Floods in May 2014 in the Sava River Basin

Brief overview of key events and lessons learned

INTERNATIONAL SAVA RIVER BASIN COMMISSION

icpdr iksd
International Commission for the Protection of the Danube River
Internationale Kommission zum Schutz der Donau

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Evacuation of people in Prud,
Bosnia and Herzegovina

1. Introduction

Days of extensive rainfall on pre-saturated soil caused devastating floods in Western Balkans in May 2014. Due to specific cyclone in mid-May 2014 a large portion of the Sava River Basin within Croatia, Bosnia and Herzegovina (B&H) and Serbia was hit by continuous, heavy rainfall. Intensive precipitation in the second half of April and the beginning of May preceded this event and caused a high saturation of soil. This combination caused flash floods, erosion and landslides along small watercourses, but also disastrous flooding along the Sava River main course and its right tributaries.

This report gives a brief overview of the flood events in the Sava River Basin in May 2014, reviews the responses of the countries, damages registered and brings forward the lessons learned.

The main sources of information provided in this document are the official reports produced by various national institutions of the Sava countries.

The report has been jointly prepared by experts of the affected countries within Flood Protection Expert Group (FP EG) of ICPDR and Permanent Expert Group for Flood Prevention (PEG FP) of ISRBC. The maps are prepared by the ISRBC Secretariat. A valuable contribution to this report has also been provided by Ad hoc Expert Group for Hydrometeorological Issues (Ah HMI EG) of ISRBC.

Proofreading and final editing of the document was made by Ms Marina Babic-Mladenović, member of FP EG and PEG FP.

2. Meteorological situation

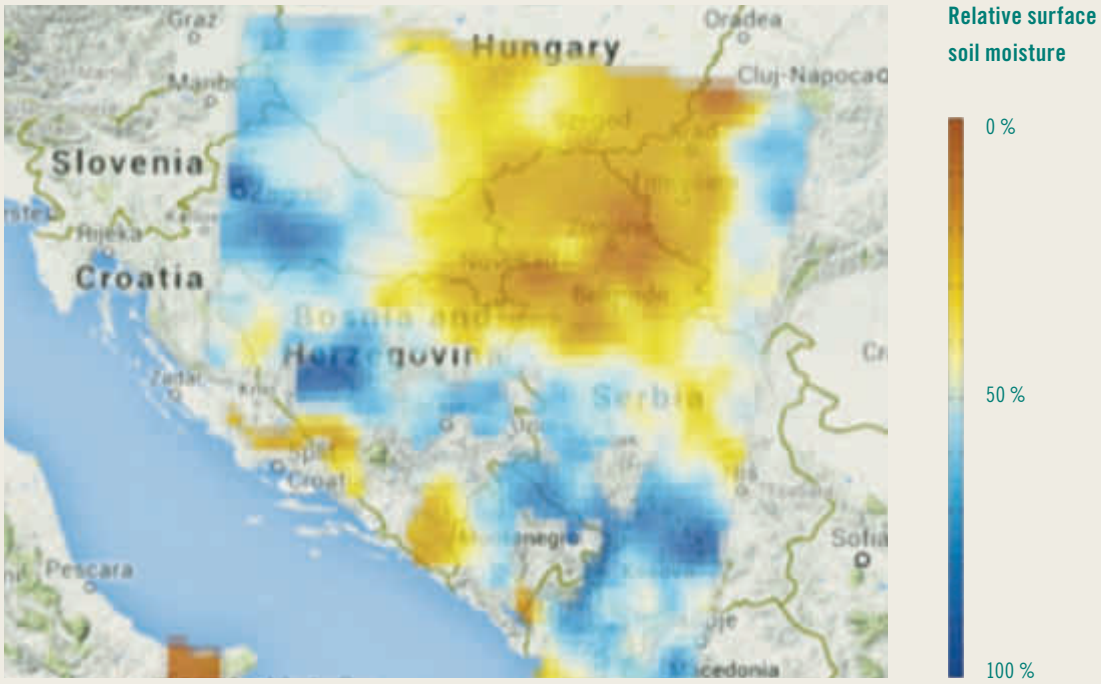
The catastrophic floods in the Sava River Basin were caused by heavy precipitation in the large area of the basin in mid-May 2014. In addition, the weather conditions in months that preceded the major event contributed significantly to the magnitude of floods. An overview of these conditions has been provided below.

2.1 Preceding conditions

The whole April 2014 can be characterized as a period of unstable weather, with intense cyclonic activity. Several cyclonic systems passed over the region during April, bringing significant temperature drops, frequent rainfalls and even snow in some mountainous areas. Continuous precipitation was recorded at some meteorological stations (i.e. Banja Luka, Doboj) from 14th April till 4th May. Recorded rainfalls were significantly above long-term average on almost all measuring stations in the middle and lower part of the basin. Unusually rainy weather caused saturation of soils on large areas in the Sava River Basin. The soil moisture content in some parts of the basin was between 60 and 100 % in mid-May (Fig 1).

Satellite image of relative surface soil moisture on 14 May 2014 (source: TU Wien, 2014).

FIGURE 1



2.2 Precipitation in May 2014

After rainy days in April and May 2014, the weather was stable for only 7 days. Then a new low pressure system developed over northern Italy on Tuesday, 13th May and shifted towards the Balkan region.

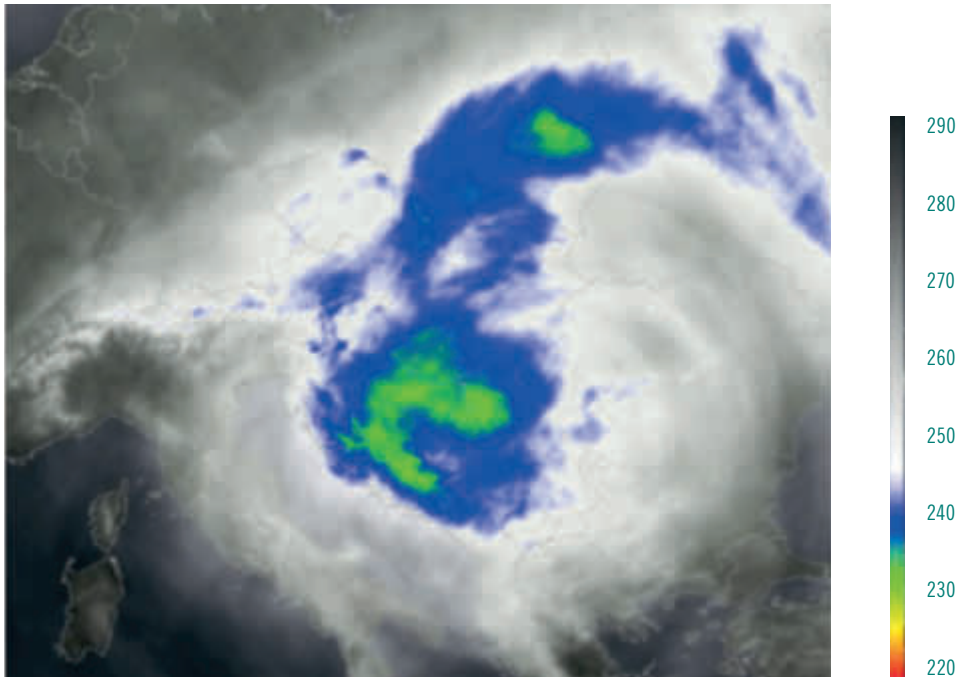
The path of the cyclone at the low level was from the Genoese Bay over the Apennines, southern Adriatic, southern Serbia, Bulgaria and Romania, with an elliptical loop over the south-eastern part of the Pannonian Plain. The cause of the loop was the simultaneous strong anticyclone system over Russia, with the centre above Caspian Sea. It obstructed the usual path of Genoa cyclone towards east and kept it over SE Europe. That self-contained low-pressure system remained steady for more than three days and generated extremely high precipitation rates, especially in the Sava River Basin.

In the critical period from 14th–18th May, weather was cold and windy, and heavy rain was constantly falling over eastern and northern Bosnia, most of Serbia (central and western regions) and eastern Croatia. Snow cover was formed on mountains higher than 1200 m.

The highest activity of the cyclone was on 15th May. Its energy weakened after 18th May and it shifted to the north.

The precipitation recorded between 14th and 18th May was higher than average sum for that month: in Croatia 1.5–1.8 times, in Republika Srpska (B&H) more than 2 times, and in Serbia more than 3 times. Precipitation data from selected meteorological stations in the Sava River Basin are shown in the Annex 1 to this Report.

Cyclone over Balkans, Met-10, 14 May 00:00 UTC – 17 May 08:00 UTC (EUMETSAT) *FIGURE 2*



3. Flood warning and monitoring

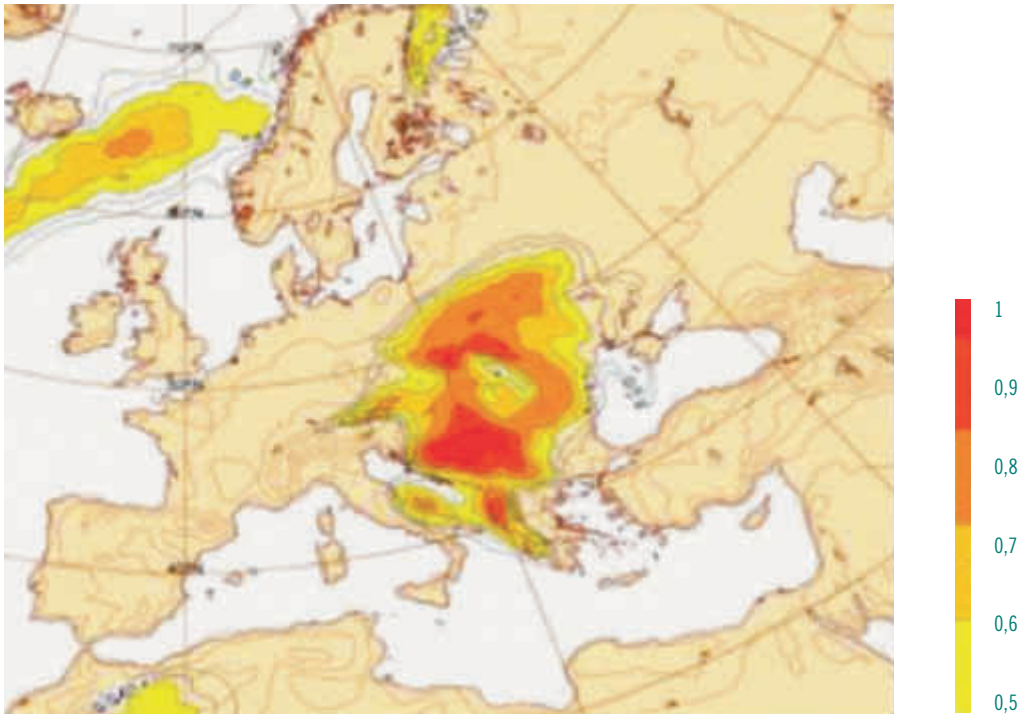
3.1 Meteorological forecasts and warnings

Hydrometeorological Services of all three countries affected by the May 2014 flood are part of the Network of European Meteorological Services (EUMETNET), and hence the members of METEOALARM, a platform aimed at providing comprehensive weather warnings across Europe.

