



# **STRATEGY FOR PROTECTION AGAINST FLOODS IN THE CZECH REPUBLIC**



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Floods in 1997 - Morava River (Olomouc)



Floods in 1998 - Bělá River (Deštné v Orlických horách)





Floods in 1999 - Cidlina River (Loukonosy)



Floods in 2000 - Elbe River (Dvůr Králové nad Labem)

**Prepared under the co-operation of  
Ministry of Agriculture and Ministry of Environment**

# **STRATEGY FOR PROTECTION AGAINST FLOODS IN THE CZECH REPUBLIC**

**(approved by Resolution of the Czech Government No. 382  
of 19 April 2000)**

Prague  
Czech Republic  
April, 2000



## **1. Introduction**

Floods are a natural phenomenon whose occurrence cannot be avoided. Their irregular occurrence and variable areal extent affect unfavourably awareness of risks they pose, which complicates efforts to implement systematic preventive measures. For the Czech Republic, the floods represent the highest direct risk stemming from natural disasters and they can be a casual factor of serious crises, which can be associated with high damages to material property and also losses of human lives in the areas affected by floods, and, in addition, with devastation of cultural landscape and ecological damages.

The above facts were also substantiated during catastrophic flood that occurred consequently to long-lasting intensive precipitation in summer 1997 and July 1998 flood, which was caused by short intensive precipitation concentrated on a small area. The consequences of these floods (60 victims and damages amounting to 62.6 milliard CZK in 1997, 10 victims and damages amounting to 1.8 milliard CZK in 1998) substantiated the fact that the society was highly vulnerable in terms of flood danger as a consequence of urbanisation, technical development, facilities of municipalities and houses, and production plants located in flood plain areas.

Simultaneously, also precautionary principle and principles that systematic preventive measures should be taken were highly neglected because the last floods with fatal consequences occurred in the Czech territory at the end of 19th century. Also the development of systems of water management structures on watercourses together with the construction of dams and formation of large water retention capacities reduced successfully the extent and consequences of less extreme floods. These facts were reflected in low awareness of the flood risks and certain stagnation of the activities focussed on the development of systems of preventive measures for protection against floods.

Protection against floods can never be absolute, however, it is possible to reduce partially the flood flows, to transform flood hydrographs and thus to affect favourably time evolution of floods, which allows us to take more effective measures for protection of lives and properties. Adequately to the development in a number of European countries, which experienced extensive floods during 90th, also the catastrophic floods that occurred in the Czech Republic in 1997 and 1998 were reflected in higher awareness of the importance of the protection against floods in the country. This change was also strengthened by high financial means that had to be allocated, mainly from public budgets, for elimination of the damages caused by the floods.

The damages caused by the floods together with predicted impacts of global warming initiated preparation of strategic materials in a number of European countries. The objectives of these materials are to analyse casual factors of the floods and their evolution, and to propose systematic measures to ensure an improvement in the flood protection. This was also one of the factors that initiated formulation of a new water policy of European Union. The development in the Czech Republic was practically identical. On the basis of the results of a detailed assessment of the catastrophic flood in 1997 and experience from basic restoration of the affected areas, the Czech Government has assigned a task to prepare a Strategy for protection against floods as a basis for a systematic approach in this area and a basic material for preparation of necessary measures.

## **2. Strategy for protection against floods**

The Strategy for flood protection is a document which uses experience from previous floods and takes into account technical standards, legislation and organisational framework in formulating further actions for reduction of devastating impacts of floods. The Strategy forms a framework for preparation of specific actions and preventive measures aimed at improving systematic protection against floods in the Czech Republic. Its objective is also to form a basis for the State or local administration in making decisions concerning selection of specific measures for protection against floods and in influencing regional developments. In addition to its factual content, this document represents also a policy affecting

the activities of the State or local administration and social-economic development in the Czech Republic.

One of the important objectives of the Strategy is also to define the scope of responsibilities in the flood protection system at levels of the State and local administration, and responsibilities of public (individuals) and business companies. Omission of these aspects leads to excessive expectations concerning full responsibilities of the State, to absence of effective prevention at local level, and to insufficient involvement of the public.

