# Development of the Information system of combined sewer overflows and their receiving waters impacts

## Développement du système d'information pour les rejets aux déversoirs d'orage et leurs impacts sur le milieu récepteur

Kabelkova I.[1], Metelka T.[2], Stransky D.[1], Hrabak D.[2], Suchanek M.[2] and Stastna G.[1]

[1]Czech Technical University, Faculty of Civil Engineering, Department of Sanitary and Ecological Eng., Thakurova 7, 166 29 Praha 6, Czech Republic
kabelkova@fsv.cvut.cz; stastnag@fsv.cvut.cz; stransky@fsv.cvut.cz
[2]DHI a.s., Na Vršich 1490/5, 100 00 Praha 10, Czech Republic
T.Metelka@dhi.cz; D.Hrabak@dhi.cz; M.Suchanek@dhi.cz

## RÉSUMÉ

L'article présente le développement d'un système d'information dédié - ISOK - pour le stockage des données sur les déversoirs d´orage (DO) et l'évaluation numérique et biologique de leurs impacts sur les cours d'eau. Le système d'information est conforme au système d'information hydroécologique (HEIS) de la République Tchèque et intègre des fonctionnalités de classification des DO selon le degré des altérations et des fonctionnalités de GIS pour la visualisation. Le modèle de données est développé et validé dans un bassin pilote. L'article décrit la méthodologie utilisée pour l'évaluation de l'impact des DO et nous présentons les premiers résultats d'une évaluation numérique du bassin versant pilote. Après avoir saisi les données, le système d'information ISOK permettra de prioriser les mesures pour répondre aux exigences de la Directive cadre sur l'eau (2000/60/CE).

## ABSTRACT

The paper presents the development of a dedicated information system ISOK for storing data on combined sewer overflows (CSOs) and data from the numerical and biological assessment of their impacts on rivers. The information system will respect Hydroecological Information System of the Czech Republic (HEIS) and contain functions for the classification of CSOs as to the rate of river disturbance and GIS functions for visualisation. The data model is developed and tested on a pilot catchment. Methodology of the CSOs impacts assessment is introduced and the first results of the pilot catchment numerical assessment and evaluation presented. After filling with further data, the information system will enable to set priorities of measures for the fulfilment of WFD requirements.

## KEYWORDS

Combined sewer overflows, Ecological status, Information system, Receiving waters

# 1 INTRODUCTION

Water management sector in the Czech Republic has been using digital information for many years. To support the state administration, the Hydroecological Information System of the Czech Republic (HEIS) was developed, setting standards for the digital passportization of rivers and streams. This information basis contains both topological and attribute data of the river network and of its structures. However, as to the pollution inputs, only WWTPs and industrial wastewater discharges are covered, although combined sewer overflows (CSOs) were proved to contribute significantly both to the pollution input and to the deterioration of the ecological status of rivers.

The approaches to the assessment of CSOs impacts on receiving water have made a certain progress in the last 5 years in the Czech Republic. A methodical guidance based on current impact-based guidelines for CSOs used in Austria and Germany (ÖWAW-Regelblatt 19, 2007; BWK-Merkblatt 3, 2001) was developed (Kabelkova et al, 2010) and has become a basis for an emerging Czech standard. To manage the CSO impacts and protective measures efficiently, the CSO assessment results have to be combined with the information in HEIS.

Thus, the goal of our project is to create an Information system of combined sewer overflows and their receiving water impacts (ISOK) gathering and evaluating information from both the numerical and biological assessment of CSO impacts and serving as a decision-support tool for the stormwater management and prioritization of protective measures at different spatial scales (local, regional).

Software ISOK will enable:

- collection and storage of information on function of CSOs,
- evaluation of the rate of the disturbance of the receiving waters by the CSOs,
- presentation of input data and evaluation results in thematic views.

This paper introduces the development of the information system and the first results of its application in the pilot catchment.

# 2 METHODS

## 2.1 Numerical assessment of CSO impacts

The numerical assessment is based on the methodical guidance Assessment of combined sewer overflows in urban catchments (Kabelkova et al, 2010) combining emission criteria and environmental quality standards (EQS). The task of emission criteria is to protect receiving waters from chronic pollution impacts whereas environmental quality standards aim at the protection from acute impacts (both pollution and hydraulic stress). The EQS and computational approaches contain high safety to target the most unfavourable situation.

Default values are suggested for the classification of the violation of emission standards and for the rate of receiving waters disturbance. However, these values can be modified by the user later.