The May 2014 event was well and on time forecasted by European and local meteorological agencies. Although precipitation rates were underestimated in certain areas, forecasts provided very good indicators for warnings on extreme weather conditions.

Forecasted index of extreme precipitation for period 14–19 May 2014 (source: ECMWF)

FIGURE 3



3.2 National flood warning and monitoring

3.2.1 Croatia

Meteorological and Hydrological Service of the Republic of Croatia (DHMZ), in accordance with its responsibilities, issued a warning on extreme weather events. For Slavonia and Baranja regions in Eastern Croatia ALADIN model predicted 24-hour rainfall between 20 and 100 mm, between 06 UTC 15th May and 06 UTC 16th May, giving approximately the actual amount of rainfall.

On 14th May the yellow alert for precipitation was issued for Slavonia region in METEOALARM, but also orange for precipitation and red for wind on 15th May.

Rainfall forecasts and water levels monitored at about 170 automatic hydrological stations (equipped with telemetry devices) were gathered in the Flood defence centre in Zagreb, located in the Croatian Waters. The possibility of occurrence of high flows was evaluated, and water levels forecasted. The first flood warning for the Sava River was issued on Thursday 15th May, and the official flood defence stages were soon proclaimed. The regional flood defence centres were activated.

3.2.2 Bosnia and Herzegovina

Having in mind the situation in April, and good forecast of heavy rain in early May, weather forecasting services in B&H followed prognostic models and evaluated the forecasted precipitation. The first written information about the expected start of heavy rain was issued on 10th May. Written information continued in next days, providing the estimates of rainfall amounts and indicating the areas where the most abundant rain can be expected.

Following METEOALARM, the red alarm for precipitation above 60 mm was issued on 12th May.

Using the real-time hydrological monitoring system, the competent institutions in both B&H entities regularly monitored water levels at about 100 hydrological stations, and estimated the occurrence and propagation of flood waves.

Hydrological data of Croatian Waters, being available on web site, were a major benefit for competent institutions in B&H.

Reports to the authorities were made, as well as public releases on web, radio and TV.

3.2.3 Serbia

Having in mind significant precipitation in Serbia between 14th April and 5th May 2014, the Centre for the hydrometeorological system of early warnings and alerts of the Republic Hydrometeorological Service of Serbia (RHMZS) has carefully followed the development of synoptic situation that might result in a new heavy rainfall.

A possibility for such a development with a high probability of occurrence was noticed on 9th May when the precipitation forecast had indicated 24-hours rainfall 40 to 60 mm, between 13th and 16th May. This information was dispatched in the Operational Hydrometeorological Bulletin (OHB) by issuing an alert on heavy rainfall, as well on significant increase of water stages on the tributaries of the Sava and Drina River (the Kolubara and Jadar). Early warnings and alerts continued on 10th and 11th May, indicating significant increase of water stages on rivers in western, south-western and central Serbia.

The OHB for 12th May gave the red alert level for 14th and 15th May indicating heavy rainfall (more than 40 mm in 12 hours). The heavy rainfall alert was sent in SMS messages and e-mails on the same day, with estimated 50–120 mm of rainfall in 72 hours, and even more locally in western and south-western Serbia. In accordance with the hydrologic modelling results, the alerts on exceeding the first and the second flood alert level were issued. The red alerts for heavy rainfall continued on 13th, 14th and 15th May through OHBs and Alert Bulletins, as well as in SMS and e-mail messages. Also, the alert on the increase of Sava River water stages through Serbia after 15th May was issued on 13th May.

Information was dispatched to the responsible state authorities and individuals, but firstly to the Emergency Sector of the Ministry of Interior of Serbia and the Water Directorate of the Ministry of Agriculture and Environment Protection. Also, information and alerts were regularly updated at the web site of the RHMZS (www.hidmet.gov.rs) and on web sites for alerts: www.meteoalarm.eu, www.meteoalarm.rs.

Beside the regular information (Weather and hydrology forecasting bulletin – 3 times a day, OHB – daily, Alert bulletin – 3 times a day, warnings and alerts at the web site), RHMZS issued up to 70 additional emergency information during the critical period (SMS alerts, e-mail alerts, measured precipitation data, measured hourly water stages data, measured 3-hours water stage data, 6-hour rainfall forecasts, etc.).

3.3 Danube EFAS response

First EFAS alert to RS, BG, RO was issued on 11th May (B&H is currently not an EFAS partner). Daily detailed reports based on EFAS and national information was provided to the Emergency Response and Coordination Centre (ERCC) of the European Commission's Humanitarian Aid and Civil Protection department (ECHO) from 12th May onwards. EFAS was employed for pre-tasking of satellites for Copernicus Rapid Mapping.

Overview active EFAS warnings for 2014-05-15 12UTC forecast (source: EFAS)

FIGURE 4

4. Key flood events

The May 2014 flood event was significant only in the middle and lower parts of the Sava River Basin. The upper part (Slovenia) and a portion of its middle part upstream of the Una River confluence were not affected at all.

The hydrologic response of the Sava tributaries to large precipitation amounts in mid-May was very quick due to high soil saturation. The torrential streams were the first to react, with floods characterized by high flow velocities, enormous amounts of sediment and numerous landslides activated in the river valleys. Huge flood waves occurred on the large right tributaries in Bosnia and Herzegovina (Una, Vrbas, Ukrina and Bosna) and Serbia (Kolubara). The contribution of the Drina River to Sava flow was also significant.

Until mid-May, the Sava River was relatively high but in recession. The May 2014 Sava flood wave had surprisingly quick rise for such a large river (only 4 days) and lasted till the beginning of June.

New historical maxima were reached on mid and lower Sava, as well as on its tributaries (Bosna, Vrbas i Kolubara), as shown in Annex 1, Table 2. The overview of the return periods for the peak discharges on the Sava River and its tributaries during the May 2014 floods is shown in Annex 2, Map 4.

Below is a brief review of the hydrological situation on the Sava main course and its large tributaries.

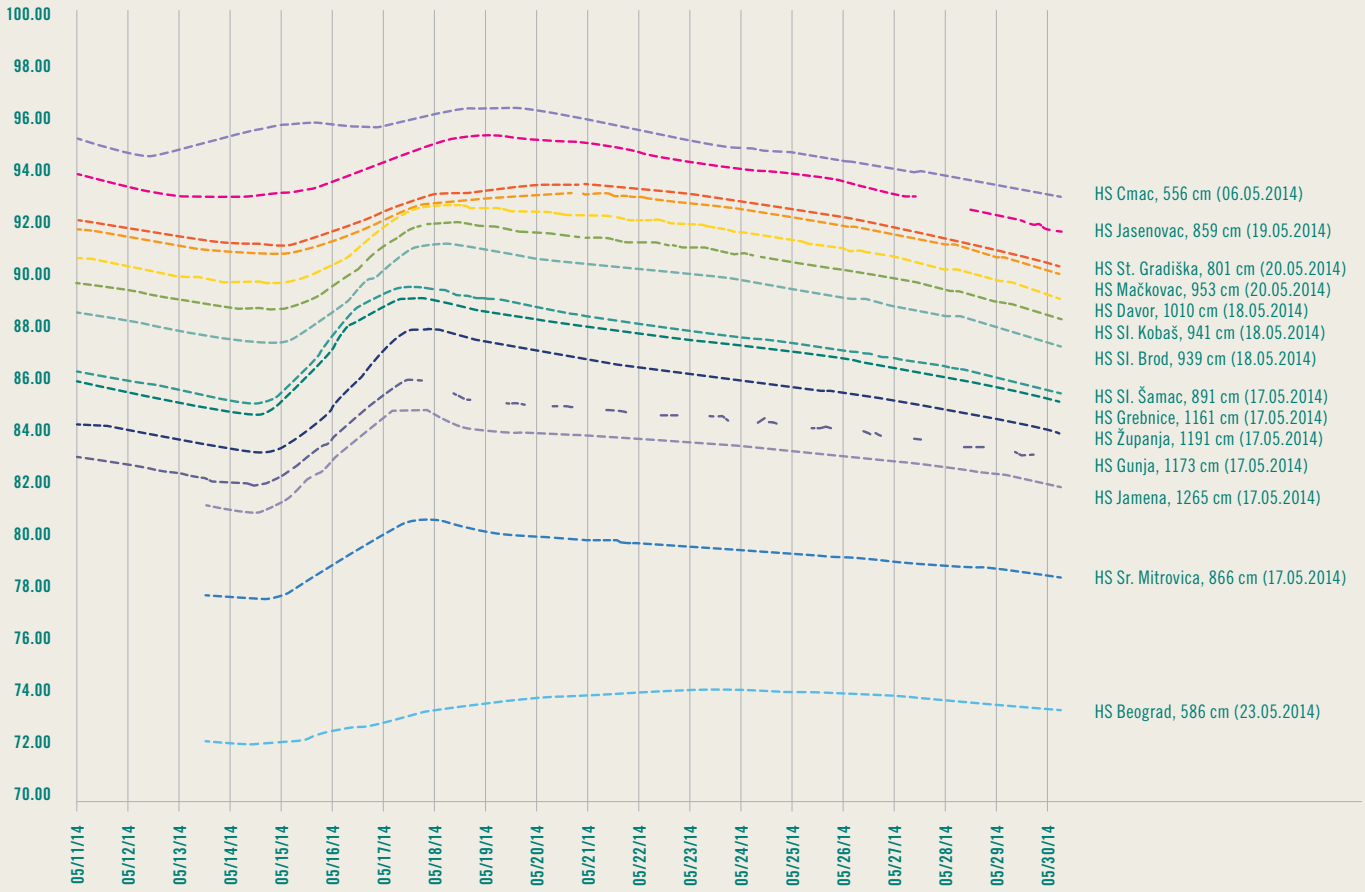
4.1 Sava River

In the period from 17th to 20th May 2014 at hydrological stations on the middle course (Slavonski Kobaš, Slavonski Brod, Slavonski Šamac, Grebnice, Županja and Jamena) and the lower course of the Sava River (Sremska Mitrovica, Šabac) the highest water levels in history of measurements were registered. The absolute maximum recorded on the stations were direct consequences of extremely large inflow from the Bosna (4,200 m^3/s), the Vrbas (1,700 m^3/s), the Drina (4,000 m^3/s), and subsequently the Una River (1,750 m^3/s).

