DAM BREAK ANALYSIS AND DISIASTER MANAGEMENT PLAN

1.0 DAM BREAK INUNDATION ANALYSIS

The objective of dam break modelling or flood routing is to simulate the movement of a dam break flood wave along a valley or indeed any area downstream that would flood as a result of dam failure. The key information required at any point of interest within this flood zone is generally:

- Travel time of flood water
- Peak water level – extent of inundation
- Peak discharge
- Duration of flooding

The nature, accuracy and format of information produced from a dam break analysis will be influenced by the end application of the data. The Dam Break Analysis for Lower Kopili hydro-electric project has been carried out to ascertain the impact of uncontrolled release of water in the downstream, in the hypothetical condition of failure of dam.

2.0 DAM BREAK MODELING PROCESS

The basic theory for dynamic routing in one dimensional analysis consists of two partial differential equations originally derived by Barre De Saint. The equations are:

i. **Conversion of mass (continuity) equation**

ii. $(\partial Q/\partial X) + \partial(A + Ao)/\partial t - q = 0$

Conservation of momentum equation

a. $(\partial Q/\partial t) + \{\partial(Q\text{^}2/A)/\partial X\} + gA((\partial h/\partial X) + Sf + Sc) = 0$

b. $\text{where} Q = \text{discharge}$;

A = active flow area
A_o = inactive storage area;
h = water surface elevation;
q = lateral outflow;
X = distance along waterway;
t = time;
St = friction slope;
Sc = expansion contraction slope and
g = gravitational acceleration

3.0 HEC-RAS MODEL

HEC-RAS 4.1 system contains two one dimensional hydraulic components for: i) steady flow surface profile computations; ii) unsteady flow simulation. The steady/unsteady flow computations are capable of modeling subcritical, supercritical, and mixed flow regime water surface profiles. The basic computational procedure is based on the solution of one dimensional energy equation. Energy losses are evaluated by friction (manning's equation) and contraction/expansion (coefficient multiplied by the velocity head). The momentum equation is utilized in situations where the water surface profile is rapidly varied. The graphics include X-Y plots of the river system schematic, cross-sections, profiles, rating curves, hydrographs and many other hydraulic variables.

Model Stability during unsteady flow simulation

HEC-RAS model uses an implicit finite difference scheme. The common problem of stability in the case of unsteady flow simulation can be overcome by suitable selection of following;

- Computational time step
- Theta weighing factor for numerical solution
- Cross section spacing along the river reach
- Solution iterations
- Solution tolerance
- Weir and spillway factor for numerical solution

Computational time step

Stability and accuracy can be achieved by selecting a computational time step that satisfies the courant condition;

$C_r = V_w\ (\Delta t/\Delta x) \leq 1.0$

Therefore: $\Delta t \leq (\Delta x/\ V_w)$

Where:

V_w= Flood wave speed
V = Average velocity of flow
Δx = Distance between the cross sections
Δt = Computational time step
For most of the rivers the flood wave speed can be calculated as:
$V_w = dQ\ /dA$

However, an approximate way of calculating flood wave speed is to multiply the average speed by a factor. Factors for various channel shapes are shown in the table below.

Channel shape	**Ratio (V_w/V)**
Wide rectangular	1.67
Wide parabolic	1.44
Triangular	1.33
Natural channel	1.5

Theta weighing factor for numerical solution

Theta is a weighing factor applied to the finite difference approximations when solving the unsteady flow equations. Theoretically theta can vary from 0.5 to 1.0. Theta of 1.0 provides the most stability, while theta of 0.6 provides the most accuracy.

Cross section spacing along the river reach

The river cross sections should be placed at representative locations to describe the change in geometry. Additional cross sections should be added at locations where changes occur in discharge, slope, velocity and roughness. Bed slope plays an important role in deciding the cross section spacing. Streams having slope require cross sections at a closer spacing say 500 m or so. For larger uniform rivers with flat slope the cross section spacing can be kept from 1000m to 3000m.

Solution iterations

At each time step derivatives are estimated and the equations are solved. All the computational nodes are then checked for numerical error. If the error is greater than the allowable tolerances, the program will iterate. The default number of iterations in HEC-RAS is set to 20. Iteration will improve the solution.

Solution tolerance

Two solution tolerances can be set or changed by the user: i) water surface calculation ii) storage area elevation. Making the tolerance larger can reduce the stability problem. Making them smaller can cause the program to go to the maximum number of iterations every time.

Weir and spillway factor for numerical solution

Weirs and spillways can often be a source of instability in the solution. During each time step, the flow over a weir/spillway is assumed to be constant. One solution is to reduce the time step.

