Prepared for:
EVD, International Public Co-operation,
Ministry of Economic Affairs, The Netherlands.

Determination of inundation area
(PPA04/SK/8/13)

Model Completion Report

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Thieu van Mierlo

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1 Introduction

1.1 Aim and scope

This document concerns the Model Completion Report of the PPA04/SK/8/13 project entitled “Determination of inundation area” (see section 1.2). The aim of this project was the transfer of technology on how to prepare flood inundation maps (or flood plain maps). In the project other type of flood maps (i.e. flood hazard maps, flood damage maps and flood risks maps) were, however, discussed as well. The Slovak Republic will also have to prepare these other type of flood maps in case the draft EU Flood Directive (see section 1.3) becomes mandatory.

In the project execution four distinct activities can be discerned, viz:
1. Project Result no 1: Cookbook
2. Project Result no 2: Initial Mission
3. Project Result no 3: Work visit of SWE staff members to the Netherlands, and
4. Project Result no 4: Final Workshop.

1.2 PPA04/SK/8/13: Determination of inundation area

The PPA04/SK/8/13 project focussed on the transfer of knowledge in the field of preparing flood maps as required in the Slovak Water Act. The Slovak Republic joined the EU in May 2004, the implementation of EU legislation in national legislation is now mandatory. Most likely the Slovak Republic will, therefore, in future also have to prepare flood maps in accordance with the EU Flood Directive.

The PPA04/SK/8/13 project is part of the PSO (Pre) Accession short Programme (PPA-Short). This PSO programme resorts under the EVD, Agency for International Business and Co-operation, Ministry of Economic Affairs, The Netherlands. Objectives of the PPA-Short programme are:
- to strengthen the relations between the governmental bodies of the Netherlands and the New Member States and Candidate Countries of the European Union, and
- to assist with or work together on the implementation and enforcement of acquis communautaire, and the harmonization of national legislation with acquis communautaire.

Beneficiary of the PPA04/SK/8/13 project is the Slovak Water Management Enterprise (SWE). More precisely, its head office in Banská Štiavnica and its four regional offices in Bratislava, Banská Bystrica, Košice and Piešťany.
1.3 The draft EU Flood Directive


1.4 Staffing of the project

This Model Completion Report was prepared by Mr. M.C.L.M. van Mierlo of WL | Delft Hydraulics, who was also the project leader on behalf of the Dutch government in assignment of the EVD, Agency for International Business and Co-operation, Ministry of Economic Affairs, The Netherlands. Dr. Radovan Hilbert (IT/GIS specialist) of the SWE head office in Banská Štiavnica was the project leader on behalf of the Slovak Water Management Enterprise (SWE). For an overview of all SWE staff members involved in the PPA04/SK/8/13 project, reference is made to Chapter 2: “Project outcome”.

1.5 Readers guide

In Chapter 2 the project outcome, the project aims, the project effect and the project sustainability are discussed. In Chapter 3, firstly the lessons learnt are discussed and thereafter recommendations for possible further cooperation are given. In Appendix A a Letter of Satisfaction is included, that is signed by the beneficiary of the project, being the Slovak Water Management Enterprise (SWE). In Appendix B a Letter of Observation is included, that is signed by the counterpart of the project, being the Ministry of Environment of the Slovak Republic. A cookbook that was specially prepared for this project (i.e. project result no. 1) is included in Appendix C. Details on the Initial Mission (i.e. project result no. 2) are given in Appendix D. Details on the visit of three SWE staff members to the Netherlands (i.e. project result no. 3) are given in Appendix E. Finally details on the Final Workshop (i.e. project activity no. 4) are given in Appendix F.
2 Project outcome

2.1 Project Results

In this section the outcome of the project activities is discussed, viz:

- Project Result no. 1: Cookbook.
- Project Result no. 2: Initial Mission,
- Project Result no. 3: Work visit of SWE staff members to the Netherlands, and
- Project Result no. 4: Final Workshop.

2.1.1 Project Result no 1: Cookbook

During the project a so-called cookbook on how to prepare flood inundation maps (or flood plain maps) was prepared. The English version of this cookbook is included in Appendix C. Except for how to prepare flood inundation maps (or flood plain maps) as specified in the Terms of Reference of the PPA04/SK/8/13 project, the cookbook also deals with the preparation of flood hazard maps, flood damage maps and flood risk maps. The scope of the cookbook was enlarged, since the three latter type of flood maps are specified in the EU Flood Directive (see section 1.3). In case the EU Flood Directive become mandatory, the Slovak Republic as any other EU member state will have to prepare these type of flood maps as well. The cookbook was finalized in close consultation with Dr. Radovan Hilbert of the Slovak Watermanagement Enterprise (SWE). The contents of the cookbook was presented and discussed in the Final Workshop (Project Result no. 4). The cookbook is to be considered as a useful project contribution. It was informed that this cookbook will be translated by SWE into the Slovak language.

2.1.2 Project Result no 2: Initial Mission

An initial mission was made by Mr. Thieu van Mierlo of WL | Delft Hydraulic to the Slovak Watermanagement Enterprise (SWE) from 22-25 March 2006. Several meetings with SWE staff members (see Appendix D) were held. Topics/activities addressed during the initial mission were:

- Type of floods of importance in Slovakia (i.e. river floods, flash and urban floods),
- Demonstration of flood mapping tools that are available at WL | Delft Hydraulics, having different levels of sophistication.
- Contents and topics to be addressed in the so-called cookbook, elaborating the preparation of flood maps for Slovak conditions,
- Out of four possible pilot areas, the river Vah reach from Kralova to Sala was selected as the pilot area. A partly 1D and partly 2D SOBEK hydrodynamic model was developed for this pilot area during the work visit of SWE staff members to the Netherlands. Further on flood maps for this pilot area were made using the Delft-FEWS Flood Mapping Utility (see also section 2.1.3).
Determination of the data to be carried by SWE staff members to Delft Hydraulics with respect to the selected pilot model for the river Vah reach from Kralova to Sala. Data such as: hydraulic data, river bathymetry, terrain elevations, data on vertical line elements that can serve as a water barrier (i.e. roads, dikes and so on), and data on historical flood events,

Explanation on the processing of the data to be carried out by SWE staff members before their arrival at WL | Delft Hydraulics.

Field visit to the Vah-Kralova-Sala pilot area.

2.1.3 Project Result no 3: Work visit of SWE staff members to the Netherlands

Three staff members of the Slovak Water Management Enterprise (SWE) came for a work visit to the Netherlands, while in the project budget only funds for the visit of two SWE staff members were available. Despite this budget restraint, SWE wished to send three staff members for the scheduled work visit to the Netherlands.