The inflow from tributaries had a major impact on propagation of flood wave along the Sava River, and also influenced the timing of extreme water levels. The presented graphs (Figure 5) reveal that the extremely high water levels at stations downstream of the Bosna River mouth (Slavonski Šamac, Grebnice, Županja, Gunja and Jamena) and the Drina River mouth (Sremska Mitrovica and Šabac) occurred on 17th May, when the extreme inflows from these tributaries emerged. The increase of inflow from the Vrbas River on 18th May induced maximum water levels downstream of this tributary (Davor, Slavonski Kobaš and Slavonski Brod), but without further increase on downstream stations. Water levels on the most downstream section of the Sava River (Belgrade) were influenced primarily by the Danube River, which was not high. That is why the highest level in May 2014 was significantly lower than the extreme of 2006.

Comparison of water levels at selected hydrological stations along the Sava River

FIGURE 5



DHMZ and RHMZS carried out several hydrometric measurements on the Sava River during the May 2014 flood event. Measured water levels, flow velocities and flow rates were higher than ever before.

DHMZ measured 6,008 m^3/s at Slavonski Šamac at water level of 889 cm. Based on the hydrological analysis it was concluded that this discharge had a return period of 1000 years.

RHMZS estimated that peak of the Sava flood wave downstream of the Drina river mouth (recorded on 17th May at Sremska Mitrovica) was 6,600 m^3/s, and had return period of 100 years. It should be noted that the flood peak was reduced because the dikes on the left bank (Croatia) and the right bank of the Sava River (B&H) breached on several locations, and large areas were flooded.

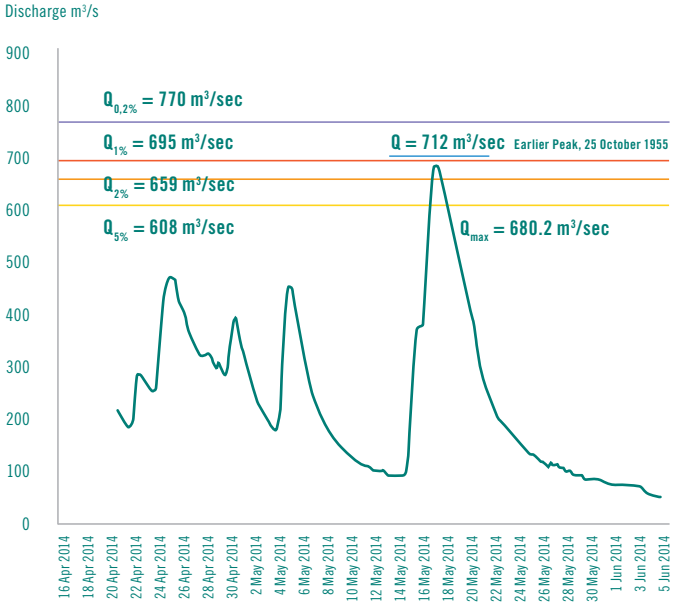
Detailed reconstruction of flood wave propagation along the Sava River, based on measured data and hydraulic calculations, is needed to provide a real assessment of this event.

4.2 Tributaries of the Sava River

4.2.1 Una River

The response of the Una River basin to abundant rainfalls happened at the very end, after the east-west shift of the cyclone. A remarkable flood wave developed between 14th and 16th May on its largest tributary – the Sana River, and caused flooding of Sanski Most, Prijedor and Novi Grad. High water levels were recorded also on the main course of the Una River, especially downstream of the Sana mouth (at hydrological station Hrvatska Kostajnica water level was 504 cm) but flooding didn't occur.

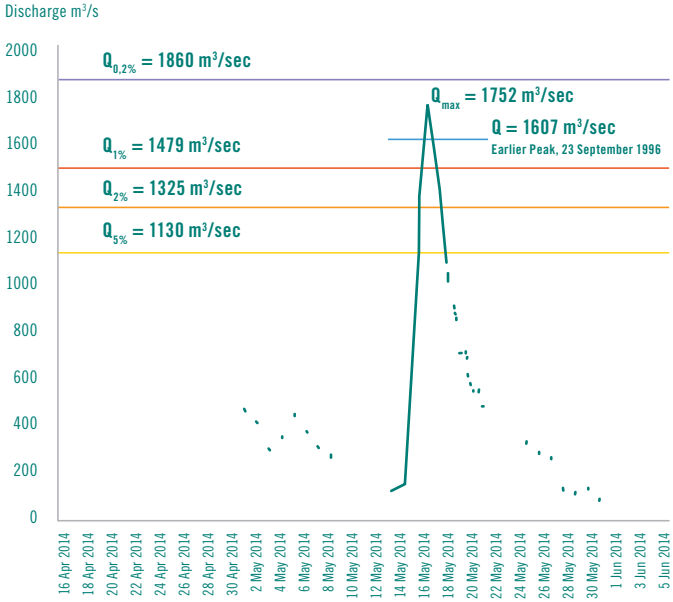
Hydrograph of the Sana River in April– May 2014, at hydrological station Sanski Most *FIGURE 6*



4.2.2 Vrbas River

High water levels on the upper reach of the Vrbas River were below earlier maxima. More difficult situation was on the middle and lower part of the river, where flooding occurred. Extremely high water levels were recorded in the city of Banja Luka, where water level raised for 7m between 14th and 16th May (at hydrological station Delibašino Selo). Some parts of Banja Luka and its suburbs were flooded.

Hydrograph of the Vrbas River in April– May 2014, at hydrological station Delibašino Selo *FIGURE 7*

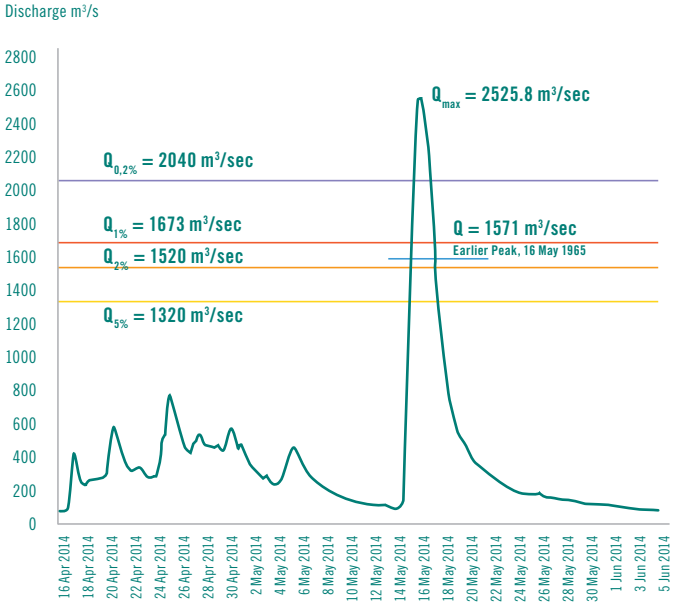


4.2.3 Bosna River

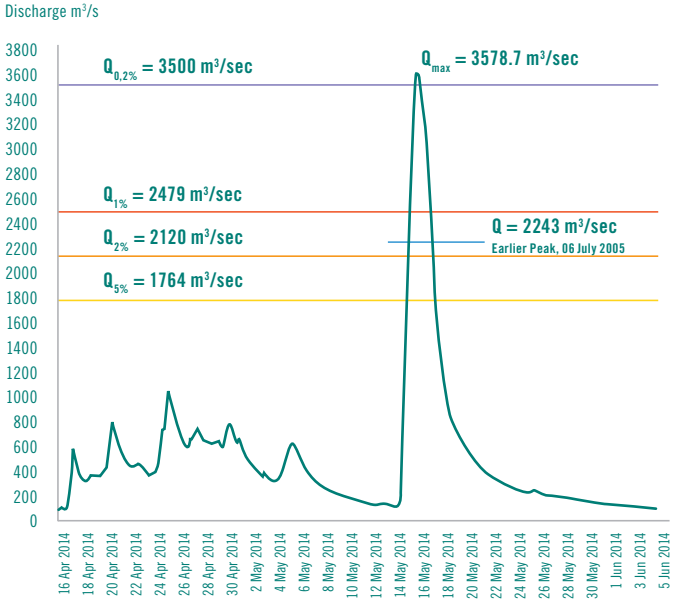
In the upper part of the Bosna River basin the water levels began to rise on 13th May. However, the water levels of the Bosna River and its tributary Miljacka in Sarajevo didn't exceed historical maxima.

Historical maxima were recorded in the middle and lower parts of the basin on 15th May, both on the Bosna main course and on tributaries (Krivaja, Usora and Spreča). The return period of the flood peak on the Bosna river was 500 years, and 100 years on tributaries. Sudden rise of water level (more than 6 m in less than 24 hours) was recorded on hydrological station Doboj. As a result, floods with disastrous consequences occurred in cities as Zavidovići, Maglaj and Doboj.

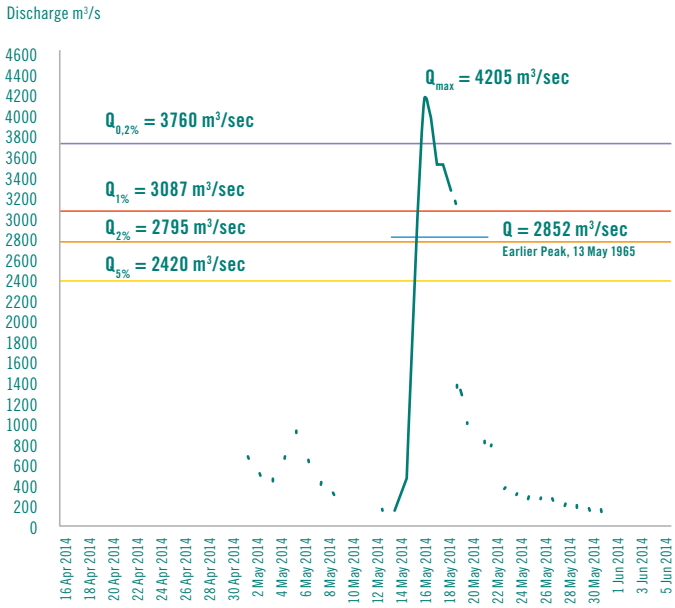
Hydrograph of the Bosna River in April– May 2014, at hydrological station Zavidovići (middle course) *FIGURE 8*



