Interreg
Danube Transnational Programme
WACOM

Water Contingency Management in the Sava River Basin

Transnational modelling tool for flood/accidental pollution emergency management

Output T2.2

Lead Institution	ERDF LP UL
Lead Author/s	Primož Banovec
Version	Draft
Date	25.11.2022

Project is co-funded by the European Union funds (ERDF, IPA)

List of contributors:

PP Acronym	Contributor
LP UL	Davor Kvočka, Jerca Praprotnik Kastelic, Matej Cerk, Primož Banovec, Ajda Cilenšek
PP5 ISRBC	Samo Grošelj, Nikola Cvjetković

Table of Contents

List of Annexes

1 Introduction

1.1 Project background and purpose

The lack of coordinated response to emergencies in case of accidental pollution and floods on transboundary watercourses presents a serious challenge in Sava River Basin. Therefore, the Water Contingency Management in the Sava River Basin (WACOM) project has been set up, whose main objective is the reduction of environmental risks related to accidental pollution and floods, especially those which have or might have transboundary impact in the Sava River Basin.

The project is focused on the implementation of three protocols of the Framework Agreement on the Sava River Basin. Two of them, Protocol on Prevention of Pollution Caused by Navigation and Protocol on Flood Protection, have already been signed and ratified by the Bosnia and Herzegovina, Croatia, Serbia and Slovenia, while Protocol on Emergency Situations is under final harmonization. The specific objectives of the project are the following:

- improved transnational procedures for response to accidental pollution and floods;
- Improved transnational cooperation among civil protection, water management and navigation agencies;
- more efficient joint response in the case of accidental pollution/flood emergencies on international Sava river basin.

The main outcomes of the project will lead to reduced risks induced by the accidental pollution and floods of transnational dimension by strengthening the transnational and trans-sectorial cooperation among institutions, especially governmental institutions that manage the flood and accidental pollution preparedness and response stage. The successful implementation of the project activities is ensured by the transnational and trans sectoral partnership, which encompasses international, national/entities authorities and research institutions dealing water management, civil protection, and navigation from the Sava River riparian countries.

The activities of the project are divided into four packages:

- Work Package T1 (WP1) – Explore and define joint preparedness and response
- Work Package T2 (WP2) – Develop joint preparedness and response toolbox
- Work Package T3 (WP3) – Verify joint preparedness and response – Pilot implementation
- Work Package T4 (WP4) – Strategy for the implementation of coordinated preparedness and response

1.2 Scope of this report

The main goal of WP2 is the development of a rapid joint preparedness and response toolbox, which would be built upon the exiting and operational family of tools developed and used by the International Sava River Basin Commission (ISRBC), i.e. GeoInformation System for the Sava River Basin (Sava GIS), Hydrological Information System of the Sava

River Basin (Sava HIS) and Flood Forecasting and Warning System in the Sava River Basin (Sava FFWS).

This report presents the development of two-dimensional (2D) hydraulic and oil spill propagation models, which is an integral part of the newly developed rapid joint preparedness and response toolbox. The development of the transnational modelling tool enables modelling (forecasting) of the flood/accidental pollution events. The numerical modelling has been conducted for approximately 700 km long section of the River Sava, i.e. the modelling area stretches from Čatež in Slovenia to Belgrade in Serbia, where River Sava discharges into the River Danube. The extent of the modelling area is presented in Figure 1. After several improvement and model extensions the modelling area stretches from Jesenice (Slovenia) to Belgrade (Serbia).

The following report sections outline the modelling approach, development of hydraulic and oil spill propagation models, general modelling outcome/results, critical assessment of the modelling concept and developed models, and summary of the main conclusions, more details on the modelling are in Annex 2.

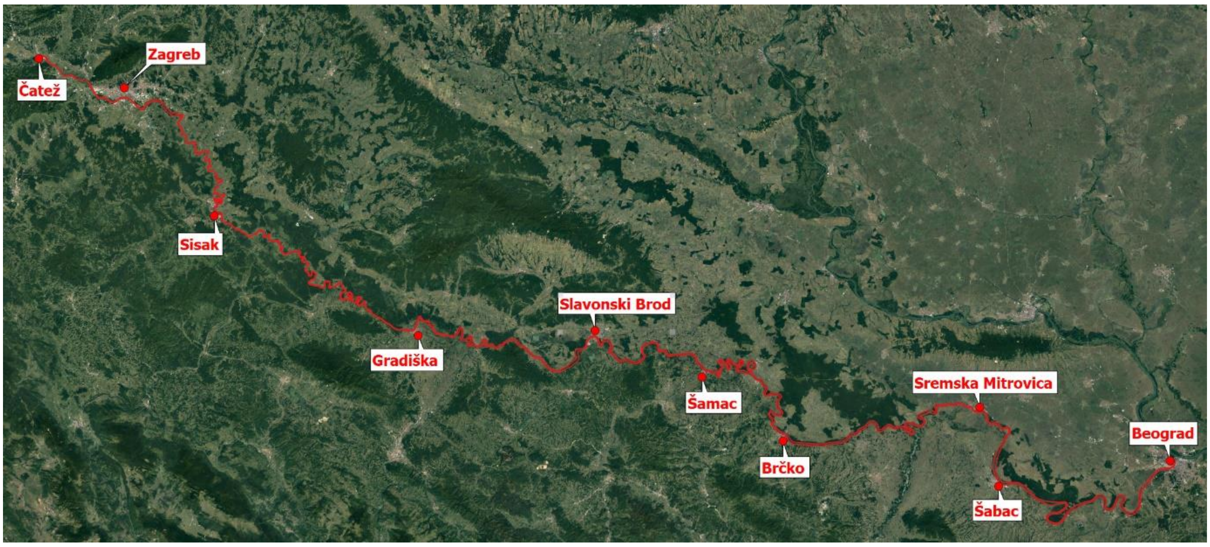

Figure 1: The extent of the modelling area (red line)

2 Transnational modelling tool requirements

The Transnational modelling tool of the WACOM project as a part of the toolbox is focused only on the prediction of the accidental pollution requirements, as the module for the flood forecasting is already fully implemented and integrated in the ISRBC and national procedures (SAVA GIS, SAVA Flood Forecasting and Warning System- Sava FFWS). The requirements for the modelling of the accidental pollution were defined as follows:

- For the purpose of the modelling of oil spill propagation the river network, which is subject to modelling has to be defined in hierarchical way in order to enable propagation (handshake) of the pollution from the upstream river reach to downstream river reach.

