CHAPTER 15

DISASTER MANAGEMENT PLAN

15.1 DAM BREAK ANALYSIS

The study of catastrophic flooding that may occur in the event of a dam failure is of great concern and importance because of the risk of life and property in the potentially inundated reaches downstream of the structure. Some of the recent disasters have focused attention on the requirement of conducting needful analysis of such cases, however remoter they may be, in order to assess probable damage and also to plan necessary measures for mitigating the losses. The studies will have to identify the inundated area, flood depth, flow velocity and travel time of the flood waves. In fact the evaluation or determination of the submersion wave of dam break due to extreme flood events is an initiative needed for defining the risk of submergence of areas located downstream of the existing dams and consequently to prepare protective measures, both active (reservoirs, dikes) and passive (emergency and evaluation plans) in the areas affected.

Floods due to failure of dams induce widespread damage to life and property due to its high magnitude and unpredictable sudden occurrence. Such flood is required to be simulated to determine the inundated area, flood depth, and travel time of the flood waves so that adequate safety measures can be provided. The review of the past works reveals that dam break problem remains a topic of continued interest since Ritter (1892) attempted its first analytical solution for a horizontal frictionless rectangular channel. Investigations are still going on (i) to evaluate performance of different forms of Governing Equations, (ii) for developing analytical solution of these equations for different situations and (iii) for developing better and suitable numerical schemes for addressing complexities of natural rivers. Over the years different investigators have developed both one dimensional (Hicks F.E. et al (1997), Sanders B. F.(2001), Macchione F, Viggiani G. (2004)) and two dimensional models (Katopodes N.D. (1984), Hromadka (1985) Akanbi, A. A. et al (1988), Zhao D.H. et al (1996), Sarma, A.K. (1999) Zoppou .C. and

Roberts S. (2000)) using both conservative and non-conservative form of governing equations for simulating dam break flood. Although computation of dam break flood has been a topic of interest for more than hundred years, numerical simulation of dam break flow in relatively simple channels is found more often compared to real river flood simulation. Natural channels with steep slopes and wide flood plains offer numerous complexities and make the computation very challenging. These channels are highly non-prismatic in nature with significant variations in bed width, bed slope and roughness characteristics. Selection of proper and suitable governing equations and use of efficient numerical scheme are some of the important issues of model development for simulating dam break flood.

Many commercial types of software developed for dam break analysis use implicit scheme, which though advantageous from stability point of view may lead to erroneous result if time step and space discretization are not done properly. Experiences has shown that Explicit Finite Difference schemes with conservative formulation of the Governing equation give reliable solution for dam break analysis for complex natural channel like that of Dibang (Sarma and Das, 2006). This being a case of disaster mitigation of an area resided by a large number of people, it was decided to carryout the analysis by three different FD schemes, namely, first order Diffusive, second order Modified Two-step Predictor Corrector, and TVD MacCormack Predictor Corrector using Van Leer Flux limiter, to have more confidence on the computed results. Validity and applicability of the numerical models in different flow conditions, i.e., subcritical, supercritical and mixed flow condition, are assessed by comparing the computed flow profiles with experimental data of Das (1978), Barr and Das (1980), Bellos (1990), and Bellos et al (1992) in terms of water depth. A hypothetical situation of instantaneous failure of the proposed dam on the river Dibang has been considered to simulate the worst possible scenario. The reservoir extends approximately up to 40,000 m upstream of the dam and the channel meets the river Brahmaputra 64,000 m downstream of the dam. The elevation of the channel bed changes from 545 m to 127 m. Change in the channel width ranges from 300 m to 5650 m and Manning's roughness coefficient at different sections are taken as 0.03, 0.032, and 0.035 based on the channel and floodplain characteristic of the river.

15.1.1 Governing Equations

To obtain the basic equations of fluids in motion following philosophy are followed:

(i) To choose the appropriate fundamental physical principles i.e., conservation of mass, momentum and energy.

(ii) To apply these physical principles to suitably model the flow

(iii) To deduce the mathematical equations to represent the flow considered. If a solid body is in translational motion, the velocity of each part of the body is same, but if the fluid is in motion, the velocity may be different at each location within the fluid. Hence to represent a moving fluid and to apply the fundamental physical principles one of the following models is used.

(i) ***Non-conservative form***

When the governing equations i.e. the continuity and momentum equations for the unsteady flow are deduced considering the fluid element which is moving along with the fluid such that same fluid particles are always inside it, the formulation is known as non-conservative form.

(ii) ***Conservative form***:

In conservative formulation the mathematical model is represented considering the fluid element fixed in space with fluid moving through it.

The movement of the wave in the dam-failure situation is governed by gradually varied unsteady flow equation in open channel, i.e., the Saint-Venant (1871) equations.

This can be written in non-conservative form as follows:

$$\frac{\partial A}{\partial x} + A\frac{\partial V}{\partial x} + \frac{\partial A}{\partial t} = 0 \quad \text{(1)}$$

$$\frac{g}{b_m}\frac{\partial A}{\partial x} + V\frac{\partial V}{\partial x} + \frac{\partial V}{\partial t} = g(S_b - S_f) \quad \text{.......} (2)$$

And in conservative form as follows:

$$\frac{\partial U}{\partial t} + \frac{\partial F(U)}{\partial x} = S(U) \quad \text{.......}(3)$$

Where:

$$U = \begin{Bmatrix} A \\ Q \end{Bmatrix} \quad \text{.......} (4)$$

$$F(U) = \begin{Bmatrix} Q \\ \frac{Q^2}{A} + gI_1 \end{Bmatrix} \quad \text{.......} (5)$$

$$S(U) = \begin{Bmatrix} 0 \\ gA(S_0 - S_f) + gI_2 \end{Bmatrix} \quad \text{.......}$$

(6)

x = direction parallel to the river, *t* = time, A= cross-sectional flow area, Q = discharge, V = Depth averaged flow velocity, b_m = mean cross sectional width, g = acceleration due to gravity, S_0 = bed slope, and S_f = friction slope.

$$I_1 = \int_0^{h(x)} [h(x) - \eta] b(x, \eta) d\eta \quad \text{.......}$$

(7)

$$I_2 = \int_0^{h(x)} [h(x) - \eta] \left[\frac{\partial b}{\partial x}\right]_{h=h_o} d\eta \quad \text{.......} (8)$$

I_1, I_2 = cross-sectional moment integrals; η = integration variable representing the vertical distance to the bottom of the section; b = cross-sectional width at height η; h = water depth above the bottom.