### *2.1.1 Emission criteria*

<u>Whole catchment criteria:</u>

CSOs emission criteria were defined as minimum percentages of annual loads of dissolved and suspended pollutants contained in wet weather flow in combined sewer systems, which have to be treated biologically at the WWTP (Table 1). The minimum drainage efficiencies apply to the whole urban catchment irrespective of the number of receiving water bodies. In case a subcatchment drained by foul sewer system is connected to the combined system, the minimum required drainage efficiencies increase as a function of their respective dry-weather flows expressed as inhabitant equivalents (IE) to $5*IE_{separate}/IE_{combined}$ (%), however, the maximum requirement is 65% for dissolved pollutants and 80% for suspended pollutants.

Table 1 : Minimum drainage efficiencies (%) of stormwater runoff (i.e. dissolved pollutants such as $NH_4$-N and an important ratio of COD, $BOD_5$, $N_{tot}$ and $P_{tot}$) and of suspended solids to the biological treatment at WWTP

| | **WWTP category (IE)** | | |
|---|---|---|---|
| | **≤10 000** | **10 001-100 000** | **>100 000** |
| **stormwater (dissolved pollutants)** | 50 | 55 | 60 |
| **suspended solids** | 65 | 70 | 75 |

The efficiencies are proved by a long-term simulation of the urban drainage system by a hydrologic or hydraulic model. In case prescribed minimum drainage efficiencies are not met, classification in Table 2 is recommended.

Table 2 : Classification of minimum drainage efficiencies violation rate

| Classification of violation | Drainage efficiency calculated/ Drainage efficiency required |
|---|---|
| none | ≥ 1 |
| low | 〈 0.9;1.0) |
| medium | 〈 0.7;0.9) |
| high | < 0.7 |

Individual CSOs criteria:

At individual CSOs the minimum dilution ratio 1:4 to 1:7 should be reached (as required by EN 752). However, the dilution ratios can be smaller if the minimum drainage efficiencies are fulfilled and EQS met. Classification of the dilution ratios compliance is suggested in categories met / not met.

Analysis of the urban drainage system behaviour:

Apart from these criteria, also information enabling the analysis of the urban drainage system behaviour and mass balancing are calculated by a long-term simulation and evaluated on a year-average basis:

CSOs / storm sewers:

- Overflow volume / Discharged volume
- Overflow duration / Discharge duration
- No. of overflows / No. of discharge events
- Pollutant loads (COD, $BOD_5$, $N_{tot}$, $P_{tot}$, suspended solids)
- $Q_{1,overflow}$

WWTP:

- Discharged volume
- Pollutant loads (COD, $BOD_5$, $N_{tot}$, $P_{tot}$, suspended solids)

### *2.1.2 Environmental quality standards (EQS)*

Hydraulic stress:

River discharge below CSOs or storm sewers outlets with the frequency 1 per year should not be higher than 1.1 to 1.5 multiple of the natural one-year flood $Q_1$ (or a two-year flood $Q_2$) in the receiving water.

The lower value applies to waters with predominantly sandy-clay streambed, low variability of the channel width and low potential of recolonization of disturbed stretches by aquatic organisms, whereas the higher value concerns waters with gravel bed, high variability of the channel width and high potential of recolonization.

The river discharge below CSOs or storm sewers is calculated by a long-term simulation of the urban drainage system including receiving waters by a hydrologic or hydraulic model. Wet weather flows discharge into the natural one-year flood $Q_1$ in the receiving water.

Ambient water quality:

Assessment of acute ammonia toxicity is required only for surface waters established as suitable for the life and reproduction of indigenous species of fish (Government Order No. 71/2003). Exceeding $NH_3$-N concentration of 0.1 mg $l^{-1}$ for salmon waters and of 0.2 mg $l^{-1}$ for carp waters is not allowed for duration longer than 1 hour and frequency higher than 1 per year.

First, exceeding of $NH_4^+$-N concentrations 1.5 mg $l^{-1}$ and 3 mg $l^{-1}$, respectively, is assessed (they correspond with $NH_3$-N concentrations 0.1 mg $l^{-1}$ and 0.2 mg $l^{-1}$ at pH=8.25 and T=20°C; Emerson et al., 1975). In case, the $NH_4^+$-N criteria are violated, a more detailed calculation of $NH_3$-N concentrations based on local pH and temperatures in the river receiving the overflows is performed.

$NH_4^+$-N or $NH_3$-N concentrations are calculated by a long-term simulation of the urban drainage system including receiving waters by a hydrologic or hydraulic model enabling mass transport calculations. CSOs discharge into the low flow $Q_{347}$ in the receiving water. Background concentration of $NH_4^+$-N is assumed that one required for the specific type of surface water by the Czech legislation (Government Order No. 61/2003) (i.e. average concentration $NH_4^+$-N 0.03 mg $l^{-1}$ for salmon and 0.16 mg $l^{-1}$ for carp waters).

