Low flows and impacts on the Rhine – (recent) study results of the ICPR expert group Low Flows

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IKSR CIPR ICBR

Internationale Kommission zum Schutz des Rheins

Commission Internationale pour la Protection du Rhin

Internationale Commissie ter Bescherming van de Rijn

International Commission for the Protection of the Rhine

Confluence of the R. Nahe with the Rhine at Bingen, November 2011

ICPR expert group LW

CH: Caroline Kan (BAFU)

F: Anne Toussirot (DREAL)

GER: Herbert Walter (WWA Aschaffenburg)

LUX: Noémie Patz (Adm. de la Gestion de l'Eau)

NL: René van den Heuvel (Rijkswaterstaat)

ZKR (observer): Kai Kempmann (ZKR)

Alsace Nature (observer): Jean Wencker

Presidency: Gerhard Brahmer (HLNUG)

Secretariat: Adrian Schmid-Breton (ICPR)

Why are we working in this group?

15th Conference of Rhine Ministers (Basel, Oct. 2013)

Extract from the communiqué on “Low water”:

“In the near future the ICPR will decide on further steps, eventually on an ICPR low water (management) plan”.

Issue treated since then by the ICPR WG H

Establishment of an EG “Low Water” in 2016

1st meeting of the EG LW 17 January 2017

Structure

(1) Mandate

(2) Definitions and approach

(3) Monitoring stations and data basis

(4) Inventory

(5) Analysis of historic discharge series

(6) Exchange with ICPMS

(7) Outlook

(1) Mandate of the EG LW

1. **Survey of knowledge on low flow in the IRBD Rhine**

   - Analysis of low flow events by gauge-related evaluation of monitoring data (long term),
   - Analysis and description of selected extreme low flow events,
   - Compilation of impacts on low flow and things affected by low flows,
   - Considerations on the impacts of climate change on low flow using the results of the EG KLIMA/CHR-Rheinblick 2050 and transfer of the change factors determined (textual presentation)
   - Exchange on national low flow monitoring, on aspects of low flow management and transboundary aspects.

(1) Mandate of the EG LW

2. **Establishment of low flow monitoring** (monitoring network and parameters)

3. **Exchange of information with the other working groups** WG S and WG B and eventually further uses with respect to specific impacts

4. Drafting of a **contribution** (report) for the ICPR WG H resulting from the mandate of the Conference of Rhine Ministers 2013 (and in the run-up to the next **Conference of Rhine Ministers**) with deliverables, state of knowledge and on the **relevance/necessity of an ICPR low water management plan**

(2) Definitions and approach

The DIN standard 4049 defines “**low water**” as
 “State of a surface water body in which the water level or discharge has reached a certain value (threshold value) or fallen below it”.

Very subjective, threshold value depending on usage or authorised values, no comparability (WS, Q)

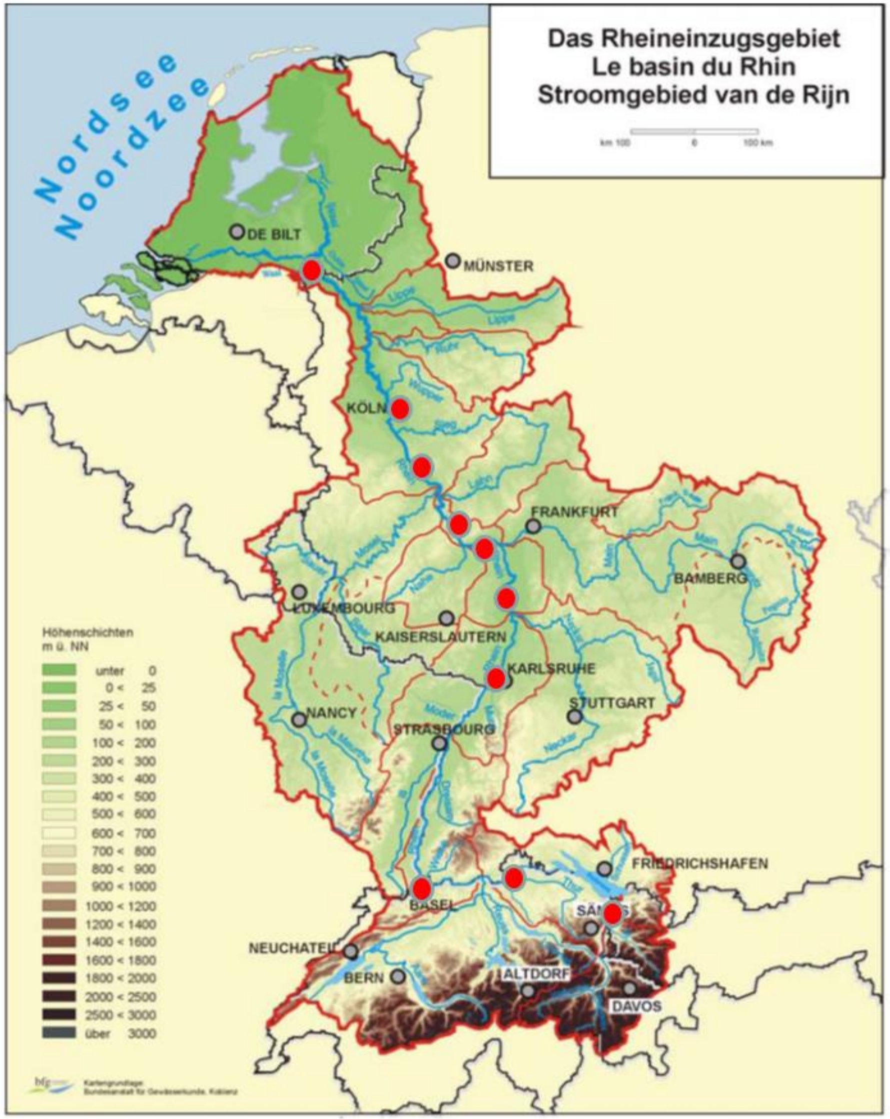
We analyse low flow parameters related to discharge and which are current in hydrology:

