

HEM

Hydroecological Monitoring



Assessment of Parameters

Methodology for the Monitoring of Hydromorphological
Parameters of Ecological Quality of Watercourses

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A. Methodology of assessment

1. Principle of assessment

The assessment is based on the principle of scoring of the particular parameters which are assessed from the viewpoint of their effect on hydromorphological quality of a watercourse.

Results of field monitoring according to HEM methodology are primarily used as input data, some of the parameters are complemented by features identified from data bases.

The scoring for most of the parameters is based on assessment of frequency or extent of occurrence of the particular assessed forms of watercourse and floodplain modifications.

The assessment reflects a hierarchical principle – the basic assessment is performed at the particular mapped reaches, from which a value for the given water body is derived.

2. Source data

The basic input data for assessment are represented by results of field mapping according to HEM methodology (Langhammer, 2007), entered in mapping printed forms, for two parameters complemented by selected data bases. HEM monitoring methodology is available at the website www.ochranavod.cz.

In addition to the mapping results, also historical maps of the 2nd Military Mapping from 1832-54 covering the period before the beginning of industrial revolution are further used for assessment of stream channel route alterations. The maps are available on-line at the server www.mapy.cz.

For the assessment of discharge variation, hydrological data from the database of the Czech Hydrometeorological Institute have been used.

3. The assessed parameters

The assessment is based on a set of in total 17 parameters characterizing the main aspects of hydromorphological quality of stream channel, bed and bank zone and of floodplain zone, including the features of flow and hydrological regime.

Stream channel and route (CHA)

- Stream channel route canalization (STR)
- Longitudinal continuity of the stream channel (LPC)
- Stream channel width variations (CHV)
- Longitudinal profile depth variations (LPV)
- Cross profile depth variations (CPV)

Stream bed (BED)

- Stream bed structures (RBS)
- Stream bed substrate (RBR)
- Stream bed modifications (RBM)
- Woody and leafy debris in the stream channel (LWD)

Bank and floodplain (FPN)

- Bank modifications (BKM)
- Bank vegetation (BKV)
- Riparian zone land use (RZL)
- Floodplain land use (FPL)

Flow and Hydrological Regime (HYD)

- Character of flow (FLO)
- Hydrological regime modifications (HRM)
- Continuity of floodplain (FPC)
- Discharge variation (QVA)

4. Assessment process

The assessment is based on the scoring of the particular parameters, which in subsequent steps serves for calculation of values for superior functional or spatial hierarchical levels. The assessment is performed in the following step sequence:

1. Scoring of hydromorphological quality for parameters under assessment within a watercourse reach
2. Calculation of partial score of hydromorphological quality for particular assessment zones
3. Calculation of resulting score of hydromorphological quality of a watercourse reach
4. Classification of hydromorphological status of a watercourse reach
5. Calculation of average value for water body

5. Basic parameter scoring

The scoring principle reflects the basic WFD requirements – the highest hydromorphological quality is reached if stream status corresponds to potentially natural conditions at the highest variation.

The scoring is performed for the given assessment parameters on the basis of classification procedures explained in Part B. The scoring of the particular parameters ranges between 1 and 5, with 1 representing the best value, and 5 the worst value.

Where the monitoring is performed separately for left and right bank, the assessment of parameters is carried out so that the least favourable score value reached on the right, and the left bank, respectively, is used.

Score values for the particular parameters were set on the basis of expert estimation, field testing and comparison with the available analogical methodologies.

6. Calculation of hydromorphological quality of a watercourse reach

Hydromorphological quality of a watercourse reach is calculated as weighted mean of score, calculated for the particular parameters.

Calculation is done in two steps. First, weighted mean is calculated separately for particular zones – i.e. zone of stream channel, stream bed, bank and floodplain zone and for flow and hydrological regime. Weight values are set to highlight the effect of parameters which are essential to the hydromorphological conditions.

The resulting hydromorphological quality of a watercourse reach is calculated as arithmetic mean of partial values calculated for particular zones.