Oxygen concentrations in river water are not allowed to drop below 5 mg $l^{-1}$ due to the overflows. Modelling is considered very uncertain, thus, a possible oxygen deficit is to be examined by a field research.

Possible impacts caused by suspended solids are indicated if the ratio of inhabitant equivalents (IE) in all subcatchments in series without suspended solids treatment and $Q_{347}$ in the receiving water is higher than 25 IE/(l/s) or 15 IE/(l/s) in case significant amount of sewer sediment is present.

Classification of the river disturbance rate targets the exceeding the EQS and further thresholds (EQS2, EQS3, EQS4) (Table 3). As supporting information, frequencies of thresholds exceeding are evaluated. Possible occurrence of oxygen deficit is distinguished only as no / yes.

Table 3 : Classification of the receiving waters disturbance rate

| **Rate of disturbance** | **Hydraulic stress** | **Ammonia toxicity** | | **Suspended solids** | |
|---|---|---|---|---|---|
| | $\frac{Q}{Q_{permiss}}$ | N-$NH_3$ (1 hour, 1 $a^{-1}$) (mg/l) | | IE/$Q_{347}$ (-/l $s^{-1}$) | |
| | | salmon waters | carp waters | sewers without sediment | sewers with sediment |
| none | ≤ 1.0 | ≤ 0.1 | ≤ 0.2 | ≤ 25 | ≤ 15 |
| low | (1.0;1.2〉 | (0.1;0.15〉 | (0,2;0.25〉 | (25;50〉 | (15;30〉 |
| medium | (1.2;1.8〉 | (0.15;0.2〉 | (0,25;0.4〉 | (50;250〉 | (30;150〉 |
| high | > 1.8 | > 0.2 | > 0.4 | > 250 | > 150 |

## 2.2 Biological assessment of CSO impacts

Biological assessment of CSO impacts in receiving waters has to be carried out for CSOs identified as critical by not meeting EQS. As an indicator, benthic invertebrates are used.

### *2.2.1 Benthic invertebrates sampling*

Benthic invertebrates are sampled in the reference locality above the urban catchment, immediately above the CSO outlet and in several biological profiles with increasing distances below the CSO outlet. 3 minutes kick sampling in multiple habitats over the reach of about 20-50 m is performed (AQEM Consortium, 2002). Sampling in autumn is preferable as the ecological status of the reach can be classified.

### *2.2.2 Evaluation of CSO impacts*

Following characteristics are determined in the samples: No. of individuals, No of taxa, No. of sensitive taxa, functional composition of the benthic community (% representation of habitat preferences, feeding preferences, velocity preferences), Saprobic index and specific species.

Based on increase or decrease of the above characteristics, the causes of disturbance (hydraulic stress, suspended solids, chemical stress) due to the CSOs can be identified (BWK-Materialien 1, 2003). Classification of the disturbance rate is to be worked out.

### *2.2.3 Determination of the ecological status*

The ecological status of the receiving water profile based on benthic invertebrates is determined according to Opatrilova et al. (2011) and classified as very good, good, moderate or poor (Directive 2000/60/EC).

## 2.3 Information system

Development of the software prototype ISOK is structured into several phases: conceptual model development phase, functional requirements definition phase, software prototype implementation phase and testing phase.

The software prototype will be developed based on specific DHI software components called MIKE Customized. The programming framework will be composed of following components:

- a database layer with an implemented data model designed based on the analysis of data requirements in dependence on the methodology of the CSOs assessment,
- a layer of „business" logics implemented in the form of specialized tools serving for particular tasks (e.g. evaluation of emission criteria and environmental quality standards compliance) and defined on top of selected database tables,
- a user interface layer created by database views and graphical presentation of data with the help of selected GIS functions.

## 2.4 Pilot catchment

### *2.4.1 Sewer system, WWTP and receiving waters*

The town of Pribram (34 000 inhabitants) was selected as a pilot catchment to test the functionality of ISOK. Most of Pribram area (685 ha, 22 460 inhab.) is drained by the combined sewer system with 10 CSOs outlets to the Pribramsky Creek and 1 CSO outlet to the Litavka River. The rest of the area (204 ha, 11 670 inhab.) is drained by a separate sewer system with 3 storm water outlets in the upper part of the Pribramsky Creek (Figure 1).

The WWTP is designed to treat wastewater from 76 300 IE, the current input pollution equals 63 300 IE. The inflow to the WWTP starts with a whirl separator (V = 21 $m^3$) diverting storm water inflows exceeding the capacity of the mechanical pre-treatment (540 l/s) to the Pribramsky Creek. After the mechanical pre-treatment, the inflow exceeding the capacity of the sedimentation tanks and of the biological treatment (350 l/s) is lead to the storm water tank (V = 1050 $m^3$) and after its filling to the Pribramsky Creek. The biological treatment includes nitrogen and phosphorous removal reaching high removal efficiencies (88% $N_{tot}$, 90% $P_{tot}$) and microfiltration of the biologically treated water.