4.0 INPUT DATA AND MODEL SETUP

Understanding a dam break analysis requires following range of data in general:

- Cross sections of the river from upstream to dam site and up to location downstream of the dam to which the study is required.
- Salient features of the all hydraulic structures at the dam site
- Design flood hydrograph
- Stage-Volume relationship for the reservoir
- Manning's roughness coefficient for different reaches of the river under study
- Topographic map of the downstream area for preparation of inundation map after dam break studies.

The reservoir is normally modelled as a storage area to describe the storage characteristics by the use of storage-volume at different levels. This point will often also be the upstream boundary of the model, where inflow hydrograph may be specified. However, in case of very long and wide reservoirs the routing of the inflow floods has to be carried out and hence the reservoir itself will also have to be represented by cross sections at regular intervals. The downstream boundary will be either a stage discharge relation or time series water level as in case of tidal waves etc.

5.0 CRITICAL CONDITION FOR DAM BREAK STUDY

The critical condition for a dam break study is when the reservoir is at Full Reservoir Level (FRL) and design flood hydrograph is impinged. Accordingly, in the present study keeping the initial reservoir level at MWL El. 229.60 m the reservoir routing has been carried out by impinging the design flood hydrograph and keeping all the spillway gates fully open.

6.0 RESULTS OF DAM BREAK ANALYSIS

The simulation results are given in Table-1.

Table-1: Maximum Water Surface Profile of Dam Break Analysis

RD (km)	Discharge (m^3/s)	Min Ch Elevation (m)	W.S. Elevation (m)	Velocity (m/s)	Depth of flow (m)	Top Width (m)
0	52185.31	170	226.69	56.69	25.21	255.04
0.65	58497.31	163	202.9	39.90	28.34	151.41
1.65	57770.67	157	205.67	48.67	25.18	150
2.65	27587.22	156	204.72	48.72	27.42	150
3.65	23269.57	150	206.69	56.69	27.95	150
4.65	52862.23	144	204.03	60.03	28.71	150
5.70	64297.14	127.7	150.67	22.97	29.75	159.64
7.00	61147.68	106.38	157.88	51.50	29.84	120
8.00	57332.24	93.45	156.65	63.00	23.05	120
9.00	53802.18	88.9	157.43	68.13	25.90	175
10.5	47899.96	80.67	156.19	75.52	27.99	155

7.0 DISASTER MANAGEMENT PLAN

7.1 Status of Emergency

The emergency planning for dam break scenario is devised on the basis of results of dam break analysis mainly the travel time of flood wave to various locations in the downstream stretch of the river. The plan is, therefore, based on such measures, which are purely preventive in nature. The degree of alertness has to enhance during high stage of river manifested with sharp increase in discharge. Though there cannot be very sharp edge demarcation between different levels of emergency yet the following flood conditions have been contemplated and the preventive measures suggested against each as given in Table-2.

Table-2: Status of Emergency

S. No.	Status of emergency	Water Level	Preventive measures
1.	Normal Flood	Below FRL i.e. EL 226.0 masl and flood discharge below 7510 cumecs	Utmost vigil observed in regulation of spillway gates

S. No.	Status of emergency	Water Level	Preventive measures
2.	Level –1 Emergency	Rises above EL 226.0masl but flood discharge below 7510 cumecs	(1) All gates fully operational (2) All the official should attend dam site. Local officials informed and warning system be kept on alert.
3.	Level –2 Emergency	Above MWL i.e. EL 226.0 masl but below top of dam i.e. EL 229.60and the discharge continues rising above 7510 cumecs	Communication & public announcement system should be put into operation and flood warning issued to people.
4.	Level –3 Emergency	Top of dam i.e. EL 232.50 masl	(1) All staff from dam site to move to safer places (2) Possibility of dam failure should be flashed to District Administration.
5.	Disaster	Rising above EL 232.50 masl and the breach appears in any form	District Administration and Project authorities be intimated and only life saving measures should be resorted too

7.2 Dam Safety and Maintenance Manual

Based on standard recommended guidelines for the safety inspection of dams a manual should be prepared by the project proponents in respect of dam safety surveillance and monitoring aspects. This should be updated with the availability of instrumentation data and observation data with periodical review. The need for greater vigil has to be emphasized during first reservoir impoundment and first few years of operation. The manual should also delve on the routine maintenance schedule of all hydro-mechanical and electrical instruments. It should be eloquent in respect of quantum of specific construction material needed for emergency repair along with delineation of the suitable locations for its stocking and also identify the much needed machinery and equipment for executing emergency repair work and for accomplishing the evacuation plan.

