Beilage C

Bericht über das Treffen der Unterarbeitsgruppe Hydrologie am 17. März 2017
Report
of the Hydrology Working Sub-group for the
Drava River
2017
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1 MINUTES

of the 3rd meeting of the Working subgroup for Hydrology for the Drava River,
Working group “Water Management”

Ljubljana, Slovenia, March 17, 2017

1.1 Attendance

In accordance with paragraph 2.8 of the minutes of the 23rd session of the Permanent Slovenian-Austrian Commission for the Drava (15 to 16 May 2014) to establish a subgroup for the hydrology within the Working group for Water Management, 3rd meeting was held at the Slovenian Environment Agency (ARSO). A list of attendance is enclosed.

The meeting was chaired by Dr Mira Kobold, head of the working subgroup on the Slovenian side. Both sides agreed that the working language of the meeting is English.

The Slovenian side thanked the Austrian side for implementation of joint hydrometric measurements on the border profile of the Drava River with demonstration of the profile measurements of suspended load, which were realized on November 4, 2016.

1.2 Adoption of the agenda

The following agenda was adopted:

1. Hydrological data for 2016
2. Suspended load of the Drava
3. Water balance 2016 (report of Carinthia)
4. Data exchange, operation of the forecasting services and communication during the high waters and floods
5. Flood forecasting model of the Drava River
6. Exchange of experience and good practices
7. Miscellaneous
1.2.1 Hydrological data for 2016

Hydrography of Carinthia:
- gauging station Lavamünd / KW Lavamünd MQ=253 m³/s
- Lavant / Pegel Krottendorf: MQ=12 m³/s
- mean discharge of the Drava River at Lavamünd Grenze: MQ=265 m³/s
- highest flood discharge of the Drava River at Lavamünd Grenze: HQ=970 m³/s (HQₜ=990 m³/s)

Verbund:
- Drava at the powerplant Lavamünd (without Lavant): MQ= 253 m³/s

ARSO:
- gauging station Črneče: MQ= 291 m³/s (determination of mean annual discharge is unsatisfied)
- highest flood discharge of the Drava River at Črneče: HQ = 970 m³/s (17.06.2016)

DEM:
- Drava at hydropower plant Dravograd MQ=265 m³/s

1.2.2 Suspended load of the Drava

Both sides presented the results of analyses of suspended load for the year 2016. ARSO doesn’t have the monitoring of suspended load on the Drava River in the frame of national monitoring. The monitoring on the Drava River is performed by the DEM company on four measuring sites of hydropower plants. For the year 2016, ARSO analyzed the DEM data of suspended load for the locations of hydropower plants Dravograd, Vuzenica, Mariborski otok and Markovci. The data for HP Dravograd are not reliable because of measurement problems.

HD Kärnten calculates the yearly balance of suspended load for four stations on the Drava river and tributaries.

Suspended load for 2016 of Drava Lavamünd Ort: 0,13 million tons. It fits with results of Verbund.
Suspended load for 2016 of Drava Lavamünd Grenze: 0,26 million tons.
1.2.3 Waterbalance 2016

Carinthia:

<table>
<thead>
<tr>
<th></th>
<th>2016 (mm)</th>
<th>1981-2010 (mm)</th>
<th>Deviation of annual values from the period (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation</td>
<td>1326</td>
<td>1198</td>
<td>+10,7</td>
</tr>
<tr>
<td>Flow rates</td>
<td>658</td>
<td>593</td>
<td>+11,3</td>
</tr>
<tr>
<td>Evapotranspiration</td>
<td>842</td>
<td>582</td>
<td>+10,3</td>
</tr>
</tbody>
</table>

1.2.4 Data exchange, operation of the forecasting services and communication during the high waters and floods

The established operational data exchange was extended as determined at the 2nd meeting of the sub-group for hydrology for the Drava River and the document “Data exchange with partner institutions ARSO – KTN AT” was revised and updated in September 2016. In the data exchange, ARSO added 8 new automatic meteorological stations and one new hydrological station Zavrč on the Drava River.