NUMERICAL SCHEMES

Numerical schemes have been developed with conservative form only as conservative formulation gives reliable result for non-prismatic channel like that of Dibang

First order Diffusive Scheme

When diffusive scheme is applied to (3), the following equation is obtained (Chunge et al, 1980):

$$U_i^{n+1} = \alpha U_i^n + (1-\alpha)\frac{U_{i+1}^n + U_{i-1}^n}{2} - \frac{\tau}{2}(F_{i+2}^n - F_{i-1}^n) + \Delta t S_i^n \quad \text{.................................... (9)}$$

$0 \leq \alpha \leq 1$

Where,

$$\tau = \frac{\Delta t}{\Delta x} \quad \text{..}$$

(10)

Macchione et al (2003) found in their numerical investigation that diffusive scheme gives increasingly accurate results as the value of coefficient α increases. For α = 0.75, the results are only slightly less accurate than those obtained through Roe's First-Order Upwind Scheme. Hence α = 0.75 have been considered here

Second order two Step schemes

In this study, following two-step second order schemes are examined:

1. *Modified Predictor Corrector* i.e., the well-known MacCormak scheme in a slightly modified form, and
2. *Total Variation Diminishing (TVD) MacCormack scheme.*

A number of explicit Second-order two-step schemes exist which have been collected by Lerat and Peyret under the following general structure (Peyret and Taylor 1990) (The well known MacCormack scheme belongs to this same family)

Predictor:

$$\overline{U}_i = (1-\beta)U_i^n + \beta U_{i+1}^n - \theta\tau(F^n{}_{i+1} - F_i) + \Delta t S_i{}^n \text{ ....}$$
(11)

Corrector: $$U_i^{n+1} = U_i^n - \tau(2\theta)^{-1}[(\theta-\beta)F_{i+1}^n + (2\beta-1)F_i^n + (1-\theta-\beta)F_{i-1}^n + (\overline{F_i^n} - \overline{F_{i-1}^n})] + \Delta t\overline{S_i} \text{ ...}$$
(12)

In MacCormack scheme (1969), θ =1, β =0

The Mac Cormack scheme is recommended by different investigators (Garcia et al. (1986), Garcia N. P. *et al* (1992), Fennema, R.J.(1990) et al, Rahman, M. *et al* (1998), and Aureli F. *et al* (2004)) for unsteady gradually varied flow computations.

***Modified Predictor Corrector**:*

The well-known Mac Cormack scheme in a slightly modified form has been used here. The set of governing equations used for modeling purpose has an inherent property of signal propagation i.e., in case of sub-critical flow the information comes both from upstream and downstream, while the information comes only from upstream if the flow is super-critical. Numerical investigations have shown that better results are produced if the direction of differencing in the predictor step is the same as that of the movement of wave front (Choudhury M H 1990).

In the sub-critical region backward F.D. approximation is used for predictor step and forward F.D. approximation is used in the corrector step. In the super-critical region as the control is always on the upstream side, use of forward F.D. approximation in the corrector step is omitted to eliminate erroneous influence of downstream flux on the computed values. This simple technique has made application of the scheme possible in the mixed flow regions also.

When it is applied to (3), the predictor step is given as:

Predictor:

$$UP_{ii} = U_i^n - \tau(F^n{}_i - F_{i-1}^n) + \Delta t S_i{}^n \ldots\ldots(13)$$

Corrector step is applied to each node on the basis of the following conditions:

If $V_i \le \sqrt{gh_i}$, for sub-critical flow

Corrector: $UC_{i_i} = U_i{}^n - \tau[FP_{i+1} - FP_{i,}] - \Delta t(SP_i)$ ………………………….. (14)

If $V_i \ge \sqrt{gh_i}$, Corrector step for super-critical flow is omitted, and thus

$UC_i=UP_i$……………………………………………..

(15)

Finally, the U vector containing value of primitive flow variables in the next time step is calculated as

$$U_i^{n+1} = \frac{UP_i + UC_i}{2} \ldots\ldots (16)$$

TVD MacCormack scheme

Among the Second-order two-step family, TVD MacCormak with Van Leer's Limiter is reported (Macchione *et al* (2003)) to demonstrate excellent behavior. Here the value of $\mathbf{U_{ii}}^{\mathbf{n+1}}$ given by the corrector step (12) is corrected by adding the following TVD term:

$$\tau(T_{i+1/2}^n - T_{i-1/2}^n) \ldots\ldots (17)$$

Where:

$$T_{i+1/2}^n = \sum_{k=1}^{2} D_{i+1/2}^{(k)} \delta w_{i+1/2}^{(k)} r_{i+1/2}^{(k)} \ldots\ldots (18)$$

The term $D^j_{i+1/2}$ which can be considered an artificial dissipation term, has the following expression:

$$D_{i+1/2}^{j} = \frac{1}{2}[(1-\phi)\left|\overline{\lambda}\right|(1-\tau\left|\overline{\lambda}\right|)]_{i+1/2}^{j} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (19)$$

In which ϕ = limiter allowing the TVD condition to be satisfied. The limiter ϕ is calculated as a function of the ratio ρ of the characteristic variations

$$\rho_{i+1/2} = \frac{\delta w_{i+1/2-\mathrm{sgn}(\overline{\lambda_{i+1/2}})}}{\delta w_{i+1/2}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (20)$$

In The present study the Van Leer limiter is considered:

$$\phi(\rho) = \frac{\rho + |\rho|}{1+\rho} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (21)$$

The variations $\delta w_{(1)(2)}$ at the point(i+1/2) are expressed as follows:

$$\delta w_{(1)(2)} = \pm\left[(Q_{i+1} - Q_{i+1}) + \left(-\frac{\overline{Q_{i+1/2}}}{\overline{A_{i+1/2}}} \pm \overline{c_{i+1/2}}\right)(A_{i+1} - A_i)\right] \ldots\ldots\ldots\ldots \quad (22)$$

$\overline{r}^{(j)}$ are the approximate Jacobian matrix eigenvectors. For the construction of such a matrix for the case of system (3) the following averaged variables should be considered for each cell (i,i+1) (Garcıa Navarro[11] et al. 1992):

$$\overline{A_{i+1/2}} = \sqrt{A_i A_{i+1}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (23)$$

$$\overline{Q}_{i+1/2} = \frac{\sqrt{A_i}\,Q_{i+1} + \sqrt{A_{i+1}}\,Q_i}{\sqrt{A_i} + \sqrt{A_{i+1}}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (24)$$

The averaged celerity is computed as follows:

$$\overline{c} = \sqrt{g\frac{I_{1_{i+1}} - I_{1_i}}{A_{i+1} - A_i}} \quad \text{When} \quad A_{i+1} \neq A_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (25)$$

$$\bar{c} = \sqrt{\frac{\frac{1}{2}g(A_{i+1} - A_i)}{\frac{1}{2}(b_{i+1} - b_i)}}$$ When $A_{i+1}=A_i$

or $(I_{1_{i+1}} - I_{1_i})(A_{i+1} - A_i) < 0$ .... (26)

So that the approximate Jacobian matrix is characterized by the following eigen values and eigenvectors:

Eigenvalues:

$$\bar{\lambda}_1 = \frac{\bar{Q}}{\bar{A}} + \bar{c}$$ .... (27a)

$$\bar{\lambda}_2 = \frac{\bar{Q}}{\bar{A}} - \bar{c}$$ .... (27b)

Eigenvectors:

$$\bar{r}^{(1)} = \frac{1}{2\bar{c}}[1, \bar{\lambda}_1]^T$$ .... (28a)

$$\bar{r}^{(2)} = \frac{1}{2\bar{c}}[1, \bar{\lambda}_2]^T$$ .... (28b)

Stability is assured by the Courant–Friedrichs–Lewy condition:

$$C_r = \frac{\max(|v| + c)}{\Delta x/\Delta t} \leq 1$$ .... (29)

Where C_r is the Courant number, v is the velocity, c is celerity = $\sqrt{gh}$ and $\max(|v| + c)$ stands for the maximum value over the whole range of grid points

15.2 SALIENT FEATURES

The salient features of the dam are as given below:

Location

Country: India

State: Arunachal Pradesh

District: Lower Dibang Valley District

Dam Site: Latitude: 28°20'07" N and Longitude: 95°46'38" E

Hydrology

Catchment area: 11276 km^2

Location of Catchment:

Latitude: 28°11’50” N to 29°25’59” N

Longitude: 95°14’47” E to 96°36’49” E

Average annual rainfall: 4405 mm

Reservoir

Maximum water level: EL 548 m

Full reservoir level: EL 545 m

Length of reservoir: 43 km

15.3 REQUIREMENT OF FIELD DATA

The basic field data required for the flow analysis are:

(i) Terrain profile – for the bed elevation and channel breadth,

(ii) Topographic characteristic of the downstream area – for using appropriate value of resistance parameter,

(iii) Height of the Dam.

