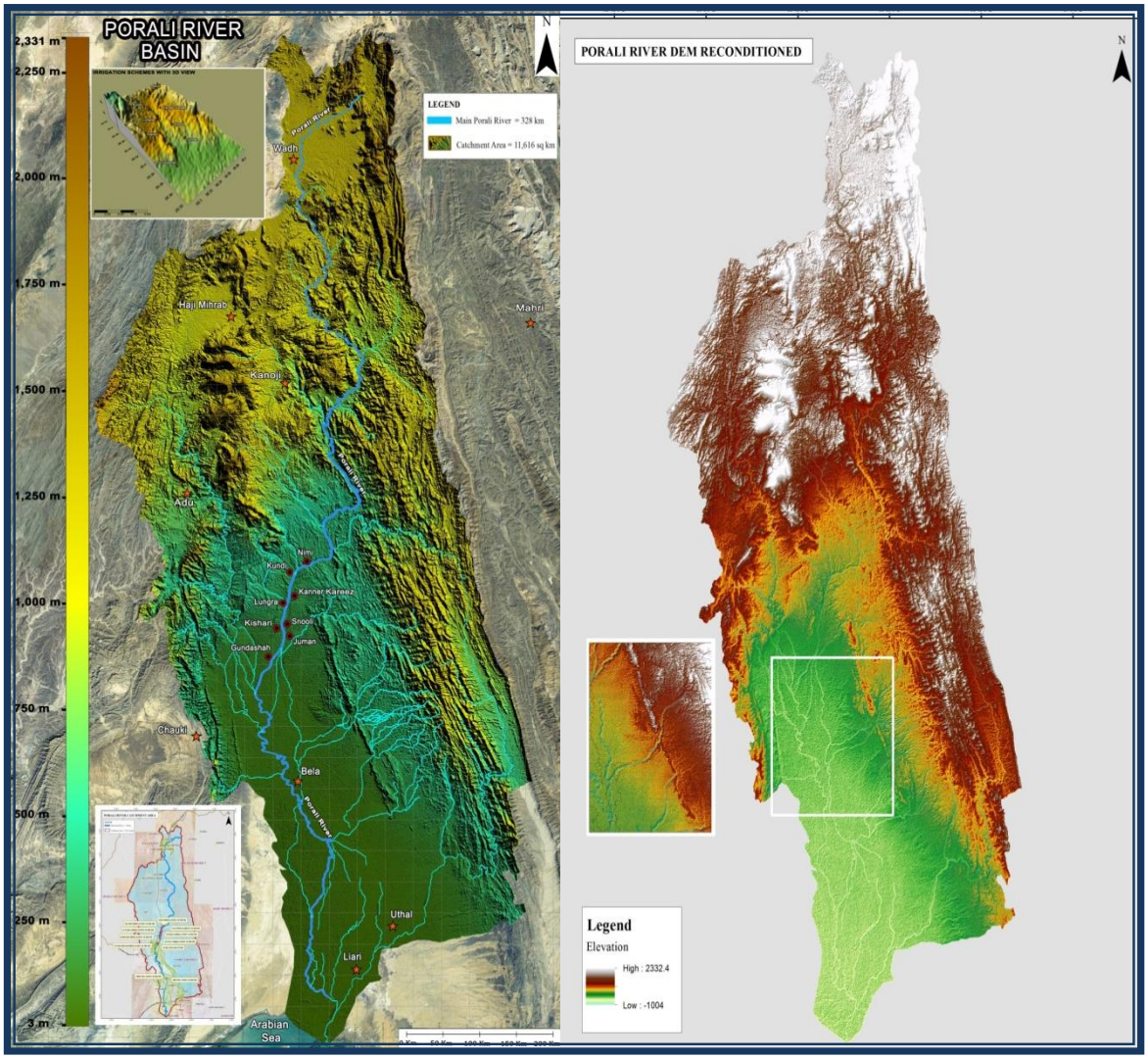
**GOVERNMENT OF BALOCHISTAN**
**BALOCHISTAN SMALL SCALE IRRIGATION PROJECT**




# Gundacha-Nurg/Hingri Irrigation Scheme
# **Design Report**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CAMEOS

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# EXECUTIVE SUMMARY

## I. INTRODUCTION

The Gundacha area lies along the middle reach of the Porali River. The river flowing in this reach covers a CCA of around 6000 acres. The main issue at Gundacha is the uncontrolled flow entering the Command area. The Gundacha – Nurg Hingri Irrigation Scheme (GNHIS) package proposes a reliable diversion system at the Gundacha stretch of Porali River.

Nurg Hingri area lies at about 5 km downstream of the Gundacha village. The existing Nurg and Hingri Weirs command the area through flood flows and cover about 8,000 and 12,000 acres respectively. The major issue in this area is the open crest high volume discharge in the downstream earthen channels. This package proposes an improvement of existing Nurg-Hingri diversion Structures and conveyance channels.

The GNHIS Package will result in overall socio-economic up-gradation of the locals and will considerably benefit the farming communities as well.

## II. TOPOGRAPHIC SURVEY

Topographic survey of both Gundacha and Nurg-Hingri areas have been carried out in detail. The command area of Gundacha has been surveyed and marked over maps on a scale of 1:15,000. Strip survey for the canal alignment has been undertaken and plotted for proposing new canals and the appurtenant structures.

Topographic survey of the existing Nurg-Hingri Weirs was carried out and presented on maps.

## III. HYDROLOGY

The Hydrological study of the proposed GNHIS covered Rainfall frequency analysis, inflow estimation at the proposed and existing Weir sites, Water availability and determination of design floods. Daily Rainfall data of Wadh, Bela and Uthal was used for the frequency analysis, Runoff estimation, mean monthly/yearly discharges and development of Hydrographs. A 100 year peak design flood of 3,768 cumecs was selected for the design of Gundacha Weir.

For the remodelling of Nurg-Hingri Weir, 25 year peak design flood of 2,317 cumecs was selected.

## IV. DESIGN OF PROPOSED WORKS

**Gundacha Perennial Irrigation Scheme**

A 410 m wide ungated overflow weir has been proposed at Gundacha. The primary purpose of this weir is to raise the water level to ensure continuous

irrigation water supply to the command area. The weir structure will also prevent the incoming sediments to enter into the main canal. An under sluice is to be provided on the right flank of the weir with 3 openings each 2.2 m wide. The head regulator for has been designed as an open intake with concrete box section. Guide bunds will be provided for protecting the command area from flooding.

**Nurg Hingri Flood Irrigation Scheme**

The existing Nurg Hingri overflow weir is a 295 m wide concrete structure with two secondary weirs of 66 m and 44 m wide water way respectively. The site survey of the Weir location indicated absence of maintenance and upkeep during past years. Based on the damage caused at the downstream of the weir, an upgradation of the weir and related structures has been proposed. The excessive discharge will be controlled by providing a breast wall on the Nurg and Hingri Weirs to limit the entering peak floods. An under sluice will be provided to keep the tendency of river flow towards the off take. Reconstruction and strengthening of the embankment bunds and spot repairs for minor damages will also be carried out.

## V. DESIGN OF IRRIGATION CANALS

A command area of about 6,300 acres has been proposed to be irrigated through the irrigation canal system. An off- take structure proposed on right bank of the river will feed the two irrigation canals serving the command area. The off take design capacity is kept 2.5 cumecs that will cater the needs of the whole Gundacha command area. Two main canals namely, Gundacha and Jamot will be fed from the offtake. The length of each canal is 12 kms. Fall structures are provided wherever needed to follow the natural ground level of the existing irrigation canals.

A number of outlets are provided at regular intervals to convey water to the fields. Drainage culverts are proposed to provide crossing to the natural streams flowing across the canals. Road culverts proposed will provide for movement of locals and animals across the canals.

## VI. PROJECT CONSTRUCTION PLANNING

The Gundacha Nurg Hingri Irrigation Scheme (GNHIS) is the main package with two main works at Gundacha & Nurg Hingri locations. The Construction activities are scheduled in order to achieve coordinated progress to avoid double handling of the resources as far as possible.

The proposed construction schedule is divided into Pre-Construction and Construction Phase. The Pre-Construction activities include Land Acquisition, Review of design and tender documents, Tendering process and Contract award. The Pre-Construction phase will be completed within 3 months. The Construction phase involves the Preparatory Works, Construction of main Weir, Under Sluice, Head Regulator and irrigation Canals. The Construction phase of the Scheme is scheduled to be completed within 30 months of the commencement of the project.

# Chapter - 1
# INTRODUCTION

## 1.1 BACKGROUND

The Gundacha-Nurg/Hingri stretch of Porali River marks the end of its middle reach. In this reach, the River channel gradually spreads out turning into a wide and shallow stream. Gundacha village is located at right bank of the River towards the upstream end of this stretch. Here, the perennial low flow channel of the River hugs its right bank. Cultivators of the area on right bank have traditionally been diverting the flows to irrigate a large chunk (over 6000 acres) of Cultivable Command Area (CCA). The diversion systems are rudimentary in nature and comprise of small earthen dykes and spurs.

Travelling downstream on Porali River, the Nurg-Hingri area starts at about 5 km downstream of Gundacha Village. This area falls under flood irrigated commands of Porali River, as no perennial flow reaches here. The spate users get benefitted through an existing diversion that facilitates partial flood flows to irrigate their lands. The total benefitted area is about 12000 and 8000 acres on Nurg and Hingri flood channels respectively. Due to the close proximity, the communities of Gundacha and Nurg-Hingri areas are closely interlinked. During the sowing and harvesting periods, the perennially irrigated crop land of Gundacha area gets extra farm labor from Nurg-Hingri. Tribal relations, cultural practices and historic old presence on the same water source (Porali River) have resulted in a closely interwoven extended community dwelling in these areas.

Consequently, long-term success of development project at Gundacha is partly dependent on equally effective measures for the immediately downstream community i.e. Nurg-Hingri area. Therefore, the package in-hand, in addition to proposed system at Gundacha, includes upgrading works of the existing Nurg-Hingri head works and conveyance channels along with the proposed diversion works at Gundacha.

## 1.2 MAJOR ISSUES

The main issue at Gundacha is the vulnerability of existing rudimentary diversion systems to flood peaks. Medium to high flood peaks not only wash away the diversion dykes but also cause uncontrolled flow entering the command area resulting in damage to crops and infrastructure. After occurrence of such a damaging event, it takes weeks (often months) for the farmers to restore supply of irrigation supplies. In the meanwhile, the crops suffer badly leading to either a total failure or extremely low yields. In some cases, depending on the time of the year, such damaging events result in the loss of the whole cropping season.

Another issue, though less frequent, is the morphological change, brought about by major floods, in the river bed. In the absence of a control structure, the low flow

perennial channel gets silted up or blocked by sand bars created during the flood events. The affected farming community of Gundacha cannot afford to deploy earthmoving machinery and have to use manual labor or small tractors at best. This takes a long time before the irrigation supplies are restored. In view of the foregoing, there is a need for a control structure and reliable off take at this location.

At the downstream end of the said river reach, the existing Nurg-Hingri diversion weir poses a different issue. This structure, built in 1987, aimed at diverting the flood flows into two channels, namely; Nurg and Hingri. However, the diversion weirs of both the channels are without any controlling device. The open weir crests of considerable waterways let high discharges enter into the downstream earthen channels. The resulting damage is twofold; viz. the channel itself and its guide banks get severely eroded and the command area gets flooded. Consequently, the system causes more frequent damages rather than benefits. It is, therefore, highly desirable to remodel the existing off takes by providing some kind of control to limit the flow passing over the diversion weirs.

## 1.3 PROJECT OBJECTIVES

Main objective of the proposed package is to provide reliable diversion system at Gundacha and to upgrade and improve the performance of existing Nurg-Hingri diversion structure and conveyance channels for achieving full benefits from the Gundacha-Nurg/Hingri package of development program. The idea is to provide compatible opportunities to the beneficiaries of both communities so that an integrated upbringing of the region is encouraged. It is expected that the successful completion of proposed package will result in overall socio-economic well-being of inhabitants of the area in general, and the farming communities (being the greatest part) in particular.

## 1.4 PROJECT PLAN

The project plan involves construction of a diversion weir at Gundacha, together with appurtenant structures such as head regulator, under sluice, energy dissipation devices and guide banks. The conveyance system for Gundacha command area comprises concrete canals and associated structures such as falls, cross regulators, road culverts, drainage crossings and outlet structures.

The plan at Nurg-Hingri is to construct weir off takes equipped with breast walls resting on piers along with necessary energy dissipation devices. In addition, an under sluice is also planned between the main weir and off takes. Necessary lengths of guide banks shall also be provided to safely lead the flow into the downstream unlined channels.

## 1.5 REPORT IN HAND

The Design Report (in hand) of Gundacha-Nurg/Hingri Irrigation Schemes elaborates the design aspects of all the major components of the Project, including the diversion weirs, appurtenant structures and Irrigation system. The report also briefly describes the topographic survey of proposed and existing weirs that was carried out on the field. A brief construction schedule has been proposed at the end of the report, highlighting the duration of the various construction activities and the milestones to be achieved.

# Chapter - 2
# TOPOGRAPHIC SURVEY AND MAPPING

## 2.1 RECONNAISSANCE SURVEY

The relevant SOP (Survey of Pakistan) Topographic sheets 35-J/6 & 35-J/7, on scale of 1:50,000 for the proposed weir sites were collected and initially utilized for obtaining topographic information for preliminary reconnaissance survey. It was also used to estimate the command area and to identify the major features within the project vicinity.

After preliminary study of proposed weir site, reconnaissance survey has been carried out through latest handheld GPS. In reconnaissance survey all previously identified features, topography and local information was verified. Primary access routes, significant land marks and other site related aspects were noted.

## 2.2 TOPOGRAPHIC SURVEY

For detailed engineering design, both Gundacha and Nurg-Hingri areas have been surveyed with total station (Sokkia 630R). The benchmarks established during this survey work will be used effectively for the layout of weir, canal and other related structures.

The survey work was reviewed and supervised by the design engineers and covered the following specific areas.

Detailed topographic survey of proposed and existing weirs had been carried out in strip form, the corridor had been adjusted. Spot elevations had been obtained in the defined survey grid. Minimum elevation found here in river bed is around 130 m above mean sea level, while the upstream strip edge touches the 177 m elevation.

The area covered by the survey from existing Gundacha irrigation channel to Nurg-Hingri weir covering high abutments flanking the stream channel. Intermediate levels were taken where elevation difference was more than 10 cm.

Following are the main objectives of the topographic survey;

- Survey and develop contours at 0.2 m interval as per site by using UTM coordinates system and WGS 84 geodetic system.
- Obtain spot elevations and draw topography.
- Survey and draw longitudinal section and cross section of all major features within the defined project boundary.
- Establish permanent bench marks for future use.

## 2.3 COMMAND AREA

Most of the command area of Gundacha Irrigation System is available on right side of the Porali River at the downstream of the proposed weir. Topographic survey of command area has been carried out and presented on a scale of 1:15,000 with contour interval of 0.5 m. Around 2274.5 ha (5618 acre) area has been surveyed and marked over map as a command area. All existing features including existing irrigated land and settlement have been surveyed and shown in map. Since distribution of flood flow in Nurg-Hingri System is not being altered, its command area has not been surveyed in detail.

## 2.4 CANAL ALIGNMENT

Strip survey of the existing irrigation channels serving the command area of Gundacha has been carried out. Approximately 24 kms of irrigation channels have been covered in the strip survey.

The command area of around 6,300 acres is to be irrigated through the proposed canals.

## 2.5 ESTABLISHMENT OF BENCH MARKS

Following survey Benchmarks (BM) were established for later use during construction works.

**Table 2.1: Bench Marks Co-ordinates & Elevations**

| GUNDACHA | | | | NURG-HINGRI | | | |
|---|---|---|---|---|---|---|---|
| S. No. | Easting (m) | Northing (m) | Elevation (m) | S. No. | Easting (m) | Northing (m) | Elevation (m) |
| G1 | 233694.000 | 2921320.000 | 176.00 | NH1 | 233502.497 | 2916727.031 | 139.747 |
| G2 | 233789.688 | 2921187.810 | 171.661 | NH2 | 233876.442 | 2916531.224 | 139.862 |
| G3 | 233843.189 | 2921097.500 | 170.474 | NH3 | 233768.771 | 2916452.747 | 138.786 |
| G4 | 234090.242 | 2920657.968 | 166.624 | NH4 | 233710.786 | 2916494.446 | 138.893 |

## 2.6 SURVEY INSTRUMENTS

The following crew and equipment's have been used for completing the survey activity, refer Table 2.2.

**Table 2.2: Crew and Equipment Details**

| **Description** | |
|---|---|
| Surveyor | 2 no. |
| Survey Crew | 10 nos. |
| Total Station (Sokkia 630 R) | 2 set |
| Handheld GPS Units (Planning and Navigation Support) | 2 no. |
| Level Machines (Nikon AS-2-32X) | 2 set |
| Survey Vehicle | 2 no. |

