

# FINAL REPORT

Project: *Support to the International Sava River Basin Commission in the development of the Sava Geographic Information System*

Contract title: *C4 – Establishment of the SavaGIS core functionalities*

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## DOCUMENT CONTROL AND DEFINITION

### Document History

Version	Issue date	Author	Changes
1.0	01.10.2015.	Jarmila Pezo, Stjepan Grđan	Initial version with annex documentation
1.1	15.10.2015.	Jarmila Pezo, Stjepan Grđan	Draft final report – version for delivery
1.2	16.10.2015.	Jarmila Pezo	Update and corrections after feedback
1.3	30.10.2015.	Jarmila Pezo	Final report

### Document Approvals

Role	Name	Signature
Contracting Authority's Project Manager	Dragan Zeljko	

## ABBREVIATIONS

Ah GIS EG	Ad hoc GIS Expert Group
APSFR	Areas of Potential Significant Flood Risk
CWG	Core Working Group
ETRS89	European Terrestrial Reference System 1989
EU	The European Union
FASRB	Framework Agreement on the Sava River Basin
FD	EU Floods Directive
FDR	Floods Directive Reporting
FGDB	File Geodatabase
FRM	Flood Risk Management
GIS	Geographical Information System
GUI	Graphical User Interface
GML	Geography Markup Language
ICPDR	International Commission for the Protection of the Danube River
ICT	Information and Communication Technology
INSPIRE	Infrastructure for Spatial Information in Europe
ISO	International Organization for Standardisation
ISRBC	International Sava River Basin Commission
IT	Information Technology
MoM	Minutes of Meeting
OGC	Open Geospatial Consortium
OS	Operating System
OVI	Objectively verifiable indicator
QA	Quality Assurance
QCR	Quality Control Records
PRTR	Pollutant Release and Transfer Register
RDBMS	Relational Database Management System
RBM	River Basin Management
RBMP	River Basin Management Plan
SRB	Sava River Basin
SRBMP	Sava River Basin Management Plan
ToR	Terms of Reference
UAT	User Acceptance Test
URL	Uniform Resource Locator

UTC	User Test Case
UWWT	Urban Waste Water Treatment
WCS	Web Coverage Service
WISE	Water Information System for Europe
WFD	EU Water Framework Directive
WFS	Web Feature Service
WMS	Web Mapping Service
XML	Extensible Markup Language



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## PROJECT DETAILS

Project title	<b>Support to the International Sava River Basin Commission in the development of the Sava Geographic Information System</b>		
Project Acronym	SavaGIS		
Contract title	C4 - Establishment of the SavaGIS core functionalities	Identification number	3-14-16
Project start date (commencement)	20.01.2015.	Project end date	31.10.2015.
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## PROJECT SUMMARY

### Preface

This Final report includes complete overview of the activities implemented during the project, summary of outputs, major problems encountered during the implementation, additional activities performed which were out of the initial project scope, recommendations for further work and project activities, as well as required technical and user documentation delivered as separate documents.

### Project background

In order to establish seamless and platform independent SavaGIS, the ISRBC contracted the implementation of the project “Establishment of the SavaGIS core functionalities” (ID: 3-14-16) with the Consortium IN2 Ltd and IGEA Ltd. Duration of the project was from January to October 2015. The project implementation was co-funded by the European Commission.

The geographical area covered by the project is the Sava River Basin. The beneficiaries of the project results are the institutions from the countries which have been cooperating under the Framework Agreement on the Sava River Basin (FASRB), through the ISRBC: Bosnia and Herzegovina, Republic of Croatia, Republic of Serbia and Republic of Slovenia (Parties to the FASRB) and Montenegro (cooperating on the basis of the Memorandum of Understanding with the ISRBC).

SavaGIS supports above stated countries in further approximation to the EU environmental acquis in the field of water management and according to the EU Water Framework Directive (WFD) and related legislation.

### Overall project objective

The overall objective of the project is to support establishment of SavaGIS as a common platform of the ISRBC community to enable sharing and disseminating of information and knowledge about protection of the water resources and water management activities in the Sava River Basin.

### Project scope

The services and deliverables within the project scope were:

- Establishment (build, test, deploy and implement) of the SavaGIS database (Sava geodatabase);
- Establishment of the web-based application for data and metadata management: loading, updating, storing and retrieving;
- Establishment of the Sava Geoportal for searching, disseminating, processing and visualization information to the stakeholders and public;
- Knowledge transfer;
- System and user documentation.

### Project management

Project management was carried out as follows:

- The Secretariat of ISRBC was tasked with the overall project management;

- Ad hoc GIS Expert Group (Ah GIS EG) acted as the project management group (PM) and was responsible for the coordination of the activities;
- Core Working Group (CWG), established by ISRBC and consisting of the representatives of beneficiary institutions from the Parties to contribute to the resolving of the specific issues during project implementation;
- Specific issues were discussed with ISRBC Permanent Expert Group for RBM (PEG RBM) and Permanent Expert Group for Flood Protection (PEG FP).

The information on the project status, open issues and results were presented and discussed at the meetings organized on different levels:

- A numerous meetings were organized between the Secretariat of ISRBC and the representatives of Contractor.
- **Three Project meetings** were organized within the framework of the Ah GIS EG with the subject of verification of deliverables' quality, adoption of the results on the expert level and recommendations for further work.
- **Specific issue meetings were** organized within the frame of the PEG RBM and PEG FP. There were two PEG RBM meetings and one PEG FP meeting where the project results were presented and adopted on the expert level.
- **Specific task meetings** organized by the Secretariat of the ISRBC with CWG for specific tasks of project performance. At the specific task meetings the open questions were discussed in order to direct and support the project implementation on specific questions like format of the data exchange, specific functionalities of the web application, test iteration steps, etc.
- At the **ISRBC session** the interim project outputs and the final deliverables were presented to the ISRBC members. The importance of SavaGIS platform establishment was emphasized and the recommendations for further development and work with SavaGIS were given.
- The two **workshops** were organized by the ISRBC with wider participation of experts from the beneficiary countries, NGOs and representatives of various governmental institutions from the Sava River Basin countries. The midterm results were presented on those workshops. The participants gave the positive feedback on the proposed solution and on project deliverables. The discussion and comments received during the workshops served as additional inputs for topics on the project meetings.

## Significance of the project implementation

SavaGIS system empowers GIS systems of the Parties to the FASRB to use, implement and maintain common and EU standards and data specification agreements thus making information and products shared in a more accessible, comparable, and understandable way.

Development of SavaGIS Geoportal is an important step in the establishment of the National SDI (NSDI). SavaGIS Geoportal facilitates sharing, integration, and use of geographic information across ISRBC Parties, stakeholders, government institutions and general public. The users are able to overview spatial datasets through the use of the SavaGIS Geoportal catalogue and metadata services.

SavaGIS system is scalable, modular and flexible solution based on Open Geospatial Consortium (OGC) standards and open source (Geoserver and Geonetwork) and ESRI (ArcGIS) technologies for viewing, searching of attribute, spatial data and metadata. The open source software was introduced in order to minimize the costs of the additional licences of the proprietary software. The modular solution based on open source technologies gives the great possibility for further extension with additional modules for target area. The system is based on interoperability, OGC standards, and geoformation

system network of the ISRBC. SavaGIS is a step towards uniform international terminology and common understanding on sustainable water resources management.

The additional benefits of SavaGIS system could be seen later in the following areas:

- Integrated River Basin Management;
- Flood Management;
- Hydrology and Meteorology Management;
- Accident Prevention and Control;
- Navigation Safety Management;
- Sediment Management, etc.

## Project deliverables

The complete list of the deliverables is listed in [Annex 1](#).

The delivered products are structured in groups:

- Project reports
- Output documents per each project component
- User manuals
- Testing
- Project management - Meeting minutes/reports.

## SAVAGIS ARCHITECTURE AND TECHNOLOGY USED

The foundation concept behind the implemented SavaGIS platform is the use of open industry standards and protocols which allow interoperability between various open source and proprietary software components.

ArcGIS Server was already licensed by the ISRBC under a proprietary license which entitles the end user for running the software on a limited number of production servers with a limited number of assigned cores/processors, as per the purchased license. However, if the load on the GIS server (and the entire system) increases dramatically (due to new users or external systems which use the data), licensing will need to be upgraded. In order to prevent those additional costs in licenses and to maximize the SavaGIS platform performance, and to follow the OGC requirements and recommendations, the open source **GeoServer** was implemented. GeoServer is an open source software server that allows users to share, edit and publish geospatial data. Designed for interoperability, it publishes data from any major spatial data source using open standards.

GeoServer supports data management using standard protocols established by the OGC:

- The Web Feature Service (WFS) supports requests for geographical feature data (with vector geometry and attributes).
- The Web Map Service (WMS) supports requests for map images (and other formats) generated from geographical data.
- The Web Coverage Service (WCS) supports requests for coverage data (rasters).

The planned Relational database management system (RDBMS) for the SavaGIS was Microsoft SQL Server 2012 Standard but the establishment of open source RDBMS (PostgreSQL/PostGIS) was recommended as the PostgreSQL/PostGIS fulfils all set requirements of the SavaGIS. The PostgreSQL/PostGIS is used to store and manage spatial data in the central SavaGIS database and to enable authentication and authorization of quality control processes.

ESRI ArcGIS for Desktop tool was used for migration of data from old to new database. The ESRI **ArcCatalog** has the tool Simple data loader, with field mapping (old field name to new field name) which was used for data migration from one database model to another with the possibility of attribute mapping.

The implementation of the metadata management system is based on **GeoNetwork** solution. GeoNetwork is an open source catalogue application for spatial data management and it is used for metadata search and editing. GeoNetwork is powerful, open source solution based on international and open standards for services and protocols (ISO TC211 and OGC standards).

SavaGIS system integrates several modules (e.g. WebGIS application, Metadata Management module etc.). To enable the unified administration of all integrated modules, the administration module based on **GeoFence** database model was implemented as referent administration module, but expanded with attributes and functionalities in accordance with the requirements of SavaGIS Web application and Metadata Management module.

