APPENDIX R

DAM SAFETY and EMERGENCY PREPAREDNESS

APPENDIX R1

DAM FAILURE SCENARIO

Yusufeli Dam Failure Calculation

1. Model

Model Setup

The downstream effects of a Yusufeli dam failure have been estimated with the Dambreak module of MIKE 11. Dambreak setup consists basically of a single channel, a reservoir and the dam structure.

River network

The topography of the river is described as accurately as possible through many cross-sections, and particularly when they are changing rapidly. The river network is defined from Yusufeli reservoir by a single branch of 24.44 kms long and 30 cross-sections are used to describe the river's topography. Cross-sections have been extracted from a 1/25000 topographic map. All the singularities of the river were described through the cross-sections geometry.

Reservoir

The reservoir is modelled as a single point with storage characteristics. This point corresponds to the upstream boundary of the model. The cross sectional area is set to a large finite value only used when calculating inflow headloss into the breach.

Dam

The dam is modelled as a Q-point where the dambreak structure is located. At this location, the momentum equation is replaced by an equation which describes the flow through the structure. This may be either critical or sub-critical.

Boundary conditions

To run dambreak, boundary conditions have been specified at both the upstream and the downstream limits of the model. The upstream boundary was a discharge of 300 m^3/s. The downstream boundary is a water level of 392 m.

Initial conditions

In many cases dam failures occur on a dry river bed downstream. However, such initial conditions are not possible in MIKE 11 which requires a finite depth of water to be present throughout the entire model. Before a dambreak simulation, it is expedient to create a steady-state to carry out the initial water level of each cross section of the river network.

Dambreak structure

A dam break structure is a dam in which a breach can develop. The shape of the dam changes in time (the breach increases and the dam crest is shortened. The Q-h relationship for the dam crest and the breach are different therefore the flow over the crest and the flow through the breach are calculated separately.

The breach is initially trapezoidal, increasing in size and changing shape. The initial breach shape is described by three parameters: level of the breach bottom, width of the breach bottom, side slope of the breach.

The development of breach is simulated from the sediment transport capacity of the breach flow. The breach development is based on erosion. Initial and final breach shape are

specified. The increase of the breach during a time step is calculated with the Engelund-Hansen sediment transport formula.

As a first step, the flow resistance in terms of the total dimensionless shear stress is calculated and then compared to the critical shear stress. If the computed shear stress is greater than the critical one, then the sediment transport is calculated. By an application of the sediment continuity equation the breach length in flow direction may be calculated, change in breach level dH_b is a time interval dt is given as:

$$\frac{dH_b}{dt} = \frac{q_t}{(1-\varepsilon)},$$ with q_t the sediment transport rate and ε the porosity

The increase of breach width is calculated as the increase in breach depth multiplied by the side erosion index.

Once the breach geometry has been computed the flow can be calculated. The flow over the dam crest and the flow through the breach are often quite different with respect to water depth, velocity and flow state. At the breach the water level is lower and the velocity is higher than at the dam crest. When the flow is drowned at the breach the flow at the crest can be either free overflow or drowned. The water level in the breach corresponds to the difference of Energy head upstream, inflow loss and velocity head in breach.

The specification of a dam failure requires to define relevant information from geometric specifications (dam height, crest length and level), breach characteristics (for erosion failure the breach slope remains constant), the failure moment (here it was taken zero hour after the start of the simulation) and the failure mode. With erosion based failure, information about dam slopes, top width of the dam crest, representative grain diameter of dam core, density, porosity and critical shear stress of dam core material, side erosion index, final bottom level, width and slope of breach are required. If the initial failure is by breaching, initial length and width are also required.

The main characteristics of the dam break structure are given bellow.

Failure moment and mode:

- Erosion Based Failure Mode
- 0 Hour after start Failure Mode

Dambreak Structure:

