BSMEFFG Istanbul Urban Flash Flood Early Warning System and Riverine Routing Multi-Agency Consortium Meetings

Istanbul, Turkey

14–18 August 2017

Final Meeting Report

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1. Executive Summary

As part of the Black Sea and Middle East Flash Flood Guidance (BSMEFFG) System, advanced FFG functionalities of Riverine Routing and Urban Flash Flood Early Warning System will be implemented in Turkey. Turkish State Meteorological Service (TSMS) as the Regional Centre for BSMEFFGS coordinates project activities amongst multi-agency consortium in Turkey, namely General Directorate of the State Hydraulic Works (DSI) and Istanbul Municipality Disaster Coordination Centre (AKOM) for implementing the two advanced modules. The main project activities are: 1) development and implementation of the advance modules; 2) provision of local data; and 3) provision of training to the employees of the multi-agency consortium.

Hydrologic Research Center (HRC) has started development of both advanced modules and has specified the local data requirements for: 1) meteorological surface observations; 2) hydrometric measurements; 3) high resolution Digital Elevation Model (DEM) data; 4) infrastructure data; and 5) operational policies of reservoirs and Hydro Electric Power Plants (HEPP).

Project partners including WMO have conducted two teleconferences on the local data requirements. On the first teleconference, HRC provided an overview of the technical and scientific background and local data requirements of both advanced modules. It was agreed that TSMS would coordinate provision of the local hydrometeorological and infrastructure data to HRC in a timely manner. Second teleconference was held to review project status and data provision in which HRC expressed its concerns about the timely provision of hydrometric and infrastructure data, and operational policies of reservoirs and HEPPs data. It was clearly stated that local data that had been provided were not sufficient for the development of both advanced modules.

In this regard, it was deemed necessary to conduct a multi-agency consortium meetings in Turkey to discuss with local project partners local data needs and availability. The main objectives of these meetings were to allow local project partners, namely TSMS, DSI, and AKOM, to better understand data requirements for the development and implementation of Riverine Routing in the Harsit River basin and the Istanbul Urban Flash Flood Early Warning System. In addition, site visits were undertaken to determine suitability and sufficiency of the expanded hydrometeorlogical network to meet the data requirements.

During the site visits, it was observed that Harsit River basin was highly regulated with five cascading reservoirs along the main river channel having interbasin transfer of water. Water is fed from the reservoirs to penstocks that transfer water downstream, sometimes several kilometres distance, to power generating stations. The system also has a number of regulators [1] to divert water.. Reservoirs also maintain ecological discharges that vary with season. It was noted that there is possibility of flooding occurring downstream at the confluence of the rive with the Black Sea.

The lower portion of the main channel of Cendere basin that is located in the urban area has been greatly modified having an artificial rectangularshape and constructed of concreate, except at the outlet of the basin with the Golden Horn. Moreover, it is likely

[1] A barrier across a stream provided with a series of gates or other control mechanisms to control the water-surface level upstream, to regulate the flow or to divert water supplies into a canal.

that the discharges in the lower portion of the river are influenced by levels of the Golden Horn that is natural extension of the Istanbul Bosporus, and as such, may also have a tidal influence.

2. Organization of the Istanbul Flash Flood Early Warning System (Istanbul Urban FFEWS) and Harsit Riverine Routing

Multi-Agency meetings of the Istanbul Urban Flash Flood Early Warning System and Harsit Riverine Routing of the BSMEFFG System were held in Istanbul Turkey from 14 to 15 August 2017 and in Trabzon from 16 to 18, respectively. They were attended by representatives of the Turkish State Meteorological Service (TSMS), Istanbul Municipality Disaster Coordination Centre (AKOM), General Directorate of State Water Works (DSI), and Istanbul and Trabzon regional directorates of TSMS and DSI as well as WMO. The lists of participants are provided in Annex 1 and 2, while the annotated workshop agenda is given in Annex 3.

3. Proceedings and Conclusions of the Istanbul Urban Flash Flood EWS

The Cendere watershed is the largest of five watersheds proposed by AKOM within the city limits of Istanbul and was was selected for implementation of the Istanbul Urban Flash Flood Early Warning System. The downstream portion of the basin is the densely populated urban area of Kagithane town, with a population of approximately four hundred thousand. Upstream of this town is mostly rural with dense forest cover that also has a number of tributaries that flow into the main stem of the river. Six of these tributaries have small reservoirs. The Cendere river flows into the Goldern Horn. Most of the main river channel and most of its contributing area is uncontrolled. The main stem channel has been extensively modified through Kagithane town, as well as upstream. There are no control structures along the main stem of the river.

3.1 Precipitation and temperature data

There are not any TSMS AWOS stations within the Cendere basin. TSMS has provided hourly precipitation and temperature data of 7 AWOS stations for the period of 2012 to 2017 that are located outside but close to the Cendere Basin.

TSMS has a C-band weather Radar located nearby the Cendere river basin. Precipitation data are available since 2012 on the BSMEFFGS servers. Cendere basin is located in the range of 35-60 km from the Radar site. In addition, precipitation data from a proposed X-band weather Radar to be located in the new Istanbul Airport north of the Cendere Basin should be available in approximately one year. Thus, two weather Radars covering the same geographical region may improve the precipitation estimation.

AKOM has provided precipitation data in minute time-step from its there (3) precipitation gauges for the period of 2014 and 2017 that are located on top of its hydrometric stations. Note that TSMS has indicated that it too could also provide data at a resolution finer than hourly if required.

