Jezero Medard

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Abstrakt

Jezero Medard se nachází v areálu bývalého povrchového dolu Medard-Libík. Napouštění z řeky Ohře začalo v říjnu 2011 a skončilo v lednu 2016. Jezero Medard je dosud největším jezerem v České republice s rozlohou 495 ha a objemem vody 119 mil. m^3.

Lake Medard

Lake Medard is located in the area of the former open-pit mine Medard-Libík. Flooding from Ohře river started in October 2011 and finished in January 2016. Lake Medard is as far the largets lake in the Czech Rapublic with surface area of 495 ha and water volume of 119 mil. m^3.

See Medard

Der See Medard befindet sich im Areal des ehemaligen Tagebaus Medard-Libík. Die Zuleitung des Wassers aus dem Fluss Eger begann im Oktober 2011 und endete im Januar 2016. Der See Medard ist mit einer Fläche von 495 ha und dem Wasservolumen von 119 Mio. m^3 bislang der größte See in der Tschechischen Republik.

Klíčová slova: Jezero Medard, napouštění, hydrogeologie, geology, Sokolovská pánev.
Key words: Lake Medard, Flooding, Hydrogeology, Geology, Sokolov Basin.

1 General informations

Lake Medard is located northwest of Sokolov between the villages Svatava, Habartov, Bukovany and Citice (Fig. 1), along the Ohře River and road I/6, in the territory of the former brown coal open-pit mines Medard and Libík (later connected in tone large open-pit mine Medard – Libík). Coal mining in this locality was stopped in 2000. Until 2008, dumping of overburden continued from the Družba open-pit mine. Shaping of final slopes of the open-pit was the main purpose of these works.

Before flooding, remediation and reclamation work was carried out in the immediate suroundings of the lake – large part of which consisted of forest-biological reclamation, as-sociated with thorough drainage and construction of service roads. An important stabilization measure was the creation of the shore fortification of the lake, which is to prevent the abrasive effects of water on the shore part of the lake. Due to sealing of the bottom of the lake as well as completion of all preparatory remediation and reclamation work, the pumping of mine water from the bottom of the future lake continued for next several years.

1.1 Flooding the Lake Most

On 30 June 2008, the pumping of mine water from the bottom of the residual pit was stopped. Thus, began the natural filling of the lake (Fig. 2). Natural flooding took place from various sources (underground water, tributaries from the river basin, water flowing through the Josef gallery, rainfall and leaks under the collecting object through the inflow channel).

The controlled flooding from the Ohře River started on October 17, 2011 and the river water was used as the main source of impregnation of the residual pit. For this purpose, an open channel was built to bring water from the river to the lake. In the period from December 21, 2010 to January 12, 2011 the functionality of this collection facility was tested. Max. the flooding volume was set at 4 $m^3.s^{-1}$, with min. flow rate in the river (6 $m^3.s^{-1}$) and meeting the quality indicators in the river Ohře.

The lake was not filled with water from the Ohře River all year round. Water supply was provided only in winter period (October-April). The main reasons were higher flow rates in the river, better water quality (lower turbidity and cyanobacteria) and greater hope of maintaining the current fish stock in the lake.

A period of controlled filling of Lake Medard from the Ohře River (Valvoda and Fultner, 2017):

- from 17. 10. 2011 to 18. 4. 2012
- from 29. 10. 2012 to 5. 4. 2013
- from 25. 11. 2015 to 21. 6. 2016

On June 21, 2016, the artificial flooding from the Ohře River was completed. The water level reached 399.8 m above sea level on this day (Fig. 2). It was not possible to reach the planned height of 400.0 m above sea level in this period due to the low level of the Ohře River (Valvoda and Fultner, 2016). The level of 399.8 m above sea level has already reached the operating level, which is set within ± 30 cm of the final level (400.0 m above sea level). The original plan of full release at the turn of 2016/2017 could not be realized due to the still low levels in the river, so the date was postponed to 21 February 2017 and continued until 3 March 2017, when it was necessary to interrupt it again due to low flow in the river. The level in the lake reached 399.95 m above sea level on this day. The second part of commencing was launched on 20 March 2017 and lasted only until 23 March 2017. The level on this day reached 400.03 m above sea level.

On March 21, 2017, for the first time, the planned level of horizon of 400.00 m above sea level was reached.

The total volume of water discharged from the Ohře River (12/2010 - 03/2017) was 88.076 million m^3. From March 2017 to the present day there was no need to enter the lake from the Ohře River and the water level fluctuates according to climatic influences within the specified range. In May 2018 the water level in the lake even briefly exceeded (by 3 mm) the set critical level of 400.3 m above sea level.

Fig. 3 shows a rapid increase of water level during all 3 phases of controlled flooding from the Ohře River while the level increase is more gradual during natural flooding (Valvoda and Fultner, 2018). From March 2017, the water level fluctuates according to season or climatic influences within the specified operating range of ± 30 cm from the specified horizon level of 400.0 m asl. The only exception is May 2018, when the water reached the height of 400.33 m asl. In 2019 (February - September 2019), the water level in the lake fluctuated above the set water level of 400.0 m asl. within ± 20 cm. Below 400 m asl. dropped at the end of September 2019 and has now reached the level of 399.95 m asl.

2 Mining history

In this part of the Sokolov district (area of Habartov and Bukovany), the coal started to be mined between 1830 and 1840.

2.1 The Rudolf Mine and the Libík open-pit mine

Libík open-pit mine excavated the upper coal seam Antonín while the underground mine Rudolf coal seam Anežka, which was placed below Antonín coal seam. Both mining units proceeded with mining from the village of Lítov to the town of Habartov, i.e. from west to east. Active mining took place between 1869 and 2000.

2.2 The Adolf-Žofie Mine

The mine was situated in the middle of today's Medard Lake and excavated coal from the Antonín and Anežka seams in the years 1898 to 1954.

2.3 The Nová jáma (Gustav) Mine

The mine excavated coal near the village of Bukovany in the Anežka seam from 1888 to 1928.

2.4 The mine Felicián

Mine excavated coal from the seams of Anežka and Antonín near the village of Citice from 1844 to 48.

2.5 The Fischer mine

The mine excavated coal near the village of Citice from the seams Antonín, Anežka and Josef from 1830 to 1958.

Tab. 1: Basic characteristics of lake Medard.

Flooding	Pumping of water from the bottom of the open-pit mine was stopped in January 2008. Flooding from Ohře river started in October 2011 and finished in January 2016.
Surface level of the lake	400 m asl (± 30 cm)
Surface area of the lake	495.8 ha
Water volume of the lake	ca 119.5 mil. m^3
Avg. depth of the lake	24,3 m
Max. depth of the lake	50.0 m
Perimeter of the bank	12 441 m
Location of the lake	Lake Medard is located in the area of the former open-pit mines Medard and Libík, which later were connected into single open-pit mine Medard-Libík.
Cadastral territories	Svatava, Habartov, Bukovany and Citice
Water source	The water from the Ohře River was fed into the lake gravitationally by an open channel. The artificial channel allows the transfer of water in the opposite direction, i.e. back into the river, after the lake is filled (at the surface of the lake at 400 m asl.).

2.6 Antonín, Anežka and Josef mines

Mines were located on a hill above the village of Lísková near Sokolov and mined coal through three pits, one from the Antonín seam, the other from the Anežka seam and the third from the Josef seam (from 1886 to 1958).

Other small mines excavating coal at the coal outcrops suroundings the future Medard - Libík open-pit mine (mostly in the first half of the 19th century) were small and insignificant.