Figure 1 shows the SavaGIS architecture:

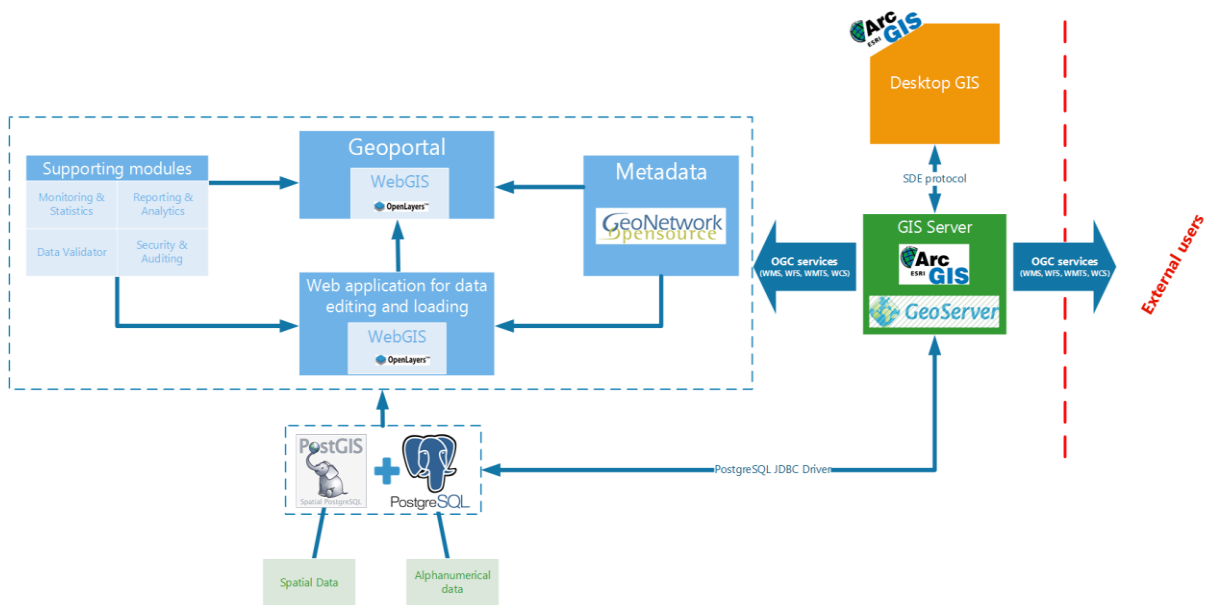


Figure 1 SavaGIS Architecture

The Table 1 gives the complete list of the SavaGIS infrastructure:

SavaGIS infrastructure:	Description
Operating System:	Windows Server 2012 R2 Standard
Relational database management system:	PostgreSQL ver. 9.3.5 with PostGIS ver. 2.1.7 extension
GIS Server:	GeoServer ver. 2.7.0 (multiple instances related to cluster) GeoFence-release-v2.2.0 Esri ArcGIS for Server Enterprise Standard ver. 10.3
Metadata catalogue:	GeoNetwork ver. 2.10.5
Java server:	Apache Tomcat ver. 7.x
Desktop GIS Software:	Esri ArcGIS for Desktop Standard ver. 10.3

Table 1 SavaGIS infrastructure

# THE OVERVIEW OF THE PROJECT ACTIVITIES AND RESULTS

## Component 1: Development of SavaGIS database

### *Key achievements*

- SavaGIS database was built, tested, deployed and implemented according to the project requirements;
- SavaGIS database is established as the central place for collecting, storing, editing, accessing and maintaining the structured RBM and Flood Risk datasets;
- RBMP database model is compliant with WFD Reporting Guidance 2016 v4.9, INSPIRE Directive and professional requirements, and ICPDR data model;
- Flood Risk Management (FRM) database model is compliant with the EU Floods Directive (FD), WFD Reporting Guidance 2016 v4.9, INSPIRE Directive and professional requirements, and ICPDR data model;
- Sava RBMP 2010 GIS data loaded into SavaGIS database model with migration and harmonization activities;
- SavaGIS Floods Directive Reporting (FDR) database loaded with data from Areas of Potential Significant Flood Risk (APsFR) datasets.

### *Work accomplished – summary of deliverables*

SavaGIS database enables collection of needed and available spatial data from the ISRBC parties in a properly structured way, storing in a central database, as well as processing and management of the data using the web-based tools. Data contributors upload their data to a common SavaGIS database via web interfaces or in other structured way and make use of the tools and processes to harmonize the data.

SavaGIS database model was significantly expanded in order to make it compliant to the WFD Reporting Guidance 2016 v4.9. SavaGIS database server was developed using PostgreSQL ver.9.3.5 with PostGIS Spatial extension ver.2.1.7. SavaGIS database model for RBMP is in a form of geodatabase relevant for storing of Sava River basin management plan data and was designed and structured in accordance to WFD Reporting Guidance 2016 v4.9, INSPIRE Directive and professional requirements. RBMP database contains 2 Feature Datasets and 28 Feature Classes, 92 Tables (Object Classes), 110 Relationship Classes and 112 Domains. Sava GIS database model for FRM is in a form of geodatabase and was designed and structured in accordance with the EU FD, WFD Reporting Guidance 2016 v4.9, INSPIRE Directive and professional requirements. FRM database contains 1 Feature Dataset and 17 Feature Classes, 26 Tables (Object Classes), 30 Relationship Classes and 25 Domains.

The complexity of the reporting schemas of WFD, geoinformation systems of the beneficiaries and existing datasets delivered by the ISRBC required additional database modelling and development efforts. The new database model complexity influenced the procedures for data sharing and reporting of data contributors to the ISRBC and delivering data to SavaGIS database. The current datasets of SRBMP for 2010 were harmonized and migrated into the central SavaGIS database.

### *Results and measurable indicators*

The measurable indicators of achieved results of Component 1 are given in the following table:



Measurable indicator	Status	Description of deliverables
Logical database approved	Approved	<ul style="list-style-type: none"> <li>SavaGIS RBMP database model – final version <ul style="list-style-type: none"> <li>SavaGIS RBMP database - GISDatasets</li> <li>SavaGIS RBMP database – GISDomains</li> <li>SavaGIS RBMP database - RBMP_2_2_Domains</li> <li>SavaGIS RBMP database - RBMP_2_2_LayersTables</li> </ul> </li> </ul>
Physical database model approved	Approved	<ul style="list-style-type: none"> <li>SavaGIS Flood risk database model – final version <ul style="list-style-type: none"> <li>SavaGIS FRM database - GISDatasets</li> <li>SavaGIS FRM database – GISDomains</li> <li>SavaGIS FRM database - FRM_2_3_Domains</li> <li>SavaGIS FRM database - FRM_2_3_LayersTables</li> </ul> </li> <li>SavaGIS Metadata specification</li> </ul>
Sava GIS database populated with existing data	Delivered	<ul style="list-style-type: none"> <li>Sava RBMP 2010 GIS data loaded into SavaGIS database model with data migration and harmonization activities</li> <li>SavaGIS FDR database loaded with APSFR datasets</li> </ul>
Procedure for data sharing approved	Approved	<ul style="list-style-type: none"> <li>SavaGIS database is established as the central place for collecting, storing, editing, accessing and maintaining of structured RBM and Flood Risk datasets</li> <li>SavaGIS Procedure for data sharing and validation process document delivered and approved</li> <li>File geodatabase Template_RBMP_2_4.fgdb provided</li> <li>File geodatabase Template_FDR_2_3.fgdb provided</li> <li>RBMP_DataEditingTemplateManual delivered</li> <li>FRM_DataEditingTemplateManual delivered</li> </ul>
Evaluation tests successfully completed	Completed	<ul style="list-style-type: none"> <li>Report on harmonization and migration of existing ISRBC RBMP database data to RBMP 2016 database delivered</li> <li>Three test iterations completed</li> </ul>
Security test successfully completed	Completed	<ul style="list-style-type: none"> <li>Security evaluation and tests executed on ISRBC GIS server</li> </ul>
Data available via web application	Completed	<ul style="list-style-type: none"> <li><a href="http://www.savagis.org">www.savagis.org</a> implemented</li> </ul>
Documentation delivered	Delivered	<ul style="list-style-type: none"> <li>As described in Annex 1</li> </ul>
Workshops on the issues delivered	Delivered	<ul style="list-style-type: none"> <li>Results presented on two project workshops</li> <li>Issues and open questions discussed during Ah GIS EG and CWG meetings</li> </ul>

Table 2: Component 1 – Measurable indicators

### Problems and issues

The data loading into SavaGIS database was more complex process than initially envisaged.

### Additional activities

The additional work (out of project scope set in ToR) was done during development of SavaGIS database and encompassed:

- After the initial analysis of existing ISRBC database and the assessment of coherence ISRBC-WFD-ICPDR, ISRBC gave the additional requirement to implement database model fully compliant with WFD reporting Guidance 2016 v4.9, ICPDR database model v.4.2, ICPDR UWWT and ICPDR PRTR, so the SavaGIS database model implementation was greatly expanded.
- Harmonisation and migration of data from old Sava GIS database, in a form of File Geodatabase (FGDB) named rbmp\_fgdb.gdb, to the new database model created based on WFD Reporting Guidance 2016, ICPDR database model v.4.2, ICPDR's UWWT and PRTR database models. The

content of mentioned “old” FGDB was limited and this database contained only data for preparation of the RBMP 2010. The old geodatabase required extension in order to include all data required in the RBMPs and to be able to meet the reporting obligations on the state of water. The new SavaGIS database model is compliant to all previously mentioned requirements

- After the initial analysis of existing ISRBC database related to FRM, ISRBC gave the additional requirement to extend the FRM database model. The new SavaGIS FRM includes: PFRA, APSFR, Flood Hazard and Risk Maps, Historical Floods and Flood Protection Structures.

The complete overview of additional works and services done is explained in the chapter [Overview of additional works and services done](#).

### ***Delivered and approved documentation***

The database model documentations with diagrams and detailed overview of the tables with all attributes are delivered as separate files.

The database description will be used when uploading or entering (manually) data into SavaGIS database. For that purpose, so called “reporting” templates are created which fully comply to the datasets, tables and attributes in SavaGIS database. The reporting templates serve to report/upload changes or new data into Sava GIS.

The complete list of delivered and approved documentation and other products of Component 1 is:

- SavaGIS RBMP database model – final version
  - SavaGIS RBMP database - GISDatasets
  - SavaGIS RBMP database – GISDomains
  - SavaGIS RBMP database - RBMP\_2\_2\_Domains
  - SavaGIS RBMP database - RBMP\_2\_2\_LayersTables
- SavaGIS Flood risk database model – final version
  - SavaGIS FRM database - GISDatasets
  - SavaGIS FRM database – GISDomains
  - SavaGIS FRM database - FRM\_2\_3\_Domains
  - SavaGIS FRM database - FRM\_2\_3\_LayersTables
- SavaGIS Metadata specification
- Report on harmonization and migration of existing ISRBC RBMP database data to RBMP 2016 database
- Report on analysis of existing ISRBC databases
- Report on coherence between existing ISRBC databases, WFD reporting schemas and ICPDR database model
- Overview of GIS infrastructures in beneficiary countries and ISRBC.