3.2. Stream Stage Data

AKOM has three (3) stream gauges located along the Cendere River. River stage data have been monitored for the period of 2014 and 2017, with these data having been provided. Note that AKOM does not compute discharge for these sites. There are no gauges in the downstream part of the catchment. DSI does not have any stream gauges in the basin. It was disused that it would be very beneficial from the modelling perspective to install one additional stream gauge in the downstream part near the outlet of the basin, with a possible location of an abandoned DSI gauge located approximately 2.5 kilometres upstream of the outlet.

It was stated that no flow measurements are taken by AKOm at its gauging sites, hence no rating curves are available for its three stream gauges. As well, the installation of equipment as the sites are not designed to capture low stage readings.

3.3 Digital Elevation Model (DEM) Data

AKOM has provided 2 meter DEM data, while TSMS has provided 10 meter DEM data. It was shown that calculation of cross sections from 2 meter DEM data was very close to the actual field measurements.

3.4. Cross-Sections

It was stated that AKOM provided cross-sectional data for the Cendere River channels at the three stream gauge locations and for an additional thirteen locations along the main river channel.

3.5. Soil and Vegetation Cover Data

Soil and vegetation cover data have been provided during the development and implementation of the BSMEFFG system, and as such are available.

3.6. Open Street Map

Open Street Map, which is open source data available on the internet showing city street details, has been provided.

3.7. Reservoirs

There are six reservoirs in the Cendere basin. Gokturk reservoir, which is the largest, was visited by the participants. It was stated that it was built three hundred years ago and currently is not used for potable water or irrigation or power generation. There was is a concrete spillway that is an overflow structure that allows water to bypass the reservoir when levels exceed a pre-set elevation. An ecological discharge of approximately 0.2 m3/s, is released directly below the reservoir. The purposes of the other reservoirs were not known to the participants.

It was stated that Istanbul Water and Sewer Administration (ISKI) is responsible for the drinking water supply and that six reservoirs located in the basin are not used for water supply purposes. It was mentioned that release policy is that spilling occurs as the water rises during the rainy season (run-of-the-river) such that the level exceeds that of the

outlet control. During the dry season, water level decreases below spill level due to evaporation, provision of ecological flows, and seepage losses. It was also mentioned that there are no manual or electronic water level measurements being taken.

3.8. Sewer and Storm Water Drainage Networks

It was stated that there are separate storm water and sewer networks and that there is no connectivity between the two. It was mentioned that there are neither retention ponds nor inlet controls. Natural drainage channels are regularly cleaned. The storm drainage network consists of pipes and pen channels. Pipes and stream channels were designed to convey the Q100 and Q500, respectively, using the Rational method (Q=CIA).

There are three water treatment facilities that are situated outside the Cendere basin, namely Golden Horn, Bosporus, and Marmara Sea. The drinking water supply within the basin is piped into the basin with none of the water within the Cendere River basin being used for its water supply. In essence, the drinking water and its subsequent effluent are not influencing the flows of Cendere River and its tributaries. It was also mentioned that storm water does not intentionally enter the domestic sewage system, where rain gutters are not connected to the sewer network. Finally, it was stated that storm water and sewer networks data were provided to HRC.

3.9. Sea Water Transfer to the Cendere Basin

It was mentioned that sea water from the Istanbul Bosporus are being pumped to the Cendere basin through the north east tributary to the main river channel and ISKI is responsible for its operations. This is done to improve water quality during low flow conditions. Although the exact regulating policy was not clear, it was clear that it was onlyoperated during the dry season to augment water levels and as such should not be a factor during high water conditions.

3.10. Cendere River Landscape Project

Representative from ISKI stated that Istanbul rivers re-design project has already been started and that it resembles a similar project that has been implemented in Seoul, Republic ofKorea. He said that within this project all river channels will be redesigned including that of the Cendere River and that this will change the flow dynamics of the rivers. He mentioned that ISKI is not involved in the project, which is under the infrastructure division of Istanbul Municipality.

The map of the Cendere catchment showing hydrometeorlogical stations, reservoirs, proposed stream gauges and meteorological stations is given in Annex 4.

3.11. Teleconference with HRC

A brief teleconference was held with HRC to explain findings from the meeting with local experts and observations from the field visit. Mr Pilon provided an overview of outcomes of the meeting, touching on the following topics: 1) provision of hydrometeorological data; 2) crosssections; 3) reservoirs; 4) sewer and storm drainage networks; and 5) sea water transfer to the Cendere basin. Following his presentation, Ms Modrick, HRC,

provided an overview of the data received, outstanding data needs, status of the model development, and next steps. She pointed out the following specific needs:

- Delineation of high resolution sub-catchments based on high resolution DEM data;
- Availability of the cross-sections of tributaries;
- Location and operational characteristics of upstream reservoirs;
- Connection of the sewer network to treatment facilities or to streams; and
- Rating curves for the stream gauges.