- Hydraulic model has to be developed for the addressed river reaches, this induces necessity for the bathymetric data of the river, which might be of concern. The bathymetric information is verified to be available for the main Sava watercourse, while for the minor river contributing to the Sava watercourse the availability of the batimetric data is very limited.

- The prognostic system for the accidental pollution is based on the scenario, that it is feasible to implement any intervention on the Sava river with the measures (i.e. retention booms, skimmers) only in the case of low to medium discharges. In the case of large discharges, estimated to be the upper quartile or quintile of discharge duration curve, flow velocity is to high to implement any measure. Beside that the dilution in the case of high discharges ishigh and coincidence probability relatively low, so it could be assessed to be of lower importance.

- The calculation time necessary for hydraulic propagation (step 1) and later implemented convection-diffusion model of the pollutant (step 2) is estimated to be approximately 2 hours for a single river reach (length approximately 30 km). This makes it impossible to calculate/model the propagation during the accidental pollution event itself. The requirement of the toolbox therefore anticipates pre-calculation of the propagation time within the river reach, based upon the discharge category estimated to be defined in the resolution of the quintile. Pre-calculated propagation time is therefore the basis for the prediction model.

- The toolbox should connect via API to the available and relevant discharge monitoring stations on the Sava river basin. This enables information on the propagation velocity at the actual discharges, nearest to the specific quintile of the pre-calculated model (hydraulic, pollution propagation).

- As for the pollutant the selection is set to the diesel fuel No. 2 as defined by the IL classification ISC 1561 or similar. The selection is set following the: occurrence of this pollutant in transport and elsewhere, low evaporation (in comparison to light-fraction petroleum distillates), and possibility of application of the intervention measures (surface pollution could be skimmed off, while for the fully dispersed pollutants in the water column only limited set of intervention measures is applicable.

- Other characteristics defining the velocity of the accidental pollution propagation downstream, which might be governing the propagation process and thus velocity of the propagation (i.e. temperature defining evaporation losses; vegetation parameters defining bank vegetation losses), should be set at medium values, taking into consideration, that it is quite impossible to address the entire spectrum of influencing parameters in advance.

- Important parameter relative to the volume (amount) of the pollutant released in the accident is certainly unknown and therefore it is impossible to assess also the amount of the pollution reaching specific point at the river downstream. In opposite to this, the velocity of the pollution head propagation is assessed to be quite independent from the amount of pollution, and is of crucial importance for the forecasting model.

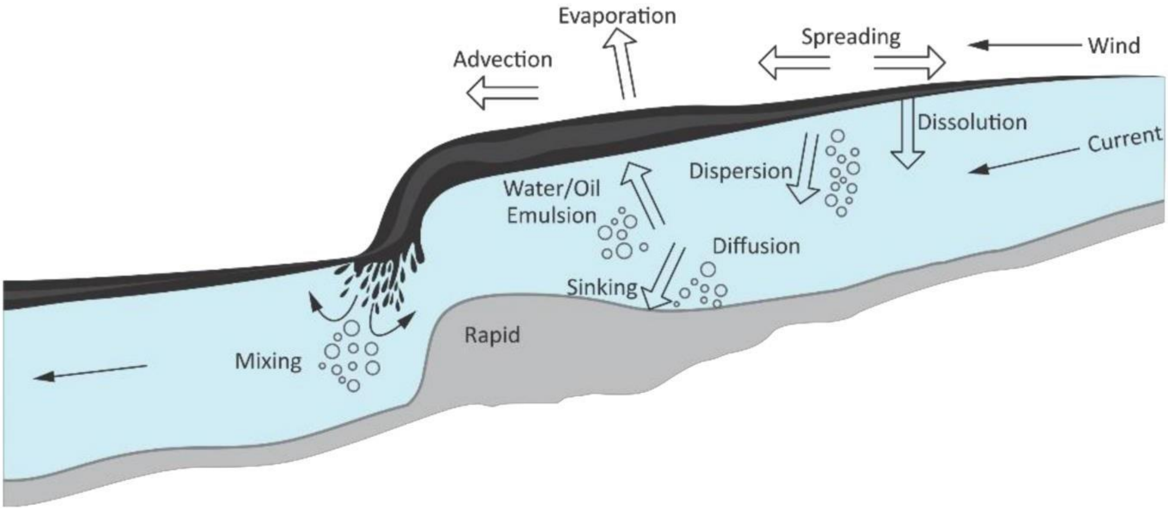

Figure 2: Governing parameters defining the oil spill dynamics in rivers [1]

The modelling tool for the forecasting of the pollution velocity propagation as a tool supporting decision making process in the related incidents will require therefore only one input from the user – the location. The location shall be set in a form of nearest settlement/town to the location of pollution. The system will provide a forecast on the basis of pre-calculated models on the velocity of propagation downstream and timing relative to the time zero of an incident (initial large-scale release).

The main issue presents the lack of available experimental data, which could be used to validate the river oil spill models and process algorithms. Therefore, more experimental studies are needed in order to better understand the river oil spill processes and consequently collect experimental data that could be used to develop, validate, and optimize new models and process algorithms. The development of decision support systems represents a novelty; they have been developed to enable real-life forecasts and response planning,help with the development of mitigation measures, and assist with post-spill analyses. Even though these systems are useful from an operational point of view, they do not contribute to the better understanding of the river oil spill processes or modeling of river oil spills in general.

Finally, the importance of river oil spill research and modeling in the context of environmental and public health protection should be more actively promoted, which would form the basis for obtaining more research funding and thus more academic attention.

[1] Kvočka, D.; Žagar, D.; Banovec, P. A Review of River Oil Spill Modeling. Water 2021, 13, 1620.

https://doi.org/10.3390/w13121620

3 Modelling of the Transnational modelling tool

The Transnational modelling tool – enabling modelling (forecasting) of the flood/accidental pollution event, based upon the available data. Flood prediction module is to large extent already operational (Sava FEWS) and presents the modelling backbone (forecasting of discharges) and provide information on flood routing and information on flood response measures. 1- dimensional model was developed for the Sava River and main tributaries.

The prediction module of the WACOM project as a part of the toolbox is focused only on the prediction of the accidental pollution requirements, as the module for the flood forecasting is already full implemented and integrated in the ISRBC and national procedures (SAVA GIS, SAVA FFWS). The requirements and the modelling approach are explained in the following chapter and more in detils explained in Annex 1.