## Component 2: Establishment of web application for editing, loading and retrieving data and metadata

### Key achievements

- Users can view, visualize, share and retrieve geographic information and datasets related to the water management in the whole basin via [www.savagis.org](http://www.savagis.org)
- Data reporting and validation procedures implemented;
- The data reporting process is established providing the SavaGIS compliant local FGDB templates for the data contributors;
- The attribute editing and history tracking of data loading and updating implemented;
- Data exporting implemented:
  - Exporting attribute data to CSV, XLS, Access, DBF and XML document format,
  - Exporting spatial data to ShapeFile, GeoJSON, KML and GML2 document format,
  - Exporting map composition using map print tool with and without legend to PNG image and PDF document format;
- Metadata catalogue implemented which allows loading, updating, storing and retrieving ISO19115/19139 compliant metadata;
- SavaGIS Admin module established with the following functionalities:
  - User rights and datasets management defined by administrator;
  - User management with user groups and roles;
  - The Geoportal data dissemination management.

### Work accomplished – summary of deliverables

SavaGIS web application for editing, loading and retrieving data and metadata is comprehensive application for data reporting, validation and editing. This is the core application of the whole SavaGIS system. Web application allows users to view, visualize, share and retrieve geographic information and RBMP and FRM datasets. Data sharing/reporting is enabled using FGDB format via upload or GML formats via web feature service (WFS).

The web application fulfils the requested functionalities throughout the following:

- Editing/Changing/Deleting alphanumeric and spatial data:
  - The forms for data editing organised logically according to Sava GIS database model and separate according to the thematic contents (general, water bodies, protected areas, etc.)
  - By authorised persons (authorisation levels should be supported)
- Editing/Changing/Deleting metadata:
  - For metadata creating and editing, web based application was developed. This application enables user to input metadata directly or upload through standardised XML file.
  - By authorised persons (authorisation levels supported).
- Loading (import) data:
  - Automatic transfer from structured forms into database enabled.
- History tracking on data change:
  - Tool to keep record on all activities executed during use of Sava GIS application and data management (collecting, changing, processing, deleting) developed. Data entered into Sava GIS database determined for deleting, use withdrawn status field.
  - Each change on data tracked in database with timestamp.
- Extracting (exporting) data:
  - Automatic transfer into various agreed formats enabled

- Viewing and retrieving data:
  - Enabled by authorised persons through both GIS application and web interface, with several levels of access, depending on subset of data that can be accessed
  - Retrieving possibilities on set of significant attributes enabled
- Geographic transformation:
  - From/to national to common coordinate reference systems enabled (European Terrestrial Reference System 1989 (ETRS89))
- Reporting on centrally stored data:
  - Set of standardised and predefined reports created: database statistics, export table in Excel xls format, create map composition with legend and export to image format png/pdf, printing map, etc.
- User and database administration:
  - Through login interface and according to access rights enabled.
- Metadata and data flow established:
  - Services and tools for data sharing and exchange established.
  - Data and metadata flow between nodes established.
  - Verification / validation rules for data implemented.
  - Preparation of reports on all testing done.
  - Preparation of user manual done.
  - Preparation written procedure for each data contributor describing how procedure should be established within contributor GISs and used for publishing/finding data completed.

The accomplished work can be grouped as follows:

### *Data Management*

The web application for editing, loading and retrieving data is accessible via [www.savagis.org](http://www.savagis.org). The following figure shows the web application for data viewing, while the next figure shows the interface for data loading:

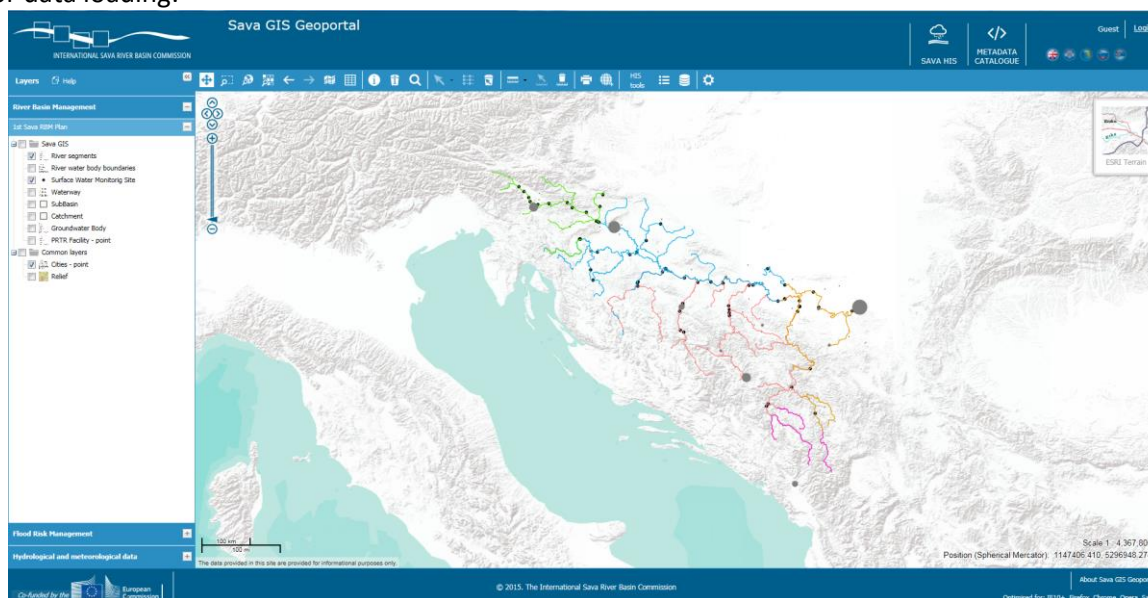


Figure 2 SavaGIS Geoportal

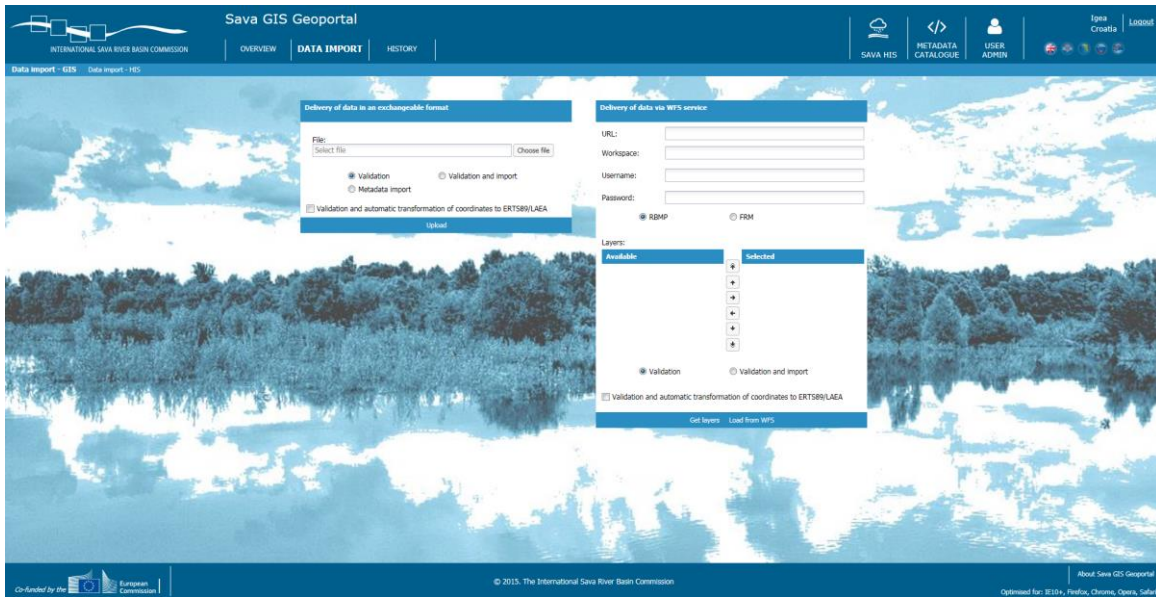


Figure 3 SavaGIS Data reporting via fgdb upload or WFS service

Figure 4 describes data flow/data reporting architecture.

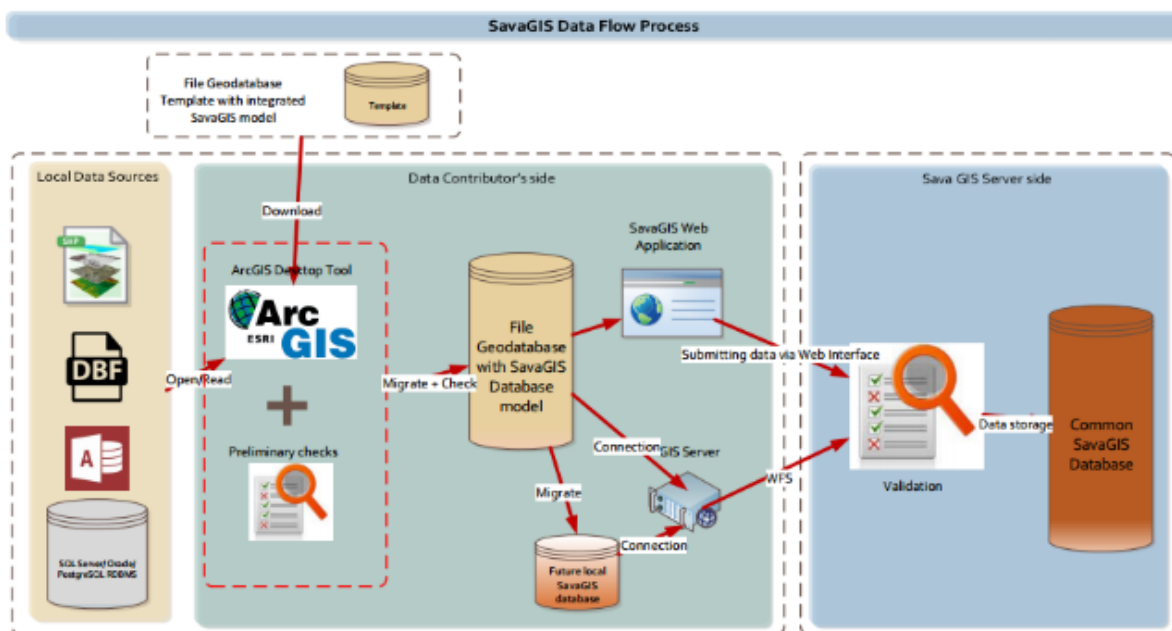


Figure 4 SavaGIS Data Flow process

The data reporting process is executing according to the following steps:

1. Data contributors download the FGDB templates with integrated SavaGIS database model structured as templates in accordance with the WFD Reporting Guidance 2016 i.e. SavaGIS RBMP and FDR central geodatabase model:
  - a. File geodatabase Template\_RBMP\_2\_4.fgdb
  - b. File geodatabase Template\_FDR\_2\_3.fgdb
2. Data contributors migrate data from local models into FGDB with integrated SavaGIS model using out-of-box ArcGIS Desktop migration/mapping tools and according to the detailed instructions provided in the documents RBMP\_DataEditingTemplateManual, FRM\_DataEditingTemplateManual (accessible in the web application for download)



3. Data contributors do preliminary data checks in accordance with SavaGIS database model during migration
4. Data contributors submit data via web interface or via WFS service
  - a. For delivery via Web interface, considering proposed format, both spatial and attribute data are delivered throughout uploading only one file. The preceding step before sending the file is compression into **ZIP file** with reason to reduce the file size.
  - b. Through WFS service, client can request a detailed description of any group of these feature types. To prove data via WFS service, well-built and structured local GIS solutions with implemented GIS Server (e.g. GeoServer, ArcGIS Server, Mapserver) is required on data contributor side. Data exchange via OGC WFS service is initiated at the request of data contributor by entering URL in particular field and sending request to SavaGIS server for accepting data. GML format is used for data exchange of spatial data and by using transactions via Web Feature Service.
5. The coordinate reference system of the SavaGIS is the ERTS89/LAEA. Data contributors can choose the automatic transformation of coordinates to ERTS89/LAEA to automatically validate and transform the data.
6. SavaGIS system makes detailed data validation at SavaGIS server side.
7. This step depends on data validation results and can be done in two ways:
  - a. If data are valid – storage/loading to common SavaGIS database is automatically permitted;
  - b. If data are not valid - report with detailed errors in \*.xls form is returned to data contributors and the corrections must be made by data contributors before repeating the whole process for data submission.