All remnants of coal seams from the underground mines were later extracted by the Medard - Libík open-pit mine. Mining in this open-pit mine was stopped in March 2000 without the full exploitation of the entire coal deposit. Decree of the Ministry of the Environment of the Czech Republic No. 206/1993, according to which the remaining coal reserves of Josef seam were depreciated due to excessive sulfur content, contributed to the premature termination of mining. From the west, the territory was limited by the Rudolf dump, from the north by the Anežka seam east, from south and east by the final mining limits. In accordance with the Mining Act, a Open-pit

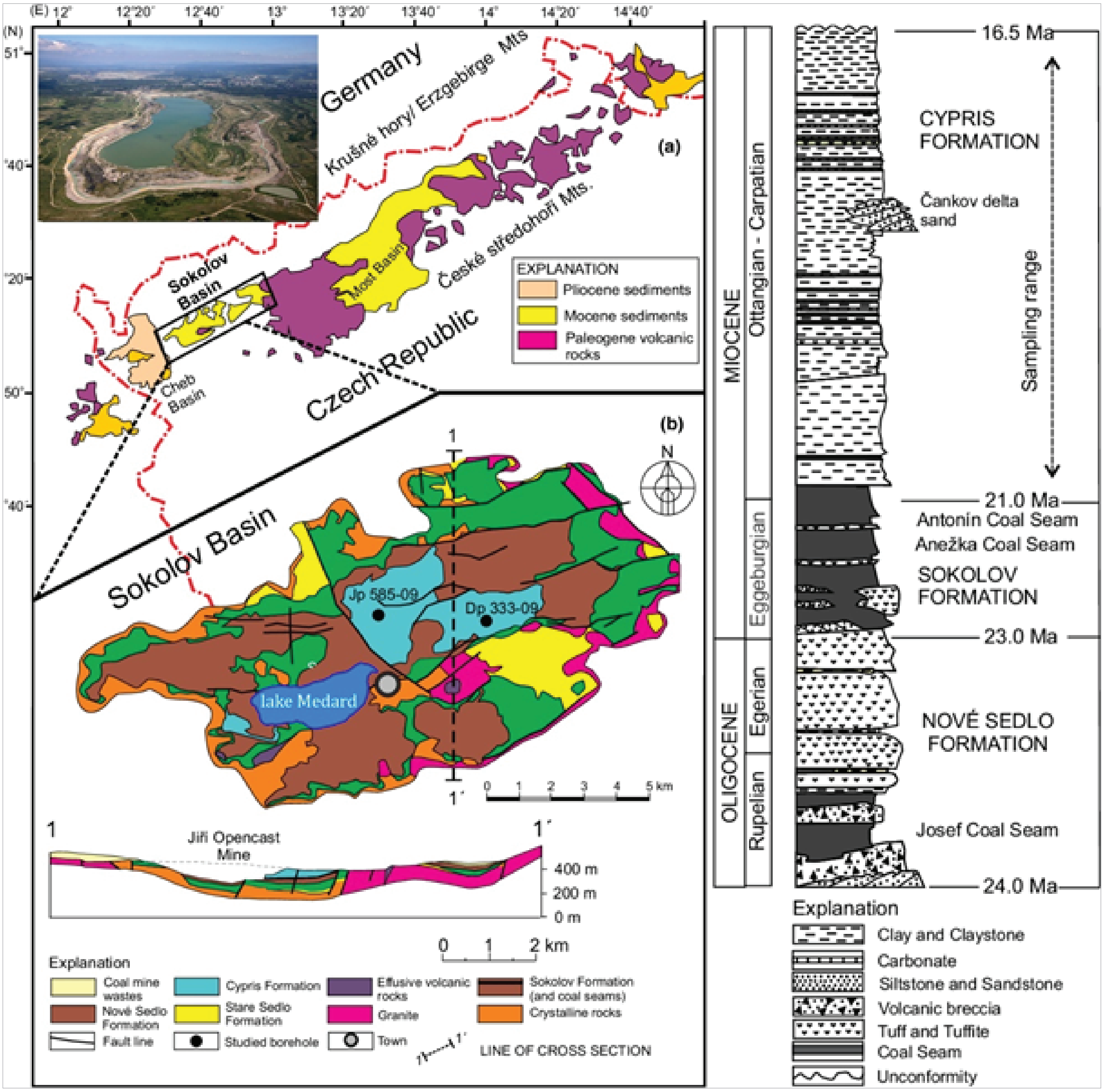

Fig. 1 Left: Geological sketch map of the Ohře Graben and a detailed map of the Sokolov Basin with location of the lake Medard. Right: Stratigraphic scheme of the Upper Oligocene to Miocene part of the Sokolov Basin fill [modified after: Matys Grygar and Mach (2013), Rojík et al. (2010) and Křibek et al. (2016)].

Disposal Plan was prepared in 1999 and assessed in the EIA process in 2001. In the following period, an internal dump was placed on the southern slopes of the open-pit.

3 Site morphology

Morphologically, the territory is very rugged. With its average altitude of about 600 m Asl, the Sokolov region is one of the highest situated districts of West Bohemia. The geological base consists mainly of Tertiary sediments and in the peripheral parts of harder older rocks (mica schist and clamp gneiss), which are covered by quaternary sediments. The original terrain sloped slightly towards the Ohře and Svatava rivers, which run down the eastern edge of the area of interest. Altitudes of the original terrain in the area were from about 400 m asl (River Ohře) to 565 m asl (Chlum Sv. Máří). The highest places in the area on the slopes above Habartov are approx. 550 m asl The original natural conditions of the interesting area and its immediate surroundings were fundamentally changed, in particular, by the in-tensive surface mining of brown coal in the 20th century. The water streams that originate in the Ore Mountains were drained into artificial channels and their water is drained off the mining area. The groundwater regime was significantly affected. Due to extensive mining activities, especially after the

Second World War, the former character of the local land-scape was completely changed.

In the western part is located Lítov dump, which is on the horizon of 570 m asl Between the Lítov dump and the Habartov slopes there is a valley with the Habartov stream and water reservoirs (approx. 470 m asl). Habartov stream turns to the south and flows into Ohře River. Radvanov stream flows into the Svatava River. The surrounding area of Lake Medard consists of the Gustav and Dvory dumps (490 m asl) and the Čistec dump (475 m asl).

4 Site geology

Lake Medard is located in the western part of Sokolov brown coal basin, west of Sokolov town (Fig. 1). The edge of the basin is tectonic, formed by a series of parallel faults. The activity of the peripheral faults led to the formation of the sedimentation area of the basin.

4.1 Quaternary sediments

Quaternary sediments belong mainly to alluvial and peat sediments of the Ohře River. Basal alluvial sediments consist from sandy gravels with boulders of rocks up to 25 cm in diameter. Towards the surface there are more sandy gravels with smaller boulders, sands with admixture of gravel, coarse-grained sands and clays with organic admixture. Locally, there are horizons formed by strongly humic loams and peat. The Quaternary horizon is bound to the relatively well permeable sands and gravels of the alluvial accumulation of the Ohře River. The Quaternary horizon is also subsidized by water from the Ohře River, whose water level lies at an altitude of about 400.0 m asl.

4.2 Miocene sediments

The Miocene Sokolov Formation is the second unit that reflects the intense basin extension associated with volcanism and settlement (Fig. 1 – right). Continuously overlaps kaolinized crystalline or oligocene tuffs. Traces of erosion, however, also violate the lower part of the Sokolov Formation. The Sokolov Formation is separated from the base unit by a hidden discordance, which is marked by erosion, weathering horizon, sharp lithofacial change, sudden change in paleontological content of deposits and structural reconstruction of the area. The feature that unifies the Sokolov Formation is the repeatedly depositing of volcanic rocks and sediments, which arose from the conditions of tectonically induced subsidence. Typical rock groups and sedimentation environments (marsh, peat, lacustrine, fluvial, volcanic and gravitational) are assigned litostratigraphic elements that cross, repeat and have uneven boundaries.