A one-day work visit was made to RIZA, Lelystad. This work visit to RIZA was coordinated by Mr. Harold van Waveren. Presentations were given by Mr. Harold van Waveren and Mr. Frank Alberts of RIZA. The primary Dutch flood defence system was discussed, including the tasks and responsibilities of the State, the Provinces and the Water boards. Findings of recent studies concerning the Dutch safety against flooding were discussed. Studies such as: the Dutch Safety against Flooding in the 21st Century (Water Veiligheid 21ste eeuw, WV21), FLORIS (Flood Risks and Safety in the Netherlands) project and the Spankracht study (Room for the River). An overview of flood maps available in the Netherlands was given, including estimates of flood damage and casualties. The aim and scope of the draft EU Directive on the Assessment and Management of Floods was discussed. Once accepted all European state members have to adhere to this EU Flood Directive.

At WL | Delft Hydraulics the work visit was coordinated by Mr. Thieu van Mierlo. The main focus of the work visit was to transfer the technology on how to prepare flood maps. Particularly on how to prepare flood inundation maps (or flood plain maps) using different hydraulic levels of sophistication. Using the SOBEK software package, the SWE staff members developed a combined 1D2D hydrodynamic model for the selected pilot area for the river Vah reach from Kralova to Sala (see section 2.1.2). Efforts were made for calibrating this pilot model. Insufficient time was, however, available for doing so. Simulations with the pilot model were made for different hydraulic conditions (i.e. upstream river discharges). In addition dike-break simulations were made with the pilot model. Flood plain maps were made using the 1D2D SOBEK hydrodynamic pilot model. Flood plain maps were also made using the Delft-FEWS Flood Mapping Utility (see section 7.1 of Appendix C: Cookbook) applying observed data as well as local flood levels computed by the SOBEK pilot model. During the work visit at WL | Delft Hydraulics attention was paid to the hydrodynamics involved in flood modelling. Aspects in flood risk determination (estimate of flood damage and number of casualties) were discussed.
In addition it was explained how to check the quality of hydro-meteorological and bathymetrical data and how to systematically calibrate and validate river models. Furthermore during the work visit the Cookbook (see section 2.1.1) and the contents of the Final Workshop (see section 2.1.4) were discussed. For information on the SWE staff members that actually came to the Netherlands as well as for a time schedule of the work visit to the Netherlands, reference is made to Appendix E.

2.1.4 Project Result no 4: Final Workshop

A final workshop was held in Hotel Bobrovnik, Liptovska Sielnica from 17-18 May 2006. The final workshop was attended by 22 staff members, coming from SWE head office in Banská Štiavnica and its four regional offices in Bratislava, Banská Bystrica, Košice and Piešťany. The consequences/obligations for European state members were discussed, once the proposed EU Flood Directive on the Assessment and Management of Floods becomes mandatory. The four different type of flood maps (i.e. flood plain maps, flood hazard maps, flood damage maps and flood risk maps) mentioned in the draft EU Flood Directive and the EXICIMAP Questionnaire 1 were discussed, including the data and expertise needed in making these flood maps. Related topics were discussed such as: how to determine the hydraulic boundary conditions corresponding to a certain return period; how to assess the accuracy of hydro-meteorological data; the different levels of sophistication and associated accuracies in which flood plain maps can be constructed; how to calibrate and validate hydrodynamic models, the importance of effects of river system behaviour on flood risk; how to estimate the damage and number of casualties invoked by a particular flood event. The latter topics were addressed/explained by Mr. Thieu van Mierlo of WL | Delft Hydraulics. Dr. Radovan Hilbert of SWE head office, who joined the work visit to the Netherlands (see section 2.1.3), kindly demonstrated the pilot Sobek hydrodynamic model developed in the Netherlands. Furthermore Dr. Hilbert demonstrated the functionality of the Delft-FEWS Flood Mapping Utility (FMU) and its application for the pilot area. More precisely this application comprised of comparing a flood plain map as computed by the FMU with a flood map resulting from a two-dimensional (hydrodynamic) SOBEK simulation. For a list of the SWE staff members that attended the final workshop as well as for a time schedule of the final workshop, reference is made to Appendix F.

2.2 Project aims

2.2.1 Results of the project for the strengthening of the bilateral relations

It can be stated that during the project execution the bilateral relations between governmental bodies of the Netherlands (i.e. RIZA) as well as the relation between the Slowak Water Management Enterprise and WL | Delft Hydraulics were further strengthened, laying a profound basis for further future cooperations.
2.2.2 Results of the project to the accession/integration process

It can be stated that the project outcome (see section 2.1) definitely assisted in the implementation and enforcement of acquis communautaire, and the harmonization of national legislation with acquis communautaire.

2.3 Project effect

It can be stated that the project was successful in transferring the technology on how to prepare flood maps (i.e. flood plain maps, flood hazard maps, flood damage maps and flood risk maps), that will be required within the framework of the EU Flood Directive on Assessment and Management of Floods. Although in accordance with the term of reference, the preparation of flood plain maps (or flood inundation maps) was emphasized, due attention was also paid to the preparation of flood hazard maps, flood damage maps and flood risk maps. During their work visit in the Netherlands, staff members of the Slovak Water Management Enterprise were made familiar with developing and applying 1D/2D hydrodynamic SOBEK models as well as with the application of the Delft-FEWS Flood Mapping Utility in preparing flood plain maps. During their work visit at RIZA Lelystad, the SWE staff members were informed on recent studies dealing with safety aspects in the Netherlands as well as with recent Dutch developments regarding the preparation of flood maps. During a two days Final Workshop in Slovakia 22 SWE staff members were informed on how to prepare the flood maps, that will be required for the EU Flood Directive. Furthermore a cookbook (see Appendix C) was developed on how to prepare flood maps.

2.4 Sustainability of the project

It can be stated that SWE gained experience in how to prepare flood inundation maps (or flood plain maps). In addition they were informed on how to prepare other type of flood maps, such as flood hazard maps, flood damage maps and flood risk maps. The cookbook, that was prepared within this project, will certainly be a useful document for preparing flood maps that will be needed for the EU Flood Directive. It is, however, considered that in future this cookbook will be further elaborated. It is to be stated that due to the limited time available for the execution of the project as well as due to the limited project funds, flood maps could only be prepared for a relatively small pilot area. This was done during the work visit of SWE staff members in the Netherlands. Hence, there was no time nor funds available for assisting SWE staff members in making flood maps for larger parts of Slovak river basins. It is considered that for the sustainability of the results of this project, assistance in preparing flood maps for large parts of Slovak river basins is essential.