3.12. Conclusions of the Istanbul Urban Flash Flood EWS Meeting

- Participants agreed to install 3 meteorological stations in the Cendere basin to measure, among others, precipitation and temperature. It is recommended that stations will be located in the northern part of the basin in the forested area with the exact locations of the meteorological stations to be determined by TSMS and AKOM in coordination with HRC.
- Participants agree that two stream gauges will be installed in the downstream portion of the Cendere basin, one near the outlet, possiblyapproximately two kilometres upstream from the outlet at an abandoned DSI gauging site. DSI will consider to renew and upgrade the existing stream gauge that is not currently operational rather than installing a gauge elsewhere. Exact locations will be determined by AKOM, DSI, and TSMS. The second gauge is to be located on the first large tributary entering the mainstem of the river, with its approximate location show on the map in Annex 4.
- Participants recommended that rating curves should be created and maintained for the three AKOM stream gauges.
- Participants agreed that AKOM and DSI will do their best to obtain reservoir data such as storage capacity, spillway, installation purposes, and operation policies, as much as is available.
- Participants agreed that AKOM will obtain information from ISKI on the operating policy of the sea water pumping into the Cendere River.
- Participants agreed that AKOM will contact with the infrastructure division of Istanbul Municipality to obtain further information about the Cendere River landscape project and will share this with everyone.

4. Proceedings and Conclusions of the Harsit Riverine Routing System

The Harsit River is located in the eastern Black Sea region of Turkey where a cascade of mountains runs parallel to the coasts with rocky steep slopes having an average height of 2,000 meters. Rivers from this region of Turkey are flowing into the Black Sea. The Harsit River has length of 160 km, and its basin covers approximately 3,000 km^2 drainage area. The annual average precipitation within the basin drastically changes from 800 mm in the slopes facing the Black Sea to 400 mm in the portion on the lee side of the mountain summit, which has an elevation of approximately 2,500 meters in the Zigana district. There are dense forest plantation, predominantly pine trees, in the northwestern slopes, while southeastern slopes are dry and barren. Major hydrometeorlogical hazards in the region are floods, flash floods, and landslides due to heavy rainfall, resulting in loss of lives and extensive property damages.

The Harsit River basin is highly regulated and also receives an interbasin transfer of water. There are a number of water management infrastructures in place, such as reservoirs, Hydroelectric Power Plants (HEPPs), regulators, weirs, penstocks, and artificial canals. Moreover, in the bottom-most 20km downstream section of the Harsit River , widespread sand and aggregate mining is being done.

4.1. Precipitation and temperature data

It was evident from the presentation made by RSMS that it has a good surface meteorological network in the basin and its immediate vicinity. Precipitation and temperature data of 39 AWOS stations are located in and around the basin, with 9 of them being located in the Harsit River basin. Data from these have been provided to HRC, as requested.

TSMS also presented on its C-band weather Radar located in Trabzon city. A field tour of the site was organized.

4.2. Snow Data

TSMS has three snow stations in the basin, while DSI has six snow stations in the basin and in its immediate vicinity. TSMS measures only snow depth, while DSI measures SWE, snow load, snow depth, snow temperature at the snow surface and bottom of the snow pack, and air temperature. DSI snow course stations are manually operated, and measurements are made once a month from the 1st to the 5th for the months of December, January, February, March, April, and May.

4.3. Evaporation Data

There are several "big" reservoirs in the Harsit River basin, created by Torul Dam, Kürtün Dam, Akkoy Dam, Yasmakli Dam, and Aslancik Dam (See Annex 5 and 6 for details).Losses due to evaporation would be significant in terms of the water budget in the basin. As well, TSMS makes pan evaporation measurements at its surface stations (see photos of Trabzon meteorological observing site as a typical monitoring installation[2] and Annex 9). It was discussed that provision of pan evaporation, winds, radiation, and relative humidity (RH) measurements would significantly improve the estimation of basin evaporation for the water budget in the basin.

4.4. Stream flow Data

DSI is in charge of the stream flow measurements in Turkey. However, DSI makes measurements for designing and building water infrastructures rather than for riverine forecasting. Given its mandate, it installs stream gauges in areas where reservoirs, dams, and hydroelectric power plants could potentially be built. Once the construction begins, gauges are closed. Those stream gauges that have been closed are marked as read circles on the map in Annex 5. There are currently five operational stream gauges located in the upstream section of the basin. Of which, hourly and daily discharge data since 2012 as well as applicable rating curves have been provided to HRC. However, HRC indicated that there are some missing data in the provided data time series and requested DSI to provide them should they be available.

[2] Selected mission photos will be available on the WMO portal at www.wmo.int/ffgs.

Moreover, HRC has proposed the installation of six new stream gauges in the basin. DSI hydrologists have visited the proposed sites and prepared a report[3] on the suitability of the proposed locations. The report has been made available to HRC and WMO. Participants conducted a field visit to investigate, among others, the HRC proposed gauging location sites and drew the following conclusions:

- **Site No 1**: a new gauge should be installed at the DSI proposed location is approximately 450 meters downstream of Aslancik Dam next to the existing wood bridge (see photos).
- **Site No 2**: HRC recommended a gauge be installed on the tailrace side of the Dogankent Hydroelectric Power Plant (HEPP) where the ecological water flow is already monitored (see photos and Annex 9). Combining the ecological flows with the flows passing through the turbines yields the flows just downstream of the site. This is why it was felt that there was no need to install a new gauge station at this location.
- **Site No 3**: the HRC recommended location was very close to the HEPP tailrace. DSI recommended a new location approximately 500 meters downstream next to an existing bridge. However, DSI stated that construction of additional control structures will commence very soon diverting the tailrace waters to a new downstream HEPP. This will result in the proposed gauge location measuring only ecological flows which will none-the-less be measured. Thus, it was concluded that it would be futile to install a new gauge at the proposed location.
- **Site No 4**: the HRC proposed location was in the reservoir of the Torul Dam. DSI recommended moving further upstream, but there are no suitable nearby locations. It was concluded that in lieu of a new gauge, use could be made of the exiting two gauges, E22A055 and E22A068 with the application of a minor correction for inflow arising from the ungauged portion of the tributary, which should be very minor.
- **Site No 5:** the HRC proposed location resides within the city limits of Gümüshane City where a new floodway project deigned t convey the Q500 is under construction (see photos and Annex 9). Given the overhanging concrete design of the floodway, DSI recommended a different location approximately 10 km upstream from the City. The installation would be next the first available suitable bridge.
- **Site No 6**: DSI recommended use of existing gauge, D22A095, which is very close to the HRC proposal for a new station. Lateral inflows on this tributary between the existing and proposed site would be minor, noting that this is dryer portion of the basin.

4.5. Ecological Flows

It was stated that there are discharge gauges monitoring all ecological flows and these data were obtained from DSI and provided to HRC during this mission. Available ecological flow data are given in the table in Annex 7.

[3] Harsit Basin Channel Routing project review of the stream gauges (AGI) request

4.6. Cross-Sections

Cross-sections of five (5) existing stream gauge locations and 16 additional cross-sections that had been requested by HRC have been provided in CAD format to HRC.

4.7. Soil and Vegetation Cover Data

It was noted that soil and vegetation cover data have been provided within the scope of the BSMEFFG project and are already available for modelling purposes.

4.8. Hazard Map

The hazard map developed by DELTARES for the Q500 flood covers the most downstream 2 km section of the Harsit River to its confluence with the sea. This has been provided to HRC.

4.9. Reservoirs and Regulators

It was explained that there are five dams in the Harsit River Basin. They are the: Aslancik Dam, Akkoy Dam, Kürtün Dam, Yasmakli Dam, and Torul Dam. There are four regulators: Dogankent Regulator, Kavraz Regulator, Elmali Regulator and Tasoba Regulator. It was stated that the sole purpose of the reservoirs and regulators are generation of electricity, with all being shown on the maps in Annexes 5 and 6. It was stated that daily reservoir operations data were available and that three of the five reservoir operations data were translated into English and provided to HRC, while the two were provided in Turkish. It was discussed in detail how to calculate the water budget in a reservoir considering inflows and outflows such as spillway, water consumption due to energy production, irrigation (hypothetically for this basin), and evaporation.

It was mentioned that there was interbasin water transfer from a neighbouring basin to the Harsit River basin. The water transfer rate from the Gokcebel Dam, which is located in the neighbouring basin called Gelevera River basin, to the Yasmakli Dam located in the Harsit River basin will be provided by DSI. This will be needed to calculate the water budget for the Yasmakli Dam. It was also mentioned that approximate discharge between two dams was 4.5-5 m3/sec, noting that when the water level decreases, discharge rates decrease as well.

It was stated that the "**rule curves**[4]" of the reservoirs if available would be beneficial for the modelling and thus should be provided to HRC. Additional follow-up effort will be needed to obtain these reservoir management plans or rule curves that are followed.

4.10. Hydroelectric Power Plants (HEPP)

It was stated that there were seven HEPPs associated with the reservoirs and regulators in the basin. Water is diverted from reservoirs and regulators via penstocks to the HEPPs. All HEPPs are shown on the maps in Annexes 5 and 6. Water diversions are indicted with the red arrows. It was mentioned that hourly data of generated electricity are available.

[4] Rule curves= Kural egrisi

DSI will request HEPP companies to get daily power production data and the equation for conversion into flowrate through the turbines.

Information regarding Dogankent, Kürtün, and Torul HEPPs is provided in Annex 8.

4.11. Sand and Aggregate Mining

It was observed that there were extensive sand and aggregate mining activities in the main downstream channel of the Harsit River extending 20 km upstream from the sea. These activities are significantly changing the natural channel characteristics and flow conditions in the River. These activities make river discharge monitoring very difficult and expensive. To circumvent these complications and the inherent increase in the uncertainty of the flow measurements, it was proposed that the most downstream monitoring location be just upstream of the area being actively mined.

4.12. Teleconference with HRC

A teleconference was held with HRC to explain the groups findings and observations. Mr Pilon provided an overview of outcomes of the meetings and field visits, touching on the following major topics: 1) current state of the Harsit River basin; 2) water infrastructure within the basin; 3) modifications to the HRC proposed gauge locations; 4) availability of reservoir and HEPP data; and 5) provision of the streamflow, hydrometeorological and cross-sectional data. Following his presentation, Ms Modrick, HRC, did not have enough time to make her presentation. However, she provided an electronic copy of her presentation that outlined the recently received data, the current progress made on analysis and model development, and outstanding data needs. Her presentation pointed out the following specific points and next steps:

- Discrepancies exist between hourly and daily discharge data. Mr Soylu, DSI, made clarification on this stating that daily discharge data have been quality controlled but hourly discharge data have not.
- Hourly discharge data are needed to examine the response of the basin and make adjustment to hydrological model parameters.
- Use will be made of hourly precipitation from FFGS gridded satellite estimates and forecasts precipitation for the development of bias adjustments of MAPs.
- The estimates of channel roughness used in modelling will be based on the photographs of the river provided.
- Use will be made of provided cross-sections to estimate conveyance characteristics of the channels and will also be used to develop regionalization approaches for all sub-catchment reaches.