3.1 Modelling approach

This report presents the development of 2D hydraulic and oil spill propagation models, which have been developed for the purpose of the WACOM project. The hydro-environmental models cover approximately 800 km long section of the River Sava between Jesenice (Slovenia) and Belgrade (Serbia). The modelling area has been divided into 31No modelling sections, with model limits being set at natural boundaries (e.g. river confluence) or at relevant infrastructure (e.g. ferry line, bridge etc.). First, a series of hydraulic models has been developed to provide information on flow velocities and distribution within the main river channel for different model flows. Second, a series of oil spill propagation models has been developed on top of the aforementioned hydraulic models, which provide information on oil spill travel times based on flow velocities. Hence, oil spill modelling is based on the pre-calculated hydraulics.

The developed 31No hydro-environmental models are based on a flexible mesh system, where the model domain is represented by a network of triangular elements which form a connected mesh. The model mesh sizes have been selected in order to provide an adequate level of resolution and allow for model simulations to be performed in a reasonable timescale. An in-house developed data processing tool called Hydrology Hub has been used to generate a 3D terrain grid of the river channel from the geodetic profiles (i.e. cross-sections) that have been surveyed for the purpose of developing the 1D hydraulic model in HEC-RAS. The roughness parameters applied in all 31No 2D numerical models are based on the roughness coefficients used in the 1D HEC-RAS hydraulic model.

The considered model flows are based on the flow exceedance curves at specific river sections, with the applied model flows covering the entire range of potential discharges (i.e. from low to high flows). Both hydraulic and oil spill propagation simulations have been performed for 5No model flows, with each model flow representing a range of discharges that have been grouped into 5No flow classes. The modelling approach is based on the “steady-state” concept. This means that hydraulic simulation time must be long enough to reach steady-state conditions. Once steady-state conditions are reached, the model is run at steady-state conditions for a period of time that is long enough to accommodate for the time that is needed for an oil slick to propagate from the start to the end of the modelling section.

The connectivity and stability of the developed 31No hydro-environmental models has been tested in a series of test simulations, which were also used to determine the optimal simulation time and thus optimise the run times. Altogether, 310No model simulations have been run, with all relevant model outputs being evaluated in the subsequent results review process. The oil spill travel-times at different model flows have been extracted for pre-specified sections of the River Sava. The extracted travel-times have been summarised in a database, which will form an integral part of the rapid joint preparedness and response toolbox.

The reliability of the modelling process and results is dependent on a variety of factors, which cannot be always managed or controlled to the desired level. Therefore, it is important to take into consideration that even though the 31No hydro-environmental models have been developed to the highest standard, the models are still posed with uncertainties and limitations. The main model uncertainty arises from the lack of high-quality filed measurements and observations, i.e. lack of proper bathymetry surveys, calibration and validation datasets and field trace studies. However, as all the key features of developed 31No models (e.g. mesh, boundary conditions, Manning's n, oil spill setup etc.) can be adjusted without the need to change the overall model configuration, the developed hydro-environmental models are relatively easy to maintain and refine. Therefore, model uncertainties and limitations could be significantly decreased in the future with periodical model revisions and refinements, which would be based on field measurement campaigns and surveys.

Despite all potential uncertainties and limitations, the modelling conducted within the WACOM project should therefore be viewed as a big step forward in both technical and scientific sphere in the countries sharing the Sava River Basin. The modelling and the subsequent rapid joint preparedness and response toolbox set up a unique framework, which can be used to improve our understanding of hydro-environmental processes associated with the River Sava, develop new research ecosystems and technical hubs, and establish better transnational cooperation between different national agencies and governmental structures.

3.2 Oil spill propagation model development

The oil spill propagation models are based on the hydraulic models, i.e. oil spill modelling is based on pre-calculated hydraulics. Thus, the setup of oil spill models requires only specification of an oil spill location, oil spill parameters (e.g. oil properties, oil spill volume) and modelling parameters (e.g. considered weathering processes, run time, ambient conditions etc.). The oil spill location has been placed at the start of the modelling domain in all 31No models. At this stage, the locations of potential monitoring profiles have also been identified, which serve as reference points within the oil slick travel-time recording process. The monitoring profiles have been predominately placed at the locations where the potential response measures could be deployed, i.e. ferry lines, bridges and where free/unobstructed access to water on both banks of the river is available.

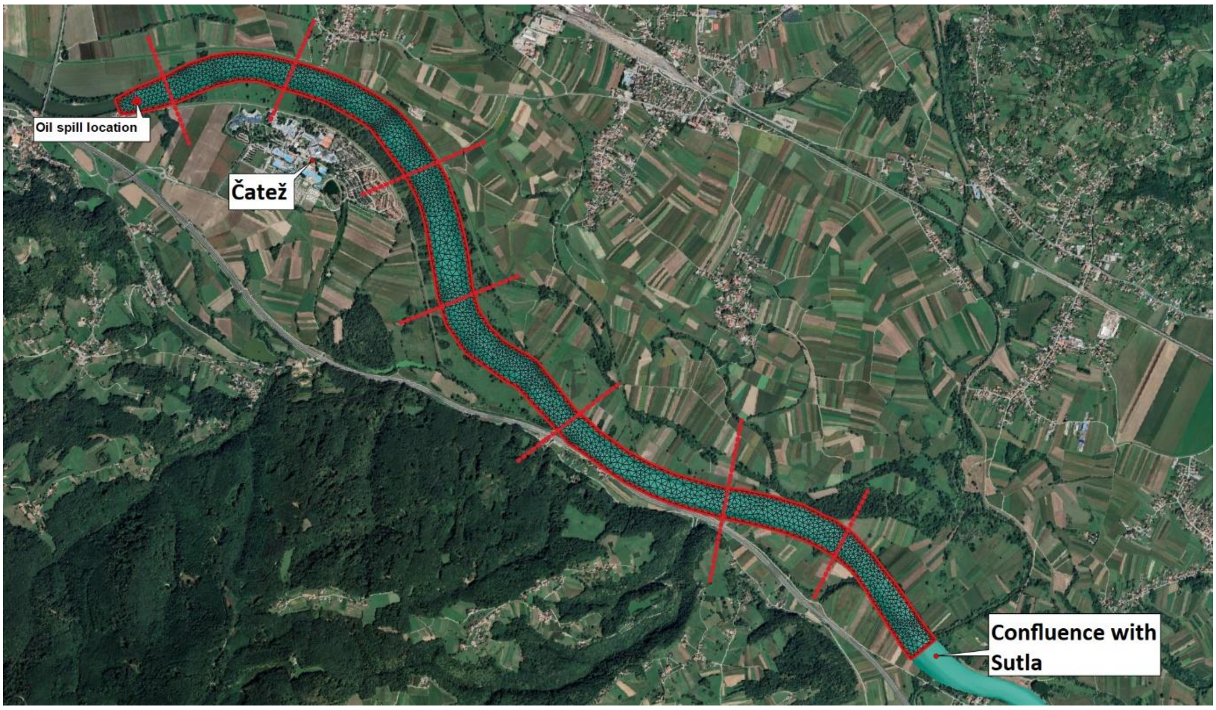

Figure 3: Definition of oil spill location and reference/monitoring profiles (red dashed lines)