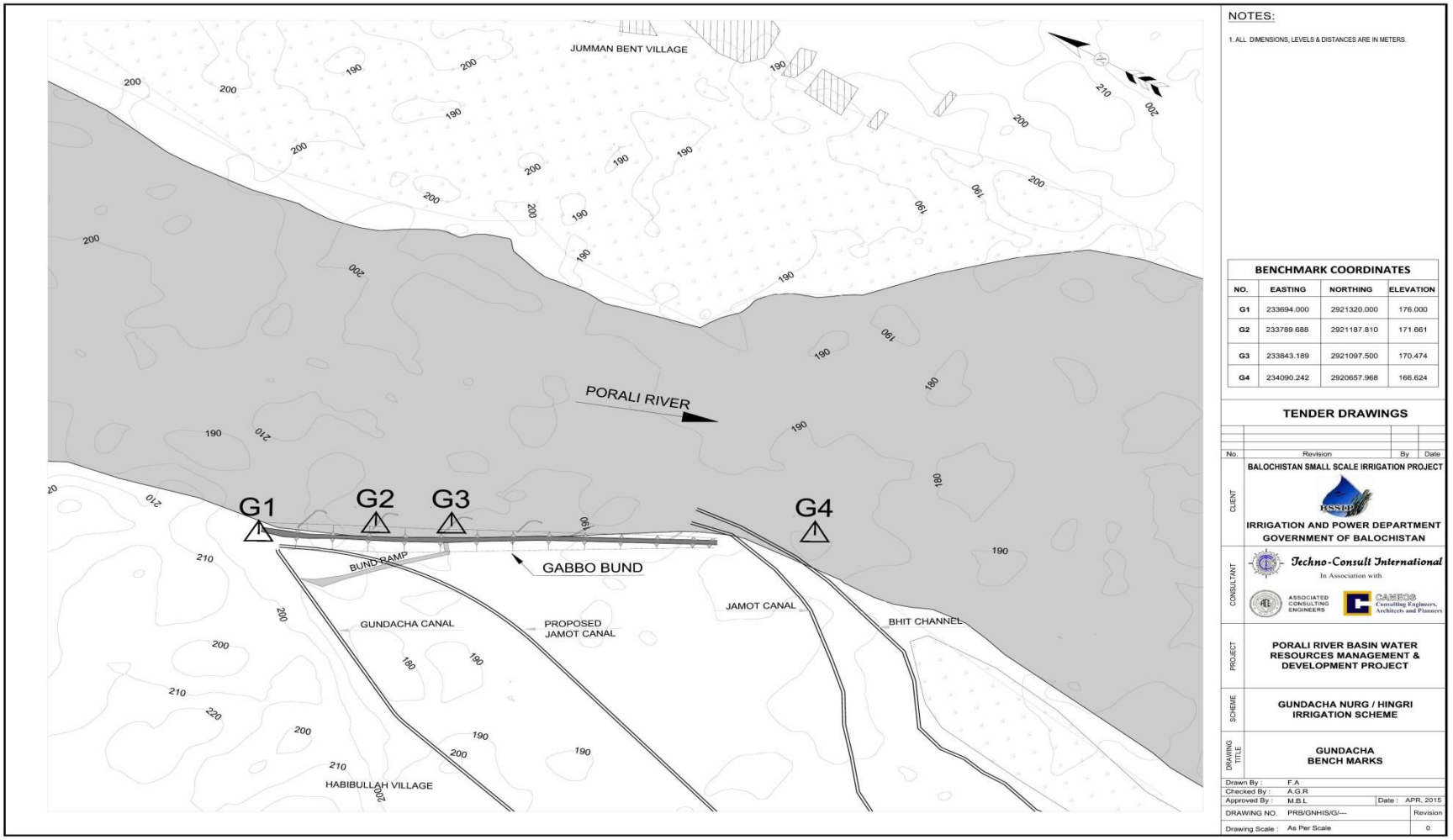



**Figure 2.1: Map showing Bench Marks at Gundacha Site**

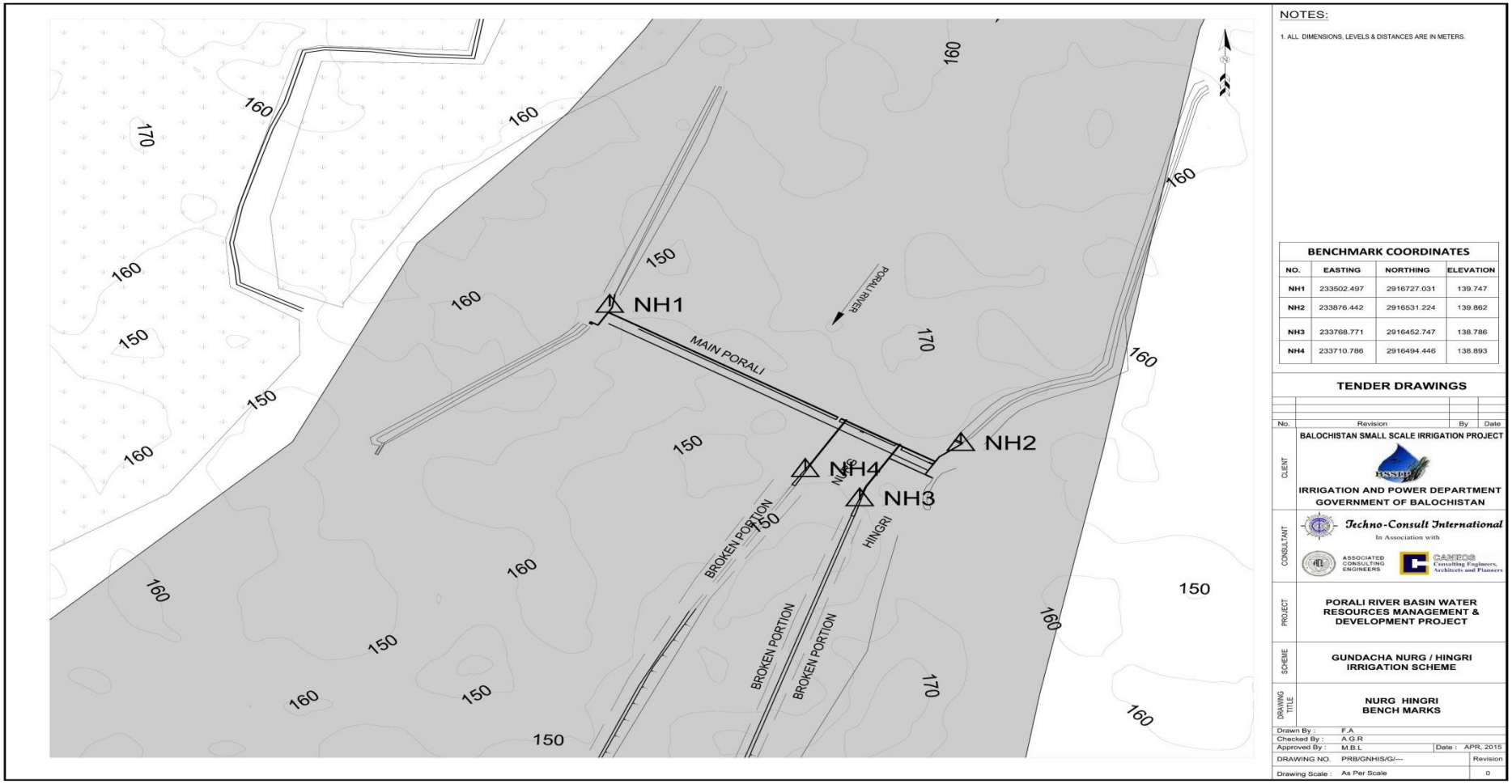



**Figure 2.2: Map showing Bench Marks at Nurg-Hingri Site**

# Chapter - 3
# HYDROLOGY

## 3.1 GENERAL

For the Design Report of Gundacha-Nurg/Hingri Irrigation Scheme, following tasks were carried out for hydrologic analysis.

- Rainfall frequency analysis
- Estimation of long term inflows at proposed site
- Water availability of the project
- Determination of design flood for weir.

## 3.2 THE CATCHMENT AREA

***Gundacha***

The Catchments area of Gundacha is about 4256 sq.km and the length of main stream is about 197 km, which were estimated by using satellite images and SOP maps, shown in Figure 3.1. The hydrological study was established on the basis of maps and reconnaissance survey of the project area. The area comprises gravels, sand, clay loam and loamy sand. Settlements were found with a broken road having short length and a primary school. Irrigated agriculture lands were found which is fed by perennial flow from nullah exists there. The nallah bed is covered with overburden comprising of boulders, shingle and coarse sand. The catchments area has steep to moderate gradient. The groundwater recharge is high and appears as regeneration in Porali River as natural slopes are generally barren having thin vegetation at places.

***Nurg-Hingri***

The Catchment area of Nurg-Hingri is about 4304 sq.km, which was estimated by using satellite images and SOP maps, shown in Figure 3.2. The characteristics like size, shape, soil type, vegetal cover, land slope, land use and topography which influence the hydrological study are established on the basis of maps and reconnaissance study of the project area. The vegetal cover is very poor as the area comprises of piedmont plains with large size of gravels and sand deposits. A few settlements are found near arable lands and the entire area is almost devoid of civil infrastructure such as road, utilities, schools, health care units and communication. Subsistence level farming is practiced where some patches of loamy soil are found, the crop water requirements are met by rain, flood or perennial flow; where available.

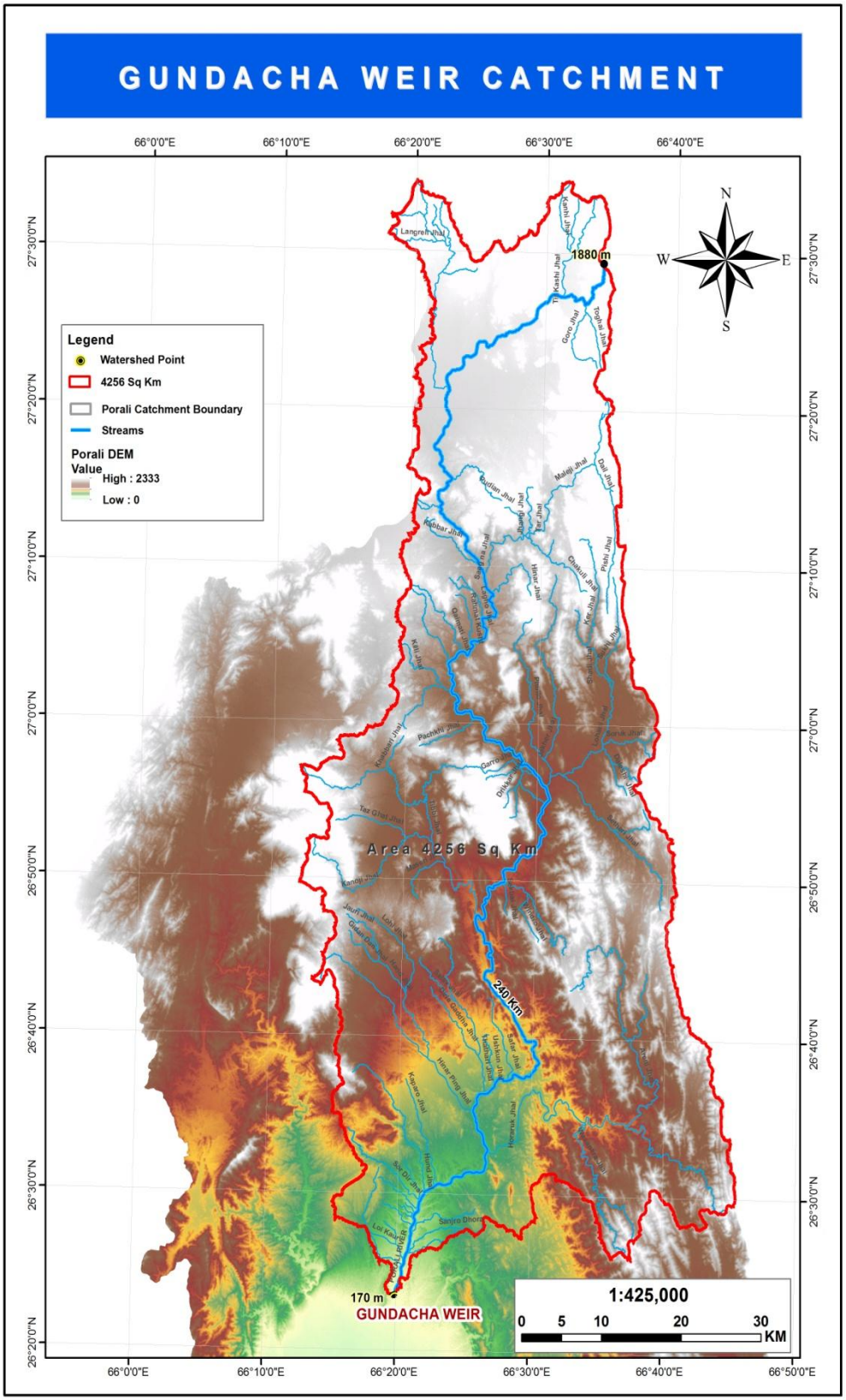



**Figure 3.1 Catchment Area for Gundacha**

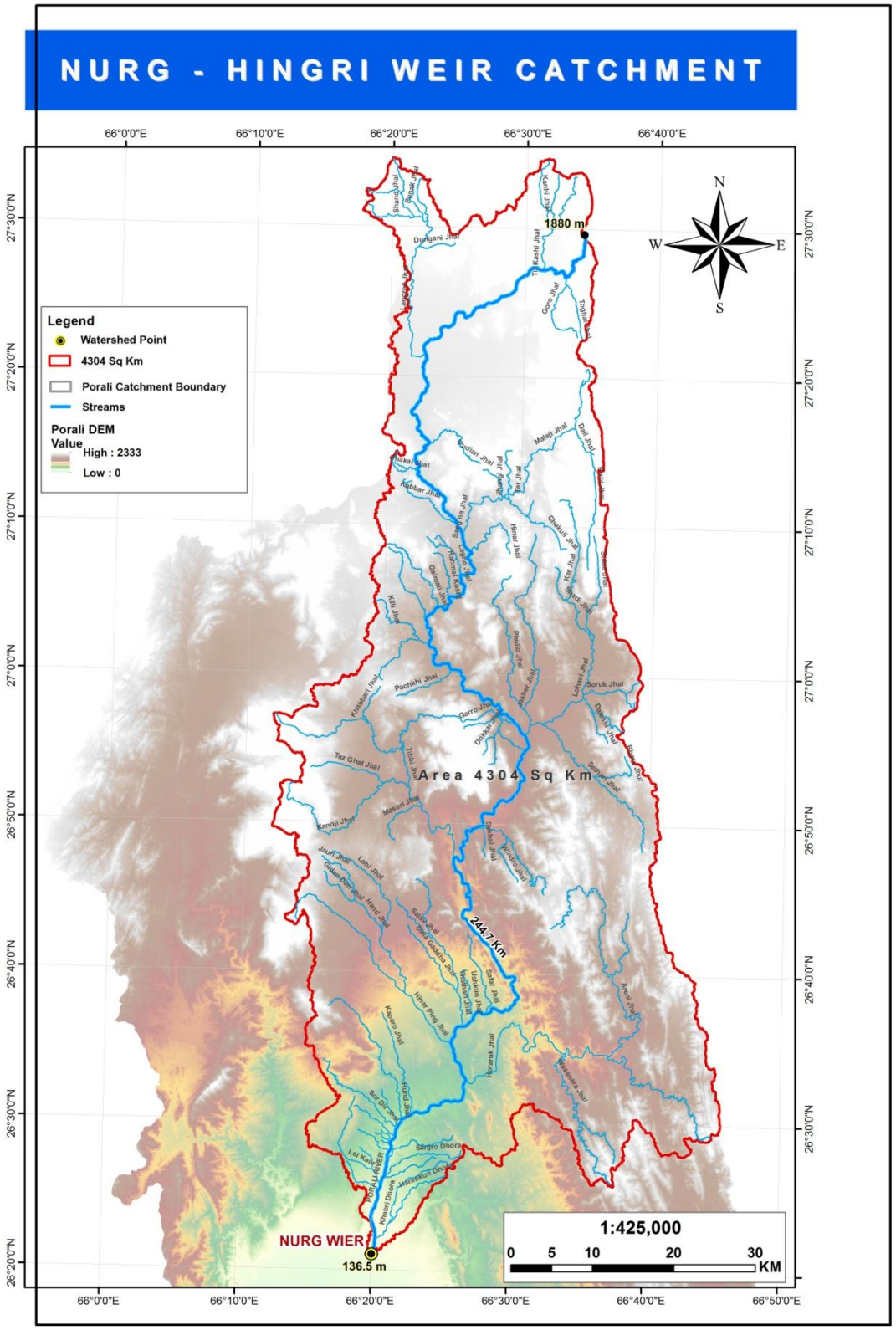



**Figure 3.2 Catchment Area for Nurg-Hingri**

## 3.3 AVAILABLE HYDRO-METEOROLOGICAL DATA

### 3.3.1 Rainfall Data

The Daily Rainfall Data of Wadh (1935-2009), Bela (1912-2011) and Uthal (1961-2012) was collected from meteorological department records. The missing rainfall data was filled with moving average and inverse distance extrapolation and then all the data was extended upto hundred years. The Bela and Wadh stations are influencing for both Gundacha and Nurg-Hingri Irrigation scheme. Therefore the weighted average of these two stations rainfall is used for the extraction of runoff from the catchment. The effective rainfall data for Gundacha and Nurg-Hingri Catchments is given in Table 3.1. The mean monthly values are given in Figure 3.3 and the annual rainfall for the years 1912 to 2011 is given in Figure 3.4.

**Table 3.1: Effective Monthly Rainfall (mm)**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1912 | 2.5 | 4.0 | 6.1 | 18.6 | 15.3 | 26.7 | 131.2 | 83.2 | 0.0 | 0.0 | 2.5 | 13.5 | 303.5 |
| 1913 | 3.9 | 69.0 | 35.5 | 7.7 | 10.0 | 48.3 | 135.5 | 61.9 | 32.9 | 15.5 | 0.0 | 47.2 | 467.4 |
| 1914 | 10.4 | 79.3 | 10.5 | 16.6 | 41.7 | 33.9 | 51.0 | 9.2 | 4.8 | 3.9 | 33.7 | 11.5 | 306.4 |
| 1915 | 25.5 | 9.5 | 9.3 | 52.2 | 0.0 | 14.6 | 27.1 | 4.2 | 6.2 | 15.5 | 6.2 | 1.9 | 172.1 |
| 1916 | 11.5 | 5.0 | 1.4 | 27.5 | 9.3 | 17.4 | 20.9 | 58.1 | 6.2 | 3.8 | 6.2 | 0.0 | 167.3 |
| 1917 | 5.1 | 3.5 | 10.9 | 23.7 | 14.3 | 9.5 | 19.1 | 36.2 | 47.3 | 1.1 | 1.9 | 1.0 | 173.5 |
| 1918 | 15.3 | 15.3 | 16.5 | 8.4 | 1.7 | 9.5 | 17.2 | 2.1 | 3.1 | 1.4 | 2.2 | 9.8 | 102.3 |
| 1919 | 12.3 | 18.8 | 2.3 | 18.3 | 13.9 | 13.5 | 30.2 | 20.5 | 0.0 | 0.0 | 0.0 | 5.4 | 135.3 |
| 1920 | 8.4 | 11.8 | 1.9 | 11.3 | 41.0 | 24.3 | 41.7 | 4.6 | 0.0 | 0.0 | 0.0 | 8.5 | 153.5 |
| 1921 | 2.8 | 5.5 | 0.0 | 11.0 | 0.0 | 16.5 | 68.4 | 13.1 | 17.4 | 0.0 | 0.0 | 11.6 | 146.3 |
| 1922 | 18.2 | 25.6 | 0.0 | 11.0 | 0.0 | 16.5 | 30.8 | 7.7 | 11.6 | 19.4 | 0.0 | 10.4 | 151.3 |
| 1923 | 2.8 | 11.7 | 7.7 | 20.7 | 0.0 | 26.2 | 31.6 | 7.7 | 0.0 | 0.0 | 0.0 | 2.3 | 110.7 |
| 1924 | 2.8 | 24.8 | 4.6 | 32.3 | 7.7 | 16.5 | 36.7 | 6.6 | 15.5 | 0.0 | 0.0 | 0.0 | 147.4 |
| 1925 | 14.4 | 7.8 | 0.0 | 11.0 | 5.4 | 38.9 | 55.9 | 5.0 | 3.8 | 0.0 | 7.7 | 0.8 | 150.8 |
| 1926 | 25.5 | 21.7 | 22.0 | 11.0 | 15.8 | 30.0 | 36.6 | 6.2 | 29.1 | 1.5 | 0.8 | 0.0 | 200.2 |
| 1927 | 11.6 | 18.2 | 3.8 | 11.0 | 3.5 | 16.5 | 40.9 | 18.9 | 7.7 | 0.0 | 0.0 | 2.3 | 134.5 |
| 1928 | 13.2 | 10.4 | 3.3 | 15.7 | 0.0 | 18.4 | 41.1 | 25.1 | 0.0 | 0.0 | 3.4 | 3.3 | 133.9 |
| 1929 | 11.0 | 12.5 | 0.0 | 14.5 | 12.8 | 15.9 | 61.9 | 3.3 | 0.0 | 0.0 | 7.2 | 17.3 | 156.3 |
| 1930 | 14.4 | 5.5 | 5.0 | 15.5 | 15.6 | 26.0 | 49.4 | 5.5 | 0.0 | 5.0 | 3.3 | 11.0 | 156.2 |
| 1931 | 6.4 | 24.3 | 16.7 | 15.6 | 8.4 | 22.8 | 33.6 | 6.7 | 1.1 | 1.1 | 0.0 | 0.0 | 136.7 |
| 1932 | 2.8 | 7.8 | 18.9 | 15.6 | 1.9 | 16.5 | 79.3 | 38.7 | 3.1 | 0.0 | 0.0 | 3.1 | 187.7 |
| 1933 | 9.2 | 13.4 | 3.8 | 26.8 | 21.7 | 13.5 | 58.3 | 33.6 | 69.7 | 0.0 | 0.0 | 0.0 | 250.0 |
| 1934 | 12.3 | 4.5 | 18.3 | 11.2 | 9.9 | 26.2 | 44.5 | 35.5 | 10.5 | 0.0 | 0.0 | 10.0 | 182.9 |
| 1935 | 15.5 | 31.0 | 2.5 | 36.6 | 0.0 | 16.7 | 34.8 | 12.7 | 0.0 | 0.0 | 0.0 | 0.0 | 149.7 |
| 1936 | 4.0 | 20.8 | 17.8 | 16.2 | 0.0 | 39.5 | 63.9 | 0.0 | 0.0 | 0.0 | 0.0 | 5.1 | 167.3 |
| 1937 | 29.0 | 9.7 | 0.0 | 14.4 | 0.0 | 24.1 | 25.1 | 0.0 | 0.0 | 0.0 | 0.0 | 2.5 | 104.8 |
| 1938 | 142.3 | 5.3 | 0.0 | 18.2 | 0.0 | 15.8 | 31.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 212.7 |
| 1939 | 39.3 | 24.8 | 40.1 | 16.3 | 18.3 | 37.8 | 21.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 197.7 |
| 1940 | 20.5 | 16.2 | 20.8 | 13.3 | 0.0 | 22.6 | 29.2 | 18.0 | 0.0 | 0.0 | 0.0 | 0.0 | 140.6 |
| 1941 | 2.8 | 13.1 | 2.5 | 28.8 | 10.2 | 19.0 | 32.0 | 5.1 | 0.0 | 0.0 | 0.0 | 0.0 | 113.4 |