4.13. Conclusions of the Harsit Riverine Routing Meeting

- Participants agreed that TSMS and DSI will provide snow data to HRC.
- Participants agreed that TSMS will provide pan evaporation, wind, radiation and relative humidity data to HRS.
- Participants agreed that DSI will provide missing daily and hourly discharge data to HRC provided they exist.

- DSI agreed that it will install two new stream gauges (No 1 and No 5) based on the HRC proposed locations. Exact locations of these new sites will be the same as stated in the DSI report.
- DSI agreed that it will obtain and provide discharge data for the water transferred from Gokcebek Dam to Yasmakli Dam.
- DSI agreed that it will obtain "rule curves" of the reservoirs if available and provide same to HRC.
- DSI agreed that it will obtain daily power production data and the equations to convert production into flow passing through the turbines.
- DSI agreed to prepare and provide hourly quality controlled discharge data for all locations to HRC.

5. Closing of the Meetings

Closing remarks were made by representatives of WMO, TSMS, DSI, AKOM and participants. Thanks were also extended to all attendees for their active participation in the meetings and spirited involvement in the discussions, which contributed to the successful conclusion of the meetings.

Annex 1

List of Participants

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Annex 3

BSMEFFG Istanbul Urban Flash Flood Early Warning System and Riverine Routing Multi-Agency Consortium Meetings

Istanbul and Trabzon, Turkey, 14-18 August 2017

Workshop Agenda

Istanbul Urban Flash Flood Early Warning System

Day 1

09:00-09:15 Opening and introduction of participants

09:15-09:30 Overview and purpose of the meeting (WMO)

09:30-10:00 Overview of the Istanbul Municipality Disaster Coordination Centre (AKOM)

10:00-10:30 Overview of State Water Authority (DSI)

10:30-11:00 Review of the Istanbul Urban FFEWS study area and HRC data its requirements (AKOM, TSMS)

11:00-11:30 Tea Break

11:30-12:00 Review of the available data for the for the Istanbul Urban FFEWS project (AKOM, TSMS)

12:00-12:30 Facilitated discussion on the data requirements and availability of data (All)

12:30-14:00 Lunch Break

14:00-18:00 Field visit to the study area

Day 2

09:30-10:00 Review of Day 1

10:00-11:00 Supplementary hydromet data requirements and possible hydromet network expansion in study area (All)

11:00-11:30 Tea Break

11:30-12:30 Visit to AKOM facility

12:30-14:00 Lunch Break

14:00-17:00 Teleconference with HRC on status of activities, review of data availability and next steps

17:00-17:30 Final Discussions and Closure (All)

Harsit Riverine Routing, Trabzon

Day 3

09:00-09:15 Opening and introduction of participants

09:15-09:30 Overview and purpose of the meeting (WMO)

09:30-10:00 Overview of Regional State Water Authority (DSI) activities (DSI)

10:00-10:30 Overview of Regional TSMS activities (TSMS)

10:30-11:00 Review of the Harsit River study area and HRC data requirements for Harsit Riverine Routing its (DSI, TSMS)

11:00-11:30 Tea Break

11:30-12:00 Review of the available data for the project for Harsit Riverine Routing(DSI, TSMS)

12:00-12:30 Facilitated discussion on the data requirements and availability of data (All)

12:30-14:00 Lunch Break

14:00-17:00 Filed visit to a DSI stream gauge station (All)

Day 4

09:00-17:00 Study Visit to the Harsit River Basin (All)

Day 5

09:30-:10:00 Review of Day 4

10:00-11:00 Review of the Availability of the hydromet data (All)

11:00-11:30 Tea Break

11:30-12:00 Reservoir Management and its operating policies (DSI)

12:00-12:30 Facilitated discussion on the possible expansion of hydromet network (All)