The step 6 includes data validation. When data delivery via upload or WFS service is completed, the following validations are performed before data loading into central Sava GIS database:

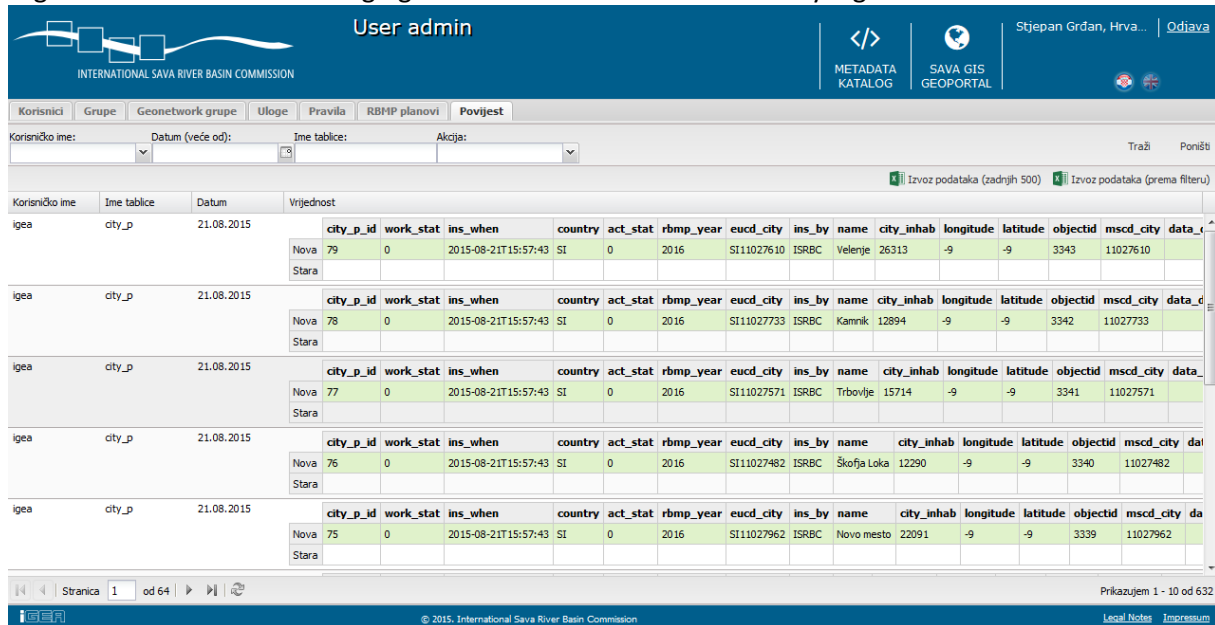
- The structure of the table – column extra or less – check if table has correct structure;
- Year check – all data must belong to correct plan
- State check – all data must belong to the state of user, exception is for ISRBC which can upload data for all states;
- Checking duplicates in the submitted data (data with the same key);
- Mandatory fields (not null);
- Length of data
- ForeignKey – check if it is completed (not null);
- ForeignKey – check if there is data in the parent table.

The validation error report is given in Excel format. The users can check the list of all errors generated during the validation. The process of submission and validation of data at SavaGIS server side is iterative and can be repeated until data content validation is completed and permit to store data into SavaGIS database obtained. Because preliminary checks during data migration are undertaken at data contributor's side, the number of iterations and validations at SavaGIS server side is minimised.

The registered users can change the data in two ways: repeating the data reporting process or **edit the attribute data** manually by using the web application. The tool for editing feature attributes opens the data form for attribute editing. The registered users can also select desired dataset, search for tables within database and open desired table to edit object attributes.

All data changes (new and altered data state) are recorded into history table. One history record also contains the information about the user (username, id), time of data change (timestamp), and

description of action which changed data and the name of original table from SavaGIS database model where data change is executed. The **history overview** and generating history log file is enabled for registered users. The following figure shows the interface for history log file:



Korisničko ime	Ime tablice	Datum	Vrijednost																																													
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Figure 5 SavaGIS History log file

**Metadata management**

The SavaGIS metadata management system is based on the GeoNetwork solution. GeoNetwork is an open source catalogue application for spatial datasets management and can be used for metadata search and editing.

Among many features, GeoNetwork contains fully functional and INSPIRE compatible Discovery Service. Discovery Service allows users and computer systems to search for spatial datasets and services based on their metadata records. It provides access to all other services, i.e. it's used to describe other services or spatial data and spatial datasets through metadata.

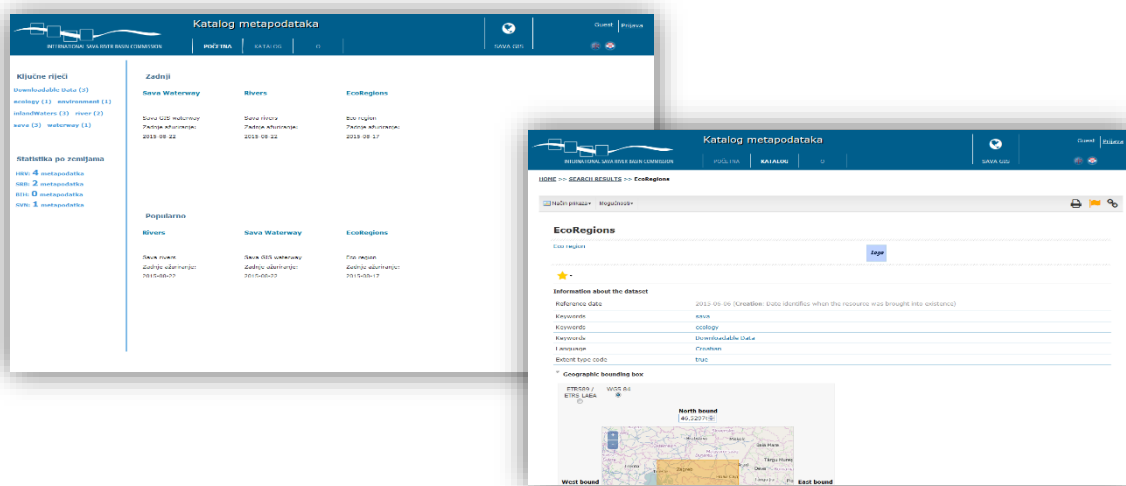


Figure 6 SavaGIS Metadata catalogue

The metadata can be provided in two ways: manually using editor or by XML file import. Metadata can be imported from external resource as XML file or harvesting. The web application interface for

metadata reporting is the same as for the datasets reporting, as showed in figure 6. The imported metadata is validated to comply with ISO 19139 schema.

The SavaGIS metadata management specification and user manual are provided as separate documents.

**User management/Admin module**

Admin module is implemented for user authentication, authorization and management of entire SavaGIS system. Considering that entire SavaGIS system consists of several related and integrated modules (e.g. WebGIS application/Geoportal, Metadata Management etc.), the Admin module manages user authority and allows or disallows access to any function of each module separately by defining user groups and user roles.

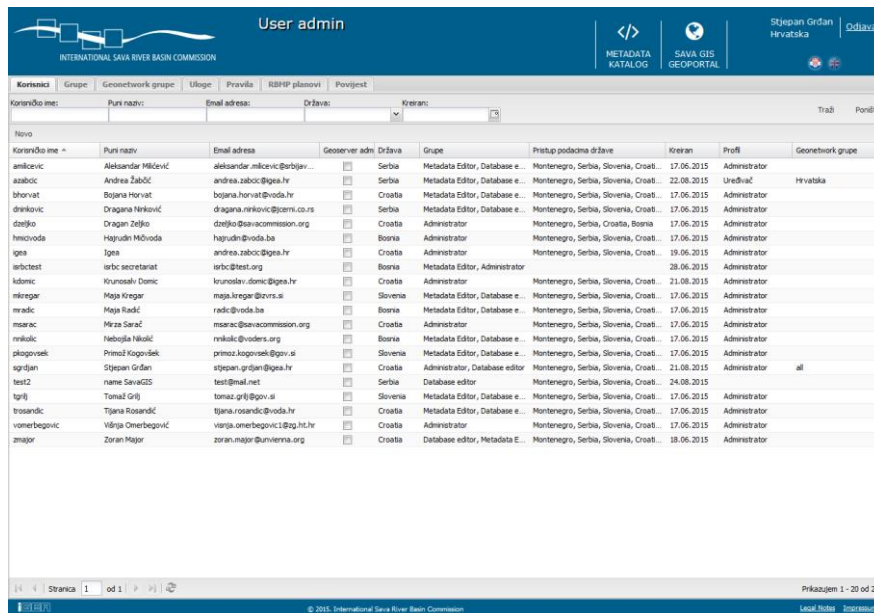


Figure 7 SavaGIS Admin module GUI

Admin module is based on GeoFence authentication/authorization engine for GeoServer which includes advanced capabilities for accessing and restricting data available over OGC services. For Metadata management module i.e. GeoNetwork separate user groups are defined and can be edited.