The principles of the Strategy for flood protection in the Czech Republic, which have been derived from the analyses of the floods in the Czech Republic and experience from other countries, are as follows:

- preventive measures for protection against floods represent the most effective type of the protection,
- it is necessary that owners and administrators of properties, including organisations at levels of regions, districts, municipalities or individuals, be involved in the implementation of preventive measures for reduction of flood damages,
- effective preventive measures have to be taken in the areas of river basins and it is necessary to take into account mutual integration of effects of individual measures implemented along watercourses,
- for effective protection against floods, it is necessary to select a suitable combination of land improvements, which support natural capacity to retain water, and technical measures affecting flood flow discharges,
- for specification of flood protection measures, it is necessary to use reliable information on geomorphological conditions, vegetation cover and soil types, and to apply advanced information technologies allowing simulation of floods, i.e. it is necessary to use those types of information which improve knowledge concerning extent and evolution of floods and simultaneously allow us to assess effectiveness of the selected measures along the whole longitudinal profile of a river,
- for the purposes of the control of measures for the protection of inhabitants and properties in flood plain areas, it is necessary to ensure an improvement of information systems providing information during floods and to improve preparation of flood protection plans,
- with respect to the geomorphology of the territory of the Czech Republic and its geographical location, it is necessary to resolve problems associated with flood protection within the framework of international co-operation, mainly through implementation of the adopted international agreements on co-operation in basins of transboundary rivers,
- with respect to financial requirements, the implementation of effective flood protection measures is a long-term objective and the State policy will be aimed at supporting preventive measures preferably to compensating flood damages,
- the Strategy is a conceptual document, which is open to further suggestions reflecting new knowledge and results of the implementation of the proposed measures.

## **2.1 Flood forecasting and warning service**

Availability of timely and reliable information is one of the basic conditions for an improvement of the protection against floods. This type of information is essential for the control of flood protection measures and contributes to substantial reduction of the flood damages.

Effectiveness of flood flow forecasting in the Czech Republic is limited by travel time of the flood flows. Theoretical time advance of the forecasts made for large rivers is 1 to 2 days, while the forecasts for small rivers in the Czech Republic are of low practical applicability because the travel time under Czech conditions is only several hours. The flood forecasting services are provided by Czech Hydrometeorological Institute together with administrators of those watercourses that are important for water management. The main aims of the services are to inform flood protection bodies and other participants involved in the flood protection about risks of flood occurrence and evolution of floods.



In recent years, high attention was paid to the development of the forecasting services. A number of investment and non-investment projects that were initiated by Czech Government in 1998 is presently in the implementation phase. These projects include mainly construction of automatic meteorological and hydrological networks including installation of meteorological radars for timely identification of possible precipitation and subsequent floods and also introduction of advanced forecasting methods based on mathematical modelling. It is necessary for the Czech Republic to ensure an improvement of medium-range weather forecasts by concluding an agreement with European Centre for Medium-range Weather Forecasts (ECWFM). This will improve forecasting of those situations that are dangerous in terms of possible flood occurrence.

The flood warning services are organised by flood protection bodies together with other participants involved in the flood protection, mainly administrators of watercourses and operators of hydraulic structures. These services ensure regular collection and dissemination of information on the flood evolution at individual river sites. This information is used by the flood protection bodies in forwarding the warning messages to the population and organising measures for protection against the flood. The system of the flood warning services is decentralised, based on the activities of all participants involved in the flood protection, adapted to local conditions and it uses all communication and warning means that are available. At individual levels of the control of flood protection activities, it will be necessary to ensure integration between flood warning services and flood protection plans.

In order to ensure timely warning in the areas exposed to a risk of the occurrence of sudden floods, whose evolution can be fast with catastrophic consequences, it is necessary to support construction of local warning systems. These autonomous systems are capable of providing warnings with a time advance which would be impossible to be ensured by using central systems. The principle of these systems is mostly based on monitoring of precipitation and assessment of its intensity. The installation of these systems should be made under supervision of Czech Hydrometeorological Institute as an organisation guarantying suitable setting of their parameters. Initiation of a Programme of the construction of local warning systems is proposed in a material on Targets of the preparation of programmes for protection against floods, which has been prepared and submitted to the Government simultaneously with the Strategy. It is necessary to ensure compatibility of warning systems at different levels of the State administration and to ensure conditions for allocation of financial means from several sources.

## **2.2 Flood control measures**

Effective flood control measures have to be based on a suitable combination of land improvements and technical measures.

### *2.2.1 Land improvements*

It is necessary to concentrate the effort towards attaining an equilibrium stage between economic development and urbanisation on the one hand and the needs to use the land for flow retardation and water retention on the other hand. In designing any measure for protection against floods, possible impacts on the environment have to be taken into account.

The land improvements include mainly changes in land use, changes in vegetation cover, grassing of river banks and natural inundations (flood plain areas), construction of protective dikes against erosion and vegetation belts, and changes in land structure made with the aim to retain water in the basin and to attain flow retardation.

Extreme precipitation can be a casual factor not only of floods but also of instability of slopes in the flooded area. The instability of slopes can be associated with extreme damages to the lands and premises and can also affect unfavourably evolution of floods. Therefore, observation and assessments of slope instabilities and measures taken to avoid landslides form one of indispensable elements of the Strategy for protection against floods.