7.3 Emergency Action Plan

Once the Emergency situation is foreseen, the Emergency Action Plan may be put in operation, which may include;

- Areas likely to be evacuated with priorities to be notified.
- Safe routes to be used for evacuation. Such routes have to be identified, discussed and planned sufficiently in advance for proper implementation of the Plan.
- Means of transportation.

- Traffic Control.
- Shelters for evacuees.
- Procedures for evacuation of people from hospitals, public places, prisons etc.
- Procedures for care and security of property from evacuated areas from anti-social elements.
- Instructions regarding assignment of specific functions and responsibilities of various members of evacuation teams

7.4 Emergency Action Committee

The emergency action committee may comprise of:

- District Magistrates of Karbi Anglong and Dima Hasao districts, Assam
- Concerned Chief Engineer of the Project
- Concerned Superintending Engineer of the Project
- Representative of P&T Department
- Representative of State Transport Department
- Representative of Civil Supplies Department
- District Agricultural Officer
- District Health Officer
- District Commandant of Home Guards
- District Publicity Office
- Local MP/MLA
- Special Invitee from Local Social Organization / NGO

7.5 Public Information System8

During a crisis following an accident, the affected people, public and media representatives would like to know about the situation from time to time and the response of the emergency authorities to the crisis. It is important to give timely information to the public in order to prevent panic and rumors.

The emergency public information can be carried out in three phases.

(i) Before the crisis

This will include the safety procedure to be followed during an emergency through posters, talks, and mass media in local language. Leaflets containing do's/ don'ts should be circulated to educate the affected population.

(ii) During the crisis

Dissemination of information about the nature of the incident, actions taken and instructions to the public about protective measures to be taken, evacuation, etc. are the important steps during this phase.

(iii) After the crisis

Attention should be focused on information concerning restoration of essential services, movement / restrictions, etc. Various tasks of the public information system would include;

- Quick dissemination of emergency instructions to the personnel and public
- To receive all calls from public regarding emergency situations and respond meticulously
- Obtain current information from the Central Control Room.
- Prepare news release
- Brief visitors/media
- Maintain contact with hospitals and get information about the casualties

7.6 Efficient Communication System

An efficient communication system is absolutely essential to achieve a successful Emergency Preparedness Plan and this has to be finalized in consultation with local authorities and administrative setup. More often the entire communication facility gets disrupted in a disaster situation. The wireless facility which is comparatively free from general encumbrances of the communication system shall be invariably a part of emergency preparedness plan. The respective department of police, who generally has this facility, must have standing instructions to convey disaster messages effectively in time. In addition, telephone facility shall be available at dam site, vulnerable points and population centers. Vehicles equipped with sirens and public address system may also be kept ready for densely populated areas. Warning sirens may also be installed in the likely affected population to save warning time.

7.7 Special Preparedness before First Filling of Reservoir

Many failures of dams have reportedly occurred at the time of first filling of reservoirs. The period of first filling is a critical period in the life of a dam. Hence special vigilance and precautionary steps are necessary at the time of first filling of the dam in order to avoid failure of the dam. It is, therefore, necessary to inspect the performance of the dam carefully during this period. The preparedness shall be carried out for the first filling of reservoir as indicated below:

- Before starting the first filling of reservoir, the EAP of the project should be completed and implemented as far as possible.
- The installation of Spillway gates including hoisting arrangement, emergency power supply etc. should be completed and trial operation of gates must be made before it becomes actually operational.
- The copy of the first filling schedule shall be sent to the District Administration, and State Dam Safety Organization, if any.
- Proper lighting facilities on and nearby the dam area shall be provided before the onset of monsoon to facilitate close vigilance of the dam behavior during the night time also. A generator and flood light shall also be provided for emergency purpose.

- The control room of the dam is to be connected with the office and residence of officers-in-charge of the dam by telephone or by wireless set. The wireless/telephone stations and telephone lines should be completely out of the flood zone.
- Sufficient amount of materials such as sand, shingle, rubble etc. should be stock piled at convenient locations near the dam site.
- Sufficient number of filled sand bags should also be kept ready for emergency purposes.
- Machineries like tippers, trucks, excavators etc. along with sufficient number of labor are to be kept ready on both the flanks of dam to start remedial measures within a very short notice.
- Access roads along the downstream of the dam as well as on the top of the dam should be established for proper movement of the machines and vehicles.

7.8 Vigilance during first year of filling of a reservoir

During the first year of filling of dam, careful vigilance needs to be kept at the dam site and in the deepest river bed portion. The dam should be inspected by the Dam Inchargein three phases.

- The first phase inspection is to be carried out just before the onset of first heavy rain.
- The second phase of the inspection will be conducted after the filling of the reservoir to half the height of the dam.
- After the second inspection, if no untoward behavior of the Barrage is observed, third inspection will be made when the reservoir would be filled up to FRL.