Dam geometry

- Upstream slope : 2.2
- Downstream slope: 1.9
- Top Width : 15

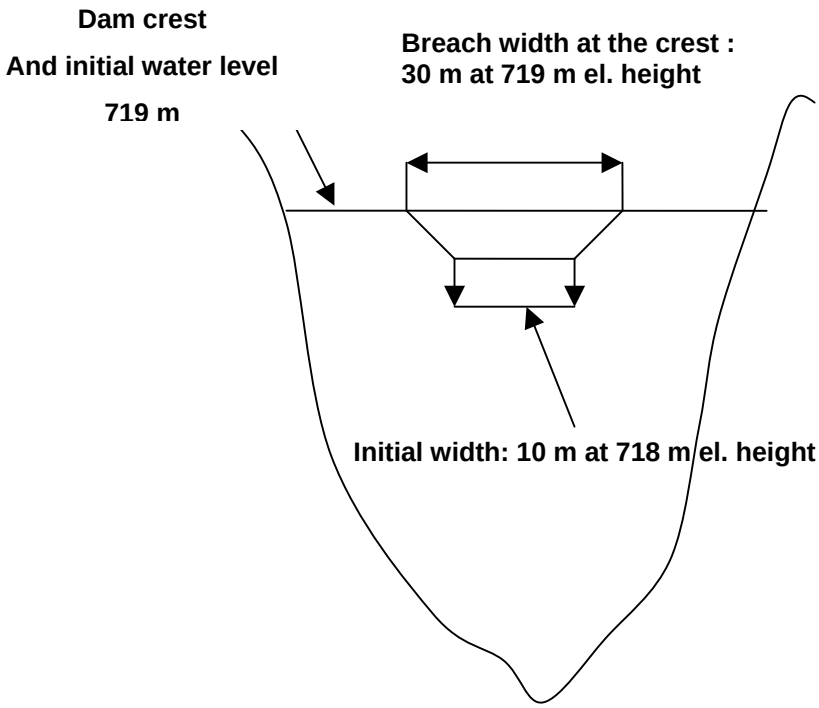
Limit of breach geometry

- Final bottom level: 490 m
- Final bottom width : 500 m
- Breach slope : 2

Breach Failure:

- Initial level : 719 m
- Initial Width : 10 m

Fig. 1: Dam Breach Starting Scenario



2. Results

Fig. 2: Peak Flood Water Level in the Downstream

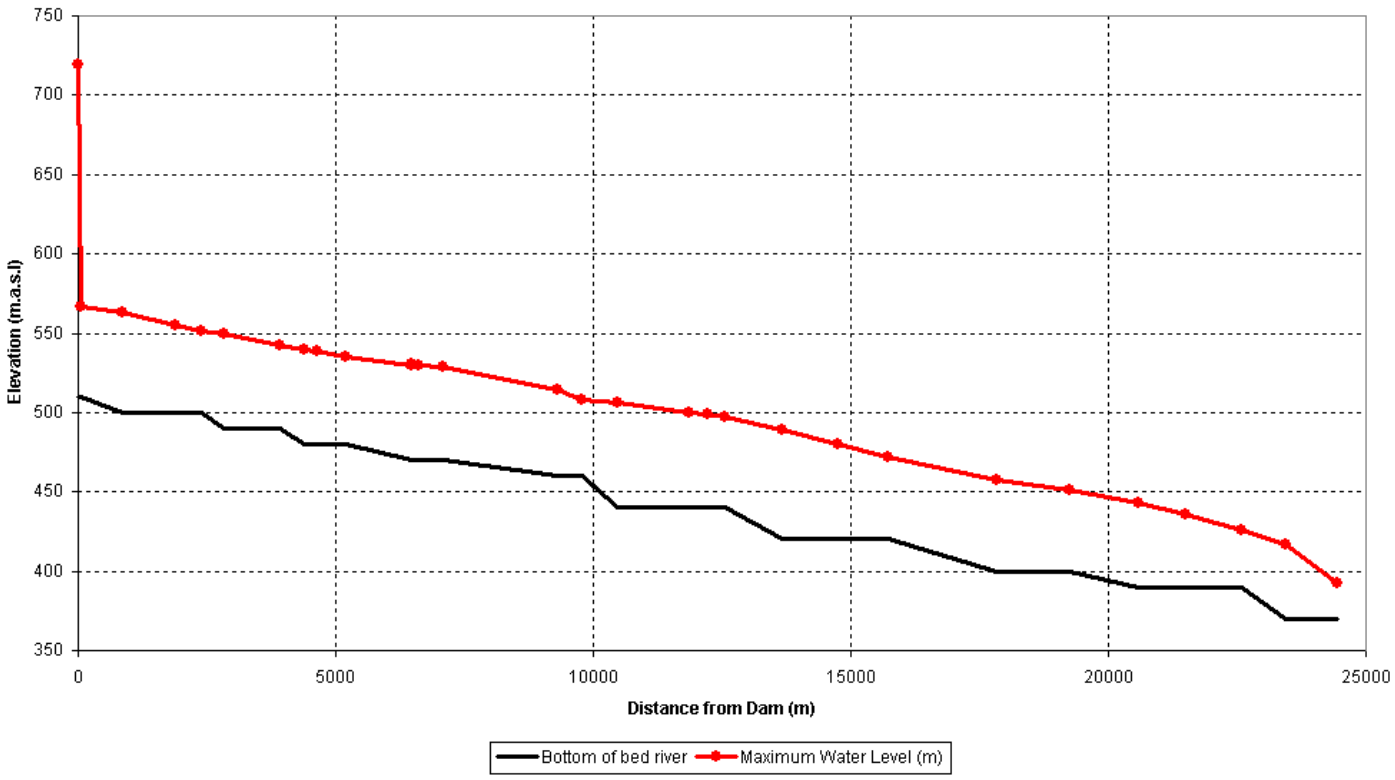


Fig. 3: Water Level Evolution at Downstream Stations

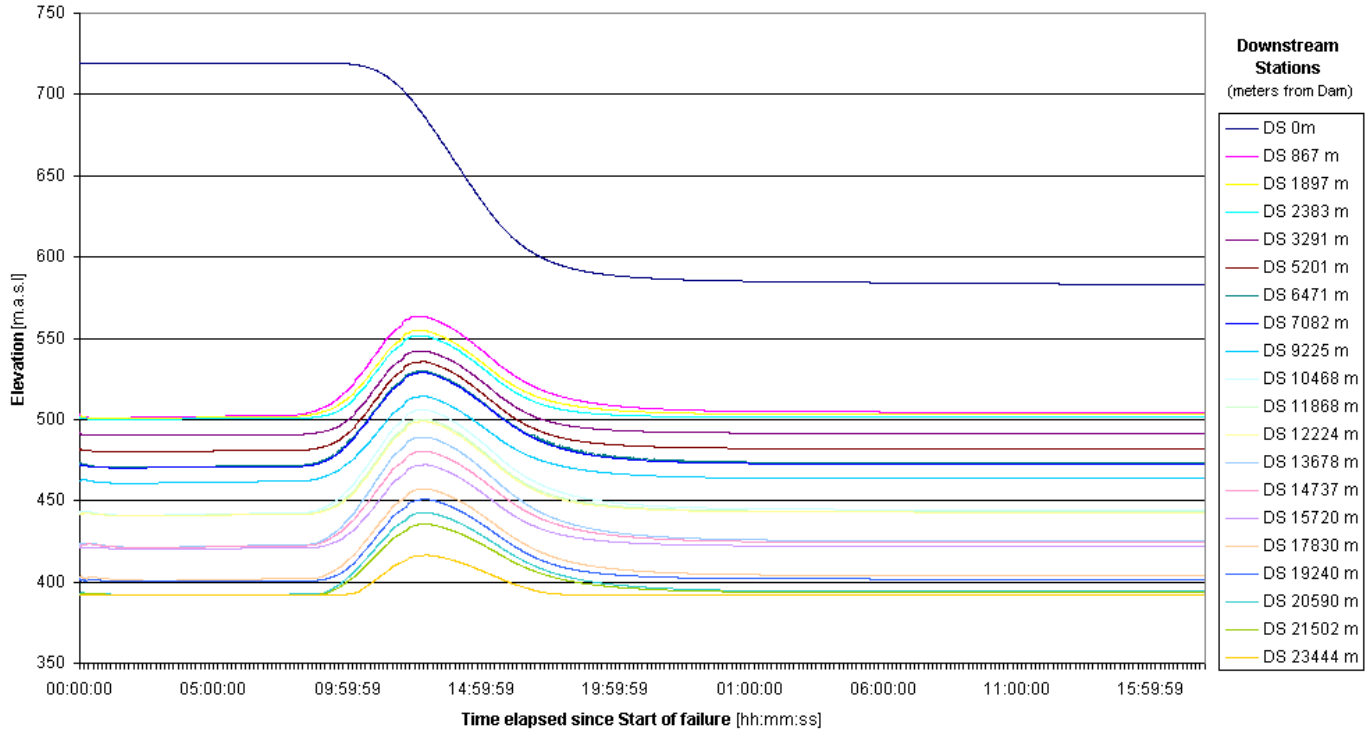
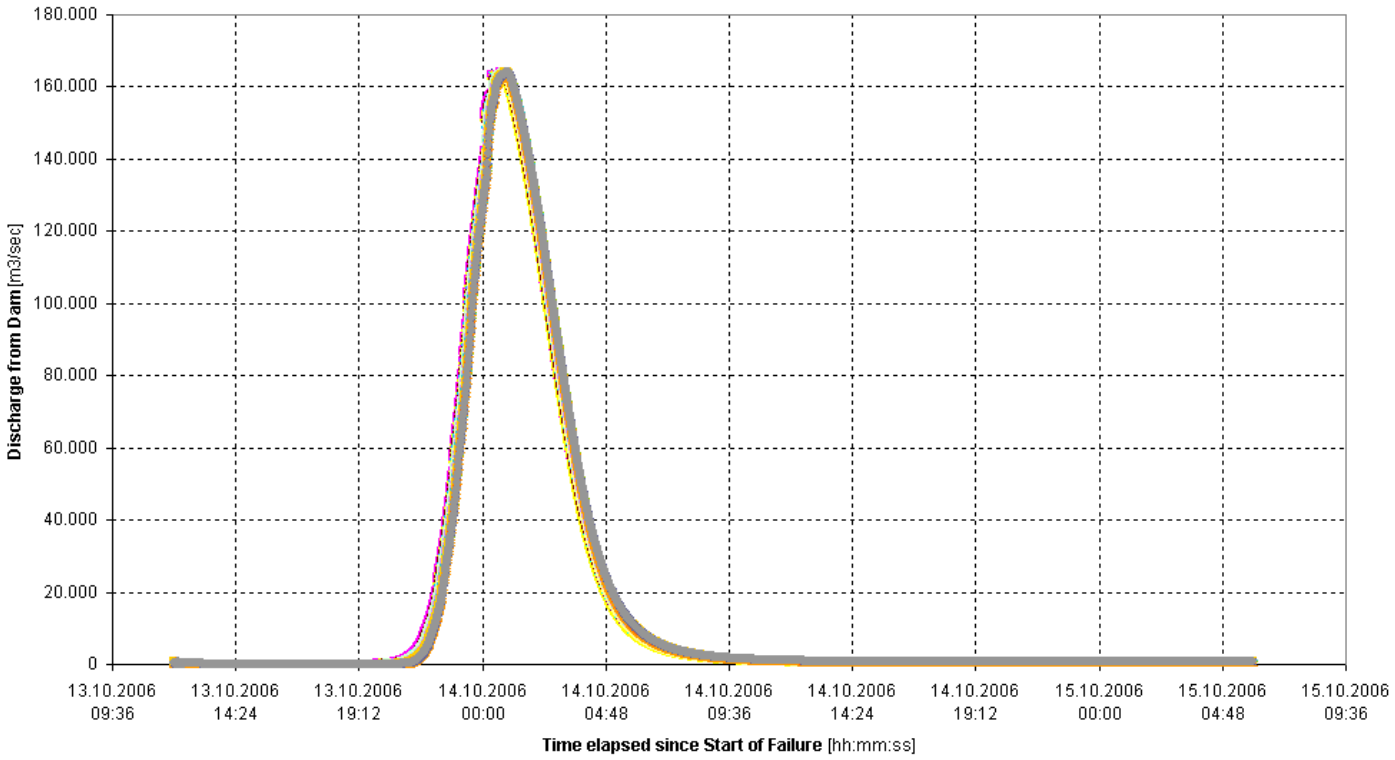