In the next step, basic oil spill properties are specified. This includes the definition of parameters such as water density, number of tracking particles, oil properties (i.e. density and viscosity), initial spill time and dispersion coefficients. After the definition of the basic oil spill parameters, the volume of the spilled oil and its release rate are specified. An oil spill release rate is specified in the form of a time-series, which defines the overall cumulative volume of the oil that enters into the river and the pace of its release rate (i.e. how quickly and in which quantities is oil entering the waterbody). At the final stage of the setup process, the user specifies which oil spill models will be considered during the simulation (i.e. which oil weathering processes will be considered), defines simulation time and output intervals and provides information on ambient conditions, i.e. wind velocities and air temperature.

3.3 Model uncertainties and maintenance

The 2D modelling of a scale considered within the WACOM project is a complex task, which requires a large amount of quality data, and high degree of experience and technical abilities. The reliability of the modelling process and results is thus dependent on a variety of factors, which cannot be always managed or controlled to the desired level. Therefore, it is important to take into consideration that even though the 31No numerical models have been developed to the highest standard, the models are still posed with uncertainties and limitations.

As mentioned, one of the more important steps in the 2D hydro-environmental modelling is the preparation of the topographical and bathymetric data, which is used to provide the three-dimensional (3D) information on the spatial characteristics of the modelling area. This information is generally obtained from the bathymetric measurement campaigns (CH2M, 2017a; 2017b). As there was no readily available bathymetry data and no measurement campaign have been planned or conducted, the 31No numerical models have been developed based on the bathymetric data collected during the geodetic survey of cross-sections. These surveys have been conducted to develop the 1D hydraulic model in

HEC-RAS used within Sava FFWS, with the 3D terrain grid being generated from the cross-sections extracted from the HEC-RAS model (see section **Error! Reference source not found.**).

The surveyed cross-sections can significantly vary in spatial distribution. For example, there is on several occasions a comprehensive gap between adjacent surveyed cross-sections. For the purpose of 1D hydraulic modelling, these gaps are generally not problematic, as they are within the recommended limits, i.e. the recommended maximum spacing between the cross-sections in the modelling area is around 5 km (CH2M, 2018). In contrast to the 1D model (which performs calculations solely at a specific cross-section), the 2D model performs calculations within the entire domain, i.e. calculations are performed at every point within the model domain. As the generated terrain grid is based on the interpolation between these surveyed cross-sections, it should be notated that the 3D bathymetric representation of the river channel is only an approximation. Namely, a lot of information on the channel geometry is lost or missing due to the large gaps between surveyed cross-sections. Therefore, a bathymetry measurement survey is needed in the future in order to fully capture the channel characteristics and thus improve model predictions.

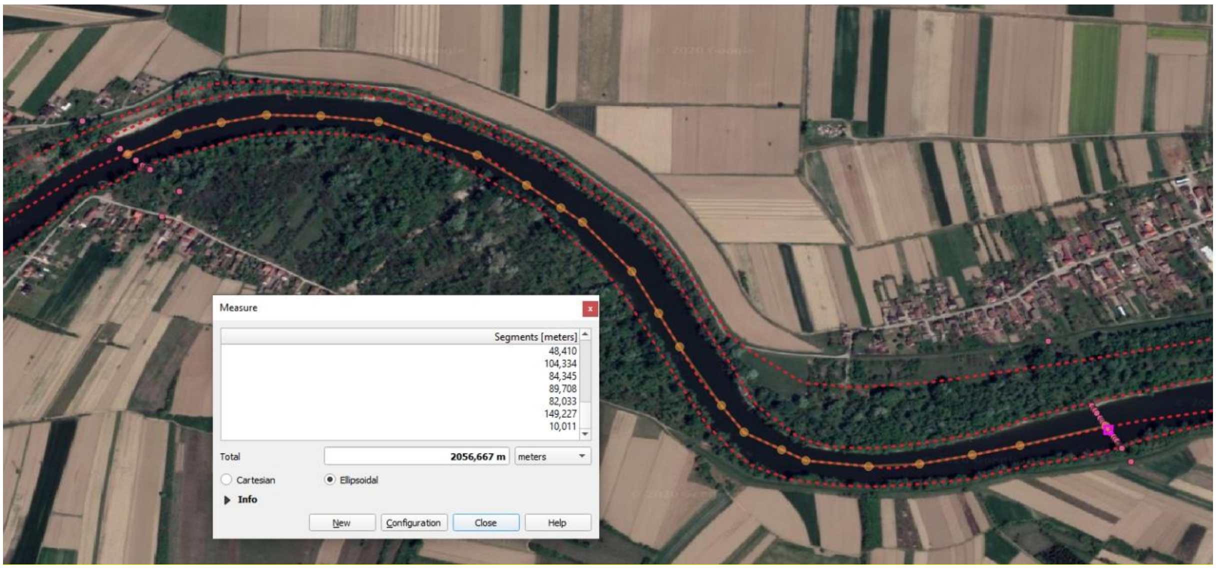

Figure 4: An example of a relatively large distance between two adjacent cross-sections

One of the key parameters within the hydro-environmental modelling is the estimation of the roughness parameter. As mentioned, the roughness parameters applied in the developed 31No hydraulic models are based on the coefficients used in the 1D hydraulic model developed in HEC-RAS (see section **Error! Reference source not found.**). In simple terms, the roughness parameter determines the friction losses, which in turn impact the river hydraulics, i.e. higher the roughness parameter the lower the flow velocity and thus higher the water level, and vice versa. In addition, the roughness parameters is also important in terms of oil retention on the river banks and later re-entry of the oil in the water column.

The value of the roughness parameters are based primarily on the type of the river vegetation. For example, a river bank covered with low grass will have a smaller roughness parameter than a river bank that is densely covered with trees (e.g. see Chow, 1959). Therefore, there is a need for a systematic inspection of river channel and banks, which will focus on mapping of the river vegetation in order to re-evaluate the considered roughness parameters. The proper estimation of the roughness parameters would enable smoother calibration and validation process, decrease the level of uncertainty and consequently improve the predictive capability of the developed models.