Maximum flood flows, particularly in small or midsize basins, can partially be reduced by measures aimed at maintaining or improving natural retention capacity of lands, watercourses and flood plain areas. Natural inundation areas should be maintained and suitably used, i.e. they should meet their function in retaining flood flows. The water which is retained will infiltrate into soil and thus this water is available for further use and simultaneously reduces risks stemming from extreme precipitation and floods.

The measures based on land improvements should not be underestimated because they constitute an important component of preventive measures, however, their effect mainly during extreme floods should not be overestimated because they are able to reduce peak flows of extreme floods only by several percent. To support the implementation of these measures, it is necessary to utilise the existing programmes that are aimed at improving conditions of the environment and its components. Schemes on integrated land arrangement are the main tools for their implementation. The implementation of these measures evokes also costs associated with buying back of lands and compensation of losses, and it is associated frequently also with the need to ensure substitutive employment opportunities because these measures affect mainly farmers.

The roles of the State in this area are mainly to specify practical measures for protection against floods, to check their implementation and effectiveness, to co-ordinate implementation of flood protection measures in river basins, to implement those investment protective measures that have been approved as a component of certain degree and type of planning documentation, to co-ordinate policies of individual sectors, to prepare a system of incentives motivating improvement in land management, and to amend and harmonise relevant legislation and technical standards.

The role of municipalities in this area is mainly to influence favourably land management practices in the territories of their administrative units.

### *2.2.2 Technical measures*

The aim of technical measures is mainly to mitigate impacts of floods by retaining a part of their volume and thus by reducing maximum flows or avoiding overflowing of water onto land.

Systematic measures whose functions are mainly to retain a part of the flood and to reduce its travel time affect favourably a degree of the flood protection in certain reach of the river (in a part of the basin) and they do not deteriorate the situation in lower parts. The implementation these measures which include mainly retention reservoirs and polders is ensured by the State. With respect to mostly high costs of the implementation of these measures, it is always necessary to take into account their effectiveness, to assess the costs in relation to assets that are protected, and to make an environmental impact assessment. Intentions to construct technical structures have to be reflected and approved in regional plans and thus they are subject to prior public inquiry. The construction of the water management (hydraulic) structures is associated also with operational costs required for maintaining of these structures in safety and operational conditions. It is mainly necessary to ensure technical and safety supervision and to use advanced measuring and control systems in the operation of these structures and in managing the retained water.

The retention capacities of small water reservoirs are normally small and thus these reservoirs are able to retain only small floods. However, flood hydrograph transformation by these reservoirs helps locally (in areas located downstream from the reservoirs) because it provides additional time for flood protection activities.

Local flood protection measures are aimed at protecting individual municipalities, which are responsible for the implementation of these measures. The role of the State is to co-ordinate the implementation of both types of measures by means of systematic planning to ensure that evolution of floods is not deteriorating in the downstream direction.

The current unfavourable situation in the flood protection cannot effectively and satisfactorily be improved only by using nontechnical measures. It was estimated that investments amounting to 10 to 20 milliard CZK would be necessary to be available in a period of about ten years to ensure adequate level of the flood protection.

Final decision concerning the flood protection techniques, degree of the flood protection and optimum combination of flood protection measures will have to be made on the basis of an assessment of the effectiveness of individual measures by using mathematical simulation models and a risk analysis involving also impacts of floods on lands and the environment. The implementation of the proposed flood protection measures should be ensured by their incorporation into relevant planning documentation.

It is necessary to open discussions about priorities of investment schemes for protection against floods in relation to the State budget and to develop a subvention policy for the investments associated with local flood protection measures of individual municipalities. The implementation of these measures could also be supported from the State budget.

Programmes aimed at meeting the above needs are proposed in a material on Targets of the preparation of programmes for protection against floods, which has been prepared together with the Strategy.

## **2.3 Reduction of risks to population and potential damages**

Continuing urbanisation and economic growth in the areas exposed to floods are associated with further increase in a number of population in danger and with potential economic and cultural damages. It is therefore necessary to designate these areas as flood plain areas or areas exposed to special floods and to regulate adequately their use.

### ***2.3.1 Delimitation of flood plain areas***

For making strategic decisions concerning the implementation and extent of flood protection measures, it is necessary to know the extent of areas exposed to flood danger and characteristics of natural and special floods (flood hydrographs, duration of floods, flow velocity in flood plain areas, etc.). These characteristics are essential for identification of a degree of danger and potential damages and subsequently for making decisions concerning the use of individual parts of the areas exposed to floods, and for risk analyses that are necessary to be made for the development of flood protection plans and adoption of short-term and long-term measures for the flood protection. These characteristics are necessary to be derived, together with the delimitation of flood plain areas or areas exposed to special floods, on the basis of assessments of runoff conditions in individual river basins.