Fig. 4: Discharge evolution at Downstream Stations



APPENDIX R2

EMERGENCY PREPAREDNESS PLAN (EPP) OUTLINE

1. General

Potential emergencies at a dam shall be identified and evaluated, with consideration of the consequences of failure, so that appropriate preventative or remedial actions can be taken.

An Emergency Preparedness Plan (EPP) shall be prepared, tested, issued and maintained for any dam whose failure could be expected to result in loss of life as well as for any dam for which advanced warning would reduce upstream or downstream damage.

A notification process shall be initiated as specified in the EPP, immediately upon finding a hazardous condition that could lead to a dam breach, or upon discovering a potential dam breach or dam breach in progress.

The dam owner or operator shall assess whether dam breach warnings should be issued directly to inhabitants in areas immediately downstream of a dam, due to the short period of time before the anticipated arrival of a flood wave.

Where preventative actions are available, these actions shall be initiated, as appropriate, to prevent failure or to limit damages where failure is inevitable.

An EPP is a formal written plan that identifies the procedures and processes that the dam operators would follow in the event of an emergency at a dam. The emergency could be, for example, failure of essential equipment such as floodgates, slope failure having the potential to cause dam failure, or a complete failure of the dam caused by overtopping, earthquake or piping.

An EPP allows for planning by municipalities, local police, provincial agencies, telephone and transportation companies and other parties affected in the event of a dam break flood, and the coordination of efforts between provincial and municipal levels of government. In the event of an emergency, an effective, comprehensive, well-tested EPP will save lives and has the potential to reduce property damage.

2. Involved Agencies

The EPP for the Yusufeli Project and the downstream dams will be prepared by the relevant 26th DSI Regional Directorate in Artvin and DSI Dam Safety department.

The EPP shall describe the actions to be taken by the dam owner (DSI) and operator (EUAS) in an emergency. The EPP shall assign responsibility for each action to be taken to an individual and/or a backup.

Input from other agencies and affected parties shall be included in the EPP, as appropriate.

Copies of the EPP, or summaries of relevant information, shall be provided to those who have responsibilities under the plan.