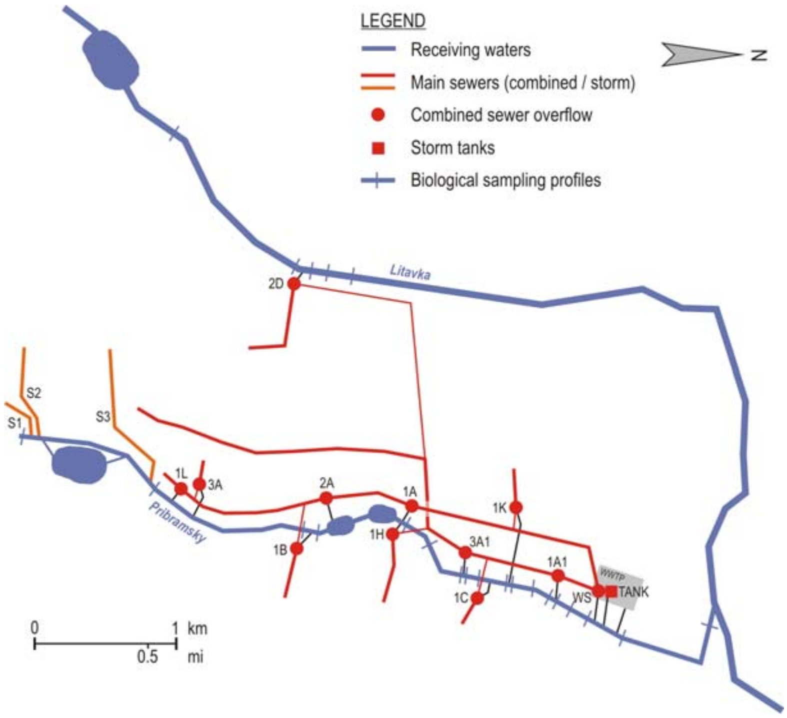


Figure 1 : Scheme of the pilot catchment

Both Litavka and Pribramsky Creek belong among salmon waters. Water quality parameters upstream of Pribram fall in classes I or II (out of V classes), except for nitrate in Pribramsky Creek (class IV). The natural one-year flood $Q_1$ ranges from 2.830 to 5.321 $m^3$/s along the investigated reach of the Pribramsky Creek, low flow $Q_{347}$ ranges from 12.1 to 21.2 l/s. $Q_1$ in the Litavka at the profile of the CSO 2D outlet is 6.213 $m^3$/s and $Q_{347}$ is 44.9 l/s. Recolonization potential of Pribramsky Creek is low (exceptionally medium - below S1+S2 and 3A1), Litavka exhibits a medium recolonization potential.

#### *2.4.2 Simulation software*

Simulations for the numerical assessment of the CSO impacts were performed in the DHI software tool MIKE URBAN. For the simulation of water quality, the sewer system had to be schematized more coarsely than in the Urban Drainage Masterplan (from 2507 manholes and 1750 subcatchments down to 134 manholes and 68 subcatchments) and the model had to be enhanced by both receiving water bodies.

#### *2.4.3 Biological sampling*

Benthic invertebrates sampling scheme can be seen in Figure 1. CSOs identified in the simulation as causing no overflows were not sampled.

## 3 RESULTS AND DISCUSSION

### 3.1 Conceptual model

#### *3.1.1 Core of the conceptual model*

The conceptual data model (CDM) was developed to serve a fundamental data structure of ISOK prototype. The CDM is built in a way to incorporate the basic SW requirements, e.g. native reading of HEIS data (river network, water bodies, River Basin Authorities), incorporation of ISVS (Public Administration Information System) data (settlements, municipalities) and inclusion of time series data. Simplified conceptual data model is presented in Figure 2.