I. Calculation of partial hydromorphological quality of the main zones

1. Stream channel and route

$$CHA = (STR*0,3 + LPC*0,3 + CHV*0,1 + LPV*0,15 + CPV*0,15)$$

2. Stream bed

$$BED = (RBS*0,3 + RBR*0,2 + RBM*0,3 + LWD*0,2)$$

3. Bank and floodplain

$$FPN = (BKM*0,3 + BKV*0,3 + RZL*0,25 + FPL*0,15)$$

4. Flow and hydrological regime

$$HYD = (FLO*0,3 + HRM*0,3 + FPC*0,2 + QVA*0,2)$$

II. Resulting hydromorphological quality of a watercourse reach

$$HMQ = (CHA + BED + FPN + HYD) / 4$$

7. Calculation of hydromorphological quality of waterbodies

Hydromorphological quality of waterbodies is expressed as weighed average of hydromorphological quality of watercourse reaches in the respective waterbody, where the reach length is considered as the weighing parameter.

$$HMQ_{WB} = \frac{\sum_{i=1}^n HMQ_i \cdot L_i}{\sum_{i=1}^n L_i}$$

HMQ_{WB} ... means hydromorphological quality of waterbody
 HMQ_i ... means hydromorphological quality of watercourse reach
 L_i ... means watercourse reach length
 n ... means number of watercourse reaches in waterbody

8. Classification of hydromorphological status of a watercourse reach

Classification of hydromorphological status is done by assigning a calculated value of hydromorphological quality of a reach to one of five degrees of hydromorphological status according to the table below.

| Hydromorphological status | | Hydromorphological quality |
|---------------------------|----------|----------------------------|
| 1 | High | 1,0 – 1,7 |
| 2 | Good | 1,8 – 2,5 |
| 3 | Moderate | 2,6 – 3,4 |
| 4 | Poor | 3,5 – 4,2 |
| 5 | Bad | 4,3 – 5,0 |

9. Reference conditions

Reference conditions of hydromorphological element, supporting the biological elements, represent the values for high ecological status.

This status is defined as follows:

- The quantity and dynamics of water flow, and the resultant connection to groundwaters, reflect totally, or nearly totally, undisturbed conditions.
- The continuity of the stream is not disturbed by anthropogenic activities and allows undisturbed migration of aquatic organisms and transport of sediments.
- Channel patterns, width and depth variations, flow velocities, substrate conditions and both the structure and condition of the riparian zone correspond totally or nearly totally to undisturbed conditions.

Every particular parameter is scored in the range of between 1 and 5, with 1 representing high status.

Reference sites

For the purpose of setting reference conditions of the biological elements, there may be used only sites with the total hydromorphological quality score equal to 1 or close to 1, and not exceeding the value of 1.7. At the same time, none of the particular parameters under assessment may reach score worse than 2. These two conditions have to be met also by a reach below and a reach above the given site.

Best available sites

Sites with hydromorphological quality score worse than 1.7 may only be used to derive reference conditions of the biological elements in the event of non-existence of reference sites.

B. Parameter Scoring

I. Stream channel and route

1. Stream route modifications (STR)

Source data

1. Results of field mapping of the current character of stream channel and route. Values in this parameter are unique, i.e. one reach may take only one parameter value (HEM methodology, parameter *Stream channel and route*)
2. The data on historical stream route are derived from the historical map compiled during the 2nd Military Mapping from 1836-52, available online at www.mapy.cz

Method of determination

The predominant category of stream route character to be marked in the form in the field, the predominant category from the period before industrial revolution to be determined from on-line maps.

| <i>Stream route</i> | <i>Predominant type</i> | <i>Signs of channelization</i> | <i>Historical status</i> |
|---------------------|-------------------------|--------------------------------|--------------------------|
| Braided | | | |
| Branched | | | |
| Meandering | | | |
| Sinuuous | | | |
| Straight | | | |
| STR | | | |

Principle of assessment

The assessment is based on comparison of the current and the historical stream route.

Change of stream route type is assessed, taking into account natural or artificially modified stream route character.

Parameter scoring

The score for the parameter STR is determined from the table below as a value corresponding to the respective combination of the categories of the current and the historical status of stream route in the given reach.

| <i>Current status (mapping)</i> | <i>Historical status</i> | | | | |
|---------------------------------|--------------------------|----------|------------|----------|---------|
| | Straight | Sinuuous | Meandering | Branched | Braided |
| Straight | 2 | 3 | 5 | 5 | 5 |
| Straight straightened | 3 | 4 | 5 | 5 | 5 |
| Sinuuous | 2 | 1 | 3 | 3 | 4 |
| Sinuuous straightened | 3 | 3 | 4 | 5 | 5 |
| Meandering | 1 | 1 | 1 | 2 | 3 |
| Meandering straightened | 2 | 2 | 3 | 4 | 4 |
| Branched | 2 | 2 | 2 | 1 | 2 |
| Branched straightened | 3 | 3 | 3 | 3 | 3 |
| Braided | 1 | 1 | 1 | 1 | 1 |

2. Longitudinal continuity of stream channel (LPC)

Source data

Field mapping of longitudinal stream profile modification categories in the given reach (HEM methodology, parameter *Longitudinal continuity of stream channel*).