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1942 | 23.0 | 33.3 | 0.0 | 10.7 | 0.0 | 23.7 | 51.7 | 7.6 | 0.0 | 0.0 | 0.0 | 25.4 | 175.4 |
| 1943 | 11.6 | 5.5 | 0.0 | 28.0 | 9.1 | 16.5 | 44.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 115.5 |
| 1944 | 24.8 | 26.8 | 29.5 | 11.0 | 16.0 | 17.3 | 30.7 | 19.1 | 3.0 | 0.0 | 0.0 | 6.9 | 185.0 |
| 1945 | 2.8 | 5.5 | 0.8 | 11.0 | 6.9 | 18.0 | 54.6 | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | 101.0 |
| 1946 | 2.8 | 14.4 | 0.0 | 11.0 | 0.0 | 20.1 | 36.5 | 18.8 | 0.0 | 0.0 | 0.0 | 0.0 | 103.5 |
| 1947 | 2.8 | 25.3 | 0.0 | 11.0 | 0.0 | 20.3 | 19.3 | 9.3 | 1.9 | 0.0 | 0.0 | 0.0 | 89.8 |
| 1948 | 2.9 | 10.4 | 0.0 | 13.0 | 0.1 | 20.1 | 19.3 | 7.7 | 0.0 | 9.7 | 0.0 | 9.7 | 92.7 |
| 1949 | 2.9 | 10.5 | 46.5 | 11.1 | 0.1 | 77.9 | 42.5 | 5.2 | 1.0 | 3.1 | 1.0 | 1.0 | 202.6 |
| 1950 | 3.0 | 10.7 | 1.9 | 11.1 | 0.2 | 19.6 | 36.7 | 5.3 | 0.7 | 0.0 | 0.7 | 0.8 | 90.9 |
| 1951 | 3.1 | 11.0 | 0.0 | 11.2 | 6.5 | 19.4 | 23.2 | 5.1 | 1.8 | 0.0 | 1.9 | 1.5 | 84.5 |
| 1952 | 3.2 | 17.0 | 0.0 | 11.2 | 15.7 | 19.1 | 23.0 | 5.2 | 1.5 | 0.0 | 1.4 | 1.8 | 99.1 |
| 1953 | 9.1 | 23.1 | 0.0 | 17.0 | 27.6 | 18.9 | 42.5 | 18.6 | 2.5 | 0.0 | 2.7 | 2.3 | 164.2 |
| 1954 | 5.3 | 27.2 | 0.0 | 11.3 | 4.4 | 18.5 | 38.5 | 5.1 | 19.8 | 17.4 | 4.2 | 2.7 | 154.6 |
| 1955 | 15.1 | 11.8 | 0.0 | 11.3 | 8.4 | 26.0 | 30.8 | 30.1 | 9.2 | 0.0 | 3.4 | 3.0 | 149.2 |
| 1956 | 5.5 | 12.1 | 5.8 | 19.2 | 0.7 | 33.5 | 90.7 | 10.9 | 16.7 | 0.0 | 3.1 | 3.7 | 201.9 |
| 1957 | 15.3 | 12.3 | 0.0 | 17.3 | 6.6 | 27.4 | 44.5 | 7.7 | 4.2 | 0.0 | 13.9 | 15.4 | 164.6 |
| 1958 | 5.7 | 13.3 | 0.0 | 15.3 | 4.7 | 21.4 | 44.3 | 4.9 | 19.2 | 0.0 | 3.9 | 10.2 | 142.9 |
| 1959 | 3.8 | 14.6 | 0.0 | 11.5 | 2.9 | 17.2 | 31.0 | 16.3 | 26.4 | 0.0 | 10.9 | 4.7 | 139.2 |
| 1960 | 3.9 | 12.9 | 1.9 | 13.4 | 4.9 | 17.0 | 30.8 | 4.8 | 4.7 | 0.0 | 10.0 | 5.2 | 109.7 |
| 1961 | 7.9 | 15.8 | 7.2 | 12.5 | 4.3 | 32.3 | 31.3 | 36.1 | 1.7 | 0.0 | 1.9 | 3.4 | 154.5 |
| 1962 | 4.5 | 8.9 | 10.3 | 22.0 | 2.2 | 30.7 | 36.2 | 20.8 | 24.0 | 0.0 | 1.7 | 3.4 | 164.6 |
| 1963 | 7.3 | 7.2 | 3.4 | 34.6 | 18.9 | 22.6 | 27.6 | 30.3 | 0.0 | 0.0 | 3.2 | 0.0 | 155.2 |
| 1964 | 23.1 | 10.1 | 0.0 | 14.4 | 3.2 | 18.2 | 110.2 | 32.4 | 0.0 | 0.0 | 0.0 | 0.0 | 211.7 |
| 1965 | 13.0 | 9.3 | 4.8 | 29.7 | 9.0 | 18.0 | 28.4 | 10.1 | 1.5 | 2.3 | 0.0 | 7.6 | 133.7 |
| 1966 | 2.8 | 13.9 | 7.6 | 21.3 | 0.0 | 32.1 | 31.3 | 3.4 | 3.4 | 15.4 | 0.0 | 0.0 | 131.2 |
| 1967 | 4.3 | 7.2 | 8.6 | 13.3 | 23.1 | 26.4 | 48.8 | 35.8 | 12.0 | 0.8 | 4.0 | 33.7 | 217.9 |
| 1968 | 21.6 | 14.5 | 2.5 | 11.0 | 5.1 | 16.5 | 26.9 | 8.6 | 0.0 | 0.0 | 0.0 | 0.8 | 107.4 |
| 1969 | 7.3 | 11.4 | 13.7 | 12.7 | 7.0 | 20.5 | 26.5 | 5.1 | 0.0 | 0.0 | 0.0 | 1.7 | 106.1 |
| 1970 | 6.2 | 19.6 | 16.8 | 18.4 | 15.2 | 25.1 | 46.1 | 13.3 | 13.7 | 0.0 | 0.0 | 4.0 | 178.5 |
| 1971 | 14.6 | 7.2 | 9.1 | 11.0 | 40.6 | 16.5 | 39.8 | 12.0 | 0.0 | 0.0 | 0.0 | 2.3 | 153.1 |
| 1972 | 28.5 | 15.6 | 2.9 | 11.0 | 0.0 | 25.6 | 51.1 | 0.0 | 0.0 | 0.0 | 3.4 | 5.0 | 143.1 |
| 1973 | 6.2 | 10.5 | 0.0 | 16.1 | 2.3 | 16.5 | 65.2 | 36.4 | 18.9 | 7.6 | 0.0 | 26.5 | 206.1 |
| 1974 | 12.8 | 7.2 | 0.0 | 18.4 | 6.9 | 16.5 | 36.8 | 6.9 | 0.0 | 0.0 | 0.0 | 0.0 | 105.5 |
| 1975 | 27.5 | 26.8 | 3.4 | 16.1 | 1.5 | 16.5 | 47.3 | 49.7 | 5.9 | 0.0 | 0.0 | 3.4 | 198.3 |
| 1976 | 13.0 | 18.8 | 40.6 | 20.3 | 0.0 | 21.6 | 38.1 | 8.4 | 44.8 | 8.6 | 0.0 | 0.0 | 214.3 |
| 1977 | 7.9 | 5.5 | 0.0 | 13.5 | 15.4 | 35.9 | 37.2 | 16.0 | 0.0 | 0.0 | 0.0 | 13.7 | 145.1 |
| 1978 | 6.2 | 15.6 | 5.5 | 26.6 | 0.0 | 32.5 | 48.0 | 17.9 | 8.6 | 0.0 | 11.8 | 0.0 | 172.8 |
| 1979 | 2.8 | 24.6 | 28.4 | 11.0 | 3.0 | 27.4 | 38.1 | 26.5 | 5.3 | 8.6 | 0.0 | 13.3 | 189.0 |
| 1980 | 4.5 | 14.1 | 5.1 | 16.7 | 1.5 | 21.1 | 49.2 | 8.6 | 0.0 | 16.0 | 5.1 | 8.2 | 150.1 |
| 1981 | 2.8 | 10.6 | 4.6 | 13.3 | 6.9 | 21.6 | 33.2 | 22.3 | 2.3 | 0.0 | 0.0 | 0.0 | 117.5 |
| 1982 | 10.4 | 21.5 | 11.1 | 46.6 | 21.9 | 16.5 | 34.5 | 34.9 | 0.0 | 13.7 | 1.7 | 9.3 | 222.1 |
| 1983 | 6.2 | 28.9 | 8.6 | 18.6 | 8.6 | 16.5 | 41.4 | 48.0 | 39.4 | 0.0 | 0.0 | 1.7 | 217.9 |
| 1984 | 6.3 | 23.9 | 9.9 | 17.9 | 8.9 | 16.5 | 42.1 | 43.3 | 25.7 | 0.0 | 0.0 | 1.7 | 196.2 |
| 1985 | 5.9 | 22.4 | 8.1 | 25.3 | 13.7 | 22.8 | 42.5 | 32.9 | 23.8 | 0.0 | 0.0 | 1.6 | 199.0 |
| 1986 | 6.0 | 23.7 | 8.1 | 17.2 | 9.8 | 17.7 | 31.2 | 36.7 | 22.4 | 0.0 | 4.6 | 1.6 | 178.9 |

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1987 | 6.3 | 21.7 | 7.8 | 18.0 | 22.0 | 24.2 | 34.0 | 30.8 | 21.0 | 0.0 | 0.0 | 1.6 | 187.3 |
| 1988 | 7.2 | 21.4 | 6.3 | 25.9 | 10.2 | 21.3 | 50.4 | 34.0 | 19.4 | 0.0 | 0.0 | 1.5 | 197.6 |
| 1989 | 6.1 | 19.6 | 7.3 | 16.8 | 10.1 | 26.8 | 44.0 | 30.4 | 17.5 | 0.0 | 5.3 | 6.1 | 190.0 |
| 1990 | 8.5 | 23.1 | 11.3 | 17.8 | 10.9 | 24.6 | 31.2 | 35.1 | 16.1 | 0.0 | 0.8 | 1.5 | 180.8 |
| 1991 | 8.3 | 22.3 | 9.3 | 17.1 | 13.1 | 24.8 | 30.6 | 33.1 | 14.3 | 0.0 | 0.6 | 1.4 | 175.0 |
| 1992 | 6.0 | 18.9 | 6.9 | 10.5 | 15.7 | 8.7 | 20.1 | 28.5 | 13.0 | 0.0 | 0.0 | 1.4 | 129.5 |
| 1993 | 5.7 | 18.0 | 3.4 | 11.8 | 17.4 | 10.1 | 19.5 | 23.8 | 12.0 | 0.0 | 0.0 | 1.4 | 123.0 |
| 1994 | 3.7 | 10.1 | 3.0 | 6.4 | 11.4 | 9.8 | 17.4 | 33.1 | 19.6 | 0.0 | 0.0 | 4.5 | 118.9 |
| 1995 | 4.6 | 10.8 | 3.5 | 3.8 | 11.2 | 13.5 | 25.1 | 25.2 | 7.6 | 2.4 | 0.0 | 1.3 | 109.2 |
| 1996 | 5.9 | 15.5 | 4.8 | 7.1 | 21.3 | 13.0 | 14.8 | 21.8 | 6.7 | 0.0 | 0.0 | 1.2 | 112.0 |
| 1997 | 4.4 | 8.3 | 10.6 | 4.4 | 16.2 | 19.2 | 7.9 | 27.3 | 7.5 | 3.9 | 0.0 | 1.7 | 111.4 |
| 1998 | 5.1 | 9.0 | 4.3 | 7.1 | 12.0 | 11.6 | 10.1 | 18.4 | 3.0 | 4.1 | 0.0 | 1.2 | 85.8 |
| 1999 | 3.3 | 11.6 | 7.7 | 3.0 | 20.3 | 12.8 | 6.0 | 16.1 | 1.4 | 0.0 | 0.0 | 1.1 | 83.3 |
| 2000 | 10.7 | 5.4 | 0.0 | 6.1 | 15.1 | 12.9 | 8.5 | 16.8 | 0.0 | 0.0 | 0.0 | 1.1 | 76.5 |
| 2001 | 0.8 | 1.5 | 0.0 | 24.7 | 1.4 | 8.6 | 40.8 | 13.9 | 0.0 | 0.0 | 0.0 | 0.0 | 91.7 |
| 2002 | 0.8 | 2.6 | 0.0 | 3.0 | 0.0 | 5.1 | 18.4 | 0.0 | 1.5 | 0.0 | 20.6 | 164.3 | 216.3 |
| 2003 | 15.5 | 9.4 | 5.3 | 25.6 | 16.5 | 9.5 | 122.5 | 6.4 | 0.0 | 0.0 | 0.0 | 0.0 | 210.6 |
| 2004 | 4.2 | 1.5 | 0.0 | 3.0 | 0.0 | 14.4 | 46.3 | 4.3 | 12.1 | 0.0 | 0.0 | 2.4 | 88.2 |
| 2005 | 1.0 | 74.1 | 51.9 | 5.7 | 40.2 | 27.2 | 28.1 | 24.5 | 10.5 | 2.1 | 0.0 | 0.0 | 265.3 |
| 2006 | 1.4 | 1.5 | 5.6 | 3.9 | 7.1 | 12.4 | 28.1 | 47.9 | 22.8 | 19.4 | 0.0 | 16.2 | 166.2 |
| 2007 | 0.8 | 17.2 | 15.6 | 8.8 | 11.1 | 132.7 | 33.7 | 12.5 | 0.0 | 0.0 | 0.0 | 0.0 | 232.4 |
| 2008 | 24.2 | 6.0 | 3.0 | 3.0 | 1.6 | 8.3 | 44.9 | 61.0 | 2.7 | 0.0 | 0.0 | 20.7 | 175.4 |
| 2009 | 13.1 | 9.8 | 7.1 | 7.7 | 7.2 | 24.3 | 46.4 | 31.5 | 10.1 | 0.0 | 0.0 | 43.8 | 200.8 |
| 2010 | 1.3 | 1.6 | 4.5 | 12.3 | 10.4 | 16.7 | 119.6 | 81.2 | 0.0 | 0.0 | 2.5 | 13.5 | 263.5 |
| 2011 | 2.7 | 63.8 | 32.5 | 3.0 | 2.3 | 38.2 | 127.2 | 62.0 | 32.9 | 15.5 | 0.0 | 47.2 | 427.4 |
| **Average** | 10.5 | 16.3 | 8.0 | 15.5 | 9.3 | 22.4 | 41.8 | 20.3 | 8.9 | 2.2 | 2.0 | 7.5 | 164.7 |
| **Max** | 142.3 | 79.3 | 51.9 | 52.2 | 41.7 | 132.7 | 135.5 | 83.2 | 69.7 | 19.4 | 33.7 | 164.3 | 467.4 |
| **Min** | 0.8 | 1.5 | 0.0 | 3.0 | 0.0 | 5.1 | 6.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 76.5 |

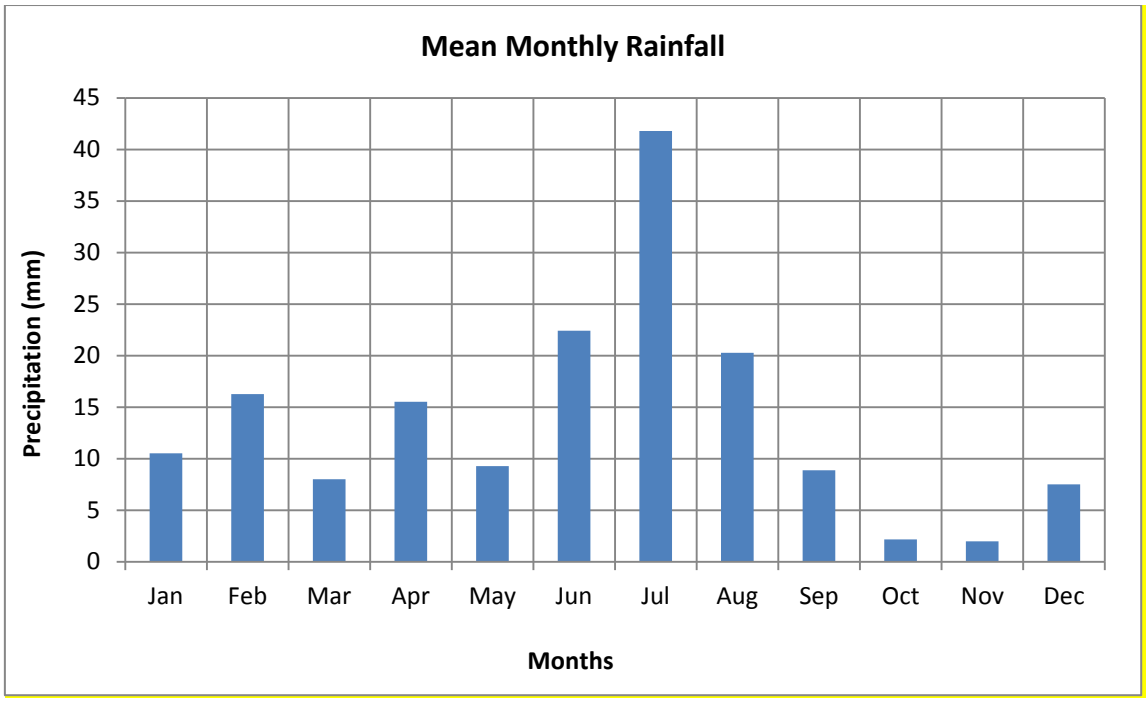



**Figure 3.3: Mean Monthly Rainfall**

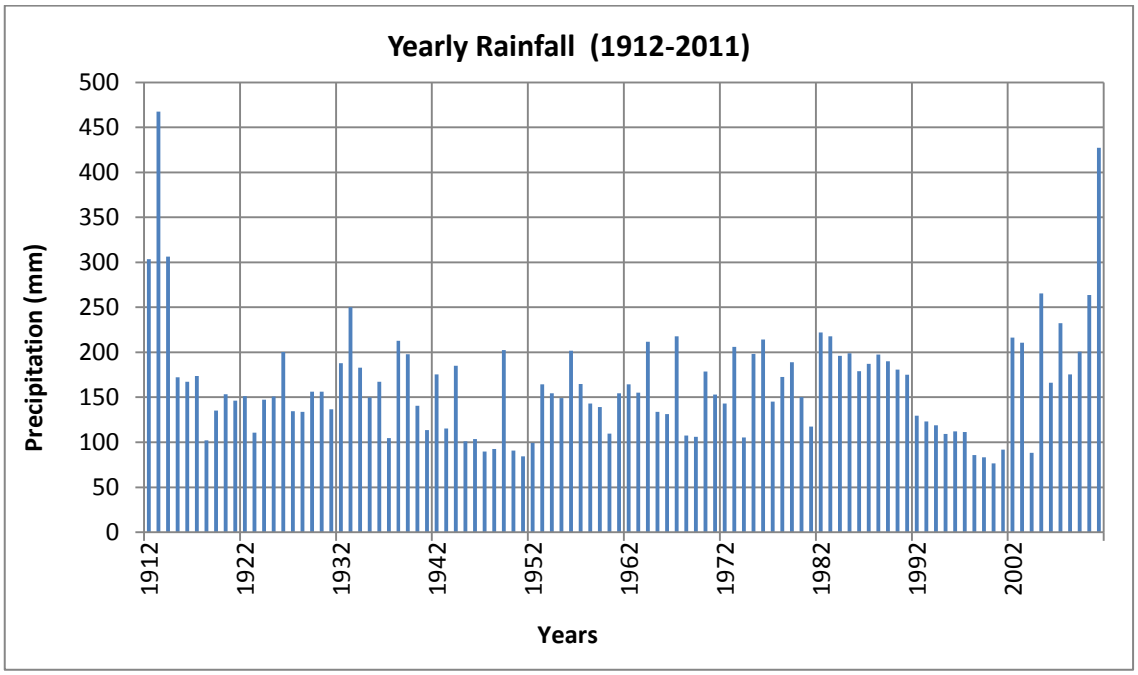



**Figure 3.4: Mean Annual Rainfall**

## 3.4 ANALYSIS OF AVAILABLE DATA

The details about the water availability are given in Chapter-5 of Volume –I (Main Report) of Feasibility Report of Porali River Basin. In this hydrology chapter of design report, relevant details about rainfall and runoff for both Gundacha and Nurg-Hingri Irrigation schemes are shown in Table 3.2.