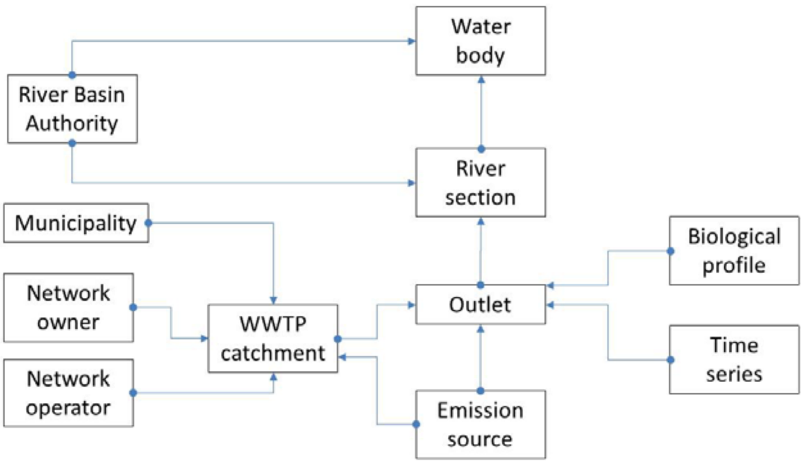


Figure 2 : Core of the conceptual model

The core of the data model is composed of 11 data tables. The table Emission source comprises all information related to the emission structures (e.g. X, Y coordinates, source type and other data necessary for the evaluation of emission criteria). Outlet data table represents the data of the outflows to the river from both combined and storm water networks (e.g. X,Y coordinates, permissible discharge). River section table contains river polyline data from HEIS. Water body table is defined on River section subset and covers information regarding the ecological status of the particular water body based on evaluation from the first round of the River Basin Management Plan. River Basin Authority table contains contact information regarding river administrator data. The same information for network owner and operator is stored in the Owner and Operator tables, respectively. WWTP catchment table comprises information regarding the drainage catchment and data necessary for the emissions evaluation (e.g. X, Y coordinates, population, calculated and required drainage efficiencies). Biological profile table stores the information from the biological assessment (list of benthic invertebrates, ecological status). Time series data table stores time series outputs from the simulation.

#### *3.1.2 Conceptual model functionalities*

The Emission source table is connected to the WWTP catchment table and to the Outlet table. The connection to the WWTP catchment table allows for the emission part of processing (drainage efficiencies) while the connection to the Outlet table makes the overall receiving water disturbance rate processing possible. The Outlet data table is connected with the Time series table to store and make time series of flows and water quality parameters ($NH_3$-N) available for analysis. In addition, the Biological profile data table is connected to the Outlet table in order to incorporate results from the biological assessment. The Outlet table makes the analysis of the receiving waters impacts possible though the connection with River section table and with the Water body table.

Both River section and Water body tables are connected with the River Basin Authority table allowing for definition of spatial queries (e.g. “Show all river sections having CSO’s not complying with the defined thresholds of the disturbance rate in the selected Water body and show the relevant River Basin Authority”). The connection between the WWTP table and Municipality, Owner and Operator tables allows for implementation of other spatial queries (e.g. “Select all CSO’s in the municipality ‘A’ not complying with the defined disturbance rate thresholds and find their operator”). The association of Outlets with River sections on one side and of Emissions sources with Owners and Operators on the other side will allow for analyses of the “polluter pays” type.

The data tables described in above include a number of attribute data necessary for the processing of required analyses. However, it is beyond the scope of this paper to go into the details of the conceptual data model and the use of attribute data.

The graphical user interface (GUI) will allow for spatial analysis of CSO’s performance based on river sections, municipality, river basin authority or water body location. The analysis will be implemented to allow for an easy classification of the CSOs based on the rate of violating EQS. Results from simulation models will be visualized in a form of time series related to the particular location. The current example of GUI is presented in Figure 3.