Method of determination

| Character of barriers in stream channel | Number of occurrences |
|---|-----------------------|
| Reach with no barriers | |
| Low steps with the height < 0.5 m | |
| Step or weir with the height < 1 m | |
| Step or weir with the height > 1 m | |
| Glide | |
| Weir with fish passage | |
| Dam/dike | |
| Average depth of a reach | |
| LPC | |

Principle of assessment

The assessment takes into account the number of occurrences of the particular barrier types in relation to stream channel depth.

Average stream channel depth is calculated as weighted average of depth categories, where depth is represented by the maximal depth of the given category and weight is represented by the percentage.

$$H_s = \frac{\sum_{n=1}^n H_n \times R_n}{\sum_{n=1}^n R_n}$$

H_s ... means average depth of a reach

n ... means the number of depth categories

H_n ... means the maximal depth of the given category

R_n ... means the percentage of occurrence of the given depth category

Parameter scoring

The score for the parameter LPC is determined from the table below as the maximal value which corresponds to the combination of barrier character categories, channel depths and the number of barriers in the given reach.

| Character of barriers in stream channel | Number of barriers Stream channel depth | 1-2 | 3-5 | 6 and more |
|---|--|-----|-----|------------|
| Reach with no barriers | | 1 | | |
| Low steps with the height < 0.5 m | 0-1 m | 2 | 3 | 4 |
| | 1 m + | 2 | 2 | 3 |
| Glide | 0-1 m | 2 | 3 | 4 |
| | 1 m + | 2 | 2 | 3 |
| Step or weir with the height 0.5-1 m | 0-1 m | 3 | 4 | 5 |
| | 1 m + | 2 | 3 | 4 |
| Weir with fish passage | 0-1 m | 3 | 3 | 5 |
| | 1 m + | 3 | 3 | 4 |
| Step or weir with the height > 1 m | 0-1 m | 4 | 5 | 5 |
| | 1 m + | 3 | 4 | 5 |
| Dam/dike | 0-1 m | 5 | 5 | 5 |
| | 1 m + | 5 | 5 | 5 |

3. Stream channel width variation (CHV)

Source data

The mapping, the minimal and the maximal channel width in the given stream reach is mapped (HEM methodology, parameter *Stream channel width – minimum and maximum*).

Method of determination

Field measurement or derived from map

| Stream morphometry | Minimum | Maximum |
|--------------------------------|---------|---------|
| Stream channel width (m) | | |
| Average stream channel width | | |
| Stream channel width variation | | |
| CHV | | |

Principle of assessment

The score for the parameter CHV (Stream channel width variation) is assigned on the basis of stream channel width variation in relation to absolute stream channel width.

Stream channel width variation B_V is calculated as a ratio of maximal to minimal stream channel width.

$$B_V = \frac{B_{\max}}{B_{\min}}$$

where B_V means stream channel width variation in a reach
 B_{\max} means maximal stream channel width in a reach
 B_{\min} means minimal stream channel width in a reach

| Value B_V | Width variation |
|-------------|-----------------|
| \geq 0 | |
| 0 1,10 | Very low |
| 1,10 1,25 | Low |
| 1,25 1,50 | Moderate |
| 1,50 2,00 | High |
| 2.00 | Very high |

Average channel width B_A is calculated as artificial variable, which enters into assessment as auxiliary criterion. Average stream channel width is calculated as average value of the minimal and the maximal stream channel width.

$$B_A = \frac{B_{\max} + B_{\min}}{2}$$

For medium-sized and large streams, due to the typical morphology, the effect of variation on hydromorphological quality is assessed as less relevant, which is reflected in the scoring.

Parameter scoring

The score for parameter CHV is determined from the table below as a value corresponding to the respective combination of categories of B_V (stream channel width variation) and B_A (average stream channel width) B_A in the given reach.

| Average channel width B_A | <10 m | 10-30 m | ≥ 30 m |
|-------------------------------|-------|---------|-------------|
| Channel width variation B_V | | | |
| \geq 0 | | | |
| 0 1,10 | 5 | 4 | 3 |
| 1,10 1,25 | 4 | 3 | 2 |
| 1,25 1,50 | 3 | 2 | 1 |
| 1,50 2,00 | 2 | 1 | 1 |
| 2.00 | 1 | 1 | 1 |

4. Stream channel depth variation (LPV)

Source data

The mapping of the percentage of the particular depth categories within a reach. In addition to depth itself, the assessment in the mapping takes into account whether the given depth category is artificially modified – artificially heightened or artificially lowered (HEM methodology, parameter *Stream channel depth variation*).