12:30-14:00 Lunch Break

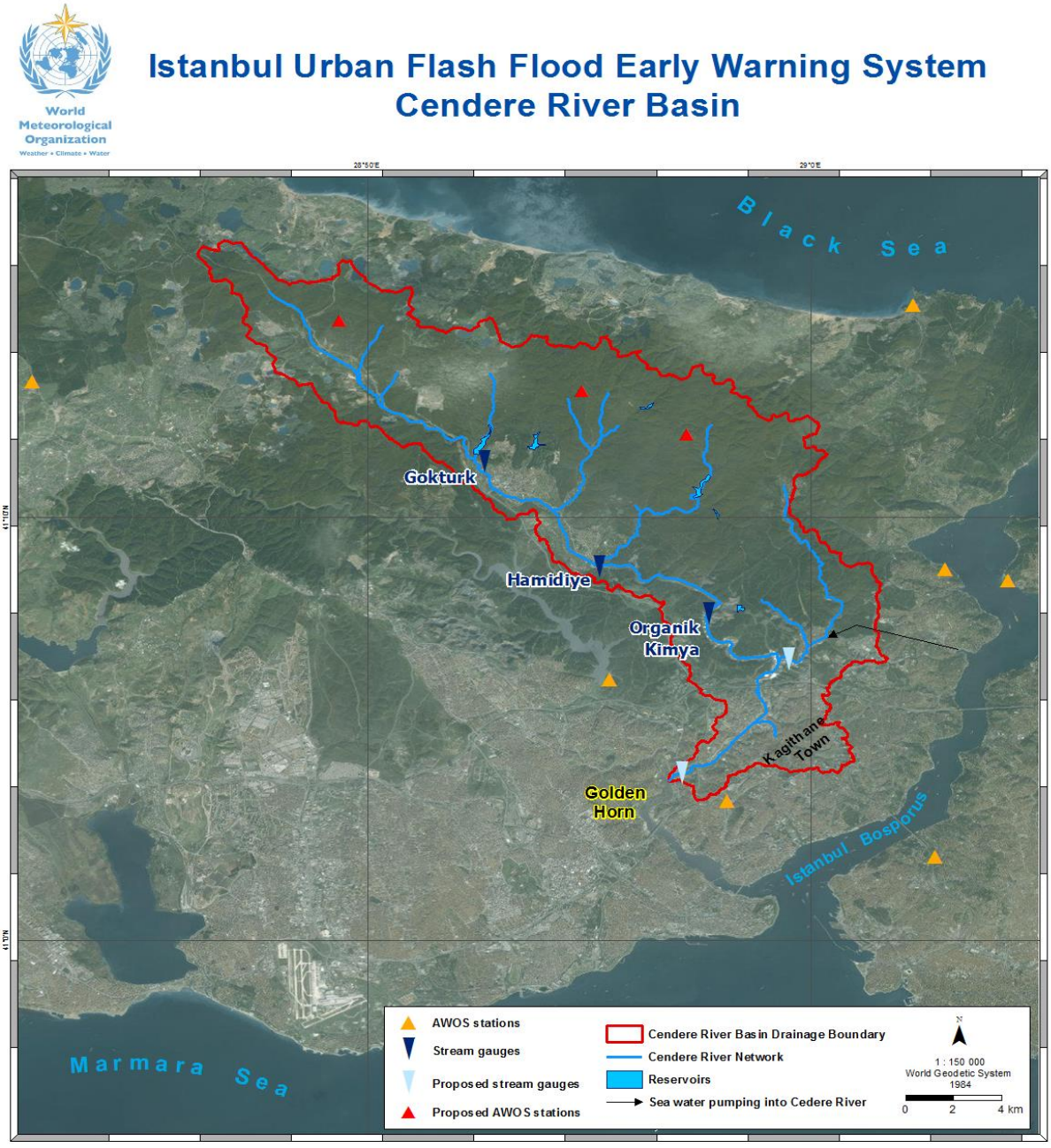
14:00-17:00 Teleconference with HRC on status of activities, review of data availability, operating policies and next steps (All)

17:00-17:30 Final Discussions and Closure (All)

