НАВОДНЕНИЕ В ДОЛИНЕ АХР, ОПАСНОЕ ДЛЯ ЖИЗНИ И БЛАГОПОЛУЧИЯ

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THE FLOOD IN THE AHR VALLEY DISASTROUS FOR LIVE AND GOODS

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В статье описывается наводнение в долине реки Ахр летом 2021 года. После некоторых вводных слов о географии и гидрологии, обсуждаются экономические аспекты различных общин. Долина Ахр имеет долгую историю наводнений, начиная с 1348 года. Краткое введение в гидрометрию, обработку данных и статистическую оценку наводнений с различным периодом возврата и экстремальных наводнений. Во время этих наводнений многие здания, дома и инфраструктура были повреждены или разрушены. Рассмотрен вопрос о том, как можно было бы минимизировать ущерб строениям и населению.

Ключевые слова: Гидрология, метеорология, наводнение, малый водосбор, предупреждение о наводнении, экстремальное наводнение, катастрофическое наводнение, парламентский следственный комитет.

The paper described the flood in the Ahr Valley in summer 2021. After some instructional words of the geography and the hydrology, the economical aspects of different communities are discussed. The Ahr Valley has a long history in floods dating back to the year 1348. A short introduction in hydrometry, data processing and statistical estimation of flood with various return period the extreme flood are described. During these flood, many building, houses and infrastructure are damaged or distroyed. The question, how could these happened will also be treated.

Keywords: Hydrology, Meteorology, Flood, Small Catchment, Flood Warning, Extreme Flood, Catastrophically Flood, Parliamentary Investigation Committee.

Introduction

The Flood Catastrophe 2021 in Western and Central Europe was a natural disaster of tremendous extent of flooding several river systems by severe flash floods in Central Europe in the summer of 2021. Parts of Belgium, the Netherlands, Austria, Switzerland, Germany and other neighboring countries were particularly affected. The most severe floods were caused by the Low Pressure System Bernd. One of these floods toke place in the River Ahr, Germany.

The aim and the main part of this paper is to describe the extreme flood event of the River Ahr on the 14th and 15th of July 2021. After a general overview of the Ahr and its catchment, the fundamental hydrological processes are described. The actual flood will be discuss into the light of the historical flood event at the River Ahr. Furthermore a general outline of possible technical and organization on avoiding extreme floods will be introduced.

Geographical and General description of Ahr Valley

The source of the River Ahr is a cellar in Blankenheim a small village. The main direction of flow is eastward and after a length of 85,2 kms discharges into the River Rhine. Furthermore it is also the shortest tributary of the River Rhine. By this means the Ahr drains a large part of the northern Eifel Mountains, and divided it by several crests from the main part of the Eifel Mountains, which is southward. The highest crest of the ridges is Mount Aremberg with 623 meters about above sea level. Other Hills are Michelsberg 588 meters and Junkersberg 557 meters above sea level.

By orographical means, the Ahr Valley is part of the rhenish shale mountains with devonian rocks mostly grey stone and slate. During the carbon age the mountains where folded by densely pressure. Furthermore the Valley belongs to the Eifel Mountain, but it has its one character and its catchment are of 897,468 km^2 drains the northern part of the Ahr Eifel. To the South, the Ahr Mountains are separated from the East Eifel and Hohe Eifel by the Ahr, in the East the range of hills flattens out towards the Rhine, in the West the Erft forms the border with the North Eifel, while to the North it slopes down to the Bay of Cologne and the Zülpicher Börde. Framing points of the Ahr Mountains would be Blankenheim in the West, Antweiler, Altenahr and Bad Neuenahr-Ahrweiler in

the South, Remagen in the East and Rheinbach and Bad Münstereifel in the North.

Germany is a Federal State and the political borders do not have anything in common with hydrological units such as catchment borders. These special issue have to take in mind, when is comes to flood warning and water law of every state. The political border between the federal states of North Rhine-Westphalia and Rhineland-Palatinate runs through the Ahr Mountains, but the main part of the catchment belongs to Rhineland-Palatinate, and will discussed here. Within the upper reach of the River Ahr there are varied meadow landscape, while the Ahr continues to flow in the middle reaches between 100 to 200 meters high rock walls with spectacular view of the narrow valley often intertwined. Downstream the Ahr travelled within a wide river bed with spacious floodplain and small villages and flows finally in the River Rhine.

