



ICOMOS-ICCROM

ANALYSIS OF CASE STUDIES IN RECOVERY AND RECONSTRUCTION CASE STUDIES

C IT IT

2020

Patan, Nepal • Taishun, China • Nyanza, Rwanda
Aleppo, Syria • San Pedro de Alcántara, O'Higgins Region, Chile
WH Cultural Landscape Wachau, Austria • San Luis Potosí, México

vol. 2





ICOMOS-ICCROM

ANALYSIS OF CASE STUDIES IN RECOVERY AND RECONSTRUCTION **CASE STUDIES**

VOL. 2

Patan, Nepal • Taishun, China • Nyanza, Rwanda Aleppo, Syria • San Pedro de Alcántara, O'Higgins Region, Chile WH Cultural Landscape Wachau, Austria • San Luis Potosí, México Published by ICCROM (Regional Office, Sharjah) and ICOMOS (International Council of Monuments and Sites).

All rights reserved. © ICCROM and ICOMOS, 2021 ISBN 978-92-9077-305-4



This publication is available in Open Access under the Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0) license (https://creativecommons.org/licenses/by-nc-sa/4.0/). By using the content of this publication, the users accept to be bound by the terms of use of any future ICCROM Open Access Repository and that of ICOMOS.

The designations employed and the presentation of material throughout this publication do not imply the expression of any opinion whatsoever on the part of ICCROM and ICOMOS concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. The ideas and opinions expressed in this publication are those of the authors; they are not necessarily those of ICCROM and ICOMOS and ICOMOS and do not commit the Organizations.

ICCROM-Sharjah

P.O. BOX 48777, Sharjah United Arab Emirates Tel: +971 (0)6 555 2250 Email: athar-centre@iccrom.org www.iccrom.org/athar

ICCROM

Via di San Michele 13 I-00153 Rome Italy Tel: +39 06 585-531 Email: iccrom@iccrom.org www.iccrom.org

ICOMOS International Secretariat

11 rue du Séminaire de Conflans 94 220 Charenton-le-Pont France Tel : 33 (0) 1 41 94 17 59 Email : secretariat@icomos.org https://icomos.org

Graphic design: Mohammed Irqsosy

Volume 2

TABLE OF CONTENTS

Post-Earthquake Recovery and Conservation-Restoration in Patan, Nepal		
Martina Haselberger, Rohit Ranjitkar and Gabriela Krist	06	
Recovery and Restoration of the Taishun Wooden Arch Bridges – Wenzhong Bridge, Xuezhai Bridge, and Wenxing Bridge		
Huang Zi	38	
The Interpretative Reconstruction of the Royal Capital in Nyanza, Rwanda		
Maya Ishizawa and Jérôme Karangwa	60	
Post-War Recovery of the Old City of Aleppo: The Rehabilitation of <i>Suq</i> al-Saqatiyya as a Pilot Project		
Ruba Kasmo and Lina Kutiefan	90	
New Approaches for Rebuilding and Preserving Rural Heritage: The Case of San Pedro de Alcántara, O'Higgins Region, Chile		
Maria de los Angeles Muñoz Martinez	116	
Flood Protection Provisions in the World Heritage Cultural Landscape Wachau, Following the Flood of 2002		
Michael Schimek	152	
Reconstruction of the Symbolic and Physical Space of the Temple of Nuestra Señora de la Asunción of Santa María Acapulco, San Luis Potosí, México		
Renata Schneider	184	