Another important aspect of 2D hydro-environmental modelling is the calibration and validation process. This generally consist of two steps: (i) fine-tuning of the models to match a specific set of measurements (calibration) and (ii) running of the fine-tuned model for conditions that were present at some other (unrelated) measurement campaign, with the aim being to see how the model predictions match to these measurements (validations). The 2D hydro-environmental models can be calibrated and validated with data from stationary measuring locations (e.g. flow measurements at river gauging stations) or dynamically changing measuring locations (e.g. ADCP velocity measurements) (CH2M, 2017a; 2017b; 2018).

As there were no measurements campaigns and thus no field data is available, only a limited calibration process has been conducted, with the calibration process being based on the data collected at the river gauging stations. Therefore, there is a need for comprehensive measurement campaigns, which will focus on collecting a wide range of river data, such as flow velocities, water levels, sediment transport rates etc. This data would be used for detailed calibration and validation of the 31No models, which should decrease the level of model uncertainty and thus increase the confidence in the model performance and predictive ability.

One of the most important steps in the 2D oil spill propagation modelling is the setting of the longitudinal and transverse dispersion coefficients. These can be defined based on the calculated values obtained from a specific equation or preferably from field and laboratory measurements. As there were no field measurements and no modification of the selected oil spill model were possible, there is a lot of uncertainty associated with the selection of the longitudinal and transverse dispersion coefficients. Even though a comprehensive testing and evaluation process has been conducted, it should be noted that the selected dispersion coefficients need a proper re-evaluation in the future.

Therefore, there is a need for a systematic collection of field measurements, which should be based on tracer-tracking studies. This is generally the only way to adequately define dispersion coefficients and thus improve the modelling tool. This should be done individually for each modelling section and preferably at different river discharges. Even though this would be an enormous task, it is the only way forward to a better understanding of the river behaviour and oil spill propagation processes.

The developed 31No hydro-environmental models are easy to use. All the key features of the models (e.g. mesh, boundary conditions, Manning's, oil spill setup etc.) can be adjusted without any need to change the overall model configuration. This means that models are also relatively easy to maintain and refine. As the river conditions are constantly changing, it is recommended that models are reviewed and updated on regular basis. These periodical model refinements should take into the consideration the following:

- the model bathymetry should be updated in regular intervals to take into account the changes in the river geomorphology
- the impact of any newly constructed river training structures (e.g. dikes) has to be adequately represented in the models
- models should be regularly calibrated and re-validated with new sets of field measurements

- major flow events should be recorded in order to test the predictive ability of the developed models
- river channel and banks should be inspected regularly in order to update the models with any new information regarding the vegetation coverage

4 Sava GIS upgrade

Project overall aim was to support further development of SavaGIS as a common platform of the ISRBC members to enable sharing and dissemination of information and knowledge about navigation management and accident prevention and control activities in the Sava River Basin.

Specific goal of the Sava GIS upgrade activities was:

- To develop (design, test, deploy and implement) SavaGIS database elements for the Navigation management and Accident prevention and control data within the existing SavaGIS platform repository;
- To develop (design, test, deploy and implement) Navigation management and Accident prevention and control modules on existing SavaGIS platform for storing, processing, dissemination and visualization of corresponding information;

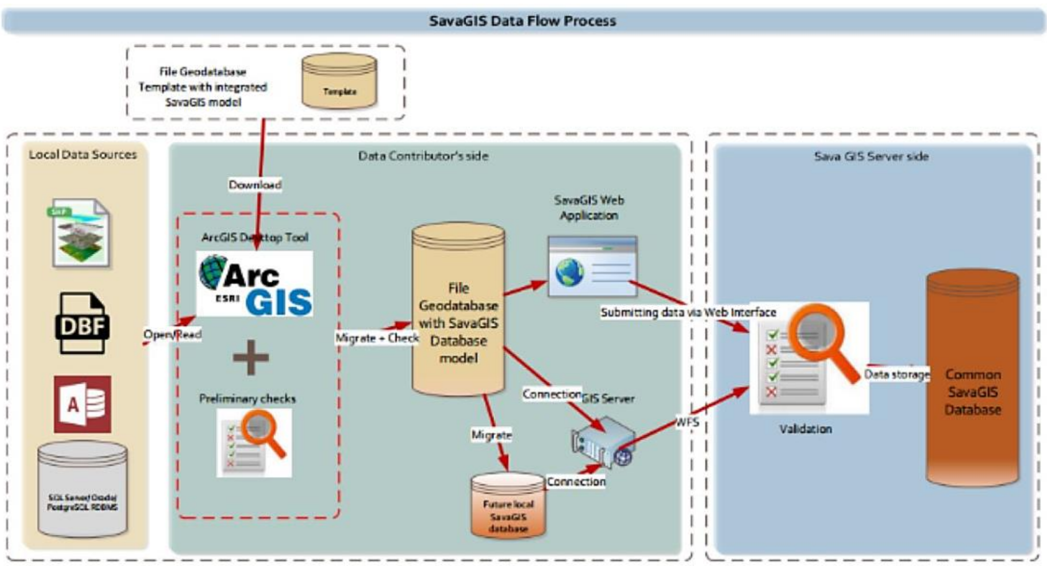

Figure 5. SavaGIS data flow process

Within the project activities the following has been achieved:

- SavaGIS extended with new feature classes for APC and NAV data
- New functionalities for import of APC data implemented
- New functionalities for import of ENC data implemented
- New functionalities for creating, viewing and editing of Album of bridges via the web forms implemented
- New web services for dissemination of APC and NAV data implemented

- Manuals and accompanying documentation delivered

Upgraded modules:

NAV module

- ENC information management and display
- Album of bridges on the Sava River and its navigable tributaries information management, integration and display