Method of determination

| <i>Stream channel depth modification type</i> | <i>Percentage %</i> | <i>Artificially heightened</i> | <i>Artificially lowered</i> |
|---|---------------------|--------------------------------|-----------------------------|
| 0-20 cm | | | |
| 20-50 cm | | | |
| 50 cm – 1 m | | | |
| 1-2 m | | | |
| 2-4 m | | | |
| > 4 m | | | |
| Number of depth types | | | |
| % of artificial modification | | | |
| LPV | | | |

Principle of assessment

Longitudinal profile variation is expressed by the number of depth categories and by the intensity of artificial modification. Percentage of artificial modification is calculated as summary percentage of reach segments, for which artificial heightening or lowering was identified.

Parameter scoring

The score for parameter LPV is determined from the table below as a value corresponding to the respective combination of categories of the number of depth types and the total percentage of artificial modification of channel depth in the given reach.

| <i>Intensity of modification</i> <i>Number of depth types</i> | <i>Natural</i> | <i>Percentage of artificial modification</i> | | |
|--|----------------|--|---------------|-------------|
| | | <i><50 %</i> | <i>50-90%</i> | <i>≥90%</i> |
| 1 | 3 | 4 | 5 | 5 |
| 2 | 2 | 3 | 4 | 5 |
| 3 and more | 1 | 2 | 3 | 5 |

5. Cross profile depth variation (CPV)

Source data

The mapping of the percentage of occurrence of depth variation categories in the given reach (HEM methodology, parameter *Cross profile depth variation*).

Method of determination

| Character of variation | Percentage % | Partial score |
|----------------------------------|--------------|---------------|
| High | | |
| Moderate | | |
| Naturally low | | |
| Low due to channel modifications | | |
| CPV | | |

Principle of assessment

The assessment of cross profile depth variations is carried out on the basis of the percentage of occurrence of the particular variation categories within the given reach.

Parameter scoring

The score for the parameter CPV is determined from the table below as the maximal value which corresponds to the combination of the particular categories of cross profile depth variations and the total percentage of their occurrence within the given reach.

Table boxes showing no value are not counted in assessment, having thus no effect on the resulting score.

| Category of cross profile depth variation | Share of the category (r) as % of reach length | | | |
|---|--|------------------|------------------|-------------|
| | $r < 10$ | $10 \leq r < 50$ | $50 \leq r < 90$ | $r \geq 90$ |
| High | | 1 | 1 | 1 |
| Moderate | | 2 | 2 | 2 |
| Naturally low | 2 | 2 | 3 | 3 |
| Low due to channel modifications | 2 | 3 | 4 | 5 |

II. Stream bed

6. Stream bed structure variation (RBS)

Source data

Field mapping of the percentage of occurrence and types of natural stream bed structures (HEM methodology, parameter *Stream bed structure variation*).

Method of determination

| <i>Stream bed structure types</i> | <i>Percentage %</i> |
|---|---------------------|
| No stream bed structures observed | |
| Berms | |
| Islands | |
| Shoals | |
| Pools | |
| Riffles | |
| Rock steps | |
| Number of stream bed structure types | |
| Total percentage of stream bed structures % | |
| RBS | |

Principle of assessment

Stream bed structure variations, in particular, the number of stream bed structure types occurring in the given reach are assessed.

The assessment also takes into account the total percentage of length of a reach in which all identified stream bed structure types in the given reach occur.

Parameter scoring

The score for the parameter RBS is determined from the table below as a value corresponding to the respective combination of categories of structure number types and the total percentage of occurrence of such stream bed structures in the given reach.

| <i>Number of types</i> | <i>Total share of structures (r) as % of reach length</i> | | |
|------------------------|---|---------------------------------------|-------------------------------|
| | <i>$r < 10$</i> | <i>$10 \leq r < 50$</i> | <i>$r \geq 50$</i> |
| 0 | 5 | | |
| 1 | 4 | 3 | 2 |
| 2 | 3 | 2 | 1 |
| 3 and more | 2 | 1 | 1 |

7. Stream bed substrate (RBR)

Source data

Field mapping of stream bed substrate types (HE methodology, parameter *Stream bed substrate*).

Method of determination

In the mapping, particular stream bed substrate types in the given reach are identified.

| <i>Stream bed substrate type</i> | <i>Percentage %</i> | <i>Partial score TS</i> |
|----------------------------------|---------------------|-------------------------|
| Bedrock | | |
| Cobbles and boulders (>256 mm) | | |
| Pebbles (64-256 mm) | | |
| Gravel (2-64 mm) | | |
| Sand (0.06-2 mm) | | |
| Silt / clay (<0.006 mm) | | |
| Peat | | |
| Artificial substrate | | |
| Number of substrate types | | <i>TS maximum</i> |
| VS | | |
| RBR | | |

Principle of assessment

The assessment takes into account variation of substrate type numbers and the percentage of the particular substrate types within the given reach.