**Table 3.2: Monthly and Annual Runoff (mm)**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual (MCM) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1912 | 6.018 | 9.588 | 14.811 | 45.238 | 37.186 | 64.866 | 318.192 | 201.767 | 0.000 | 0.000 | 6.032 | 32.668 | 6.018 |
| 1913 | 9.368 | 167.507 | 86.084 | 18.680 | 24.159 | 117.233 | 328.625 | 150.126 | 79.873 | 37.587 | 0.000 | 114.565 | 9.368 |
| 1914 | 25.330 | 192.388 | 25.359 | 40.179 | 101.057 | 82.172 | 123.646 | 22.401 | 11.765 | 9.397 | 81.703 | 28.001 | 25.330 |
| 1915 | 61.953 | 23.106 | 22.472 | 126.680 | 0.000 | 35.297 | 65.807 | 10.189 | 14.934 | 37.524 | 14.934 | 4.698 | 61.953 |
| 1916 | 27.883 | 12.008 | 3.457 | 66.787 | 22.598 | 42.164 | 50.696 | 140.952 | 15.026 | 9.334 | 15.026 | 0.000 | 27.883 |
| 1917 | 12.274 | 8.506 | 26.517 | 57.452 | 34.649 | 22.925 | 46.404 | 87.937 | 114.788 | 2.650 | 4.563 | 2.305 | 12.274 |
| 1918 | 37.061 | 37.040 | 39.971 | 20.469 | 4.033 | 22.925 | 41.657 | 5.185 | 7.421 | 3.342 | 5.231 | 23.823 | 37.061 |
| 1919 | 29.852 | 45.672 | 5.600 | 44.360 | 33.791 | 32.750 | 73.293 | 49.686 | 0.000 | 0.000 | 0.000 | 13.130 | 29.852 |
| 1920 | 20.392 | 28.745 | 4.698 | 27.434 | 99.379 | 59.011 | 101.091 | 11.200 | 0.000 | 0.000 | 0.000 | 20.534 | 20.392 |
| 1921 | 6.671 | 13.343 | 0.000 | 26.685 | 0.000 | 40.028 | 165.963 | 31.861 | 42.286 | 0.000 | 0.000 | 28.190 | 6.671 |
| 1922 | 44.258 | 62.130 | 0.000 | 26.685 | 0.000 | 40.028 | 74.763 | 18.667 | 28.190 | 46.984 | 0.000 | 25.296 | 44.258 |
| 1923 | 6.671 | 28.340 | 18.794 | 50.177 | 0.000 | 63.520 | 76.693 | 18.794 | 0.000 | 0.000 | 0.000 | 5.600 | 6.671 |
| 1924 | 6.671 | 60.200 | 11.200 | 78.304 | 18.794 | 40.028 | 88.921 | 15.899 | 37.587 | 0.000 | 0.000 | 0.000 | 6.671 |
| 1925 | 34.862 | 18.943 | 0.000 | 26.685 | 13.130 | 94.416 | 135.716 | 12.165 | 9.334 | 0.000 | 18.794 | 1.867 | 34.862 |
| 1926 | 61.898 | 52.544 | 53.297 | 26.685 | 38.426 | 72.853 | 88.858 | 14.997 | 70.476 | 3.733 | 1.867 | 0.000 | 61.898 |
| 1927 | 28.233 | 44.238 | 9.334 | 26.685 | 8.432 | 40.028 | 99.283 | 45.830 | 18.667 | 0.000 | 0.000 | 5.600 | 28.233 |
| 1928 | 32.080 | 25.278 | 8.000 | 38.200 | 0.000 | 44.526 | 99.770 | 60.784 | 0.000 | 0.000 | 8.142 | 8.000 | 32.080 |
| 1929 | 26.637 | 30.251 | 0.000 | 35.096 | 31.165 | 38.537 | 150.101 | 8.000 | 0.000 | 0.000 | 17.405 | 41.974 | 26.637 |
| 1930 | 34.991 | 13.411 | 12.072 | 37.631 | 37.761 | 63.113 | 119.722 | 13.334 | 0.000 | 12.214 | 8.000 | 26.668 | 34.991 |
| 1931 | 15.445 | 58.961 | 40.428 | 37.919 | 20.356 | 55.332 | 81.444 | 16.285 | 2.667 | 2.667 | 0.000 | 0.000 | 15.445 |
| 1932 | 6.671 | 18.943 | 45.956 | 37.949 | 4.698 | 40.028 | 192.286 | 93.905 | 7.467 | 0.000 | 0.000 | 7.467 | 6.671 |
| 1933 | 22.322 | 32.479 | 9.334 | 64.958 | 52.521 | 32.750 | 141.447 | 81.550 | 169.142 | 0.000 | 0.000 | 0.000 | 22.322 |
| 1934 | 29.722 | 10.874 | 44.357 | 27.081 | 24.001 | 63.645 | 107.963 | 86.189 | 25.548 | 0.000 | 0.000 | 24.285 | 29.722 |
| 1935 | 37.573 | 75.146 | 6.162 | 88.673 | 0.000 | 40.582 | 84.317 | 30.809 | 0.000 | 0.000 | 0.000 | 0.000 | 37.573 |

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual (MCM) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1936 | 9.814 | 50.437 | 43.133 | 39.255 | 0.000 | 95.854 | 154.962 | 0.000 | 0.000 | 0.000 | 0.000 | 12.324 | 9.814 |
| 1937 | 70.323 | 23.571 | 0.000 | 34.819 | 0.000 | 58.390 | 60.933 | 0.000 | 0.000 | 0.000 | 0.000 | 6.162 | 70.323 |
| 1938 | 345.295 | 12.788 | 0.000 | 44.061 | 0.000 | 38.364 | 75.567 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 345.295 |
| 1939 | 95.402 | 60.173 | 97.357 | 39.625 | 44.365 | 91.787 | 51.012 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 95.402 |
| 1940 | 49.804 | 39.222 | 50.527 | 32.231 | 0.000 | 54.816 | 70.730 | 43.749 | 0.000 | 0.000 | 0.000 | 0.000 | 49.804 |
| 1941 | 6.671 | 31.828 | 6.162 | 69.818 | 24.647 | 46.190 | 77.508 | 12.324 | 0.000 | 0.000 | 0.000 | 0.000 | 6.671 |
| 1942 | 55.781 | 80.753 | 0.000 | 25.946 | 0.000 | 57.404 | 125.509 | 18.486 | 0.000 | 0.000 | 0.000 | 61.618 | 55.781 |
| 1943 | 28.238 | 13.343 | 0.000 | 67.969 | 22.183 | 40.028 | 108.317 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 28.238 |
| 1944 | 60.279 | 65.102 | 71.477 | 26.685 | 38.820 | 41.876 | 74.427 | 46.214 | 7.394 | 0.000 | 0.000 | 16.637 | 60.279 |
| 1945 | 6.671 | 13.343 | 1.849 | 26.685 | 16.637 | 43.725 | 132.348 | 3.697 | 0.000 | 0.000 | 0.000 | 0.000 | 6.671 |
| 1946 | 6.671 | 34.909 | 0.000 | 26.685 | 0.000 | 48.654 | 88.599 | 45.598 | 0.000 | 0.000 | 0.000 | 0.000 | 6.671 |
| 1947 | 6.671 | 61.301 | 0.000 | 26.685 | 0.000 | 49.246 | 46.699 | 22.464 | 4.698 | 0.000 | 0.000 | 0.000 | 6.671 |
| 1948 | 6.959 | 25.154 | 0.000 | 31.528 | 0.144 | 48.670 | 46.699 | 18.755 | 0.000 | 23.492 | 0.000 | 23.492 | 6.959 |
| 1949 | 6.959 | 25.442 | 112.762 | 26.887 | 0.288 | 189.046 | 102.991 | 12.722 | 2.305 | 7.399 | 2.305 | 2.305 | 6.959 |
| 1950 | 7.247 | 26.018 | 4.698 | 26.973 | 0.576 | 47.518 | 89.126 | 12.917 | 1.613 | 0.000 | 1.728 | 2.017 | 7.247 |
| 1951 | 7.507 | 26.594 | 0.000 | 27.117 | 15.662 | 46.942 | 56.263 | 12.433 | 4.264 | 0.000 | 4.494 | 3.745 | 7.507 |
| 1952 | 7.737 | 41.266 | 0.000 | 27.232 | 38.148 | 46.279 | 55.860 | 12.687 | 3.630 | 0.000 | 3.342 | 4.321 | 7.737 |
| 1953 | 22.120 | 55.937 | 0.000 | 41.356 | 66.930 | 45.789 | 102.985 | 45.207 | 6.165 | 0.000 | 6.453 | 5.473 | 22.120 |
| 1954 | 12.954 | 65.910 | 0.000 | 27.405 | 10.693 | 44.925 | 93.473 | 12.456 | 48.105 | 42.286 | 10.229 | 6.626 | 12.954 |
| 1955 | 36.677 | 28.611 | 0.000 | 27.463 | 20.436 | 63.142 | 74.706 | 73.052 | 22.334 | 0.000 | 8.297 | 7.202 | 36.677 |
| 1956 | 13.444 | 29.331 | 14.095 | 46.545 | 1.728 | 81.216 | 220.010 | 26.321 | 40.552 | 0.000 | 7.605 | 8.930 | 13.444 |
| 1957 | 37.137 | 29.763 | 0.000 | 41.904 | 16.112 | 66.400 | 107.851 | 18.674 | 10.198 | 0.000 | 33.748 | 37.467 | 37.137 |
| 1958 | 13.761 | 32.363 | 0.000 | 37.086 | 11.467 | 51.873 | 107.374 | 11.996 | 46.502 | 0.000 | 9.564 | 24.639 | 13.761 |
| 1959 | 9.264 | 35.326 | 0.000 | 27.837 | 7.003 | 41.756 | 75.219 | 39.472 | 64.070 | 0.000 | 26.425 | 11.350 | 9.264 |
| 1960 | 9.466 | 31.203 | 4.698 | 32.622 | 11.990 | 41.180 | 74.643 | 11.765 | 11.466 | 0.000 | 24.356 | 12.618 | 9.466 |
| 1961 | 19.153 | 38.305 | 17.566 | 30.324 | 10.504 | 78.406 | 75.822 | 87.576 | 4.160 | 0.000 | 4.585 | 8.321 | 19.153 |

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual (MCM) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1962 | 10.832 | 21.663 | 24.963 | 53.310 | 5.252 | 74.451 | 87.782 | 50.338 | 58.246 | 0.000 | 4.076 | 8.321 | 10.832 |
| 1963 | 17.763 | 17.503 | 8.321 | 84.005 | 45.765 | 54.816 | 67.038 | 73.498 | 0.000 | 0.000 | 7.858 | 0.000 | 17.763 |
| 1964 | 56.133 | 24.434 | 0.000 | 35.006 | 7.858 | 44.188 | 267.376 | 78.576 | 0.000 | 0.000 | 0.000 | 0.000 | 56.133 |
| 1965 | 31.634 | 22.585 | 11.555 | 71.982 | 21.724 | 43.725 | 68.886 | 24.499 | 3.697 | 5.546 | 0.000 | 18.490 | 31.634 |
| 1966 | 6.671 | 33.681 | 18.490 | 51.648 | 0.000 | 77.930 | 75.817 | 8.321 | 8.321 | 37.444 | 0.000 | 0.000 | 6.671 |
| 1967 | 10.368 | 17.503 | 20.802 | 32.231 | 55.930 | 64.064 | 118.344 | 86.901 | 29.123 | 1.849 | 9.706 | 81.814 | 10.368 |
| 1968 | 52.436 | 35.067 | 6.009 | 26.685 | 12.481 | 40.028 | 65.189 | 20.802 | 0.000 | 0.000 | 0.000 | 1.849 | 52.436 |
| 1969 | 17.763 | 27.672 | 33.284 | 30.846 | 17.100 | 49.734 | 64.320 | 12.481 | 0.000 | 0.000 | 0.000 | 4.160 | 17.763 |
| 1970 | 14.992 | 47.548 | 40.673 | 44.712 | 36.981 | 60.830 | 111.876 | 32.357 | 33.284 | 0.000 | 0.000 | 9.706 | 14.992 |
| 1971 | 35.331 | 17.503 | 22.183 | 26.685 | 98.461 | 40.028 | 96.620 | 29.123 | 0.000 | 0.000 | 0.000 | 5.555 | 35.331 |
| 1972 | 69.078 | 37.842 | 7.067 | 26.685 | 0.000 | 62.215 | 123.894 | 0.000 | 0.000 | 0.000 | 8.321 | 12.018 | 69.078 |
| 1973 | 14.992 | 25.361 | 0.000 | 39.166 | 5.546 | 40.028 | 158.104 | 88.287 | 45.765 | 18.486 | 0.000 | 64.255 | 14.992 |
| 1974 | 31.166 | 17.503 | 0.000 | 44.712 | 16.642 | 40.028 | 89.225 | 16.642 | 0.000 | 0.000 | 0.000 | 0.000 | 31.166 |
| 1975 | 66.766 | 65.112 | 8.321 | 39.166 | 3.697 | 40.028 | 114.647 | 120.648 | 14.330 | 0.000 | 0.000 | 8.321 | 66.766 |
| 1976 | 31.634 | 45.699 | 98.461 | 49.336 | 0.000 | 52.509 | 92.459 | 20.339 | 108.630 | 20.802 | 0.000 | 0.000 | 31.634 |
| 1977 | 19.153 | 13.343 | 0.000 | 32.694 | 37.439 | 87.173 | 90.147 | 38.829 | 0.000 | 0.000 | 0.000 | 33.284 | 19.153 |
| 1978 | 14.992 | 37.842 | 13.403 | 64.588 | 0.000 | 78.857 | 116.490 | 43.448 | 20.802 | 0.000 | 28.660 | 0.000 | 14.992 |
| 1979 | 6.671 | 59.566 | 68.874 | 26.685 | 7.394 | 66.376 | 92.464 | 64.250 | 12.940 | 20.802 | 0.000 | 32.357 | 6.671 |
| 1980 | 10.832 | 34.145 | 12.481 | 40.552 | 3.697 | 51.119 | 119.270 | 20.802 | 0.000 | 38.824 | 12.481 | 19.876 | 10.832 |
| 1981 | 6.671 | 25.824 | 11.091 | 32.231 | 16.642 | 52.509 | 80.441 | 54.086 | 5.546 | 0.000 | 0.000 | 0.000 | 6.671 |
| 1982 | 25.162 | 52.172 | 26.811 | 113.128 | 53.159 | 40.028 | 83.680 | 84.594 | 0.000 | 33.284 | 4.160 | 22.651 | 25.162 |
| 1983 | 14.992 | 70.199 | 20.802 | 45.175 | 20.802 | 40.028 | 100.317 | 116.483 | 95.681 | 0.000 | 0.000 | 4.160 | 14.992 |
| 1984 | 15.332 | 57.919 | 24.075 | 43.327 | 21.651 | 40.028 | 102.165 | 104.967 | 62.407 | 0.000 | 0.000 | 4.076 | 15.332 |
| 1985 | 14.313 | 54.353 | 19.529 | 61.284 | 33.252 | 55.195 | 103.145 | 79.813 | 57.822 | 0.000 | 0.000 | 3.991 | 14.313 |
| 1986 | 14.653 | 57.540 | 19.679 | 41.629 | 23.689 | 42.895 | 75.567 | 88.951 | 54.341 | 0.000 | 11.091 | 3.906 | 14.653 |
| 1987 | 15.186 | 52.703 | 18.830 | 43.764 | 53.436 | 58.625 | 82.360 | 74.718 | 50.944 | 0.000 | 0.000 | 3.821 | 15.186 |

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual (MCM) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1988 | 17.374 | 51.854 | 15.283 | 62.928 | 24.708 | 51.721 | 122.329 | 82.413 | 47.123 | 0.000 | 0.000 | 3.736 | 17.374 |
| 1989 | 14.847 | 47.609 | 17.707 | 40.707 | 24.538 | 65.039 | 106.658 | 73.709 | 42.454 | 0.000 | 12.940 | 14.742 | 14.847 |
| 1990 | 20.732 | 56.002 | 27.524 | 43.084 | 26.406 | 59.644 | 75.567 | 85.118 | 39.057 | 0.000 | 1.849 | 3.566 | 20.732 |
| 1991 | 20.053 | 54.159 | 22.549 | 41.580 | 31.719 | 60.267 | 74.233 | 80.298 | 34.800 | 0.000 | 1.456 | 3.481 | 20.053 |
| 1992 | 14.497 | 45.789 | 16.739 | 25.521 | 38.002 | 21.106 | 48.640 | 69.017 | 31.532 | 0.000 | 0.000 | 3.396 | 14.497 |
| 1993 | 13.818 | 43.625 | 8.236 | 28.670 | 42.104 | 24.502 | 47.250 | 57.737 | 29.019 | 0.000 | 0.000 | 3.311 | 13.818 |
| 1994 | 8.918 | 24.441 | 7.217 | 15.429 | 27.765 | 23.823 | 42.109 | 80.220 | 47.550 | 0.000 | 0.000 | 10.905 | 8.918 |
| 1995 | 11.279 | 26.180 | 8.386 | 9.316 | 27.255 | 32.870 | 61.005 | 61.111 | 18.425 | 5.915 | 0.000 | 3.057 | 11.279 |
| 1996 | 14.294 | 37.682 | 11.564 | 17.273 | 51.551 | 31.546 | 35.830 | 52.979 | 16.132 | 0.000 | 0.000 | 2.972 | 14.294 |
| 1997 | 10.555 | 20.196 | 25.834 | 10.715 | 39.211 | 46.583 | 19.104 | 66.314 | 18.247 | 9.428 | 0.000 | 4.181 | 10.555 |
| 1998 | 12.275 | 21.715 | 10.381 | 17.234 | 29.123 | 28.068 | 24.536 | 44.672 | 7.387 | 9.982 | 0.000 | 2.802 | 12.275 |
| 1999 | 7.899 | 28.192 | 18.780 | 7.278 | 49.317 | 31.125 | 14.434 | 39.057 | 3.396 | 0.000 | 0.000 | 2.717 | 7.899 |
| 2000 | 25.974 | 13.128 | 0.000 | 14.906 | 36.601 | 31.189 | 20.500 | 40.730 | 0.000 | 0.000 | 0.000 | 2.588 | 25.974 |
| 2001 | 1.819 | 3.639 | 0.000 | 59.838 | 3.512 | 20.899 | 99.063 | 33.644 | 0.000 | 0.000 | 0.000 | 0.000 | 1.819 |
| 2002 | 1.819 | 6.227 | 0.000 | 7.278 | 0.000 | 12.395 | 44.654 | 0.000 | 3.697 | 0.000 | 50.034 | 398.548 | 1.819 |
| 2003 | 37.496 | 22.864 | 12.817 | 62.056 | 40.114 | 22.932 | 297.105 | 15.466 | 0.000 | 0.000 | 0.000 | 0.000 | 37.496 |
| 2004 | 10.261 | 3.639 | 0.000 | 7.278 | 0.000 | 34.825 | 112.373 | 10.352 | 29.330 | 0.000 | 0.000 | 5.792 | 10.261 |
| 2005 | 2.533 | 179.688 | 125.954 | 13.828 | 97.619 | 65.888 | 68.096 | 59.435 | 25.472 | 5.094 | 0.000 | 0.000 | 2.533 |
| 2006 | 3.421 | 3.639 | 13.585 | 9.461 | 17.103 | 30.106 | 68.096 | 116.233 | 55.262 | 46.942 | 0.000 | 39.227 | 3.421 |
| 2007 | 1.819 | 41.726 | 37.796 | 21.397 | 26.855 | 321.968 | 81.851 | 30.275 | 0.000 | 0.000 | 0.000 | 0.000 | 1.819 |
| 2008 | 58.683 | 14.531 | 7.302 | 7.278 | 3.857 | 20.159 | 108.851 | 147.981 | 6.550 | 0.000 | 0.000 | 50.289 | 58.683 |
| 2009 | 31.707 | 23.847 | 17.248 | 18.607 | 17.491 | 58.853 | 112.587 | 76.295 | 24.453 | 0.000 | 0.000 | 106.134 | 31.707 |
| 2010 | 3.168 | 3.887 | 10.866 | 29.724 | 25.178 | 40.631 | 290.219 | 196.956 | 0.000 | 0.000 | 6.032 | 32.668 | 3.168 |
| 2011 | 6.518 | 154.826 | 78.908 | 7.278 | 5.600 | 92.656 | 308.672 | 150.286 | 79.873 | 37.587 | 0.000 | 114.565 | 6.518 |
| **Average (MCM)** | 25.541 | 39.490 | 19.426 | 37.693 | 22.487 | 54.345 | 101.377 | 49.211 | 21.543 | 5.306 | 4.835 | 18.212 | 25.541 |

The mean monthly runoff and the annual distribution (1912-2011) for the Gundacha and Nurg/Hingri Irrigation Schemes are shown in Figure 3-5 & Figure 3-6 respectively.