15.3.1 Field Survey

Reconnaissance of the entire area was carried out by both aerial and ground survey during 10th to 12th of January 2006. The survey was carried out basically to have an understating of the terrain to determine roughness characteristic of different river reaches and to suggest the appropriate methodology for collecting Bathymetry data. GERMIN Global Positioning System (GPS) was used for collecting the location information of various points in World Geodetic System, 1984 (WGS84).

15.3.2 Topographic Characteristics

The topographic characteristic varies significantly within the computation domain. Figure 15.1 shows the different terrain condition through which the river Dibang passes during its course from hills of Arunachal to the plains of Assam. The river passes through deep gorges, terrains with pebbles and boulders and then through alluvial plains. Most of the portion on downstream of the dam lies in the plains. While it was possible to rely on the satellite based DEM data (Developed from Stereo pair) for elevation value of the hilly portion lying upstream side of the dam, it was not advisable to use elevation data derived from the stereo pair for the plain area. As such the concerned organization was requested to conduct cross-sectional survey using TOTAL STATION to acquire the required elevation data.

Fig. 15.1: Different terrain condition

15.3.3 Channel Roughness

Choosing a correct roughness coefficient is quite important in unsteady flow simulation in a natural channel. Standard values of Manning's roughness coefficient "n" for natural streams has been given by Chow, V.T. ( ) and Choudhary H.M.( ) as given below.

(i) As complied from Chow

Type of the channel	"n" value
Clean and Straight	0.030
Bottom gravels, cobbles and boulders	0.040
Bottom cobbles with large boulders	0.050

(ii) As given by Chaudhry MH. (1993) "Open-channel flow". Prentice-Hall. India Pvt.Ltd. M-97, New-Delhi.

Type of Channel bottom	Left bank	Right bank	"n" value
Slime covered cobble and gravel	Cemented cobbles	Cobble set in gravel	0.024
Sand and clay	Smooth and free vegetation	Smooth and free vegetation	0.030
Smooth Cobble"d_{10}=0.15m"	Smooth Cobble"d_{10}=0.15m"	Smooth Cobble"d_{10}=0.15m"	0.032
Gravel and boulders"d_{10}=1.72m"	Overhanging bushes	Trees	0.036
Boulders"d_{10}=1.4m"	Gravel, boulders and trees	Gravel, boulders and trees	0.041
Angular Boulders"d_{10}=0.70m"	Angular Boulders"d_{10}=0.70m"	Angular Boulders"d_{10}=0.70m"	0.050
Boulders"d_{10}=2.10m"	Boulders"d_{10}=2.10m"	Boulders"d_{10}=2.10m"	0.060
Fine sand	Sand, silt with heavy growth of trees	Sand, silt with heavy growth of trees	0.070
Boulders"d_{10}=2.20m"	Boulders, bushes, trees	Boulders, bushes, trees	0.075

Based on these tables, it has been found that value ranging from 0.03 to 0.035 can be considered for different reaches of the entire channel under consideration.

15.3.4 Numerical Applications

Numerical models formulated have been applied in the natural river Dibang. Performances of these models under different flow conditions have been tested against laboratory data to ensure their validity and applicability.

Application in Dibang River

The numerical application analyzed here concerns the instantaneous and total removal of a large dam placed across the non-prismatic channel of river Dibang. The expected flood due to the failure of the proposed dam has been analyzed.

Input data

Initially the cross section data of Dibang River obtained earlier from NPC was used to compute the flow profile. Variation of channel width along the channel reach is presented in the figure 15.2. Longitudinal profile of the channel bed along with the computed flow profiles is presented in the figure 15.3. The input data in the programme is given in the form of regularly spaced grids. To accomplish it, the actual data acquired at convenient chainage points on the riverbed is linearly interpolated. The total channel reach is represented with a total no of 1000 grid points.

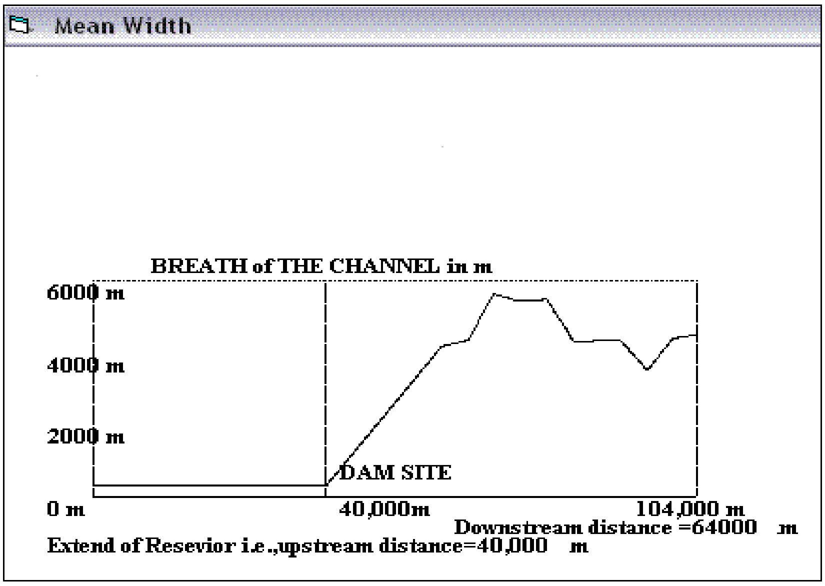


Fig. 15.2: Graph showing variation of channel width along the channel reach

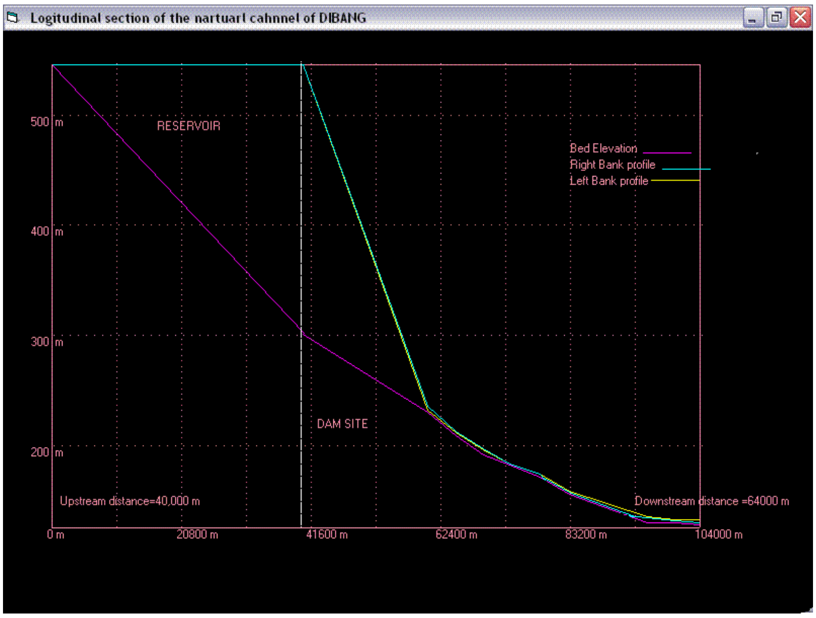


Fig. 15.3: Channel bed and computed flow profiles

Initial and Boundary Conditions

In this problem, the upstream boundary coincides with the upstream extremity of the reservoir at 40,000m and the downstream one with its confluence with River Brahmaputra, at 64,000m from the dam site. At upstream of the dam the initial profile has been considered as the surface of the still water stored in the reservoir at maximum storage level. For computational advantage, a water depth of 0·1 m is assumed in the dry downstream portion. To start the numerical computation an initial profile computed by Ritter's equation after elapse of 1 sec, since failure of the dam, has been introduced. Boundary values are obtained with the help of method of characteristics.