5 Hydrological and hydrogeological conditions

Two main hydrogeological collectors can be defined in the area of interest:

- Shallow (quaternary) collector, which is bound to loam--sand gravels and overthrows the zone of cracked miocene cypris claystones. Its thickness is in the order from first meters to tens of meters.
- Deeper collectors of the Antonín seam strata, where the original relatively low fracture permeability of the coal seam was significantly increased from the original values of the filtration coefficient n.10^{-5} to 10^{-6} to n.10^{-2} to 10^{-4} m.s^{-1} due to underground mining.

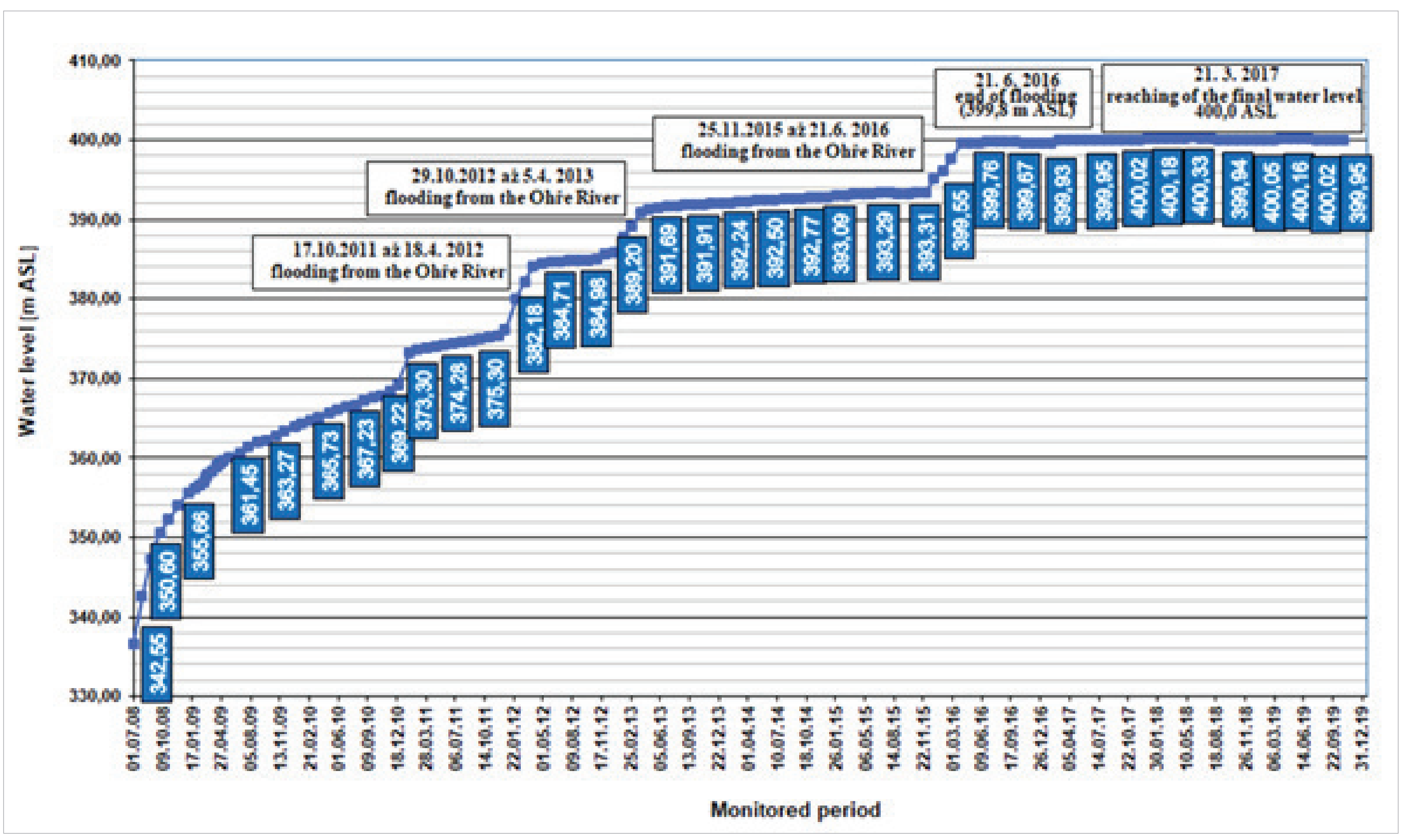

Fig. 2: Water rise in the Lake Medard from 2008 to 2019 (Valvoda and Fultner, 2018).