FLOOD PROTECTION PROVISIONS IN THE WORLD HERITAGE CULTURAL LANDSCAPE WACHAU, FOLLOWING THE FLOOD OF 2002

Michael Schimek, Dipl.-Ing. MA



TABLE OF CONTENTS

Lis	List of Illustrations	
1.	The Heritage Resource and Its Context Before the Impacting Event	155
	1.1. Description, Designation and Recognition	155
	1.2. History and Context	156
2.	The Nature of the Impacting Event	157
	2.1. The Hydrological Aspects of the Flood	157
	2.2. Lack of Practical Experience with a 100-yearly Flood	159
	2.3. Damage Witnessed	159
3.	Post-Event Appraisals	160
4.	Response Actions, Timeframes, Resources and Costs	163
	4.1. Immediate Action	163
	4.1.1. Cleaning rUp	163
	4.1.2. Financing the Recovery of Damaged Houses and Furniture	163
	4.1.3. Recovery of the Dry Stone Wall Terraces	163
	4.2. Preventive Actions from 2002 to 2013	164
	4.2.1. Provisions for Civil Protection	164
	4.2.2. Nature Protection Projects	164
	4.2.3. Flood Protection Systems	164
	4.3. The Giant Flood of 2013	172
	4.4. Actions from Around 2013 to 2019	173
	4.4.1. Additional Financial Means for the Remaining Projects	173
	4.4.2. Implemented Additional Flood Protection Projects	173
	4.4.3. Not yet Finished Protection Projects	176
5.	The Outcomes and Effects	178
6.	Additional Comments	178
7	Datails of the Export Completing the Case Study	170
1.	Details of the Expert Completing the Case Study	179
Bił	bliography	182

List of Illustrations

- Fig. 1 The World Heritage region Wachau, in: Zech *et al.* 2017, 24–25
- Fig. 2 Flood marks at the house Oberarnsdorf 16 (M. Schimek 2019)
- Fig. 3 The flood 2002 at the Kamp river, in: Godina *et al.* 2004, 19
- Fig. 4 The August 2002 flood on the Danube, in: Godina *et al.* 2004, 32
- Fig. 5 Flood levels in August 2002 from the Wachau downwards, in: Godina *et al.* 2004, 33
- Fig. 6 Flood marks inside Gasthaus Reiböck in Spitz - the house itself is raised about a meter above street level (M. Schimek 2019)
- Fig. 7 Dry stone walls still are the backbone of wine production in the Wachau (M. Schimek 2006)
- Fig. 8 The base walls of the flood protection systems should about equal the height of the guard rails along the main road (M. Schimek 2019)
- Fig. 9 Trial mounting of the flood protection system at Oberarnsdorf (R. Schütz 2012)
- Fig. 10 Trial mounting of the flood protection system near Melk (P. Strobl 2019)
- Fig. 11 Grounding of the walls near Rührsdorf (R. Schütz 2011)
- Fig. 12 Location of the pump house at Emmersdorf (M. Schimek 2019)
- Fig. 13 Different wall designs (M. Schimek 2019)
- Fig. 14 Flood protection system at Luberegg (Google Maps, cartography M. Schimek 2019)
- Fig. 15 Luberegg castle and the flood protection wall (M. Schimek 2019)
- Fig. 16 The flood wall replaced the garden wall (M. Schimek 2019)
- Fig. 17 Flood gate at Luberegg (M. Schimek 2019)
- Fig. 18 Flood protection system at Hundsheim (Google Maps, cartography M. Schimek 2019)
- Fig. 19 Hundsheim chapel and the flood protection solution around (M. Schimek 2019)
- Fig. 20 Upper corner of the flood protection at Hundsheim (M. Schimek 2019)
- Fig. 21 Flood protection system at Weißenkirchen, Joching, and Wösendorf (Google Maps, cartography M. Schimek 2019)
- Fig. 22 Flood wall in the relatively open land near Joching (M. Schimek 2019)