Low flow discharge: NM7Q (1, 3, 7, 21, 60 days)

Low flow duration: maxD < MNM7Q
Mean **A**nnual **M**inimum (7days)

Threshold values: Above values of defined return periods

(3) Monitoring stations and data basis



Average daily discharge 1920-2015

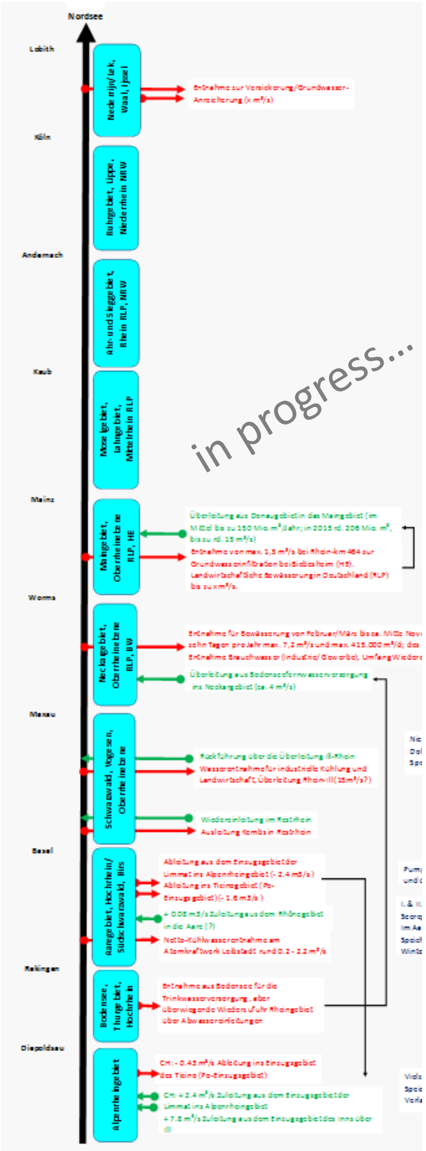
Monitoring sites

MNM7Q an Rheinpegeln:

(1961 -2011)

Lobith	1095 m³/s
Köln	1028 m³/s
Andernach	998 m³/s
Kaub	851 m³/s
Mainz	850 m³/s
Worms	720 m³/s
Maxau	645 m³/s
Basel	527 m³/s
Rekingen	238 m³/s
Diepoldsau	92 m³/s

(4) Inventory: Diversion of water and abstractions, lag time of discharge by management



Expansion and management of reservoir volumes
(Total reservoir volume upstream of Basel is in excess of 1.8 billion m³ with retention during the summer and release during the winter)

Diversion of water and abstractions (max. daily values)

Diversion into Ticino catchment		-0.43 m³/s
Diversion from R. Inn vial R. Ill		+7.8 m³/s
Abstraction Lake Constance	~	- 4 m³/s
Return flow via R. Neckar	~	+ 4 m³/s
Diversion into Ticino catchment		-1.6/s
Diversion from Rhone area		+0.08 m³/s
Abstraction for irrigation	up to	- 4.8 m³/s
Abstraction to raise ground water	up to	- 1.5 m³/s
Diversion from Danube area	up to	+15 m/s
		=========
		+ 14.5 m³/s

plus surplus discharge in winter ~~ + 60 m³/s ?
(Due to reservoir management) (+ 40 to +80 m³/s)

(4) Inventory: Impacts

Impacts on water quality and ecology *(see Laura Gangi's presentation)*

During low water events in summer with high water temperatures (as in 2003): Fish and mussel die-offs

Impacts due to usage

Water provision - abstraction restrictions

Agriculture - Ban on abstracting water from groundwater or surface waters

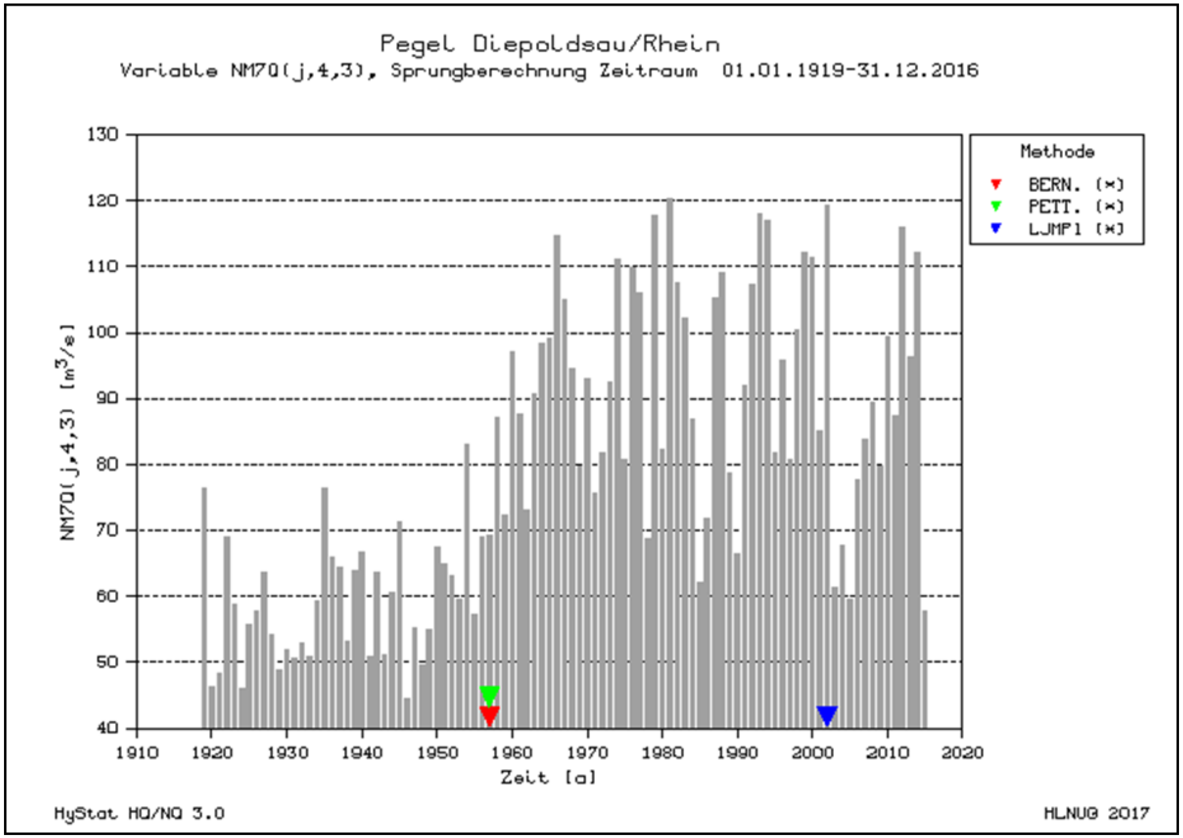
Energy production - restrictions on thermal discharges
- reduced power plant output
- increased prices for electricity