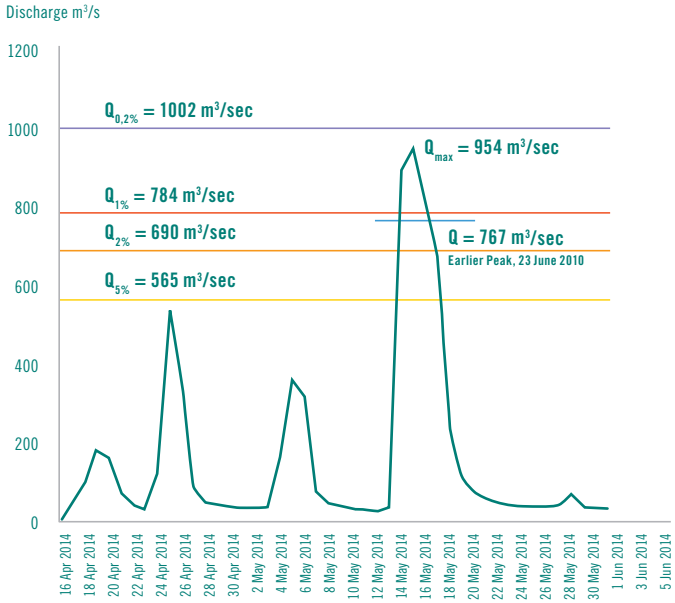
Hydrograph of the Bosna River in April– May 2014, at hydrological station Maglaj (middle course) *FIGURE 9*



Hydrograph of the Bosna River in April–May 2014, at hydrological station Doboj (lower course) *FIGURE 10*



Hydrograph of the Kolubara River in April–May 2014, at hydrologic station Beli Brod (middle course) *FIGURE 11*



4.2.4 Drina River

Extreme rainfalls were not recorded in the upper part of the Drina River basin, on the Piva, Tara and Lim catchments. Therefore, flood wave on the upper and middle course of the Drina was moderate, having the 20 year return period at hydrological station Radalj (with peak discharge of 3940 m^3/s). Downstream of Radalj, along its lower course, the Drina received flood waters of its tributaries (Jadar and Janja) and flooded the municipality of Bijeljina.

4.2.5 Kolubara River

Kolubara River, as a result of intensive rainfall, began to rise in the night between 13th and 14th May and reached its maximum on 15th May 2014. At the location of the hydrological station Beli Brod it rose 7 m for 24 hours. Simultaneous flood waves were recorded on all tributaries of the Kolubara River. The result was disastrous flooding throughout the Kolubara River basin, including the open-pit mine (received about 190 million m^3 of water and mud) and the Obrenovac city, at its mouth into the Sava River.

5. Affected areas and Flood interventions

5.1 Affected areas

When in the middle of May 2014 a three-month amount of rain fell in just three days, the disastrous flood occurred and had devastating impacts in B&H, Croatia and Serbia. The rough estimate based on satellite imagery revealed that the flooded areas were very large: 266.3 km^2 in B&H (Federation B&H 179.5 km^2, Republic of Srpska 72 km^2 and Brčko District 14.7 km^2), 53.5 km^2 in Croatia, and 22.4 km^2 in Serbia. The flooded areas and locations of dike breaks along the Sava River are presented in Figure 12. Approximate areas affected by floods in the Sava River Basin are shown on Map 1.

Flooded areas and locations of dike breaches along the Sava River *FIGURE 12*

5.2 Flood interventions on the left bank of the Sava River

5.2.1 Croatia

Natural lowland retentions along the Sava River, which usually have a very important role in the system of flood management on this river, were activated with 600 million m^3, which is about one third of the available volume. Greater involvement of their capacity was not possible since the flood wave was formed downstream of retention ponds.

On Thursday 15th May, the first warning on the Sava water level rise was issued. The flood defence was promptly proclaimed, and local flood protection centres activated. On many locations flood levels exceeded the stages for declaring state of emergency. The state of emergency at the county level remained in force until 4th June, even if the flood wave passed.

The flood defence activities were organized along 214 km of the Sava River levees. Almost simultaneous breaching of dikes at two locations (Rajevo Selo and Račinovci) occurred on 17th May afternoon, and nearby lowland area was flooded. Dikes breached approximately at the flood peak at this section of the Sava River, when water level was 1 m above the design value.

It was estimated that this event had return period of once in 1000 years. The flood water entered the hinterland with great force, spreading in general to the north and east, towards the Spačva forest area. Based on volumetric curve it was estimated that about 80 million m^3 of water inundated the area up to the maximum water level (79.88 m).

Closing of the dike breach was not possible for a few days, due to inaccessibility and high flow force. It started when water levels of the Sava River dropped to some extent. Both breaches were used for evacuation of water from flooded area, but the breach near Račinovci had to be additionally deepened to increase water outflow.

Croatian Waters, companies contracted for preventive flood defence works, National Protection and Rescue Directorate (DUZS), Croatian Army, police, firefighters, Red Cross, local residents and many others were engaged in flood defence.

Emergency defence in Županja, Croatia *FIGURE 13*

Emergency defence in Gunja, Croatia *FIGURE 14*

Dike breach near Rajevo Selo, Croatia *FIGURE 15*

Flooded village in Eastern Slavonia, Croatia *FIGURE 16*

Flood in Gunja settlement, Croatia *FIGURE 17*

5.2.2 Serbia

The part of the Srem region in Serbia was flooded when the Sava River breached left-bank dike at two locations in Croatia on 17th May. Water progressed over flat areas at HR-RS border towards Serbia and flooded the Jamena village. Several other villages (Sremska Rača, Bosut, Visnjićevo and Morović) were protected by 40 km of temporary dikes built in only 48 hours. The water from flooded area was evacuated using pumping station (capacity 30 m^3/s) and weir Bosut, when the Sava level dropped down.

In the Sremska Mitrovica city quays, due to city planning requirements, provide a level of protection lower than 100 year flood level. Sand bags had to be put on the top of structures, because the Sava River level exceeded the historical maximum by almost 70 cm. Flood protection of this area was successful, due to involvement of more than 5000 volunteers, and professionals of PWC Vode Vojvodine. Altogether, more than 1.5 million sand bags were used in the Srem region.

All dikes reconstructed in the previous period to enable protection from 100 year flood with 1.2 m freeboard sustained this flood event, with minor problems. The natural floodplain between Kupinovo and Sremska Mitrovica was flooded, including some villages and farmland in that area.

5.3 Flood interventions on the right bank of the Sava River

5.3.1 Bosnia and Herzegovina

On 17th and 18th May dikes on the right bank of the Sava River in B&H breached at several locations, causing flooding of large areas in Odžačka Posavina, Srednja Posavina and Semberija regions.

In Odžačka Posavina, which is the area upstream of the Bosna River mouth into the Sava River, coincidence of high flows of the Sava and Bosna rivers caused dike overtopping and breaches. Dike overtopping, both on the right and left bank, occurred firstly closely upstream of the Bosna River mouth, where the river suddenly narrows from 2.5 km to 0.75 km. On 17th and 18th May high waters of the Sava River caused dike breaches on 6 locations (total length 460m).

Dikes along the Sava River at this section do not have a design freeboard of 1.2 m above the theoretical 100-year flood level, and could not sustain the May 2014 flood which was a 1000-year event. Flooding of Odžačka Posavina area affected Prud, Trnjak, Vojskova, Donja Dubica and Novi Grad settlements.

Flooded village in Eastern Slavonia, Croatia *FIGURE 18*

Dike overflow in Prud, B&H *FIGURE 19*

Emergency measures in Prud, B&H

FIGURE 20

City of Šamac was completely flooded when both dikes at the Sava River and at the right bank of Bosna River breached. The flood waters originating from the Bosna River, progressed through hinterland of the right Sava dike towards the Srednja Posavina area. That is why settlements Tišina and Grebnice and towns Domaljevac-Šamac and Orašje were in fact flooded by the Bosna River.

The Sava dike breach on the section Kopanice contributed to flooding of Srednja Posavina region (downstream from the Bosna river mouth), in addition to flooding by the Bosna River. The 80m long dike breach was in the sharp band of the Sava River, where the flood channel narrows from 3 to 1 km. The flood spread downstream from Orašje towards the Brčko town.

Flooded town of Brčko, B&H

FIGURE 21

Dike breach in Kopanice, B&H *FIGURE 22*

Flooded village near Bijeljina, B&H *FIGURE 23*

Evacuation of flood waters from Odžačka and Srednja Posavina started after the Sava water level dropped down. Pumping stations had to be rehabilitated after flood damage, outlets opened, additional mobile pumps included, and dike breaches deepened, in order to evacuate the remaining water from the flooded area as soon as possible. Rehabilitation of dikes and closing of breaches started on 5th June, and was completed in 40 days.

The dike on the right bank of the Sava River in Semberija region collapsed at two locations – in Batković downstream of the Dašnica channel mouth to the Sava (in length of about 1 km) and, in Rača between the new and old border crossing (in the length of about 1.5 km) despite the attempts to heighten low sections of the dike with sand bags.

The overflow and breach resulted in a fast flooding (in about 12 hours) of the riparian land, inundating the 4–5 km wide, 14 km long area (from the dike of the Dašnica-stara channel to the dike on the left Drina bank in Balatun). Several villages were flooded, and damages on buildings and agricultural land were encountered. A total area of 27,800 ha has been inundated in May 2014 in Semberija, due to Sava and Drina flooding.

Flooded area at the Drina River mouth, on 19th May 2014 *FIGURE 24*

Emergency measures along Sremska Mitrovica quay, Serbia *FIGURE 25*

Emergency dike on the top of right Drina River dike, Serbia *FIGURE 26*

Emergency measures along a low part of the dike upstream of Šabac, Serbia *FIGURE 27*

Emergency measures along a part of the dike where reconstruction was ongoing, upstream of Šabac, Serbia *FIGURE 28*

5.3.2 Serbia

Reconstruction of the line of defence along the right bank of the Sava River in Serbia has not been completed, even though it began back in 1974. Consequently, extreme efforts were needed to prevent overtopping or breaching of the old embankment in the Mačva area, which is a single flood cell between Šabac and the Drina river mouth.

There were 3 weak sections in this area:

(1) low-crest dike along the right bank of the Drina river, where 9.5 km long earthen emergency dike was built in only 14 hours;
(2) old and low-crest dike (5 km long), where the crest had to be upraised using sand bags and
(3) 2 km long section where reconstruction started prior to flood, where complex emergency measures had to be implemented.

Flood defence lasted for 15 days and involved the military and citizens in addition to relevant institutions. Dike breaches were successfully prevented, but the cost of these activities was very high.

5.4 Flood interventions on tributaries of the Sava River

5.4.1 Una River

Water levels on the Una River reached the highest values since 1955. In Croatia the river caused flooding in the towns of Hrvatska Kostajnica and Dvor in the Banovina region. In B&H almost half of Bosanska Kostajnica was flooded and several villages in the surrounding area, where hundreds of homes were damaged.