Since the lower Ahr Valley lies leewards of the Eifel Mountain, it has a particularly favorable climate, and the southern slopes of the Ahr Mountains between Altenahr and Bad Neuenahr are ideal for viticulture. About 80 per cent are red wine are produced and some people call this famous red wine Ahr Bourgogne. In autumn, numerous wine festivals attract visitors from other parts of Germany and foreign Countries. While the Ahr Valley is used intensively for viticulture, the rest of the Ahr Mountains are mostly forested and only sparsely populated.

One of the biggest wine growing community within the valley is Bad Neuenahr-Ahrweiler with over 300 hectares of planted vineyards are located within the district of the district town. But these are only one attraction of the town. The particular attraction is the casino in Bad Neuenahr, where Roulette, Baccarat and Blackjack tables can be played. Approximately a quarter of a million visitors can be accounted per year. Another important and famous basis is Bad Neuenahr — a spa for over 160 years and therefore committed to health. The homepage of Bad Neuenahr bounded the history and the future of the spa town quite courteously.

Over the whole timespan the traditional spa town has become an attractive health and wellness town. The flood of July 2021 left clear traces here as well. But the goal of combining concentrated medical expertise with an attractive range of wellness, cultural and active activities is still trend-setting for the future in Bad Neuenahr under the motto — Healthy Satisfaction from Head to Toe. Thirteen clinics and rehabilitation facilities, over 100 specialists and more than 50 therapy practices form the central pillars of the health and wellness city. Almost all medical specialties are covered here in order to guarantee the best possible treatment success. Some facilities are still being rebuilt due to the flooding — a stay in the spa is still worth it! All these points make the Ahr Valley and especially Bad Neuenahr — Ahrweiler to an attractive living place [1].

Hydrology in a Broader Sense

Hydrology is the science that treats of waters the Earth, their occurrence, circulation, distribution, their chemical and physical properties, and their reaction with their environment, including their relation with living things.

This definition, which was prepared for the President of the United States in 1962 describe the state and the movement of the water on the Earth surface quite well, but to investigate the water movement on an particulate river more profound knowledge and hydrological information are required. There are many good text books on hydrology and related problems. During following paragraph many issues of water movement including the hydrological cycle are described.

However, water as a natural resource for human wellbeing is only one aspect. Water in its different physical phases, like liquid, solid and gaseous, may pose risks to life,

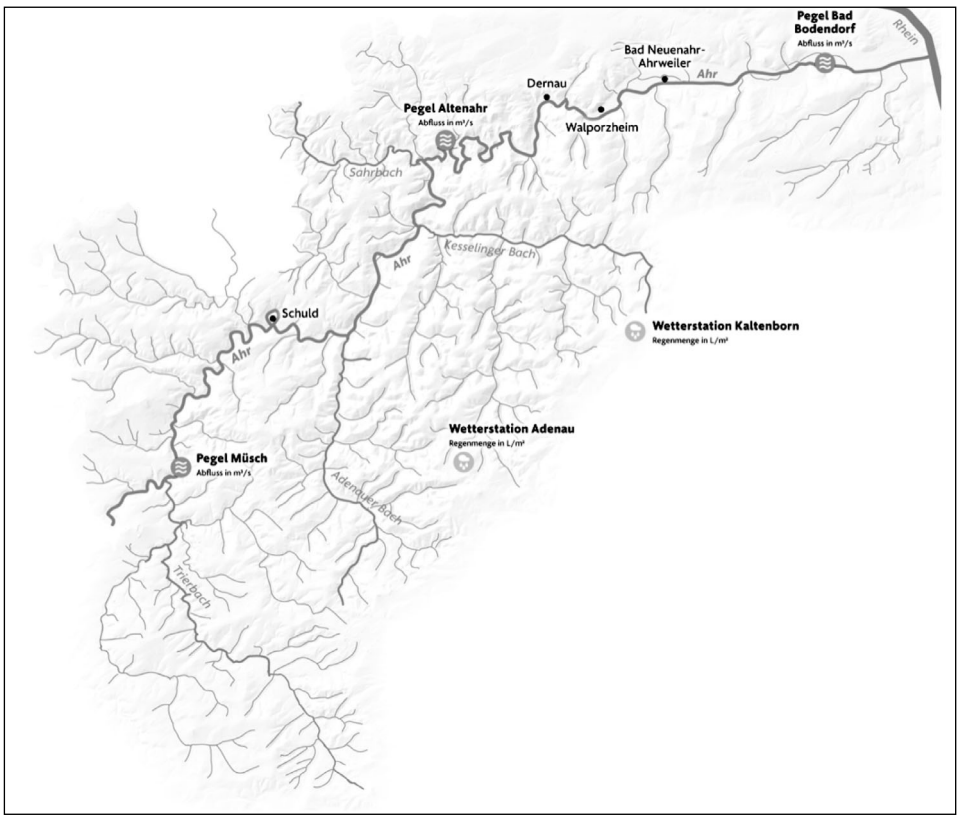

Fig. 1. The River Ahr with its tributaries, Frankfurter Allgemeine Zeitung, 21.08.2021