For the delimitation of the flood plain areas it is necessary to ensure exploration of high conditions in areas located along individual watercourses and production of accurate maps. However, the costs of these activities exceed those which could reasonably be covered from budgets of water management authorities. An effective technique could be aerial geodetic photographing and subsequent use of the photographs for the production of digital (computerised) relief model and ortho-photomaps. In addition, all available and relevant results of geodetic measurements can be used. The use of the digital relief model will permit the application of technologies of mathematical modelling which can provide significantly wider knowledge of the flood evolution. However, high costs of these activities are one of the factors which hinder the progress in delimiting the flood plain areas. By the present, the delimitation has been completed for about one third of the watercourses which are important for water management.

The above problems accounted for the fact that one of the priority objectives of the Strategy is to ensure fast delimitation of the flood plain areas along all important watercourses, while further actions will depend on the results of a necessity assessment. Financial requirements associated with this stage are about 300 million CZK.

For special floods, it will firstly be necessary to select priority regions to be assessed with respect to possible evolution of special floods and to prepare a timetable for delimitation of areas exposed to a danger of the occurrence of special floods. In these activities, new knowledge gained from mathematical technologies should be applied.

In an implementation phase, evolution of special floods and the extent of areas exposed to special flood danger will be derived for the priority regions.

The flood plain areas delimited for natural floods will be shown in a Map of flood plain areas of the CR 1:10 000. Availability of this information for public will further be facilitated by the development of its digitised version, which will be a component of Basic Database of Geographical Data (designed by acronym ZABAGED). A contour line of the areas flooded during catastrophic flood in July 1997 (derived in a Project on an assessment of July 1997 flood) will also be transferred into the ZABAGED database together with other flood contour lines available.

Individual municipalities can optionally prepare a Map of flood plain areas of a municipality in higher resolution (it is recommended to use 1:5000) showing also risks in terms of flow velocities and water levels during floods. These maps should not be in contradiction with the Map of flood plain areas of the CR 1:10 000, however, these more detailed maps can be a component of graphic documentation of development plans of municipalities. In producing these maps, it is necessary to meet provisions of technical standards concerning water sector and also those concerning geographical information. Maps of this type should be a component of flood protection plans or evacuation plans for contingency control. Their use should also be taken into account in legislation on appraising fixed properties.

Further delimitation of the flood plain areas located also along small watercourses will be made in strategic and planning documentation of basin authorities.

Information on flood plain areas and regulations issued by water management authorities for the use of the areas in natural inundations form binding limits to be applied in the preparation of the development plans. This approach will ensure that the principles of the strategic protection system will be reflected in the development plans of large regions as well as of individual municipalities.

### *2.3.2 Regulation of use of flood plain areas*

Basic trends that are presently applied in foreign countries are based on limiting economic activities in flood plain areas instead of taking flood protection measures irrespective of the costs. This trend defined as to give space to water is not presently supported by the Czech legislation and thus majority of available financial means is used for restoration activities in flood plain areas. The first step towards supporting this trend was made in new Water Law by defining active and passive zones in flood plain areas.

The requirements of the Strategy are to limit the existing housing and production functions of active zones and to prohibit new construction of those structures that have completely been destroyed by floods. Further objective is to achieve protection appropriate for conditions in individual localities by promoting investment activities of local population aimed at improving flood protection of their premises.

The use of agricultural land in flood plain areas should be aimed at maintaining water infiltration capacity of soil, mainly at avoiding high compression and erosion of soil, and at developing a network of agricultural roads which would take into account ecological requirements, including practices such as contour tillage. Newly constructed flood polders should preferably be used as meadows and pastures and also wetlands should be restored where appropriate.

Examination of the status of the flood protection in areas exposed to floods can be ensured through flood protection inspections that have been incorporated into the existing legislation and form also a component of proposals that are being prepared. Relevant authorities should significantly promote their activities in applying this control tool.



## **2.4 Protection of property**

One of the most important principles of the Strategy is that it is everybody's duty to protect adequately his property against floods. The principles proposed in relation to property protection were already incorporated into A proposal of systematic measures for land restoration after floods or other natural disasters, which was adopted by the Czech Government Resolution No. 721 of 14 July 1999. The proposal reflects views of district authorities and of some municipalities from areas affected by floods.

With regard to the costs of the flood protection, Law of Czech National Council No. 130/1974 Coll. On the State administration in the water management sector, as amended by later regulations, specifies that legal and natural persons cover the costs of the protection of their lives and property, the costs of the protection concerning watercourses are covered by the their administrators and the costs associated with the protection and safety of hydraulic structures are covered by owners or users of these structures. On the basis of experience from compensation of damages caused by 1997 flood, it was proposed to adopt wider differences in the approaches to individual types of the property owners. These principles were also incorporated into a proposal of new Water Act.