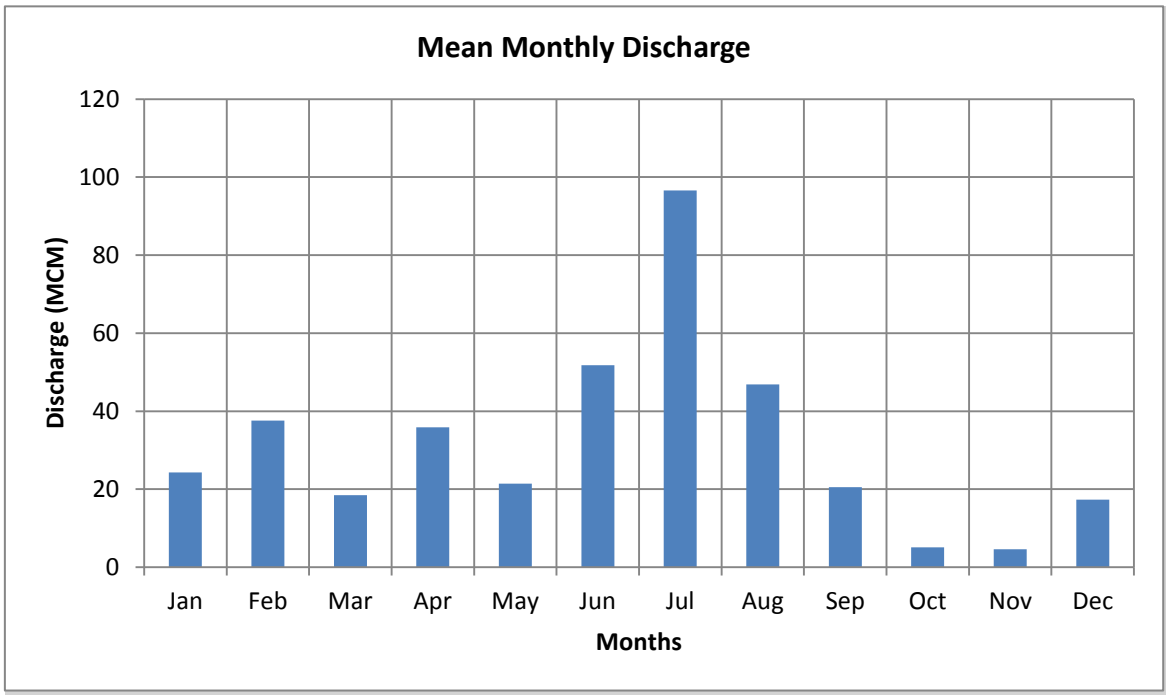



**Figure 3.5: Mean Monthly Inflow**

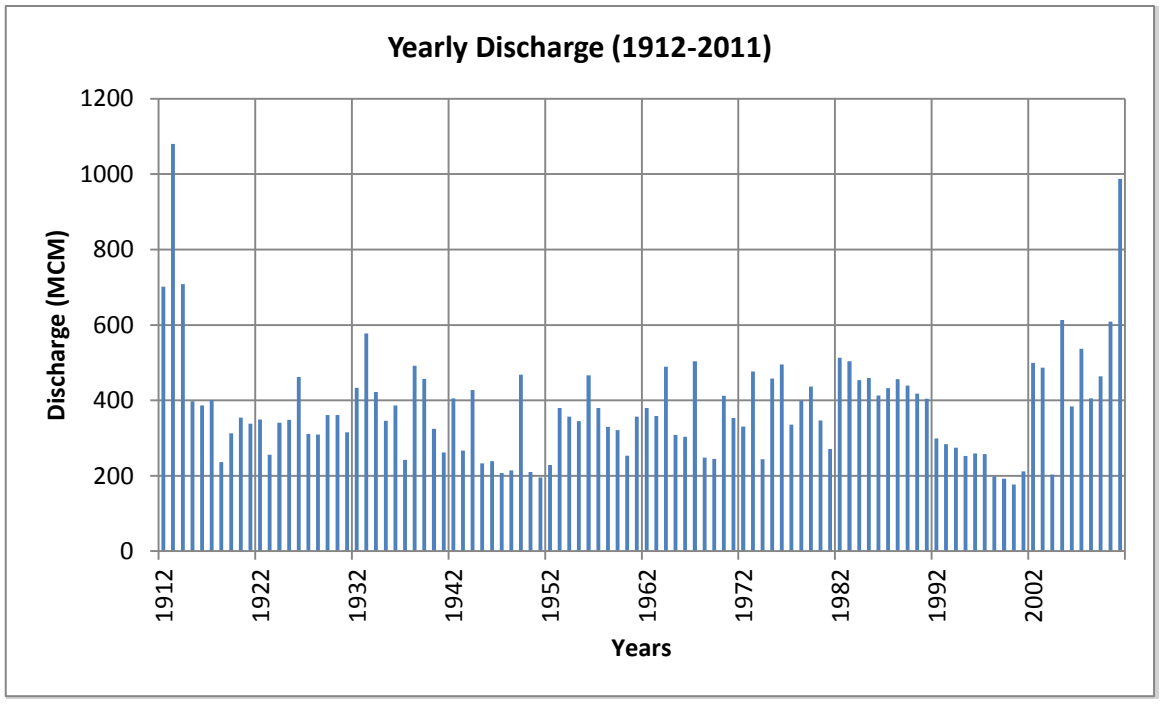



**Figure 3.6: Mean Annual Runoff**

## 3.5 SYNTHESIS OF DESIGN FLOOD HYDROGRAPHS

Design return period of 100 years was adopted for the design of Gundacha weir. Synthesis of design flood hydrograph is based on 24 hour annual maximum precipitation. Flood hydrograph was calculated on the basis of hourly distribution of rainfall.

### 3.5.1 Design Storm

#### *3.5.1.1 Rainfall Frequency Analysis*

1-Day annual maximum rainfall data of Bela and Wadh was used for Frequency analysis. 24-hr maximum rainfall event is plotted and shown in Table 3.3. Frequency analysis of the data was carried out using Extreme Gumbel probability paper, Figure 3.7 shows Rainfall against different return periods and listed in Table 3.4 below.

**Table 3.3: Annual Maximum Rainfall in (mm)**

| Year | Bela | Wadh | Year | Bela | Wadh | Year | Bela | Wadh |
|---|---|---|---|---|---|---|---|---|
| **1912** | 144.8 | - | **1941** | 20.3 | 17.8 | **1989** | 38.1 | - |
| **1913** | 154.9 | - | **1942** | 35.6 | 33.0 | **1990** | 27.9 | - |
| **1914** | 83.8 | - | **1943** | 50.8 | 33.0 | **1991** | 26.0 | - |
| **1915** | 53.3 | - | **1944** | 63.5 | 27.9 | **1992** | 79.2 | - |
| **1916** | 76.2 | - | **1945** | 58.4 | 25.4 | **1993** | 27.9 | 47.0 |
| **1917** | 50.8 | - | **1946** | 33.0 | 20.3 | **1994** | 35.6 | - |
| **1918** | 17.8 | - | **1947** | 20.3 | - | **1995** | 52.3 | 17.3 |
| **1919** | 20.3 | - | **1948** | 12.7 | - | **1996** | 31.8 | 18.3 |
| **1920** | 35.6 | - | **1949** | 76.2 | - | **1997** | 30.5 | 40.6 |
| **1921** | 58.4 | - | **1950** | 20.3 | - | **1998** | 13.7 | 36.8 |
| **1922** | 25.4 | - | **1951** | 0.0 | - | **1999** | 28.4 | 35.1 |
| **1923** | 12.7 | - | **1952** | 0.0 | - | **2000** | 24.9 | 12.2 |
| **1924** | 22.9 | - | **1953** | 35.6 | - | **2001** | 50.3 | 22.6 |
| **1925** | 27.9 | - | **1954** | 22.9 | - | **2002** | 5.1 | 16.3 |
| **1926** | 38.1 | - | **1955** | 33.0 | - | **2003** | 75.9 | 32.3 |
| **1927** | 25.4 | - | **1956** | 83.8 | - | **2004** | 3.0 | 21.1 |
| **1928** | 27.9 | - | **1957** | 20.3 | - | **2005** | 25.0 | 34.5 |
| **1929** | 40.6 | - | **1958** | 7.6 | - | **2006** | 37.0 | 20.7 |
| **1930** | 27.9 | - | **1959** | 27.9 | - | **2007** | 57.3 | 24.9 |
| **1931** | 15.2 | - | **1960** | 5.1 | - | **2008** | 85.4 | 28.3 |
| **1932** | 73.7 | - | **1961** | - | 50.8 | **2009** | 23.7 | 20.1 |
| **1933** | 91.4 | - | **1962** | 0.0 | 35.6 | **2010** | 27.9 | - |
| **1934** | 30.5 | - | **1963** | 20.3 | 38.1 | **2011** | 45.0 | - |
| **1935** | 38.1 | 25.4 | **1964** | 157.5 | 64.8 | **2012** | 203.2 | - |
| **1936** | 81.3 | 35.6 | **1965** | 27.9 | 15.2 | | | |
| **1937** | 25.4 | 25.4 | **1966** | 22.9 | 22.9 | | | |
| **1938** | 71.1 | 139.7 | **1967** | 38.1 | 40.6 | | | |
| **1939** | 68.6 | 45.7 | **1968** | 12.7 | 27.9 | | | |
| **1940** | 20.3 | 25.4 | **1969** | 17.8 | 20.3 | | | |

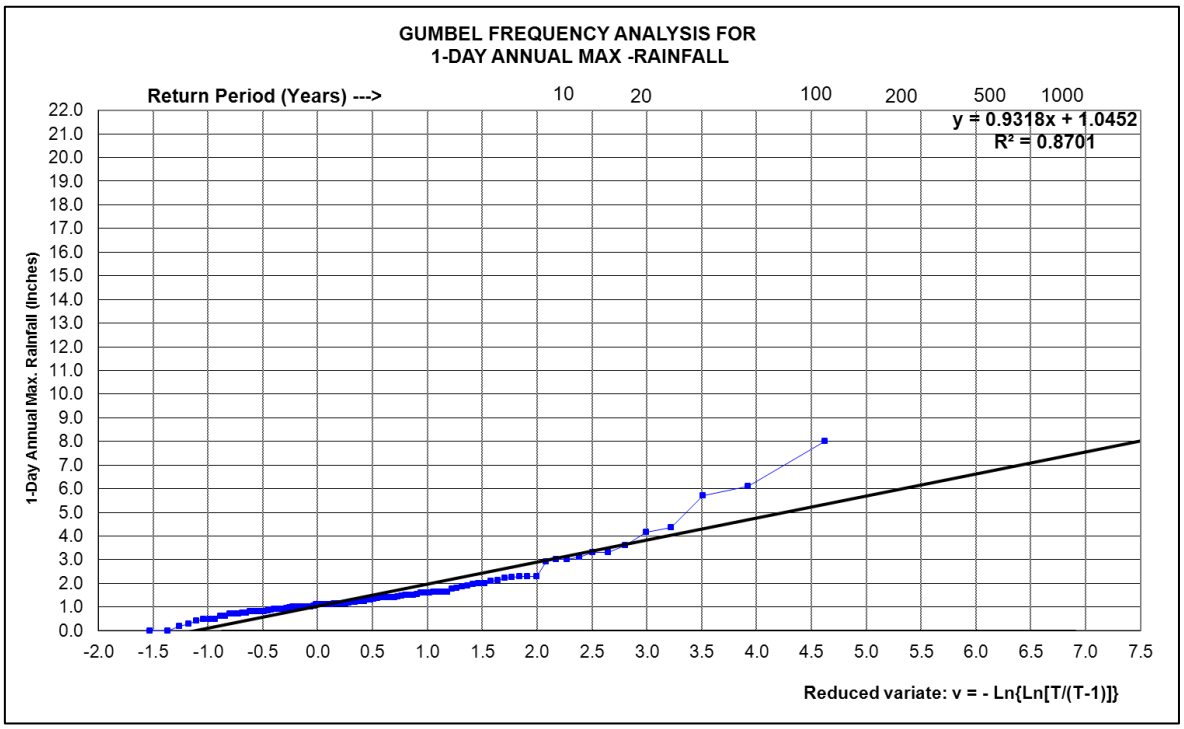



**Figure 3.7: Gumbel Frequency Analysis**

**Table 3.4: Rainfall Estimation by Gumbel Method**

| Return Period | 24 hr. - Rainfall (mm) |
|---|---|
| **2.33** | 40.24 |
| **10** | 79.81 |
| **50** | 118.9 |
| **100** | 135.42 |
| **500** | 173.61 |
| **1000** | 190.03 |

### *3.5.1.2 Inflow Hydrograph*

From SCS curve number publication curve number CN of 80 was selected for antecedent Moisture Condition II. After determining curve number CN considering antecedent conditions and imperviousness of catchments, hydrological characteristics, in-house Hydrological model was used for determining inflow hydrograph for proposed weir site against different return periods using SCS dimensionless unit hydrograph technique in above mentioned hydrological model. Time of concentration worked out using Kirpich Formula is 25.11 hrs. Inflow hydrographs for 100 years return period for Gundacha is calculated as graphically shown in Fig 3.8. Whereas, inflow hydrograph for Nurg-Hingri has been computed for 25 years return period and shown in Fig 3.9.

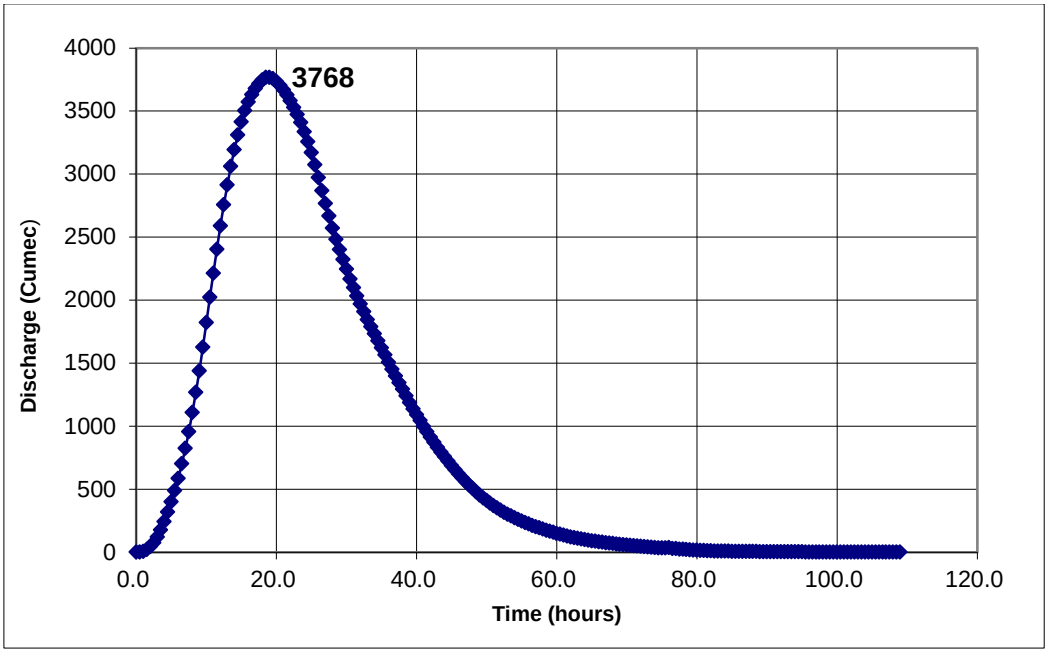



**Figure 3.8: Inflow Flood Hydrograph for Gundacha *(*100 year return period)**

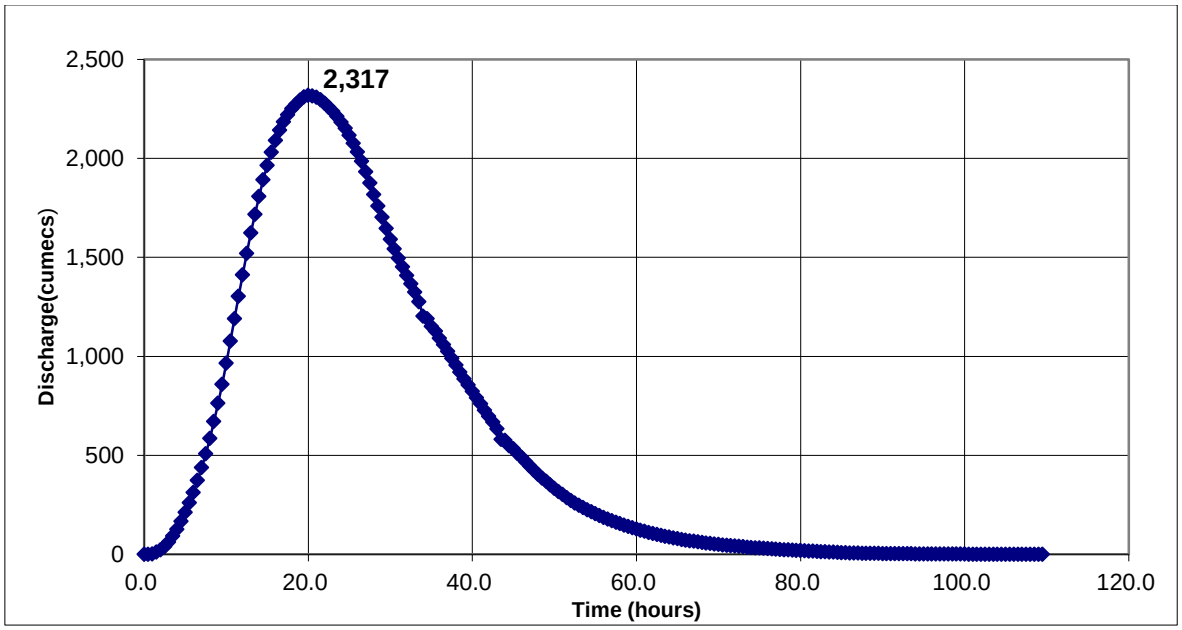



**Figure 3.9: Inflow Flood Hydrograph for Nurg-Hingri *(25* year return period)**

Similarly peak flood discharges for different return periods were also calculated using the SCS Curve No. method. The results are tabulated in Table 3.5 & 3.6. The inflow hydrographs for floods of each return period were developed using dimensionless unit hydrographs methods and shown in Figure 3.10 & 3.11.