Navigation = main transboundary affected actor
less loading capacity (in 2003 only 20-30 %)

Industry - supply of raw materials and sources of energy

Security - instability of protecting dikes in the Netherlands (2003 subsidence of peat dikes)

NM7Q development:
Human footprint at the alpine Rhine



Storage volume of reservoirs

Rheinabschnitt bzw. Nebenfluss	Volumen [hm³]	Summe des Volumens [hm³]
Vorderrhein	253,14	253,14
Hinterrhein	289,36	542,50
Tamina	38,50	581,00
Ill (A)	183,40	764,40
Bregenzerach	8,40	772,80
Bodensee	1,40	774,20
Thur	0,60	774,80
Hochrhein (CH)	7,26	782,06
Aare	496,95	1279,01
Reuss	153,19	1432,20
Limmat	314,86	1747,06
Hochrhein (D)	112,85	1859,91
Oberrhein	27,63	1887,54
Ill (F)	24,29	1911,83
Neckar	37,99	1949,82
Main	59,64	2009,46
Nahe	14,05	2023,51
Lahn	6,63	2030,14
Moselle	103,58	2133,72
Mosel	50,53	2184,25
Sauer	71,40	2255,65
Wied	4,45	2260,10
Ahr	0,73	2260,83
Sieg	123,10	2383,93
Wupper	140,43	2524,36
Erft	51,00	2575,36
Ruhr	496,06	3071,42
Lippe	50,01	3121,43

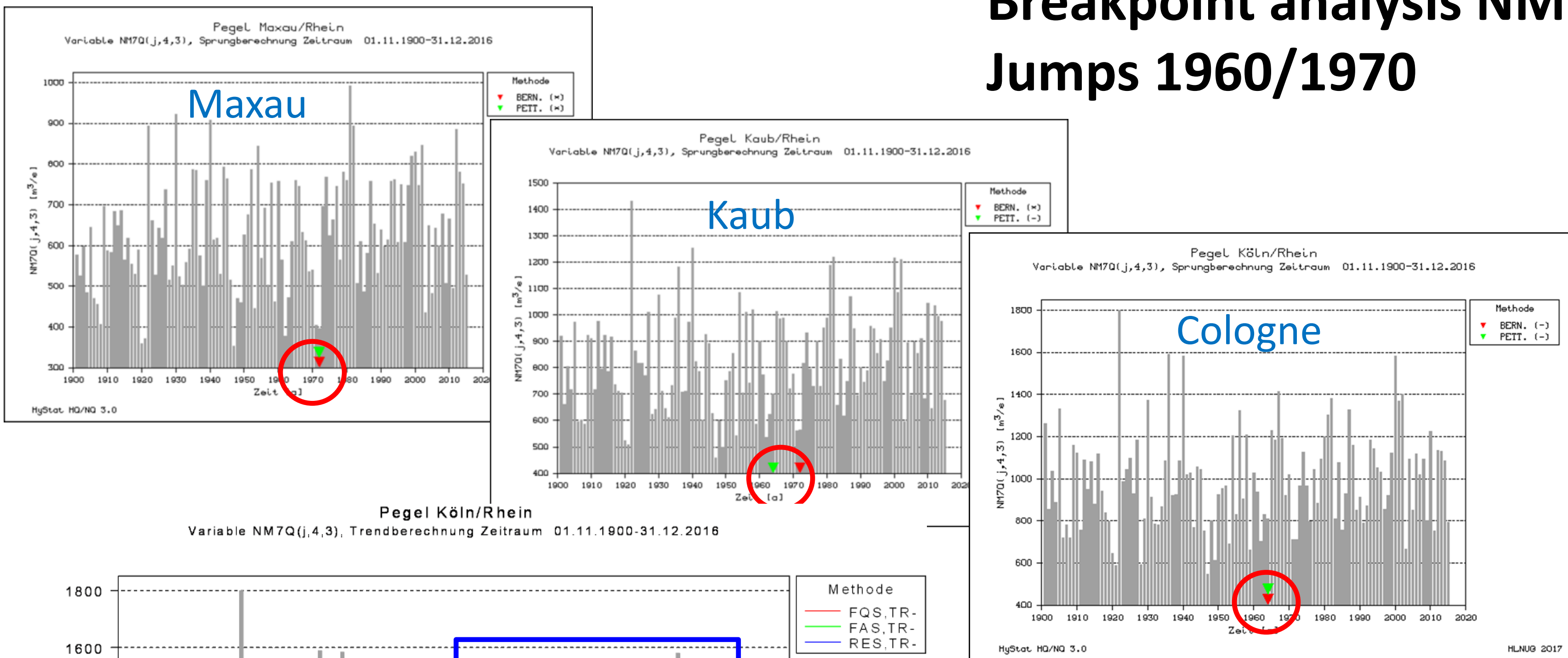
(source: WILDENHAHN & KLAHOLZ, 1996)