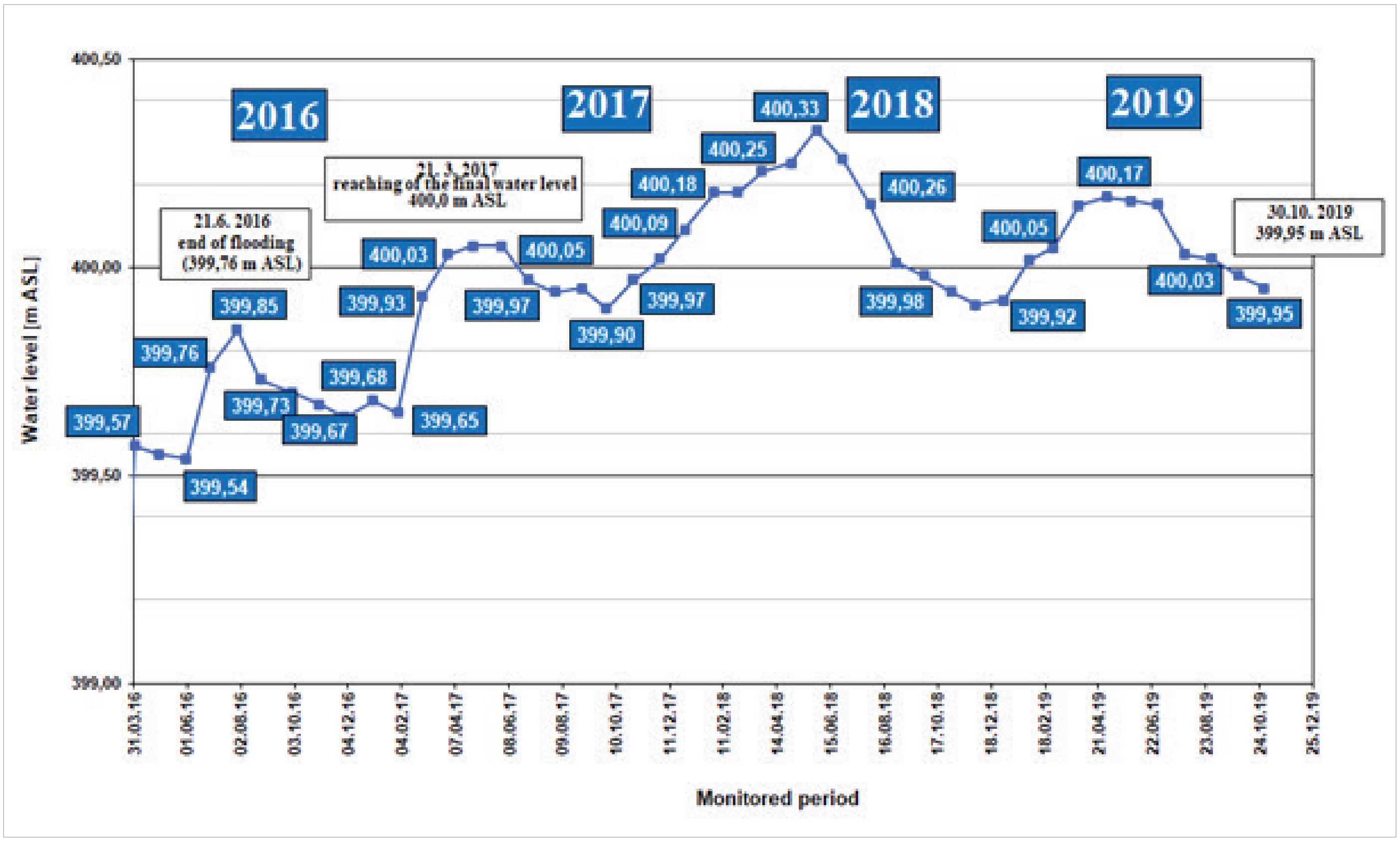

Fig. 3: The water level in Lake Medard since the end of flooding from the Ohře River (Valvoda and Fultner, 2018).

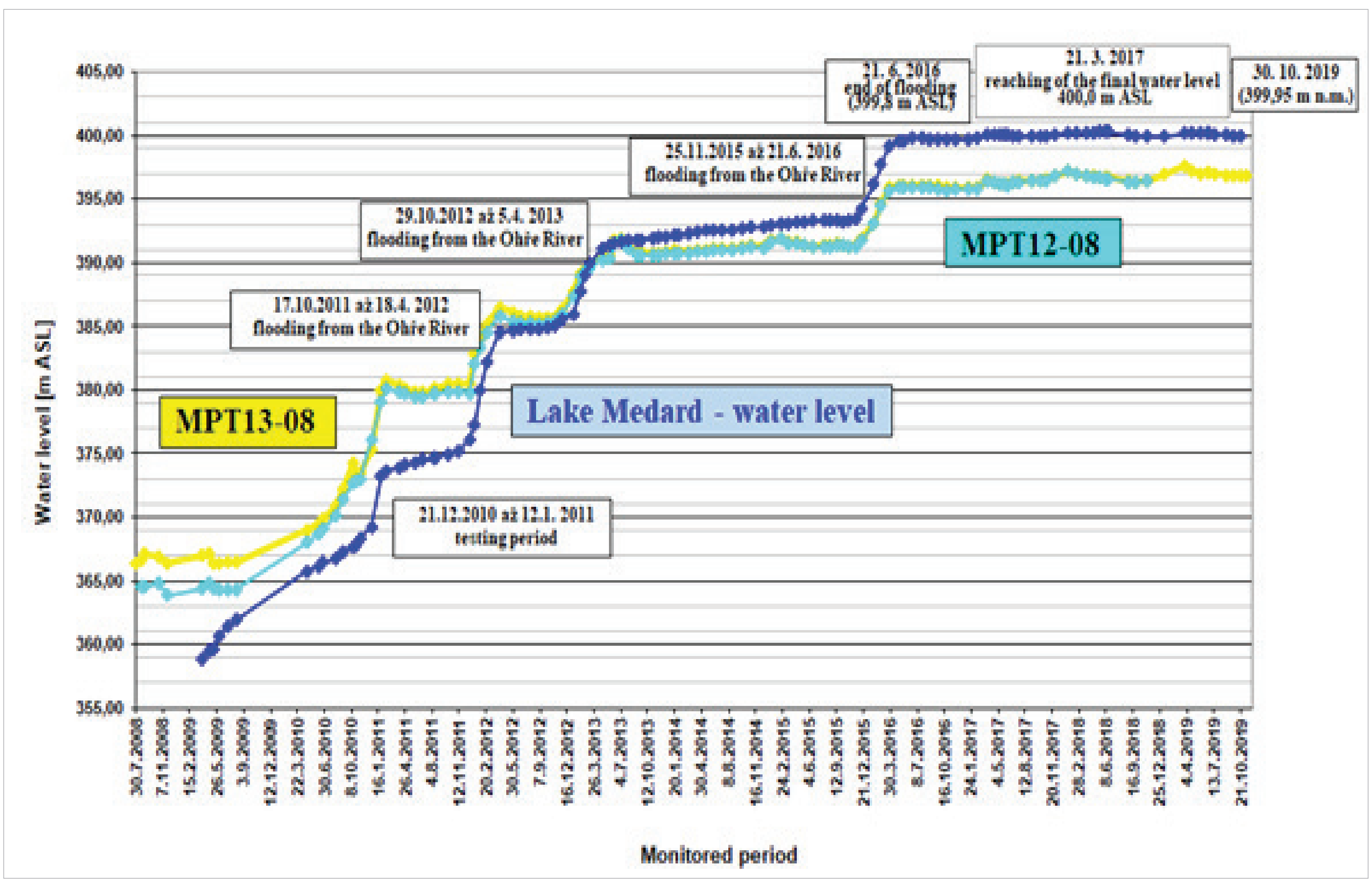

Fig. 4: Groundwater levels in boreholes MPT 13-08 and MPT 12-08 (Valvoda and Fultner, 2018).

