# PRINCIPLED WATER MANAGEMENT CONCEPT OF 2000 - overview

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THE FUTURE OF BORDER MURA

BILATERAL CONFERENCE

Radenci, Slovenia

8. - 9. May 2019

# Principled Water Management Concept

- The Principled Water management concept for border Mura of 2000 (PWMC) is a crucial water management document!
- Is a result of long going cross border cooperation
- Presents the basis for „Border Mura 2030“ plan to be developed in goMURra project
- Within goMURra an evaluation of PWMC has been prepared as a first step in preparing the „Border Mura 2030“ plan

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# PWMC structure

- Three fields of work and numerous thematic areas (t.a.):

- Water management:
  - t.a. 1.1 – floods
  - t.a. 1.2 – changes in riverbed
  - t.a. 1.3 – sediment transport basis
  - t.a. 1.4 – river morphology
  - t.a. 1.5 – water engineering structures
  - t.a. 1.6 – sediment transport model
  - t.a. 1.7 – low water analysis
- River ecology:
  - t.a. 2.1 – ichthyological assessment
  - t.a. 2.2 – HM Structures
  - t.a. 2.3 – macrozoobenthos
- Vision:
  - t.a. 1.18 – vision: water management aspect
  - t.a. 2.18 – vision: ecological aspect
  - t.a. 0.18 – vision discussion

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→ Result: 17 volumes with over 1200 pages and ~ 60 maps

# Water Management

- t.a. 1.1 – floods
- t.a. 1.2 – changes in riverbed
- t.a. 1.3 – sediment transport basis
- t.a. 1.4 – river morphology
- t.a. 1.5 – water engineering structures
- t.a. 1.6 – sediment transport model
- t.a. 1.7 – low water analysis

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# Them. area 1.1 – floods

- Purpose: analysis of flood hazard and support other thematic areas.
- Methodology:
  - 1-D flow model (HEC RAS) with 351 computational sections (between Ceršak dam and bridge in Petanjci)
  - Model calibrated on measurements at 360, 1000 and 1108 $m^3/s$
- Results:
  - Flow results for Q30 (1490 $m^3/s$ ) and Q100 (1800 $m^3/s$)
  - Flood maps
- Comments:
  - 1D analysis outdated by today's standards for analysing flow such as river Mura
  - Authors commented on lack of measurements for calibration