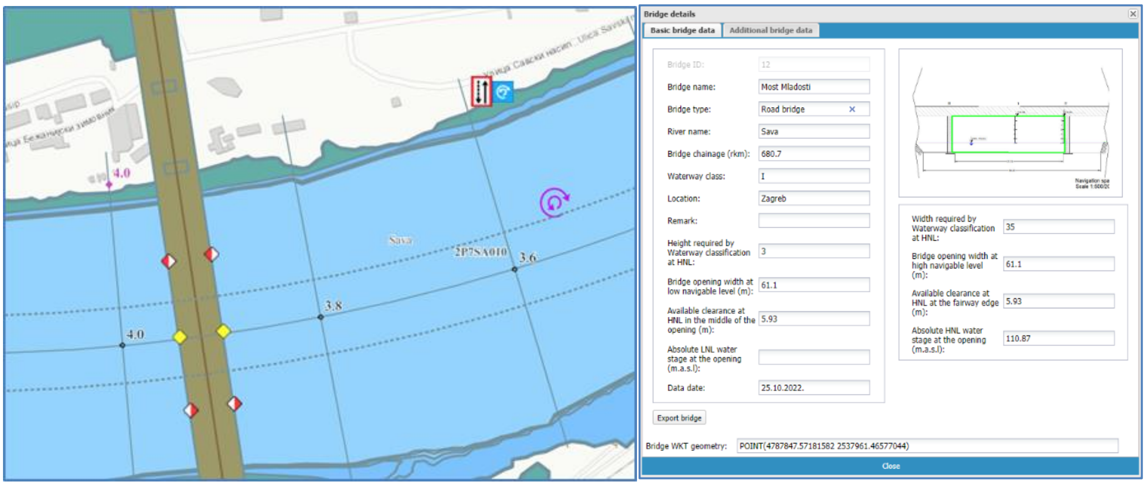

Figure 6: Developed NAV module

APC module

- Calculation of time needed for pollution to spread downstream
- Lookup table with discharge→ travel time
- Discharge from hydrological stations

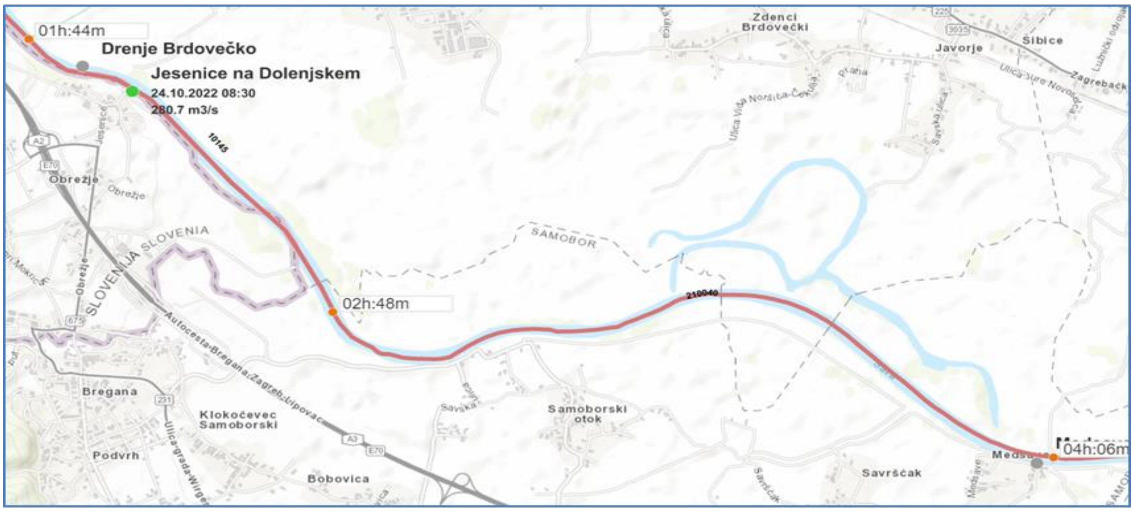

Figure 7: Developed APC module

Newly developed NAV and APC modules have been successfully deployed on the Sava GIS production platform:

https://www.savagis.org

Pollution propagation set of tools (part of the APC module) has been solely deployed on the Sava GIS test platform:

https://test.savagis.org

Remark: NAV and APC modules advanced functionalities are only available to Sava GIS registered users (ISRBC terms and conditions apply).

5 Transnational modelling tool

Transnational modelling tool is focusing on modelling of oil spill modelling in River Sava. In the operational management of an accident with a hazardous spill into a river, it is necessary to analyse the event in a spatio-temporal perspective. The spread of contamination along a river can take place with different dynamics. In order to activate the forces appropriately, both in time and location, a spill prediction tool should be used in this type of accident.

In case of the simulated event of the accidental pollution, the elements included are the dynamic information exchange, activation of headquarters and forces, and second, the dynamics of propagation of the pollution downstream the Sava River which dictates the tempo of the response activities. The propagation is based on predefined conditions for propagation and simulations of propagation using the WACOM tool. The information exchange and activation of forces will base on the existing procedures which will be supported with the WACOM tool, the platform for exchange of information.

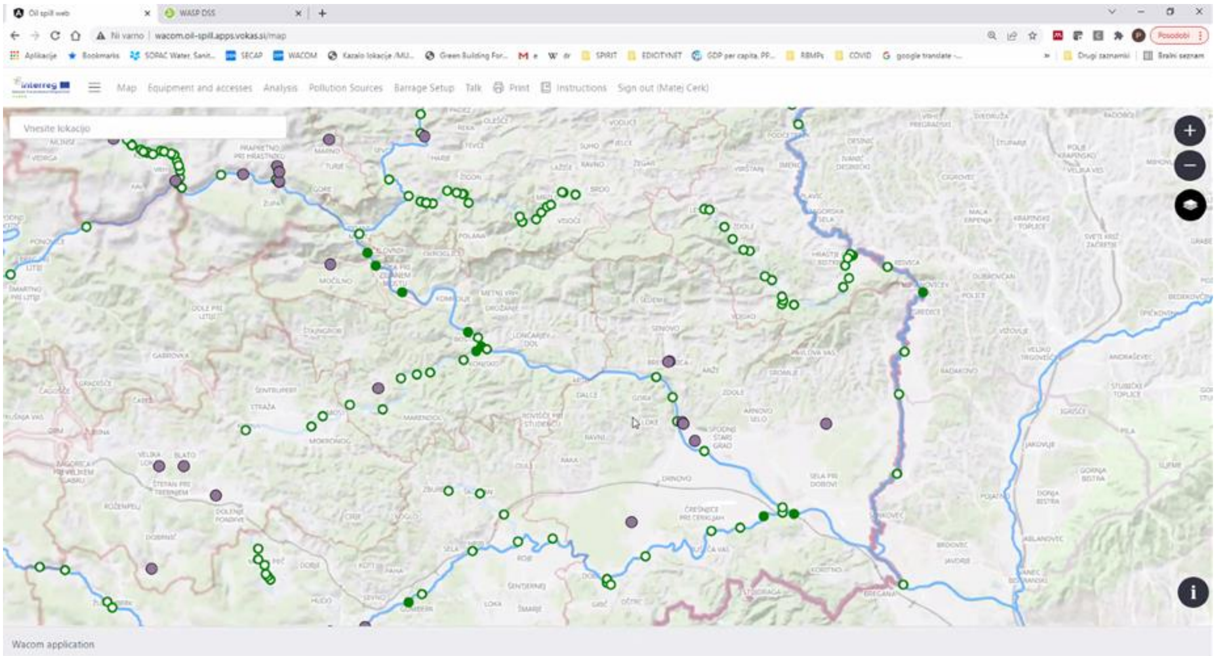

Figure 8: Transational modelling tool - Oil Spill Web

5.1 Where can I find the app?

The app is located on the link: http://wacom.oil-spill.apps.vokas.si

5.2 What does the app include?

When opening the app, a map showing watercourses in Europe opens. The map is a main feature of the app, as it allows a quick assessment of the spread of pollution in watercourses in the event of a spill. On the top of the page there is a main task bar which shows the map as the first option (Figure 9).