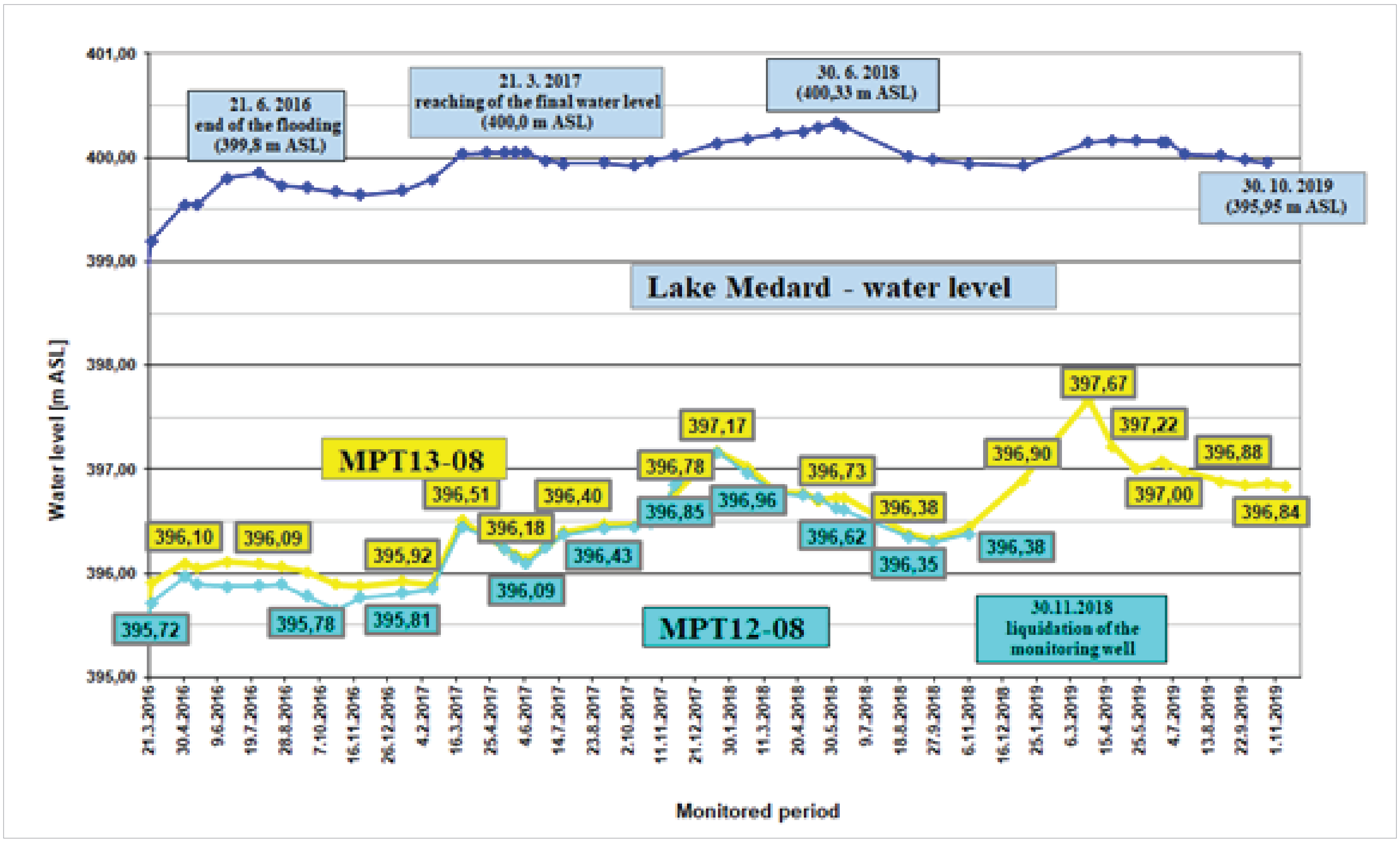

Fig. 5: Groundwater levels in boreholes MPT 12-08 and MPT 13-08 from the end of the flooding from Ohře river (Valvoda and Fultner, 2018).

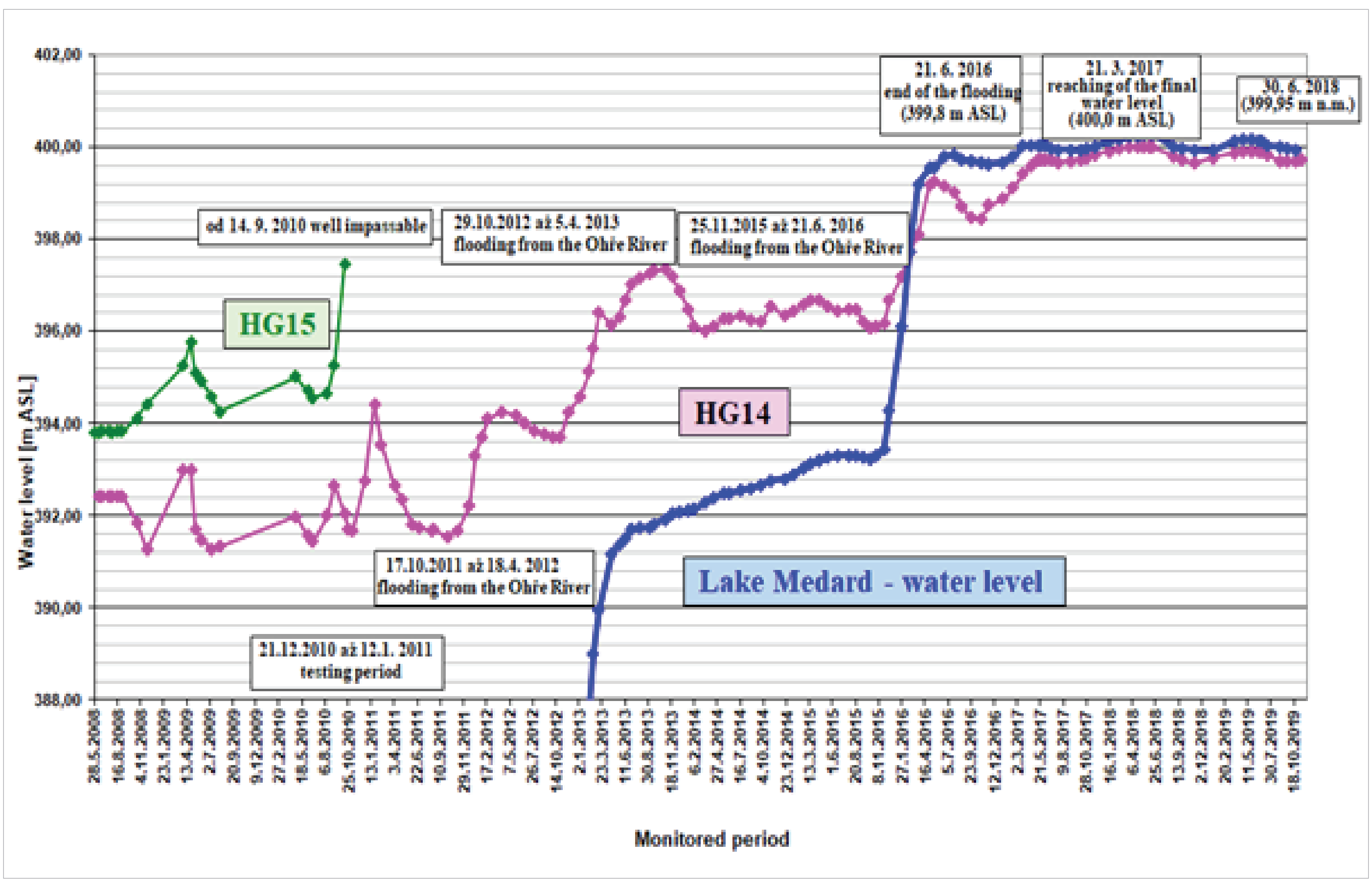

Fig. 6: Groundwater levels in monitoring wells HG14 and HG15.