residences, and industrial plants. Heavy precipitation, floods, storm surges, and ice are only some examples for the occurrence of risks and the related problems. Therefore the knowledge about the movement of water on the land surface and the interactions with oceans and the atmosphere is a key issue. The hydrological cycle is a closed system in the sense that water circulating in the system always remains within the system. The whole cycle is driven by the excess of incoming solar radiation over outgoing radiation. The cycle consists of several subsystems, namely: the atmosphere, surface runoff, subsurface water (or unsaturated zone), groundwater (or saturated zone), river networks, and the oceanic subsystem. It is obvious that the occurrence of water on the land plays a major role within this cycle, because it is mainly there where man and the hydrological cycle interact. This part is called surface hydrology and it follows the atmospheric hydrology, which deals with the atmospheric motion of water usually in the form of vapor and water fluxes, and finally subsurface hydrology, which deals with the water in porous underground. The subdivision of the hydrological cycle into subsystems above and below the land surface is somewhat arbitrary, because continuous, but spatially and temporally varying, interchanges between them take place in the dynamic processes of the water movement.

Within these highly dynamic processes of the water movement, the main activities of the mankind take place with all the cities, industrial plants and harbors on lakes, rivers, estuaries, or coastal waters. Even if all these facilities did not release any kind of substance which is not harmful, they would have influence on the dynamic water motion. Change in vegetation, e. g. from forest to arable land, has influence on the movement of water and it variation in time. There will be changes in water storage, precipitation, and even loss of soil into the rivers. The soil in the river can also cause reactions like erosion and sedimentation in other parts of the river system. Urbanization and the creation of impervious areas affect both the hydrology and hydraulics of drainage systems. They change the runoff characteristics and have adverse effects on the designed drainage structures, such as bridges, culverts, and sewers.

To quantify the water movement in particular area of investigation, hydrological information and measured data are necessary. By these means another subject called hydrometry provide the required information. One of the most used and establish tool is the gauging station. In the simplest way, water level is measured by staff gauge. Nowadays gauging stations are high end technical equipment and often with self working data transmitter. Along the River Ahr there are several gauging station providing information about the water level along the river.

The Hydrology of the River Ahr

To assess the natural behavior and dynamic of flow of Streams, gauging stations, which measure water level are necessary. With the help of a rating curve, which is a graph of discharge versus water level reading, the stream discharge in m^3/s can be calculate at certain point on a river. To establish a rating curve various measurements of discharge over the whole variation of water level readings are necessary. The entire procedure and the required emplacement are give in every hydrological text book e.g. Hershey R. W. [3]. The River Ahr drains the catchment area of 897.5 km^2, approximately 76 per cent belong to Rhineland-Palatinate which is 683.0 km^2. The remaining part pertain to North Rhine-Westphalia. The average slope is 0.4 per cent, but is the upper reach it varies between 0.4 and 0.8 percent. The mean annual precipitation within the catchment are in the range of 675 mm and belongs to the areas of rivers with less precipitation. Except the part which belong the mountain called Hohen Eifel, which is the section who contribute the development of floods. Due to the high proportion of forest within the catchment, the mean long-term evaporation is above average evaporation.

Within a mountain catchment, it is obviously that there are some small rivers and rivulets take place. The most significant tributaries are Armuthsbach and Sahrbach, which drains on the left side into the Ahr. On the right Ahbach, Trierbach, Adenuaer Bach and Staffelbach flow into the River Ahr. Along the River Ahr and their tributary there are serval gauging stations like: — Bad Bodendorf, Altenahr and Müsch 2 on the Ahr itself, Kirmutscheid on Trierbach, Niedenau on Adenauer Bach, Denn on Kesselinger Bach and Kreuzberg on Sahrbach. The actual water level readings of all stations are available via the homepage of the responsible Water Authority. It is worth to mention, that these station provide the required hydrological information. In addition the stations Altenahr, Kreuzberg and Kirmutscheid are published in the Annual Hydrological Year Book (Deutsches Gewässerkundliches Jahrbuch, Teil III Rheingebiet, DGJ, 2019). Within the proceeding of hydrological data there are many steps of checking and validating involved. Therefore the actually of the Annual Hydrological Year Book are not always direct in time. For this part of the paper the data are used form the Year Book of 2019 used. The Hydrological Year Book provide not only the water level and discharge for the particular year, it gives also basic statistical outlook and an expansive view of the dynamic behavior of the hydrological system. As the main issue of this paper is the extreme flood in summer 2021 only the station Altenahr will be discussed in detail. The station Altenahr lies 31.7 km above the River Rhine and has a catchment area of 746 km^2. During the whole year of 2019 the natural variation of water and discharge showed following main data:

Lowest discharge (LQ) of 0.527 m^3/s on 26th of July 2019
Mean discharge (MQ) of 5.41 m^3/s and
Highest discharge (HQ) of 62.3 m^3/s on 10th of February 2019, with a water level of 183 cms.

Only these three values gives an impression of the dynamic of stream flow. The observation on this particular station goes back the year 1947, which means 73 years of observation. Therefore the basic statistic of the Hydrological Year Book of 2019 gives a general description over the whole time period with daily and monthly values of water level and discharge and other information like precipitation and flow duration curve. The mean discharge at the Altenahr gauge is 6.76 m^3/s calculates over the whole time series of 73 years. Another imported information is the ranking of extreme events. The lowest and highest values discharge for the last ten years. The table below shows extreme events with date of appears over the last ten years. There is a very distinctive variation in discharge over the whole course, which can be described as rather unbalanced. By figuring the ratio of the highest to lowest discharge value it comes out with proportion: Low Water : High Water = 1 : 800.

Table 1. Extreme Events of Low Water and High Water at gauging station Altenahr, Ahr [4].

	Low Water Events		High Water Events		
	m^3/s	Date	m^3/s	cm	Date
1	0,292	08.07.1976	236	371	02.06.2016
2	0,415	09.07.2017	214	349	21.12.1993
3	0,479	11.08.2003	192	393	30.05.1984
4	0,479	31.07.1964	190	391	16.03.1988
5	0,480	20.09.2018	178	380	11.12.1966
6	0,506	10.08.1996	175	378	31.01.1961
7	0,511	15.08.1973	167	370	23.11.1984
8	0,527	26.07.2019	165	311	23.01.1995
9	0,527	07.09.2013	158	362	07.02.1984
10	0,547	18.07.2015	145	293	12.01.1993

For this particular statistic, most of these High Water Events appear during the winter season, whereas the Low Water episode take place during summer season. Due to the geographical, topographical and meteorological conditions, floods on the River Ahr are not uncommon and various authors have investigate and describe the floods.

Seel, K. A. [5] characterized in a compendium of flood events on the River Ahr that 31 of the 64 recorded floods occurred in a summer half-year (May to October) and 33 in a winter half-year (November to April). Whereas nine events with particularly high water levels, five floods are summer floods and happened in the years 1601, 1804, 1818, 1848, 1910. The remaining four are winter floods and toke place in 1687, 1739, 1795, 1880. Further more he pointed out, that the reported damage, the most damaging floods are the summer floods of 1601, 1804 and 1910, all of which were powered by thunderstorms. The characteristic of the summer floods of the Ahr is the rapid increase in water level combined with high velocities and a accelerated decline. The River Ahr behavior likes as well as a torrent in the Alps. Winter floods, on the other hand, increase slowly, usually have a preliminary phase with high water levels and longer duration, before gradually falling back to mean water levels.

Floods and floods related information like description about damage or lost of live dated back to the 14th century. Detailed information is easy available via world wide web e.g. Wikipedia:, Liste der Hochwasserereignisse an der Ahr'. There are two tremendous floods, which can be named as Extreme Event. One happened on the 21st of July 1804 and the other on 12nd — 13rd June 1910.

The flood on 21st of July 1804 caused 63 people their lives and severe devastation. During the time span of 1794 to 1813/1814 the Ahr Valley and other parts of Rhineland was under the power of french government (Napoleon Bonaparte, 1769–1821). Therefore the flood itself and their damage are well documented. Just to mention some figures, 129 houses, 162 barns or stables, 18 mills and 8 forges as having be completely destroyed. 469 houses, 234 barns or stables, two mills and a smithy were badly damaged. 78 horses and draft cattle were reported drowned, many other cattle must have drowned. The vineyards and fruit trees in the Ahr Valley were largely destroyed. Almost all bridges collapsed, almost 30 bridges were named. As written in the table, the flood in July 2016 hat a peak discharge of 236 m^3/s. The 1804 event was reconstructed by the use of a flood level marks in Walporzheim and Dernau to a discharge of 1208 m^3/s [6]. The mean discharge at gauging station Altenahr is about 8 m^3/s. Both author also investigated other floods in the Ahr Valley. By this means they reconstructed the 1910 flood with a discharge of 585 m^3/s for Bad Neuenahr — Ahrweiler. This discharge is approximately half of the flood in event 1804. During the whole flood 52 people lost the lives. At this time the Ahr Valley Railway was under construction, and many workers are from abroad. Therefore most of the victims were Italian and Croatian workers who, regardless of presumed warning they hang around in a canteen below the village of Müsch. A newspaper report insinuated: Many of those who drowned caused their own deaths by not following the warnings but going to the canteens instead to keep save [8]. There are many papers, articles and essays describing the disastrous power of floods.