Analysis of the results

The numerical simulations with the above-mentioned explicit FD schemes are done for the conservative formulations of unsteady flow. Figure 15.3 illustrates that the conservative formulation of all the FD methods taken here, results excellent flow profiles. Form practical point of view considering factors such as wave propagation time, depth of flow; and peak arrival time, simulated flood profiles by these FD schemes are quite comparable to one another.

Figure 15.4 represents the plot of flow variables up to 200 second since dam failure at three different cross-sections; one at dam site, one 2496 m upstream of the dam and another 2706 m downstream the dam. It is clear from this plot that the changes in discharge and velocity with respect to spatial distance and time are quite less compared to the flow area. The shapes of the flow area hydrographs at the three different sections are observed to be completely contrasting. At upstream the flow area decreases with time with a reducing rate while at downstream it increases gradually with time. At dam site first it rises sharply with time and then falls down gradullly to a more or less constant value. But in case of discharge and velocity hydrographs, similar pattern is maintained in all the three sections. Therefore numerical models with non-conservative formulation, where the variation of cross sectional area with space is computed separately, becomes unstable for dam break flow in such non-prismatic natural channel, as error associated with the calculation of area gets compounded with time. It shows that, as rightly used in this project, the numerical formulations of such flow problem should be in conservative form.

It has been reported (Choudhury M. H.1990, Jin et al 1997) that applicability of the numerical schemes are difficult when sub critical and super critical flows are present either simultaneously in different parts of the channel or if they occur in the same section in sequence at different times. Models developed in this study using conservative form have exhibited their capability of handling mixed flow region. Figure 15.4 illustrates the flow conditions in the entire flow domain considered in this study. Here mixed flow condition has been observed, where sub critical flow changes to high supercritical, with a moving sub/super critical interface. This of course is obviously an expected case for a real large dam break case. The Diffusive scheme which is simplest among FD schemes; also provides excellent results even in complex flow situations when it is formulated in conservative form with small spatial grid points to maintain the high non prismatic nature of the complex real river channel.

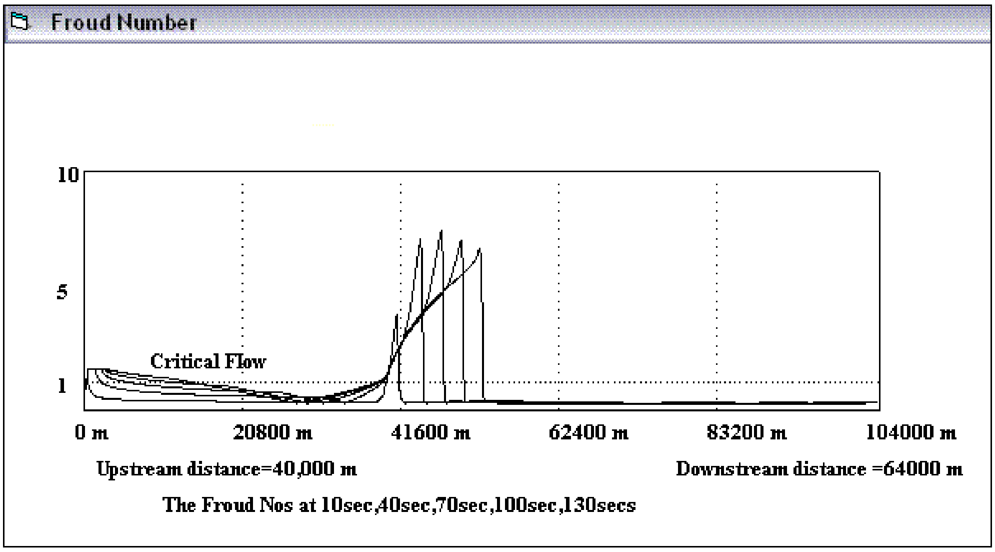


Fig. 15.4: Flow conditions at different time, i, e., Froud number of the flow

Implementation effort

The flood in the real cases has to be simulated for a quite long period of time over river stretches of several kilometers long for proper flood management. Therefore, the runtime of the numerical formulation is one of the most important parameters to be considered. Among the above three FD method the diffusion scheme is the easiest to implement and most advantageous even from runtime point of view. The modified predictor corrector takes 146% that of diffusive scheme runtime. The runtime in case of TVD MacCormack is 380% of the diffusive scheme, as TVD correction requires calculation of Jacobian matrix. But there is no significant difference among the flow depths and time of wave propagations when schemes are formulated in conservative form.

15.3.5 Need of Considering Extended Width

The flood depth computed by considering the limited width of the cross sectional area has shown that the channel will not be sufficient to contain the flow within that limit. Thus the depth computed by these data cannot be considered logical, as flow will spread beyond this limit. Therefore, the concern organization was requested to collect terrain data beyond this limit up to the required distance as assessed from the first study. On receiving these data it has been found that the terrain can be approximated as a parabolic channel. The channel width thus obtained is presented in the figure 15.5. The main channel of Dibang is also shown in this figure. In fact several channels are there in the entire width shown in the plan view. In case of dam failure flood as the depth will be quite high all these channel will merge and will flow as a single channel covering the required width to carry the flow volume. Using the FD Diffusive scheme in conservative form the flow was computed keeping other boundary conditions same as before. The flow depth computed by this procedure has been found to be quite logical and accepted for the computing submerged area due to instantaneous failure of the dam.