A license for the Delft-FEWS Flood Mapping Utility was provided by WL | Delft Hydraulics to the Slovak Water Management Enterprise (SWE) free of cost. Unfortunately, within EVD regulations no funds could be made available for the providing SWE a 1D2D SOBEK software license. This means that presently SWE can not make use of the knowledge gained in the application of the 1D2D SOBEK software package in preparing flood plain maps. It is not known whether SWE will purchase a 1D2D SOBEK software licence from their own resources.
3 Lessons learnt and recommendations

3.1 Lessons learnt

3.1.1 Internal project logic

It can be stated that the internal project logic was sound. Meaning that defined project results were in line with the project aim, being the transfer of the technology on how to prepare flood inundation maps (or flood plain maps). Further on the sequence of project activities were coherent and logical.

Two set-backs in executing the project that are not related to the internal project logic as such comprise of the fact that:

1. Too little time within the allowable project duration as well as too limited funds were available for staff members of the Slovak Water Management Enterprise (SWE) to apply the knowledge gained in how to prepare flood maps for larger parts of Slovak river basins. This is a pity, since this would definitely have ensured the sustainability of the transferred technology,
2. The experience gained in preparing flood plain maps using the 1D2D SOBEK software package can presently not be applied by SWE, since no 1D2D SOBEK license is available at SWE.

3.1.2 External factors

In the project execution external factors such as the EU proposal for a Directive on the Assessment and Management of Flood {Sec(2006) 66} and the findings of the EXCIMAP Questionnaire 1 (EXCIMAP, February 2006) were taken into account.

3.1.3 Workplan

As mentioned before (see section 3.1.1) too little time within the workplan (or time-schedule) was available for SWE staff members to apply the knowledge gained in how to prepare flood maps for larger parts of Slovak river basins. This is a pity, since this would definitely have ensured the sustainability of the transferred technology.

3.1.4 Human resources

The Slovak Water Management Enterprise (SWE) made sufficient staff members available for both the work visit to the Netherlands (see Appendix E) and the final workshop (see Appendix F).
3.1.5 Organisation

The Slovak Water Management Enterprise was very keen and constructive in obtaining knowledge on how to prepare flood maps that will be required by EU member state once the EU Flood Directive on the Assessment and management of Flood becomes mandatory.

3.1.6 Budget

As mentioned before the budget was too limited to allow for the assistance of Dutch experts in the application of the transferred technology by SWE staff members to larger parts of Slovak river basins. In addition according to EVD regulations no funds could be made available for the transfer of the 1D2D SOBEK software package to the Slovak Water Management Enterprise.

3.1.7 Sustainability

As mentioned before the technology on how to prepare flood plain (or inundation) maps as well as flood hazard maps, flood damage maps and flood risk maps was transferred to SWE staff members. It is considered that the sustainability of the project would have been enlarged in case there would have been time as well as funds for assisting SWE staff members in applying the acquired technology for preparing flood maps for larger parts of Slovak river basins.

3.2 Recommendations

3.2.1 Follow up

In the PPA04/SK/8/13 project the transfer of the technology on how to prepare flood inundation maps (or flood plain maps) was emphasized. In addition it was explained how to prepare other type of maps (i.e. flood damage maps and flood risk maps) that will be needed once the EU Flood Directive becomes mandatory.

For possible follow up activities following is suggested:

- to provide Dutch assistance in preparing flood inundation maps (or flood plain maps) for larger parts of Slovak river basins, and
- to provide Dutch assistance in preparing flood damage maps and flood risk maps for larger parts of Slovak river basins.

3.2.2 Other actions

Presently no suggestions for other actions are given.
A Letter of Satisfaction
B    Letter of Observation
C Project result no 1: Cookbook
Cookbook for preparation of Flood Maps

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1 Introduction

1.1 Aim and scope

This document can be considered as a kind of “cookbook” for preparing flood maps. The “cookbook” was made in the framework of the PPA04/SK/8/13 project entitled “Determination of inundation area” (see section 1.2). The aim of this project was the transfer of technology on how to prepare flood inundation maps (or flood plain maps). This cookbook, however, also explains how to make other types of flood maps.

In the draft EU Flood Directive (see section 1.3) it is proposed that all EU member states should prepare flood risk maps and flood risk management plans. Hence, this cookbook can be considered as a contribution in achieving these EU Flood Directive requirements.

1.2 PPA04/SK/8/13: Determination of inundation area

The PPA04/SK/8/13 project focussed on the transfer of knowledge in the field of preparing flood maps as required in the Slovak Water Act. The Slovak Republic joined the EU in May 2004, the implementation of EU legislation in national legislation is now mandatory. Most likely the Slovak Republic will, therefore, in future also have to prepare flood maps in accordance with the EU Flood Directive.

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Beneficiary of the PPA04/SK/8/13 project is the Slovak Water Management Enterprise (SWE). More precisely its head office in Banská Štiavnica and its four regional offices in Bratislava, Banská Bystrica, Košice and Piešťany.

1.3 The draft EU Flood Directive

1.4 Staffing

This document (i.e. cookbook) was prepared by Mr. M.C.L.M. van Mierlo of WL | Delft Hydraulics. On behalf of the Netherlands, the PPA04/SK/8/13 project was conducted by Mr. M.C.L.M. van Mierlo. On behalf of Slowak Water Management Enterprise, Dr. Radovan Hilbert (IT/GIS specialist, SWE Banska Stiavnica head office), Mr. Radovan Sunega (Head of GIS department of SWE Piešťany office) and Ms. Jana Rožňovjaková (Hydrologist of SWE Košice office) were involved in the PPA04/SK/8/13 project.

1.5 Readers guide

In Chapter 2, four different types of floods are described. Chapter 3 describes the type of flood maps (i.e. flood plain map, flood hazard map, flood damage map and flood risk map), that EU member states might have to prepare when the EU Flood Directive becomes mandatory. In Chapter 4 an overview is given of the large amount of data, which is necessary for preparing these flood maps. In Chapter 5 an overview of the expertise required in preparing these flood maps is given. In Chapter 6 it is discussed how hydraulic boundary conditions can be derived for flood events, having a certain probability of flooding (or return period). In Chapter 7 three different hydraulic levels of sophistication are discussed in which flood maps and data for flood hazard maps can be determined. Furthermore a description of the functionality of the Delft-FEWS Flood Mapping Utility is given. In Chapter 8 methods are discussed for determining the number of casualties and damage invoked by a particular flood event, that are needed for preparing flood damage maps and flood risk maps.
2 Type of Floods

A flood, flooding or inundation refers to the overflowing by water of areas that are under normal conditions not covered by a water layer. Four different types of floods can be discerned:

1. Coastal floods,
2. Large river floods,
3. Flash floods, and
4. Urban floods

The Slovak Republic is suspect to large river floods, flash floods as well as urban floods.