### ***2.4.1 State property***

The State administration and institutions administrating the State property undertake responsibility for adequate protection of this property against floods. In case that the State property is damaged by a flood, the Government will preferably allocate financial means for elimination of this damage, recovery of necessary economic functions and restoration of watercourses in the flooded areas.

In case that budgets of individual Ministries are augmented with the aim to compensate flood damage to the State property, it is always necessary to ensure that these financial means are related to particular list of damages and the use of this money is subject to subsequent inspection. Similar procedure shall be adopted in case of augmentation of budgets of district authorities.

The State property may be insured against risks of flood damages if appropriate with respect to the type of the property and if the insurance costs in distant time horizon do not exceed probable level of the damages.

### ***2.4.2 Property of municipalities***

Individual municipalities can take measures for the protection of urban areas in their territories. The costs associated with the implementation of these measures are covered from budgets of individual municipalities, which can also apply for the State subsidy. The municipal authorities may also require financial contribution from owners of the property which is protected by the implemented measures.

The municipal property may be insured against risks of flood damages. With respect to Articles 170 and 171 of Agenda Habitat adopted in Istanbul in June 1996 (Habitat II), the Government may adequately contribute to the implementation of measures for restoration of school and health care facilities which are ownership of a municipality or a region.

In order to create sufficient financial reserve, the proposal of Water Law assumes an establishment of special items in budgets of regions. These financial reserves could be used for the implementation of flood protection preventive measures in river basins and for compensation of flood damages.

### ***2.4.3 Property of population and business companies***

Natural and legal persons (individuals and business companies) should pay the costs of their measures directed towards protection of their property against floods. Individuals and business companies should be protected against damage or destruction of their movable and immovable property by relevant insurance agreements. Insurance companies in the Czech Republic offer sufficient market of insurance products in the area of property insurance and insurance against liability for damage. An analyses con-

ducted by the insurance companies did not identify any barriers or geographic regions which could constrain conclusion of agreements insuring property of the population against risks of damages caused by floods.

Financial social aid for overcoming emergency situation (purchase of basic foodstuff or clothing) is unacceptable to be conditioned by property insurance and also State financial assistance for restoration of housing should not be related to this fact. The State financial assistance for the housing restoration should preferably be implemented through loans and credits and this system could offer some advantages to those who have concluded insurance agreements.

It has been proposed to promote public awareness and approaches by reflecting flood risks in individual localities into simple economic parameters. Such risk should be reflected e.g. in land market, mainly in the prices of building sites, urban areas and lands covered by arable soil. Immovable property owners and farmers could be motivated to conclude flood insurance e.g. by direct tax advantage allowing them to abstract the insurance payments from the income. Methods of indirect economic incentives could favourably affect the number of insurance agreements concluded for immovable property, mainly for residences, and consequently also indirect financial reserves potentially available for compensation of flood damages.

#### *2.4.4 Assessment of effectiveness of measures taken*

For further progress in strategic decision making, it is necessary to assess effectiveness of measures that have been taken with the aim to limit flood damages. To meet this purpose, it is necessary, for collecting and assessing data on flood damages in long-term time horizon, to use such methods and forms which are able to ensure types of information corresponding to those collected in member states of European Union. For statistical analyses of flood damages, it is therefore appropriate to use geo-statistical models supported by GIS environment.

The statistical information and the model could be used for the purposes as follows:

- for making immediate decision about material and financial aid from the State reserves in cases of catastrophic floods,
- for governing activities aimed at restoring the flooded areas,
- for assessing effectiveness of measures that have been taken.

The geo-statistical model of flood damages could be combined with flood routing models for simulation of potential risks associated with floods of different types and extremities. In order to facilitate the use of the models for assessments of economic effectiveness of measures taken, it is necessary to impose duties on insurance companies to provide data on compensations paid for damages caused by floods, if such information is necessary and required for the purposes of State Authorities undertaking responsibility for the geo-statistical information. Types and particulars of the information and conditions under which such information can be provided will have to be specified in new legislation.

The surveys and analyses of flood damages cannot be ensured by applying provisions of Law No. 89/1995 on State statistical services because these analyses will use individual data. It is therefore necessary to adopt a special law which will specify conditions and procedures for initiating and conducting these analyses. It is simultaneously necessary to develop a method for this type of investigation and analyses. This method should be submitted to Czech Statistical Office for its approval.

The statistical investigation and analyses of flood damages do not substitute flood assessments which are being made in accordance with Czech Government Decree No. 100/1999 Coll. and which have been incorporated into a proposal of new Water Law. The statistical investigation and analyses of flood damages can be applied also in emergency management and will be harmonised with actions required by the Law No. 240/2000 on emergency management and Law No. 239/2000 on integrated rescuing system.