**Results and measurable indicators**

The measurable indicators of achieved results of Component 2 are given in the following table:

Measurable indicator	Requirement	Status	Description of deliverables
Functional specification of web application prepared and approved	n/a	Delivered and approved	<ul style="list-style-type: none"> <li>SavaGIS Functional specification</li> <li>SavaGIS Procedure for data sharing and validation process</li> <li>SavaGIS User authentication and user roles specification</li> <li>Web application implemented and installed at ISRBC premises</li> </ul>
Detailed design prepared and approved	Web application for standard web browsers	Delivered and approved	<ul style="list-style-type: none"> <li>Web application implemented and installed at ISRBC premises</li> </ul>
Evaluation tests successfully completed	Test established services and tools for	Delivered	<ul style="list-style-type: none"> <li>SavaGIS_public_geoportal_metadata_U TC</li> </ul>



Measurable indicator	Requirement	Status	Description of deliverables
	data sharing and exchange; Test data and metadata flow between nodes;		<ul style="list-style-type: none"> <li>SavaGIS_registered_geoportal_data_delivery_metadata_and_history.UTC</li> <li>SavaGIS_Admin_Module.UTC</li> </ul>
Security test successfully completed	Test results reporting	Completed	<ul style="list-style-type: none"> <li>Security evaluation and tests executed on ISRBC GIS server</li> </ul>
User Acceptance test passed	Test results reporting	Completed	<ul style="list-style-type: none"> <li>Three test iterations completed and passed</li> </ul>
Web application ready for use	Editing/Changing/Deleting alphanumeric, spatial data and metadata; Loading (import) data; History tracking on data change; Viewing, retrieving and exporting data; Geographic transformation; Reporting on centrally stored data; User and database administration; Establishing metadata and data flow	Completed	<ul style="list-style-type: none"> <li>www.savagis.org implemented and ready for use</li> <li>Note: Spatial data editing/changing/deleting is implemented via filegeodatabase data editing and upload</li> </ul>
Documentation delivered	Prepare user manual. Prepare written procedure for each data contributor describing how procedure should be established within contributor GISs and used for publishing/finding data	Delivered	<ul style="list-style-type: none"> <li>UserManual_Geoportal</li> <li>UserManual_Metadata Catalogue</li> <li>UserManual_Admin Module</li> <li>RBMP_DataEditingTemplateManual</li> <li>FRM_DataEditingTemplateManual</li> </ul>
Workshops on the issues delivered	n/a	Delivered	<ul style="list-style-type: none"> <li>Results presented on two project workshops</li> <li>Issues and open questions discussed during Ah GIS EG and CWG meetings</li> </ul>

Table 3: Component 2 – Measurable indicators

### Problems and issues

Due to the complexity of SavaGIS database model and data to be reported by data contributors, the additional analysis of data formats for exchange was required. The complexity of SavaGIS database model stems from complexity of the WFD and reporting requirements which resulted in the creation of many nested tables and relationship among them.

### Additional activities

The additional work (out of project scope set in ToR) in this Component comprised the server infrastructure and network configuration services in order to prepare secure and stable infrastructure for SavaGIS platform setup. Specifically they included:

- Security evaluation and test of IT infrastructure
- Windows Server 2012R2 update with latest versions and patches
- Reconfiguration of servers, Domain and Local Admin group setting

- Configuration of the local LAN (IP, Gateway, DNS) and removing the public IP address from the network adapter to eliminate the security risks
- Hyper-V server configuration for Virtual Switch
- Reservation of local IP address for HAProxy Load balancer
- Traffic redirection from the public to the local IP address

The complete overview of additional works and services done is explained in chapter [Overview of additional works and services done](#).

### ***Delivered and approved documentation***

The complete list of delivered and approved documentation of Component 2 is:

- List of specifications:
  - SavaGIS Functional specification
  - SavaGIS Procedure for data sharing and validation process
  - SavaGIS User authentication and user roles specification
- Documents and deliverables to be used during data reporting process:
  - SavaGIS RBMP database model – final version
    - SavaGIS RBMP database - GISDatasets
    - SavaGIS RBMP database – GISDomains
    - SavaGIS RBMP database - RBMP\_2\_2\_Domains
    - SavaGIS RBMP database - RBMP\_2\_2\_LayersTables
  - SavaGIS Flood risk database model – final version
    - SavaGIS FRM database - GISDatasets
    - SavaGIS FRM database – GISDomains
    - SavaGIS FRM database - FRM\_2\_3\_Domains
    - SavaGIS FRM database - FRM\_2\_3\_LayersTables
  - SavaGIS Metadata specification
  - File geodatabase Template\_RBMP\_2\_4.fgdb
  - File geodatabase Template\_FDR\_2\_3.fgdb
  - RBMP\_DataEditingTemplateManual
  - FRM\_DataEditingTemplateManual
- User manuals:
  - UserManual\_Geoportal
  - UserManual\_MetadataCatalogue
  - UserManual\_AdminModule
- Test scenarios:
  - SavaGIS Master Test Strategy for UAT
  - SavaGIS\_public\_geoportal\_metadata\_UTC
  - SavaGIS\_registered\_geoportal\_data\_delivery\_metadata\_and\_history\_UTC
  - SavaGIS\_Admin\_Module\_UTC

## Component 3: Establishment of SavaGIS Geoportal

### Key achievements

- [www.savagis.org](http://www.savagis.org) established as SavaGIS Geoportal;
- Implemented SavaGIS Geoportal facilitates sharing, integration, and use of geographic information across ISRBC Parties, stakeholders and general public;
- SavaGIS Geoportal for registered users and public users implemented;
- Sava GIS spatial data visualization and management implemented;
- User interface design improved;
- The RBMP 2010 datasets can be viewed, visualized and searched via the SavaGIS Geoportal;
- The FRM APSFR datasets can be viewed, visualized and searched via the SavaGIS Geoportal;
- The new RBMP and FRM datasets can be uploaded, validated, viewed, visualized and searched via the SavaGIS Geoportal.

### Work accomplished – summary of deliverables

Sava GIS Geoportal with its viewing/graphical and catalogue/metadata functionalities is scalable and flexible with implementation towards open source technologies.

The SavaGIS Geoportal fulfils the requested functionalities throughout the following:

- Designed SavaGIS Geoportal in the form of tiles:
  - Tiles defined the page template, allowing for consistency across all pages
- SavaGIS Geoportal content and functionalities adjusted:
  - Metadata management system delivered an operational;
  - GIS viewer delivered and operational;
  - Monitoring system's traffic and performance delivered and operational
- Setup, configuration and migration completed:
  - Technical specification and configuration setup report and documentation delivered
  - Administration Guides delivered;
  - User Guides delivered;
- Deployment and testing completed, user acceptance obtained and system has been handed over by the ISRBC:
  - Test results reported;
  - Administration setup documentation delivered;
  - End user Quick Reference documentation delivered;
  - Hand over report delivered.

The focus of SavaGIS Geoportal is the WebGIS application for spatial data visualization and management. The SavaGIS Geoportal is accessible via [www.savagis.org](http://www.savagis.org) public address. SavaGIS solution justified the use of a GeoServer and GeoNetwork software component for web-based spatial data management. Stakeholders (general public, private entities, government institutions, etc.) are able to overview spatial datasets through the use of the SavaGIS Geoportal catalogue and metadata services.

Sava GIS Geoportal functionalities include spatial data visualization and management of the public and registered users.

Public can view all datasets of RBMP 2010 and FDR APSFR on SavaGIS Geoportal, select particular dataset and search for data (Figure 8). Registered users are able to view more datasets and its attributes, search for data, and view uploaded datasets in RBMP 2016 and FDR. The data editing and viewing of history log file are only enabled for registered users (Figure 9).