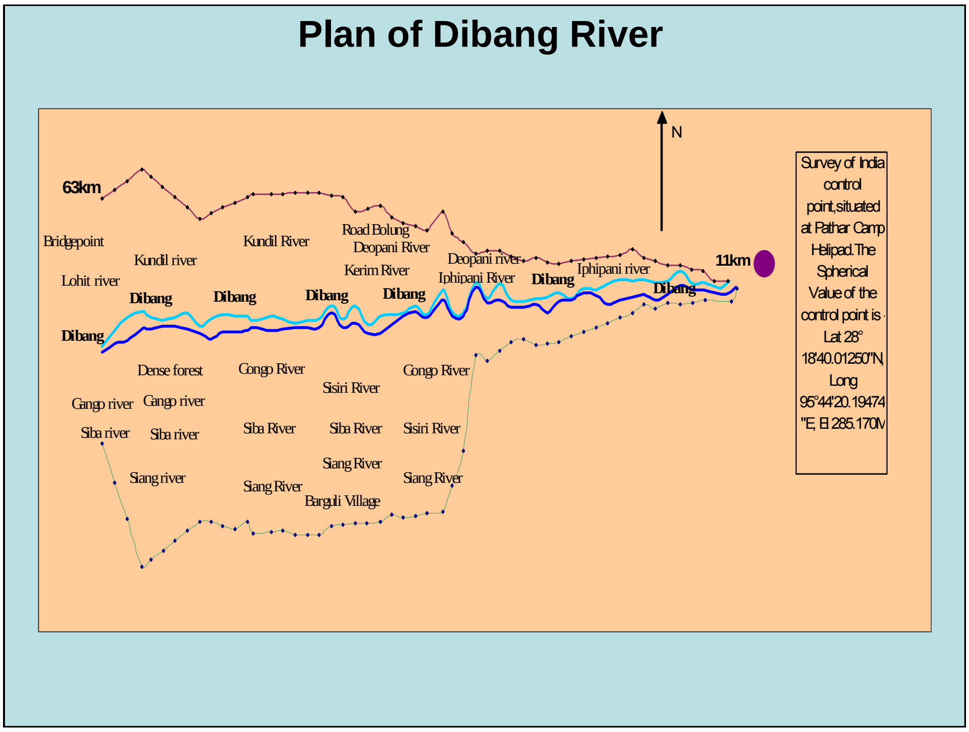


Fig. 15.5: Plan of Dibang River

The channel sections for the entire width presented in the fig 15.5 have been approximated as parabolic channel for the purpose of computing dam break flow passing over the terrain. Figure 15.6 shows the way of representing the cross section for computation purpose. Figure 15.7a 15.7b & 15.7c, show the computed flow depth considering the parabolic channel representing the entire cross-section. Figure 15.8 shows the difference in flow depth computed by the (i) concept of rectangular channel of limited width and (ii) concept of parabolic channel of entire cross section. From the comparison it is clear that the flow depth computed by considering the parabolic channel is realistic as the depth drops with the expansion of the channel, which is logical. However, for making disaster management plan we suggest to increase the depth by 10% than that computed by the parabolic section, as the channel section has been approximated. Figure 15.9 represent the peak arrival time, which is quite vital for mitigation measures. Figure 15.10 shows the maximum flow velocity, which is helpful for assessing the extent of intensity of damage to the existing structures. **Figure 15.11a & 15.11b show the submerged area without considering the additional 10% depth. In fig 15.11c the graph showing maximum probable depths at different distance from dam axis at downstream (d/s) is presented.**

Assumed Channel section for computations at 29 km downstream the dam considering the whole terrain

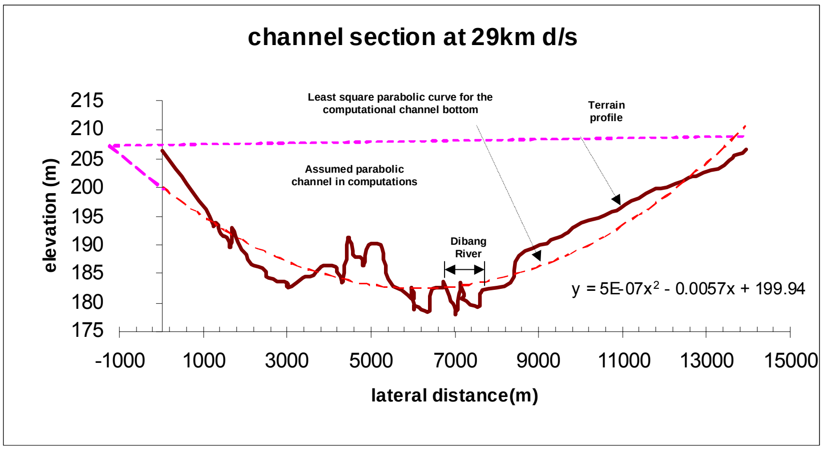


Fig. 15.6: Approximated channel section

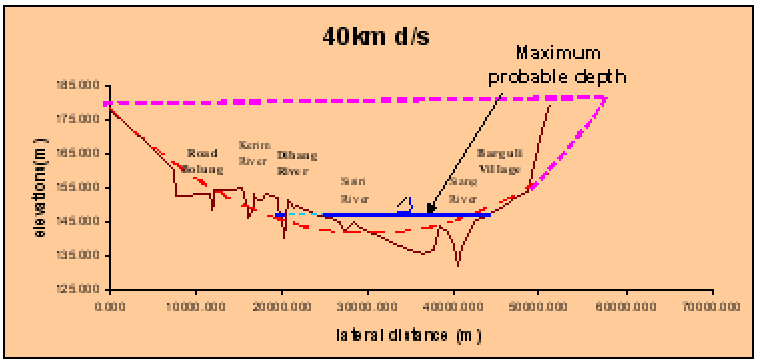


Fig. 15.7a: Flow at 40 km d/s

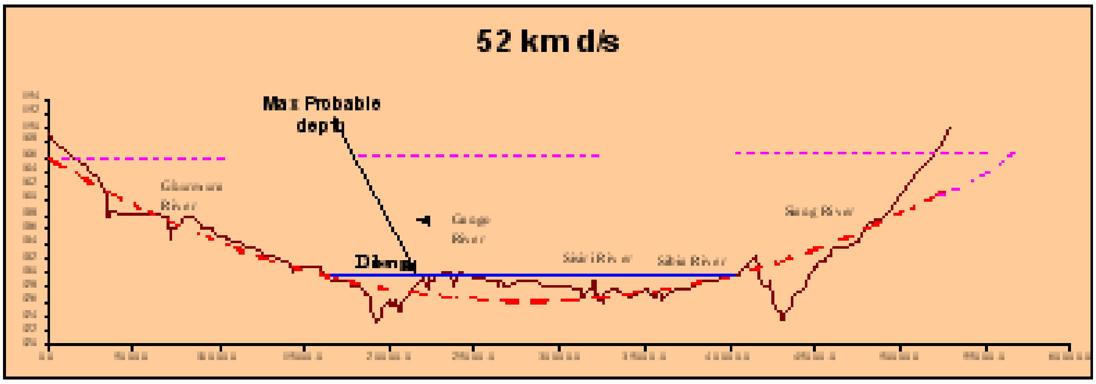


Fig. 15.7b: Flow C/S at 52Km d/s

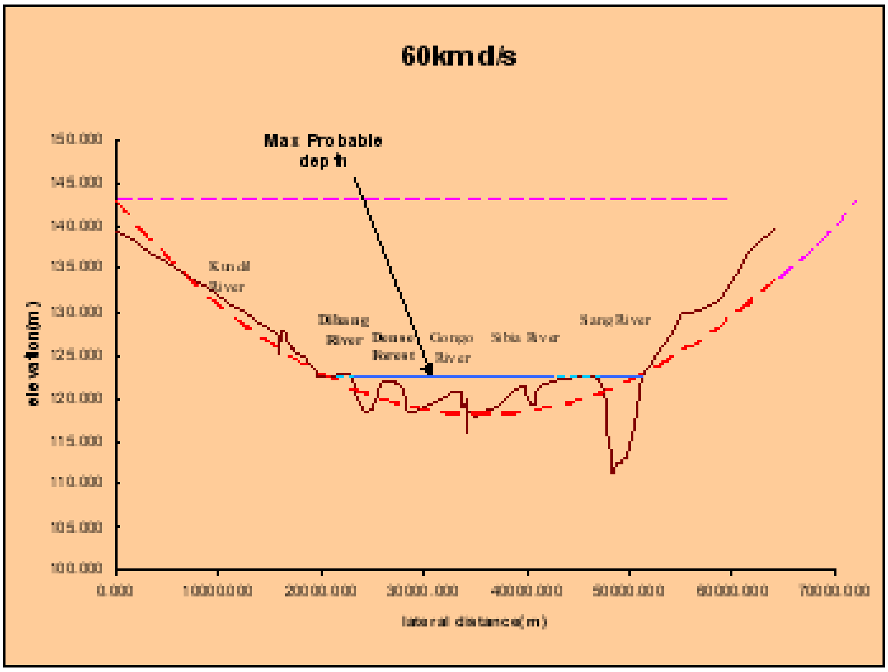
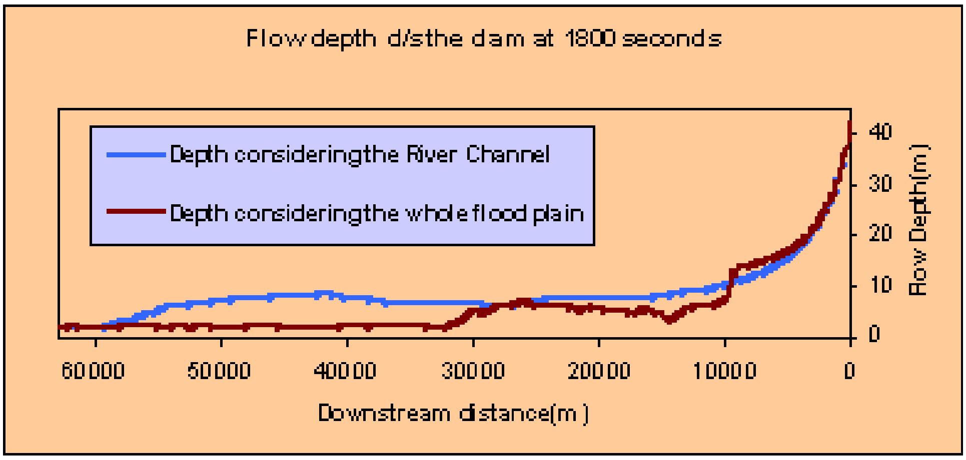