Parameter scoring

The scoring proceeds in two steps. First, the score for partial parameters of substrate variation (VS) and substrate type (TS) is calculated separately, the resulting score for the parameter is then calculated as arithmetic average of partial parameters.

The score for partial parameter of substrate variation VS is determined from the table below on the basis of the number of substrate types occurring in the given reach.

| <i>Number of substrate types</i> | <i>VS</i> |
|----------------------------------|-----------|
| 1 | 4 |
| 2 | 3 |
| 3 | 2 |
| 4 + | 1 |

The score for partial parameter of substrate type TS is determined from the table below as the maximal value which corresponds to the combination of the particular categories of stream bed substrate types and the percentage of their occurrence in the given reach.

Combinations of categories with no value shown have no effect on the resulting score.

| <i>Category of stream bed substrate type</i> | <i>Share of the category (r) as % of reach length</i> | | | |
|--|---|---------------------|---------------------|-------------|
| | <i>r<10</i> | <i>10 ≤ r<50</i> | <i>50 ≤ r<90</i> | <i>r≥90</i> |
| Bedrock | | 1 | 1 | 1 |
| Cobbles and boulders (>256 mm) | | 1 | 1 | 1 |
| Pebbles (64-256 mm) | | 1 | 1 | 1 |
| Gravel (2-64 mm) | | | 1 | 1 |
| Sand (0,06-2 mm) | | | 2 | 2 |
| Silt / clay (<0.006 mm) | 2 | 2 | 3 | 4 |
| Peat | | 1 | 1 | 1 |
| Artificial substrate | 3 | 3 | 4 | 5 |

The resulting score for the parameter RBR is calculated as arithmetic average of the value of partial parameters VS and TS:

$$\text{RBR} = (\text{VS} + \text{TS}) / 2$$

8. Stream bed modifications (RBM)

Source data

The mapping of the character of stream bed modifications within a reach (HEM methodology, parameter *Stream bed modifications*).

Method of determination

| Character of stream bed modifications | Percentage % | Partial score |
|---|--------------|---------------|
| Stream bed with no signs of modifications | | |
| Stone block paving | | |
| Concrete reinforcement | | |
| Culvert | - | - |
| Stream piping, covering | | |
| Regular stream channel dredging or other form of artificial deepening | | |
| Sediments and artificial substrate adding | | |
| RBM | | |

Principle of assessment

Character of stream bed modifications identified by mapping is assessed, for the scoring then the modification character itself and the percentage within a reach is taken into account.

Parameter scoring

The score for the parameter RBM is determined from the table below as the maximal value which corresponds to the combination of the particular categories of the character of stream bed modifications and the percentage of their occurrence in the given reach.

Table boxes with no value shown are not counted in assessment, thus having no effect on the resulting score.

| Category of stream bed modifications | Share of the category (r) as % of reach length | | |
|---|--|------------------|-------------|
| | $r < 10$ | $10 \leq r < 50$ | $r \geq 50$ |
| Stream bed with no signs of modifications | | | 1 |
| Stone block paving | 3 | 3 | 4 |
| Concrete reinforcement | 3 | 4 | 5 |
| Stream piping, covering | 4 | 5 | 5 |
| Regular stream channel dredging or other form of artificial deepening | 2 | 3 | 4 |
| Sediments and artificial substrate adding | 2 | 3 | 4 |

9. Woody debris and leafy debris in stream channel (LWD)

Source data

The mapping aims to identify the number of occurrences of woody debris and leafy debris in the given reach (HEM methodology, parameter *Woody debris and leafy debris in stream channel*).

Method of determination

| <i>Woody debris and leafy debris occurrence</i> | <i>Number of occurrences</i> | <i>Percentage %</i> |
|---|------------------------------|---------------------|
| Woody debris in stream channel | | |
| Leafy debris in stream channel | | |
| total | | |
| LWD | | |

Principle of assessment

The assessment includes the number of identified occurrences of woody debris and leafy debris, expressed for a unit of reach length.

Parameter scoring

The scoring proceeds in two steps.

1. First, the number of occurrences of woody debris and the number of occurrences of leafy debris are summarized and translated to 1 km of a stream (partial parameter RD).