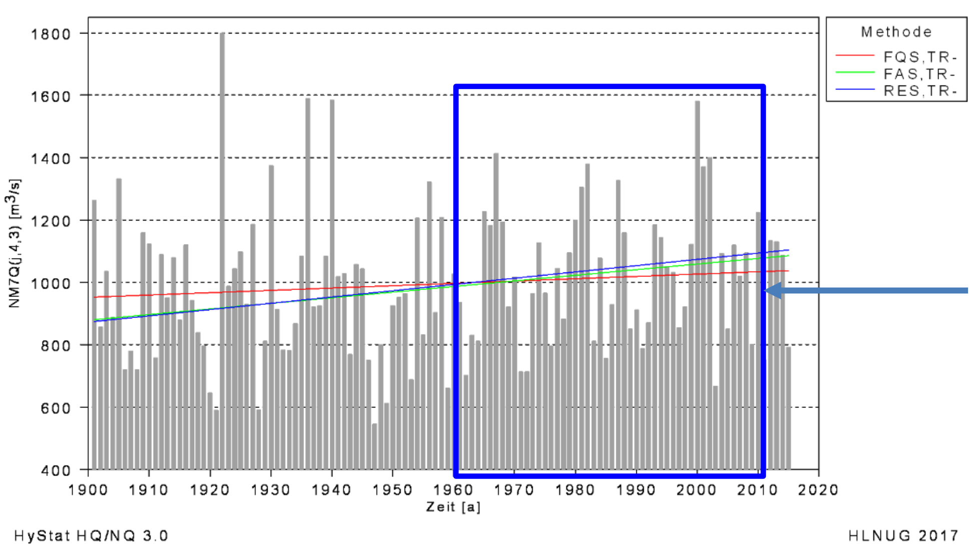
Volume up to Diepoldsau 774 mio m³

Volume up to Basel > 1800 mio m³

(5) Analysis of historic discharge series

Breakpoint analysis NM7Q: Jumps 1960/1970





Reference period 1961–2010
(50 years)
for statistical categorising

(5) Analysis of historic discharge series

Low flow discharge NM7Q for different return periods

Probability of low water discharge: Kind of series NM7Q(j,4,3), Distribution GEV-LM, Runoff in [m³/s]						
Return period:	T=2a	T=5a	T=10a	T=20a	T=50a	T=100a
Diepoldsau/Rhine	92.6	77.2	69.3	62.9	55.8	51.2
Rekingen/Rhine	234	194	176	162	147	137
Basel/Rhine	518	439	402	374	344	325
Maxau/Rhine	644	530	473	427	377	345
Worms/Rhine	716	593	533	486	434	401
Mainz / Rhine	839	702	638	588	535	501
Kaub/Rhine	841	699	632	580	524	489
Andernach/Rhine	982	812	732	670	604	563
Cologne / Rhine	1010	840	761	701	637	597
Lobith / Rhine	1075	908	829	769	705	665

same for:

NM1Q
NM3Q
NM21Q
NM60Q

(5) Analysis of historic discharge series

Low flow duration (in days) below threshold value MNM7Q for different return periods

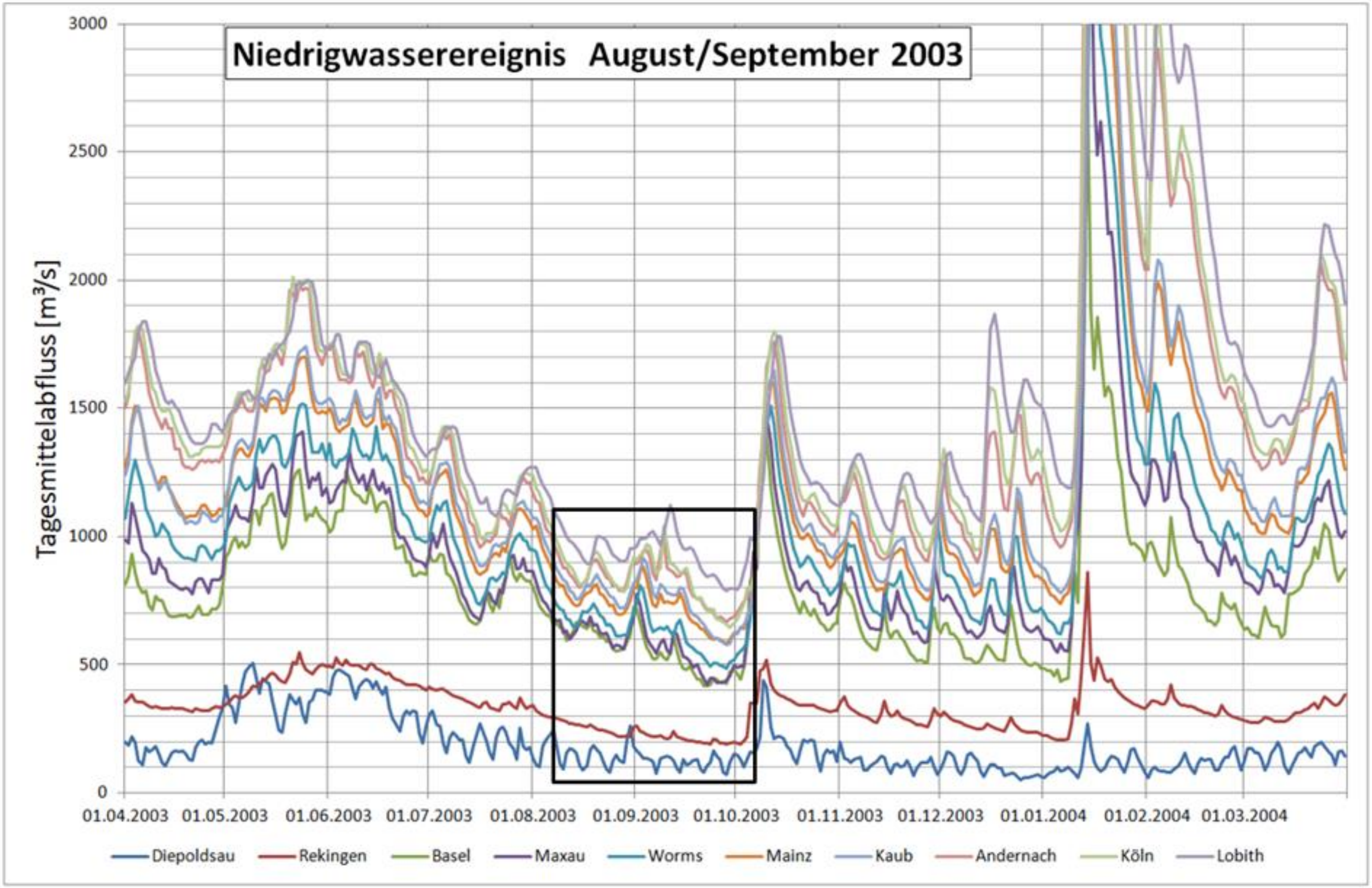
	T = 2a	T = 5a	T = 10a	T = 20a	T = 50a	T = 100a
Diepoldsau	3.5	9.1	14.0	16.6	21.2	26.3
Rekingen	7.0	30.8	49.0	65.9	85.1	
Basel	5.1	23.6	34.9	47.5	54.8	83.7
Maxau	4.9	23.4	34.2	47.4	63.7	89.4
Worms	5.4	23.5	35.1	49.3	67.8	
Mainz	5.6	24.5	38.1	55.7	80.9	
Kaub	5.5	23.3	35.7	55.0	74.4	
Andernach	5.8	23.8	39.7	52.9	73.2	85.2
Cologne	5.8	23.8	38.2	52.1	75.1	87.8
Lobith	5.4	26.2	46.1	68.4	88.9	