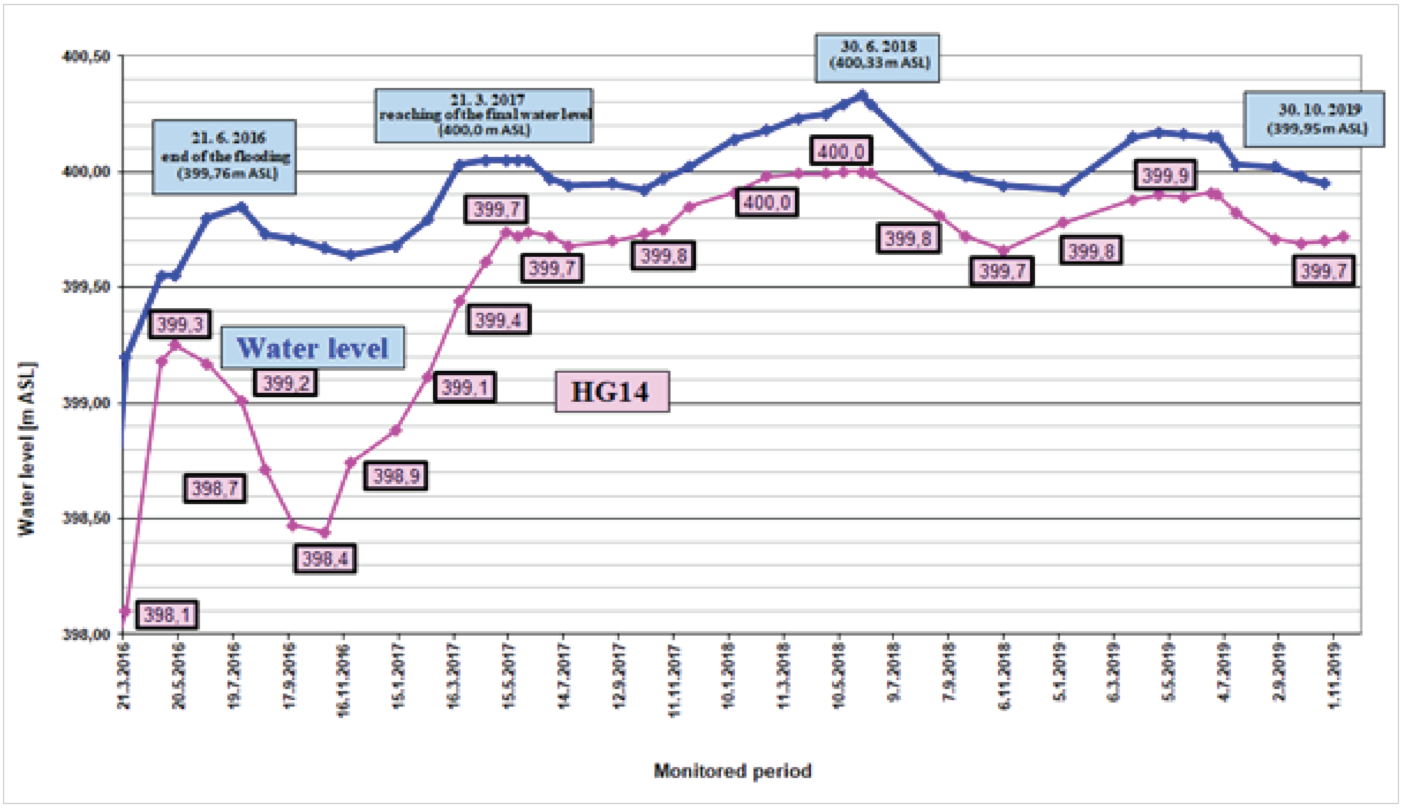

Fig. 7: The figure shows the development of water level in the HG14 well since June 21, 2016, i.e. since the end of the third stage of flooding from the Ohře River.

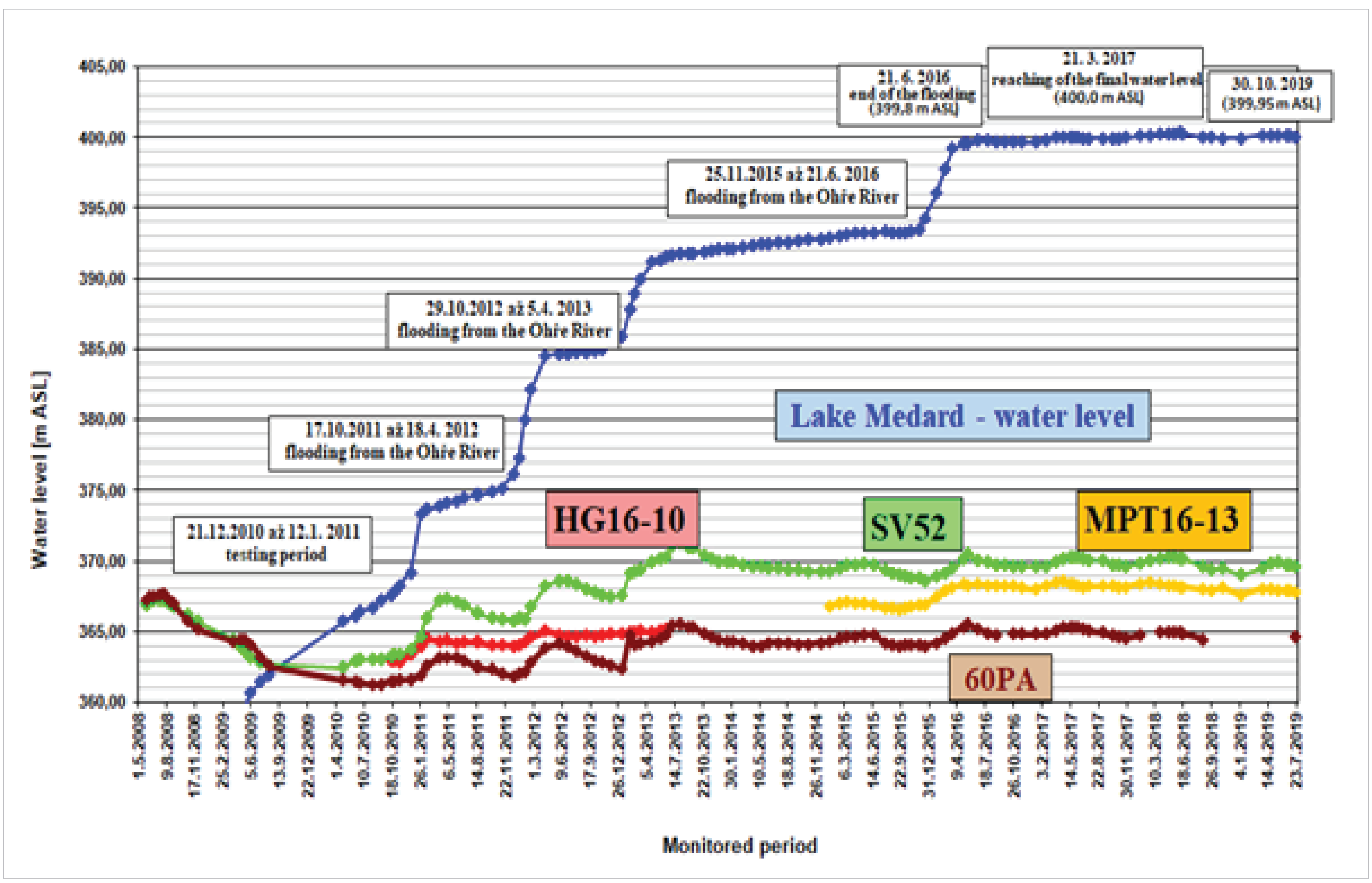

Fig. 8: The development of groundwater levels in wells MPT16-13, HG16-10 and in continuously measured wells SV52 and 60PA (Valvoda and Fultner, 2018).