-**End of Meeting**-

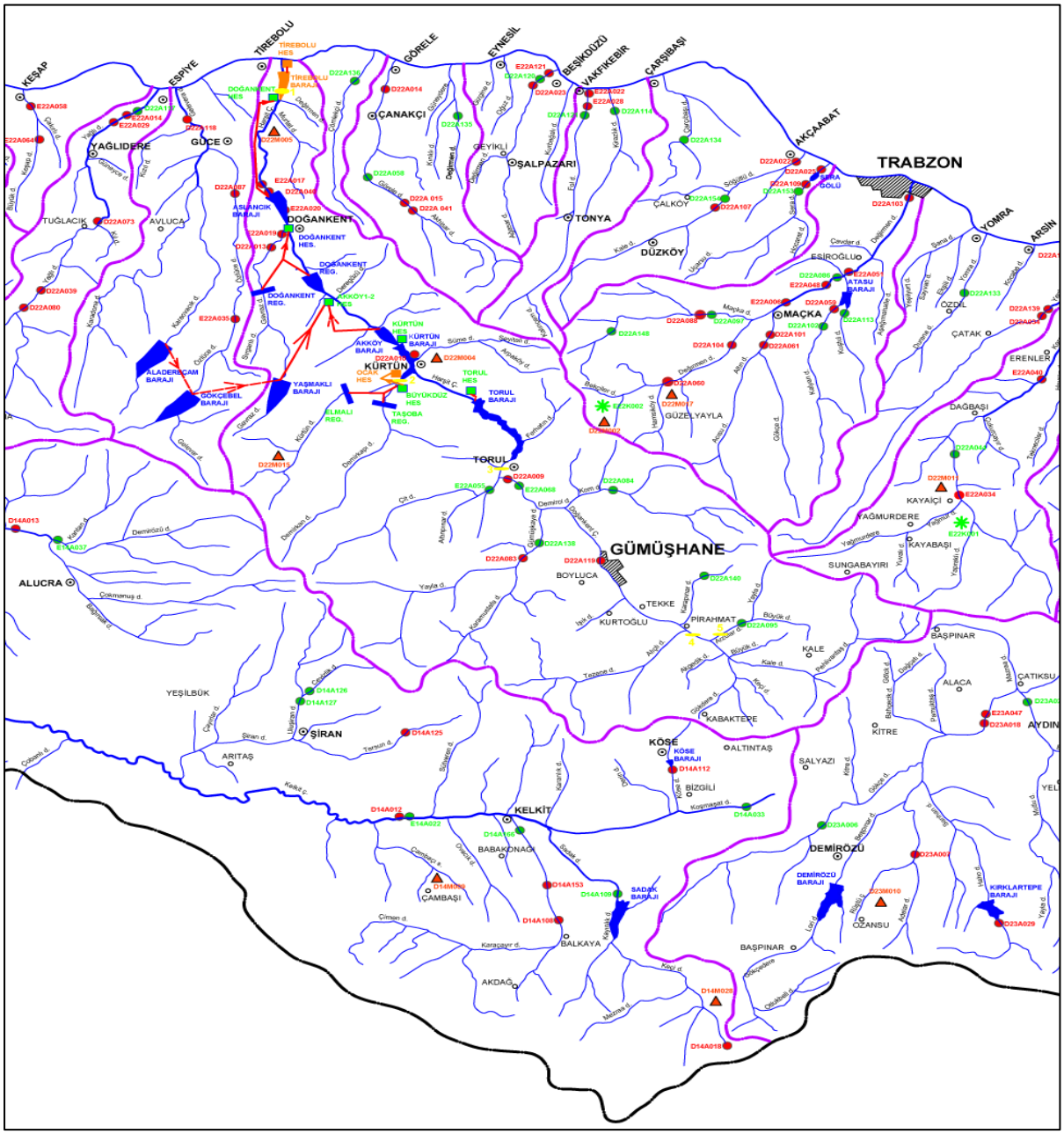
Annex 4

Cendere River Basin Map



Annex 5

Harsit River Basin Map

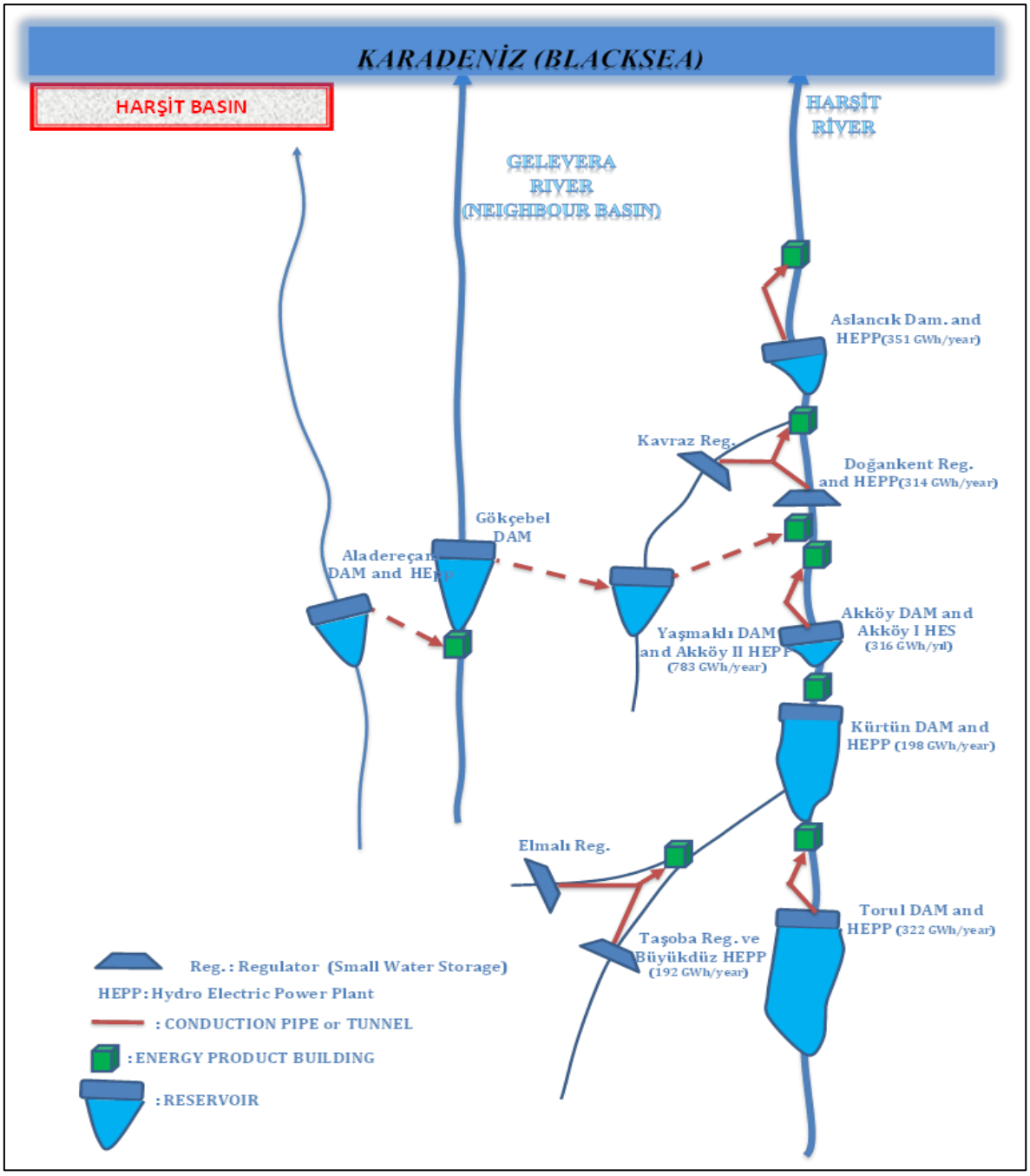


Legend:

- Reg: Regulator
- HES: Hydroelectric Power Plant (HEPP)
- Reservoirs and Dams
- Water pipe or tunnel
- Operational Stream gauges
- Closed Stream gauges
- Operational DSI Met Stations
- Closed DSI Met Stations