2.1 Coastal floods

With coastal floods is referred to the flooding of areas as result of extremely high sea levels. Usually land is inundated by salt water, which causes additional damage as compared to fresh water. The high sea levels may be caused by (wind) storms at sea, large land slides or earth quakes (tsunamis). Extreme high sea levels may develop within a few hours only, leaving little time for evacuation of people and life-stock as well as for taking flood mitigating measures. Resuming, coastal floods are to be considered as a dangerous type of floods.

2.2 Large river floods

With large river floods is referred to the flooding of areas as a result of extremely large river discharges. These extremely large discharges are caused by heavy rainfall (often in combination with snowmelt) in upstream catchment areas. Usually these extremely large discharges can be predicted several days in advance, leaving sufficient time for the evacuation of people and life-stock as well as for taking flood mitigating measures. Hence, large river floods are not as dangerous as coastal floods or flash floods.

2.3 Flash floods

Flash floods occur in hilly or mountainous river basins, having steep catchment slopes and only limited (storage) depressions. For these type of river basins yields that the response time to rainfall (or time of concentration) might amount to a few hours only, while the ratio of runoff volume and rainfall volume can be very large. Hence, heavy local rainfall may lead to unexpected relatively large river discharges. Although discharges associated with flash floods are usually an order of magnitude smaller than discharges associated with large river floods, flash floods are still to be considered as a dangerous type of flood.

2.4 Urban floods

Urban floods occur in case local rainfall exceed the drainage capacity of the urban drainage/sewerage system. Although urban floods may result in a lot of damage, this type of flood is not to be considered as dangerous.
3 Type of Flood maps that might be required for the EU Flood Directive

The draft EU Flood Directive (European Commission {Sec(2006) 66}, January 2006) states that flood maps and indicative flood damage maps (or flood risk maps) should be prepared by EU member states for river basins, sub basins and stretches of coastline. These flood maps should be prepared for different probabilities of occurrence or return periods (T):

- frequently occurring flood events (T = 10 year),
- less frequently occurring flood events (T= 100 year), and
- extreme flood events (T >> 100 year)

In the EXCIMAP Questionnaire 1 (EXCIMAP, February 2006) four different type of flood maps are discerned:

1. flood plain maps,
2. flood hazard maps,
3. flood damage maps, and
4. flood risk maps.

The flood map and flood risk map described in the draft EU Flood Directive correspond to the flood plain map and flood risk map as described in the EXCIMAP Questionnaire 1. A flood damage map is a prerequisite for making a flood risk map. The flood hazard map refers to an additional type of flood map that is suggested by EXCIMAP.

Hereunder, a description of the four different types of flood maps is given.

3.1 Flood plain map

A flood plain map show the area that will be flooded during a particular flood event, having a certain probability of occurrence (or return period). Basic information depicted on a flood plain map are the inundation depths. In addition flood plain maps might contain information on maximum flow velocities.

3.2 Flood hazard map

It was understood that a flood hazard map aims at providing information on the danger level of a certain flood prone area. Parameters of interest that might be depicted on a flood hazard map are for instance:

- maximum water depths,
- maximum flow velocities,
- maximum speed in which water levels can attain certain flood depths, including associated flow velocities.
3.3 Flood damage map

A flood damage map provides information on the potential damage invoked by a particular flood event, having a certain probability of occurrence (or return period). Damage is usually expressed as the total number of casualties and the total amount of Euros lost.

3.4 Flood risk map

A flood risk map provides information on the flood risk, expressed as the probability of flooding multiplied by its potential damage. Flood risk is usually expressed as the number of casualties per year and the amount of euros lost per year.
4 Data needed for making flood maps

In this Chapter a brief overview is given of the large amount of data, which is required in making the flood maps (see sections 3.1 to 3.4).

4.1 Historical flood data

Following data on historical floods are of importance:

- The probability of occurrence (or return period) of the flood,
- The extend of the flood,
- Observed discharge hydrographs, preferably as function of time,
- Observed flood levels, preferably as function of time,
- Maximum flood depths,
- Observed or estimated local maximum flow velocities,
- Dikes (or other water barriers) that were overtopped,
- Details on possible dike breaches or collapsed water retaining structures,
- The effectiveness of evacuation procedures,
- The effectiveness of flood mitigation measures,
- Number of casualties,
- The loss of life-stock,
- Economic damage (agriculture, housing, industry, infrastructure, etc),
- Environmental damage (destroyed eco-systems, deposition of toxic agents, etc),
- The loss of historical and cultural values
- Indirect economic damage (f.i. loss of economic productivity).

4.2 Hydro-meteorological data

Following hydro-meteorological data is required:

- Location of gauging stations, including gauge-zero and list of observed parameters,
- Location of meteorological stations, including list of observed parameters,
- Observed water levels at river gauging stations as well as in flood plain areas,
- Observed discharges at river gauging stations as well as in flood plain areas,
- Stage-discharge relationships, including stage-discharge data and the cross-sectional profile of the measuring section (preferably covering the river, including its flood plain areas),
- Hydraulic characteristics of structures (culverts, weirs, reservoirs etc); characteristics such as structural details and structure equations,
- Bathymetric data (i.e. river bed elevations),
- Type of river bed material (silt, sand, gravel etc) and type of vegetation in flood plain areas,
- Information on floods (observed flood levels and maximum flooding extend),
- Precipitation data.
4.3 **Geographical data**

Following geographical data is required:
- Digital elevation models,
- Location and elevation of vertical line elements, that can act as water-barriers (f.i. dikes and (rail)roads),
- Location of culverts in vertical line elements,
- Land-use maps,

The above data should preferably be available in a GIS format.

4.4 **Socio-economic data**

Following socio-economic data is required:
- Number of inhabitants,
- Number and value of life-stock,
- Investments in agriculture, housing, industry, etc.
- Investments in infrastructure (dikes, (rail)roads, communication-lines etc.),
- Location of toxic depots as well as the type and quantities of chemicals stored,

The above data should preferably be available in a GIS format.
5 Expertise involved in preparing flood maps

The preparation (or determination) of flood maps (see sections 3.1 to 3.4), requires the involvement of various fields of expertise. The fields of expertise that actually should be involved in developing flood maps for a particular areas can for instance depend on:

- The type of hydro-meteorological phenomena, that result in floods,
- The complexity of the hydraulic phenomena occurring in the river basin,
- Type of water retaining structures in the flood prone area,
- Degree of influence of flood mitigation measures effected in riparian states,
- The population density in the area (needs for evacuation).
- Type of investments in economic properties and life-stock,
- The presence of toxic depots,
- The presence of environmental, historical, and cultural assets,

Hereunder a summary of experts that could be involved in making flood maps is given. The experts are listed in alphabetic order. The author fully realizes that the list of experts will definitely not be a complete one:

- Chemical experts,
- Coastal engineers,
- Environmental experts,
- GIS experts,
- Hydraulic engineers,
- Hydrologists,
- Institutional experts,
- Socio-economists,
- Statisticians,
- Structural engineers.
6 Hydraulic conditions and return periods.