High waters of the Sana River, the right tributary of the Una, caused overtopping of the left dike on 14th May. All suburban areas near the river, as well as most of the Sanski Most urban area were flooded. Drinking water and electricity supply were cut-off in most parts of the municipality. A large number of rock and landslides completely interrupted road communication with many villages. Large damage to residential and commercial buildings, infrastructure, livestock and agricultural land was recorded.

Similar situation happened in the area of downstream town Prijedor.

5.4.2 Vrbas River

In May 2014 the Vrbas River flooded several villages, some parts of the Banja Luka city and its suburban areas, where several bridges were destroyed. Also torrential floods on small tributaries (Krupa, Suturlija, and Vrbanja) caused significant damages. State of emergency has been declared in this municipality.

5.4.3 Bosna River

Bosna River completely flooded Doboj, Zavidovići, and Maglaj in central Bosnia as well as Šamac at its mouth to Sava. Landslides swept away the entire hamlet of Parići in Hrasno Donje (municipality of Kalesija), and also affected Željezno polje in Zepče municipality, Tuzla and other smaller areas in the basin. One of the most severe events happened in Topčič Polje village, which was destroyed by three torrents.

The high levels of the Sava prevented the Bosna River from freely discharging and created a backwater effect that raised water levels in this tributary. In the case of the Bosna River at Šamac town this is considered to be a significant factor that led to the flooding of the town.

Flooded area in Sanski most, B&H *FIGURE 29*

Flooded area in Banja Luka, B&H *FIGURE 30*

Flood in Doboj, B&H *FIGURE 31*

Flooded area in Šamac on the Bosna River confluence, B&H *FIGURE 32*

5.4.4 Drina River

Heavy rains did not affect tributaries of the Drina River in Montenegro, especially the most important one – Lim River. Thus, the peak flows on its upper and middle course were not extreme. Immediately downstream of Zvornik dam the peak had 20 years return period (3940 m^3/s), but it was enlarged further downstream due to extreme flows on all tributaries, especially the Jadar and Janja rivers. The heavy rains in the most downstream part of the Drina River valley caused landslides that cut off villages and closed roads.

The heavy rainfall in May 2014 triggered high water flows of torrential streams in western Serbia. The most notable example was the flood in Krupanj (small tributary of Jadar River), where several small torrential streams joined forces. Krupanj was flooded in a very short time; the trained sections of the channels were totally destroyed and covered with enormous amounts of sediment, while many landslides were activated.

May 2014 floods heavily affected both protected and unprotected areas in the Jadar valley (municipalities Osečina and Loznica). The flood protection structures were overtopped or breached on many locations, and the damage was high.

On 14 May 2014 the Drina River overflowed its banks downstream of Janja and flooded settlements in the Bijeljina area, including the entire industrial area (Fig 24).

5.4.5 Kolubara River

Not the first but certainly the worst floods in history hit the Kolubara River basin and damages were of catastrophic scale. Landslides were triggered and caused collapse of roads and bridges. Numerous tributaries of the Kolubara had extremely high flows and the flood caused damage to settlements, infrastructure and farmland. At the Kolubara River, the flood defences within the City of Valjevo sustained considerable damage (with minor overtopping in the city centre), the bridges were either damaged or destroyed, and the open pit coal mine “Tamnava– West Field” was transformed into the lake with 187 million m^3 of water and 3 million m^3 of mud.

Scenes from Krupanj, Serbia

FIGURE 33

Entire settlements including Obrenovac (one of the municipalities of the Belgrade city) were literally submerged having as a consequence human losses, thousands of people in collective shelters, destroyed houses and infrastructure. Obrenovac, surrounded by the Tamnava, Kolubara and Sava rivers, was flooded because the dikes on tributaries were breached some ten kilometres upstream from the city. In parts of the flooded area, the water was several meters deep. Then the Sava dike failed at two locations, and the water from the flooded area gravitated to the Sava as much as possible due to a highly unfavourable configuration of the terrain on which the city is located.

Namely, some residential areas are situated on very low-lying land – abandoned branches of the Sava and the Kolubara, from which flood water had to be pumped. Serbian main electrical power production facility – TPP Nikola Tesla was also endangered.

Flooded open pit coal mine "Tamnava – West Field", Serbia *FIGURE 34*

TPP Nikola Tesla surrounded by flood, Serbia *FIGURE 35*

Flood in Obrenovac, Serbia *FIGURE 36*

5.5 Summary of actions

During the May 2014 flood in the Sava River Basin all three affected countries: Bosnia and Herzegovina, Croatia, and Serbia have undertaken various actions to prevent and reduce harmful consequences.

It is also important to emphasize that solidarity among the affected countries was in place during the whole event. Solidarity was also shown by other neighbouring countries, and international aid mechanisms including numerous institutions and organizations which were activated. A brief description of the activities in each country is given below.

5.5.1 Croatia

In the Republic of Croatia, holders of authority and responsibilities for flood defence started to implement measures and actions of flood control in line with legal provisions, as of beginning of May. The system of protection and rescue at the local, regional and state level was activated. In addition to the relevant participants and operational and rescue forces, police and the army were also included.

Following the water level increase on the Sava River and tributaries, the appropriate flood defence stages have gradually been declared, and the implementation of the prescribed preventive actions started. State of emergency was declared at a large number of defence sections. Significant capacities of Croatian Waters, DHMZ, firefighting, civil protection, public health, the Croatian Red Cross, Croatian Mountain Rescue Service (HGSS), utility companies, headquarters for protection and rescue and civil defence headquarters, police, Armed Forces, local residents and volunteers were engaged.

For the first time in history, based on the Law on Protection and Rescue, the Croatian government declared a disaster.

Operational activities during flood included: some 225,000 bags filled with sand; about 135 meters of provisional dikes, 498 meters of temporary dikes, 100 meters temporary military road built; around 1625 meters of the road rehabilitated, and 2250 bags used for bank protection.

National Protection and Rescue Directorate sent bilateral assistance to Bosnia and Herzegovina with 7 cars and 3 boats with 19 members of the Directorate, 2 helicopters with 15 members of the Armed Forces and a lot of other activities. The special police unit was sent to Obrenovac (Serbia) to help in rescue operations.

5.5.2 Bosnia and Herzegovina

In Bosnia and Herzegovina, likewise in Croatia, the competent institutions for preventive and active flood defence started their activities as of April and early May, due to the intensive rainfall and a significant increase in water levels on watercourses.

Firstly regular and then emergency flood protection have been declared at watercourses where flood protection structures exist, even before reference water levels were reached, due to fast water level increase.

Government of the Federation of B&H declared state of emergency on 15th May, and the Government of Republika Srpska declared an emergency for its entire territory on 17th May.

Institutions responsible for implementing active flood protection measures, according to legal provisions and administrative structure of the state, took operational steps, with the involvement of civil protection services, Armed Forces, police and other institutions, citizens and volunteers.

In Federation of B&H, the most active institutions in the operational flood defence were: Agency for Sava River Basin District, Sarajevo, Federal HM Service, Federal civil protection headquarters (along the cantonal and municipal headquarters), and in Republika Srpska: Public institution Vode Srpske, RHM Service, and Republic Administration of Civil Protection.

Besides already mentioned assistance from Croatia, the teams from several EU countries provided assistance to B&H in protection and rescue actions. Through the EU Civil Protection Mechanism following was provided: 2 helicopters, 12 high capacity pumping modules, 85 pumps, 25 rescue boats and 14 water purification modules. In addition, 11000 water purification tablets, 14000 blankets and more than 1000 tents have been channelled through the EU Civil Protection Mechanism to the affected people in Bosnia and Herzegovina. The European Commission is co-financing transportation costs to deliver aid to the affected areas. The European Commission's Emergency Response Coordination Centre (ERCC) has been in constant contact with the relevant authorities in B&H to match the incoming offers for assistance with needs on the ground.

After the flood event several institutions from Slovenia developed hydrological model for Bosna River Basin, as a Slovenian government help to Bosnia and Herzegovina. The model sufficiently and successfully simulates the flood event of May 2014 giving an insight to river water balance and is also useful for the future predictions of flood levels for the Bosna River.

5.5.3 Serbia

Operational Headquarter of the Republic Headquarters for Emergency Situations of the Republic of Serbia has coordinated all activities of headquarters throughout the territory. Sector for Emergency Situations informed all ministries on the engagement of the inspection services under its jurisdiction, to immediately go to the most critical places, in order to organize mitigation and alleviating the flood consequences.

Due to extraordinary events, floods and landslides caused by heavy rain, Government of the Republic of Serbia declared the emergency situation throughout the country on 15th May.

The following institutions were engaged in flood defence: Republic Directorate for Water, Public Water Companies Srbijavode, Vode Vojvodine and Beogradvode, RHMZS, Ministry of Interior, fire and rescue units, specialized units of civil protection and rescue on the water and under water, the Serbian Army and other services, residents and volunteers. 15,870 m of temporary dikes were made of sand bags to reinforce the existing dikes.

Assistance to Serbia in protection and rescue actions has been provided by rescue teams from 13 countries: Russia, Belarus, Slovenia, Bulgaria, Denmark, Czech Republic, Germany, Romania, Austria, France, Hungary, Macedonia and Montenegro, which also provided rescue equipment. Helicopters from Russia, Slovenia, Switzerland, Germany, Macedonia, Hungary, Belarus, and EULEX were engaged for the rescue, survey and delivery of food and other necessities. Croatia has sent police unit with a team of divers to the area of the most vulnerable city of Obrenovac. It is important to note that for the purposes of assistance in coordinating of engagement of international teams in Serbia, there was a team from the United Nations and a team of the European Commission (for facilitation of assistance of the European Civil Protection Mechanism).

The ministries, according to their competencies, activated inspection services. The cleaning of contaminated soil and removal of dead cattle in places where there was access to flooded areas was organized.

5.5.4 ISRBC

In response to the most significant flood event in the Sava River Basin, looking at the period since its establishment, ISRBC took a number of activities within its jurisdiction.

Two urgent high-level meetings were organized by the ISRBC in June 2014: the strategic meeting of the Sava Commission and the Ministerial meeting on regional cooperation in flood protection in the Sava River Basin, held in Belgrade on 16th June. Firm support to jointly agreed activities has been provided by the participants of the ministerial meeting. The Ministers in charge of water issues and other high representatives of Sava River Basin countries have also supported *the additional strengthening of the role of the Sava Commission as a mechanism of coordination of regional cooperation, including the analysis of opportunities for changes and amendments to the Framework Agreement on the Sava River Basin (FASRB), in terms of empowering the Sava Commission to reach binding decisions in the water management sector as well*[*].

The ISRBC also prepared comprehensive information on the consequences of May 2014 flood in the Sava River Basin and asked all relevant international institutions for support.

A complete issue of the official bulletin of the Sava Commission, Sava Newsflash was dedicated to the floods, while some activities that were planned within the Sava Day 2014 were cancelled or postponed.