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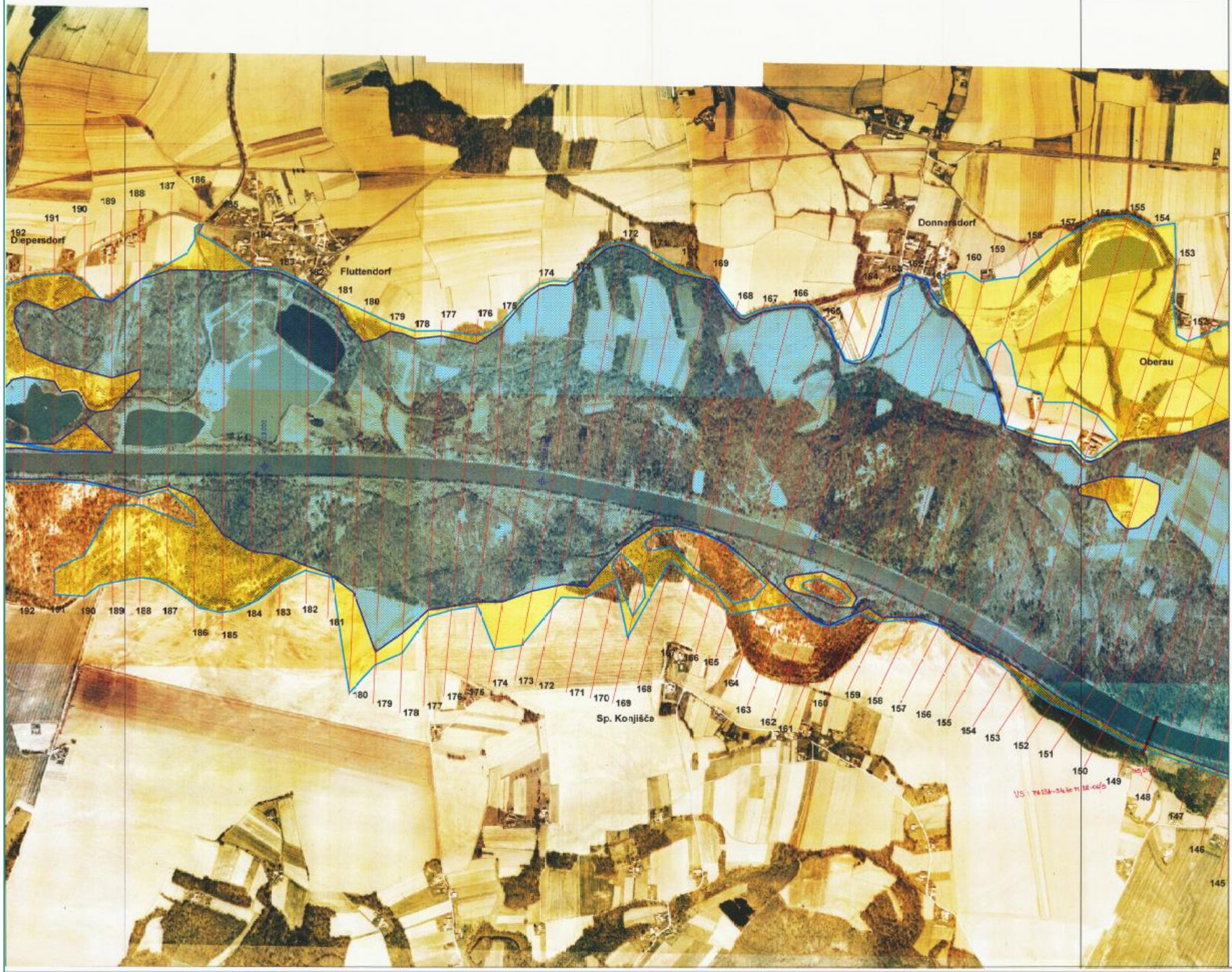