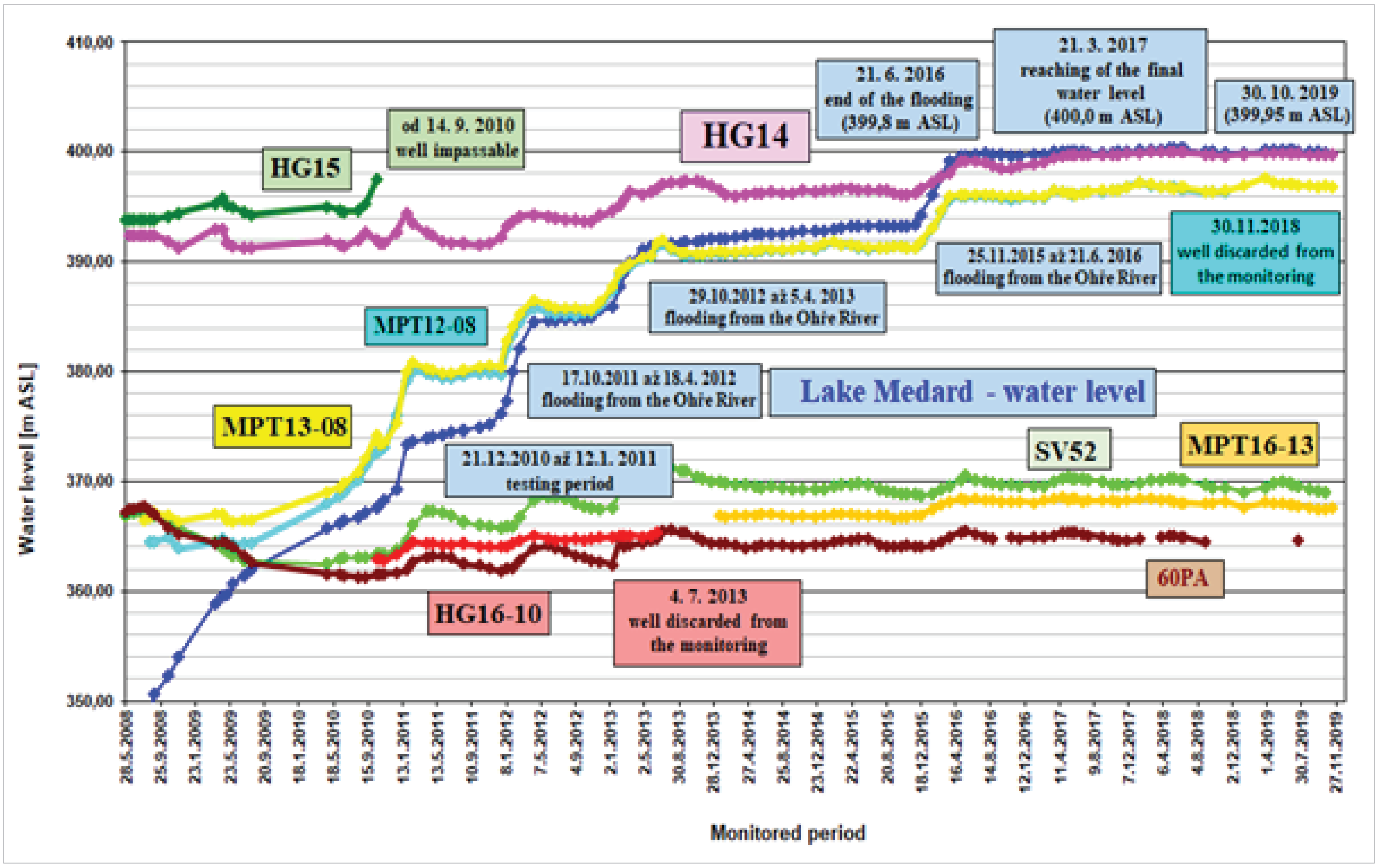

Fig. 9: Summary of groundwater levels in all observation wells (Valvoda and Fultner, 2018).

5.1 Groundwater monitoring around Lake Medard

Monitoring around Lake Medard illustrates rising groundwater levels in the immediate vicinity of the impregnated lake (Kabrna, 2018). Changes in the hydrogeological regime were monitored here both before the impregnation started and during the entire flooding and now after reaching the final lake level.

The groundwater regime in the vicinity of the infused Medard Lake is reduced by observation boreholes HG14, HG15, MPT12-08 and MPT13-08 from 2008 and by HG16-10 borehole since August 2010. In October 2010, the HG15 borehole (observation column violation) and the HG16 borehole were decommissioned. -10 is decommissioned from 4 July 2013 (the borehole burnt down and was subsequently liquidated). The borehole was later replaced by the MPT16-13 in December 2013. The borehole MPT12-08 was decommissioned on 30 November 2018 due to mining.

The measured values are supplemented by water levels from the previously constructed observation boreholes SV52 and 60PA, which allow monitoring changes in the hydro-regime in the wider surroundings of the lake (Valvoda and Fultner, 2011).

- The monitoring borehole MPT13-08, which is located in the Svatava pillar in DP Svatava in the embankment of the train bed, monitors the status of groundwater in the Nové Sedlo Formation - the Josef strata. The well maps the changes in the hydrogeological regime in the area of the Svatava pillar. Until the end of November 2018, the MPT12-08 borehole fulfilled the same function.
- The HG14 borehole is located in the southern slopes of Lake Medard and monitors the permeability of anthropogenic sediments below the Ohře River pillar. These sediments were a permanent source of water inflows to the former open-pit during the mining operations. Water communication from the river to the lake and vice versa is still ongoing.
- The observation borehole MPT16-13 replaced the discarded borehole HG16-10 and is situated in the road pillar above the village of Svatava and serves to evaluate the groundwater regime in the Sokolov Formation - the

Tab. 2: Pumping of water from the bottom of the Medard-Libik open-pit mine (Valvoda Fultner, 2011).

Year	[m³]
1999	5 787 120
2000	6 542 980
2001	7 651 476
2002	9 478 432
2003	4 981 680
2004	7 359 011
2005	6 899 216
2006	1 015 213
2007	965 356
2008	431 082

Antonín strata. This well also monitors the permeability of the Svatava fault, where possible increased inflows of water were monitored, especially during the period of lake flooding.

- The borehole SV52 monitors the groundwater level in the Nové Sedlo Formation - the Josef strata. The 60PA borehole records the groundwater level of the Staré Sedlo formation.

After the pumping of water from the bottom of the mine stopped in June 2008, the process of increasing the water level in the lake started, which was immediately reflected in a gradual rise in groundwater levels in the observation boreholes MPT12 and MPT13. Data on the amount of water pumped from the bottom of the mine are shown in Tab. 2.

In the following Figs. 2-21, 2-22, 2-23, 2-24, 2-25 and 2-26, the measured values of ground-water levels in all previously measured observation wells are recorded and compared. The graphs also show the results of the continuous measurement of the levels of wells SV52 and 60PA and the water level rise in the Medard Lake.

6 Climatic conditions

6.1 Overview of precipitations

Tab. 3 show annual overview of atmospheric precipitation (2008 – 2019), as measured by the precipitation measuring station Habartov. Unlike in 2018, which was significantly below the precipitation, precipitation in 2019 roughly reached its average

Tab. 3: Monthly overview of atmospheric precipitation in 2008 – 2019.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
	[mm]											
JAN	42.3	44.0	59.7	76.0	144.5	84.9	33.1	75.6	65.6	46.4	69.1	96.9
FEB	37.8	89.6	28.9	13.3	36.9	53.8	11.9	8.5	61.1	30.6	14.2	19.9
MAR	95.3	74.7	48.6	9.0	21.2	23.0	20.9	47.9	34.5	67.8	48.9	62.3
APR	104.6	84.0	27.5	25.4	41.3	26.9	36.1	33.3	24.7	58.1	29	30.8
MAY	39.3	82.2	76.2	54.6	44.4	156.3	78.7	19.2	23.9	33.5	87.8	46.9
JUN	37.9	42.4	81.6	77.6	40.8	174.2	20.7	60.5	109.3	90.4	44.6	61.8
JUL	104.0	85.7	98.1	91.7	79.2	13.2	114.3	69.4	130.9	86.6	42.7	60.9
AUG	66.4	30.7	188.5	78.4	54.9	54.3	88.7	58.0	26.3	118.8	28	86.7
SEP	82.2	30.8	58.4	64.5	55.4	81.1	51.2	40.6	89.6	59.1	69	79.3
OCT	81.7	84.9	19.1	55.1	51.0	46.7	89.1	60.1	51.4	108.6	32.2	56.3
NOV	32.8	67.6	113.3	0.8	73.1	31.7	18.4	81.8	37.6	77.9	42.6	N/A
DEC	65.7	79.7	104.1	129.2	100.5	20.4	27.2	32.7	30.5	72.8	58.1	N/A
Sum	**790.0**	**796.3**	**904.0**	**675.6**	**743.2**	**766.5**	**590.3**	**587.6**	**685.4**	**850.6**	**566.2**	**N/A**
Avg.	**65.8**	**66.4**	**75.3**	**56.3**	**61.9**	**63.9**	**49.2**	**49.0**	**57.1**	**70.9**	**47.2**	**N/A**