Flood maps (i.e., flood plain maps, flood damage maps and flood risk maps) are made for flood events (see Chapter 3), having a certain probability of occurrence (or return period). Hydro-meteorological boundary conditions are required in making flood maps. These hydro-meteorological boundary conditions are stochastic parameters and might comprise of:

- The magnitude and duration of upstream river discharges,
- The magnitude and duration of downstream (sea) levels,
- The magnitude and duration of wind velocities, and
- The magnitude and duration of local rainfall.

A prerequisite is that the joint probability of occurrence of the hydro-meteorological boundary conditions (i.e., stochastic parameters), that are applied to determine the hydraulic properties of a particular flood, are in accordance with the probability of occurrence of this particular flood. To meet this prerequisite is not always that easy, since hydro-meteorological boundary conditions might be mutually correlated. Furthermore, it is possible that different sets of hydro-meteorological boundary conditions, having the same joint probability of occurrence, result in flooding events with different magnitudes for flood depths, flood duration and flood extent.

River systems can be very complex. No general recipe can, therefore, be given for determining hydro-meteorological boundary conditions that correspond to a particular flooding probability. Therefore, hereunder only some examples are given:

- For friction dominated rivers (meaning that downstream a rating curve can be applied), the probability of flooding might depend on the magnitude of upstream discharges only. In such case the return period of the flood event will be directly related to the return period of the maximum discharge. The return period of the maximum discharges can be derived from its probability density function that can be established using observed discharges. However, the magnitude of the flooded area still depends on the duration (or volume contained) in the upstream discharge hydrograph. This means that a statistic relationship between maximum discharge and the shape of the upstream discharge hydrograph is needed. In the Netherlands for this purpose a so-called wave generator was developed (Adaptation of wave generator - in Dutch-, 2004).

- For tidal rivers yields that a rating curve can not be applied as a downstream boundary condition. Furthermore, for a tidal river yields that local water levels usually depend on the magnitude and duration of sea-levels, wind velocities and upstream river discharges. Hence, the probability of exceedance of design water levels in a tidal river can depend on various stochastic parameters that might be mutually correlated. In such case usually a calibrated hydrodynamic model is applied in determining the probability of exceedance of local design water levels. With this hydrodynamic model simulations are made for a large range of different hydro-meteorological boundary conditions. Using these simulation results, probabilities for the exceedance of local design water levels are determined. This can be done by either numerical integration, Crude Monte Carlo, Smart Monte Carlo (Directional sampling or Importance sampling) or by a Form analysis). In the
Netherlands this is done using the Hydra B probabilistic software package. (Geerse, C.P.M. - Dutch-, 2003).

Above only hydro-meteorological parameters were considered as stochastic parameters. The probability of occurrence of a flood event, however, might depend on other stochastic parameters as well. Stochastic parameters such as:
- Actual strength of water retaining structures against hydraulic loads,
- Magnitude and duration of hydraulic loads exerted on water retaining structures,
- Uncertainties in executing flood mitigation measures,
- Temperatures (runoff due to snowmelt, probability of ice-jamming).

Taking into account the above mentioned stochastic parameters, makes the determination of the flooding probability even more complicated.

Furthermore, effects of river system behaviour might be of importance. With effects of river system behaviour is meant that the safety of a particular area can depend on the safety of other areas within the river basin. Effects of river system behaviour on flood risk can be beneficial or adverse. Beneficial effects might occur due to a dike breach along an upstream area, resulting in a decrease of water levels near downstream located areas and hence in an increase of safety against flooding of these downstream located areas. Adverse effects might occur due to the local heightening of embankments (f.i. using sand bags), resulting in increased discharges along downstream located areas and hence in a decrease of safety against flooding of these downstream located areas. In determining effects of river system behaviour the uncertainty in hydraulic parameters, structural parameters, effectuation of flood mitigation measure, etc. are to be taken into account. A computational method was developed in the Delft Cluster research project DC 02.01.01, that can take all uncertainties into account (van Mierlo et al, 2003). This computational method was successfully applied in two example river configurations. Presently computational constraints, however, prohibit the application of this computational method to large river systems. Furthermore, additional computational, geotechnical, structural and statistical research is still needed.
7 Making flood plain and flood hazard maps

From the hydraulic point-of-view, flood plain maps and flood hazard maps can be constructed with different levels of sophistication:

1. Straightforward interpolation of observed flood levels only (see section 7.2),
2. Interpolation of flood levels, computed by a one-dimensional (1D) hydrodynamic model (see section 7.3), and
3. Computing hydraulic flood data using a two-dimensional (2D) hydrodynamic model (see section 7.4).

The straightforward interpolation of observed flood levels as well as the interpolation of flood levels computed by a 1D hydrodynamic model can be done using the Delft-FEWS Flood Mapping Tool (see section 7.1).

7.1 The Delft-FEWS Flood Mapping Utility (FMU)

The Delft-FEWS Flood Mapping Utility (hereafter shortly referred to as the FMU) was developed at WL | Delft Hydraulics (Werner, 2001). The FMU allows the construction of flood plain maps by the spatial interpolation of either observed or computed flood levels. No hydrodynamics are involved in the construction of these flood plain maps. For information on the method how flood levels are interpolated by the FMU, reference is made to the Delft-FEWS Configuration Guide (2005) and the Stand-alone FMU User Guide (2006). The FMU includes a PostSOBEKModelAdapter, which can directly read SOBEK computational output data. SOBEK is a 1D/2D hydrodynamic modelling system, developed at WL|Delft Hydraulics. The FMU is available as an additional module in Delft-FEWS (Delft-FEWS Configuration Guide, 2005) and as a stand-alone version (Stand-alone FMU User Guide, 2006). Delft-FEWS is a flood early warning system developed at WL|Delft Hydraulics.

The FMU needs following input data:
- Observed or computed flood levels,
- The locations (x,y points), where flood levels are available,
- Digital terrain model of the flood prone area,
- A GIS raster grid containing the river-axis, and
- A flood section map (GIS raster grid), dividing the flood prone area into separate flood map sections. Flood map sections are needed in case of distinct differences in local flood levels (for instance directly upstream and downstream of a dam).