same for:

NM1Q
NM3Q
NM21Q
NM60Q

(5) Analysis of historic discharge series

Event August / September 2003



same for:
20
events
between
1921 and
2015

Discharge hydrographs for the low flow event in August/September 2003

(5) Analysis of historic discharge series

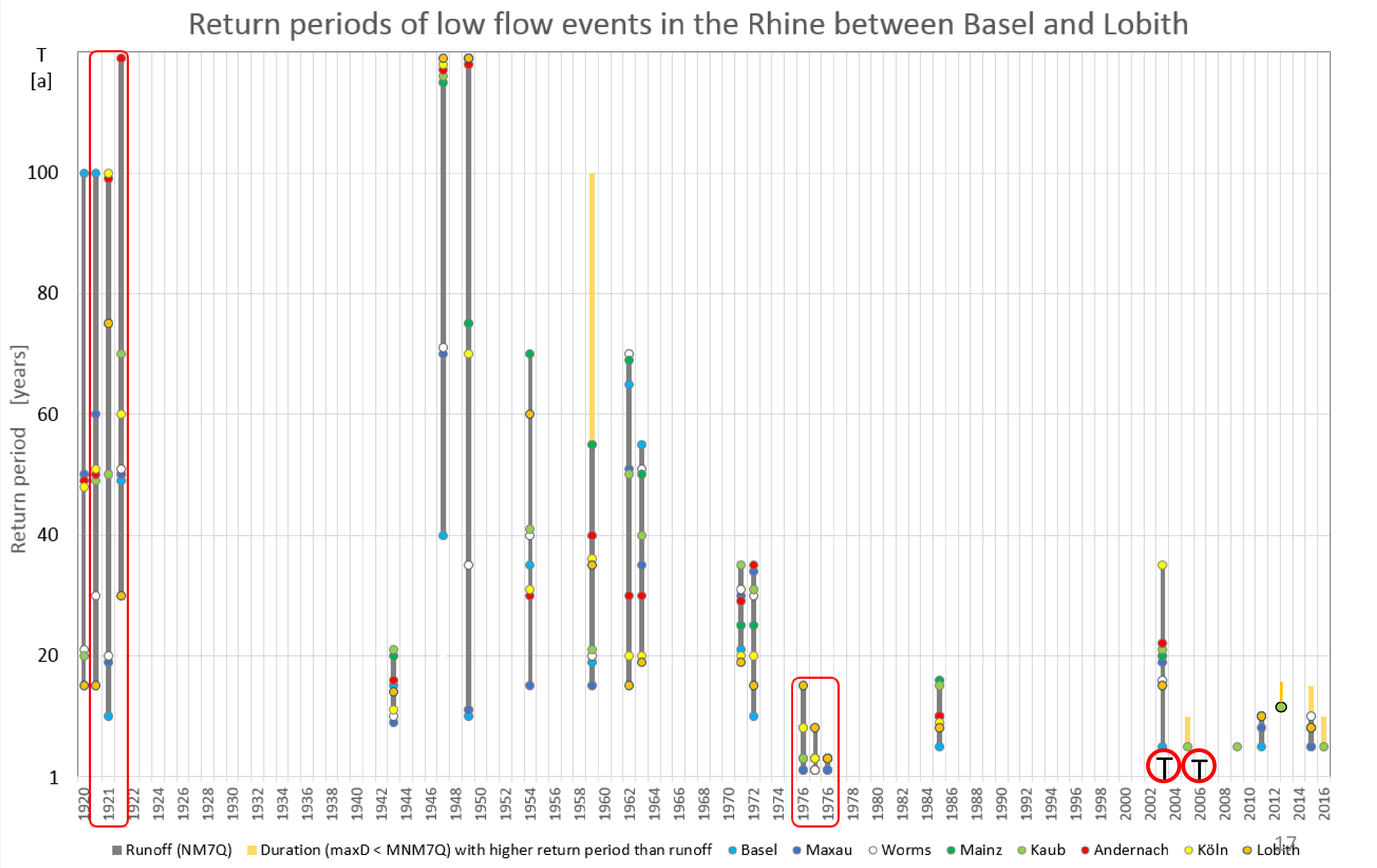
Classification of low flow parameters of the event 2003 into return periods

	Low water discharge [m³/s]			Low water duration [days]		
	MNM7Q 1961-2010	NM7Q Sep 2003	Return period Sep 2003	MaxD < NM7Q2 1961-2010	MaxD < MNM7Q Sep 2003	Return period Sep 2003
Diepoldsau	92.2	108	< 2	4	2	< 2
Rekingen	238	193	5	7	22	2-5
Basel	527	431	5	5	20	5
Maxau	645	435	20	5	31	5-10
Worms	720	500	15	5	31	5-10
Mainz	850	596	20	6	33	5-10
Kaub	851	595	20	6	32	5-10
Andernach	998	682	20	6	62	30
Cologne	1028	666	35	6	33	5-10
Lobith	1095	808	15	6	34	5-10