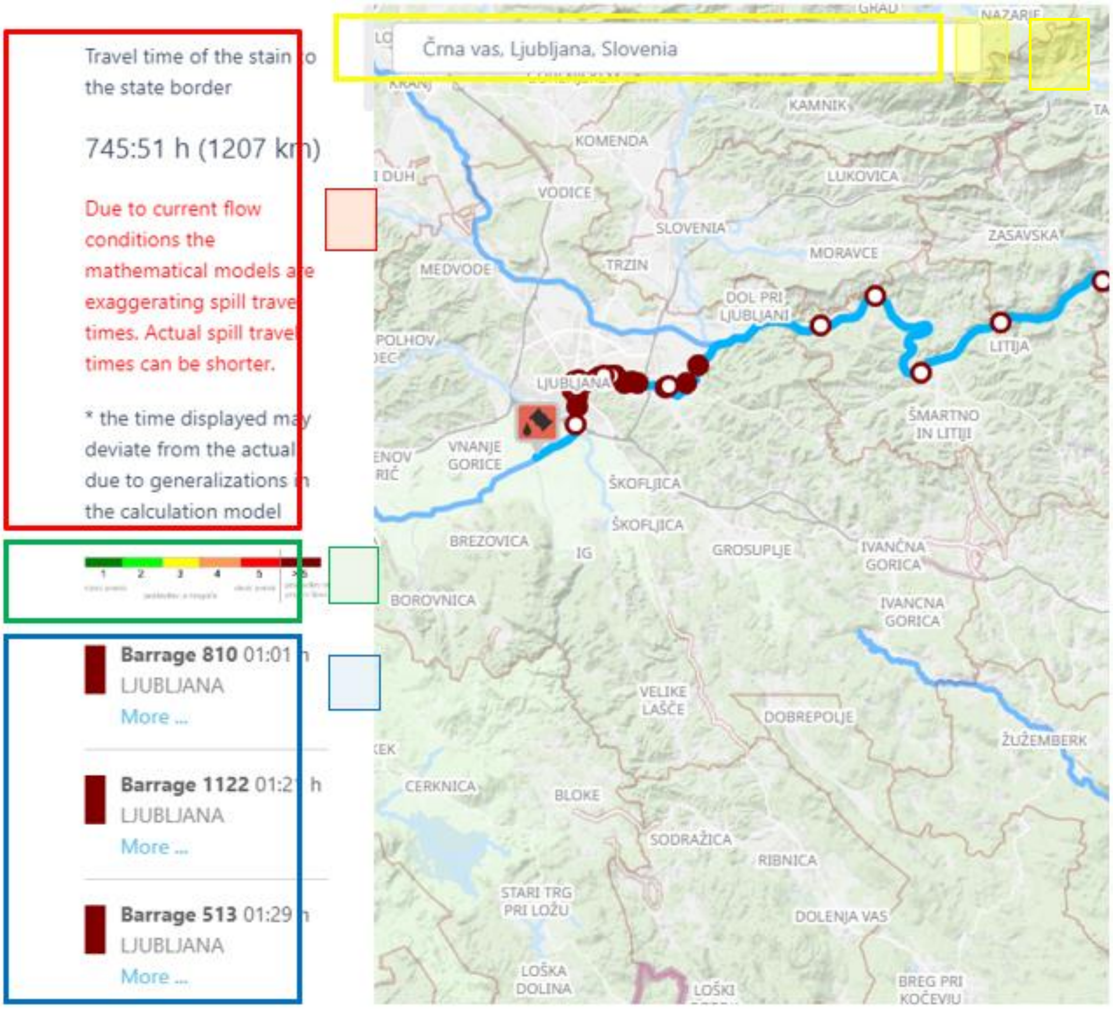

Figure 9: Results of the spill travel time

In the »More...« section, more functions can be found, for example barrage list, and additional information about the barrage site, and other information, such as:

- information on the competent fire brigade and volunteer firefighters' association,
- site access information,
- current flow category through the barrage site,
- information on the gauging station and
- a potential comment on the barrage site.

5.3 Modelling Tool testing

After the development of prototypes, the users – PPs, ASPs and other invited stakeholders – target groups (local, national, utilities, enterprises, international) assess the operation. The assessment was performed in two stages – (1) testing of the three modules prototypes and (2) beta testing of the WACOM toolbox – three modules. A template form for collecting feedbacks were prepared. A template form (factsheet) were filled in by PPs and ASPs. The first testing phase was conducted in June 2022 and the second testing phase in September 2022. Comments were collected from all PPs and ASPs in a prepared factsheet.

On the basis of feedback from the testing reports will be prepared describing the comments of the users and ways to improve the tools under development.

Compliments on the tool:

- Useful to know the propagation times
- Easy to use
- Timely information allows for better response and faster reaction in crisis situations.
- Slovenia region has more data (sewage networks, pollution sites, ...) than other countries
- Missing translations for other languages
- Displaying of flow rate (m3 per second) could be misleading to untrained user
- Fluctuations of flow rate on adjacent river sections
- What is the accuracy of the tool
- Calculations at high flow rates
- Proposal for harmonization with additional maps of risks, impacts and capacities.

After testing several improvements were made:

- General bugs and fixes
- Drina river was added
- Login & Password details:
  - Authentication removed (on pages without sensitive data)
  - Authentication remaining (chat, equipment, analysis)

5.4 The tool applicability

The WASP tool integrating and managing the modelling results, also enabling prediction of the accidental pollution propagation was less commented by the partners and therefore requires less upgrades for the final version. The tool applicability is in many countries limited by the limited spatial data on different spatial entities that either provide:

- improved spatial information on potential sources of accidental pollution (sources),
- improved spatial information on potential locations about the locations where intervention measures could be applied, and
- improved spatial information on potential vulnerabilities downstream the accidental spill locations (water abstractions, drinking water protection zones using river bank filtrate).