The FMU can produces following output:
- Flood plain maps for specified output-time steps,
- A maximum flood plain map, containing for each raster grid cell its maximum flood level for the considered time-period,
- A maximum flood contour map, containing contours of maximum flood levels for the considered time period.
7.2 Straightforward interpolation of observed flood levels

For friction dominated rivers, flood levels can be derived from rating curves. Local flood levels can be obtained by interpolating between locations where rating curves are available. This method will potentially result in an overestimation of flood levels, since the attenuation of the flood wave, while travelling in downstream direction, is neglected. Using these local flood levels, one can make estimates of maximum flood depths and the maximum flood extent by for instance assuming horizontal flood levels perpendicular to the river axis (or thalweg) or by using the Delft FEWS Flood Mapping Utility (see section 7.1). In case of wide flood plains, that are not accounted for in the rating curves, the straightforward interpolation of observed water levels might become very inaccurate, since in reality the local storage of flood water may result in large attenuations of the flood wave.

Please note that:

1. If necessary rating curves may have to be extrapolated beyond the range of observed stage-discharge data (e.g., using the conveyance method).
2. If necessary in applying rating curves one should make corrections for backwater effects (e.g., using the normal or constant step method).

For tidal rivers, yields that rating curves are not applicable. A simple method of establishing floodplain maps for deltaic areas, that are located below sea-level, is assuming that flood levels will not exceed the lowest level of the surrounding dikes. This method is referred to as the bath-tube method. In this method, however, hydrodynamics are not accounted for. Hence it is not verified if sufficient time is available during the period of high sea-levels for filling-up the bath-tubes. Hence, the bath-tube method will most likely overestimate flood depths.

Concluding, the straightforward interpolation of observed flood levels:

- Should be done with care and understanding of the hydrodynamics involved in order to obtain realistic results,
- Provides only local flood levels and local flood depths,
- Provides no information on flow velocities and the speed in which flood water levels might rise.

7.3 Interpolation of 1D computed flood levels

Flood levels can be determined using one-dimensional (1D) hydrodynamic models. 1D hydrodynamic models only require a limited amount of computational time (few minutes). Such 1D hydrodynamic model should be properly calibrated and validated against the largest observed flood events. One should take care that all areas, that from a physical point-of-view could be inundated, are included in the 1D model schematisation. It is to be mentioned that in a 1D hydrodynamic model usually assumptions/schematisations for real 2D hydrodynamic phenomena are to be made. Developing a good 1D hydrodynamic model is, therefore, more difficult than developing a proper 2D hydrodynamic model. In a 1D hydrodynamic model, water level and discharge hydrographs can be computed at various locations along the river-axis (or thalweg). Hence output data can be computed having a spatial discretization that is much smaller that the distance between river gauging stations. Furthermore hydraulic phenomena, as for instance the attenuation of a flood wave while travelling in downstream direction, are accounted for in a 1D hydrodynamic simulation. The
computed local flood levels are, therefore, much more accurate than local flood levels obtained by interpolating between river gauging stations (see section 7.2). All computed model data, however, still refers to one dimensional information only. Hence, still interpolation of the computed local flood levels is needed for obtaining flood plain maps. This interpolation can be done using the Delft-FEWS Flood Mapping Tool (see section 7.1).

Concluding, the interpolation of 1D computed flood levels:
- Has the advantage that local flood levels are computed taking into account the hydrodynamic characteristics of the river system, such as for instance the attenuation of flood waves,
- Only limited computational time (few minutes) is required for 1D hydrodynamic simulations,
- Provides local flood levels and local flood depths,
- Provides cross-sectional lumped information on flow velocities as well as the speed in which flood water levels might rise.

7.4 Using 2D hydrodynamic models

Flood levels can be determined using two dimensional (2D) hydrodynamic models. 2D hydrodynamic models require a lot of computational time. Depending on area covered by the 2D model and its grid-size, the computational time can amount to several hours or even a few days. Such 2D hydrodynamic model should be properly calibrated and validated against the largest observed flood events. One should take care that all areas, that from a physical point-of-view could be inundated, are included in the 2D model schematisation. For 2D hydrodynamic models also yields that hydraulic phenomena, as for instance the attenuation of a flood wave while travelling in downstream direction, are accounted for in the hydrodynamic simulation. The computed local flood levels are, therefore, much more accurate than local flood levels obtained by interpolating between river gauging stations (see section 7.2). These 2D hydrodynamic model usually provide as output GIS maps, containing per 2D grid cell its maximum water level, its maximum water depth and its maximum flow velocity, including the point-in-time of occurrence. Hence interpolation of computed flood levels by for instance the Delft-FEWS Flood Mapping Tool (see section 7.1) is not needed.

Concluding, using a 2D hydrodynamic model:
- Has the advantage that local flood levels are computed taking into account the hydrodynamic characteristics of the river system, such as for instance the attenuation of flood waves,
- Has the disadvantage that the computational time can amount to several hours or even a few days,
- Provides local flood levels and local flood depths,
- Provides local flow velocities as well as the local speed in which flood water levels might rise,
- Provides GIS maps, containing per 2D grid cell its maximum water level, its maximum water depth and its maximum flow velocities (including the point-in-time of occurrence)
8 Making flood damage and flood risk maps

The number of casualties and damage associated with a particular flood event are needed for preparing a flood damage map (see section 3.3) and a flood risk map (see section 3.4). Methods for estimating the number of casualties and damage associated with a particular flood event are, respectively, discussed in sections 8.1 and 8.2.

8.1 Method for estimating the number of flood casualties

Asselman and Jonkman (2003) proposed a method for estimating the number of casualties in a particular flood event (see Figure 8-1). This method was applied in estimating the number of flood casualties in the Dutch dike-rings 7, 14 and 36 for probable flood events (Jonkman and Clappendijk, - in Dutch - 2006). For each dike-ring, taking into account the existing infrastructure and the hydraulic characteristics of the flood event:

1. *Firstly*, the number of inhabitants unable to escape (or evacuate) were estimated,
2. *Secondly*, the number of casualties among the inhabitants that could not escape (or not evacuate) were estimated.

More details on the first and second step are given below.