From the hydrological and meteorological point of view, the situation of the 1910 flood was similar to that in 1804. Before the cloudbursts and the resulting flood wave moved rapidly down on the 12nd–13rd of June, 1910, it had also rained for weeks, so that the Ahr and the streams that flow into it, especially the Nohnbach, Trierbach, Ahbach and Adenauerbach, swelled to torrents and caused devastating damage. In the 1920s, concrete plans for flood protection were drawn up due to the previous flood catastrophe. These included flood retention basins that could have held back a total of 11.3 million cubic meters of water. However, these plans were shelved in favor of the construction of the Nürburgring (Racing Circuit) and have not been implemented to this day [9]. In this context he pointed out that the flood of 2016 with 236 m^3/s

would have been a warning signal for itself and that more engineering work for flood protection should take place. We see the romantic Valley of the Ahr can be not so romantic and even deadly as during the flood of July 2021 where more than hundred people lost their lives.

The Flood of July 2021

By asking the World Wide Web, What is the Reason for a Flood or What Cause a Flood?

You will get countless answers, but the shortest and most convenient answer is:

Severe flooding is caused by atmospheric conditions that lead to heavy rain or the rapid melting of snow and ice. Geography can also make an area more likely to flood. For example, areas near rivers and cities are often at risk for flash floods.

These short paragraph by NOAA, SciJlinks aim to be inspires and engages students to learn about weather, satellite meteorology and Earth science (SciJlinks). All these reasons in the description above happened within the Ahr Valley and its catchment. The weather conditions were primarily characterized by the Low Air Pressure System ‚Bernd' over Central Europe during the 12nd to 15th of July 2021, which led to severe flood particulate within the Ahr Valley, Rhineland-Palatinate and North Rhine-Westphalia. In conjunction with a high-level depression slowly approaching from France, the troposphere was stratified with increasing instability. Warm and very humid air masses from the Mediterranean region reached Germany in a rotary motion around the «Bernd» low-pressure zone. Due to forced uplift (orographic and dynamic) and slight plugging up effects in the western low mountain ranges like Eifel, Sauerland and Westerwald), recurrent or persistent heavy precipitation first occurred regionally and later extensively. After the 15th of July the High Pressure System ‚Dana' pushed Low Pressure System ‚Bernd' towards south-eastern Europe. Later on the whole weather condition relaxed more [12].

Another imported factor on the formation of floods are the pre-weathering condition. Snowmelt in low mountain areas or in the Alps have a significant influence on the development of river flood, because heavy rain falls on totally saturated soil, therefore the flood will be more stronger, as the water cannot infiltrate into the ground and all water flow directly into the streams. However, during the first six months of 2021, the flood-plains received mostly more precipitation than the long-term mean of the same period would suggest. However, the excess precipitation of up to 15% can at best be described as moderate. In absolute terms, the flood areas recorded between 0 and 50 mm more precipitation than usual during the first half of 2021. Thus, after a long-term analysis, the pre-weathering presented itself as not particularly wet, but almost saturated [14]. However, the extreme rainfall over the time span from the 14th of July to 15th, 2021 led to extreme flooding on many rivers originating in the Eifel Mountains, including the Ahr, Kyll, Erft, Rur, as well as rivers in Luxembourg and Belgium. Due to the meteorological condition, extreme discharges occurred in the entire watercourse of the Ahr. Water levels began to rise in the early morning of July 14, with peak discharges-where they could be measured-occurring in the late evening of July 14 and the early hours of July 15. Data collection stopped at many gauges during the flood, including the Altenahr and Bad Bodendorf gauges. The gauge at Müsch, which is in the upper reaches delivered water data throughout, which therefore plays an important role in classifying the event. The end of the flood event can only be estimated due to the lack of level data in many cases, but it largely subsided over the course of 17th of July 2021.