3. Step for Development of the EPP

The steps in developing an EPP are as follows:

1. Identify those situations or events that would require initiation of an emergency action; specify the actions to be taken and by whom.
2. Identify all jurisdictions, agencies, and individuals who will be involved in implementing the EPP.

3. Identify primary and auxiliary communications systems, both internal (between persons at the dam) and external (between dam personnel and outside agencies).
4. Identify all persons and agencies involved in the notification process, and draft a notification flowchart, which shows whom should be notified, in what order and what other actions are expected of downstream agencies. Each provincial and local government agency involved may have its own general emergency plan. This would normally require amending to include actions required as a result of dam break flooding.
5. Develop a draft of the EPP.
6. Hold coordination meetings with all parties included in the notification list for review and comment on the draft EPP.
7. Make any revisions, obtain any necessary regulatory approval, finalize and distribute the EPP.

4. Contents of the EPP

The EPP shall include the following procedures and information:

- Emergency identification and evaluation
- Preventative actions (where available)
- Notification procedure
- Notification flowchart
- Communication systems
- Access to site
- Response during darkness
- Response during adverse weather
- Sources of equipment
- Stockpiling supplies and materials
- Emergency power sources
- Inundation maps
- Warning systems

4.1 Emergency Identification and Evaluation

Potential emergencies at a dam shall be identified and evaluated, with consideration of the consequences of failure, so that appropriate preventative or remedial actions can be developed. If detected early enough, potential emergencies can be evaluated and preventative or remedial actions taken. The EPP should contain clear procedures for taking action when a potential emergency is identified. Notification of emergency situations requires that a responsible contact person initiates the remedial action and decide if and when an

emergency should be declared and the EPP executed. Clear guidance should be provided in the EPP on the conditions, which require that an emergency be declared.

The Emergency Preparedness Plan (EPP) should include a discussion of procedures for timely and reliable identification, evaluation, and classification of existing or potential emergency conditions. Major elements of these procedures are:

- Listing of the conditions or events, which could lead to or indicate an existing or potential emergency. Situations involving flood emergencies due to a breach or other structural failure as well as a major flood without a breach should be included. Breach conditions could occur as a result of such occurrences as piping, floods, earthquake, sabotage or landslide induced waves.
- Brief description of the means by which potential emergencies will be identified, including the data and information collection system, monitoring arrangements, surveillance, inspection procedures and other provisions for early detection of conditions indicating an existing or potential emergency. (For non-exhaustive list see Annex 1)
- Procedures, aids, instructions and provisions for interpreting information and data to assess the severity and magnitude of any existing or potential emergency.
- Designation of the person responsible for identifying and evaluating the emergency. This would normally be the owner or his representative: however, if the owner does not have the proper technical expertise, responsibility may need to be assigned to another individual. Appropriate alternatives should be designated to ensure that continuous coverage is provided.

4.2 Preventative Action

Where there are provisions for preventative actions available they should be clearly detailed in the EPP. These could include listings of the availability of machines, equipment, material and labour that are ready available to the dam operator in an emergency situation.

4.3 Notification Procedures

Notification Procedures must be clear and easy to follow. The EPP should contain a list of all persons to be notified in the event that an emergency is declared (For responsibilities of DSI units see Annex 3)

4.4 Notification Flowchart

A notification flowchart is a diagram showing the hierarchy of notification during an emergency. It is a pictorial representation of the notification procedure. The EPP should contain a notification flowchart clearly summarizing the notification procedure for each of the emergency conditions considered. (Draft see Annex 2)

4.5 Communications Systems

Full details of internal and external communications systems as they apply to the EPP should be included.

4.6 Access to the Site

The description of access should focus on primary and secondary routes and means for reaching the sites under threat under various conditions (e.g. foot, boat, helicopter, snowmobile)

4.7 Response During Darkness

The EPP should cover the response to potential or actual emergency conditions during periods of darkness including those caused by power failure.

4.8 Response During Adverse Weather

The EPP should address emergency response under adverse weather conditions including extremes of cold, snow or storms.

4.9 Sources of Equipment

The location and availability of equipment and contractors that could be mobilized in case of an emergency should be included.

4.10 Stockpiling Supplies and Materials

The location and availability of stockpiled materials and equipment for emergency use should be addressed.

4.11 Emergency Power Sources

Details on the location and operation of emergency power sources should be included.

4.12 Inundation Maps

Inundation map of the area will be prepared to show number of houses that would be affected by a major flood caused by a sudden failure of Yusufeli dam. These houses will be marked on the inundation map and approximate timing of first houses being hit by water after the dam failure will be indicated.

Inundation maps are needed by local authorities to develop an adequate evacuation plan. These will be developed by means of Inundation scenario studies.