The communication during the high waters between forecasting services is good. The automated dissemination procedure is operational and is not experiencing any problems. In July 2016 Hydrological forecasting service at ARSO asked for extending the list of recipients of the high water warnings issued by HD Kärnten. ARSO provided the list of mobile phone numbers and an email address, which were then added. At the following high water event (August 2016), all previous and additional recipients received the warning via SMS and email.

ARSO also contacted Verbund and asked for adding an additional mobile phone number to the recipient list in case of issued warning. It was agreed to add the recipient. Up to date, there were no flooding events and consequently no warnings issued.

1.2.5 Flood forecasting model of the Drava River

In the Slovenian hydrological forecasting system (HFS) that is operational at ARSO, only the Drava River is not covered by the model. Based on good experience with the Mur model that was developed in joint cooperation with the Hydrographic department of Styria, ARSO is also interested in cooperation on the Drava model.

HD Kärnten is not very interested to set up the new model for the Drava river basin because they use its own model. But they are ready to provide all necessary data and information if
ARSO wants to establish the model for the Drava river catchment in AUT and SLO with MIKE technology. The potential model results will be distributed to HD Kärnten. In the case of some project they will be an end user.

Slovenia (ARSO) started the inception phase of the model in autumn 2016 in which the required data (geographical data, historical meteo and hydro data, list of automatic stations for operational phase) were identified. The request for support with necessary data was sent to Hydrography of Carinthia, however the organisations have not yet discussed the details or the next steps. ARSO is proposing a meeting in second half of May 2017 in Klagenfurt, dedicated to the Drava model development, beginning with an overview of available historical data and expanding the current real-time data transfer from meteo and hydro stations.

1.2.6 Exchange of experience and good practices

At the last meeting Mr. Moser informed Slovenian side about the method of determining of GF100 factors. ARSO sent the Q100 for Slovenian side of the Drava River basin to make the comparison with Austrian catchments.
Comparison of HQ100 of rivers near the border of Carinthia and Slovenia