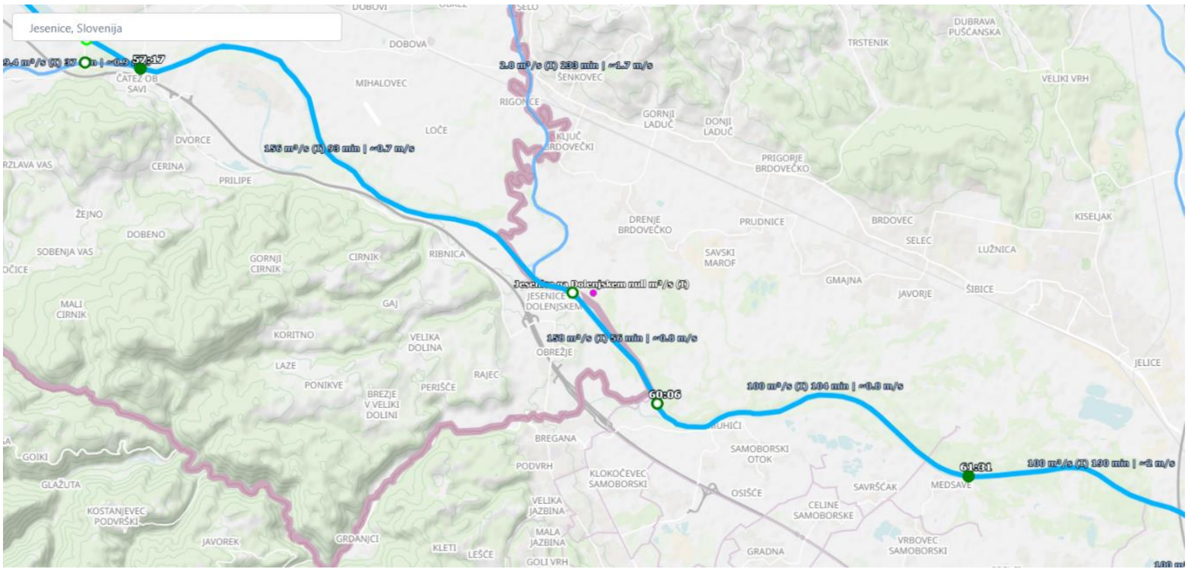

Figure 10: Necessity for the complex harmonization between the measured and modelled discharge information on different sections of the Sava river

The analysis on the second stage data collection has also identified the necessity to improve the API (Application Program Interface) data exchenge with the souces of the information of discharges on the addressed river sections. The main challenge occurs when the information on the discharge on specific river section is not available and the modelled discharge should be used instead.

6 Conclusions

In order to reduce the environmental risks related to accidental pollution and floods, especially those that have or could have transboundary impacts in the Sava River Basin. For this reason, the WACOM (Water Contingency Management in the Sava River Basin) project developed a rapid joint preparedness and response toolbox. Transnational modelling tool of the WACOM project is focused on the prediction of the accidental pollution requirements, as the module for the flood forecasting is already fully implemented and integrated in the ISRBC and national procedures (SAVA GIS, SAVA FFS).

Tranasnational modelling tool is focusing on modelling of oil spill modelling in River Sava. In the operational management of an accident with a hazardous spill into a river, it is necessary to analyse the event in a spatio-temporal perspective. The spread of contamination along a river can take place with different dynamics. In order to activate the forces appropriately, both in time and location, a spill prediction tool should be used in this type of accident.

In case of the simulated event of the accidental pollution, the elements included are the dynamic information exchange, activation of headquarters and forces, and second, the dynamics of propagation of the pollution downstream the Sava River which dictates the tempo of the response activities. The propagation is based on predefined conditions for propagation and simulations of propagation using the WACOM tool. The information exchange and activation of forces are based on the existing procedures which are supported with the WACOM tools, the platform for exchange of information.

The modelling of the Tranasnational modelling tool included the development of two-dimensional (2D) hydraulic and oil spill propagation models, which was integral part of the newly developed rapid joint preparedness and response toolbox. The development of the transnational modelling tool should enable modelling (prediction) of the flood/accidental pollution events. The numerical modelling has been conducted for approximately 700 km long section of the River Sava, i.e. the modelling area stretches from Čatež in Slovenia to Belgrade in Serbia, where River Sava discharges into the River Danube.

One of main goals of modelling and the development of a rapid joint preparedness and response tool, was to improve the exiting and operational family of tools developed and used by the International Sava River Basin Commission (ISRBC), i.e. GeoInformation System for the Sava River Basin (Sava GIS), Hydrological Information System of the Sava River Basin (Sava HIS) and Flood Forecasting and Warning System in the Sava River Basin (Sava FFWS). Newly developed NAV and APC modules have been successfully deployed on the Sava GIS production platform. Also the pollution propagation set of tools (part of the APC module) has been solely deployed on the Sava GIS test platform.

The transnational modelling tool is one of the main outcomes of the project will lead to reduced risks induced by the accidental pollution and floods of transnational dimension by strengthening the transnational and trans-sectorial cooperation among institutions, especially governmental institutions that manage the flood and accidental pollution preparedness and response stage.

7 References

CH2M. (2017a). FAST Danube: Measurements Report-first campaign - Surveys, investigations & measurements CH2M, Bucharest, Romania: 56 pages. Availabe online: http://www.fastdanube.eu/sites/default/files/official_docs/FAST-Danube_MeasurementsReport_FirstCampaign_31Jul17_EN_FinVer.pdf (Accessed on: 22/03/2021).

CH2M. (2017b). FAST Danube: Measurements Report-second campaign - Surveys, investigations & measurements CH2M, Bucharest, Romania: 30 pages. Availabe online: http://www.fastdanube.eu/sites/default/files/official_docs/Report%20Campaign%202_EN_20171003%20fin.pdf (Accessed on: 22/03/2021).

CH2M. (2018). FAST Danube: New Mathematical Models Report - Development/Calibration/Validation. CH2M, Bucharest, Romania: 131 pages. Availabe online: http://www.fastdanube.eu/sites/default/files/official_docs/FAST-Danube_ModelBuildCalibrationReport_Revised_23Jan18_clean1.pdf (Accessed on: 22/03/2021).

Chow, V. T. (1959). *Open Channel Hydraulics*, McGraw-Hill. New York, 680 p.

Kvočka, D., Žagar, D. and Banovec, P. (2021). A Review of River Oil Spill Modeling. *Water, 13*(12), 1620. DOI: https://doi.org/10.3390/w13121620