4.13 Warning Systems

Warning systems (e.g. acoustic) are planned to provide warnings to settlements that are close to the dam. Full details should be contained within the EPP.

4.14 Appendices

Additional items may be covered in appendices to the EPP. General site plans may be useful. Drawings showing the potential breach location used in the inundation study may be included. Tables showing the variation in flood stage with time at key locations in the flooded area should also be included.

5. Testing and Maintenance of the EPP

The EPP shall be issued to those affected, and all registered copies of the EPP shall be updated.

The EPP shall be tested.

As updates or amendments to the EPP are produced they are forwarded to each holder (as listed in the EPP) and acknowledged by the recipient. Telephone numbers and names of contact persons should be updated on a regular basis, at least annually. It is helpful to place the EPP in a loose-leaf binder so that outdated pages can be easily removed and replaced with updated information, to ensure a complete, current and workable plan. A list of plan-holders should appear in the EPP.

Testing is an integral part of EPP to ensure that both the document and the training of involved parties are adequate. Tests can range from a limited tabletop exercise to a full-scale simulation of an emergency and can include multiple failures.

6. Training Program

Training shall be provided to ensure that dam personnel involved in the EPP are thoroughly familiar with all elements of the EPP, the availability of equipment, and their responsibilities and duties.

Technically qualified personnel should be trained in problem detection and evaluation and appropriate remedial (emergency and non-emergency) measures. This training is essential for proper evaluation of developing situations at all levels of responsibility, which initially, is usually based on observations on-site. A sufficient number of people should be trained to ensure adequate coverage at all times.

7. Inundation Studies

As part of the EPP preparation an inundation study shall be carried out based on assumptions that will indicate all areas that could be flooded for the most severe combination of reasonably possible conditions.

Various dam failure scenarios are normally studied: these cover rapid failure times, large breach sizes and conservative antecedent conditions. The potentially inundated area should be determined and the following conditions considered:

- Design flood failure
- Fair-weather dam failure:
    - At full supply level (piping, earthquake)
    - During winter conditions where ice jam formation is possible
- Failure induced by failure of an upstream structure

Using the results of the above modelling calculations, inundation maps showing the maximum flooded areas should be prepared.

Inundation maps should also be prepared for the reservoir rim and for areas affected by the backwater effect upstream of the reservoir. Two cases should be analyzed:

- Extreme flood exceeding the discharge capacity
- Reduction of discharge capacity during the passage of a large flood (for example, blockage by debris, or malfunction or non-operation of gates).

Legislation References

- Law No. 4373 on protection against floodwaters and flood.
- Law No. 6200 on DSI General Directorate's organization and duties.
- Law No. 7269 on Precautions and Aids in Case of Disasters Affecting Public, which was changed by Law No. 1051 and which was further amended by Law No. 5511.
- Municipality Law No. 5272.
- Law No. 5302 on Special Provincial Administration.
- Law No. 1593 on General Public Health Protection.

Annex 1. Emergency State Detection Systems

Emergency state detection is provided by means of:

- Observation stations
- Early warning systems
- Communication systems

Observation Stations

Observation stations in general are established according to;

- Recommendations of the District Directorates,
- Proposal of Department Head of Investigations and Planning Dept. and
- The approval of DSI General Directorate.

To be included in annual programmes, taking into consideration the following so that necessary logistics could be provided:

a) Observation stations for precipitation, flow and level are established at the places where life and property losses were experienced and declared as flood zones. if not already previously established by DSI or other institutions.

b) Snow observation stations are established in basins where spring floods are important due to snow melting.

c) Observation stations are installed to record reservoir inlet and outlet flows for reservoir operation studies of dams, which also function as flood protection.

However, for the case of Yusufeli Dam, the observation stations that would be set up shall be located at the confluence of side rivulets, which will be observed regularly during rainfalls to feed data into the system.