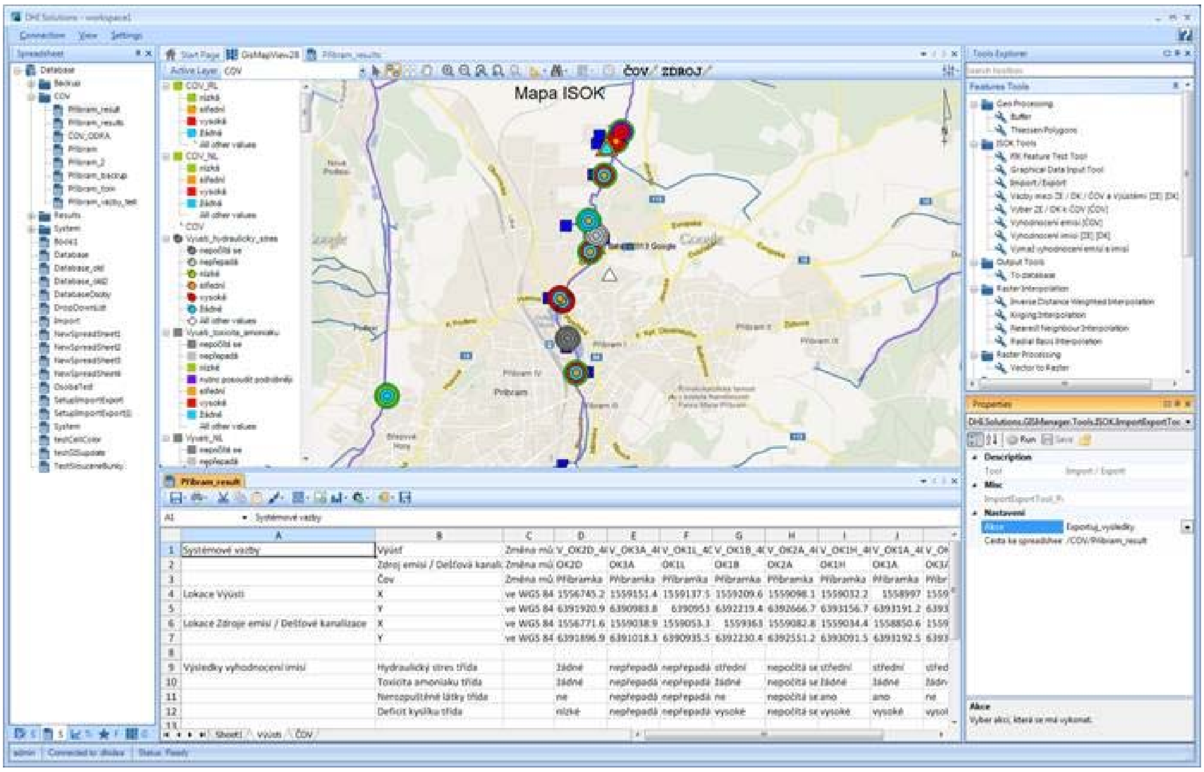


Figure 3 : Current example of GUI

## 3.2 Pilot catchment evaluation

Only results of the numerical assessment are presented as the biological samples haven’t been evaluated yet.

### *3.2.1 Emission criteria*

The average volume of stormwater inflow to the combined sever system in Pribram is 523 765 $m^3$/a whereas the total overflow volume is 208 585 $m^3$/a. Thus, the stormwater drainage efficiency makes

60.2%. A substantial amount of stormwater (144 363 $m^3$/a) is relieved via the whirl separator at the WWTP having a very small suspended solids removal efficiency (less than 1% according to ÖWAW-Regelblatt 19, 2007). Although the sedimentation efficiency of the stormwater tank at WWTP is higher (20%), it contributes to the total TSS removal efficiency negligibly as its overflow volume makes only 11 282 $m^3$/a. Therefore, the suspended solids drainage efficiency 60.9% is only slightly higher than the stormwater drainage efficiency. Whereas the stormwater drainage efficiency complies with the required value, the suspended solids drainage efficiency makes only 84% of the required efficiency (Table 4).

Table 4 : Evaluation of the drainage efficiencies (%) in the pilot catchment

| | **Required drainage efficiency (Table 1)** | **Increased required drainage efficiency due to foul sewers** | **Calculated drainage efficiency** | **Calculated/required** |
|---|---|---|---|---|
| **stormwater** | 55 | 57.6 | 60.2 | 1.05 |
| **suspended solids** | 70 | 72.6 | 60.9 | 0.84 |

3 CSOs (1L, 3A, 1C) do not overflow at all, the dilution ratios of the rest complies with the required criteria (Table 5).

### *3.2.2 EQS*

The numerical assessment of hydraulic stress indicates different rates of the disturbance of the Pribramsky Creek whereas no hydraulic stress in the Litavka River (Table 5). Both impacts of single stormwater outlets and cumulative impacts in the downstream direction were evaluated. Stormwater from the separate system outlet S3 in the upper part of the Pribramsky Creek causes medium hydraulic stress, propagating downstream. The ponds mitigate the hydraulic stress to a certain degree, thus the stress below CSOs 1H and 1A is classified as low. Downstream 3A1 the stress increases to medium due to the cumulative impacts. Significant intensification of hydraulic stress is identified below the whirl separator causing further high stress below the stormwater tank.

Acute ammonia toxicity due to the overflows can be excluded for the Litavka River and for the upper part of the Pribramsky Creek. Downstream of 3A1, $NH_4^+$-N concentrations 1.5 mg $l^{-1}$ are exceeded, however, their duration is shorter than 1 hour. The overflows from the whirl separator cause high acute ammonia toxicity in the Pribramsky Creek that is amplified by the overflows from the stormwater tank. Their impacts progress further downstream to the Pribramsky Creek mouth. Assessing impacts of single structures, both the positive effect of dilution from upstream (1B) and negative cumulative impacts of CSOs from more structures (lower part of Pribramsky Creek, especially whirl separator and stormwater tank) can be seen.

The field survey revealed oxygen concentration below 5 mg $l^{-1}$ only in the reach downstream of CSOs 1H and 1A.