**Table 3.5: Peak Discharge Values for Different Return Period**

| Return Period | Rainfall (mm) | Peak discharge (cumec) |
|---|---|---|
| **10** | 79.81 | 1566 |
| **50** | 118.90 | 3078 |
| **100** | 135.42 | 3768 |

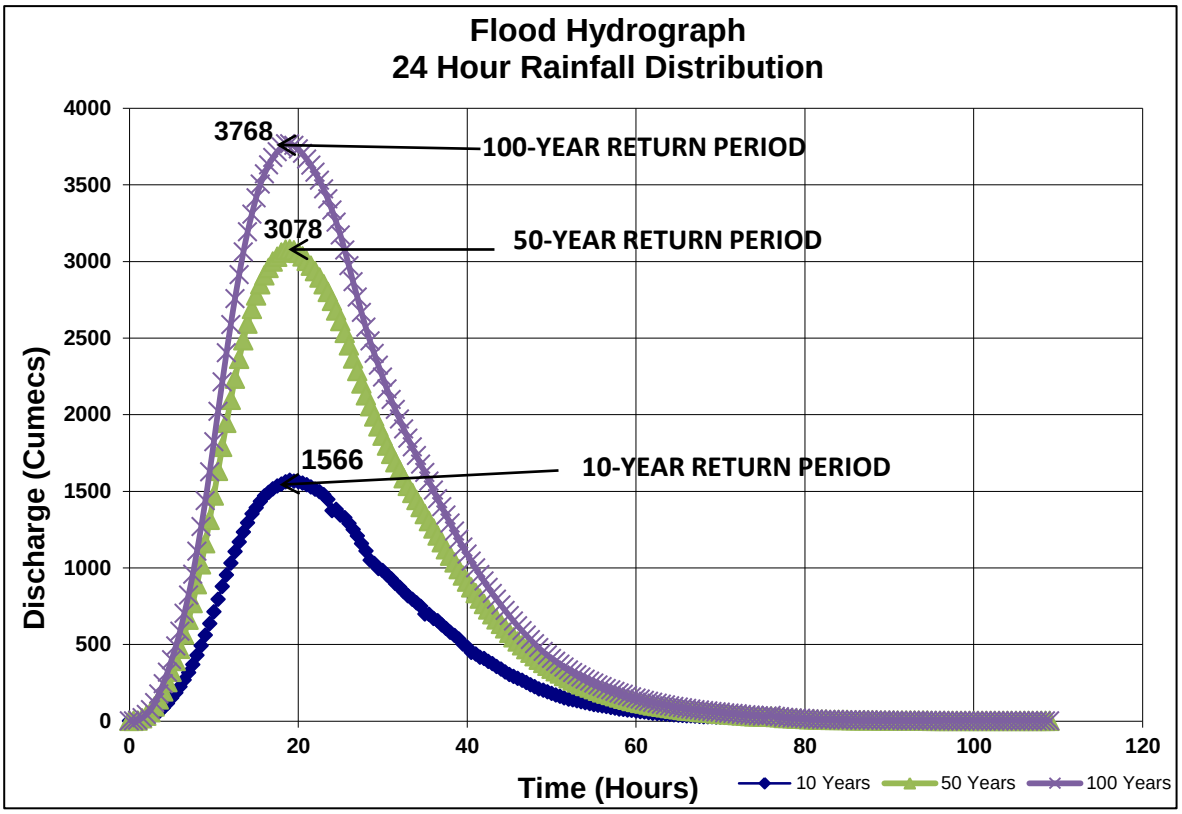



**Figure 3.10: Flood Hydrographs of Gundacha for Different Return Periods**

**Table 3.6 Peak Discharge Values for Different Return Period**

| Return Period | Rainfall (mm) | Peak discharge (cumec) |
|---|---|---|
| **2.33** | 40.24 | 343 |
| **5** | 62.05 | 925 |
| **10** | 79.81 | 1504 |
| **25** | 102.25 | 2317 |
| **50** | 118.9 | 2960.58 |

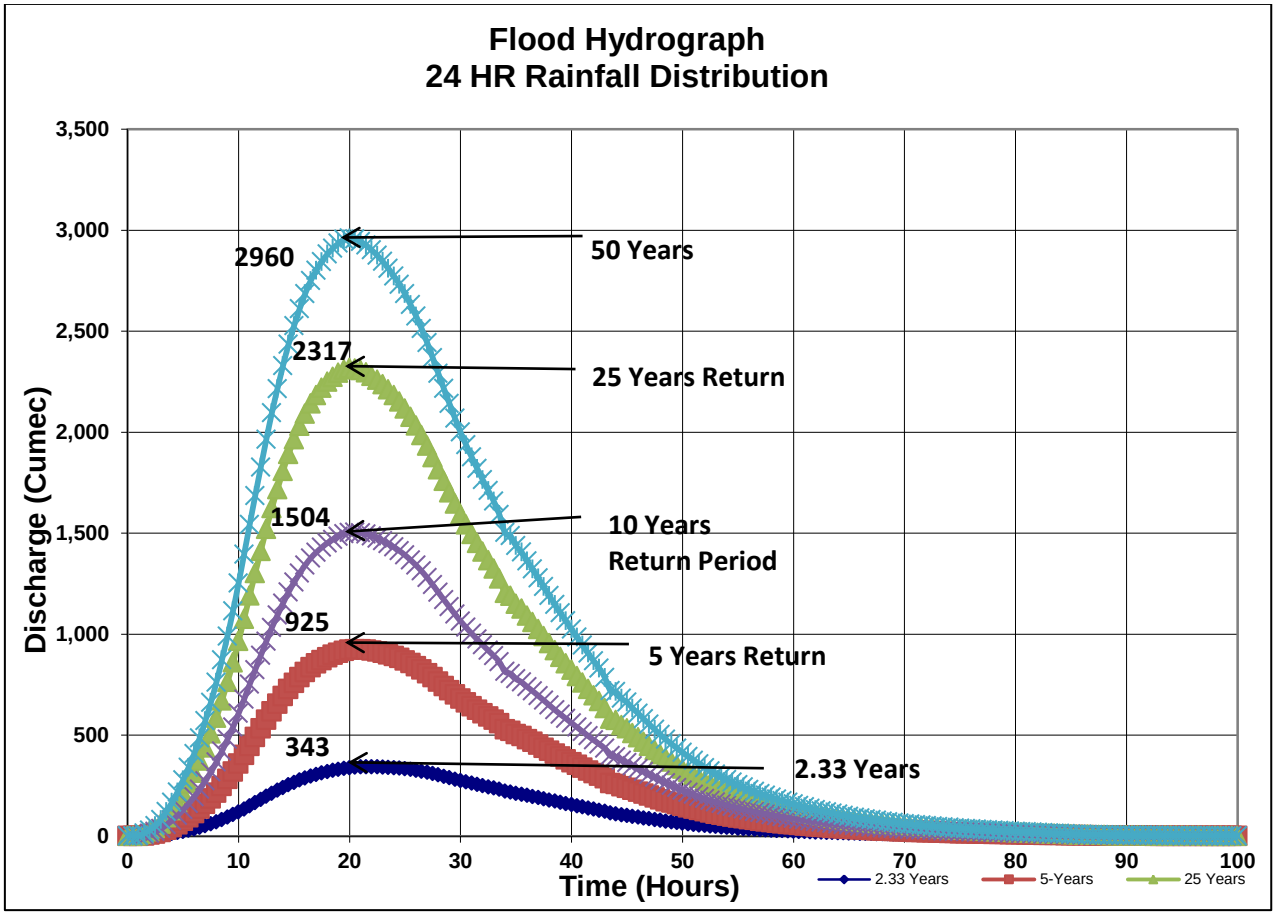



**Figure 3.11: Flood Hydrographs of Nurg-Hingri for Different Return Periods**

# Chapter - 4
# DESIGN OF PROPOSED WORKS

## 4.1 GENERAL

Hydraulic design of the Weir, Under Sluice and Head Regulator is based on criteria described in Section 17 “Barrages and Dams on Permeable Foundation” given in “Handbook of Applied Hydraulics” by C.V. Davis.

***Gundacha***

The weir needs to be constructed for improving irrigation supply and protection by uncertain flood which sometimes hits cultivated land; the reasonable portion of command area will be increased.

***Nurg-Hingri***

The Nurg-Hingri existing weir needs to be upgraded / rehabilitated, as some damages were found in all components of the structure and the upstream is totally silted up with large & small gravels and sand, so existing weir is not functioning effectively, local people suffer by uncertain flood which hits settlements, sweep out cultivated land and by drought as no water retains at upstream side. So, by upgrading the existing weir, the reasonable portion of command area will be irrigated eventually, water discharged from weir will improve hydraulic conditions and productivity of freshwater.

## 4.2 GUNDACHA WEIR LAYOUT AND COMPONENTS

The diversion weir is designed for the following requirements:

- raise the water level to ensure continuous irrigation water supply to the command area.
- to prevent incoming sediment bed load from entering the main canal.

The head works and associated structures consist of the following components:

- Overflow Weir
- Under sluice
- Head Regulator
- Guide Bunds and Retaining Walls

Layout plan of the weir and its components are shown in Figure 4.1

Layout features of each of these are described below:

### (i) Overflow Weir

The overflow weir is an un-gated concrete structure with its crest at EL 172.5 m. Length of the weir is 410 m. The crest of the overflow weir is broad crested shaped with upstream slope of 1V:1H & downstream slope of 1V:2H. The floor level on

upstream of the weir is kept at EL 171.0 m. The weir is designed for 100 years return period flood discharge of 3,700 cumec.

**(ii) Under sluice**

The under sluices in the weir structure are provided to flush out sediment deposit from upstream of head regulator, and discharge flood water.

The under sluice portion is located on the right flank of the weir and just abutting the head regulator on its left side. It is an open weir with vertical grooves to accommodate stop logs without breast wall. The floor level of under sluice is kept at EL 171.0 m and 0.5 m below the sill level of head regulator. The under sluice portion has three openings each 2.2 m wide (clear) with 0.7 m thick piers.

**(iii) Head Regulator**

The head regulator is designed as an open intake with concrete box section. It consists of two (2) barrels each of size 0.7 m wide x 1.0 m high (clear). Vertical grooves will be provided to insert stop logs regulating the flow. Sill of regulator is provided at EL.171.5 m which is 0.50 m above the crest of under sluice to prevent sediment from entering the main canal. After box culvert, head regulator slopes down on 1V:1H to floor EL 170.75 m. The head regulator is designed for a perennial discharge of 2.5 cumec. The oversize of head regulator will require careful operation to avoid overflowing of main canal.

**(iv) Guide Bund**

The Guide bund will be built with locally available sand and gravel with a top width of about 5 m and side slopes of 2H: 1V. The upstream length is usually kept equal to 1.1 L, while the downstream length is 0.25 L, L being the length of the hydraulic structure. The top of guide bund is kept at an elevation about 1.5-2.5m above the high flood level. The water face of the straight portion and both faces of the curved heads are pitched with stone to protect them from erosion.

## 4.3 HYDRAULIC DESIGN FEATURES FOR GUNDACHA

### 4.3.1 Main Weir

Hydraulic design computations for the weir were carried out as recommended by USBR. Salient Features of the design are described below.

| | |
|---|---|
| Type of Weir | Un-gated Broad Crested Weir with USBR Stilling Basin Arrangement |
| Weir Crest Level | 172.5 m |
| Width of Weir Waterway | 410 m |

| | |
|---|---|
| Design Flood (100 Year Return Period) | 3,700 cumec |
| Weir Height from River Bed | 1.5 m |

The weir is designed as free over fall weir with coefficient of discharge 'C' considered as 1.71 in the following weir equation. The value of 'C' adopted is as recommended by USBR for broad crested weir crest.

$$Q = CLH^{3/2}$$

where
Q = Discharge in cumec
C = Co-efficient of Discharge
H = Head over weir crest including Head due to velocity of approach (m)
L = Length of crest (m)

Design features for the weir are described below.

The length of overflow weir is kept as 410 m. This gives an intensity of discharge over the weir crest as 9.01 cumec per meter. Pond level for perennial discharge is worked out as 172.5 m.

### 4.3.2 Stilling Basin

For dissipating the energy of incoming flows a hydraulic jump type stilling basin has been designed. The flow velocity at the toe of weir glacis works out to 9.82 m/s with depth of flow as 0.92 m and Froude Number of 3.27. As recommended by USBR (Design of Small Dams), for this range of Froude Number, Type-IV, basin with chute blocks, and dentate sill has been provided. Dimensions of the basin, length, size / spacing of chute blocks and the dentate sill are provided as recommended by USBR.

Stilling basin floor elevation is worked out as El 170.5 m and overall length of the basin as 22 m.

### 4.3.3 Concrete Block Aprons

Aprons of un-reinforced concrete blocks are provided on downstream of the stilling basin. The blocks shall be cast in place and of size 1.0 m x 1.0 m and 1.0 m. The downstream blocks are cast with a 35 mm space between each and all adjoining blocks to permit relief of uplift pressure. Length of each concrete apron is 8.0 m.

### 4.3.4 Stone Aprons

In addition to concrete block aprons, stone aprons are provided on both upstream and downstream. The lengths of upstream and downstream stone aprons are 10 and 15 m respectively.

## 4.4 HYDRAULIC CHECKS

### 4.4.1 Exit Gradient

Loss of material from the riverbed at the end of the structure by “piping” may occur if the weight of the sand is overcome by the upward flow of water through it. Good design requires that pressure gradient in the foundation material at the end of the structure, causing this upward flow, be as low as possible consistent with other requirements of design.

The analysis has shown that the maximum exit gradient worked out is 1 in 14.7 which is safe (against allowable value of 1 in 6 for coarse sand).

### 4.4.2 Uplift Pressure for Concrete Floor

Concrete cut-off at both upstream and downstream ends of all structures floors has been provided. The depth of cut off is primarily based on the criteria of 1.5 R and 2.0 R below upstream and downstream water levels respectively; R being the Lacey’s scour depth. The cut-off wall shall be provided along left and right flanks of the weir thus boxing the structure on all sides. Uplift is one of the principal factors governing the design of the Weir and its components.

For determining the uplift pressures following critical flow condition has been considered.

- no flow over the weir crest
- u/s water level at weir crest and water level on d/s at end sill level

Thickness of concrete floor is computed at different locations using the respective uplift pressure.

## 4.5 STRUCTURAL DESIGN CRITERIA

The weir and its components are designed on allowable foundation bearing capacity of 380 kPa. The soil strata underneath weir foundation primarily consist of sand and gravel. For this type of soil, shear strength parameters between concrete and foundation used in the design are:

Angle of internal friction: $\phi = 35^{o}$

Cohesion: c = 0

Walls are designed as cantilever retaining type. Approach slab and stilling basin are primarily designed as concrete gravity structures nominally reinforced for temperature variation.

Allowable working stresses considered for concrete for structural design is 28 days cylinder strength for normal loading conditions whereas 33% overstressing has been allowed for extreme loading conditions.

Concrete classes and cylinder strengths are as given below:

**Table 4.1: Concrete Classes & Cylindrical Strengths**

| Concrete Class | Location | 28 days Cylinder Strength MPa (Psi) |
|---|---|---|
| C-21 | Mass Concrete and Cut- off | 21 (3000) |
| C-15 | Lean Concrete | 15 (2100) |

Higher strength reinforcing steel conforming to ASTM Designation A-36 with minimum yield strength of 414 MPa shall be used.

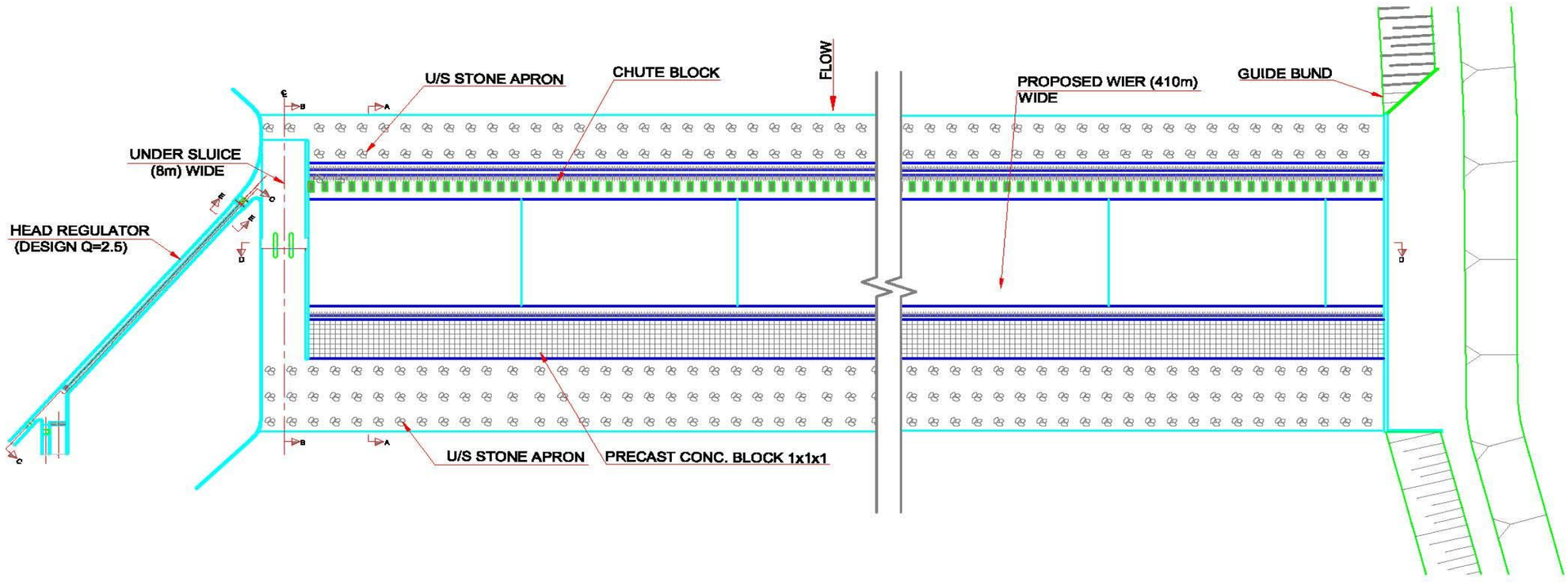
The Design summary of Weir and appurtenant structures is attached as Annexure – I at the end of the report. The Salient features of the Gundacha weir and related structure are given in Table 4.2

**Table 4.2: Salient Features of Gundacha Irrigation Scheme**

| | |
|---|---|
| **A. Main Weir** | |
| Type of Weir | Un-gated Broad Crested Weir with USBR Stilling Basin Arrangement |
| Weir Crest Level | 172.5 m |
| Width of Waterway | 410 m |
| **B. Under Sluice** | |
| Type | Open rectangular channel |
| Sluice Crest Level | 171 m |
| Width Waterway | 8 m |
| **C. Head Regulator** | |
| Type | 2 cell box culvert |
| Crest Level | 171.5m |
| Width Waterway | 1.5 m (clear span) |

| | |
|---|---|
| **D. Irrigation Channel** | |
| Length | 24,000 m |
| Section | 1 m wide concrete channel |
| Design Capacity | 2.5 cumec |
| **E. Structures** | |
| Drainage Culverts | 12 |
| Road Culvert | 13 |
| Outlets | 8 |
| Fall Structures | 5 |

**Figure 4.1 Layout plan of the Weir and its components for Gundacha**



## 4.6 NURG-HINGRI WEIR LAYOUT AND COMPONENTS

**Existing Condition**

The Nurg-Hingri diversion weir, located on Porali River at about 5 km downstream of Gundacha, is an existing structure in moderate working condition. The structure was constructed in year 1987 and has experienced several flood peaks. The main weir stretches across the Porali River bed and has two diversion weir crests at its left end. The diversion weir at extreme left serves the Hingri channel while the next one feeds the Nurg channel. Following are the lengths and elevations of the weir crests:

| Weir | Length (m) | Crest Elevation (m) |
|---|---|---|
| Main Weir | 295 | 136.6 |
| Nurg Weir | 66 | 136.3 |
| Hingri Weir | 44 | 136.0 |

The existing overflow weir is an un-gated concrete structure with its crest at El. 136.6 m. Length of the weir is 295 m. The overall existing condition of the structure is indicative of absence of maintenance and upkeep during past years. This is evident from the damaged conditions of water bodies and eroded away portions of guide banks. The existing un-controlled weir off-takes have resulted in entrance of excessive flood peaks into downstream earthen channels. This has caused twofold damage. Firstly, the erosive damage to channel sections and guide banks and secondly, the flood damage to the command area.

**Proposed Upgrading**

In view of the foregoing conditions, the package in-hand proposes to upgrade the facilities for optimizing the benefits. Four (4) different components have been identified where improvements should be implemented. These are briefly described in the following:

- The existing un-controlled diversion weir crest of Nurg and Hingri channels needs be equipped with a breast-wall to limit the entering flood peaks within a reasonable value.
- One or more under-sluice(s) should be provided to keep the low river channel tending towards the off takes.
- The washed out portion of divide bund (embankment) should be re-constructed and strengthened to withstand future floods.
- Spot repairs to minor damages in main weir and appurtenances should be undertaken to prevent further loss.

Layout plan of the weir and its components are shown in Figure 4.2

**(i) Breast Wall**

A suspended concrete wall on the top of the crest, spanning between the piers is proposed to the piers, so as create rectangular opening above the crest level to pass the flow as a weir upto water levels remaining below the bottom of this wall. As the water level rises, the opening transforms to an orifice, there by controlling the flow.

The lengths of span for are approax.66 m and 44 m for Nurg and Hingri respectively. The height of opening below the breast wall is 1.5 m, the height of breast wall above the opening is 2.5 m.

**(ii) Under sluice**

For upgrading the existing weir structure under sluice will be provided to flush out sediment deposit from upstream and discharge flood water.

The under sluice portion will be located on the left flank of the weir. It is an open weir with stop logs. Axis of under sluice weir will be in line with that of the main weir except that the crest elevation. The under sluice portion will has six openings each 2.5 m wide (clear) with 0.6 m thick piers. Stop logs each of size 2.5 m wide x 0.30 m high will operate in between piers.