Early Warning Systems

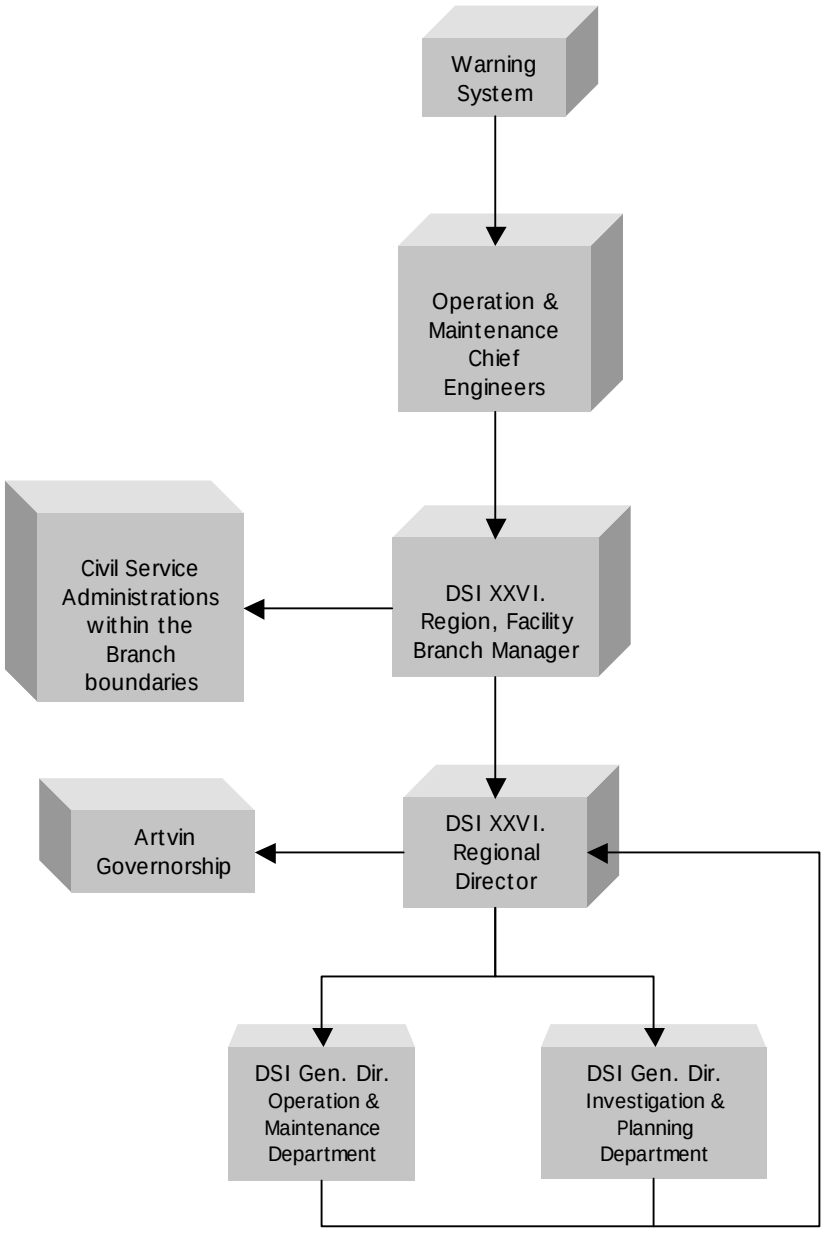
The number of automatic or semi-automatic warning systems will be increased in accordance with the outline of the new Yusufeli Reservoir established according to recommendation of District Offices, investigation of Head Departments of Survey and Planning, Operation and Maintenance and approval of DSI General Directorate by being included in annual programmes.

“Remote Sensing” and “Topographic Data System” will be installed to forecast or foreseen the flood, taking into consideration flood effects on river basin or river and characteristics of the basin.

Communication Systems

Effective communication system is established between the stations of precipitation, flow and warning, which are installed in the basin and bed of rivers that cause life and property losses, and the branch and operation centres of those stations, which the stations are affiliated to.

Annex 2. Notification Flow Chart



Annex 3. Responsibilities

1) Duties of the 26th DSI Regional Director:

Below are the duties of the Regional Director in the event of flood.

- Having been informed about the occurrence of flood, the Regional Director reports the situation and the damages thereof to the relevant department at the General Directorate via the most quick communication means.
- In the mean time he also informs the Governor of Artvin Province and issues necessary instructions to the relevant persons to mobilize the Maintenance Crews at susceptible areas for the protection of the installations.
- He then proceeds to the flood hazard area to see, inspect the magnitude and effect of the flood, its progression, and to observe the measures already taken and to decide in situ for the necessity of any further measures to be implemented/
- The Regional Director reports every day or at more frequent intervals during the flood period to the Heads of the Operation and Maintenance Department and the Investigation and Planning Department at the DSI General Directorate about the developments in the flood area.

2) Duties of the Installations Manager:

Below are the duties of the Installations Manager of DSI District Directorate in the event of flood.

- Having been informed about the occurrence of flood within the area of his department, the Installations Manager immediately reports the situation to the Regional Director and the Civil Service Administrator of the region via the most quick communication means.
- He secures transfer of the assigned maintenance crew to DSI's facilities to take measures for protection during the flood period within the boundaries of the branch and proceeds to the flood hazard area in order to inspect the implementation of measures.
- He maintains the continuous stay of the observers at the flow observation stations in order to take the necessary records throughout the rain fall and until the water level recedes to the normal level. A person is kept on duty day and night at the District centre in order to record all the information to be provided at any time from the flow observation stations in the flood hazard area.
- He evaluates the status of the flood, its continuity, damages if any, extent of the effected areas, the measures taken and the effectiveness of the said measures in consideration of the information obtained from the peripheral meteorology stations; and reports them to the Regional Directorate.