## Legenda

- Q100
- Q30
- Profil
- Kilometraža

N W E S

## Pretoki in kote gladin

| PROF. | STAC. km | Q30 m3/s | E30 m | Q100 m3/s | E100 m | Qr.l. m3/s | Qr.d. m3/s |
|---|---|---|---|---|---|---|---|
| 192 | 113.861 | 1490 | 225.12 | 1800 | 225.89 | 1135 | 1138 |
| 191 | 113.763 | 1490 | 225.01 | 1800 | 225.68 | >1800 | 1015 |
| 190 | 113.645 | 1490 | 224.90 | 1800 | 225.26 | >1800 | 1118 |
| 189 | 113.546 | 1490 | 224.75 | 1800 | 225.19 | >1800 | 1196 |
| 188 | 113.466 | 1490 | 224.66 | 1800 | 225.10 | 1084 | 1100 |
| 187 | 113.345 | 1490 | 224.52 | 1800 | 224.96 | 1113 | 1032 |
| 186 | 113.245 | 1490 | 224.39 | 1800 | 224.81 | 1065 | 1523 |
| 185 | 113.146 | 1490 | 224.28 | 1800 | 224.71 | 1042 | 1207 |
| 184 | 113.045 | 1490 | 224.19 | 1800 | 224.64 | 1100 | 1192 |
| 183 | 112.945 | 1490 | 224.08 | 1800 | 224.53 | 1019 | 1224 |
| 182 | 112.845 | 1490 | 223.97 | 1800 | 224.33 | 1086 | 1376 |
| 181 | 112.714 | 1490 | 223.78 | 1800 | 224.24 | 1088 | 1245 |
| 180 | 112.651 | 1490 | 223.66 | 1800 | 224.08 | 1112 | 1240 |
| 179 | 112.569 | 1490 | 223.58 | 1800 | 224.02 | 1087 | 1182 |
| 178 | 112.477 | 1490 | 223.53 | 1800 | 223.98 | 1044 | 1091 |
| 177 | 112.366 | 1490 | 223.39 | 1800 | 223.81 | 868 | 1132 |
| 176 | 112.283 | 1490 | 223.22 | 1800 | 223.62 | 949 | 966 |
| 175 | 112.174 | 1490 | 223.08 | 1800 | 223.51 | 929 | 1038 |
| 174 | 112.068 | 1490 | 223.01 | 1800 | 223.45 | 1082 | 1181 |
| 173 | 111.981 | 1490 | 222.83 | 1800 | 223.30 | 792 | 1067 |
| 172 | 111.866 | 1490 | 222.58 | 1800 | 223.25 | 1174 | 1080 |
| 171 | 111.786 | 1490 | 222.46 | 1800 | 223.05 | 1120 | 1048 |
| 170 | 111.670 | 1490 | 222.34 | 1800 | 222.66 | 979 | 1069 |
| 169 | 111.572 | 1490 | 222.23 | 1800 | 222.63 | 936 | 1016 |
| 168 | 111.491 | 1490 | 222.07 | 1800 | 222.40 | 957 | 925 |
| 167 | 111.389 | 1490 | 221.92 | 1800 | 222.21 | 781 | 940 |
| 166 | 111.299 | 1490 | 221.81 | 1800 | 222.11 | 1072 | 1050 |
| 165 | 111.207 | 1490 | 221.70 | 1800 | 221.97 | 1096 | 961 |
| 164 | 111.117 | 1490 | 221.55 | 1800 | 221.81 | 1084 | 1255 |
| 163 | 111.025 | 1490 | 221.42 | 1800 | 221.60 | 1153 | 1329 |
| 162 | 110.935 | 1490 | 221.32 | 1800 | 221.70 | 1122 | 1248 |
| 161 | 110.846 | 1490 | 221.20 | 1800 | 221.52 | 1032 | 1219 |
| 160 | 110.753 | 1490 | 221.10 | 1800 | 221.32 | 931 | 1104 |
| 159 | 110.602 | 1490 | 220.88 | 1800 | 221.05 | 977 | 910 |
| 158 | 110.564 | 1490 | 220.73 | 1800 | 221.01 | 971 | 911 |
| 157 | 110.464 | 1490 | 220.58 | 1800 | 220.85 | 974 | 939 |
| 156 | 110.367 | 1490 | 220.41 | 1800 | 220.72 | 752 | 969 |
| 155 | 110.269 | 1490 | 220.22 | 1800 | 220.44 | 1054 | 1070 |
| 154 | 110.170 | 1490 | 220.06 | 1800 | 220.25 | 1083 | 1194 |
| 153 | 110.071 | 1490 | 219.95 | 1800 | 220.16 | 1045 | 1309 |
| 152 | 109.972 | 1490 | 219.82 | 1800 | 220.09 | 983 | 1366 |
| 151 | 109.874 | 1480 | 219.70 | 1800 | 219.93 | 916 | 1401 |
| 150 | 109.768 | 1490 | 219.44 | 1800 | 219.74 | 923 | 849 |
| 149 | 109.665 | 1490 | 219.16 | 1800 | 219.69 | 942 | 1214 |

## M 1:5000

300 m 0 300 m 600 m

# NAČELNA VODNOGOSPODARSKA ZASNOVA ZA MEJNO MURO
## I. faza, 1998-2000

Stalna slovensko - avstrijska komisija za Muro

## Tematsko področje 1.1

Označitev pretoka do roba polne struge in območij 30-letne in 100-letne visoke vode