MaxD = maximum duration of days in a row < MNM7Q
NM7Q2 = two-yearly low water discharge NM7Q
Indications of return periods refer to the reference period 1961 - 2010

Same for: 20 events between 1921 and 2015

(5) Analysis of historic discharge series



(6) Exchange with ICPSMS
Int. Com. for the Protection of Mosel and Saar

2 meetings with ICPMS

Jean-Pierre WAGNER

(DREAL Grand Est – France)

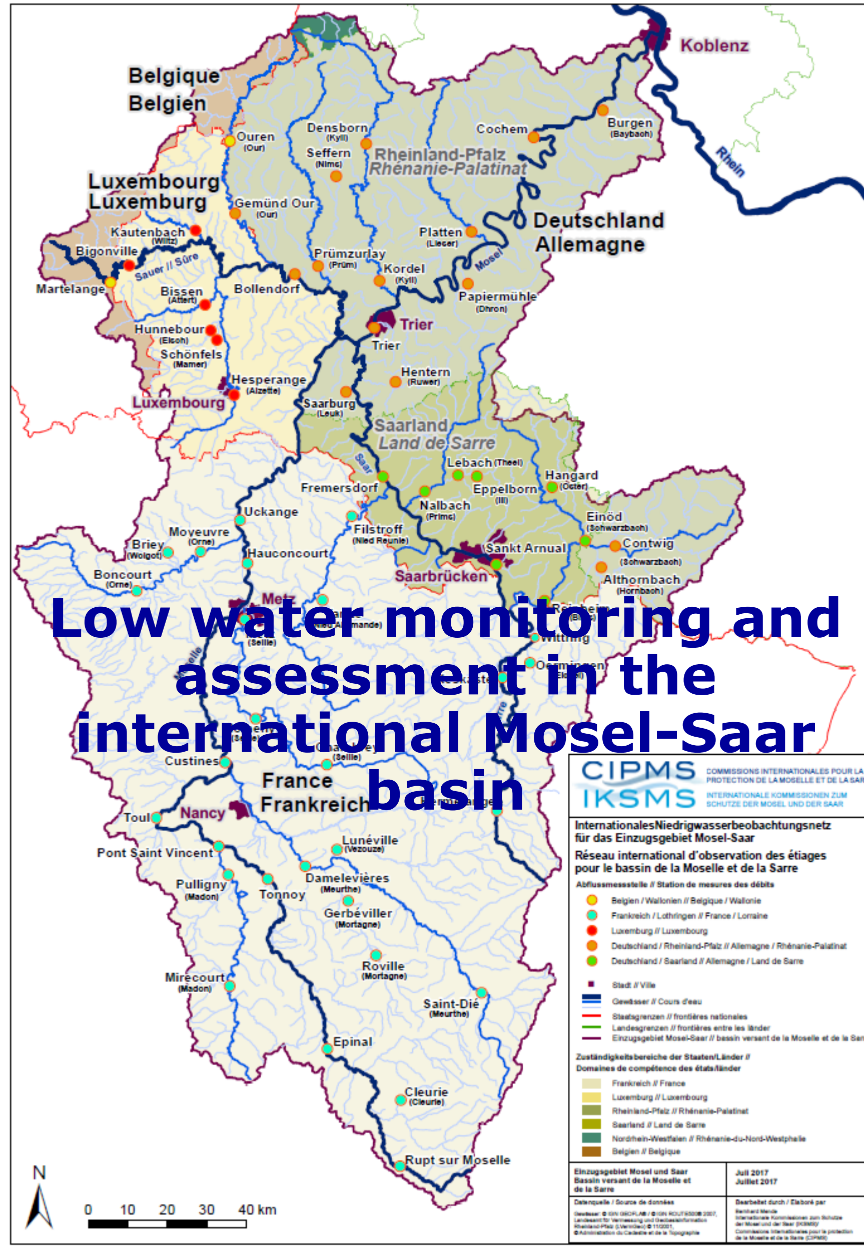
Exchange on approach

Coordination of threshold values

ICPMS works on the issue of low water

1st report Dec 2014

final report in 2018



(6) ICPMS Foreseen developments:

* Requirements of WFD und EU-Guidance documents about LW

* presentation of the low water monitoring network of the ICPMS
* retrospective low water monitoring at 17 gauging stations

* low water internet pages of the ICPMS

* low water forecast (requirements, needs for an operational implementation)

* Impacts of the reduced discharge by LW on the waterbody ecological status (contribution of the water quality working group)

* changes in the LW thresholds with climate change

* do we need a ICPMS LW management plan to achieve the WFD environmental objectives?