Suspended solids assessment shows a very high disturbance rate of the Pribramsky Creek starting from the most upstream CSO 1B. Especially alarming is the situation in all reaches downstream CSOs 1H and 1A (km 2.80). This finding corresponds with the low suspended solids drainage efficiency. The CSO 2D to the Litavka River causes probably only minor disturbance due to the suspended solids.

## 4 CONCLUSIONS

Pilot study evaluation was performed independently of the information system ISOK as it will be used for a check of the proper ISOK functionality in the subsequent phase of the project. However, it shows that using the methodology suggested, a good overview of the urban drainage system performance is given and problems are identified easily.

In Pribram four main problems are apparent: low suspended solids drainage efficiency to the WWTP, suspended solids impacts, hydraulic stress and acute ammonia toxicity in the Pribramsky Creek. A better usage of the stormwater tank at the WWTP would increase the drainage efficiencies. For the reduction of the hydraulic stress, BMPs (especially stormwater infiltration) in the S3 subcachment can be recommended. In case more water is lead to the stormwater tank, hydraulic stress and acute ammonia toxicity in Pribramsky Creek reaches bellow the whirl separator would decrease at the same time. However, the final design of measures should be preceded by the biological assessment of CSO impacts and determination of the ecological status of the Pribramsky Creek.

Table 5 : Evaluation of the receiving waters disturbance rate in the pilot catchment (P – Pribramsky Creek, L – Litavka)

| **Structure** | | | **S1+S2** | **S3** | **1L** | **3A** | **1B** | **2A** | **1H** | **1A** | **3A1** | **1C** | **1K1** | **1A1** | **WS** | **TANK** | **2D** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Rec. water** | | | P | P | P | P | P | P | P | P | P | P | P | P | P | P | L |
| **Chainage** | | km | 5.10 | 4.70 | 4.30 | 4.30 | 3.40 | pond | 2.80 | 2.80 | 2.20 | 2.05 | 1.85 | 1.40 | 1.00 | 1.00 | 43.20 |
| **Behaviour analysis** | **No. overflows** | -/a | | | 0 | 0 | 93 | 8 | 16 | 0.5 | 7 | 0 | 1 | 7 | 71 | 14 | 28 |
| | **Overflow duration** | h/a | | | 0 | 0 | 65 | 4 | 6 | 0.1 | 4 | 0 | 0.3 | 3 | 69 | 20 | 12 |
| | **Overflow volume** | $m^3/a$ | | | 0 | 0 | 35415 | 2587 | 4486 | 15 | 3045 | 0 | 153 | 3242 | 144363 | 11282 | 3997 |
| | **$Q_{overflow,1}$** | $m^3/s$ | 1.057 | 1.312 | 0 | 0 | 1.516 | 0.767 | 0.894 | 0 | 0.637 | 0 | 0.119 | 0.888 | 2.888 | 0.190 | 0.406 |
| | **Dilution ratio** | | | | | | 4.0 | 10.8 | 29.8 | 16.3 | 30.2 | | 69.0 | 31.1 | 16.3 | - | 29.0 |
| **Hydraulic stress single** | **$Q/Q_{permiss}$** | | 1.06 | 1.30 | | | 1.12 | - | 1.08 | 0.91 | 0.87 | | 0.85 | 1.06 | 1.29 | 0.94 | 0.82 |
| | **Frequency Q>EQS** | -/a | 2 | 23.6 | 0 | 0 | 4.1 | - | 2.8 | 0 | 0.2 | 0 | 0 | 1.3 | 26.2 | 0 | 0 |
| **Hydraulic stress cumulative** | **$Q/Q_{permiss}$** | | 1.06 | 1.62 | | | 1.43 | - | 1.20 | 1.20 | 1.27 | | 1.31 | 1.49 | 1.63 | 1.84 | 0.85 |
| | **Frequency Q>EQS** | -/a | 2 | 46 | | | 18.9 | - | 14.1 | 14.1 | 86.1 | | 76.8 | 100+ | 71 | 100+ | 0 |
| **Ammonia toxicity single** | **Frequency $N\text{-}NH_3$>EQS** | -/a | | | | | 18 | - | 0 | 0 | 0 | | 0 | 0 | 22 | 7 | 0 |
| | **Frequency $N\text{-}NH_3$>EQS2** | -/a | | | | | 14 | - | | | | | | | 18 | 7 | |
| | **Frequency $N\text{-}NH_3$>EQS3** | -/a | | | | | 0 | - | | | | | | | 12 | 6.5 | |
| | **Frequency $N\text{-}NH_3$>EQS4** | -/a | | | | | | - | | | | | | | 7 | 6.5 | |
| **Ammonia toxicity cumulative** | **Frequency $N\text{-}NH_3$>EQS** | -/a | | | | | 0 | - | 0 | 0 | 0 | | 0 | 0 | 43 | 60 | 0 |
| | **Frequency $N\text{-}NH_3$>EQS2** | -/a | | | | | | - | | | | | | | 15 | 17 | |
| | **Frequency $N\text{-}NH_3$>EQS3** | -/a | | | | | | - | | | | | | | 7 | 9 | |
| | **Frequency $N\text{-}NH_3$>EQS4** | -/a | | | | | | - | | | | | | | 3 | 5 | |
| **Susp.solids** | **suma $IE/Q_{347}$** | $-/l\ s^{-1}$ | | | - | - | 319 | - | 295 | 806 | 2472 | - | 0 | 2379 | 2981 | - | 27 |
| **Oxygen** | **$O_2$ deficit** | | | | - | - | no | - | yes | yes | no | - | no | no | no | no | no |