## 4.7 HYDRAULIC DESIGN FEATURES FOR NURG-HINGRI

### 4.7.1 Main Weir

The existing weir bodies for offtakes of Nurg and Hingri channels are already significantly damaged. Further, the introduction of piers for constructing the breast wall will need dismantling of considerable portion of the existing weir bodies. Accordingly, it has been proposed to completely demolish, remove and to construct entirely new weirs at slightly downstream location.

On upstream end of the new weirs, a skimming platform, 0.5 m high is proposed to prevent bed load entering at offtakes. The low platform on upstream of skimming weir leads to under sluice.

Hydraulic design computations for the proposed offtakes weirs have been performed against a design return period of 25 years.

| | |
|---|---|
| Type of Weir | Weir with Breast Wall |
| Energy Dissipation Device | USBR Stilling Basin Arrangement |
| Weir Crest Level | 136 m |
| Design Flood (25 Year Return Period) | 2317 cumec |

| | |
|---|---|
| Weir Height from River Bed | 2 m |

The weir is upgraded as free over fall weir with coefficient of discharge 'C' considered as 1.7 in the following weir equation. The value of 'C' adopted is as recommended by weir with breast wall.

$$Q = CLH^{3/2}$$

where
- Q = Discharge in cumec
- C = Co-efficient of Discharge
- H = Head over weir crest including head due to velocity of approach (m)
- L = Length of crest (m)

Design features for the existing weir are described below.

The length of upgraded weir will be 275 m. This gives an intensity of discharge over the weir crest as 8.42 cumec per meter for peak flow of 25 years return period.

### 4.7.2 Under-sluice

| | |
|---|---|
| Number of openings | 6 |
| Type of gates | Stop-log |
| Height of opening | 1.5 m |
| Width of opening | 2.5 m |
| Elevation of the sill | El 135.1 m |

Opening condition: Under the differential water head corresponds to flood discharge of 115 cumec when opening is not blocked by stop logs.

A stop-log slot will be provided in front of each under sluice bay for raising water levels during low flows.

### 4.7.3 Breast Wall

**Design Parameters**

- Design discharge = 25 year return period,
- Check discharge = 50 year return period,
- Weir coefficient = 1.7
- Minimum discharge = 5 year return period (weir flow).

The beam of the breast wall spanning between the pier and abutment/pier shall be designed to resist the moments due to:

a) Dead load of the breast wall;

b) Uplift;

c) Water pressure;

d) Seismic forces and moments, if any; and

e) Hydrodynamic forces due to seismic conditions, if any.

It shall be designed to resist the moments in both horizontal and vertical directions. The beam will be checked for torsional moments also and suitably reinforced. The stem will also be designed as per the criteria for the design of beam and the stem may also be checked as a deep beam subjected to the various loads and moments though generally it may not govern the requirements of reinforcement.

Breast walls shall be reinforced concrete beams resting on piers formed within the existing weir bodies.

### 4.7.4 Guide Bund

The Guide bunds will be built along the flow direction in places where damages have occurred and left of Hingri Channel. These will be built with locally available sand and gravel with an existing top width. Guide bank shall be compacted to 95% AASHTO density and shall be protected by stone pitching on filter material where required.

## 4.8 STRUCTURAL DESIGN CRITERIA

The existing weir and its components are upgraded on allowable foundation bearing capacity of 380 kPa. The soil strata underneath weir foundation primarily consist of sand and gravel. For this type of soil, shear strength parameters between concrete and foundation used in the design are:

Angle of internal friction: $\phi = 35^{o}$
Cohesion: c = 0

Approach slab and stilling basin will primarily be improved as concrete gravity structures nominally reinforced for temperature variation.

Allowable working stresses considered for concrete for structural design is 28 days cylinder strength for normal loading conditions whereas 33% overstressing has been allowed for extreme loading conditions.

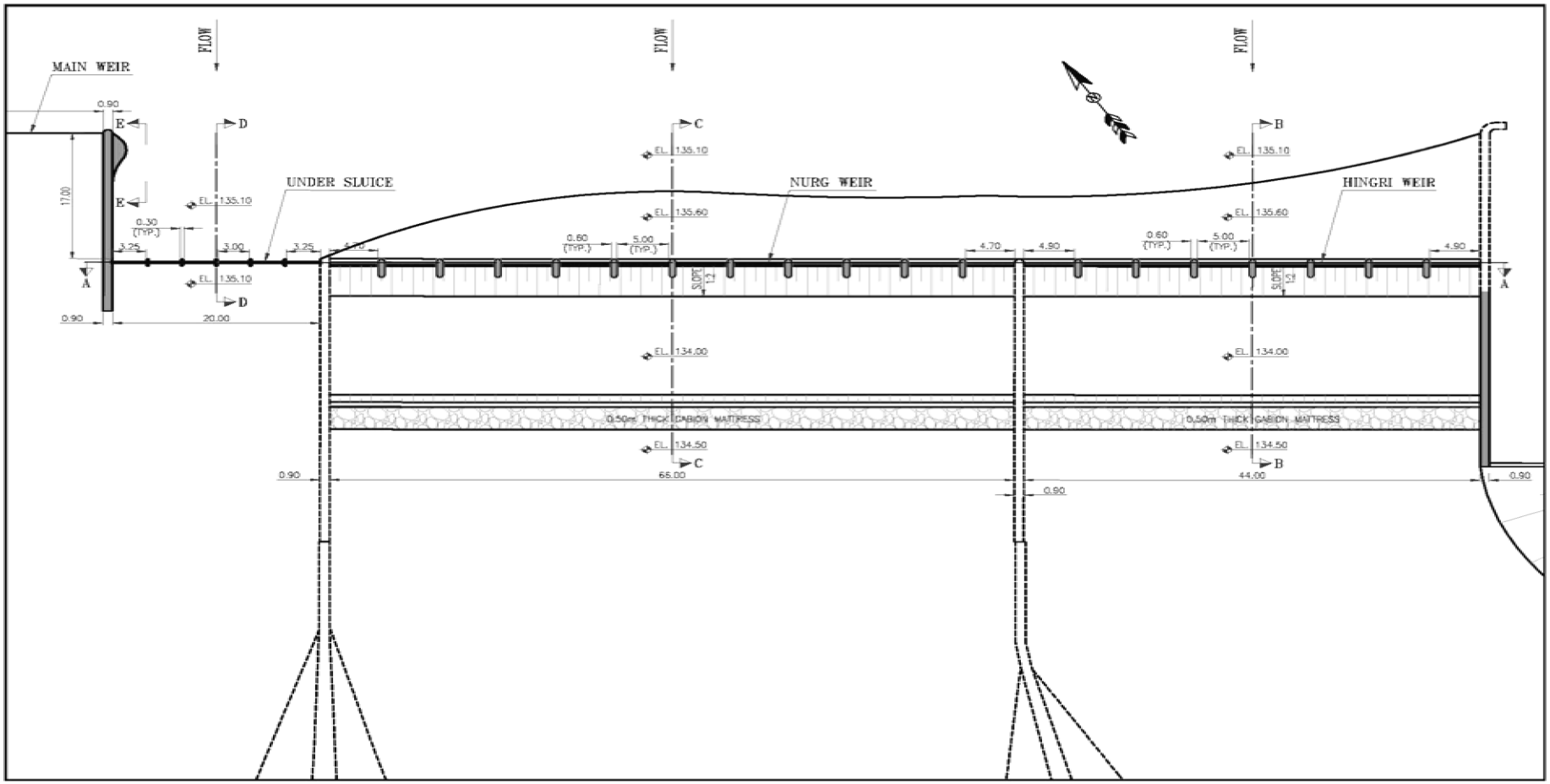
Higher strength reinforcing steel conforming to ASTM Designation A-36 with minimum yield strength of 414 MPa shall be used.

The Design summary of Weir and appurtenant structures is attached as Annexure – II at the end of the report. The Salient Features of Nurg Hingri Irrigation scheme are given in Table 4.3.

**Table 4.3: Salient Features of Nurg Hingri Irrigation Scheme**

| | |
|---|---|
| **A. Main Weir** | |
| Type of Weir | Un-gated Broad Crested Weir with USBR stilling Basin |
| Weir Crest Level | 136 m |
| Width of Waterway | 295 m |
| (i) Nurg Weir | |
| Length | 66 m |
| Crest Elevation | 136.3 m |
| (ii) Hingri Weir | |
| Length | 44 m |
| Crest Elevation | 136 m |
| **B. Under Sluice** | |
| Type | Open rectangular channel with stop logs |
| Sluice Crest Level | 135.1 m |
| Waterway Width | 2.5 m |
| Height of Waterway | 1.5 m |

**Figure 4.2: Layout Plan of Weir and its components for Nurg-Hingri**



## 4.9 LIST OF REFERENCES

I. USBR (1967), Design Standard No.3, Canals and Related Structures, Chapter 3 – Diversion Dams, Section 3.4 – Maximum Flood Flow. “Diversion dams are designed to safely pass flood flows of 50-or 100-year probable frequency”.

II. Bureau of Indian Standard Guidelines IS:6966 Part I (1989): “Hydraulic Design of Weirs – Guidelines” have recommended following floods for alluvial reaches:

- Standard Project Flood (SPF) or 500 year return period flood for designing freeboard.
- 50 years return period flood for designing of items other than freeboard

III. Sharma & Sharma (2004), Irrigation Engineering, Chapter 10 – headwork Section 10.14: “Waterway or the length of the barrage is fixed to cater for the maximum flood discharge corresponding to 50 year frequency” page 262.

“Generally, a freeboard of 1.5 to 2m above affluxes water level on the upstream side due to flood of 500 years frequency or the standard project flood and above the highest flood level (un-retrogressed) on the downstream side is provided” page 264.

IV. Iqbal Ali (1993), Irrigation and Hydraulic Structures, Chapter 3 – Low Head Diversion Dams, page 52: “Depending on the life of the structure, capital cost, and economic importance of the project, the design flood can be 50yr or 100yr flood”.

V. Government of Balochistan (1988), Weir Design Manual, Part 6 – Hydraulic Characteristics.

” Whenever possible it is recommended that the following design criteria be adopted:

- The main weir and stilling basin should be deigned to pass a 1 in 50 year flood, with a two to three feet freeboard to the top of the abutments.
- The weir should then be checked for a 1 in 100 year flood. The peak flow should be allowed to encroach on the freeboard, but not overtop the abutments and the stilling basin should be checked to ensure that the jump remains on the basin.
- Minor upstream and downstream guide bunds and channel protection bunds should be designed for a 1 in 25 year flood event where overtopping and failure of the bunds will not result in catastrophic failure of the weir”.

VI. Davis (1993), Handbook of Applied Hydraulics, 4th Edition, Chapter-12, Barrages and Dams on Permeable foundations, page 12.4.

"In Pakistan and India, barrages were formerly designed to pass the maximum flood previously experienced, with some margin of safety. In terms of modern hydrology the designs in practice were capable of accommodating floods of about 40 or 50 year frequency".

# Chapter - 5
# DESIGN OF IRRIGATION CANALS

## 5.1 GENERAL

Gundacha Irrigation Canal Network has been planned and designed to serve a command area of about 6,300 acres in safe and efficient manner.

Since the Command area has been divided into Two (2) distinctive chunks of land by an old Ravine, accordingly, the planned irrigation network has been configured in a way to have separate commands for irrigating two sides of the Ravine (Dhora).

The detailed design of the irrigation network has been based on field investigations. A survey party arranged by M/s. Techno Consult International was sent for detailed topographic survey to cover the existing Gundacha Irrigation Land/Network and command area. The surveyed information was processed digitally and required maps were prepared. The survey data was effectively used for the layout of Irrigation canals and other related structures.

## 5.2 OFFTAKE STRUCTURE

An off-take structure has been proposed on right bank of the river in order to provide head to the two (2) off-taking canals namely, Gundacha and Jamot. The Canal off-take has been designed for gross discharge 'Q' required to feed these irrigation canals.

## 5.3 ALIGNMENT

To cater irrigation needs of the command area on the right bank of the Gundacha River, existing alignment will be followed. The slope of the irrigation canals have been so set in order to maintain a self-cleansing and sub-critical velocity. The outline of the existing irrigation network has been traced based on the survey data.

## 5.4 SIZING OF THE CANALS

According to served area needs, the required flow based on Crop Water Requirements is worked out. The Canal Section has been selected to be the most cost and workability efficient. Local material and labor will be used in order to come up with an economical canal system. Concrete lined canals have been proposed with Manning's roughness coefficient "n" adopted as 0.016 (considering old concrete after use of few years). The depth of flow has been worked out in view of canal cross sections and longitudinal slopes by use of Manning's formula.

## 5.5 CROSS DRAINAGE AND OUTLET STRUCTURES

A number of structures are proposed on canals including Outlet structures, drop structures, road culverts, and drainage culverts for existing natural drainage channels.

The canal structures are proposed taking into account the following considerations:

- Topography of the irrigation channel proposed.
- Interval of outlets are decided according to the size of the land allocated to be served

  However, the actual location of the crossing structures and outlets will be decided as per the field observation of ownership groups and cropping pattern to meet the technical and social suitability.

### 5.5.1 Outlet/Time Division Structures

Main Conveyance canal discharge has been selected on time division basis. The sub areas of the command will be irrigated by providing outlets/time division structures at appropriate locations on the Main Canal. These outlets will be provided with manually operated vertical gates. The outlet structures have been designed at appropriate locations taking into consideration the following criteria.

- Size of the openings is adjusted to be proportional to the water rights allocated to each of the downstream channels.
- Flow over the weir on every opening must be free flowing (i.e. flow must not become submerged by the downstream water level backing up). For this reason, it is recommended that the drop across the weir for these small structures should be at least 150 mm.

The water depth over the weir of any division structure is determined by the height of the incoming channel banks. The existing tertiary canals will be fed through the proposed outlets.

### 5.5.2 Drop Structures

The design of drop structures is based on the principle of energy dissipation. The depth of drop structures provided on the irrigation canal has been kept as 2 m. The energy at the drop structures is calculated using the equation

$$E = y + v^2/2g$$

where,
y = depth of flow
v = velocity

g = gravitational acceleration

The stilling basin and end sill elevations are fixed in order to dissipate the energy caused by the drop.

### 5.5.3 Drainage Culverts

The Drainage Culverts have been designed on the basis of water flowing at the natural nullah at the proposed locations. The discharge of drainage culvert is computed using the following equation.

$$Q = CIA$$

where,
C = discharge coefficient
I = intensity of Rainfall
A = Area under the rainfall

The Drainage culvert dia is kept as 0.6 m and the no of cells of each drainage culvert is decided on the basis of discharge at the proposed location.

### 5.5.4 Road Culverts

The road culverts are provided near the settlements in order to provide easy access to the cattle & farmers.

Table 5.1 contains the salient features of canal length and related structures provided on the two main canals.

**Table 5.1: Salient Features of the Irrigation System**

| **Main Canal** | |
|---|---|
| Length | 24,000 m |
| Section | 1 m wide concrete channel |
| Design Capacity | 2.5 cumec |
| **Canal Structure** | |
| Outlets Structures | 8 Nos. |
| Road Culverts | 13 Nos. |
| Drainage Culverts | 12 Nos. |
| Fall Structures | 5 Nos. |

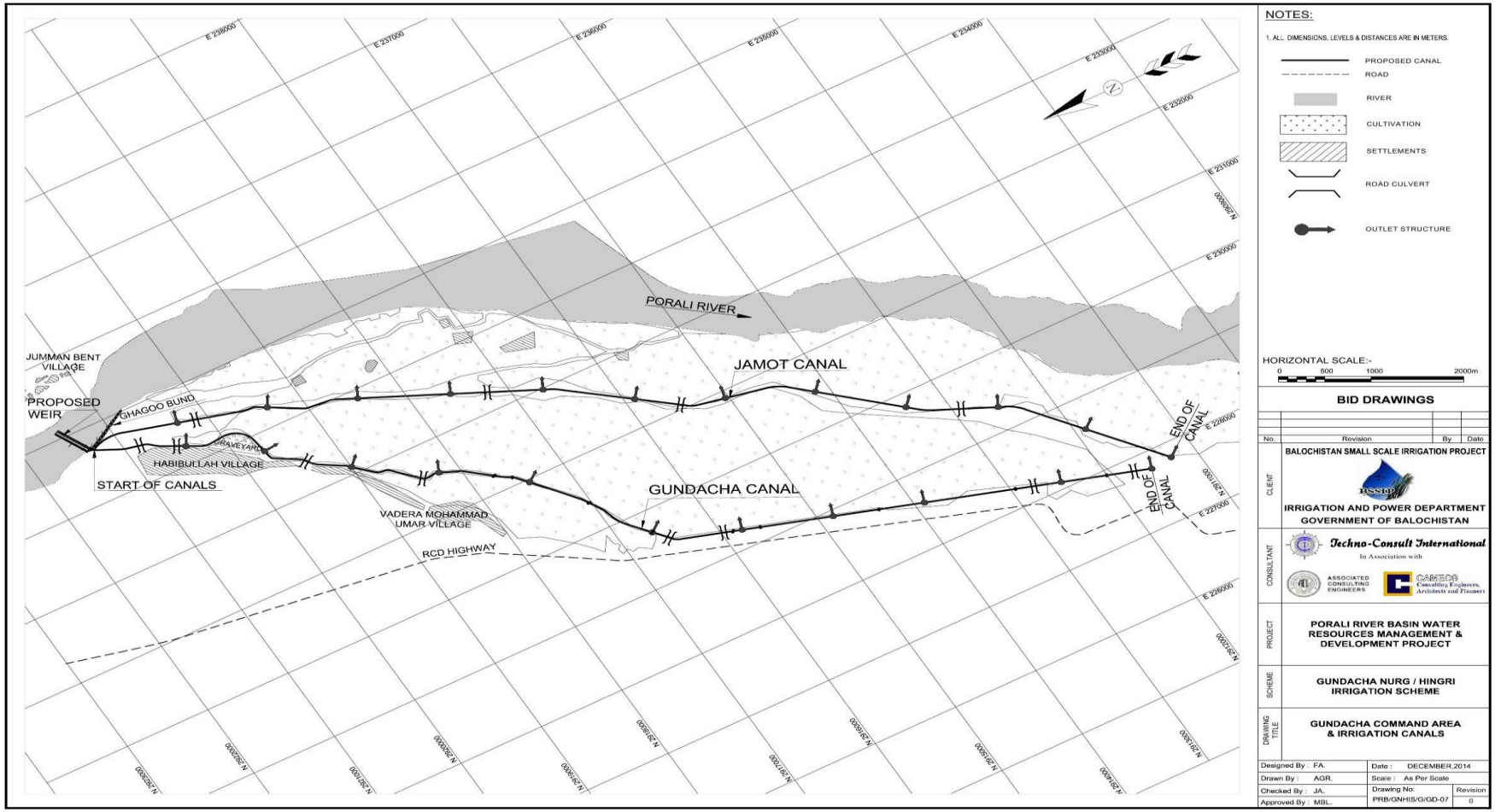



**Figure 5.1: Map showing Command Area and Irrigation Canals of Gundacha**

# Chapter - 6
# PROJECT CONSTRUCTION PLANNING

## 6.1 GENERAL

The Gundacha – Nurg/Hingri project consists of following works:

***Gundacha***

(i) Main weir, 1.5 m high from river bed and 410 m wide

(ii) 8 m wide Under Sluice with stop log grooves

(iii) 3 m wide Head Regulator leading into Outlet Irrigation Channel

(iv) Guide Bunds

Irrigation Canal is 24 km long with around 40 structures.

***Nurg-Hingri***

(i) Weir off-take 66 & 44 m wide

(ii) Under Sluice 2.5 m wide

(iii) Main weir upgrading works

(iv) Flood channels dressing

(v) Guide Bunds

It is estimated that the above construction work can be completed within 30 months from its start on 1$^{st}$ month of the commencement year.

## 6.2 CHARACTERISTICS OF CONSTRUCTION SITE

The site is conveniently located from construction point of view as the required construction materials are available in the vicinity and the main highways provide access to them. There is substantial perennial base flow in the river bed. Ground water therefore can be tapped by excavating shallow pits or through pumping at the Weir site. Electric power can be made available from Bela about 30 km from weir site. Alternatively temporary generator system may be established during construction stage. Unskilled labour is available from nearby villages, while skilled labour can be hired from Bela Town.