Situacija - list 5

| OBDELOVALEC: | DATUM/ODDAJA OBDELOVALCA |
|---|---|
| VODNOGOSPODARSKI INŠTITUT (VGI) Hajdrihova 28, SLO-1115 Ljubljana<br>Dipl.-Ing. Dr. techn. Kurt KRATZER Glacisstraße 57, Graz | 30. 6. 2000 |

| | | | |
|---|---|---|---|
| Merilo načrta: | 1:5000 | Obdelal: dr. M. Četina, Rok Fazarinc, dr. K. Kratzer, mag. A. Vidmar, M. Zabrajšek, M. Zorčak, dr. G. Zagar | |
| Številka načrta: | 5/10 | | |
| Velikost načrta: | DIN A0 | | |
| Merilo podlog: | 1:5000 | Digitalne podlage: Digitalni ortofoto posnetki | |
| Datum izdelave podlog: | 31. 05. 1999 | | |
| Izdaja načrta: | junij 2000 | Izvedrokolne podlage: Profili, merjene gladine in pretoki | |
| Vložek št.: | 1.1/3.5 | Izvod: A | |

# Them. area 1.2 – changes in riverbed

- Purpose: show riverbed changes and areas of gravel deposits (areas suitable for widenings).
- Methodology:
  - Riverbed analysis based on regular measurements of 14 cross sections in the period 1971 – 2000
  - Analysis of erosion areas based on 79 gravel extractions (only in Austria)
- Results:
  - Riverbed analysis:
    - riverbed deepening on average ~ 50 cm
    - annual gravel outflow of 29.000 m3
    - Spatial and temporal representation od riverbed dynamics
  - Erosion areas:
    - Maps of gravel deposits and depth of tertiary layer (only in Austria) – best locations at Dietzendörfl and Gassdorf
- Comments:
  - More accurate assessment of riverbed changes possible with modern technology (terrain model)
  - Gravel deposits assessed only for the Austrian side

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# Them. area 1.3 – sediment transport basis

- Purpose: to prepare information for establishing a sediment model in t.a. 1.6.
- Methodology:
  - Analysed 30 linear and volumetric samples of river sediments
  - Assessment of drag forces based on 20 flow measurements
- Results:
  - Sediment samples indicate long duration of riverbed deepening (before regular measurements of cross sections since 1970)
  - Input data for the sediment model: sediment composition, drag forces (both from measurements and modelling done in t.a. 1.1.), calculated start of sediment transport.

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# Them. area 1.4 – river morphology

- Purpose: to assess the state regarding hydromorphology and propose measures.
- Methodology:
  - Comparison of current state and state before regulation works in late 19th century
- Results:
  - 19th century Mura was a braided river and in dynamically stable state (regarding changes in riverbed)
  - Current state assessed for 5 sectors of the border Mura
  - Comparison shows reduced river dynamics, especially in sectors 3 (G. Radgona – Petanjci) and 5 (Mureck – G. Radgona).
  - Sectors 3 and 5 are areas where measures for increasing river dynamics are most suitable
- Comments:
  - A very comprehensive analysis with room for modernisation (e.g. DPSIR approach)

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# Them. area 1.5 – water engineering structures

- Purpose: overview of current state of water engineering structures, evaluation of different variants of measures, and define (general) measures locations
- Methodology:
  - variants of measures evaluated based on 13 indicators (most qualitative) for reaching 4 goals
- Results:
  - A description of history of regulation works with description of structures
  - Evaluation of 6 possible variants of measures – best proposed solution: river widenings to approx. 200 m
  - Separate analysis of measure locations (one for Austria, one for Slovenia)
- Comments:
  - Results of evaluation of variants prone to subjective results (many qualitative indicators)
  - Different analyses of measure locations (due to lack of geology knowledge on Slovene side). Room for improvement regarding land ownership, and contributions to other goals (e.g. Natura 2000 goals).