Fig. 15.7c: Flow C/S at 60 km d/s

Comparison of depths of flow downstream the dam



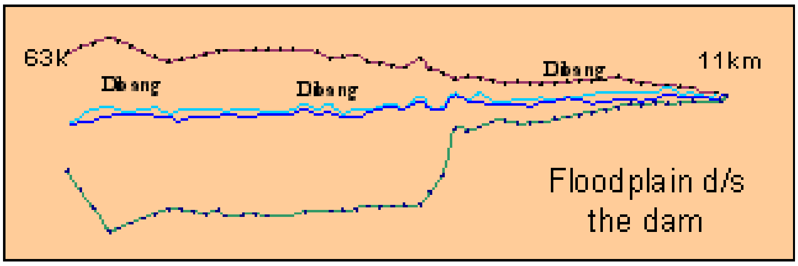


Fig. 15.8: Comparison of Flow depth

Time of Peak Arrival at various sections D/S

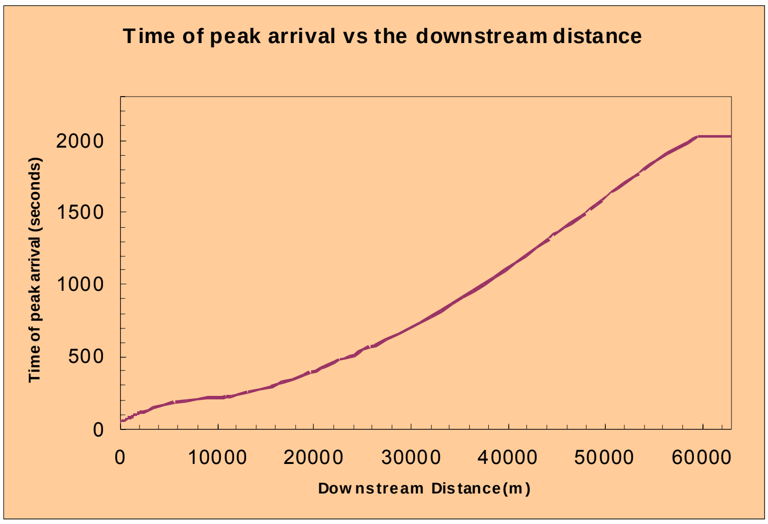


Fig. 15.9: Peak arrival of time

Maximum Probable Velocity

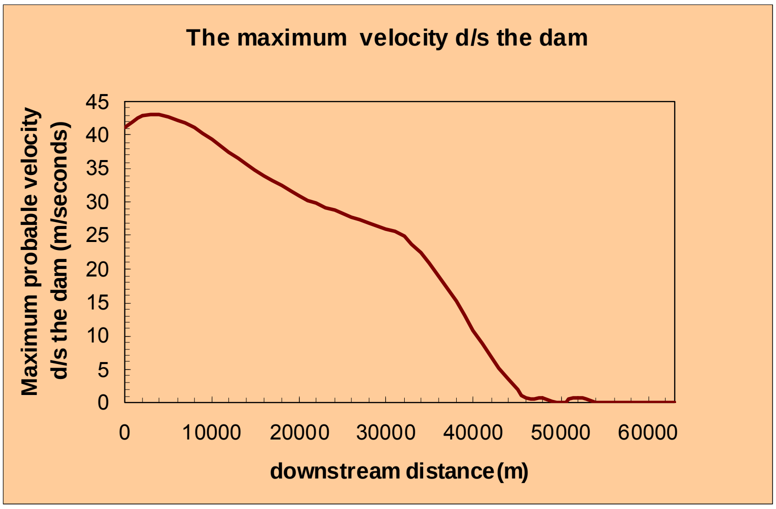


Fig. 15.10: Maximum velocity

Maximum Probable Submergence

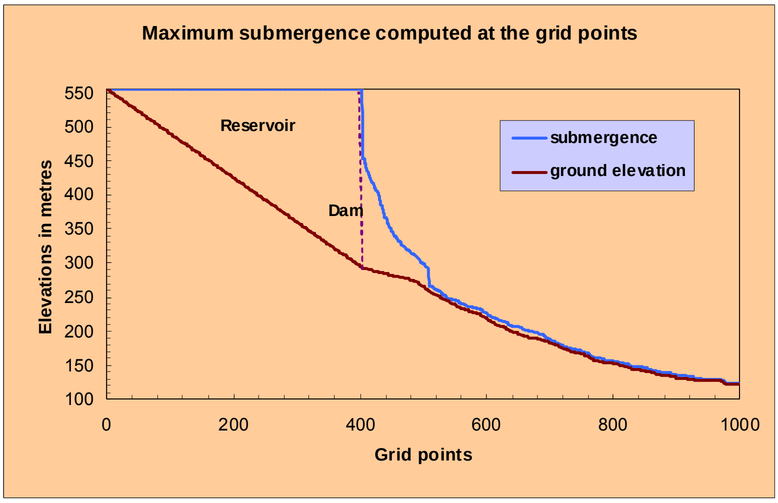


Fig. 15.11a: Sectional view of maximum Submergence

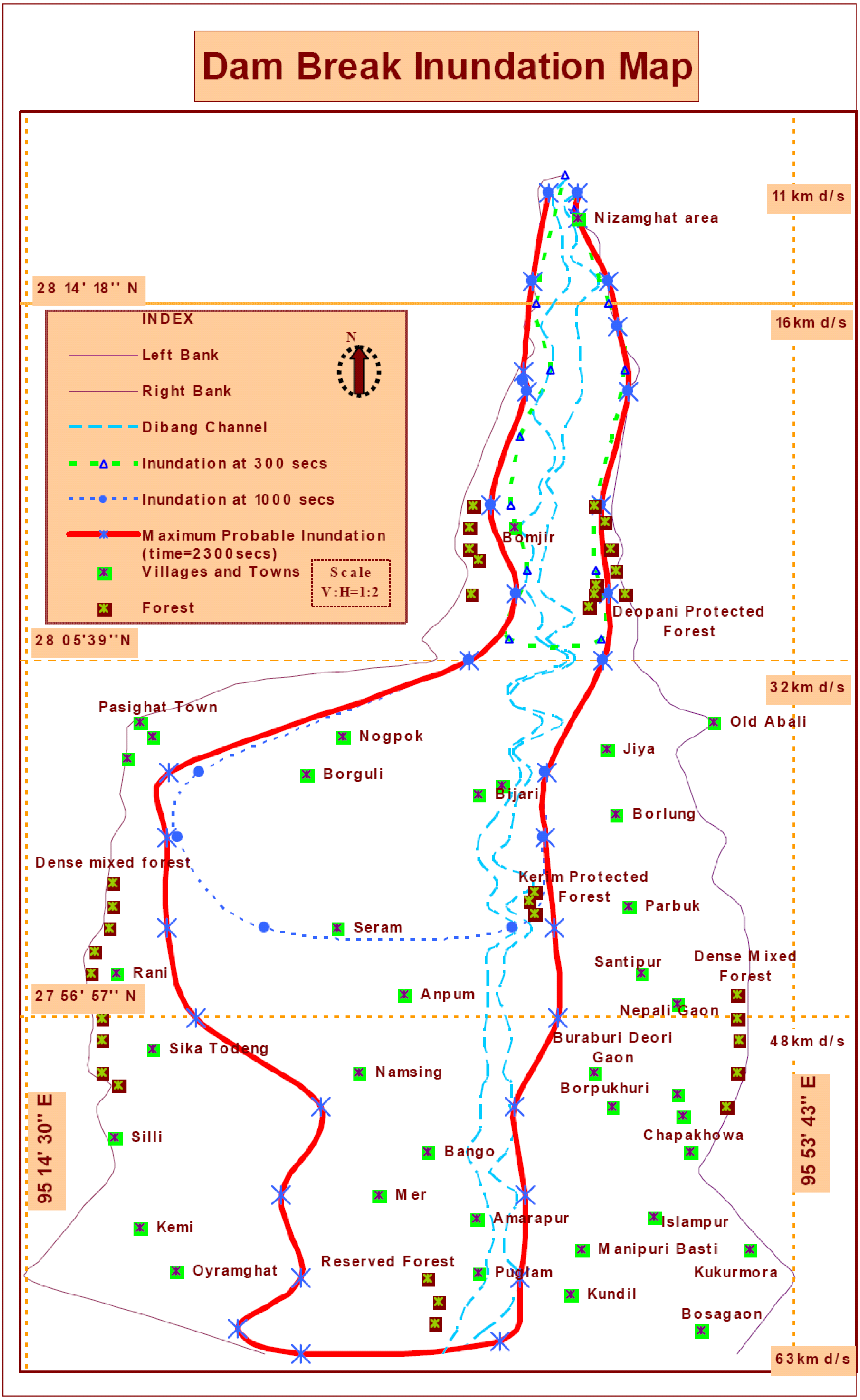


Fig. 15.11b: Plan view of flooded area at different time without considering additional 10%

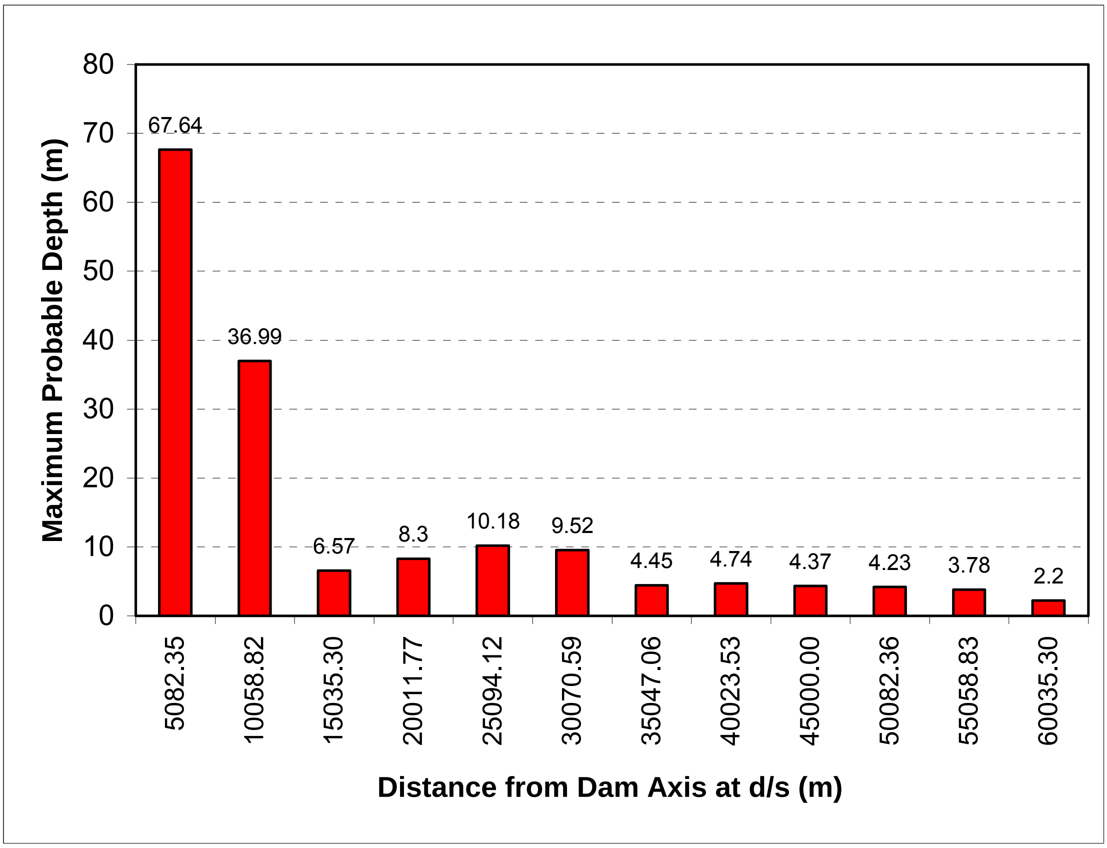


Fig. 15.11c: Graph showing maximum probable depths at different distance from dam axis at downstream (d/s)

15.4 EMERGENCY ACTION PLAN

The important purpose of the dam break study is to prepare an Emergency Action Plan that will lessen or mitigate its impact upon human habitations and properties. The thrust area of action plan will be as follows:

i. To prepare an inundation map,
ii. To evaluate risk at down stream habitations, potential areas etc., and
iii. To prepare a disaster management plan

15.5 DISASTER MANAGEMENT PLAN

In the event of any breach, it is to be ascertained that losses to lives and properties could be kept at minimum by administering the feasible measures. To achieve this, non-structural measures are found to be substantially effective. The important measures are:

i. To provide flood forecasting services and quick dissemination of forecasts to important and heavily populated towns, villages, including other potential areas.
ii. To formulate flood proof communication system, and