## 6.3 ACCESS

There exists a fair weather shingle/dirt road up to the weir site from RCD Highway. The road needs improvement as a whole especially at river / nallah crossings. It is desirable that the road be converted into an asphalted road so that this can be used as a permanent access road for operation and maintenance of weir and related works.

## 6.4 CONSTRUCTION CAMP AND FACILITIES

For construction of weir and appurtenant works construction, camps and temporary production facilities base can be located in the vicinity of the weir site for stone quarries etc. Major works on the project will be carried out from right flank. Concrete processing plants can be located either on right bank or on some high ground on upstream or downstream of weir.

For construction of Canal and Nurg/Hingri works, same camp and facilities can best be used. However moveable field offices can be shifted from place to place during progress of work.

## 6.5 AVAILABILITY OF CONSTRUCTION MATERIALS / EQUIPMENT

For construction of weir and appurtenant works under construction, materials such as fine and coarse aggregates are available in the near vicinity of the weir site. Stone crushing and processing plant will however be required to be installed at the site for producing concrete aggregate. River bed material may also be used as aggregate in making concrete but would require processing to achieve proper gradation.

Water required for construction can be obtained from the river or by abstraction through wells. Groundwater has to be checked for SAR and necessary cement should be used accordingly.

Cement is supposed to be procured from, Karachi. Most of the other construction supplies such as fuel, steel and lubricants can also be arranged from Karachi.

Construction materials such as rolled steel members, ordinary metal structures, timber, lumber, pumps and transmission line instruments, insulation material, instruments to be installed in the weir body need to be brought from Karachi. Heavy construction equipment and machinery including tower cranes and concrete batching plants may be available in Karachi on rental basis or otherwise have to be imported from western countries or Japan.

## 6.6 PARTICIPATION OF LOCAL CONTRACTORS

There are a few local contractors in Balochistan who have experience of working on large highway projects, small dams and buildings and housing schemes. These construction firms possess construction equipment manufactured by Japan, Italy and USA and can come forward and participate the construction of works in this project.

These construction firms may form joint ventures to overcome their deficiencies such as lack of experience in construction of big concrete work across river, concrete structures, foundation preparation including grouting, handling river diversion etc.

## 6.7 MAJOR QUANTITIES OF WORK

Quantities of various items of works involved in the construction of this package have been worked out from drawings based on detailed design of each project component.

## 6.8 CONSTRUCTION SCHEDULE

Works this package involves construction of 410 m long weirs for Gundacha and Nurg-Hingri respectively and nearly 2 m high concrete weir. 8.0 m wide under sluice, 2 m wide head regulator and 2,400 m long Irrigation canal system with structures at Gundacha.

In addition, 2 off-takes weirs, 66 & 44 m wide for Nurg-Hingri respectively and under sluice 8 m wide, including construction of guide banks and armour stone work at Nurg-Hingri.

The Project Works are divided accordingly in the following four main activities.

**Activity – 1:** Pre Construction Activities

(include: land acquisition, review of design and tender documents and award of contract).

**Activity – 2:** Preparatory Works

(include improvement of existing access road to weir site, construction of offices, material testing laboratory, mobilization of construction equipment etc).

**Activity – 3:** Construction of weir and appurtenant works. (include construction of diversion channel, cofferdams, grouting, foundation excavations and instrumentation

**Activity – 4:** Irrigation Canal System including main canal and crossing structures.

## 6.9 CONSTRUCTION OF WEIR AND APPURTENANT WORKS

### 6.9.1 General

The meteorological and river flow data show that the best suited period for construction is from September to end of April next year. During this period river flows are low and interruptions in the construction activities due to rain will be less frequent. Construction work may however continue with some interruptions in May to August each year. Values of monthly rainfall based on recorded data at Bela is shown in Table 3.1 while Table 3.3 shows river flows (average monthly values) based on estimated flows of Porali river at the proposed weir site. In formulating the

construction schedule it has been assumed that the contract will be awarded by the beginning of the Construction Phase.

Main factors which affect the construction programme are planning for material utilization and the proposed scheme for diverting river flows during construction. In view of the work load involved the construction of the weir and related works have been proposed to be completed in a period of 26 months (beyond preconstruction and preparatory works). The river flows are proposed to be diverted through a diversion channel which is aligned through left flank of the river.

In order to achieve economical construction, material obtained from the required excavation of diversion channel, weir and under sluice will be used in constructing the diversion channel, main weir, under-sluices and other structures.

### 6.9.2 Proposed Construction Schedule

The proposed construction schedule shown at the end of the report provides for construction of under sluice, head regulator and main weir to proceed simultaneously so as to achieve coordinated progress permitting direct placement of excavated material from the under sluice, head regulator and main weir to avoid double handling as far as possible. The construction activities shown in the construction programme are as described below.

**(i) Pre-Construction Phase**

It is important that all works under preconstruction activities including review and approval of design, land acquisition Tendering process are completed prior to the award of contract package. The period for pre-construction activities will extend over the first 3 months of the commencement year.

**(ii) Construction Phase**

**(a) Preparatory Works**

The construction phase will start as soon as the contract is awarded. It is important that all works discussed under preparatory activities including improvement works for the existing access road are completed prior to the award of contract for the construction of the weir and related works.

Mobilization for this project will include the logistics of assembling all the necessary plant and construction equipment, providing housing facilities with water sanitary and power utilities, training and organizing the work forces and getting the construction work underway.

**(b) Diversion Channel and Coffer Dams**

The work on excavation and lining of diversion channel (where needed) will be taken up just before the start of main flood period. It is expected that the channel will be excavated by the mid of 3$^{rd}$ month of the commencement of the Construction Phase. Work on the construction of upstream and downstream coffer

dams will be completed in 2 months. The river flows will now be diverted through the temporary diversion channel thus making the main two third of weir area ready for taking up the construction.

The work involving Under Sluice and Head Regulator will be commenced after the Diversion works are completed.

**(c) Under Sluice**

Site clearance and bulk excavation in the under sluice area shall be completed in nearly 2 months. Foundation excavation for the weir structure, basin will be taken up after the bulk excavation and will be completed within 1 month.

Foundation grouting and laying of foundation drainage along the weir, will also be undertaken simultaneously. Placement of stone apron and Precast CC Blocks will be carried out in 1 month. Concreting of Approach Slab, Cut-off walls and Stilling Basin will be completed in 1 month time.

**(d) Head Regulator**

The work on the head regulator will be started simultaneously with under sluice. The location of both Head Regulator and Under Sluice are attached with each other near right bank. It is needed therefore that both of these will complete together so that in case of any unusual flow in the river some water can be passed through it without much damage.

**(e) Main Weir**

The work on major construction activity of main weir will be completed in 10 months. During the construction of under sluice and head regulator, 65% work of Main Weir will be completed, while the river flows will continue to pass through the diversion channel. After the construction of two-third of the main weir, river flow will be diverted towards under sluice and then the work on remaining portion of weir will be commenced.

**(f) Irrigation Canals**

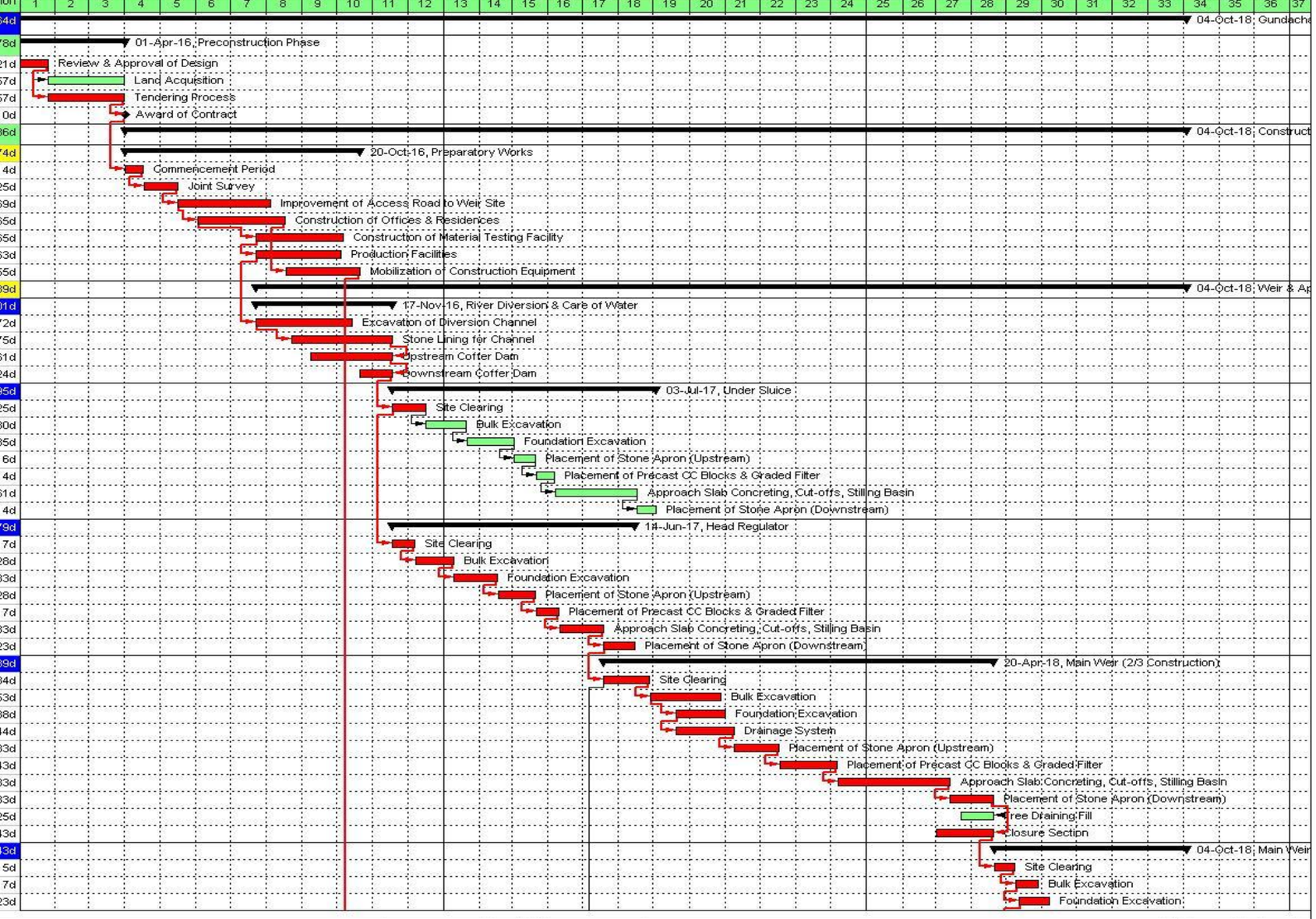
Works proposed for construction of the irrigation system may be awarded to the contractor(s) under a separate contract package(s). With a view to beneficially use storage provided at Porali weir it is important that the proposed irrigation works are also completed along with the construction of weir. These works can be completed in a period of around 6 months.

The proposed construction schedule for Gundacha and Nurg-Hingri Irrigation scheme is attached at the end of the report.

GUNDACHA-NURG / HINGRI IS

PROPOSED CONSTRUCTION SCHEDULE

| Activity ID | Activity Name | Original Duration |
|---|---|---|
| **Gundacha** | | 864d |
| **Preconstruction Phase** | | 78d |
| 10 | Review & Approval of Design | 21d |
| 20 | Land Acquisition | 57d |
| 30 | Tendering Process | 57d |
| 40 | Award of Contract | 0d |
| **Construction Phase** | | 786d |
| **Preparatory Works** | | 174d |
| 42 | Commencement Period | 14d |
| 45 | Joint Survey | 25d |
| 50 | Improvement of Access Road to Weir Site | 69d |
| 60 | Construction of Offices & Residences | 65d |
| 70 | Construction of Material Testing Facility | 65d |
| 80 | Production Facilities | 63d |
| 90 | Mobilization of Construction Equipment | 55d |
| **Weir & Appurtenant Works** | | 689d |
| **River Diversion & Care of Water** | | 101d |
| 100 | Excavation of Diversion Channel | 72d |
| 110 | Stone Lining for Channel | 75d |
| 120 | Upstream Coffer Dam | 61d |
| 130 | Downstream Coffer Dam | 24d |
| **Under Sluice** | | 195d |
| 140 | Site Clearing | 25d |
| 150 | Bulk Excavation | 30d |
| 160 | Foundation Excavation | 35d |
| 170 | Placement of Stone Apron (Upstream) | 16d |
| 180 | Placement of Precast CC Blocks & Graded Filter | 14d |
| 190 | Approach Slab Concreting, Cut-offs, Stilling Ba... | 61d |
| 200 | Placement of Stone Apron (Downstream) | 14d |
| **Head Regulator** | | 179d |
| 210 | Site Clearing | 17d |
| 220 | Bulk Excavation | 28d |
| 230 | Foundation Excavation | 33d |
| 240 | Placement of Stone Apron (Upstream) | 28d |
| 250 | Placement of Precast CC Blocks & Graded Filter | 17d |
| 260 | Approach Slab Concreting, Cut-offs, Stilling Ba... | 33d |
| 270 | Placement of Stone Apron (Downstream) | 23d |
| **Main Weir (2/3 Construction)** | | 289d |
| 280 | Site Clearing | 34d |
| 290 | Bulk Excavation | 53d |
| 300 | Foundation Excavation | 38d |
| 310 | Drainage System | 44d |
| 320 | Placement of Stone Apron (Upstream) | 33d |
| 330 | Placement of Precast CC Blocks & Graded Filter | 43d |
| 340 | Approach Slab Concreting, Cut-offs, Stilling Ba... | 83d |
| 350 | Placement of Stone Apron (Downstream) | 33d |
| 360 | Free Draining Fill | 25d |
| 370 | Closure Section | 43d |
| **Main Weir (1/3 Construction)** | | 143d |
| 380 | Site Clearing | 15d |
| 390 | Bulk Excavation | 17d |
| 400 | Foundation Excavation | 23d |




Actual Work | Critical Remaining Work | Summary
Remaining Work | Milestone

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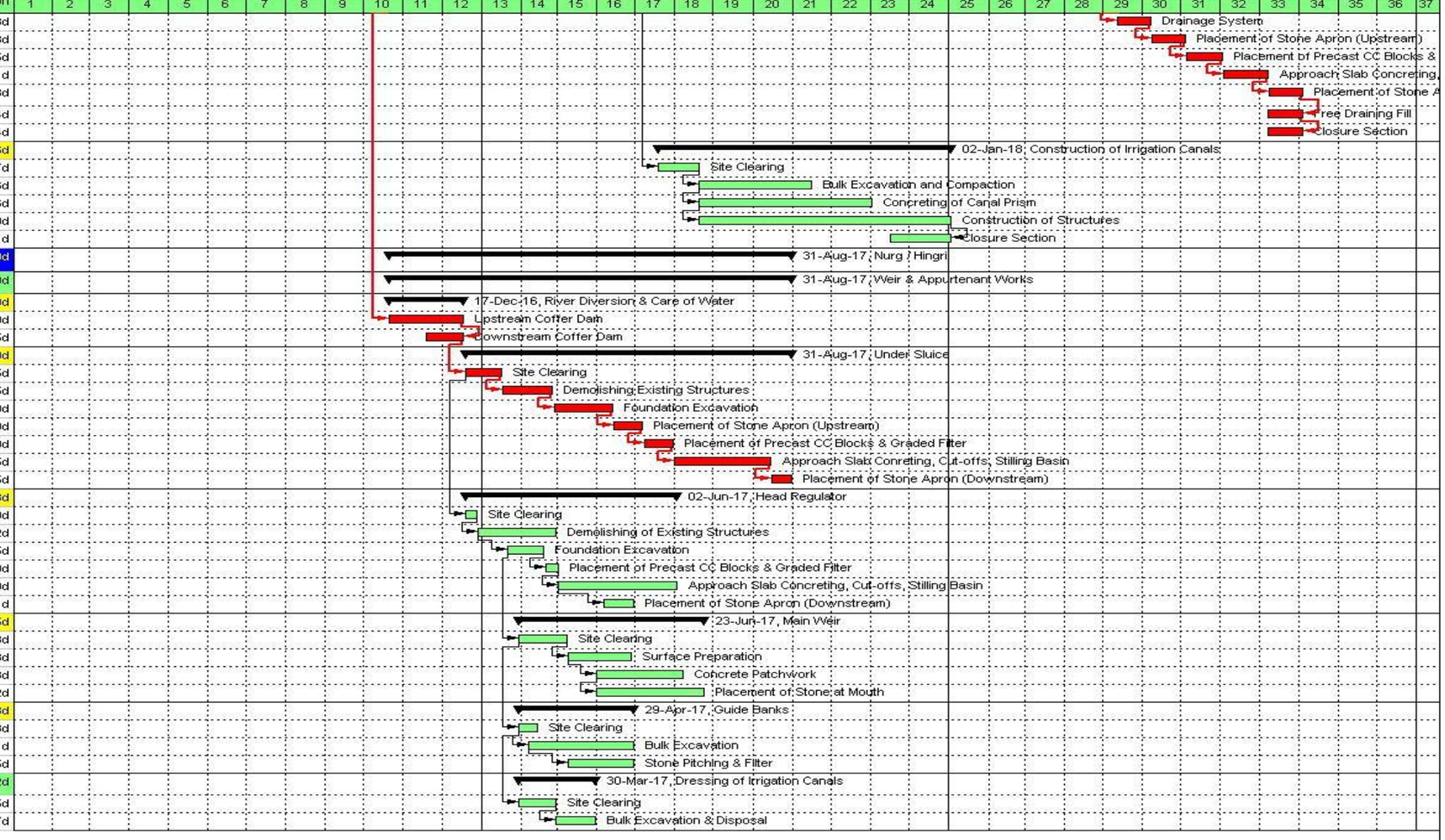
GUNDACHA-NURG / HINGRI IS

PROPOSED CONSTRUCTION SCHEDULE

| Activity ID | Activity Name | Original Duration |
|---|---|---|
| 410 | Drainage System | 23d |
| 420 | Placement of Stone Apron (Upstream) | 23d |
| 430 | Placement of Precast CC Blocks & Graded Filter | 25d |
| 440 | Approach Slab Concreting, Cut-offs, Stilling Ba... | 31d |
| 450 | Placement of Stone Apron (Downstream) | 23d |
| 460 | Free Draining Fill | 24d |
| 470 | Closure Section | 24d |
| **Construction of Irrigation Canals** | | 196d |
| 480 | Site Clearing | 27d |
| 490 | Bulk Excavation and Compaction | 76d |
| 500 | Concreting of Canal Prism | 116d |
| 510 | Construction of Structures | 169d |
| 520 | Closure Section | 41d |
| **Nurg / Hingri** | | 270d |
| **Weir & Appurtenant Works** | | 270d |
| **River Diversion & Care of Water** | | 50d |
| 530 | Upstream Coffer Dam | 50d |
| 540 | Downstream Coffer Dam | 25d |
| **Under Sluice** | | 220d |
| 550 | Site Clearing | 25d |
| 560 | Demolishing Existing Structures | 35d |
| 570 | Foundation Excavation | 40d |
| 580 | Placement of Stone Apron (Upstream) | 20d |
| 590 | Placement of Precast CC Blocks & Graded Filter | 20d |
| 600 | Approach Slab Conreting, Cut-offs, Stilling Basin | 65d |
| 610 | Placement of Stone Apron (Downstream) | 15d |
| **Head Regulator** | | 143d |
| 620 | Site Clearing | 9d |
| 630 | Demolishing of Existing Structures | 52d |
| 640 | Foundation Excavation | 25d |
| 650 | Placement of Precast CC Blocks & Graded Filter | 9d |
| 660 | Approach Slab Concreting, Cut-offs, Stilling Ba... | 80d |
| 670 | Placement of Stone Apron (Downstream) | 21d |
| **Main Weir** | | 125d |
| 680 | Site Clearing | 33d |
| 690 | Surface Preparation | 43d |
| 700 | Concrete Patchwork | 58d |
| 710 | Placement of Stone at Mouth | 72d |
| **Guide Banks** | | 78d |
| 720 | Site Clearing | 13d |
| 730 | Bulk Excavation | 71d |
| 740 | Stone Pitching & Filter | 45d |
| **Dressing of Irrigation Canals** | | 52d |
| 750 | Site Clearing | 25d |
| 760 | Bulk Excavation & Disposal | 27d |




Actual Work | Critical Remaining Work | Summary
Remaining Work | Milestone

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