1000	kg_f/m^3
Shear stress	τ	9.3	N/m^2
		1.0	kg_f/m^2
Shields parameter	τ_{*c}	0.205	dimensionless
Particle at threshold of motion	D_{cr}	0.01	m

Table-13. Analysis result for Bedload per unit channel width

		metric units	
Depth	d	**0.75**	m
Slope	S	**0.00127**	m/m
Diameter sediment	d_s	**0.00282**	m
Gravitational acceleration	g	9.81	m/sec^2
Density fluid	ρ_f	1000	kg/m^3
Density sediment	ρ_s	2650	kg/m^3
Relative density	s	2.65	dimensionless
Shear stress	τ	9.3	N/m^2
Dimensionless parameter	Ψ	4.89	
Bed-load transport (Meyer-Peter)	Φ	0.501	
	q_s	0.0003	m^2/s
Bed-load transport (Einstein$_{42}$)	Φ	0.318	
	q_s	0.00019	m^2/s
Bed-load transport (Einstein$_{50}$)	Φ	0.635	
	q_s	0.00038	m^2/s
Ackers and White	n	0.019	
	U	1.52	m/s
	q_b	0.00013	m^2/s

Therefore, based on the Meyer-Peter analysis, the bed load transport for the studied river Yamuna reach taking average width as 940 metres is 24,365 m^3/day or **29,23,800 m^3/year** taking 120 days as turbulent river flow.

Table-14. Analysis result using Resistance Manning's and D'Arcy-Weisbach equations

Resistance Manning's and D'Arcy-Weisbach		metric units	
Depth	d	**0.75**	m
Slope	S	**0.00127**	m/m
Diameter sediment	d_s	**0.00282**	m
Max depth	d_{max}	**1.5**	m
Gravitational acceleration	g	9.81	m/sec^2
Resistance factor = sqrt(8/*f*)			
Colebrook-White Eq (Hey 1979) for D_{84}	u/u*	17.4	
Leopold, Wolman & Miller (1964) for D_{84}	u/u*	17.2	
Griffiths (1981) for D_{50}	u/u*	15.7	

Manning's roughness coefficient (n):			
Colebrook-White Eq (Hey 1979) for D_{84}	n	0.0175	
Leopold, Wolman & Miller (1964) for D_{84}	n	0.0177	
Griffiths (1981) for D_{50}	n	0.0193	
D'Arcy-Weisbach friction factor:			
Colebrook-White Eq (Hey 1979) for D_{84}	f	0.0265	
Leopold, Wolman & Miller (1964) for D_{84}	f	0.0270	
Griffiths (1981) for D_{50}	f	0.0323	

5.0 CONCLUSION & RECOMMENDATIONS

5.1 Conclusion on Estimation of Sand Replenishment

The annual Bajri/ sand replenishment in mine lease area has been calculated using the Meyer-Peter equation. It is found that the annual replenishment rate 2.34 million m^3 **(Table-15)** for the studied reach of river Yamuna.

Thus the sand replenishment is 120% **(Table-16)** of the targeted production as given in the mining plan by the lease holder.

Table-15. Estimation of sand replenishment using the Meyer-Peter analysis:

Lease Area (in Ha)	Estimated Bed Load (Tonnes/day)	Sediment Load Deposition per day (in Tonnes)	Sediment Load Deposition per month (in Tonnes)	Annual Replenishment (in Tonnes)	Estimated Annual Replenishment (in million m^3)*
89.48	48,729.60	38,983.68	11,69,510.40	46,78,041.60	2.34

*Specific gravity of sand = 2.0 tonne per m^3

Table-16. Status of Sand Replenishment vis-à-vis annual planned production

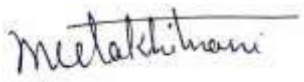
*Estimates Reserve (in million m^3)	*Annual average Production Capacity envisaged (as per mining plan in million m^3)	Estimated Annual replenishment (in million m^3)	Replenishment Status vis-à-vis planned production
19.50	**1.95**	**2.34**	**Replenishment is more than planned annual production**

*** As per Mining Plan approved by Department of Mines and Geology, Government of Haryana**

5.2 Recommendation

The estimation of sand replenishment is based on empirical and analytical approaches to the problem as discussed in Chapter 4 which can be approved for targeted production of 1.95 MCM/year as the estimated annual replenishment of 2.34 MCM is more. The authentic replenishment can only be established in the post-monsoon period of 2018 after actual verification of the ‘replenishment pits’ and river ‘cross sections’ (difference in elevation) already established in the field.

Dr. Meeta Khilnani



(Dr. Meeta Khilnani)