The ISRBC also actively participated in preparation of donor conference held in November 2014 and took part in its work.

The Fifth Meeting of the Parties to the FASRB which took place in Zagreb on 2 December 2014 strongly supported the resumption of joint activities aimed at further improvement of flood management in the Sava River Basin. The Parties committed themselves to further cooperation on the preparation of the "Flood Risk Management Plan", establishing a flood forecasting, warning and alert system, exchanging the information relevant for sustainable flood protection, as well as undertaking any other agreed activities that can contribute to the improvement of the flood management in the basin.

[*] ISRBC is currently empowered with reaching decisions in the navigation sector and issuing recommendations to countries in the area of water management.

6. Casualties and assessment of damages

6.1 Croatia

In Croatia, 38,000 people were affected by May 2014 flood. In the most critical southern Slavonia region around 15,000 inhabitants were evacuated and 3 casualties were registered.

The economic impact of floods in Croatia was estimated at 300 million EUR.

6.2 Bosnia and Herzegovina

In Bosnia and Herzegovina floods affected about 1.0 million people in central, north and east areas of the country were 90,000 people were evacuated. The floods caused 25 casualties.

In sum, the total economic impact of the disaster (destruction or severe damage to property, infrastructure and goods as well the effects of destruction on livelihoods, incomes and production, among other factors) is estimated at 2.04 billion EUR, which represents an equivalent of nearly 15% of the B&H GDP.

6.3 Serbia

The floods affected 1.6 million people in 38 municipalities mostly located in central and western Serbia. The floods and landslides caused 51 casualties, 23 of which were by drowning. About 32,000 people were evacuated from their homes, out of which 25,000 were from Obrenovac. The total economic impact of the disaster is estimated to 1.53 billion EUR.

Summary of damages and losses in the affected countries *TABLE 1*

Country	Affected	Evacuated	Casualties	Damage and losses (mil EUR)	Cause
Serbia	1.6 million	32,000	51	Damage: 860 Losses: 662 Total: 1532	Torrents, landslides, dike breach
Bosnia-Herzegovina	1 million	90,000	25	Damage: 1274 Losses: 763 Total: 2 037	Torrents, landslides, dike breach
Croatia	38 000	15,000	3	300	Dike breach

7. Lessons learned

Flood risk management is a cyclic process, comprised of three stages: response to a flood event, recovery, and preparedness for the next event. After the disastrous 2014 flood and following necessary repairs of flood defences, there will be an opportunity to define an appropriate set of preventative measures for the international and national river basins, and to implement such measures in the coming years.

7.1 Land Use and Spatial Planning

Very high damages on housing and infrastructure were induced by May 2014 flood in all countries. These damages were mainly the result of inappropriate use of water land (high flow channel or "real" flood-prone area) and potentially flooded areas (protected by dikes). It is therefore very important to the countries to prepare flood hazard and flood risk maps and implement results of mapping in spatial plans of municipalities. Municipalities should prohibit further development in real flood-prone areas, but also limit the increase of flood risk in potentially flooded areas through special conditions and permits.

It is very important to designate erosion-prone areas with a set of conditions for their use, to sustain existing forests, and afforest hilly and mountain regions in the Sava River Basin. These may prevent enormous sediment movement and landslides, which induced huge damages in May 2014.

May 2014 flood issued the question of environmental protection in case of flooding, since many hot-spots were endangered. Future implementation of appropriate land use regulations would substantially contribute to environmental protection. Furthermore, floodplain zoning can regulate the location of polluting industries and waste water treatment plants, thus preventing pollution due to flooding.

7.2 Structural measures

The lessons learned from May 2014 floods in the Sava River Basin indicate that the existing flood protection programmes as well as the ongoing and planned projects should be adjusted, in order to increase the flood protection level.

In all Sava countries, dikes along the Sava main course were built to provide protection in case of 100-year flood (with the freeboard of 1.2 m). These criteria were set 40 years ago, but still are not secured at a number of dike sections, some of which were overtopped in May 2014. One of the targets of the riparian countries should be to achieve the designed level of protection along the whole stretch of the Sava River, with priority given to protection of the cities.

In May 2014 flood the large floodplain and wetland in the Middle Posavina (Lonjsko Polje) didn't have a significant influence on flood wave attenuation and reduction of flood risks downstream, because the right Sava tributaries downstream of it had major contribution to the Sava River flow. However, Sava countries are aware of the importance of water retention, which contributes to reduction of flood risks and also is in line with the environmental objectives of the EU WFD. Therefore it is not only important to preserve existing retentions and natural floodplains, but also to create new retention capacities, wherever possible. The use of existing reservoirs and retentions for flood management should be enhanced and coordinated between Sava countries. Also, maintaining and developing the conveyance capacity of the floodway is very important both on the Sava main course and on smaller rivers.

Continued maintenance, monitoring and restoration of water management and flood control facilities must be ensured on a long term basis. Similarly, the approval procedures for planning and building flood protection facilities should be simplified and accelerated wherever possible.

The safety and operational readiness of the system of regulated retentions relies heavily on employees with the necessary of the local and technical knowledge, therefore the staff of the state water management agencies should be further trained on the basis of recent experience.

May 2014 flood confirmed that sediment and torrent management measures are very important for flood risk alleviation. It is important to permanently monitor and inspect and control the erosion processes at torrential rivers.

7.3 Non-structural measures

Structural measures can never completely eliminate the risk of flooding. However, because of their physical presence, they have the potential to create a false sense of security which can lead to the catastrophic consequences of residual risks. On the other hand, non-structural measures, besides their role in reducing the flood risk, have limited environmental consequences and should be actively considered as viable options, both as independent or complementary measures.

Of all non-structural measures, flood forecasting and warning is the most widely used. An efficient flood forecasting allows concerned people and authorities to take preventive and emergency measures. Authorities can respond appropriately with adequate flood control operations, such as opening and closing the gates of the flood defence structures, emptying of reservoirs in order to secure flood control storage capacity etc., as well as to make necessary preparations in all other flood defence activities.

The Sava countries have been aware of the need for more efficient exchange of information even before this catastrophic event. During 2014 flood, all possible means to exchange information, based both on official and private communications, were used. However, it is sure that an efficient flood forecasting and warning system for the Sava river basin would provide help to competent authorities in decision making.

A major step in that regard was achieved by signing “Guidelines for the Exchange of Hydrological and Meteorological Data and Information in the Sava River Basin” in July 2014. The document, prepared in cooperation with WMO, was signed by all 6 HMSs operating in the Sava River basin and 2 agencies in charge for water management.

In order to support the above process ISRBC, with assistance of ICPDR, is in the process of developing the Sava Hydrologic Information System (Sava HIS), which will enable presentation of real time data from the selected stations in the basin on one place, as well as the storage of those data at the central location, with the core statistical services.

Regarding development of a joint /coordinated flood forecasting and warning system (FFWS) a consensus among the countries cooperating within ISRBC was reached to work toward development of such system[1]. This common intention reached the implementing phase in June 2014 when the project “Improvement of Joint Flood Management Actions in the Sava Basin”[2] has been approved by Western Balkan Investment Framework (WBIF). By implementing of the project by the end of 2017 it is expected that an operational FFWS covering the complete Sava River Basin shall be in place.

[1] Protocol on flood protection to the FASRB states: The Parties shall establish a coordinated or joint Flood Forecasting, Warning and Alarm System in the Sava River Basin

[2] The project consists of the 2 components: Preparation of the Sava FRMP and development of the FFWS for the Sava River Basin

The extreme 2014 flood should also trigger a new Hydrological Study for the Sava River basin, which was already at the list of priority projects of the ISRBC. It should, due to its fundamental character, address all meteorological and hydrological elements relevant for integrated water and flood risk management in the Sava River Basin. It should be based on mutually agreed methodology and period of analysis, and provide an essential input for future projects on further development and upgrade of the flood protection system in Sava countries.

Complementary to the above action further efforts must be invested in continuation of activities of improvement of existing hydrological and hydraulic models, developed either in the frame of cooperation coordinated by ISRBC or by individual country efforts. ISRBC PEG FP, on its meeting held in April 2014, expressed the need to model extreme scenarios, including dike breaches along the Sava River in various locations with the aim of evaluating the residual risk (which, unfortunately, after May 2014 flood became an urgent topic of interest). It is expected that further enhancement of this tools shall be achieved through cooperation with the US Army Corps of Engineers. A specific problem in that regard is the inadequate input data, especially those related to terrain representation. A few project proposals are prepared for preparation of high-precision digital elevation models based on Lidar technology.

Also, additional efforts must be undertaken in each country to improve meteorological and hydrological monitoring infrastructure as well as human capacities of responsible institutions. In order to achieve an improvement in flood forecasting and early warning, the properly qualified staff by countries must be committed on a long term basis with continual exchange of experiences.

The needs of additional research on the mechanism of, warning on and response to torrential floods was also recognized. Special attention should be paid to rising of public awareness, and building the preparedness for quick reaction in case of torrential flood.

7.4 Preparedness and mitigation (rapid disaster response)

Worst-case-scenarios should be taken into account for flood management planning. Flood management should be considered holistically, at the river catchment scale, and in line with plans for protection and rescue in emergency situations on the state and municipality level.

The water sector in all three countries affected by May 2014 floods encountered huge deficits in human resources during floods. Even if volunteers replaced the missing man-power in some cases, the technical capacities off competent authorities have to be reinforced.

Authorities on municipality level are not well prepared for handling such an extreme emergency situation, and the available plans have serious deficiencies. The update of these plans is needed and an appropriate training programme for municipalities and stakeholders has to be organized.

Based on experiences gained prior, during and after the May 2014 flood, the following measures can be important for the future:

- The awareness of the communities on flood risk should be raised and maintained, with a clear understanding of their role in appropriate response to emergency situations. Community actions are essential in coordinated evacuation from the affected area, maintenance of health/hygienic conditions in flooded areas and prevention of accidental pollution;
- Communication with the media is very important, but should be organized better. Competent institutions should agree on one responsible service/department for gathering and distribution of information to media;

- The evacuation and rescue operations can be improved by:
  (a) Further development of monitoring and warning system, as these information are crucial for adequate decision-making in the rescue operations;
  (b) Performing simulation exercises, for training of operational and rescue forces at the decision-makers level;
  (c) Better cooperation between citizens and rescuers during evacuation. Representatives of local community should be associated with rescue teams, because they know the situation on the ground, and can indicate the priorities during evacuation (as locations of elderly or disabled people);
  (d) Police should join the rescue teams and, if necessary ensure that the evacuation order is implemented (in May 2014 some citizens were not willing to leave their properties, being unaware of the risk);
  (e) Volunteers should not have access into the action zone, as they are an additional burden if not prepared in advance and associated with rescue team.