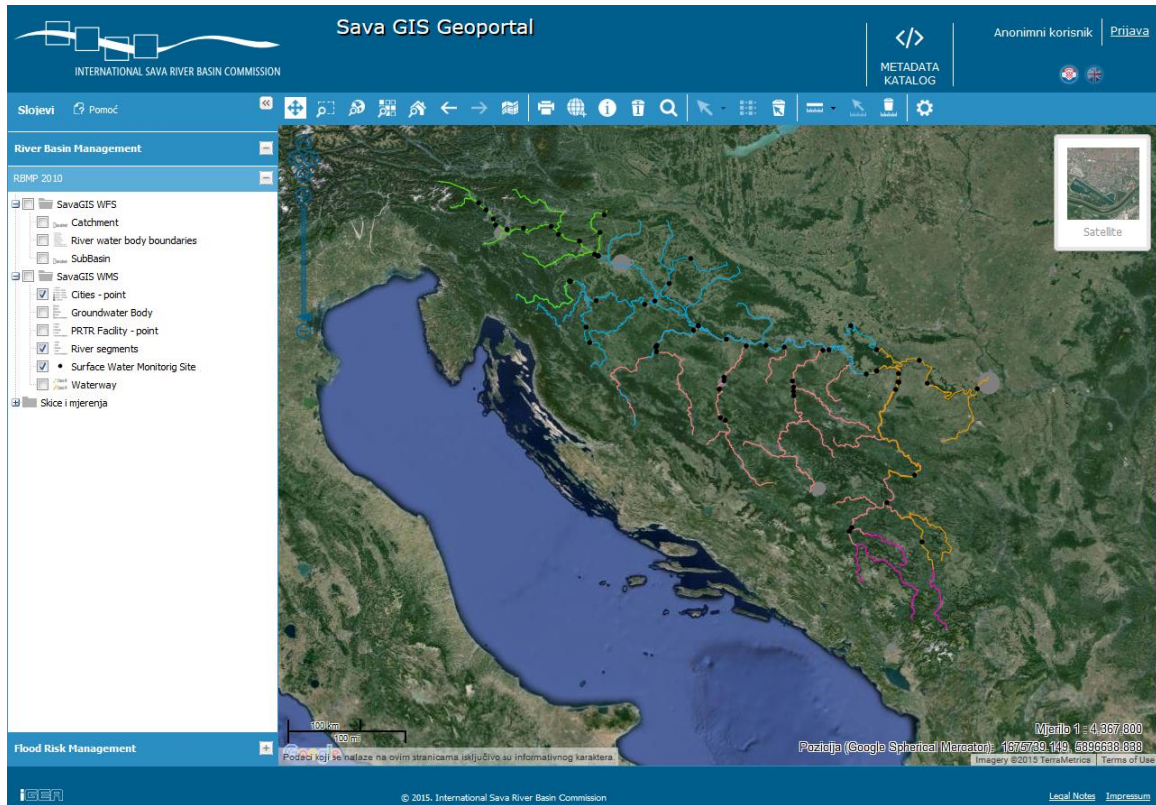


Figure 8 SavaGIS Geoportal for public

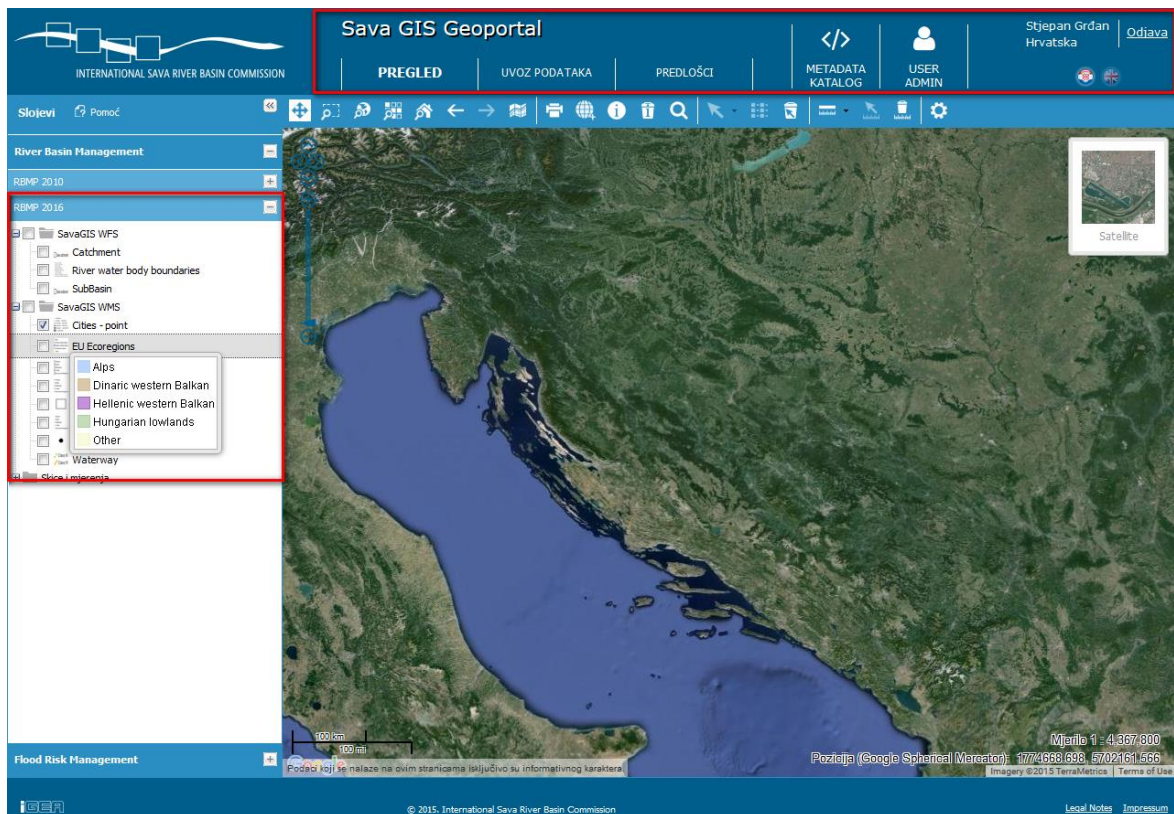


Figure 9 SavaGIS Geoportal for registered users

Furthermore, the particular attention was given to the SavaGIS Geoportal design in order to build attractive, responsive and easy-to-use portal, allowing users to receive the content of SavaGIS



Geoportal in fast and intuitive way (in the form of picture/map). Additionally, the new basemaps were added, layers in the legend were separated in groups (RBMP, FDR etc.), layer description hovering over the layer name was implemented, reporting and export of data etc.

SavaGIS Geoportal consists of the following segments:

- **Toolbar:**
  - Contains set of GIS functionalities for data viewing, searching and manipulation
- **Table of contents:**
  - Displays all layers and enables user to turn layers on or off
- **Map window:**
  - Central part of the portal with map overview
  - Attribute data shows as additional table data in the map window
- **Pan Zoom component:**
  - Navigation for zoom and pan with scale bar and pan buttons
- **Subpages:**
  - The subpages relate to the other parts of SavaGIS Geoportal which is metadata management, login page for data management, reports, etc.
  - The metadata catalogue provides the platform for discovery of geospatial information resources. It enables the creation, upload and management of beneficiaries' metadata.

### **Results and measurable indicators**

The measurable indicators of achieved results of Component 3 are given in the following table:

<b>Measurable indicator</b>	<b>Requirement</b>	<b>Status</b>	<b>Description of deliverables</b>
Functional specification of SavaGIS Geoportal prepared and approved	n/a	Delivered and approved	<ul style="list-style-type: none"> <li>• SavaGIS Functional specification</li> <li>• SavaGIS Geoportal implemented and installed at ISRBC premises</li> </ul>
Detailed design prepared and approved	Design SavaGIS Geoportal in the form of tiles	Completed and approved	<ul style="list-style-type: none"> <li>• <a href="http://www.savagis.org">www.savagis.org</a> in defined tiles</li> <li>• SavaGIS Functional specification</li> <li>• SavaGIS Geoportal implemented and installed at ISRBC premises</li> </ul>
Evaluation tests successfully completed	Test results reporting	Delivered	<ul style="list-style-type: none"> <li>• SavaGIS_public_geoportal_metadata.UTC</li> <li>• SavaGIS_public_geoportal_metadata.UTC_summary</li> </ul>
Security test successfully completed	Test results reporting	Completed	<ul style="list-style-type: none"> <li>• Security evaluation and tests executed on ISRBC GIS server</li> </ul>
User Acceptance test passed	Test results reporting	Completed	<ul style="list-style-type: none"> <li>• Three test iterations completed and passed</li> </ul>
SavaGIS Geoportal ready for use	Metadata management system  GIS viewer  Monitoring system's traffic and performance	Completed	<ul style="list-style-type: none"> <li>• <a href="http://www.savagis.org">www.savagis.org</a> implemented and ready for use</li> <li>• SavaGIS Geoportal consist of GIS viewer and metadata management system</li> <li>• Monitoring system's traffic and performance ensured with Google Analytics tool</li> </ul>
Documentation delivered	Technical specification and configuration setup report and documentation  Administration Guides	Delivered	<ul style="list-style-type: none"> <li>• System documentation</li> <li>• UserManual_Geoportal</li> <li>• UserManual_Metadata Catalogue</li> <li>• UserManual_Admin Module</li> </ul>

Measurable indicator	Requirement	Status	Description of deliverables
Workshops on the issues delivered	User Guides n/a	Delivered	<ul style="list-style-type: none"> <li>Results presented on two project workshops</li> <li>Issues and open questions discussed during Ah GIS EG and CWG meetings</li> </ul>

Table 4: Component 3 – Measurable indicators

### **Additional activities**

The Contracting Authority installed the OS software and the ArcGIS licences in May and June 2015, respectively. However, ISRBC was not able to secure a fast broadband internet and the static IP addresses needed for establishment of the Sava Geoportal at the same time. That was the reason for decision to deploy the SavaGIS on the Contractor's infrastructure. Once the Contracting Authority secured all needed ICT infrastructure (Internet connection, public access to application, IP addresses and network configuration) the whole SavaGIS platform and all related applications were migrated to the production environment on the ISRBC servers. However, the additional efforts from the Contractor were needed to adjust ISRBC infrastructure for migration and deployment of SavaGIS from its infrastructure. The actions undertaken by the ISRBC and additionally by the Contractor included installation and configuration of ICT infrastructure as the prerequisite for the application and databases migration and integration testing.

The additional activities in Component 3 are the same as in Component 2:

- The network setup for SavaGIS was additionally configured in order to fulfil system and professional requirements, and security level.

The complete overview of additional works and services is explained in chapter [Overview of additional works and services done](#).

### **Delivered and approved documentation**

The complete list of delivered and approved documentation of Component 3 is:

- List of specifications:
  - SavaGIS Functional specification
  - SavaGIS User authentication and user roles specification
  - SavaGIS System documentation
- User manuals:
  - UserManual\_Geoportal
  - UserManual\_MetadataCatalogue
  - UserManual\_AdminModule
- Test scenarios:
  - SavaGIS Master Test Strategy for UAT
  - SavaGIS\_public\_geoportal\_metadata.UTC
  - SavaGIS\_Admin\_Module.UTC

## Component 4: Preparation of the users' training plan and training material, conduct trainings

### Key achievements

- Training plan delivered;
- Training report delivered;
- Trainings covered:
  - Training for end-users of SavaGIS Geoportal,
  - Training for users responsible for data management/web application,
  - Training for System administrators;

The training organization and logistics was organized by ISRBC.

### Work accomplished – summary of deliverables

The training plan contained the methodology, training resources and curriculum to be addressed during the training.

The following trainings for SavaGIS knowledge transfer were conducted:

- Training for end-users of SavaGIS Geoportal:
  - SavaGIS Geoportal for public use – detail functionality
  - SavaGIS Metadata Catalogue for public use – detail functionality
- Training for users responsible for data management/web application:
  - RBMP data preparation, report and validation; data editing and history tracking
  - FRM data preparation, report and validation; data editing and history tracking
  - Metadata preparation, import, validation and editing
- Training for system administrators:
  - SavaGIS – application administration (users, roles, rights)
  - Database admin functionalities
  - Helpdesk and maintenance activities
  - Statistic monitoring of incidents and their management.

The training for end-users of SavaGIS Geoportal was delivered during several expert group meetings, as detailed presentations of functionalities. The comprehensive user manual was also delivered. For the users responsible for data management, training was done as a session with practical exercises. The training for system administrators was organized for ISRBC personnel only, as the ISRBC representative is the system administrator for SavaGIS platform in further use. After successfully held trainings, the training evaluation reports were created. The user trainings were evaluated by participants as very satisfactory and successful.

### Results and measurable indicators

The measurable indicators of achieved results of Component 4 are given in the following table:

Measurable indicator	Status	Description of deliverables
Number of users successfully completed trainings.	Completed	<ul style="list-style-type: none"> <li>• The trainings covered:               <ul style="list-style-type: none"> <li>○ Training for end-users of SavaGIS Geoportal,</li> <li>○ Training for users responsible for data management/web application,</li> <li>○ Training for System administrators;</li> </ul> </li> </ul>

Measurable indicator	Status	Description of deliverables
User trainings are judged satisfactory and successful by Client.	Completed	<ul style="list-style-type: none"> <li>The Training plan delivered</li> <li>The Training report delivered with devaluation results</li> </ul>

Table 5: Component 4 – Measurable indicators

### ***Delivered and approved documentation***

The complete list of delivered and approved documentation of Component 4 is:

- SavaGIS Training Plan
- SavaGIS Training Report
- Training materials:
  - SavaGIS\_Geoportal\_Training\_Cases
  - SavaGIS\_MetadataCatalog\_Training\_Cases
  - UserManual\_Geoportal
  - UserManual\_MetadataCatalogue
  - UserManual\_AdminModule



## Component 5: Preparation of the system's and user documentations

### Key achievements

- The technical specifications, the system and user documents delivered.