(6) ICPMS: Low water monitoring network

59 gauging stations

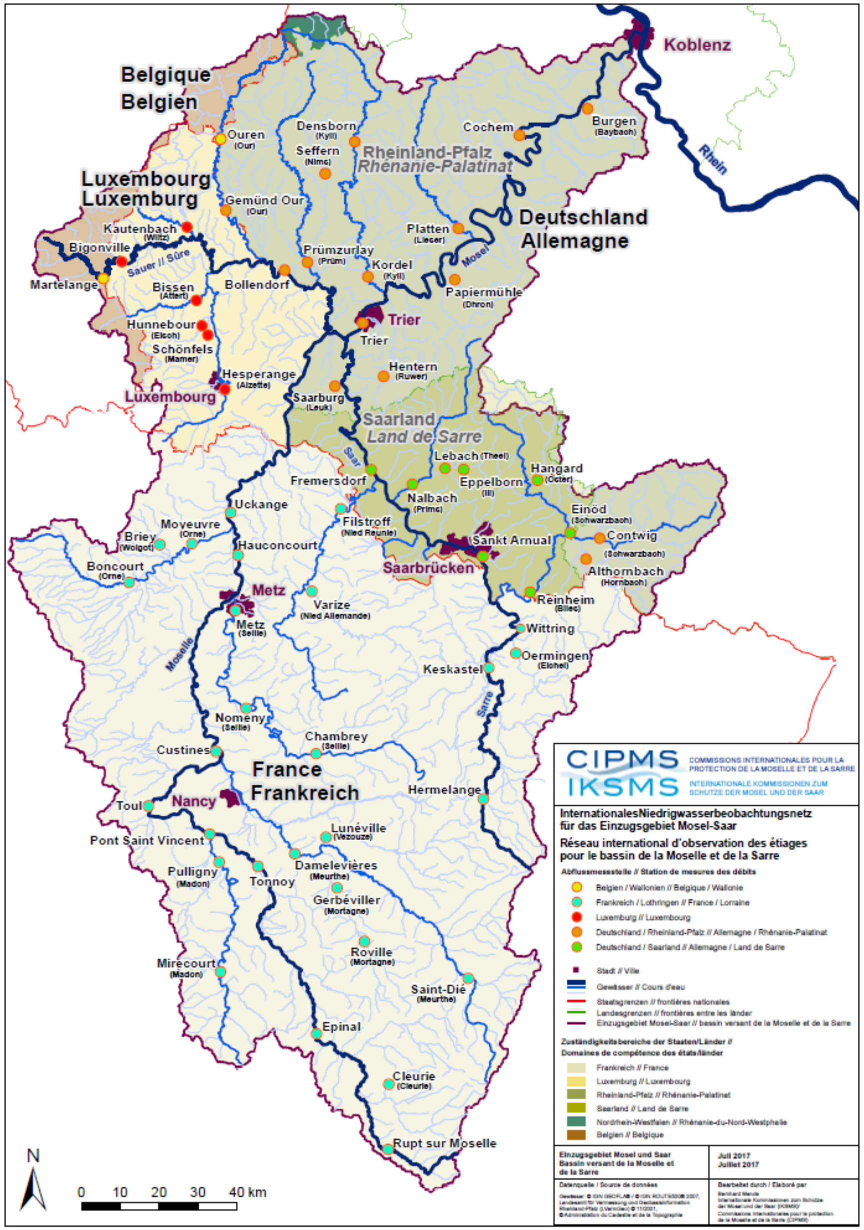
Weekly assessment of the 7-day Moving Average Minimum (MAM7) from week 18 till week 43 since 2015

Low water classification in use

VCN7 (T = 2 ans) *FRÉQUENT*	VCN7 (T = 5 ans) PEU FRÉQUENT	VCN7 (T = 10 ans) RARE	VCN7 (T = 20 ans) TRÈS RARE	VCN7 (T = 50 ans) *EXTRÊMEMENT RARE*
NM7Q (T = 2 Jahre) *HÄUFIG*	NM7Q (T = 5 Jahre) WENIGER HÄUFIG	NM7Q (T = 10 Jahre) SELTEN	NM7Q (T = 20 Jahre) SEHR SELTEN	NM7Q (T = 50 Jahre) EXTREM SELTEN

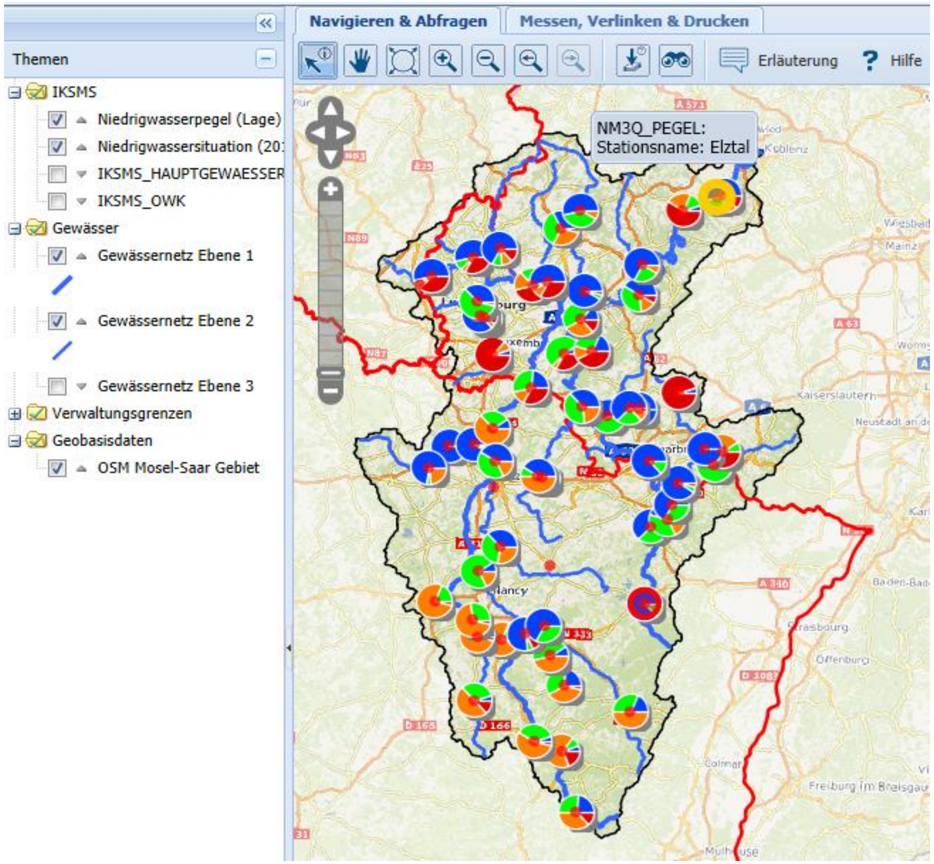
Rough values sent per email each Monday to the competent authorities