After putting the information system ISOK into operation, a systematic record of CSOs will be gradually developed and stored in the system, the assessment of the receiving waters impacts will be unified and the evaluation will be presented in a well-arranged way.

After filling ISOK with further data, it will support setting of priorities of measures to fulfill the requirements of the Directive 2000/60/EC (i.e. reaching good ecological status of all water bodies) - not only at local but also at the watershed or regional scales. Emission criteria (drainage efficiencies) must always be met to ensure receiving waters protection from pollutants with cumulative and chronic impacts. Thus, in case the drainage efficiencies are too low, measures in the urban drainage system have to be adopted. Priorities and type of measures for the fulfillment of EQS depend on the ecological statuses of the receiving water reaches below and above the CSO. In case the ecological status of the reach below the CSO (or their group) is at least good, no protective measures have to be applied. In case it is moderate or poor, the priorities must be set with respect to the ecological status of the reach above the CSO: if already the ecological status of this reach is moderate or poor, stream revitalization and decrease of pollution input from sources above the urban drainage catchment (e.g. diffusive pollution) might be of a greater benefit than measures in the urban drainage system. However, these measures will have to be adopted later as well.

ISOK will also support keeping the continuity of information after adopting the measures and evaluation of their efficiency.

With increasing amount of data and knowledge, ISOK will give a background for the adjustment of emission criteria and EQS including the thresholds of the disturbance rate.

## ACKNOWLEDGEMENT

Project “Information system of combined sewer overflows and their receiving waters impacts" (ISOK) is supported by the Technology Agency of the Czech Republic (Project No. TA02020238).

## LIST OF REFERENCES

AQEM Consortium (2002): *AQEM – Manual for the Application of the AQEM System*.

BWK-Materialien 1 (2003): *Begleitband zu dem BWK-Merkblatt 3*.

BWK-Merkblatt 3 (2001): *Ableitung von immissionsorientierten Anforderungen an Misch-und Niederschlagswassereinleitungen unter Berücksichtigung örtlicher Verhältnisse*. 2. Auflage.

BWK-Merkblatt 7 (2008). *Leitfaden zur detaillierten Nachweisführung immissionsorientierter Anforderungen an Misch- und Niederschlagswassereinleitungen gemäss BWK-Merkblatt 3.*

EN 752 (2008): Drain and sewer systems outside buildings. European Committee for standardization.

Emerson, K.R., R.C. Russo, R.E. Lund, and R.V. Thurston (1975): *Aqueous ammonia equilibrium calculations: effect of pH and temperature*. Journal of Fisheries Research Board of Canada 32, pp.2379-2383.

European Parliament and the Council (2000), Directive 2000/60/EC of 23 October 2000 establishing a framework for Community action in the field of water policy.

Government Order No. 61/2003 Coll., on the indicators and values of permissible pollution of surface water and wastewater, mandatory elements of the permits for discharge of wastewater into surface water and into sewerage systems, and on sensitive areas.

Government Order 71/2003 Coll., establishing surface waters which are suitable for the life and reproduction of indigenous species of fish and other aquatic fauna and determining and evaluating the quality of these waters.

Jordan, C. (1989): *The mean pH of mixed fresh waters*. Wat. Res. 23(10), pp. 1331-1334.

Kabelkova, I., Havlik, V., Kuba, P. and Sykora, P. (2010): *Assessment of combined sewer overflows in urban catchments* (in Czech), Methodical guidance, ČVTVHS.

Opatrilova L., Kokes J., Syrovatka, V., Nemejcova D. and Zahradkova S. (2011): *Assessing running waters of the Czech Republic using benthic macroinvertebrates: development and description of the evaluation method* (in Czech), VTEI 53, pp.6-9.

ÖWAW-Regelblatt 19 (2007): *Richtlinien für die Bemessung von Regenentlastungen in Mischwasserkanälen*.