![Figure 8-1 Flow Chart of the loss of life model](image)

Figure 8-1 Flow Chart of the loss of life model (Asselman and Jonkman, 2003; Delft Cluster report DC1-233-7)
i) Estimating the number of inhabitants unable to escape (or evacuate):
Decisive hydraulic parameters are the speed in which certain water depths are attained, including associated flow velocities (i.e. data available on flood hazard maps, see section 3.2). In determining how many inhabitants can be evacuated four stages are discerned (see Figure 8-2):

1. The decision making phase (evacuation or not)
2. The warning phase
3. The response phase, and
4. The actual evacuation

The duration of the first two phases was determined from literature review. Time required for phase 3 and 4 were determined by the evacuation calculator (University of Twente, 2004). Please note that inhabitants reaching flood shelters (i.e. four story buildings) within dike-ring areas are not considered as being evacuated. The number of inhabitants that can not timely leave the flood-prone area is a function of the time needed for evacuation (i.e. phase 1 to 4) and the available time for evacuation. The available time for evacuation is the time-span between the forecast issue of a critical situation and the point-in-time that flooding prohibits evacuation operations. How much time in advance a critical situation can be forecasted depends on the type of the flood (see Chapter 3). Van der Doef and Clappendijk (in Dutch, 2005) provide more detailed information on how the number of evacuated inhabitants was determined.

![Figure 8-2](source: Van der Doef and Clappendijk -in Dutch - 2005)

ii) Number of casualties:
Three different areas (see Figure 8-3) are discerned in the method, which determines the number of casualties among the inhabitants that could not escape (or evacuate):

1. Areas with large flow velocities (people washed away, collapsing buildings), usually these areas are located directly behind dike beach locations,
2. Areas in which water levels rise quickly (people can not reach shelter areas); fast rising water levels can occur in relatively small compartmentalized areas, located in the vicinity of dike breach locations,
3. Other areas with less severe hydraulic conditions, but casualties are due to for instance hypothermia, hart-attacks, collapsing buildings and so-on),

![Figure 8-3](source: Van der Doef and Clappendijk -in Dutch - 2005)
For each area so-called casualty-functions were determined on basis of data, available for the disastrous flood in the South-western part of the Netherlands in 1953. These casualty-functions express the number of casualties as function of the hydraulic properties of the flood event (i.e. data available on flood plain maps and flood hazard maps, see sections 3.1 and 3.2). The casualty-function for an area with large flow velocities is given in Figure 8-4, more precisely yielding for an area in which \( v \geq 2 \text{ m/s} \) and \( h.v \geq 7 \text{ m}^2/\text{s} \), where \( v = \text{flow velocity} \) and \( h = \text{waterdepth} \). For more information on the casualty functions applied for estimating the number of casualties, reference is made to Jonkman et al (2002) and Jonkman (2004).

Figure 8-3 Area for which different casualties damage functions were used (source Jonkman and Clappendijk, - in Dutch - 2006)

Figure 8-4 Casualty-function as applied by Jonkman and Clappendijk (in Dutch, 2006) for areas with large flow velocities, meaning that \( v \geq 2 \text{ m/s} \) and \( h.v \geq 7 \text{ m}^2/\text{s} \) (\( v = \text{flow velocity}; h = \text{waterdepth} \))

### 8.2 Method for estimating flood damage

Flood damage might refer to:
- loss of live-stock and damaged houses, cars, crops, commercial and industrial facilities, dikes, (rail)roads, other type of infrastructure and so on,
- Indirect economic damage (i.e. loss of economic activity in the flooded area)
- environmental damage (i.e. deposition of contaminated silt and toxic agents),
- loss of cultural and historical values.
The amount of flood damage invoked by a particular flood event depends on:

- Speed of water level rise (available time for safeguarding economic properties),
- Magnitude of flow velocities (collapse of houses, buildings, bridges and so on),
- Magnitude, extend and duration of flood depths,
- Type of flood water (i.e. fresh water, salt water, contaminated water, mud flows)

Flood damage is determined using so-called damage functions. These damage functions specify a damage factor as function of the exposure to a particular hydraulic parameter. The actual damage is computed at the potential (or maximum) damage multiplied by the damage factor. Damage functions yield for a particular type of land-use (for instance residential areas, specific crop, etc.). Furthermore, a damage function is subdivided in a number of hydraulic parameter classes. Meaning, that for instance for a maximum water depth of 1.0 - 3.0 m only 85% of the potential damage can occur, while for a maximum water depth larger than 4.0 m the actual damage will be equal to the potential damage for the concerning type of land-use (see Figure 8-5).

![Figure 8-5](image)

Figure 8-5  Example of a damage function for residential area and other type of land-use. The damage factor varies as function of water depth class. Actual damage equals the potential damage multiplied by the damage factor.

In the Netherlands, determination of casualties (i.e. the method explained in section 8.1) and damage assessments are made using the so-called “HIS-Schade en Slachtoffer Module (HIS-SSM)”. Using this method the anticipated economic damage due to a flooding can be established. In establishing possible damage use is made of GIS oriented databases. Using these databases, for a arbitrary area in the Netherlands an inventory can be made of the number of inhabitants, houses, cars, agricultural land and so on. In computing the anticipated damage for each area following (hydraulic) parameters are used, being: the speed in which water levels rise, the maximum inundation depths, the maximum flow velocities, a shelter factor, and the occurrence of wind-induced waves. For more information on the HIS-SMM model, reference is made to Vrisou van Eck, Huizing and Dijkman (2002) and to Vrisou van Eck, Kok and Vrouwenvelder (2000).
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D  Project result no 2: Initial Mission

In this Appendix an overview is given of the SWE staff members met by Mr. Thieu van Mierlo during his initial mission to the Slovak Watermanagement Enterprise from 22-25 March 2006.

Discussions were held with following SWE staff members.
- Mr. Jozef Farkaš (Overall Technical director of all SWE)
- Mr. Boris Rakssanyi (Technical Director of SWE Piestany office)
- Dr. Radovan Hilbert (IT/GIS specialist, SWE Banska Stiavnica head office),
- Mr. Radovan Sunega (Head of GIS department of SWE Piestany branch)
- Mr. Roman Sirucek (GIS expert of SWE Piestany branch),
- Mr. Ivan Malinka (Hydrologist of SWE Piestany branch),
- Ms. Bozena Jakesova (Environmentalist of SWE Piestany branch)
- Ms. Edita Stefankova (Hydrologist of SWE Piestany branch),
- Ms. Z. Predmeska (Hydrologist of SWE Piestany branch),
E Project result no 3: Time schedule of the Work visit to the Netherlands

In this Appendix details on project result no. 3: “Work visit of SWE staff members to the Netherlands” are given. The list of staff members that made a work visit to the Netherlands is given in section E.1. The time schedule of the work visit (including the topics addressed) is given in section E.2.