Partial parameter RD is calculated as aggregate of the number of occurrences of all woody debris and leafy debris in the given reach, applied to 1 km of stream length.

$$RD = \frac{WD + LD}{L}$$

where is:

WD number of woody debris

LD number of leafy debris

L stream length in km

2. Second, based on the table, parameter score is assigned to the respective category.

The score for the parameter LWD is determined from the table below as a value which corresponds to the respective calculated value of partial parameter RD.

| <i>RD</i> | <i>LWD</i> |
|-------------------|------------|
| $RD \geq 20$ | 1 |
| $10 \leq RD < 20$ | 2 |
| $5 \leq RD < 10$ | 3 |
| $1 \leq RD < 5$ | 4 |
| $RD < 1$ | 5 |

III. River Bank and Floodplain

10. Bank modifications (BKM)

Source data

Field mapping of the character of the right and the left bank modifications (HEM methodology, parameter *Bank modifications*).

Method of determination

| Character of bank modifications | Percentage % | | Partial score | |
|--|--------------|------------|---------------|------------|
| | left bank | right bank | left bank | right bank |
| Bank with no signs of modifications | | | | |
| Vegetation reinforcement | | | | |
| Gabions | | | | |
| Semi-vegetation slabs | | | | |
| Stone rip-rap | | | | |
| Stone block paving | | | | |
| Concrete reinforcement | | | | |
| Contiguous modification of the profile | | | | |
| Maximum | | | | |
| BKM | | | | |

Principle of assessment

For individual categories, partial score is determined according to the table separately for the right and the left bank.

Parameter scoring

The score for the parameter BKM is determined separately for the left and the right bank from the table below as the maximal value which corresponds to the combination of the particular cross profile depth variation categories and the percentage of their occurrence in the given reach.

The resulting score of the parameter represents the maximal value identified in individual partial parameters on both banks.

| Category of bank modification | Share of the category (<i>r</i>) as % of reach length | | |
|--|---|------------------|-------------|
| | $r < 10$ | $10 \leq r < 50$ | $r \geq 50$ |
| Bank with no signs of modifications | 3 | 2 | 1 |
| Vegetation reinforcement | 1 | 2 | 3 |
| Gabions | 2 | 3 | 4 |
| Semi-vegetation slabs | 2 | 3 | 4 |
| Stone rip-rap | 2 | 3 | 4 |
| Stone block paving | 3 | 4 | 4 |
| Concrete reinforcement | 3 | 4 | 5 |
| Contiguous modification of the profile | 4 | 5 | 5 |

11. Bank vegetation (BKV)

Source data

Field mapping of occurrence of bank vegetation type categories separately for the right and the left bank (HEM methodology, parameter *Bank vegetation*).

Method of determination

| Predominant character of bank vegetation | Percentage % | | Partial score (according to table) | |
|--|--------------|------------|------------------------------------|------------|
| | Left bank | Right bank | Left bank | Right bank |
| Natural forest | | | | |
| Production forest | | | | |
| Gallery vegetation | | | | |
| Interrupted vegetation belts | | | | |
| Single trees, shrubs | | | | |
| High plants | | | | |
| Banks without vegetation | | | | |
| Maximum | | | | |
| BKV | | | | |

Principle of assessment

The percentage of occurrence of the particular bank vegetation categories within the given reach is assessed.

Parameter scoring

The score for this parameter is determined separately for the left and the right bank from the table below as the maximal value which corresponds to the combination of the particular cross profile depth variation categories and the percentage of their occurrence in the given reach.

Table boxes with no value shown are not counted in assessment, thus having no effect on the resulting score.

The resulting score of the parameter BKV represents the maximal value identified in individual partial parameters on both banks.

| Category of bank vegetation | Share of the category (r) as % of reach length | | | |
|------------------------------|--|------------------|------------------|-------------|
| | $r < 10$ | $10 \leq r < 50$ | $50 \leq r < 90$ | $r \geq 90$ |
| Natural forest | | 1 | 1 | 1 |
| Production forest | | 2 | 2 | 2 |
| Gallery vegetation | | 2 | 2 | 2 |
| Interrupted vegetation belts | 2 | 2 | 3 | 3 |
| Single trees, shrubs | 2 | 3 | 3 | 4 |
| High plants | 3 | 3 | 4 | 4 |
| Banks without vegetation | 3 | 4 | 5 | 5 |

12. Riparian zone land use (RZL)

Source data

Field mapping of the riparian zone land use categories separately for the right and the left bank. The riparian zone is delimited as a 50 m wide belt adjoining a stream channel (HEM methodology, parameter *Riparian zone land use*).

Method of determination

| Character of the riparian zone land use (Percentage %) | Riparian zone (up to 50 m from stream) | | Partial score (according to table) | |
|---|---|------------|---------------------------------------|------------|
| | Left bank | Right bank | Left bank | Right bank |
| Forest | | | | |
| Meadow | | | | |
| Pasture land | | | | |
| Water areas | | | | |
| Agricultural land | | | | |
| Scattered housing | | | | |
| Urban area, industry | | | | |
| Maximum | | | | |
| RZL | | | | |

Principle of assessment

The percentage of occurrence of the riparian zone land use character categories within the given reach is assessed.