3) Duties of the Operation and Maintenance Chief Engineers and Operation and Maintenance Engineers:

Below are the duties of the Operation and Maintenance Chief Engineers and Operation and Maintenance Engineers of DSI in the event of flooding.

- The Operation and Maintenance Chief Engineer and Operation and Maintenance Engineer on duty in the area of flood keeps contact with his installations manager and reports the situation and acts upon the instructions of the installations manager regarding measures to be taken.
- He inspects the activities of the crew assigned to alleviate the possible damages to the installations during flood and keeps continuous contact with the installation manager to inform him regarding the ongoing implementations.
- He reports to his department the information to be obtained from the observers in the observation stations and relevant departments.
- The Operation and Maintenance Engineer in charge of the Yusufeli Dam studies and evaluates daily the reservoir water level fluctuations, which is recorded continuously by means of installed water level gauge. The evaluation takes into consideration the daily riparian discharges through the bottom outlet, daily discharge for power production, spillway discharge and evaporation from the reservoir based on meteorological data. In this way seasonal variations of the reservoir level are determined for the whole year. The operation of the reservoir being under the responsibility of DSI aims to keep the water level at Elevation 710 m ASL as close as possible, for which the spillway gates are to be operated whenever the level tends to increase above 710 m ASL. If this tendency coupled with meteorological forecast indicates an expectation of an exceptional inflow then he immediately informs the Installations Manager so that necessary standby alarms could be given to the responsible Public Administrators.

4) Duties of the Observers:

The observers report to the nearest DSI organization via the fastest communication means as soon as the rainfall and water level increase starts. The observer acts upon the instructions he is given.

He stays on duty during the rainfall until the normal status of water level is reached; he keeps the necessary records as long as the flood lasts and frequently reports the situation to his managers as per the instruction he is to be given.

5) Duties of the Operation and Maintenance Department at DSI General Directorate:

Below are the duties of the Operation and Maintenance Department:

- Evaluates the information to be obtained from the District Directorate, and defines the requirement of immediate measures for maintenance and repair.
- He investigates the installations as regards the damages and deteriorations that have occurred and defines the needs for maintenance-repair and conducts the removal of the damages and deteriorations within the scope of annual or additional programs.

6) Duties of the Investigation and Planning Department at DSI General Directorate:

Below are the duties of the Investigation and Planning Department:

- This department confirms the information in the content of the news obtained from Operations and Maintenance Department and establishes contacts with the District Directorate in order to obtain more detailed information of flood. Makes evaluation of the information obtained. Where necessary, reports them to the General Directorate. Furthermore, he also informs the Operation and Maintenance Department of damages to the DSI installations if any.
- He also evaluates the flood information directly obtained from the District Directorates and informs the relevant authorities where necessary.
- It conducts in situ examinations according to the magnitude of the flood. If required, establishes joint groups in cooperation with the Project and Construction Department and the Operation and Maintenance Department for the execution of in situ examinations.

7) Responsibilities of the Regional Directorate

a) During Operation of Yusufeli Dam

After completion of the Yusufeli dam and its appurtenant structures, "Yusufeli Dam Safety Study File" and its appendices that are prepared in the planning, design and construction phases, will be kept by the Head of Operating and Maintenance Department at DSI General Directorate and at the 26th Regional Directorate. Necessary precautionary measures will be taken in line with the principles of "Dam Protection Regulation" and related Regional Directorate will determine the way of benefiting from dam and its appurtenant structures and related prohibitions.

b) During the Failure

DSI, 26th Regional Directorate established a "Flood Commission" to deal with flood related emergency situations. The commission comprises of the Regional Director, three Deputy Regional Director and six Section Managers, in total ten persons. As soon as an alert of dam failure is received the "Flood Commission" gathers under the chairmanship of the Regional Director; in his absence the Deputy Regional Director heads the Commission. The Commission decides about the measures to be taken and monitors the implementation until the emergency situation ends.

According to 7269 and 4373 numbered Laws, Province Governorates are authorized starting from the moment flood alert is given to take measures in the flooded area by utilizing personnel and the means of the Public Administrations.

DSI, 26th Regional Director acts as an assistant and technical consultant to the Artvin Governor for the measures that will be taken by the Governorate to evacuate the flooded areas and to make preparations for emergency response teams in terms of material and equipment. DSI organization unit managers are held available with available resources and equipment to assist all kind of measures that will be taken by Public Administration to mitigate the damages resulting from flood.