## 3. Implementation of the Strategy and related aspects

### 3.1 Legislative measures

Law on waters which is just being adopted will be a basic legislative document regulating the management of the activities in the flood protection. Actions and responsibilities in ensuring rescue activities will be specified in the Laws on emergency management and on integrated rescuing system, whose draft is currently being discussed by the Chamber of Deputies of the Parliament, and Law on economic measures for emergency situations. Responsibilities in eliminating flood damages will be specified in Law on land restoration after floods or other natural disasters, which is just being prepared.

### 3.2 Integrating elements

Planning and strategic documents in the area of the protection and use of water are one of the main tools for the implementation of the State and regional policies in this area and these documents form also background materials for regional planning and formulation of strategic intentions of regional development. Types of these documents are formulated more specifically in the new Water Law, whose intention is to develop an integrated system, which would meet also relevant requirements of EU legislation. One of the substantial aspects of these documents focuses on mitigation of harmful impacts of water and on preventive measures, which should be taken in individual basins in several steps as follows:

- an assessment of current conditions including delimitation of flood plain areas, areas exposed to risk of the occurrence of special foods and estimation of potential flood damages,
- development of preliminary alternatives of flood protection measures, including evaluation of associated costs, technical feasibility assessment and environmental impact assessment,
- implementation of risk analysis and determination of a degree of the flood protection, discussion and consideration of the preliminary alternatives and selection of a final alternative,
- detailed development of the final alternative,
- development of action plan,
- transposition of the measures from the action plan into regional development plans and flood protection plans.

Regional planning is a tool which ensures permanent and integrated planning of functions and use of the region, specifies principles for its organisation and co-ordinates investment activities and other activities affecting the region. It should also form conditions for ensuring permanent harmony of all natural, civilisation and cultural functions in the region. Further role of the regional planning is to advocate implementation of the planned measures, to make proposals for appropriate use of flood plain areas and to resolve conflicts with other requirements for the use of the region.

### 3.3 Objectives of science and research

Research programmes should support mainly the development of rainfall-runoff mathematical models and models for simulation of flood hydrographs. In this area, an international co-operation could be developed. The national research should preferably be focused on examination of model parameters for the territory of the Czech Republic and on methods for assessing potential damages in the areas exposed to flood risk. In carrying out these projects, particular attention should be paid to assess the requirements for resolution, precision and accuracy of the digital elevation model, which is based on topographic data of the ZABAGED database maintained by Czech Office for Surveying, Mapping and Cadastre. This part of the research cannot be substituted by international experience.

It is also necessary to pay further attention to the development of methods for the use of photogrammetry and remote sensing in investigating and documenting flood situations. Research in the area of instability of slopes will be focused on several-year exploration and studies of slope deformations in the Czech Republic with the main objective to assess risk exodynamic phenomena in selected regions.

### *3.4 International aspects*

Geographical location and characteristics of the territory of the Czech Republic are factors responsible for the fact that the international co-operation in the flood protection has traditionally been developed within the framework of the activities of International Commissions for protection of large rivers (the Elbe, Oder and Danube).

The highest progress in this area has been achieved in the Oder Basin, for which the co-operating countries have developed a joint strategy involving also aspects of regional planning and land use regulation. The attention has presently been focused on the development of a joint Action plan.

An assessment of the status with regard to flood protection has also been made for the Elbe Basin, with the main attention paid to water management activities and less effort given to relationships with regional planning. The activities are presently aimed at making an inventory of problems and proposing possible solutions.

An international reporting and warning system for the Danubian countries, which has been put into operation, is aimed at ensuring timely warning in case of transboundary pollution. This system communicates also via satellite and it is intended that it could be used in case of floods and ice formation.

The objective of this international co-operation is to develop joint documents specifying strategies and action programmes aimed at improving protection against floods. Relevant projects could financially be supported from programmes and funds of European Union, such as PHARE CBC, INTERREG or SAPARD, however, actions of individual co-operating countries and sectors have to be co-ordinated.

## **4. Conclusion**

**Problems associated with the existing preventive system in the area of flood protection, which were detected by the analyses of floods in 1997 and 1998, will require adoption of integrated and systematic measures. These facts initiated the preparation of this Strategy, whose objective is to improve significantly the flood protection system. The basic principle of the Strategy is based on prevention, which uses advanced approaches for the development of efficient and cost-effective measures. The aims of the Strategy should be ensured by implementation steps that are specified in Targets of the preparation of programmes for protection against floods, which were prepared simultaneously with the Strategy. A necessary condition for the implementation of the Strategy is to ensure financial resources for projects aimed at collecting information for making decisions about individual flood protection measures and subsequently for the implementation of these measures. Another relevantly important objective is to improve public awareness concerning flood risks in the Czech Republic and to ensure that both the State Authorities and wide public are involved in the implementation of the preventive actions.**