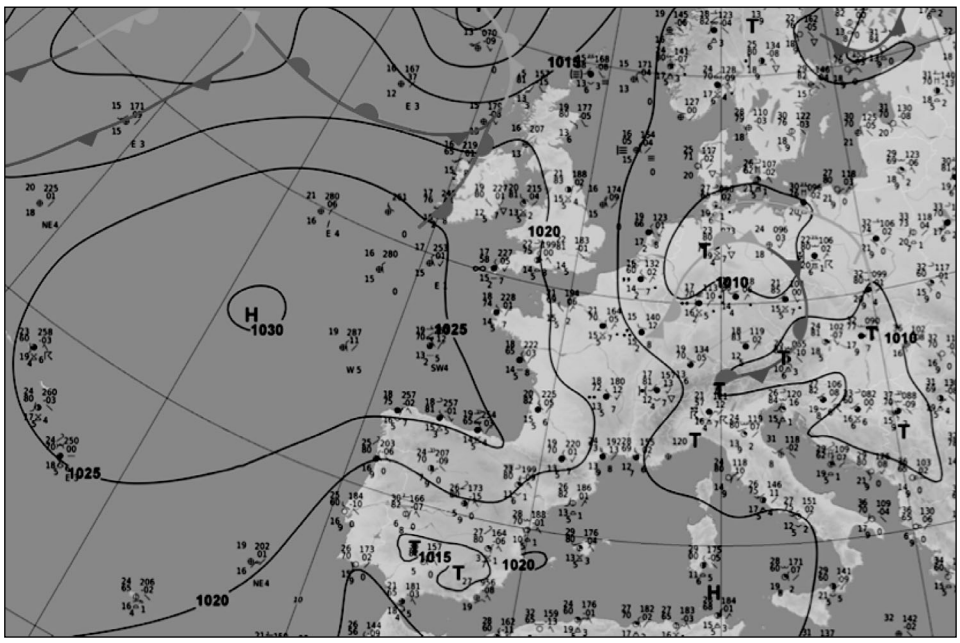

Fig. 2. Ground pressure analysis with front systems of the Low Pressure System, Bernd', 14th July, 2021, Source: DWD

The table above shows the Extreme Flood in the year 2021 within the Ahr Valley in relation to the highest measured discharge in 2016. Previous floods that as 1804 and 1910 mentioned in Chapter Hydrology of the River Ahr are higher, but their values are estimated and therefore carefully to use as reference. It does not mean they are

Table 2. Measured and estimated Discharge of the Flood July 2021 in relation of Flood Event 2016 Source: Internet page of the Hydrological Service of Rhineland-Palatinate

Gauging Station	Catchment Area km²	Highest Discharge Measured on Date	HQ100	Flood 2021	
Müsch	352	132 m³/s	02.02.2016	152 m³/s	320 m³/s (HQ_{100} × 2.10) 14.07.21 19:00 h
Altenahr	746	236 m³/s	02.02.2016	241 m³/s	332 m³/s 14.07.21 19:15 h

Table 3. Mean Factors for $HQ_x = f * HQ_{100}$" for small catchments 100—1000 km² in Baden-Wuerttemberg

HQ_{200}	HQ_{500}	HQ_{1000}	HQ_{2000}	HQ_{5000}	HQ_{10000}
1.13	**1.30**	**1.44**	**1.58**	**1.79**	**1.95**

Source: https://udo.lubw.baden-wuerttemberg.de/projekte/;jsessionid=56F88D6030DE0CF86539176F37089E57

unacceptable. The discharge of the 2016 flood are in the range of HQ_{100}, this is a statistical value which means flood of these amount return ones in hundred years. Or in other words the one hundred year recurrence interval means that a flood of that magnitude has a on per cent change go occurring in any given year. There are various methods to calculate the magnitude of a flood with a certain return period, but this would be not in the scope of this paper. The discharge at the gauging station Müsch is numbered with 320 m³/s for the July flood 2021 and explained with the multiplication factor of 2.10. These factor is based on statistical investigation on regional runoff values. Because there is a limitation in the statistical estimation of floods with greater return period if the available observed time series much shorter than the value of estimation. For example a time series of seventy years and the estimation of HQ_{100} is trustable, bigger estimations with the same time series like HQ_{200}, HQ_{500}, HQ_{1000}, HQ_{2000}, HQ_{5000} and HQ_{10000} are mendacious. For this reason the hydrologist of the Water and Environmental Authority of Baden-Wuerttemberg investigated runoff key features on small catchments see Table 3. As the hydro climate and the geography having that characteristics in common it is a possibility to evaluate the flood in this way. In this context the floods of 1804 and 1910 can be evaluate with the factors for higher return periods see Table 3. Roggenkamp, T. & Herget, J. [6] reconstructed several historical floods, including the events 1804 with discharge 1208 m³/s and 1910 with discharge 585 m³/s. As there are no measurements of peak discharge for the 2021 flood at these stations, the estimation would be approximately 2.1 × HQ_{100} (241 m³/s) = 506 m³/s. By using the HQ_{100} factor 2.1 for the upstream gauging station Müsch the result would be in the range of the 1910 flood, but significantly lower that the 1804 event.