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# Them. area 1.6 – sediment transport model

- Purpose: propose measures for long term riverbed stabilisation
- Methodology:
  - Model MORMO: sediment data (t.a. 1.3), hydrological data (Mureck), cross sections (from 1998), and calibration data (t.a. 1.2)
  - Analysis period – 60 years (105 years) from 1995 onward
- Results:
  - Analysis of several variants with a well calibrated model shows:
    - Stabilisation can be reached with annual input of 13.600 $m^3$ of gravel (20 lorries per week)
    - Best solution proposed: river widenings (included 2.500 $m^3$ gravel inflow on upstream border per year)
- Comments:
  - Possible improvements regarding: hydrological prognosis (climate change), better side erosion model, improve knowledge on geology (Slovene side and depth of tertiary layers), measurements of gravel flow at Cersak.

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# Them. area 1.6 – sediment transport model

- Proposed best solution to stabilise river bed for 60 years:
  - gravel input at Ceršak (2.500 $m^3$ per annum)
  - 4 widenings at different times:
    - Widening A (km 114,8-115,8) to 150 m in years 0-15,
    - Widening C1 (km 109,1-112,6) to 146 m in years 15-30,
    - Widening B (km 106,1-109,1) to 144 m in years 30-45 and
    - Widening C2 (km 102,7-106,1) to 150 m in years 45-60
  - Activation of certain smaller gravel hotspots (D1 in km 122,7-128,5 and D2 in km 118,8-122,3).
- For long term stabilisation in Radgona/Radkersburg (proposed bed enhancement – measure E in km 97-102,7) not needed until year 105 (2100).

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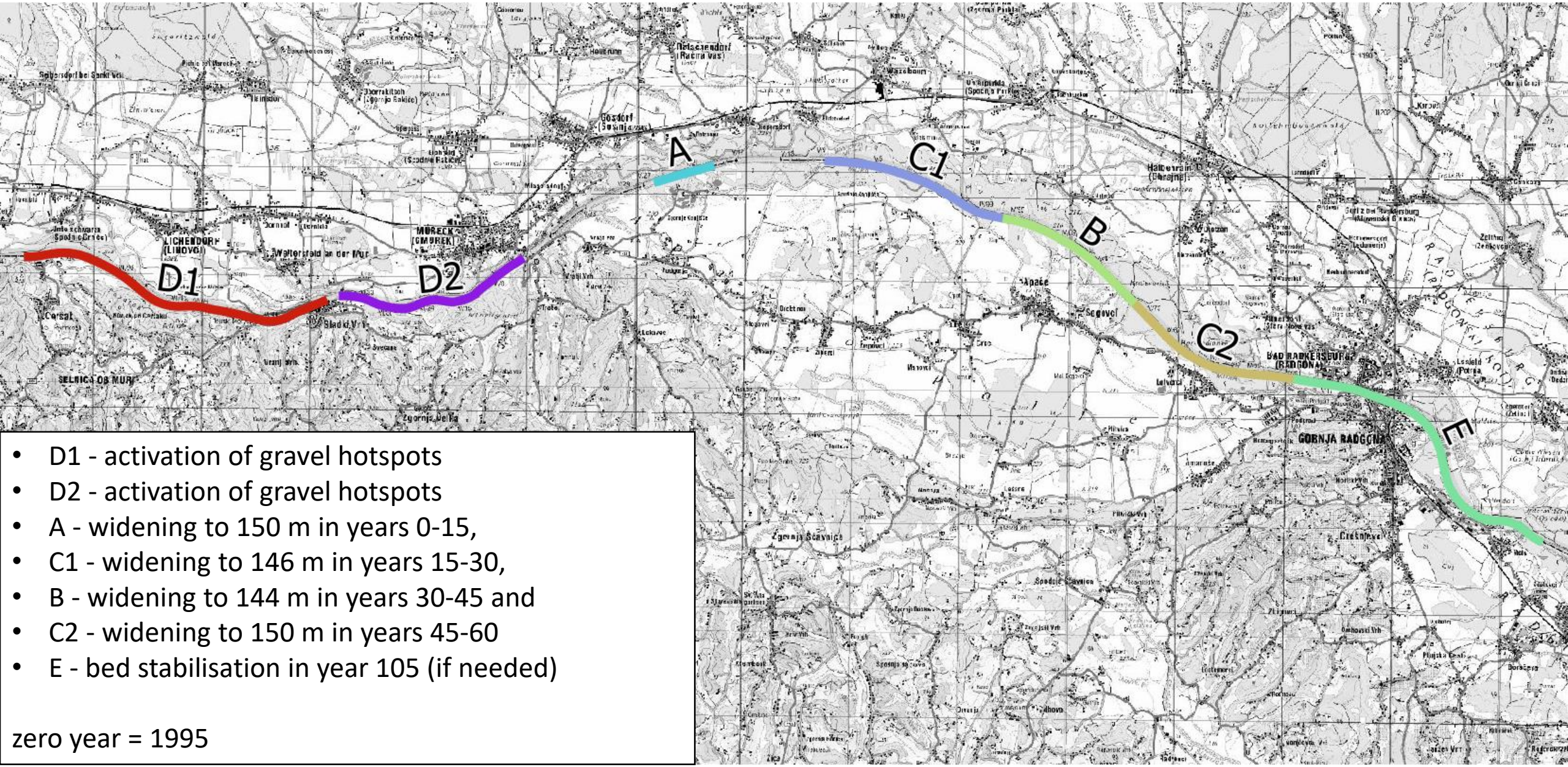