# APPENDIX

## Complementary information on problems associated with floods in the Czech Republic

### *Formation and assessment of floods*

In accordance with a definition laid down in Czech Government Decree 100/99 Coll. on protection against floods, a flood is a temporary noticeable increase in the water level in a watercourse or other surface water body, posing danger of overflowing the channel or already flooding the surrounding land, and being possible causing factor of a damage; a flood is also a condition under which water cannot temporarily flow away in a natural manner or the outflow of water is insufficient (e.g. due to ice jam). A flood can be caused by natural casual factors, mainly by snow melting, rain or transport of ice masses (natural flood) or by artificial factors, particularly by a failure of a hydraulic structure, which can lead to its damage, or by an emergency measure taken in critical situation in terms of safety of a hydraulic structure (special flood). A flood causes economic damages by dynamic impacts of the running water, by flooding of lands, houses and installations and can also be a casual factor of losses of human lives.

Magnitude of a flood is normally assessed by its maximum (peak) flow (m<sup>3</sup>/s). In designing flood protection measures and assessing their effectiveness, a flood (its peak flow) with given return period (e.g. 10, 20, 50, 100 years) is frequently used. Volume of flood hydrograph is less frequent parameter in assessing flood magnitude, and synthetically derived flood hydrographs are used only in special cases.

Typical attribute of extreme and damaging floods is irregularity of their occurrence. Historical data indicate that extreme floods were relatively frequent in the second half of the last century. The flood frequency was gradually decreasing and it was particularly low during the first half of the 20th century. However, during recent years, mainly in 1997 and 1998, the Czech territory experienced damaging floods, whose extremity in terms of the extent and consequences exceeded that of any flood that occurred in given regions of the Czech Republic during the last 100 or 200 years.

The natural floods that occur in the CR can be divided into several types related to their seasonal occurrence:

- winter and spring floods caused by snow melting which can be combined with rain,
- summer floods caused by long-lasting regional precipitation,
- summer floods caused by short high-intensity storms (these floods occur mainly on small rivers with catastrophic consequences mainly in those basins which are highly declined and fan-shaped, these local floods are most frequent in the CR),
- winter floods, which can occur also during lower flows being caused by blocking of the flow by formation and transport of ice masses.

Hilly character of the most part of the CR territory (altitude of 78% of the CR territory is between 200 and 600 m a.s.l.) is a casual factor of the facts that precipitation water does not retain on the territory for long time and water from storms outflows very quickly. The time interval between the occurrence of a rain and of resulting flood is mostly very short. Under these conditions, it is very important to ensure high-level forecasting, mainly hydrometeorological forecasting services.

### *Flood damages*

The territory of the Czech Republic does not belong into risk areas in terms of the occurrence of natural disasters of seismic or volcanic origin, nor disasters originating from climate extremes such as hur-

ricane or tornado, and thus floods represent the highest natural risk. Results of a systematic examination of flood damages in the CR during 1971-1990 show that mean annual flood damages amounted to 500 million CZK (at 1990 price level). However, this period experienced floods, whose damages were several-fold compared to this average, such as the flood in 1991, whose damages exceeded 3 milliard CZK. Results of a detailed examination show that damages caused by 1997 July flood reached 62.6 milliard CZK and those of 1998 July flood amounted to 1.8 milliard CZK.

The flood damages depend mainly on the following factors:

- magnitude and evolution of the flood, which can be described by its maximum flow, shape and volume of the hydrograph, and the duration of the flood,
- conditions and capacity of river channels, extent and effectiveness of preventive technical and non-technical measures for protection against floods,
- structure and use of urban areas and mainly their location with respect to flood plain areas,
- reliability of the flood forecasting and warning services,
- time advance of public notification concerning flood danger,
- readiness and ability to organise measures for protection of lives and properties during floods,
- readiness to organise flood rescue activities and their promptness.

### ***Development of approaches for protection against floods***

The development in the area of flood protection in the Czech Republic was affected by the fact that for long time before 1997 the territory of the CR did not experience any flood with really catastrophic consequences. This was reflected in insufficient awareness of the risks stemming from possible floods and consequently in increasing risks associated with the use of lands in flood plain areas and decreasing awareness of the importance of preventive measures to be taken for protection against floods. Practically no advance was made in the area of the use and development of nontechnical preventive measures.

Main tools in use for the protection against floods were as follows:

- regulation of river channels and extension of their capacities with the aim to attain the highest possible protection of urban areas and agricultural lands,
- technical measures that were applied for watercourses and in flood plain areas frequently to ensure fast outflow of water,
- flood forecasting and warning systems (hydrometeorological forecasts, etc.)
- development of flood protection plans of territorial units, determination of the activities of rescue services, etc.