<table>
<thead>
<tr>
<th>Country</th>
<th>River / Station</th>
<th>EZG (km²)</th>
<th>HQ100 (m³/s)</th>
<th>GF100 = HQ100/EZG^0.6</th>
<th>method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>Drau / Rosegg</td>
<td>6927</td>
<td>2300</td>
<td>11.41 stat + reg</td>
<td></td>
</tr>
<tr>
<td>Car</td>
<td>Drau / Pegel Lavamünd Ort</td>
<td>10915</td>
<td>2700</td>
<td>10.20 stat + reg</td>
<td></td>
</tr>
<tr>
<td>Car</td>
<td>Drau / Pegel Lavamünd Grenze</td>
<td>11884</td>
<td>2800</td>
<td>10.05 stat + reg</td>
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</tr>
<tr>
<td>Car</td>
<td>Rosenbach / Mündung</td>
<td>41.2</td>
<td>110</td>
<td>11.82 reg</td>
<td></td>
</tr>
<tr>
<td>Car</td>
<td>Feistritzbach / Mündung</td>
<td>35.9</td>
<td>95</td>
<td>11.08 reg</td>
<td></td>
</tr>
<tr>
<td>Car</td>
<td>Loblbach / Pegel Tscheppschlucht</td>
<td>44</td>
<td>95</td>
<td>9.81 stat + reg</td>
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<tr>
<td>Car</td>
<td>Veilach / Pegel Miklauzhof</td>
<td>194.3</td>
<td>270</td>
<td>11.44 stat + reg</td>
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<tr>
<td>Car</td>
<td>Feistritzbach / Pegel Feistritz</td>
<td>8.7</td>
<td>30</td>
<td>8.19 stat + reg</td>
<td></td>
</tr>
<tr>
<td>Car</td>
<td>Loblbach / Pegel Loibach</td>
<td>19.9</td>
<td>44</td>
<td>7.31 stat + reg</td>
<td></td>
</tr>
<tr>
<td>Slo</td>
<td>Drava / HE Dravograd</td>
<td>12071.3</td>
<td>2612</td>
<td>9.29 stat</td>
<td></td>
</tr>
<tr>
<td>Slo</td>
<td>Meza / Oltiski Vrh I</td>
<td>550.89</td>
<td>372</td>
<td>8.43 stat</td>
<td></td>
</tr>
<tr>
<td>Slo</td>
<td>Meza / Podklanc</td>
<td>309.5</td>
<td>215</td>
<td>5.89 stat</td>
<td></td>
</tr>
<tr>
<td>Slo</td>
<td>Meza / Cma</td>
<td>94.77</td>
<td>130</td>
<td>8.47 Studie IzvRS</td>
<td></td>
</tr>
<tr>
<td>Slo</td>
<td>Suhodolnica / Starl Trg I</td>
<td>59.2</td>
<td>93.3</td>
<td>8.06 stat</td>
<td></td>
</tr>
<tr>
<td>Slo</td>
<td>Sava Dolska / Kranjska Gora</td>
<td>44.98</td>
<td>86.4</td>
<td>8.80 stat</td>
<td></td>
</tr>
<tr>
<td>Slo</td>
<td>Sava Dolska / Jesenice</td>
<td>257.5</td>
<td>259</td>
<td>9.26 stat</td>
<td></td>
</tr>
<tr>
<td>Slo</td>
<td>Radovna / Podhom</td>
<td>166.8</td>
<td>165</td>
<td>7.66 stat</td>
<td></td>
</tr>
<tr>
<td>Slo</td>
<td>Mosenik / Tržic</td>
<td>38.5</td>
<td>88.4</td>
<td>9.89 stat</td>
<td></td>
</tr>
<tr>
<td>Slo</td>
<td>Tržiska Bistrica / Preska</td>
<td>121.1</td>
<td>159</td>
<td>8.61 stat</td>
<td></td>
</tr>
<tr>
<td>Slo</td>
<td>Koka / Kokra I</td>
<td>112.3</td>
<td>182</td>
<td>10.71 stat</td>
<td></td>
</tr>
<tr>
<td>Slo</td>
<td>Koka / Kranj II</td>
<td>220.2</td>
<td>241</td>
<td>9.47 stat</td>
<td></td>
</tr>
<tr>
<td>Slo</td>
<td>Poljanska Sora / Ziri III</td>
<td>54.4</td>
<td>182</td>
<td>16.55 stat</td>
<td></td>
</tr>
<tr>
<td>Slo</td>
<td>Selska Sora / Železniki</td>
<td>104.1</td>
<td>409</td>
<td>24.82 stat</td>
<td></td>
</tr>
<tr>
<td>Slo</td>
<td>Lucnica / Luce</td>
<td>57.5</td>
<td>161</td>
<td>14.16 stat</td>
<td></td>
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<tr>
<td>Slo</td>
<td>Dreta / Krase</td>
<td>100.8</td>
<td>267</td>
<td>16.77 stat</td>
<td></td>
</tr>
<tr>
<td>Slo</td>
<td>Savinja / Kazanje</td>
<td>457</td>
<td>609</td>
<td>15.44 stat</td>
<td></td>
</tr>
<tr>
<td>Slo</td>
<td>Savinja / Solcava I</td>
<td>61.7</td>
<td>129</td>
<td>10.67 stat</td>
<td></td>
</tr>
</tbody>
</table>

stat + reg... Statistical and regional analysis methods
stat... statistical method
reg... Regional analysis methods (no gauging station)

1.2.7 Miscellaneous

Experts agree that measurements of hydrological parameters in the middle of accumulation are not suitable. The Austrian experts have good experience with measurements at stations located below the hydropower plants. ARSO should think about the moving of existing hydrological station at Čmeče below the HP Dravograd, where the location is convenient for discharge, turbidity and suspended load measurements.