- D1 - activation of gravel hotspots
- D2 - activation of gravel hotspots
- A - widening to 150 m in years 0-15,
- C1 - widening to 146 m in years 15-30,
- B - widening to 144 m in years 30-45 and
- C2 - widening to 150 m in years 45-60
- E - bed stabilisation in year 105 (if needed)

zero year = 1995

# Them. area 1.7 – low water analysis

- Purpose: analysis of low waters and computation of low water levels
- Methodology:
  - Analysis of low water levels with data from 4 water gauge stations
  - Computation of low water levels using the numerical model from t.a. 1.1
- Results:
  - Calculations of water levels for three low water discharges (64 $m^3/s$, 58 $m^3/s$ and 40,5 $m^3/s$)
  - Measurements are not fully consistent between gauging stations (notable differences)
  - Comparison of daily average low waters and daily minimum low waters indicates daily changes in water levels (operation of upstream dams?)
- Comments:
  - Reasons for differences between water gauging stations are not well understood.

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# River Ecology

- t.a. 2.1 – ichthyological assessment
- t.a. 2.2 – HM Structures
- t.a. 2.3 – macrozoobenthos

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# Them. area 2.1 – ichthyological assessment

- Purpose: to assess and evaluate state of fish biota
- Methodology:
  - Reference state was defined as state of Mura before regulations in late 19. century. Reference state was assessed based on historical and previous research.
  - Actual state was assessed based on previous research and sampling (electric fishing)
- Results:
  - Historical state: 52 fish species covering all 16 ecological groups
  - Current state: 54 fish species (also non indigenous) covering 14 groups, but several populations degraded (low number of individuals, low biomass).
  - Changes in populations are consistent with HM degradation of river sectors (t.a. 2.2)
  - To improve status it is crucial to establish high variety of water environments.
- Comments:
  - Proposed enhancement of the analysis.

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# Them. area 2.2 – HM Structures

- Purpose: analyse HM, structural specifics and connectivity (for t.a. 2.1), and analysis of riparian vegetation.
- Methodology:
  - HM assessment based on mapping structures per sections of border Mura: 14 types of structures mapped on 3 out of 6 sections
- Results:
  - Assessment of 3 sections shows different attractiveness for fish biota,
  - Assessment of riparian vegetation shows main habitat types that are under stress. Proposals for improvements include: rising underground water level, inducing river dynamics, improving water quality, reduce non indigenous plants and improve forestry and agricultural practices.
  - Analysis of connectivity shows high downstream connectivity, and very limited lateral connectivity
- Comments:
  - HM analysis only covered 3 out of 6 sections, knowledge of riparian vegetation is very limited.