- Emergency operations shall be improved if:
  (a) Both vertical and horizontal responsibilities are clearly defined;
  (b) Methodology for assessing of a disaster consequences by sectors (e.g. people care, agriculture, animal evacuation, cleaning of soil, etc.) is established;
  (c) Obligations of local utility companies in the management of waste induced by the flood are defined;
  (d) Plan and the capacity to care for people affected by the disaster is in place, both immediately after the evacuation and on long-term bases if needed;
  (e) Detailed plans for handling of cultural institutions and the owners/users of cultural property in the time of crisis are prepared.

It needs to be highlighted that the focus should put on the efforts to strengthen regional cooperation. Following the May 2014 flood the European Commission had organised a Regional Conference on Flood Prevention and Management on 24th November 2014 to enhance regional governance and cross-border cooperation. The Conference concluded on the need to develop and strengthen policies to implement flood prevention and flood risk management, and to promote regional cooperation in river basin management.

The basis for regional action on flood prevention exists already in the necessary regional structures and mechanisms:

a) the EU's two macro-regional strategies, the Danube and Adriatic-Ionian, are the appropriate frameworks for coordinated financial support to such type of actions;
b) ICPDR and ISRBC are platforms to coordinate regional actions in flood and river basin management and have developed a range of activities for this purpose.

7.5 Climate change

ISRBC and other relevant institutions in the region have produced several important documents and reports pointing to the issue of the impact of climate change in the Sava River Basin.

One of the components of the ISRBC project "Building the link between flood risk management planning and climate change assessment in the Sava River Basin" dealt with compilation of various existing climate change scenarios for the region, their expected impacts on water cycle and more specifically on frequency and magnitude of extreme flood events. This study examined the meteorological-climatological aspects and impacts of climate change on flood events, and preliminary identified possible adaptation measures.

The most recent document dealing with climate change in the region is "Water & Climate Adaptation Plan for the Sava River Basin" (WATCAP, produced by World Bank in 2014).

One of the key conclusions of the WATCAP is that the climate within the Sava River Basin is changing and the basin will be vulnerable to the consequences in the future due in part to socio-economic factors, particularly bad since the time of the global financial crisis of 2007, a general migration of the population away from agricultural areas towards cities, but also due to the past legacy of the former Federal Republic of Yugoslavia that provided poor environmental management. Consequently the Sava River Basin bears the signs of aging infrastructure that is poorly constructed, badly maintained and housing, which is ill-suited to cope with storms, floods or heat waves, or to protect its people from the impacts of such extreme events.

WATCAP confirmed that the core issues within the Sava River Basin that are important in the context of climate change are navigation, flood protection, agricultural water management/ irrigation, hydropower and water supply. Regarding that, WATCAP assessed the different climate adaptation strategies, as a result from several case studies, which are transposed to the guidance notes for the above mentioned sectors.

WATCAP proposed a packages of short-term, medium-term and long-term mitigation measures for flood protection in the Sava River Basin in the time of changing climate. The proposed short-term measures over the next three years are estimated at the cost of 50 million EUR, mid-term measures to be implemented over the next 15 years are estimated to 1 billion EUR while the long-term measures to be implemented over the next 50 years are roughly estimated to 2 billion EUR.

Since the national flood risk management plans in the Sava countries are being developed a more precise estimation of the planned costs can be provided once the plans are prepared.

7.6 Financing aspects

7.6.1 Croatia

Remedying the consequences of the flood of May 2014 in the Republic of Croatia, more precisely in the Vukovarsko-Srijemska County will take place over a longer period. This is evidenced by the Law on the rehabilitation of consequences of the disaster in the Vukovarsko-Srijemska County (Official Gazette No. 77/2014), which was enacted after the flood event for a period of one year from its entry into force. Damage caused by flooding in Croatia is estimated at 300 million EUR, while damage to flood protection structures amounts to about 10 million EUR.

7.6.2 Bosnia and Herzegovina

The recovery needs in B&H after May 2014 floods are divided into short, medium and long-term priorities. The allocation of short, medium and long-term priority needs have been determined with consideration for the mobilization of resources, internal budget capabilities, and the international donor and International Financial Institutions (IFI) assistance. Having in mind the country's existing capacities in terms of governance and available resources, as well as disaster risk reduction considerations, the early recovery period will be essential and will focus on mitigating the short-term impact of the disaster through restoring critical services and infrastructure, sustaining livelihoods, and reducing vulnerability and future risks in longer-term rehabilitation. Concerns remain with regards to the absorption capacities of both public structures and the private sector that will need to form a close partnership in undertaking the recovery effort.

The flood protection assets in B&H suffered a substantial damage, which is estimated at EUR 25.77 million. The losses associated with this disruption of the flood protection structures is reflected in other sectors, namely due to the destruction of housing and the damage and losses to agriculture, other productive activities and commerce, leading to a considerable impact on livelihoods.

It is important to stress that in the near future more care has to be taken about the management of torrent catchments because these play a crucial role in the segment for protection against the severe effects of water in low-lying reaches of a watercourse.

The costs for recovery which include total flood protection facilities reconstruction with repair damages, data collection, improve planning, reduce risks in B&H are estimated to 183.45 million EUR.

7.6.3 Serbia

A special Law on post-flood rehabilitation in Republic of Serbia, valid for the period 22 July 2014 – 22 July 2015 was adopted to facilitate distribution of humanitarian and other aid to affected areas and their reconstruction. State budget and budgets of local authorities, donations, loans and EU financial aid are sources of financing. The Office for Aid and Reconstruction of Flooded Areas has been established, providing management and coordination of activities, reporting on the received humanitarian and other aid, verification and reporting on the estimates of damages in the flooded areas. By this Law, Republic of Serbia is acting as investor for reconstruction of buildings and facilities affected by floods.

Also, Regulation on determining the State program of reconstruction of damaged structures for river training, flood control, erosion and torrent control, and drainage was adopted, to recover costs of PWCs Srbijavode, Vode Vojvodine and Beogradvode in flood defence. Cost of emergency measures on the flood protection structures along Sava and its tributaries during May 2014 flood was 0.55 million EUR, while repairs on these structures amounted 16.6 million EUR.

Reconstruction and upgrade of the system will be planned carefully, and implemented in the next period depending of financing opportunities.

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Annex 1: Tables

Total and peak rainfall in the Sava River Basin

TABLE 1

Country	Meteorological station	Total Rainfall (mm)		Maximum May Daily Rainfall (mm)			
		May 2014 13.05. 06UTC 17.05. 06UTC	May Monthly Average Earlier period (1961–1990)	Earlier period	Date	May 2014	Date
Slovenia	Ljubljana	51,3*	121,5	79,7	31.05.2001	30,8	12.05.2014
	Celje	66,6*	96,5	100,0	20.05.1969	34,1	12.05.2014
	Novo mesto	50,5*	95,6	71,4	21.05.1999	25,4	12.05.2014
Croatia	Karlovac	27,7	93,7	42,1	07.05.1987	14,4	17.05.2014
	Zagreb Maksimir	31,5	78,7	50,4	16.05.1961	27,1	16.05.2014
	Slavonski Brod	59,6	73,0	65,5	30.05.1964	29,9	16.05.2014
	Županja	115,2	–	–	–	64,5	15.05.2014
	Ogulin	56,8	124,7	110,8	07.05.1987	23,7	14.05.2014
	Sisak	36,4	81,7	85,3	07.05.1987	14,3	16.05.2014
	Kutjevo	149,4	–	–	–	91,1	16.05.2014
	Lipik	83,9	–	–	–	48,4	16.05.2014
	Požega	78,9	71,2**	45,4**	28.05.1975	38,5	16.05.2014
Bosnia and Herzegovina	Bihać	79,7	116,0	105,2	31.05.1968	70,8	04.05.2014
	Prijedor	86,6	85,0	57,6	07.05.1987	65,8	16.05.2014
	Bugojno	70,3	72,0	38,5	15.05.1975	43,7	14.05.2014
	Mrkonjić Grad	136,2	102,0	62,1	31.05.1968	66,8	16.05.2014
	Banja Luka	107,5	98,0	49,0	10.05.1980	32,1	17.05.2014
	Drinić	156,5	118,0	164,3	31.05.1968	80,7	16.05.2014
	Gradačac	191,4	92,0	102,5	30.05.1982	69,0	16.05.2014
	Sarajevo	130,6	82,0	49,7	18.05.1989	**73,3**	14.05.2014
	Zenica	136,5	76,0	47,2	23.05.1970	**51,8**	15.05.2014
	Tuzla	248,6	92,0	55,8	03.05.1978	**94,6**	15.05.2014
	Sokolac	177,4	73,0	65,0	15.05.1989	73,4	14.05.2014
	Bijeljina	178,2	66,0	57,4	07.05.1987	89,2	15.05.2014
	Zvornik	204,3	92,0	76,2	25.05.1986	86,0	15.05.2014
	Srebrenica	166,9	104,0	56,0	22.05.1967	77,7	15.05.2014
	Višegrad	88,4	72,0	36,4	25.05.1975	44,8	14.05.2014
Serbia	Loznica	218,6	82,7	82,0	24.05.1937	**110,0**	15.05.2014
	Valjevo	199,6	88,1	77,5	25.05.1926	**108,2**	15.05.2014
	Beograd	190,4	70,7	68,7	21.05.1927	**107,9**	15.05.2014
	Sremska Mitrovica	125,8	58,2	53,5	26.05.1934	**69,1**	15.05.2014
	Sjenica	70,8	73.9	46,5	–	33,9	14.05.2014
	Zlatibor	109,2	100,0	53,2	–	38,1	14.05.2014
Montenegro	Bijelo Polje	54,2	74,5	48,8	29.05.1977	51,6	26.05.2014
	Pljevlja	83,5	68,8	49,8	28.05.1966	38,1	14.05.2014