During the two days and one night the live of many people, their houses and related infrastructure changed dramatically. Infrastructure like water supply, energy (gas and electricity), roads and railways line are undermined. Several bridges collapsed due to the debris of wood and other material. Sewer system collapsed. Waste water treatment plants were submerged and partial damaged. Heading system of many houses break down to the lack of electricity and heating fuel oil tanks lost the stability and oil spoiled into the River Ahr. It is very difficult to describe what happened and even what makes this disastrous flood with the people who lived there. Someone lost every thing like house and personnel belongings. The human pain is immeasurable and question arise, how could these happened and why was there not sufficient warning.

Only some numbers of the ruinous flood 2021. Within the affected area, sixty-two bridges were destroyed

Fig. 3 and 4. Spa Building Bad Neuenahr — Ahrweiler, 15th August 2021, © C. J. Blasi

and another thirteen badly damaged, fourteen schools and nineteen Day Care Centers were also damaged. More than three hundred thirty people had to be transported by helicopters from roofs and trees. In the city of Sinzig, which is located close to river mouth of the Ahr twelve residents of a Disabled Home by the name Lebenshilfe-Haus died. The flood reached the Disabled Home to faster than they could have been brought to a safety place.

All in all one hundred thirty-three people lost their lives during the flood, including twelve souls of the weakest people of a society.

On the other hand, it is amazing how fast and conducive people giving hands on others how need immediately help. Contractors, Craftsman and other volunteers, some from other federal states, made their way to affected areas with excavators, tractors, wheel loaders and other facilities to help and support the work of the rescue workers. The urgent problem was to collect all kind of waste from the areas and transport it damping places. These helping hands is still undergoing, because the financial fond with the application procedure is very time consuming. An another merit is the financial support also from private people and companies. It such kind of situation people are very creative and they established various charity fonds.

The Political Dimension of the Flood

The question how could these happened and who is responsible has a medial and political issue. Under these circumstances it is difficult to give sufficed answers, especially in the light that the whole issue is not worked out. The regional Television Channel ‚SWR' provide a chronology paper of the whole event [15]. This might be give a impression / explanations of the whole flood. In the following paragraph only some key fetchers of these document are emphasized, otherwise it review would be overloaded.

One of the great question is, when where flood warnings issued from which authorities and what happened on site? The responsible authorities had already warned on Saturday the 10th of the impending storm on Wednesday the 14th. These warnings have become more and more seriously. Also on this day the 10th of July the German Weather Service (DWD) and the European Flood Awareness System (EFAS) become active and looking more intensive on the weather condition. On Wednesday morning it started to rain occasionally, but it got more extensively and it he doesn't stopped. The Ahr gauging stations reacted heavily to the rain fall. At 11:00 A.M., The Flood Warning Centre of Rhineland-Palatinate issued the second highest warning level. In the afternoon the water level rises more rapidly and the regional Crisis Team of the Ahr Valley District established its service. At 17:17 P.M. the Hydrological Warning Centre released the highest warning level. 19:30 P.M. 19:30 P.M. first cellars are flooded, and nearly half hour later the water level of 5.00 meters where prognosticated. The water level at station Altenahr reached 5.75 meters at 20:45 P.M. At this time the flood was full developed and nothing could stopped it and measurement of water reading was not possible, regarding to the break down of the measuring devices. First damaged on various roads were reported. Neighboring Districts calling out the catastrophe case. The Ahr Valley District set the catastrophe case partial at 23:15 P.M.

During the whole night, many local residents spend the night on rooftops, because their places where cut off from the outside world. Some people where rescued from the roofs. Sometime the rescue operation were very difficult and sometimes impossible.

On Thursday morning the 15th the full extent of the catastrophe gradually become apparent, because only gradually will it become known how many people are actually still lost in the floods.

After these catastrophically flood, two questions are in the focus of public interest:

— How does it come to such huge floods in comparatively small water course?

— And how much responsibility does the Crisis Team of the Ahr Valley District have?