iii. To form a disaster mitigation network/system, including relief fund.

along with the above, few important structural measures, like (I) time to time verification of gates, sluices etc,(II) human dwelling, animal shelter and storage of essential commodities on raised structures/platforms (above maximum depth of inundation) and(III) to improve drainage system pertaining to railway lines, National Highways etc. against any possible contestation; are to adopted.

The area down stream of the dam will remain vulnerable to a large-scale disaster either due to high volume release of water from the reservoir compounding the flood scenario down stream or due to passage of dam break flood. The environmental management plan therefore has taken cognigence of such eventualities and has dealt with various aspects of disaster management.

15.5.1 Dimension of disaster and area/population likely to be affected

The area as shown in fig. 15.11b is the basis of the preparing for disaster management plan. Areas on bath north bank and south bank are likely to be prone to disaster caused by high floods. Various components of Disaster Mitigation Plan is described below –

Planning

The purpose of disaster management planning is to anticipate future situations and requirements and establish the frame work to meet them. The plan should include all disaster related activities in the pre disaster period, during a disaster and afterward events. But it never goes exactly as envisaged in a plan during an actual disaster. No disaster plan, even well thought out, will provide all the necessary answers to every problem to be faced. But the mental discipline entailed in preparing and practicing will enable a better grasp and help to cope much more effectively whenever it happens.