### Work accomplished – summary of deliverables

All required system and uses documentation is delivered during the project implementation. The complete list of documentation is presented in [Annex 1](#) of this Final Report.

The system documentation comprise all documents pertaining to the development of SavaGIS applications, including specifications, technical documentation, test cases and manuals that explain the functionality of the application.

The system documentation contains the maintenance and operational manuals. The documentation contains the definition of the software support environment, the roles and responsibilities, and the regular activities essential to the support and maintenance of modules, GIS tools and database structures. This is part of system documentation and other components deliverables.

The user manuals contain all essential information for the user to make full use of the application with a description of the system functions and capabilities.

The document entitled as System documentation describes:

- procedures for utilisation of services,
- system configuration setup,
- system and data maintenance and management,
- security management,
- protection of authorial, user and data rights,
- backup strategy proposal,
- Help-desk procedures.

The System documentation is comprehensive document that support the post-production activities during system operation. It explains the maintenance procedure and helps the Contracting Authority to perform operational steps and procedures for configuration setup, security management and backup steps.

### Results and measurable indicators

The measurable indicators of achieved results of Component 5 are given in the following table:

Measurable indicator	Status	Description of deliverables
System documentation consisting of functional specification and Project documentation (detail design, database model development and deployment setup, test cases and production/operation environment description), as well as User documentation consisting of administrator manuals, end-user guides, user reference manuals, are completed	Completed	<ul style="list-style-type: none"> <li>• All delivered documentation during the project – listed in Annex 1</li> </ul>
Procedures for utilisation of services, help desk, security management, protection of authorial, user and data rights, backup, software asset management and protocols for communication with ISRBC parties' geoinformation systems, utilisation of agreed	Completed	<ul style="list-style-type: none"> <li>• Delivered in System documentation document</li> </ul>

Measurable indicator	Status	Description of deliverables
standards, data maintenance and management, are completed		

Table 6: Component 5 – Measurable indicators

### **Delivered and approved documentation**

The complete list of delivered and approved documentation of Component 5 is:

- System documentation:
  - System configuration,
  - Procedures for use of services,
  - System and data maintenance,
  - Security management,
  - Backup strategy,
  - Helpdesk procedures;
- RBMP\_DataEditingTemplateManual
- FRM\_DataEditingTemplateManual
- UserManual\_Geoportal
- UserManual\_MetadataCatalogue
- UserManual\_AdminModule
- Annex 1 list of documentation.

### **Testing of the system**

The testing of the system covered all project components. It was organized in several iterations. The test preparation steps included the delivery of the following test documentation:

- Master Test Plan - which provided the Testing Strategy for the project;
- Test Guideline - which describes test plan (the scope, approach, resources, and schedule of the testing activities for its specified level of testing, identify the items being tested, the features to be tested, the testing tasks to be performed, the personnel responsible for each task), test design and test procedure;
- 1<sup>st</sup> test iteration Test cases;
- 2<sup>nd</sup> test iteration Test cases;
- Integration Test cases;
- Test Report with summary of all test cases results.

#### **1<sup>st</sup> test iteration**

The 1<sup>st</sup> test iteration was held in June 2015. The Contractor delivered the guidelines and expectations for the testing to the stakeholders. The test plan with test scripts (IEEE 829 compliant) and detail descriptions for each test case were produced and delivered to the testers for the applications: User management, Metadata management application, and functionalities of Geoportal/WebGIS application. The applications were tested in single and multi-user environments.

The objective of the first test iteration was to identify any blocking, critical bugs, and to test the most of the SavaGIS functionalities:

- Functionalities of SavaGIS Geoportal/WebGIS application:
  - Public part

- Private part
- SavaGIS database model test
- Overview of spatial datasets from RBMP2010
- User management
- Data management for accessibility
- Metadata management application:
  - Public part
  - Private part

### **2<sup>nd</sup> test iteration**

The 2<sup>nd</sup> test iteration was held in end of August and beginning of September 2015. The test plan with test scripts (IEEE 829 compliant) and detail descriptions for each test case were delivered to the testers for the applications: User management, Metadata management application, and functionalities of SavaGIS Geoportal/WebGIS application. The applications were tested in single and multi-user environments.

The objective of the second test iteration is to identify remaining high and medium bugs, retest corrections from the first test iteration and to test the remaining SavaGIS functionalities:

- Functionalities of SavaGIS Geoportal/WebGIS application retest
  - Public part
  - Private part
- Upload of the fgdb datasets
- Editing of datasets
- Reporting
- User management retest
- Data management for accessibility retest
- Metadata management application retest
  - Public part
  - Private part
- Remaining overall functionalities.

### **User Acceptance Testing**

The final user acceptance testing was held in October 2015. The test plan with test scripts (IEEE 829 compliant) and detail descriptions for each test case were delivered to the testers.

System Integration Test and final UAT test objective was to make integration and final acceptance test for each component:

- SavaGIS Geoportal and metadata management for public access
- Data and metadata reporting for registered users
- Admin module

User Acceptance Test was performed after the migration and installation of all applications, database and user rights at the ICT infrastructure of the Contracting Authority. The complete documentation was provided for the UAT execution. Complete UAT documentation is accessible at the SavaGIS Geoportal under registration session at the Templates module.

## OVERVIEW OF ADDITIONAL WORKS AND SERVICES DONE

During the project implementation the additional works and services were done that were out of project scope set in the ToR. The complexity of data reporting process between data contributors and the Contracting Authority was discussed in several iterations. It required the additional analysis of data formats exchange because of complexity of SavaGIS database model which contains great number of nested tables and relations in order to be compliant with WFD Reporting Guidance. Additionally, the initial data migration and loading into SavaGIS database was more complex process than initially planned in the Terms of reference (ToR). The complete overview of additional works and services done is given in the following table:

ToR requirement	Activities done	Explanation of add-on	Additional resources spent
The Contractor should perform an assessment of the coherence between conceptual model and reporting schemas and their corresponding technical descriptions as specified in WFD Reporting Guidance 2016, which is provided as the supporting document to this tender. The result of the assessment should be a list of all prioritised adjustments (tasks) identified according to the criteria (urgency, complexity, resources). Taking into account that new reporting demands of the second RBMPs were not available during preparation of the conceptual model and time constrain for accomplishment of this assignment, only tasks (adjustments) of the highest priority confirmed by the ISRBC ah GIS EG will be a subject of this assignment. For remaining tasks, a plan (work&resources) should be proposed as a part of the continuation and sustainability of Sava GIS.	The analysis of existing ISRBC DBs and the assessment of coherence ISRBC-WFD-ICPDR were done first. As additional requirement by ISRBC was given to implement database model fully compliant with WFD reporting Guidance 2016 v4.9, ICPDR database model v.4.2, ICPDR UWWT and ICPDR PRTR, the SavaGIS database model implementation was greatly expanded.	As the SavaGIS database model was greatly expanded to be fully compliant with WFD Reporting Guidance v4.9, the additional resources were engaged. Not only the highest priority adjustments were made on database, as requested by ToR, but the whole new SavaGIS database was implemented. During implementation the ISRBC required the complete WFD Reporting Guidance compliance implementation. This is great benefit for ISRBC and data contributing countries, but Consultant spent additional efforts and resources for database development than initially planned and requested by ToR.	15MD
Initial load of all available data must be carried out by the Contractor within deployment activity of the project.	Data from old Sava GIS database, in a form of File Geodatabase named rbmp_fgdb.gdb was harmonized and migrated to a new database model which was created based on WFD reporting Guidance 2016, ICPDR database model v.4.2, ICPDR UWWT and ICPDR PRTR database models. The content of mentioned old File Geodatabase was limited and this database contained only data which were required to produce	The ToR required the initial load of all available data. For migration of data from old to new database in some cases was only used ArcCatalog tool Simple data loader, with field mapping (old field name to new field name). However, in some cases before loading of data was necessary to engage additional effort and works: to add some fields, recalculate values in fields, to align them to different field type, or to change values based on values defined in new domains, creation of parent-child datasets where missing, cleaning double data records, etc. Additionally, in some cases was necessary to add data in existing fields, when they were empty,	15MD



	<p>River Basin Management Plan 2010. The geodatabase had to be expanded to include all of the elements that are needed in the management of the river basin and to be able to meet all the obligations of reporting on the state of water compliant with new SavaGIS database model.</p>	<p>but new model required data (AllowNulls=False). There was lack of data for mandatory fields, and some feature classes and tables did not contain information in primary key field EUCD, or this field was filled incorrectly. As the ToR requirement was initial data load, this harmonization and migration of datasets was additional effort and additional time consuming for the Consultant.</p>	
<p>SavaGIS database model to consider the structure and description of the flood protection related datasets and GIS layers described in Appendix 2 of the ToR: APSFR and Flood Risk Assessment: Thematic Datasets and GIS Layers</p>	<p>The SavaGIS FRM database model was expanded containing: PFRA, APSFR, Flood Hazard and Risk Maps, Historical Floods and Flood Protection Structures. The model was implemented with ICPDR and FM directives recommendations.</p>	<p>The ToR did not provide database model and entries for of FRM data. After data assessment, the ISRBC gave the instructions and inputs for FRM database modelling with FM directives and ICPDR recommendations. The large number of documents was consulted. The database model was greatly expanded than initially planned by ToR. Beside additional effort on database modelling, the additional work was done on FRM data management: template creation, data reporting and validation and integration of FRM layers in SavaGIS Geoportal.</p>	<p>8MD</p>
<p>The ISRBC shall provide functional IT infrastructure i.e. servers, software licences, communication facilities, etc. for deployment and production of Sava GIS in due time and prior to it deployment into production platform.</p>	<p>The network setup for the Sava GIS had to be additionally configured by the Contractor in order to fulfil system and professional requirements and security level.</p>	<p>The additional efforts were required to adjust ISRBC infrastructure for migration and deployment of Sava GIS from Contractor's infrastructure. The actions undertaken by the ISRBC and additionally by the Contractor included establishment of ICT infrastructure system configuration as the prerequisite for the application and databases migration and integration testing.</p>	<p>2MD</p>

Table 7 Additional works and services done

The ToR covered initial requirements on SavaGIS implementation and it did not anticipate the complexity of required database model, scope of datasets migration and ICT infrastructure establishment. During project implementation phase the additional work was required which resulted with engagement of additional resources with influence on the project budget and timeframe.

## CONCLUSION AND RECOMMENDATIONS

### Conclusion on implementation

SavaGIS database, SavaGIS Geoportal and SavaGIS web application for data reporting and validation are implemented and deployed at the Contracting Authority's GIS servers at ISRBC premises as fully functional Sava GIS components. The SavaGIS Geoportal and web application can be accessed via [www.savagis.org](http://www.savagis.org).