Within the Ahr Valley approximate 56.000 people live there and 42,000 people are affected. At least 17.000 of them have lost belongings or are facing significant damage. The flood carried away at least 467 buildings, including at least 192 homes. It is estimated that more than 3,000 of the 4,200 buildings along the Ahr, or in other words

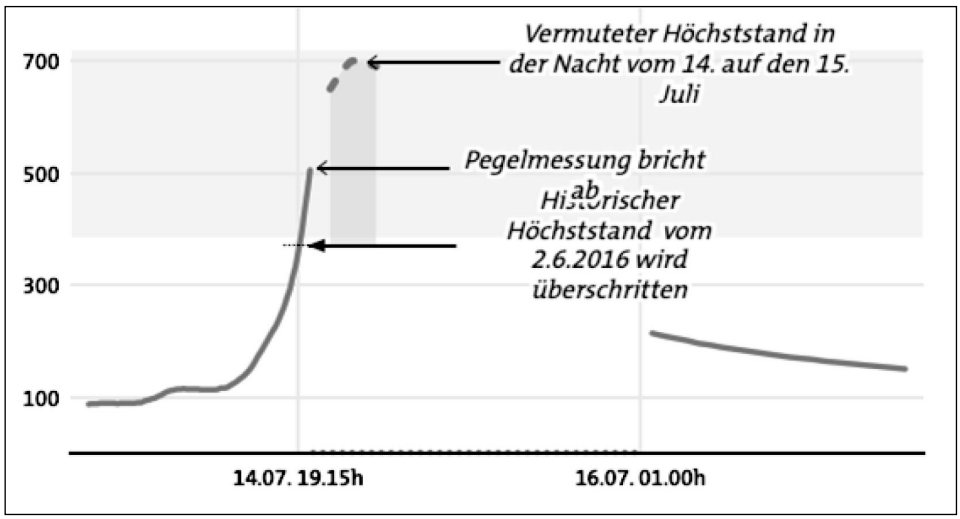

Fig. 5. Water level at Gauging Station Altenahr during the 14th to 15th of July 2021.

more than 70 percent of all buildings, were damaged. Even nonresident and outside observer could not find words in view of the flood disaster in the Ahr Valley. All those affected people have a right to know what exactly happened, and whether and where there were omissions in the long chain of informations and events.

By this means the opposition party in the government of Rhineland-Palatinate claimed for a Parliamentary Investigation Committee. The investigation invited a wide range of outstanding experts like Meteorologist, Hydrologist and other Engineering Discipilins. All come out with the result, a flood has always an indication before. It cannot be prevented, but the lost of live is entirely unacceptable. In one of the previous chapters Büchs [9] pointed out, that the flood of 2016 with 236 m^3/s would have been a warning signal for itself and that more engineering work for flood protection should take place. In this context the public prosecutor's office in Koblenz announced that it was investigating the initiation of preliminary proceedings against the head of the crisis team following the severe weather disaster in the Ahr Valley. There was an initial suspicion of negligent homicide and negligent bodily injury as a result of possibly omitted or delayed warnings or evacuations. Another critical issue is the reaction of the Ministry for Climate Protection, Environment, Energy and Mobility during the time span of 14th to 15th July. This Ministry is responsible for the supervision of the Hydrological Service. On the afternoon of 14th of July she released a official statement with ‚No Extreme Flooding' was expected. The notice also was a published advice and guidance for campground operators should near-shore areas be flooded. Also other Minister and President of the Government where invited and interviewed. As the Investigation Committee is still in duty, the final results cannot discussed here.

Summary

The Flood of July 2021 was an event with catastrophically dimension. Many people lost the home and outer their live. Regarding the expert from the Parliamentary Investigation Committee, a flood like this cannot totally prevented, but sign for reaction to bring people and here belongings like cars to a save place was given. The first warning from EFAS and DWD should be considered seriously and the Crisis Team should be better prepared. On the other hand, the Ahr Valley has a long history in floods from which experts can learn. Even the flood of 2016 with a return period of one in hundred indicate that there is a great potential hazard of flood and prevention engineering work should be discussed. After the flood of 1910 there were plans to build a flood retention pond. Another point to discussed is to investigate the whole catchment in the light of hydrological mechanism to find runoff factors. Vineyards in this area are very steep, therefore the water rushed down very fast. Even here the might be the possibility to retain the water in small ponds or lowering the velocity be rough materials. Bridges are always a problem. In Switzerland, there are similar problems, Engineers solved the problem with lift up bridge so that the water can run free. To train and educate the Crisis Team is also an option.

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