When the spillway starts working, the Superintending Engineer should inspect the Barrage periodically during the entire period of overflowing. If any sweat, excessive settlement, leakage, cracking or sloughing of slopes is noticed, it should be brought to the attention of the higher authorities immediately. Daily reports about stage of reservoir filling, condition and behavior of the dam must be submitted by the Engineer responsible to his immediate superior as a part of the continuous vigilance of the dam.

7.9 Actions following Discovery of Problems

A close vigilance of the dam by Executive Engineer a competent person is the basic requirement for the Emergency Action Plan. When some distress in the dam is noticed, the nature and potentialities of the problems are required to be identified immediately by the Executive Engineer incharge of dam. Immediately, initiative for remedial measures and further activities for involving the operation of Emergency Action Plan be taken.

The information of any unusual development on the dam should be immediately flashed/ conveyed by the Executive Engineer in charge of the dam to the higher officials in the Department by means of the fastest available communication facilities such as wireless message/ telephone or telegram. In the event of likely failure of dam, the man with highest designation present at the dam site shall initiate the actions as described in notification procedure and possible construction repairs depending on the seriousness of the development. Therefore, it is necessary that the staff posted on the vigilance and maintenance of the dam be adequately trained/ experienced to handle various emergent situations.

7.10 Notification Procedures

Notification procedures are an integral part of any emergency action plan. Separate procedures should be established for slowly and rapidly developing situations and failure. Notifications would include communication of either an alert situation or an alert situation followed by a warning situation. An alert situation would indicate that although failure or flooding is not imminent, a more serious situation could occur unless conditions improve. A warning situation would indicate that flooding is imminent as a result of an impending failure of the dam. It would normally include an order for evacuation of delineated inundation areas.

Copies of the EAP shall be displayed at prominent locations, in the rooms and locations of the personnel named in the notification chart. For a regular watch on the flood level situation, it is necessary that the flood cells be manned by two or more people so that an alternative person is always available for notification round the clock. For speedy and unhindered communication, a wireless system is a preferable mode of communication. Telephones may be kept for back up, wherever available. It is also preferred that the entire flood cells, if more that one, are tuned in the same wireless channel. It will ensure communication from the dam site to the control rooms. The communication can be established by messenger service in the absence of such modes of communication.

- Using multiple warning channels (police, radio, television, telephone, sirens, loudspeakers, mobiles etc.)
- Using official sources for warning (city civil officials, police, fire fighting etc.)
- Repeat warnings
- Ensuring that warnings are consistent and accurate
- Giving specific instructions about what actions should and should not be taken by people of the area to protect themselves.
- Conveying to the affected persons, possible extent of duration of flood/danger and urgency. However, this should not be overplayed to cause panic.

All departments, which are charged with the emergency preparedness, shall be identified and nodal officer in each department shall be identified from each department in advance. Such officers shall be provided residential telephone/cell phone in addition to their office telephones during the flood season. It is evident that the emergency preparedness plan is an integrated matter requiring technical expertise, specific administrative skill and spontaneous public participation (if is required) to be practical, pragmatic and successful.

7.11 Management after receding of Flood Water

The officer-in-charge of relief camp shall assist in the process of timely evacuation and rehabilitation of the persons likely to be affected, cattle and property. He shall also maintain record of persons/families in the camp and make arrangements for essential items of daily use and ensure reasonable health, sanitation, water supply and street lighting facilities. A daily situation report shall be sent to the control room. Some of the measures which need to be implemented are listed as below:

- Provision of various food items and shelter to the evacuees.
- Provision of fuel for various evacuees.
- Provision of adequate fodder supply.
- Arrangements for potable water supply.
- Commissioning of low cost sewage treatment and sanitation facilities, and disposal of treatment sewage.
- Expeditious disposal of dead bodies human and livestock.
- Immunization programmes for prevention of outbreak of epidemics of various water related diseases.
- Adequate stocks of medicines of various diseases, especially water-related diseases.

8.0 COST ESTIMATES

The budget for different activities required to be carried out for mitigation and prevention of dam break hazard exclusively from the dam is Rs. 370.0 lakh as per details given in Table-3.

Table-3: Cost Estimate for Implementing DMP

S. No.	Particular	Cost (Rs. lakh)
1.	Installation of alert system in control room	30.0
2.	Setting up of communication system in various villages	50.0
3	Setting up of communication system between dam and d/s settlements	100.0
4	Public information system	30.0
5	Setting up of a seismic observatory at dam site	100.0
6	Flood Forecasting Arrangements	30.0
7	Training and miscellaneous	30.0
	Total	**370.0**