Prepared by:

Dr Mira Kobold
2 DATA - HD KÄRNTEN

- Discharges 2016: Drava: Lavamünd with Lavant
- Suspended load 2016
- Suspended load 2009 – 2016
- Water balance of Carinthia
- Results of comparison of HQ100
2.1 Discharges 2016 Drava River: Lavamünd with Lavant (Lavamünd Grenze)
2.2 Suspended load 2016

Lavamünd Grenze:
### 2.3 Suspended load 2009-2016

#### Suspended load [ million tons ]

<table>
<thead>
<tr>
<th>Gaugingstation</th>
<th>Average per year (Mil. t)</th>
<th>Sum 2016 (Mil. t)</th>
<th>Area (km²)</th>
<th>Sum 2009 - 2016 (Mil. t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amlach / Drau</td>
<td>0.57</td>
<td>0.60</td>
<td>4.713.3</td>
<td>4.5</td>
</tr>
<tr>
<td>Federaun / Gall</td>
<td>0.22</td>
<td>0.09</td>
<td>1.304.9</td>
<td>1.7</td>
</tr>
<tr>
<td>Lavamünd Ort / Drau</td>
<td>0.20</td>
<td>0.13</td>
<td>11.051.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Lavamünd Grenze / Dravu</td>
<td>0.26</td>
<td></td>
<td>12.030.0</td>
<td></td>
</tr>
</tbody>
</table>

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Data Hydrographie Kärnten
Working subgroup for Hydrology for the Drava River
Data Hydrographie Kärnten

Working subgroup for Hydrology for the Drava River
Wasserbilanz Kärnten 2016 - im Vergleich zum Durchschnitt 1981-2010

Gebietsniederschlag
1326 mm (1198) = +10,7%

Gebietsverdunstung
642 mm (582) = +10,3%

Gebietsabfluss Kärnten
638 mm (593) = +11,3 %
= 196 m³/s (170,6)

Zw-Speicher / Umschärfe
+20 mm

Abfluss KW Kaprun
4,42 m³/s (4,23) = +4,5%

Zufluss Obere Drau
58,7 m³/s (58,4) = +0,5%

Zufluss Gall
3,89 m³/s (3,98) = -2,3%

Zufluss Gallitz
7,34 m³/s (7,31) = +0,4%

Abfluss Drau
265 m³/s (245) = -8,3%

2.4 Water balance of Carinthia 2016

HYDROgrafik
Kärnten
...am Puls des Wassers...
Wasserhaushalt Kärnten
Bilanz 2016 im Vergleich zur Periode 1981 - 2010

Wasserbilanz Kärnten 2016 im Vergleich 1981 - 2010

% - Anteile des Ablusses und der Verdunstung am Niederschlag 2016 und der Periode 1981-2010

Zu- und Abläufe (m³/s): 2016 1981-2010
Ktn Zuflüsse MQ: 73,20 72,62
Ktn Abläufe MQ: 269,2 248,6
Ktn Gebietsabfluss MQ: 196,0 176,2

Grenze Slo/Drau: 2016 1981-2010
NQ (m³/s): 51
HQ (m³/s): 970 1672
HQ(60 = 2800 m³/s

Ktn-Zuflüsse: Drau (Osttirol), Gall, Gallitz, Olsa, Görtschitz, Levant. Ktn-Abläufe: Drau, Möll, KW Kaprun
Δ - Bilanz Modell- u. Datenspeicherkärnten bzw. Wasserzweckverwendung (- aus Vorjahr, + fürs nächste Jahr)
2.5 Results of comparison of HQ100

Graphical presentation of GF100 factors
Data Hydrographie Kärnten

Working subgroup for Hydrology for the Drava River
FLOOD EVENT / HOCHWASSER AM 15.08.2016

Area / Schwerpunkt: Gebiet Sittersdorf, Gösselsdorf und Globasnitz
An example: Flood-event 2016; Sagerbergbach HQ=20 m³/s; E = 3.8 km²; GF = 9.0
(Anuality: 115)  GF100=8.5
3 DATA - SLOVENIAN ENVIRONMENT AGENCY (ARSO)

3.1 Discharges 2016 for the Drava River: gauging station Črneče

Gauging station Črneče on the Drava River:
Mean value discharge 2016 : MQ = 291 m³/s
Highest discharge 17.06.2016: HQ = 970 m³/s

Correlation between mean velocity measured with fixed ADCP and mean velocity measured with ADCP on boat (hydrometric measurement) at gauging station Črneče is not very good.