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# Them. area 2.3 – macrozoobenthos

- Purpose: offer insight into state of macrozoobenthos
- Methodology:
  - Based on literature and mainly on sampling according to module 1 of current Austrian guidelines (level of analysis: orientative saprobiological survey)
- Results:
  - Identified 109 taxa (dominant filtrators and grazers)
  - Saprobiological level II-III (alpha mezosaprobial – beta mezosaprobial)
  - Despite evident pressures, the macrozoobenthos cinosis shows big potential for revitalising Mura and tributaries – proposed increase in river dynamics
- Comments:
  - Study offers only a very limited insight. More surveys on higher level of analysis proposed.

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# Vision

- t.a. 1.18 – vision: water management aspect
- t.a. 2.18 – vision: ecological aspect
- t.a. 0.18 – vision discussion

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# Them. area 1.18 – vision: water management aspect

- Purpose: prepare a vision for border Mura and propose measures.
- Methodology:
  - The vision was developed by forming the „ideal vision“, analysing key deficits and proposing an „operational vision“.
- Results:
  - The ideological vision was defined as the state of Mura before anthropogenic pressures (source: 3rd military survey map), and was described for 5 sections of the border Mura (5 parameters)
  - Two deficits were defined: HM (reduction of width, reduction of side channels, increased radius…) and water management (bed instability, effects to infrastructure…)
  - Operational vision was proposed as: increasing width to 200 – 250 m (where possible) as a starting point. As a permanent solution the following is proposed: offer even more space to river dynamics (sediment and habitats) and secure upstream gravel inflow.
  - Operational vision was spatially represented by description of measures to be undertaken on 5 sections (sections A, B, C, D and E).
- Comments:
  - A phase II PWMC is proposed (before executing measures) that would answer questions regarding land ownership, more cohesion between WM and habitat goals, inclusion of ground water, confluents, and monitoring of a pilot measure. The proposed measures are securing 60 years stability. In this time upstream inflow of gravel should be secured.

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# Them. area 2.18 – vision: ecological aspect

- Purpose: prepare a vision for border Mura and propose measures.
- Methodology:
  - The vision was developed by forming the „ideal vision“, analysing key deficits and proposing an „operational vision“.
- Results:
  - The ideal vision was based on descriptions of the 19th. century Mura. This means a very dynamic ecosystem with high diversity (52 fish species covering all 16 ecological groups).
  - Two types of deficits were defined: fish ecology deficits (deficits for 15 ecological groups) and river system deficits. Both show a lack of living area diversity.
  - Proposed measures for improving state tackle this lack of diversity: (shallow, deep water, with low and fast flows, connected and unconnected side arms, connection with tributaries…). The proposed widenings are seen as a step towards the ecological vision, but not sufficient.
- Comments:
  - Improve knowledge (especially for macrozoobenthos).

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# Them. area 0.18 – vision discussion

- Purpose: to form a common transboundary operational vision (vision discussion) of the border Mura.
- Methodology:
  - Two sectoral visions and 4 workshops as a basis for forming a common approach to reaching main goals:
    - reduce bed erosion,
    - reduce flood risk and
    - enable a dynamic river system.
- Results:
  - Description of WM measures for 5 sections of border Mura (A, B, C1, C2, D1, D2 and E) and ecological approach for the whole border Mura.
- Comments:
  - Knowledge lacks; vision not very operational (need for phase II). Only two sectoral views acknowledged addressing three goals (not including problems such as: groundwater connections, water balance, water needs, not including sidearm and tributaries).
  - ‚New' important concepts to consider: climate change adaptation (and others)

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# Conclusions

- PWMC is a comprehensive source of knowledge and inspiration
- It covered a broad field of work to develop a long-term strategy for border Mura and proposed measures

- After 18 years it is time to rethink this
- To prepare a new (upgraded) plan for the future

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# THANK YOU!

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