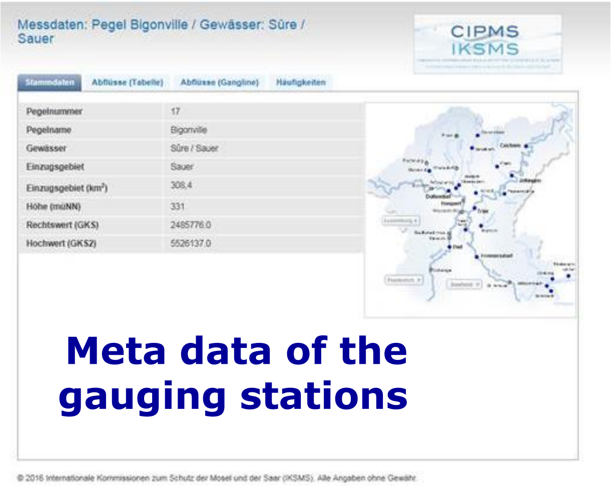
Proofed data from the low water monitoring available the following year



(6) Preview ICPMS low water web pages

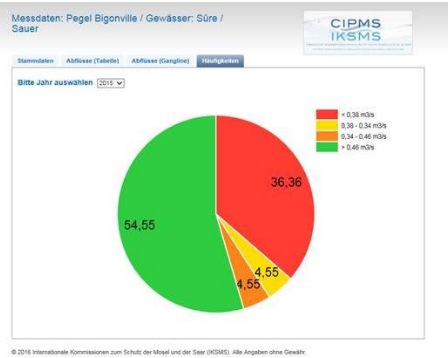
Home page





Meta data of the gauging stations

Weekly values for one selected year at one gauging station



Low water status distribution for one selected year at one gauging station

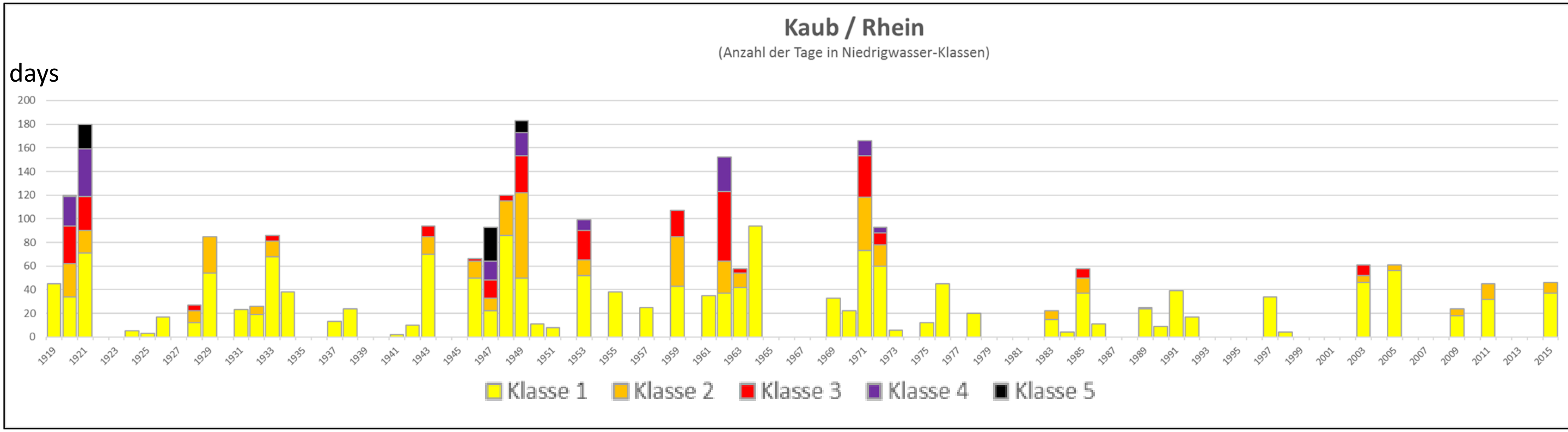
(7) Outlook: Threshold values / Monitoring

Determination on low flow classification

Colour	Classi-fica-tion	Characteristic	Description	
green	0	>= NM7Q(T2)	normal = no low flow	
yellow	1	< NM7Q(T2)	frequent low flow	
orange	2	< NM7Q(T5)	less frequent low flow	
red	3	< NM7Q(T10)	rare low flow	
violet	4	< NM7Q(T20)	very rare low flow	
black	*5*	*< NM7Q(T50)*	*extremely rare low flow*	

(coordinated with ICPMS)

(7) Outlook: “Retrospective monitoring”



Average annual days in low flow classes						
Year	Class 1	Class 2	Class 3	Class 4	Class 5	Total
1921 - 1930	16.2	6.0	3.4	**4.0**	2.1	31.7
1931 - 1940	18.5	2.0	0.5	0.0	0.0	21.0
1941 - 1950	**30.1**	**14.1**	6.2	3.6	**3.9**	**57.9**
1951 - 1960	16.6	5.5	4.7	0.9	0.0	27.7
1961 - 1970	26.3	3.9	**6.3**	2.9	0.0	39.4
1971 - 1980	21.6	6.3	4.5	1.8	0.0	34.2
1981 - 1990	10.0	2.1	0.8	0.0	0.0	12.9
1991 - 2000	9.4	0.0	0.0	0.0	0.0	9.4
2001 - 2010	12.0	1.7	0.9	0.0	0.0	14.6
1921 - 2010	17.9	4.6	3.0	1.5	0.7	27.6
1921 - 1960	20.4	6.9	3.7	2.1	1.5	34.6
1961 - 2010	15.9	2.8	2.5	0.9	0.0	22.1

(7) Outlook: "Predictive monitoring" / Impact of climate change

Use of the

- Results of the EG KLIMA
- Results of Rheinblick2050
- Results of KLIWA and KLIWAS

Average annual days in low flow classes						
Year	Class 1	Class 2	Class 3	Class 4	Class 5	Total
1961 - 2010	15.9	2.8	2.5	0.9	0.0	22.1
1971 - 2000	?	?	?	?	?	?
2021 - 2050	?	?	?	?	?	?

Low flow decrease up to – 10 % in summer halfyear

(7) (preliminary) Conclusion

Compared to the first half of the last century, recent low flow events can rather be designated as minor to moderate.

Direct impacts on the discharge of the Rhine rather tend to support low flow discharge.

It seems difficult to imagine direct possibilities of intervention.

Low flow events in summer together with high water temperatures seem to indicate a new challenge.

Rhine at Wiesbaden, August 2003