Levels of Planning

It is suggested that the project authorities should prepare some thing like a mission plan which can be called as master plan setting out the over all frame work within well laid policies.

Plans at lower levels like districts, sub division should be worked out in consultation with local administration and communities. At this level it should be tailor made to more specific confidences.

The higher level mission plan will support the district & sub division level plan.

Disaster management drills

Practice or drills to manage disaster should be conducted to orient the concerned organisations and personnel on annual basis. This will help in getting immediate response. Materials and facilities like boats, ropes, medicines, first aid etc. should be kept ready with the onset of monsoon every year.

The following aspects should be considered in the disaster management plans:

Needs

1. Evacuation
2. Food
3. Shelter
4. Drinking water
5. Health care
6. Sanitation

Safety measures

The buildings, electrical distribution infrastructure, communication infrastructure like telecommunication and road to the disaster prone area should be planned and built to withstand worst kind of disaster in the prone area.

Shelters

Raised platforms can be constructed as part of the strategy to meet the disasters environment. These platforms should be higher than maximum expected flood water level, safe from erosion by the recurring floods and should be located near health centres having communication to the extent possible.

Inundation Map and Risk at Down Stream Habitation/Potential Areas

An inundation map depicts the downstream areas vulnerable to inundation by the dam break flood. An inundation map is prepared on the basis of analysis result and is shown in **fig. 15.11b.** In the present study, the inundation map was prepared up to 63 km downstream of dam site. Several villages viz. Nizamghat area, Bomjir, Nogpok, Borguli, Bijari, Seram, Anpum, Namsing, Bango, Mer, Amarapur and Puglam are likely to be come in inundation zone.

15.6 FINANCIAL OUTLAY FOR DISASTER PREPAREDNESS AND MITIGATION

Occurrence of Disaster due to high flood and disaster like situation can not be ruled out in this project. The project area being under seismic Zone-V disaster management gains much importance both due to earth quake, change of river courses and floods. The financial provisions included under EMP are discussed below.

15.6.1 Financial Outlay for Installation of VSAT Communication System

The cost of deployment and maintenance of a telecommunication system in disaster prone areas is not as important as the availability, reliability and quick restoration of the system. The cost of both satellite bandwidth and the ground components of the satellite communication system has been decreasing rapidly like that of V-SAT (Very Small Aperture Terminal) based systems supporting a couple of voice and data channels. Some highly superior communication systems in VSAT without time delay are marketed by National agencies like HECL, HFCL and HCL Connect. There are two different types *of* systems with the above mentioned capabilities available in the market viz. SCPCDAMA and TDMA. However, the first one named SCPCDAMA has been recommended. The estimated cost of installation of such a communication system has been given in Table 15.1.

Table 15.1: The estimated cost of setting up of a satellite communication system

S. No.	Product	Amount (Rs. in Lakhs)
1.	Product Name: SCPCDAMA (4 sites) @ Rs. 20.00 lakhs per site a) Antenna 4 x 2.4 M b) RF 4 x 2 W c) Modem 4 x 1 No.	80.00
2.	Generators 4 x 1 No. (21KVA)	10.00
3.	UPS 4 x 1 No. (2KVA)	10.00
4.	Installation and maintenance of system, maintenance and running cost of UPS, generators, etc. @ 10% of the total cost for 7 years	65.00
	Total	**165.00**

15.6.2 Evacuation Plans

Emergency Action Plan includes evacuation plans and procedures for implementation based on local needs. These are:

- demarcation/prioritization of areas to be evacuated,
- notification procedures and evacuation instructions, .
- safe routes, transport and traffic control.
- shelter areas, and

- functions and responsibilities of members of evacuation team.

The flood prone zone in the event of dam break of Dibang shall be marked properly at the village locations with adequate, factor of safety. As the flood wave takes sufficient time in reaching these villages, its population shall be informed well in time through wireless and sirens etc. so that people may take shelter at some elevated place beyond the flood zone which has been already marked as safe.

15.6.3 Notification

Notification procedures are an integral part of any emergency action plan. Separate procedures shall be established for slowly and rapidly developing situations and in case of failure. Notifications will include communications of either an alert situation or an alert situation followed by a warning situation. An alert situation will indicate that although failure or flooding is not imminent a more serious situation can occur unless conditions improve. A warning situation will indicate that flooding is imminent as a result of an impending failure of the dam. It will normally include an order for evacuation of delineate inundation areas. For a regular watch on the flood level situation, it is necessary that two or more people man the flood cell so that in alternative person Is available for notification round the clock.

The copies of the Emergency Action Plan should also include the inundation map which would be displayed at prominent locations and in the rooms and locations of the personnel named in the notification chart. Inundation maps will be displayed in the Village Panchayats nearby the project area and also of the villages falling under flood prone zone. For speedy and unhindered communication, a wireless system will be a preferable mode of communication. Telephones would be kept as backup, whenever required. t is also preferred that all the flood cells if more than one, are tuned in the same wireless channel. It will ensure communication from the dam site to the control rooms. An amount of **Rs. 35.00 lakhs** has been allocated in the project cost for undertaking notification and publication procedures.

In addition, a few guidelines to be generally followed by the inhabitants of flood prone areas, which form part of public awareness for disaster mitigation include:

- listen to the radio for advance information and advice,
- disconnect all electrical appliances and move all valuable personal and household goods and all clothing out of reach of floodwater,
- move vehicles, farm animals and movable goods to the highest ground nearby,
- move all dangerous pollutants and insecticides out of reach of water, and
- do not enter floodwaters on foot, if it can be avoided.

15.7 COST ESTIMATE

A summary of cost estimates for the implementation of disaster management plan is given in Table 15.3.

Table 15.2: Summary of cost estimates for disaster management

S.No.	Particulars	Amount (Rs. in lakhs)
1.	Installation of alert systems, setting up of control room, etc.	55.00
2.	Setting up of VSAT communication system	165.00
3.	Notification and publication procedures, miscellaneous, etc.	35.00
	Total	**255.00**

Hence an amount of Rs. 255 lakhs has to be earmarked for Disaster Management Plan

15.8 CONCLUSIONS

The Dam break analysis has been done for the worst situation that may arise due to failure of Dibang dam. The dam break flood has been routed through the Channel of Dibang River up to the confluence of Brahmaputra River. It has been observed that the reservoir become empty much before the flood wave reaches the confluence. It has also been observed that a large volume of released water will be retained in the Dibang Basin and will return to the main stream of Dibang quite later. Therefore, the effect of this dam failure on the flow of the River Brahmaputra has not been considered in this study. However, if the dam-break-flood-wave reaches the River Brahmaputra simultaneously with a natural flood wave of the Brahmaputra itself, a situation worst than that of the estimated one may occur. However, simultaneous occurrence of such event i.e., the time of dam break flood reaching the confluence and time of a natural flood of Brahmaputra reaching the confluence of Dibang being same, that too with a complete instantaneous failure, is definitely a very rare one.

The Dam break analysis of Dibang dam has been carried out using three different FD schemes. Out of all these schemes the most convenient one, namely the FD Diffusive scheme has been tested for its validity with laboratory data generated elsewhere and then adopted for computing various information, required for preparation of disaster management plan to mitigate flood hazard in the event of failure of the dam. Computed result has shown that several villages located at the downstream side of the dam is expected to be flooded in the event of instantaneous failure. The inundation area shown in the fig will be more by 10% in terms of depth of submergence. This has to be taken into consideration as a safety margin, while preparing the actual disaster management plan for any eventuality of breaking of the DAM.