These measures and activities were organised mainly by the bodies of the State administration but without wider involvement of the public and users of relevant lands. Further lacks in the development in the area of the flood protection were as follows:

- absence of a system of responsibilities and financing of measures for protection against floods,
- absence of an integrated system for planning of preventive flood protection measures,
- insufficient identification of flood plain areas, their insufficient protection and insufficient regulation of their use,
- absence of a risk analysis as a background for an assessment of possible flood damages and a comparison of the damages and costs of the implementation of the measures,
- unsuitable implementation of protective measures, which resulted in elimination of natural inundation areas and subsequently in worsening the situation in middle and lower reaches of the rivers,
- insufficient technical equipment of flood forecasting services, which is substantial aspect in natural conditions of the Czech Republic.

One of the main lacks in the preventive protection against floods was in the fact that flood plain areas were identified for only small parts of the longitudinal profiles of important watercourses. Similarly, no systematic or integrated system was applied in the area of the development and implementation of

preventive technical and nontechnical measures. The situation has been improving since 1998 as a result of an establishment of internationally supported projects that are focussed on the application of mathematical models in simulation of flood hydrographs and subsequent identification of flooded areas and assessments of the effectiveness of planned protective measures. These national and international projects (carried out jointly with experts from Denmark and the Netherlands) are concentrated on those basins which were mostly affected by the floods in 1997 and 1998. Simultaneously, Ministry of Agriculture has initiated implementation of a programme for an assessment of runoff conditions in river basins. The aim of a further programme which is carried out is to ensure determination of flood plain areas along the whole longitudinal profiles of the important watercourses (about 17 000 km). This programme should be completed during 10 years.

### ***Legislation***

Law No. 138/1973 Coll. on waters (the Water Law), as amended by later regulations, which defines the framework for the protection against floods is a basic act in this area. More detailed provisions concerning responsibilities in the flood protection are laid down in Law No. 130/1974 Coll. on the State administration in the water management sector, as amended by later regulations and in connected Czech Government Decree No. 100/1999 Coll. on protection against floods.

Efforts to use regional planning and to regulate regional development with respect to the interests of the flood protection have been developed only recently. Low effectiveness of these efforts stems from the fact that Decree of Ministry for Regional Development No. 131/1998 Coll., which ensures linkages between the flood protection system and a system of regional planning, cannot effectively be implemented because flood plain areas are presently delimited only along 30% of the longitudinal profiles of important watercourses. Additional problem is in the absence of principles to be applied for functional arrangement of flood plain areas.

An improvement in this area will be ensured by relevant provisions of new Water Act (it is envisaged that this Act will enter into force in January 2001), which will lay down characteristics of flood plain areas, methods for their determination and responsibilities of legal and natural persons and the State in the prevention against floods.

By the present, no legislation has been adopted which would specify rules concerning restoration of the flooded areas and therefore this is solved by executive decisions made by the Government for individual flood events. However, the Government has charged Ministry of Regional Development with the preparation of relevant act by the end of 2000.

### ***International aspects of the protection against floods***

The territory of the Czech Republic is located on important European water divide and thus it is formed by upper parts of the basins of large rivers – the Elbe, Oder and the Danube, which drains water from eastern part of the country through its tributary, the Morava River. Due to the fact that practically all water outflows from the Czech Republic towards the territories of the neighbour countries, the flood protection is associated with important international aspects. Therefore, the protection against floods has been incorporated into the activities of international commissions that have been established by adoption of the following international agreements:

- Convention on the International Commission for the Elbe River Protection (ICEP), which entered into force on 13 August 1993, specifies the agreement of the contracting parties (CR, FRG, EEC) to co-operate in the area of the protection of the Elbe River and its basin through the activities of the ICEP.
- Convention on the International Commission for the Oder River Protection (ICOP), which entered into force on 28 April 1999, specifies the agreement of the contracting parties (CR, Poland, FRG and EU) to co-operate through the ICOP with particular attention to be paid to the flood protection.
- Convention on Co-operation for the Protection and Sustainable Use of the Danube River, which represents multilateral co-operation of the countries located in the Danube Basin. The Czech Republic signed and ratified the Convention on 10 March 1995. The implementation of the objectives the

Convention was supported by the establishment of International Commission for the Protection of the Danube River.

The approach based on ensuring protection against floods within the framework of individual river basins is relatively new in Europe. It was initiated by countries affected by floods of the Rhine River repeatedly occurring during the first half of the nineties. These countries have made a decision to develop a joint strategy of preventive protection against floods and a joint action plan of measures.

Similar effort was also initiated by the International Commission for the Oder River Protection, which established a working group for the development of similar documents with the aim to ensure integrated protection against floods. Also the International Commission for the Elbe River Protection has adopted such approach.

In the area of the flood protection, the international activities of the Czech Republic in the Danube Basin are concentrated on bilateral co-operation with Austria and Slovakia. The problems associated with flood protection have also been addressed by the International Commission for the Protection of the Danube River.