The results of the project will have positive impact on the water data management in the beneficiary countries. The most important benefit of the SavaGIS system is an integrated platform for data collection and visualization of RBM and FRM related information in the Sava Basin. This will be the central place for overview of data in the whole Sava Basin. It shall also help the beneficiaries to enhance the process of collecting, processing and exchange the data.

Full participation of all relevant stakeholders involved with the project implementation is widely recognised as a crucial issue for securing successful implementation and sustainability of the project lifecycle. Very good engagement of Ah GIS EG and CWG members was crucial during project implementation and especially during testing period. As the project activities progressed, the communication with stakeholders became very good in information exchange.

With the system post-production, the maintenance and support activities start. The system documentation provided in Annex document cover maintenance strategy issues and system documentation.

### Recommendations for further steps

After project implementation the system maintenance starts, covering infrastructure and application maintenance. The application maintenance is, in accordance to the Contract, covered by the Contractor over the next 12 months. On the other hand, the infrastructure maintenance of the Sava GIS servers and the backup activities is covered by the Contracting Authority. The recommendation for further steps is to extend the maintenance for the entire GIS platform standard system software and network infrastructure maintenance with the Contractor and to plan additional budget for that services. In that way the Contracting Authority will have the single point of communication for the maintenance of the SavaGIS platform so the corrective and perfective actions in the future will be faster and more effective.

To utilize the implemented system and services, the focus is primary on the ISRBC and beneficiary institutions. However, the lack of human resources in ISRBC in the field of GIS and ICT support is recognized, and the second recommendation would be to focus on resolving that issue. It is also very important that the activities of beneficiary institutions in data exchange process and system use continues. The awareness of SavaGIS importance must be continuously communicated and the good cooperation is of vital importance.

The third recommendation for further steps is the preparation of a project for development of the Sava GIS advanced functionalities, as planned in the ISRBC's strategic documents. This is recognized as a vital step in the enhancement and further development of Sava river basin data exchange process.

## ANNEX 1 OVERVIEW OF DELIVERABLES

### Introduction

The following chapters give the complete list of delivered documentation during the project. The technical documentation that was used and delivered during project implementation was delivered and approved as annex documents in the reports requested by project management procedure.

### A. Project reports

Document	Format		Accepted version
	Digital	Paper	
Inception Report	Word, pdf	Yes	SavaGIS PM IR Inception Report v1.7.1_final
Interim report	Word, pdf	Yes	SavaGIS PM INTR Interim Report v1.5_final
Draft Final Report	Word, pdf	Yes	SavaGIS PM DFR Draft Final Report v1.2
Final Report	Word, pdf	Yes	SavaGIS PM FR Final Report

Annex Table 8: List of the project reports

### B. Deliverables per project component

#### Component 1: Development of SavaGIS database

Deliverable	Format
SavaGIS database containing: <ul style="list-style-type: none"> <li>• RBMP schema</li> <li>• FRM schema</li> </ul>	Postgre+PostGIS database installed on ISRBC GIS Server
SavaGIS database loaded with the first Sava RBM Plan datasets	Datasets loaded in SavaGIS database
SavaGIS RBMP database model description – final version	Word file
SavaGIS RBMP database - GISDatasets	Excel file
SavaGIS RBMP database – GISDomains	Excel file
SavaGIS RBMP database - RBMP_2_2_Domains	JPEG file, Visio file
SavaGIS RBMP database - RBMP_2_2_LayersTables	JPEG file, Visio file
SavaGIS Flood risk database model description – final version	Word file
SavaGIS FRM database - GISDatasets	Excel file
SavaGIS FRM database – GISDomains	Excel file
SavaGIS FRM database - FRM_2_3_Domains	JPEG file, Visio file
SavaGIS FRM database - FRM_2_3_LayersTables	JPEG file, Visio file
SavaGIS Metadata specification	Word file
Report on harmonization and migration of existing ISRBC RBMP database data to RBMP 2016 database	Word file

Deliverable	Format
Report on analysis of existing ISRBC databases	Word file
Report on coherence between existing ISRBC databases, WFD reporting schemas and ICPDR database model	Word file
Overview of GIS infrastructures in beneficiary countries and ISRBC	Word file

Annex Table 9: Component 1 deliverables

**Component 2: Establishment of web application for editing, loading and retrieving data and metadata**

Deliverable	Format
Web application installed and configured at ISRBC GIS server <a href="http://www.savagis.org">www.savagis.org</a>	n/a
RBMP_DataEditingTemplateManual	Word file
FRM_DataEditingTemplateManual	Word file
SavaGIS Procedure for data sharing and validation process	Word file
SavaGIS User authentication and user roles specification	Word file

Annex Table 10: Component 2 deliverables

**Component 3: Establishment of SavaGIS Geoportal**

Deliverable	Format
Sava Geoportal installed and configured at ISRBC GIS server <a href="http://www.savagis.org">www.savagis.org</a>	n/a
SavaGIS Functional specification	Word file

Annex Table 11: Component 3 deliverables

**Component 4: Preparation of the users' training plan and training material, conduct trainings**

Deliverable	Format
Trainings held according to ToR	n/a
SavaGIS Training Plan	Word file
SavaGIS Training Report	Word file
Training materials:	
SavaGIS_Geoportal_Training_Cases	Word file
SavaGIS_MetadataCatalog_Training_Cases	Word file

Annex Table 12: Component 4 deliverables

**Component 5: System's and user documentations**

Deliverable	Format
System documentation (System configuration, Procedures for use of services, System and data maintenance, Security management, Backup strategy, Helpdesk procedures)	Word file



Deliverable	Format
Source code and objects code	code

Annex Table 13: Component 5 deliverables

## C. User documentation

Document	Format
UserManual_Geoportal*	PDF file
UserManual_MetadatalCatalogue*	PDF file
UserManual_AdminModule	PDF file

Annex Table 14: User documentation for public use

\*These documents are publicly available at the [www.savagis.org](http://www.savagis.org) application.

## D. Documentation used for test management

Document	Format
SavaGIS Master Test Strategy for UAT	Word file
1 <sup>st</sup> test iteration:	
SavaGIS TM.Guideline	Word file
SavaGIS_1_Admin_Module_UTC	Word file
SavaGIS_1_Geoportal_UTC	Word file
SavaGIS_1_MetadatalCatalogue_UTC	Word file
SavaGIS_Admin_Module_UTC_Summary_Description	Word file
SavaGIS_Geoportal_UTC_Summary_Description	Word file
SavaGIS_MetadatalCatalogue_UTC_Summary_Description	Word file
2 <sup>nd</sup> test iteration:	
SavaGIS_2_Data_Sharing_and_Validation_UTC	Word file
SavaGIS_2_HistoryLog_UTC	Word file
SavaGIS_2_Reports_UTC	Word file
SavaGIS_TestCases_Data_Sharing_and_Validation_SUMMARY	Word file
SavaGIS_2_HistoryLog_UTC_SUMMARY	Word file
SavaGIS_2_Reports_UTC_ISRBC_SUMMARY	Word file
Final user acceptance and integration test:	
SavaGIS_3_Admin_Module_UTC	
SavaGIS_3_public_geoportal_metadata_UTC	Word file
SavaGIS_3_registered_geoportal_data_delivery_metadata_and_history_UTC	Word file

Document	Format
SavaGIS_Geoportal_and_Metadata_public_UTC_acceptance_testing_SUMMARY	Word file

Annex Table 15: Documentation used for test management

## E. Project management - Meeting minutes/reports

Meeting date	Meeting place	Meeting topic	Meeting minutes file name
<b>Project meetings (Ah GIS EG)</b>			
13.03.2015	Zagreb, ISRBC	11 <sup>th</sup> Ah GIS EG meeting, inception phase - SavaGIS system establishment	Report_11th_ah_gis_eg_meeting.pdf
01.07.2015	Zagreb, ISRBC	12 <sup>th</sup> Ah GIS EG meeting	AD.3.3.1_Information Management Issues_Doc 3_Report_12th Ah GIS EG Meeting
22.09.2015	Zagreb, ISRBC	13 <sup>th</sup> Ah GIS EG meeting	Report_13th_ah_gis_eg_meeting.pdf
<b>Specific issue meetings (PEG RBM, PEG FP)</b>			
18.06.2015	Zagreb, ISRBC	29th ISRBC PEG RBM Meeting	Report_29th_peg_rbm_meeting.pdf
10.09.2015	Zagreb, ISRBC	27th ISRBC PEG FP Meeting	Report_27th_PEG_FP_Meeting.pdf
30.10.2015	Zagreb, ISRBC	30th ISRBC PEG RBM Meeting	Report_30th_peg_rbm_meeting.pdf
<b>Specific task meetings (CWG)</b>			
09.02.2015	Zagreb, ISRBC	SavaGIS CWG meeting, inception phase	SavaGIS_CWG_1_MoM_final_20150223.pdf
04.03.2015	Zagreb, ISRBC	Preparation for project workshop with materials	n/a
30.04.2015	Zagreb, ISRBC	Preparation for SavaGIS CWG meeting	n/a
08.05.2015	Zagreb, ISRBC	SavaGIS CWG meeting - Establishment of the Sava GIS core functionalities	SavaGIS MM Minutes of the meeting 20150508_CWG_final.pdf
16.06.2015	Zagreb, ISRBC	SavaGIS CWG meeting - Testing of SavaGIS applications (1 <sup>st</sup> iteration)	SavaGIS MM Minutes of the meeting 20150616_CWG_final.pdf
04.08.2015	Zagreb, ISRBC	Overview of Interim report, preparation for SavaGIS CWG meeting and 2 <sup>nd</sup> test iteration	n/a
24.08.2015	Zagreb, ISRBC	SavaGIS CWG meeting - Testing of SavaGIS applications (2 <sup>nd</sup> iteration)	SavaGIS MM Minutes of the CWG meeting 20150824_Final.pdf
07.10.2015	Zagreb, ISRBC	Overview of server configuration status and ICT infrastructure; Project status overview	n/a
30.10.2015	Zagreb, ISRBC, Webex	SavaGIS CWG meeting – Integration testing	n/a
<b>ISRBC sessions</b>			
20.10.2015	Zagreb, ISRBC	39th Session of the ISRBC	Report_39th_session_of_the_isrbc-za_web.pdf
<b>Workshops</b>			
12.03.2015	Zagreb, hotel Panorama	SavaGIS 1 <sup>st</sup> Workshop, inception phase	Report_11th_ah_gis_eg_meeting.pdf
21.09.2015	Zagreb, hotel International	SavaGIS 2 <sup>nd</sup> Workshop, implementation phase status	Report_13th_ah_gis_eg_meeting.pdf

Annex Table 9: List of meetings held during the project implementation

Co-funded by the



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