Parameter scoring

The score for this parameter is determined separately for the left and the right bank separately from the table below as the maximal value which corresponds to the combination of the particular cross profile depth variation categories and the percentage of their occurrence in the given reach.

Table boxes with no value shown are not counted in assessment, thus having no effect on the resulting score.

The resulting score of the parameter RZL represents the maximal value identified in individual partial parameters on both banks.

| Category of the riparian zone land use | Share of the category (r) as % of reach length | | | |
|--|--|------------------|------------------|-------------|
| | $r < 10$ | $10 \leq r < 50$ | $50 \leq r < 90$ | $r \geq 90$ |
| Forest | | | 1 | 1 |
| Meadow | | 2 | 1 | 1 |
| Pasture land | | 2 | 2 | 2 |
| Water areas | - | - | - | - |
| Agricultural land | 2 | 3 | 3 | 3 |
| Scattered housing | 3 | 3 | 4 | 4 |
| Urban area, industry | 4 | 4 | 5 | 5 |

13. Floodplain land use (FPL)

Source data

Field mapping of floodplain land use categories separately for the right and the left bank (HEM methodology, parameter *Floodplain land use*).

Method of determination

| Character of floodplain land use (Percentage %) | Floodplain (entire width) | | Partial score (according to table) | |
|--|------------------------------|------------|---------------------------------------|------------|
| | Left bank | Right bank | Left bank | Right bank |
| Forest | | | | |
| Meadow | | | | |
| Pasture land | | | | |
| Water areas | | | | |
| Agricultural land | | | | |
| Scattered housing | | | | |
| Urban area, industry | | | | |
| Maximum | | | | |
| FPL | | | | |

Principle of assessment

The percentage of occurrence of the particular riparian zone land use character categories within the given reach is assessed.

Parameter scoring

The score for this parameter is determined separately for the left and the right bank from the table below as the maximal value which corresponds to the combination of the particular cross profile depth variation categories and the percentage of their occurrence in the given reach.

Table boxes with no value shown are not counted in assessment, thus having no effect on the resulting score.

The resulting score of the parameter FPL represents the maximal value identified in individual partial parameters on both banks.

| Predominant category | Share of the category (r) as % of reach length | | | |
|----------------------|--|------------------|------------------|-------------|
| | $r < 10$ | $10 \leq r < 50$ | $50 \leq r < 90$ | $r \geq 90$ |
| Forest | - | 1 | 1 | 1 |
| Meadow | - | 2 | 1 | 1 |
| Pasture land | - | 2 | 2 | 2 |
| Water areas | - | - | - | - |
| Agricultural land | 2 | 2 | 3 | 3 |
| Scattered housing | 2 | 3 | 4 | 4 |
| Urban area, industry | 3 | 4 | 5 | 5 |

IV. Flow and hydrological regime

14. Character of flow (FLO)

Source data

Field mapping of the basic flow type categories in the given reach (HEM methodology, parameter *Character of flow*).

Method of determination

Percentage of particular flow character categories in the reach.

| Character of flow | Percentage % |
|------------------------------|--------------|
| Waterfall | |
| Steps, cascade | |
| Reach with riffles | |
| Tide | |
| Glide | |
| Pools | |
| Impoundment | |
| Number of flow types | |
| Average stream channel width | |
| FLO | |

Principle of assessment

The number of flow types occurring in the given reach in relation to average stream channel width is assessed. Average stream channel width B_A is determined as arithmetic average of the minimal and the maximal stream channel width identified by the mapping (see parameter Stream channel width variation, p. 9).

Parameter scoring

The score for the parameter FLO is determined from the table below as the maximal value which corresponds to the combination of the particular flow type number categories and average stream channel width in the given reach.

| Number of flow types | Average channel width B_A (m) | | |
|----------------------|---------------------------------|--------------------|---------------|
| | $B_A < 10$ | $10 \leq B_A < 30$ | $B_A \geq 30$ |
| 1 | 5 | 4 | 3 |
| 2 | 3 | 2 | 2 |
| 3 and more | 1 | 1 | 1 |

15. Hydrological regime modifications (HRM)

Source data

Field mapping of the percentage of hydrological regime modification categories within a reach (HEM methodology, parameter *Hydrological regime modifications*)

Method of determination

| <i>Artificially modified discharge</i> | <i>Percentage %</i> | <i>Partial score</i> |
|--|---------------------|----------------------|
| Dynamics without changes | | |
| Periodic impoundment | | |
| Permanent impoundment / discharge regulation | | |
| Water abstraction / discharge | | |
| HRM | | |

Principle of assessment

The percentage of occurrence of the selected hydrological regime modification categories in the given reach is assessed.