Annex 6

Reservoirs and Hydroelectric Power Plants in Harsit River Basin



Annex 7

Harsit River Ecological Water Discharge Data

ECOLOGICAL WATER (l/s)												
	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Akköy 1 Regulator*	3483	3483	3483	3483	3483	3483	3483	3483	3483	3483	3483	3483
Aslancik Dam	1100	1100	3430	3430	3430	3430	1100	1100	1100	1100	1100	1100
BUYUKDUZ HEPP												
Tasoba Regulator	300	300	300	300	300	300	300	300	300	300	300	300
Elmali Regulator	400	400	400	400	400	400	400	400	400	400	400	400
YASMAKLI												
Gokcebel Dam	153	153	153	153	153	153	153	153	153	153	153	153
Yasmakli Dam	256	256	256	256	256	256	256	256	256	256	256	256
Alederecam Dam	153	153	153	153	153	153	153	153	153	153	153	153
TORUL Dam												
KURTUN Dam												
DOGANKENT Regulator												
DOGANKENT KAVRAZ Regulator												

*Regulator: Barrier across a stream provided with a series of gates or other control mechanisms to control the water-surface level upstream, to regulate the flow or to divert water supplies into a canal.

Annex 8

Hydroelectric Power Plant Production Information

TORUL Hydro Electric Power Plant (HEPP) Production Info Note		
Name of the Applicant		Directorate of Electrical Production Inc. (EUAS)
Production facility/or project name		TORUL HEPP
Location of the Production facility/or project name (City/Cities)		Gumushane
Total production capacity of the facility (ISO standards)		105.5 MW (m), 103.26 MW (e)
Production facility type		
Reservoir information		Reservoir
	Reservoir Area at max. water level	3.62 km2
	Reservoir volume	168.000.000 m3
	Dam Crest Volume (m3)	4.250.000 m3
Energy source		Hydraulic
Turbine type		Francis
No of turbines		2
Installed power capacity	Group 1	52.8 MW (m), 51.63 MW (e)
	Group 2	52.8 MW (m), 51.63 MW (e)
Generator output voltage	Group 1	13800V, cosΦ 0.85
	Group 2	13800V, cosΦ 0.85
Predicted average yearly electrical production amount		263.800.000 KWH
Annual reliable electric production amount		130.000.000 KWH
Connection to the national grid and voltage		Switchyard 13.8 KV
Current physical conditions of the production facility		Installed and ready for operation
KURTUN Hydro Electric Power Plant (HEPP) Production Info Note		
Name of the Applicant		Directorate of Electrical Production Inc. (EUAS)
Production facility/or project name		KURTUN HEPP
Location of the Production facility/or project name (City/Cities)		Gumushane
Total production capacity of the facility (ISO standards)		80 MW (m), 72.8 MW (e)
Production facility type		
Reservoir information		Reservoir
	Reservoir Area at max. water level	2.62 km2
	Reservoir volume	108.200.000 m3
	Dam Crest Volume (m3)	3.000.000 m3
Energy source		Hydraulic
Turbine type		Francis
No of turbines		2
Installed power capacity	Group 1	40 MW (m), 39.10 MW (e)
	Group 2	40 MW (m), 39.10 MW (e)
Generator output voltage	Group 1	13800V, cosΦ 0.85
	Group 2	13800V, cosΦ 0.85
Predicted average yearly electrical production amount		132.900.000 KWH
Annual reliable electric production amount		140.000.000 KWH
Connection to the national grid and voltage		Switchyard 13.8 KV, 154 KV
Current physical conditions of the production facility		Installed and ready for operation
DOGANKENT Hydro Electric Power Plant (HEPP) Production Info Note		
Name of the Applicant		Directorate of Electrical Production Inc. (EUAS)
Production facility/or project name		DOGANKENT HEPP
Location of the Production facility/or project name (City/Cities)		Giresun
Total production capacity of the facility (ISO standards)		75.9 MW (m), 73.3 MW (e)
Production facility type		
Reservoir information		Channal type
	Reservoir Area at max. water level	
	Reservoir volume	
	Dam Crest Volume (m3)	
Energy source		Hydraulic
Turbine type		Francis
No of turbines		5
Installed power capacity	Group 1	8.65 MW (m), 8.2 MW (e)
	Group 2	8.65 MW (m), 8.2 MW (e)
	Group 3	8.65 MW (m), 8.2 MW (e)
	Group 4	8.33 MW (m), 8.2 MW (e)
	Group 5	41.7 MW (m), 40.5 MW (e)
Generator output voltage	Group 1	10600V, cosΦ 0.80
	Group 2	10600V, cosΦ 0.80
	Group 3	10600V, cosΦ 0.80
	Group 4	10600V, cosΦ 0.80
	Group 5	13800V, cosΦ 0.90
Predicted average yearly electrical production amount		220.000.000 KWH
Annual reliable electric production amount		200.000.000 KWH
Connection to the national grid and voltage		Switchyard 154 KV, 34.5 KV
Current physical conditions of the production facility		Installed and ready for operation

Annex 9

Selected Mission Photos of Harsit River

Pan Evaporation Measurements 	**DSI proposed stream gauge No 1** 
HRC proposed stream gauge No 5 	**DSI proposed stream gauge No 5** 

Selected Mission Photos of the Cendere Watershed, Istanbul

Cendere flows into Golden Horn 	**Outlet of Cendere Watershed** 
Cendere River Channel app. 3 km up from the Outlet 	**Gokturk Stream Gauge**