Tab. 4: An overview of average monthly temperatures in the years 2008 – 2019.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
	[mm]											
JAN	1.7	-4.7	-4.6	-1.1	0.1	-1.5	0.3	0.7	-0.7	-5.3	2.9	-0.5
FEB	2.8	-0.8	-1.9	-1.8	-5.0	-2.1	1.8	-0.9	2.1	1.8	-2.7	1.3
MAR	2.8	3.0	2.7	4.1	5.6	-1.1	5.9	4.4	2.9	6.0	1.4	5.6
APR	7.1	11.8	8.1	10.3	7.7	7.7	10.5	7.7	7.5	7.2	12.1	9.5
MAY	13.6	13.3	10.5	13.5	14.1	11.1	11.8	12.8	13.2	13.9	16.0	10.7
JUN	17.4	14.6	16.3	16.2	16.3	15.3	16.3	16.0	17.1	18.1	17.5	20.9
JUL	17.7	17.1	20.1	15.7	17.5	19.7	19.0	20.2	18.3	18.3	19.4	19.2
AUG	16.8	18.3	16.0	17.4	18.4	17.3	15.2	20.9	17.1	17.8	20.1	18.4
SEP	11.2	14.0	11.0	14.3	12.9	12.0	14.1	12.0	15.5	11.3	13.6	13.1
OCT	7.6	7.0	5.9	7.7	6.9	8.4	10.5	7.4	7.8	10.1	9.4	9.4
NOV	3.7	5.6	3.5	2.4	3.4	7.2	6.8	6.0	3.0	4.1	4.3	N/A
DEC	0.1	-1.0	-5.8	1.8	-0.8	5.4	2.9	4.6	0.3	1.4	1.6	N/A
Avg.	**8.5**	**8.2**	**6.8**	**8.4**	**8.1**	**8.3**	**9.6**	**9.4**	**8.7**	**8.7**	**9.7**	**N/A**

values, which significantly influenced the water level in Lake Medard (Kunešová and Valvoda, 2019).

6.2 Overview of monthly temperatures

The following Tab. 4 show the average monthly temperatures for the period from January 2008 to October 2019, as measured from the Cheb weather thermometer. In 2019, similarly as in 2018, we recorded slightly higher average especially summer temperatures than long-term averages.

7 Geotechnical problems

7.1 Penetration survey – CPT (Cone Penetration test)

Between 1999 and 2018, 129 CPT were carried out in the interior dump area of the former Medard-Libík mine. The basis for the evaluation of the penetration survey is finding the minimum values of resistance on the penetration record. These minimum resistance values fit the least-squares trend lines of the minima. The mathematical modelling of the penetration tip behaviour by the FEM method showed that the dependence of resistance on depth is linear for homogeneous soil, so that the trend line characterizes the strength properties of the soil. By converting the parameters of this line (i.e. the slope of the line and the intersection of the line with the ground surface), the shear strength parameters of the penetrated soil can be obtained using mathematical relations.

The evaluated results of penetration measurements enabled to monitor changes that occurred in the body of the inner dump before, during and after the complete filling of the residual pit of the mine. The results of the penetration measurements evaluation were statistically processed and used as input data for stability calculations. which aim to verify what values of safety levels the internal dump of the former Medard-Libík mine shows. The stability of the monitored slopes of the Medard-Libík mine was assessed in the computational pro-files, which cover the area of the inner dump.

7.2 Geodetic monitoring of redeveloped slopes

Geodetic monitoring of redeveloped slopes takes place in the vicinity of Lake Medard in two areas (Pichler. 2009 and 2010):

Geodetic monitoring under the village of Bukovany

Since 28 November 2007. the measurement of the monitoring points B6, B7, B11, B12, B13 and the so-called Nail have been regularly measured on the southern slopes of the Medard-Libík mine, below the village of Bukovany. This previously unstable part of the slope was remedied in 2009 by local stabilization and drainage systems. All points were measured at monthly intervals (until June 29. 2012) and then at quarterly intervals. Geodetic points B7, B12, B13 and Nail showed no movement since the beginning of the measurement and this fact was confirmed in 2019, they are currently measured half-yearly (from 29 March 2019).

Creeping slope movements have been observed for a long time at locations of geodetic points B6 and B11, where the quarterly measurement interval was maintained. These especially horizontal movements slowed significantly in 2019. The

Fig. 10: Tension crack on the southern slope of Lake Medard below the village of Bukovany in 2017.

Fig. 11: Tension crack on the southern slope of Lake Medard below the village of Bukovany in 2018.

Fig. 12: Tension crack on the southern slope of Lake Medard below the village of Bukovany in 2019.

average movement for the whole measured period (from 28 November 2007) is B6 - 50 cm per year (4.2 cm per month) and B11 - 64 cm per year (5.3 cm per month). For the last year (until September 2019), the total absolute movement has been recorded at point B6 - 9 cm and at point B11 - 12 cm, which represents an average movement of 1 cm (B6) or 1.3 cm (B11) per month.

Geodetic monitoring under the village Habartov

Since 14 May 2006, regular measurements have been carried out at the geodetic points 0 to 19 in the area of the Libík-south redeveloped slope near the road D1 – D5 below the village of Habartov. Geodetic points are designed to monitor the functionality of the stabilization bench, which was built during the mining operations, to ensure long-term stability of the slope.

Until 31 July 2012, geodetic measurements were performed at quarterly intervals, in 2013 at six-month intervals and in the following period until now only at annual intervals. Measurement intervals increased due to the fact that there was practically no movement in measured points 0 to 19 in this monitored area in the monitored period. This fact was con-firmed by the results of measurements in 2019. We can therefore say that this area is stable in the long term and the redevelopment activities implemented in the past were effective.

7.3 Tension crack on the southern slope of Lake Medard below the village of Bukovany

On the southern slope of Lake Medard below the village of Bukovany, above the area of geodetic points B6 and B11, where creeping horizontal movements are observed, the observed tension crack is visually monitored within the monitoring. The crack length is approx. 76 m. Even after 2019, the crack does not increase significantly after visual inspection. The outflow of groundwater is observed in the western part of the crack and even in the dry season, this part of the slope is considerably saturated by groundwater. In the vicinity of the crack the planted forest stands grow and this area becomes less and less accessible. To compare the situation, photos from the years 2017, 2018 and 2019 are shown here (Figs. 10 - 12).

Fig. 13: Redeveloped and reclaimed northern slopes of Lake Medard (Photo: P. Valvoda, 04/2014).

Fig. 14: Shore line with anti-abrasive system (Photo: P. Valvoda, 04/2013).

8 Reclamation

The reclamation of the area around the lake was carried out mainly by forest-biological methods. These are groups of trees alternately supplemented by grassy areas and solitaires. Planting of trees was carried out in such a way as to gradually create a rugged area, consisting of a combination of small woods, groups of trees, respectively solitary trees and free grassy areas. In addition to landscaping and ecostabilization functions, open areas near municipalities also play an important role in short-term recreation. The stands are established in such a way that they are accessible and fulfill the aesthetic, health-efficient and recreational functions (form of peri-urban forests). Of the total area of 1 183 ha, forest reclamation is 619.42 ha, hydrological is 497.88 ha, agricultural reclamation is 50.73 ha and the rest is 14.97 ha. A view of the reclaimed northern slope of the lake is shown in Fig. 13. An important stabilization element was the creation of the shore fortification of the lake, which should prevent the abrasive effects of water on the shore part of the lake Fig. 14. Due to the seabed sealing and completion of all preparatory remediation and reclamation work lake.

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