Parameter scoring

The score for the parameter HRM is determined from the table below as the maximal value which corresponds to the combination of the particular hydrological regime modification categories and the percentage of their occurrence in the given reach.

| <i>Category</i> | <i>Share of the category (r) as % of reach length</i> | | |
|--|---|---------------------------------------|-------------------------------|
| | <i>$r < 10$</i> | <i>$10 \leq r < 50$</i> | <i>$r \geq 50$</i> |
| No artificial modification | 1 | 1 | 1 |
| Periodic impoundment, water abstraction, discharge | 2 | 3 | 5 |
| Permanent impoundment / discharge regulation | 2 | 3 | 5 |

16. Continuity of floodplain (FPC)

Source data

Field mapping of features representing potential barriers to longitudinal and lateral continuity of the floodplain, separately for the right and the left bank (HEM methodology, parameter *Continuity of floodplain*).

Method of determination

| Type of structure in floodplain | Occurrence | |
|---|------------|------------|
| | Left bank | Right bank |
| Structures running across floodplain -road and railway embankments, etc. (number) | | |
| Flood control dikes and levees along stream channel (percentage %) | | |
| Structures running parallel to stream channel – road and railway embankments, etc. (percentage %) In case of occurrence, distance from stream channel should be stated | | |

| Continuity of floodplain | Value | Partial score |
|---|-------|---------------|
| Number of structures across floodplain | | |
| Average percentage of longitudinal dikes and levees % | | |
| FPC | | |

Principle of assessment

The occurrence of structures constraining longitudinal and lateral continuity of the floodplain is assessed.

Parameter scoring

The scoring proceeds in two steps. First, the score is calculated separately for partial parameters (barriers to longitudinal continuity (BL) and barriers to lateral continuity (BT) of the floodplain). The resultant score of the parameter is then calculated as their arithmetic average.

The score for partial parameter showing barriers to longitudinal continuity of the floodplain (BL) is determined from the table below on the basis of the number of cross barriers occurring in the given reach.

| Category | Number | 0 | 1 | 2+ |
|--|--------|---|---|----|
| Structures running across floodplain -road and railway embankments, etc. | 1 | | 3 | 5 |

The score for partial parameter showing barriers to lateral continuity of the floodplain (BT) is determined from the table below as the maximal value which corresponds to the combination of the percentage of the particular longitudinal barriers occurring in the given reach.

| Category | Share of the category (r) as % of reach length | | | | |
|--|--|-----------------|------------------|------------------|-------------|
| | $r < 1$ | $1 \leq r < 10$ | $10 \leq r < 50$ | $50 \leq r < 90$ | $r \geq 90$ |
| Flood control dikes and levees running along stream channel | 1 | 2 | 3 | 4 | 5 |
| Structures running parallel to stream channel – road and railway embankments, etc. | 1 | 2 | 3 | 4 | 5 |

The resultant score of the parameter FPC is calculated as arithmetic average of the value of partial parameters BL and BT:

$$FPC = \frac{BL + BT}{2}$$

17. Discharge variation (QVA)

Source data

Average daily discharge values and average annual discharge values for the time period of min. 3 years at the respective gauging station in the waterbody.

If there is no gauging station available in the respective waterbody the parameter will be assessed analogically to the closest hydrologically similar catchment.

Method of determination

| | |
|-----------------------|-------|
| Discharge variation | Value |
| Variation coefficient | |
| QVA | |

Principle of assessment

Daily discharge variation within a year, expressed on the basis of variation coefficient, is assessed.

Parameter scoring

The scoring proceeds in two steps.

First, based on daily discharge set, variation coefficient C_v is calculated.

Then the resultant score is determined by assignment according to the table.

Variation coefficient C_v , the basic measure of data variability, is calculated as a ratio of standard deviation to average value of the set, here average annual discharge and is expressed in per cent (1) and (2).

$$C_v = \frac{\sigma}{Q_a} \times 100, \quad (1)$$

whereas:

$$\sigma = \sqrt{\frac{\sum_{i=1}^n (Q_d - Q_a)^2}{n}}, \quad (2)$$

where σ means standard deviation,
 Q_a means average annual discharge,
 Q_d means average daily discharge,
 n means the number of members of the set.

Assignment of the score on the basis of variation coefficient value is done according to the table below.

| Flow rate/Discharge variation | Value C_v | QVA |
|-------------------------------|-------------|-----|
| Very high | 80 and more | 1 |
| High | 70-80 | 2 |
| Medium | 50-70 | 3 |
| Low | 30-50 | 4 |
| Very low | 0-30 | 5 |