*Period of data 12–19 May / **Period of data 12–18 May

Peak water levels in the Sava River Basin

TABLE 2

Country	River	Hydrological station	Earlier peak		May 2014*	
			Water level (cm)	Date	Water level (cm)	Date
Slovenia	Sava	ŠentJakob	856	01.11.1990	432	12.05.2014
	Sava	Jasenice na Dol.	622	01.11.2004	273	14.05.2014
Croatia	Sava	Jasenovac	907	18.01.1970	859	19.05.2014
	Sava	Stara Gradiška	898	30.10.1974	801	20.05.2014
	Sava	Mačkovac	1023	30.10.1974	953	20.05.2014
	Sava	Davor	1037	30.10.1974	1010	18.05.2014
	Sava	Slavonski Kobaš	937	30.10.1974	**941**	18.05.2014
	Sava	Slavonski Brod	883	31.10.1974	**939**	18.05.2014
	Sava	Slavonski Šamac	777	18.01.1970	**891**	17.05.2014
	Sava	Županja	1064	19.01.1970	**1191**	17.05.2014
	Una	Hrvatska Kostajnica	537	10.10.1955	504	18.05.2014
Bosnia and Herzegovina	Sava	Gradiška	855	19.03.1977	808	20.05.2014
	Sava	Grebnice	994	11.01.2010	**1161**	17.05.2014
	Una	Kralje	655	23.12.1982	496	16.05.2014
	Sana	Sanski Most	530	25.10.1955	517	16.05.2014
	Sana	Prijedor	511	09.10.1955	**546**	16.05.2014
	Vrbas	Delibašino Selo	687	23.09.1996	**760**	16.05.2014
	Bosna	Reljevo	527	20.12.1968	498	15.05.2014
	Bosna	Doboj	578	13.05.1965	**730**	15.05.2014
	Bosna	Zenica	530	20.12.1968	**601**	15.05.2014
	Bosna	Maglaj	740	03.07.2005	**980**	15.05.2014
Serbia	Sava	Jamena	1104	12.01.2010	**1265**	17.05.2014
	Sava	Sremska Mitrovica	800	26.10.1974	**866**	17.05.2014
	Sava	Šabac	590	25.03.1981	**664**	17.05.2014
	Sava	Beljin	764	25.03.1981	755	18.05.2014
	Sava	Beograd	738	16.04.2006	586	23.05.2014
	Drina	Bajina Bašta	857	20.12.1968	482	15.05.2014
	Drina	Radalj	660	02.12.2010	**623**	15.05.2014
	Jadar	Lešnica	436	23.06.2010	**446**	16.05.2014
	Kolubara	Valjevo	230	21.06.2001	**335**	15.05.2014
	Kolubara	Slovac	500	13.05.1965	**583**	15.05.2014
	Tamnava	Ćemanov most	444	20.03.1981	**507**	15.05.2014
Montenegro	Tara	Trebaljevo	497	18.10.1992	72	01.05.2014
	Lim	Bijelo Polje	455	16.12.1952	124	01.05.2014

*Period of data 12–19 May

Sava River Basin: Flood Event, May 2014 / Flooded Area

MAP 1

[1] Source: European Commission - COPERNICUS, Emergency Management Service and EsriDRP - LandSAT

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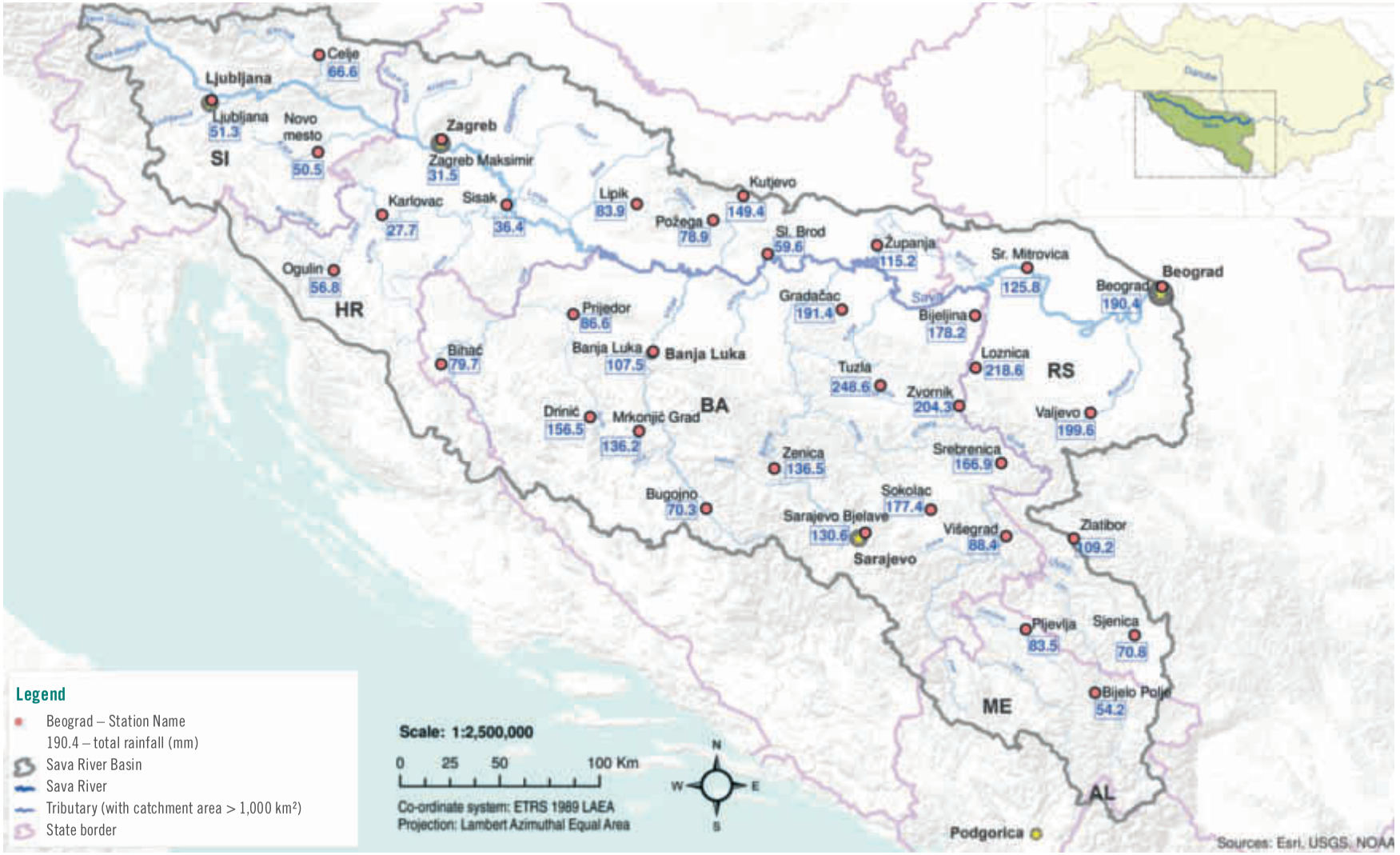
Sava River Basin: Flood Event, May 2014 / Total Rainfall, 13–17 May 2014

MAP 2



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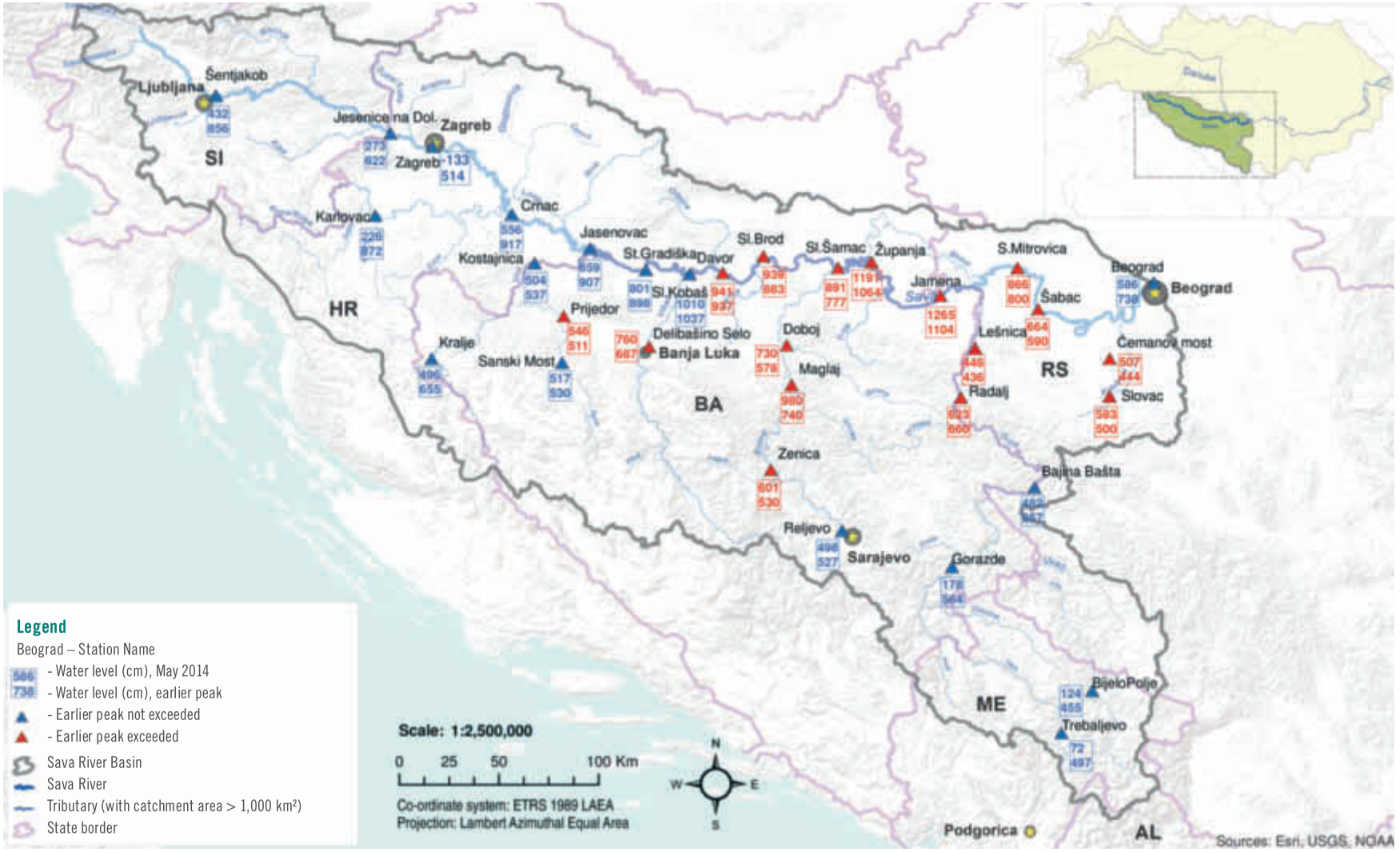
Sava River Basin: Flood Event, May 2014 / Water level peaks in May 2014 related to earlier peaks

MAP 3



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Sava River Basin: Flood Event, May 2014 / Return periods for the peak discharges on the rivers during the floods

MAP 4

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Contact

ICPDR Secretariat
Vienna International Centre / D0412
P.O. Box 500 / 1400 Vienna / Austria
T: +43 (1) 26060-5738 / F: +43 (1) 26060-5895
icpdr@unvienna.org / www.icpdr.org

ISRBC Secretariat
Branimir Centar
Kneza Branimira 29 / 10000 Zagreb / Croatia
T: +385 (1) 48869-60 / F: +385 (1) 48869-86
isrbc@savacommission.org / www.savacommission.org

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