E.1 SWE staff members that made a work visit to the Netherlands

The three SWE staff members who made a work visit to the Netherlands are:
1. Dr. Radovan Hilbert (IT/GIS specialist, SWE head office in Banská Štiavnica),
2. Mr. Radovan Sunega (Head of GIS department, SWE Pieštany office), and
3. Ms. Jana Rožňovjaková (Hydrologist, SWE Košice office)

E.2 Time schedule of the Work visit

Sunday: 23-04-2006:
- Arrival in Delft, The Netherlands.

Monday: 24-04-2006:
- Inventory of the GIS and hydraulic data carried by the SWE staff members to the Netherlands,
- Finalization of the proposed Time and Activity schedule,
- Discussion on the content of the Cookbook “Preparation of Flood Maps”.

Tuesday: 25-04-2006:
- Introduction (including Tutorial exercises) to the 1D and 2D hydrodynamic flow modules of the SOBEK-Rural software package, Part I.
- Validation techniques for assessing quality of hydro-meteorological data
- Introduction (including Tutorial exercises) to the 1D and 2D hydrodynamic flow modules of the SOBEK-Rural software package, Part II.

Wednesday: 26-04-2006:
- Introduction (including Tutorial exercises) to the 1D and 2D hydrodynamic flow modules of the SOBEK-Rural software package, Part III.
- Brief background knowledge on hydrodynamics involved in flood modelling,
- Construction of a 1D&2D SOBEK model for the Vah-Kralova-Sala pilot area, Part I

Thursday: 27-04-2006:
- Construction of a 1D&2D SOBEK model for the Vah-Kralova-Sala pilot area, Part II
- Explanation on how to calibrate and validate hydro-dynamic river models,
- Calibration and verification (i.e. as good as possible within the limited time available) of the Vah-Kralova-Sala SOBEK pilot model, Part I.
Friday: 28-04-2006:
- Calibration and verification (i.e. as good as possible within the limited time available) of the Vah-Kralova-Sala SOBEK pilot model, Part II.
- Simulations with the Vah-Kralova-Sala SOBEK pilot model in which various dambreaks were simulated

Saturday: 29-04-2006:
Day-off

Sunday: 30-04-2006:
Day-off

Monday: 01-05-2006:
- Computations with the Vah-Kralova-Sala SOBEK pilot model for hydraulic conditions for different hydraulic conditions with different return periods,
- Explanation of the Delft-FEWS Flood Mapping Utility,
- Application of the Delft-FEWS Flood Mapping Utility for the Vah-Kralova-Sala SOBEK pilot area using observed as well as by SOBEK computed data, Part I

Tuesday: 02-05-2006:
- Application of the Delft-FEWS Flood Mapping Utility for the Vah-Kralova-Sala SOBEK pilot area using observed as well as by SOBEK computed data, Part II,
- Review of the Cookbook regarding “Preparation of Flood Maps”.
- Comparison of flood maps, made by different level of sophistication viz: the DelftFEWS Flood Mapping Utility and the 2D SOBEK Overland Module, Part I

Wednesday: 03-05-2006:
- Visit to the Institute for Inland Water Management and Waste Water Treatment (RIZA) in Lelystad.
- Following topics were addressed:
  - The primary Dutch Flood defense system; Tasks and responsibilities of the State, the Provinces and the Water boards,
  - Overview of studies concerning the Dutch safety against flooding: Dutch safety against Flooding in the 21st century (Water Veiligheid 21e eeuw, WV21), The FLORIS (Flood Risks and Safety in the Netherlands) project; The Spankracht study (Room for the River),
  - Overview of available flood maps in the Netherlands; Estimates of Flood Damage and Casualties in the Netherlands,
  - The draft EU Directive on the Assessment and Management of Floods.

Thursday: 04-05-2006:
- Comparison of flood maps made by different level of sophistication viz: the DelftFEWS Flood Mapping Utility and the 2D SOBEK Overland Module, Part II.
- Introduction on aspects related to flood risk assessments: Dutch way of determining flood damage; Assessment of probability of flooding
- Discussion on the scope of the Final Workshop to be held in the Slovak Republic
- Meeting Mr. Bons, director Inland Water Systems of WL | Delft Hydraulics.
- Evaluation of the work visit to the Netherlands

Friday: 05-05-2006:
- Departure for Slovak Republic
Project result no 4: Final Workshop

In this Appendix details on project result no. 4: “Final Workshop” are given. The Final workshop was held in Hotel Bobrovnik, Liptovska Sielnica, Slovakia from 17-18 May 2006. The list of participants of the Final Workshop is given in section F.1. The time schedule (including the topics discussed) of the Final Workshop is given in section F.2.

F.1 List of participants of the Final Workshop

<table>
<thead>
<tr>
<th>Meno (First Name)</th>
<th>Priezvisko (Family Name)</th>
<th>Org. Zložka (SWE office)</th>
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<tr>
<td>Roman</td>
<td>Širuček</td>
<td>OZ PN</td>
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<td>Juraj</td>
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<td>Radovan</td>
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Notes:
1. PR BS = SWE head office in Banská Štiavnica
2. OZ BA = SWE office in Bratislava
3. OZ BB = SWE office in Banská Bystrica
4. OZ KE = SWE office in Košice
5. OZ PN = SWE office in Piešťany
F.2 Time schedule of Final Workshop

Wednesday, May 17th 2006
10:15 - 10:30 Opening of Workshop
10:30 - 11:15 The PPA04/SK/8/13: Determination of inundation area and the draft EU Flood Directive
11:15 - 11:45 Different type of floods, different type of flood maps
11:45 - 12:15 Data and expertise needed in making flood maps
12:15 - 13:00 Hydraulic conditions and return periods
13:00 - 14:00 Lunch break
14:00 - 14:30 Demonstration of SOBEK 1D/2D functionalities
14:30 - 15:15 Accuracies of hydraulic input data and validation techniques
15:15 - 15:30 Coffee break
15:30 - 16:30 Different levels of sophistication in making flood plain maps and flood hazard maps
16:30 - 17:30 Importance of effects of river system behaviour on flood risk
17:30 - 18:15 Demonstration of the SOBEK model for river Vah from Kralove to Sala
18:15 - 18:30 Closing and evaluation of the first workshop day

Thursday, May 18th 2006
09:00 - 09:45 Estimating the number of flood casualties and flood damage (Part 1)
09:45 - 10:30 Estimating the number of flood casualties and flood damage (Part 2)
10:30 - 11:00 Coffee break
11:00 - 11:45 The Delft-FEWS Flood Mapping Utility (FMU)
11:45 - 12:15 Exercise No. 1: Delft-FEWS Flood Mapping Utility
12:15 - 12:45 Exercise No. 2: Delft-FEWS Flood Mapping Utility
12:45 - 13:00 Closing and evaluation of workshop