Due to the poor correlation between measured velocities, the correlation between discharges on hydropower plant (HP) Dravograd and gauging station Črneče is not optimal:
Data ARSO Slovenia
Working subgroup for Hydrology for the Drava River

Drava - discharge 2016 at g.s. Črneče and HP Dravograd

Regression equation:

\[ y = 0.7483x + 62.312 \]

\[ R^2 = 0.8983 \]
3.2 Suspended load 2016 for the Drava River: DEM data for HP Dravograd
Correlation between discharge and turbidity on HP Dravograd is not very good. In January 2016 turbidity sensor measured high turbidity, but discharge on measuring point was not increased. Last three months of the year the turbidity was increasing permanently while discharge remains mean between 250 and 350 m³/s.

For some events with increased turbidity on HP Dravograd in 2016 the analyses between discharge, turbidity and precipitation in the catchment have been performed.

Discharge and turbidity on HP Dravograd and precipitation at twelve stations in Austria. Despite the fact that the amount of precipitation is small, the turbidity on 18 July 2016 significantly increased.
Increased turbidity does not always coincide with an increased discharge at the monitoring site, but can be a reflection of rainfall in the catchment area.

Turbidity sensors on HP Dravograd, Vuzenica, Mariborski otok, and Markovci on the Drava River in Slovenia show good consistency. For example in March 2014, travel of high turbidity is well seen in the figure below. Maximum turbidity on HP Dravograd was measured 27.3.2014 at 07:00, on HP Vuzenica 27.3.2014 at 11:00, on HP Mariborski otok 28.3.2014 at 17:00 and on HP Markovci 29.3.2014 at 00:00.
Turbidity sensors on four measuring sites on the Drava River show good consistency
4 ATTENDANCE LIST

Ljubljana, 17 March 2017

ATTENDANCE LIST

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
<th>Signature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bogdan Lalic</td>
<td>ARSO</td>
<td></td>
</tr>
<tr>
<td>Mira Kubold</td>
<td>ARSO</td>
<td></td>
</tr>
<tr>
<td>Saso Kreslin</td>
<td>DE17</td>
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<tr>
<td>Karlovo Agrotchnijsi</td>
<td>VEB ROVD</td>
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<td>Flojana Weg</td>
<td>ARSO</td>
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<td>Andelj Golob</td>
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<td>Elisabeth Gutschi</td>
<td>HD Kärnten</td>
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<td>Christian Kopingk</td>
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<tr>
<td>Johannes Moser</td>
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</tr>
</tbody>
</table>

25
Attachment to the report of the Working Sub-group for Hydrology for the Drava River, 2017

Adapted Values for suspended load at the Carinthian gauging stations:

<table>
<thead>
<tr>
<th>Gaugingstation</th>
<th>Average suspended load 2016</th>
<th>Sum of suspended load 2009-2016</th>
<th>Catchment area</th>
<th>River</th>
<th>Sum of suspended load 2009-2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amlach</td>
<td>0.55</td>
<td>0.42</td>
<td>4.713,50</td>
<td>Drava</td>
<td>4.4</td>
</tr>
<tr>
<td>Federaun</td>
<td>0.22</td>
<td>0.12</td>
<td>1.304,90</td>
<td>Gail</td>
<td>1.7</td>
</tr>
<tr>
<td>Lavamünd Ort</td>
<td>0.19</td>
<td>0.11</td>
<td>11.051,80</td>
<td>Drava</td>
<td>1.5</td>
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<tr>
<td>Lavamünd Grenze</td>
<td>0.21</td>
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</tbody>
</table>

18.05.2017; Moser