- Fig. 23 The flood gate at Wösendorf (M. Schimek 2019)
- Fig. 24 Aluminum panel storage hall near Joching (M. Schimek 2019)
- Fig. 25 Flood protection system at Spitz (Google Maps, cartography M. Schimek, 2019)
- Fig. 26 The double paneled flood gate at Hinterhaus (M. Schimek 2019)
- Fig. 27 Storage halls at Spitz (M. Schimek 2019)
- Fig. 28 Flood walls surrounding the Spitzer Bach mouth (M. Schimek 2019)
- Fig. 29 New design of the Spitz landing (M. Schimek 2019)
- Fig. 30 Flood protection system at Oberarnsdorf (Google Maps, cartography M. Schimek, 2019)
- Fig. 31 Center part of the Oberarnsdorf flood protection (M. Schimek 2019)
- Fig. 32 Part of the new "village square" along the Danube in Oberarnsdorf (M. Schimek 2019)
- Fig. 33 Storage hall seen from the main road (M. Schimek 2019)
- Fig. 34 Flood protection system at Rührsdorf (Google Maps, cartography M. Schimek, 2019)
- Fig. 35 Walls are needed deep into the vineyards because of the flat land surrounding Rührsdorf (M. Schimek 2019)
- Fig. 36 Aluminum panel washing machine at work during a practice with the Austrian army in Weißenkirchen (M. Schimek 2019)
- Fig. 37 The June 2013 flood on the Danube, in: Godina *et al.* 2014, 32
- Fig. 38 Design elements along the main square in Melk (M. Schimek 2019)
- Fig. 39 The "World Heritage Lens" enhances the visibility of the baroque abbey from the Danube landing (M. Schimek 2019)
- Fig. 40 Emergency lane at Unterloiben (M. Schimek 2019)
- Fig. 41 Massive walls at the upstream part of the flood protection in Unterloiben (M. Schimek 2019)
- Fig. 42 Location of the flood protection walls in Emmersdorf directly at the Danube (M. Schimek 2019)
- Fig. 43 Newly designed bus waiting zone at Seegarten (M. Schimek 2019)
- Fig. 44 The World Heritage region Wachau, in: Zech *et al.* 2017, 24-25, cartography M. Schimek, 2019, Overview over all flood protection projects

1. The Heritage Resource and Its Context Before the Impacting Event

1.1. Description, Designation and Recognition

The World Heritage cultural landscape of Wachau in Lower Austria is a riverine landscape along the Danube. Generally, the Danube in south-eastern Bavaria and most of Austria follows the southern fringe of the medium high mountains that make up the so-called Bohemian Massif. On some occasions, though, it runs through the mountain range, cutting off small parts and creating scenic valleys.

The peaks along the Danube in the Wachau are usually around 500 m above the sea level of the river, which in turn is about 200 m above the sea. The location between two large climate zones – Atlantic and Continental – and the specific features of the landscape – aspect, geology, sunshine hours – have created a landscape which features many rare warmth-loving animals and plants and a certain Mediterranean flair which is unique in Austria.

The Roman Empire used the Danube as its northern border and introduced wine growing in the region.

During the Middle Ages, monasteries upstream colonialised the Wachau as their major wine growing area. Wine growing still accounts for about two thirds of the landscape, on dry stone terraces cultivated and maintained mostly manually. Despite the economically challenging way of working, the wine growing area has stayed constant during the last 50 years. White wines from the Wachau rank among the best worldwide and achieve prices which allow the wine growers to continue working and make a reasonable living out of it on the historic terraces.

The Wachau valley was already designated as a Protected Landscape under the Lower Austrian Nature Protection Act in 1955. In the 1970s, a large citizen movement successfully opposed plans to destroy the landscape by building a hydroelectrical power plant opposite the medieval town of Dürnstein. Since 1994, it has been awarded the European Diploma for Protected Areas by the Council of Europe under the condition that all plans for such a power plant are banned forever. Subsequently, the Wachau was enlisted as a cultural landscape into UNESCO's World Heritage List in 2000 (fig. 1).



Fig. 1. The World Heritage region Wachau, in: *Zech et al.* 2017, 24-25

Today, the Wachau is commonly described as the part of the Danube valley which starts and ends at the cities of Melk and Krems. It is framed by two famous baroque monasteries – Melk and Göttweig – and is about 36 km long. At least a part of the World Heritage perimeter is held by fifteen different municipalities. They are organised in a voluntary association which has been assigned the task of managing the World Heritage status in the World Heritage Management Plan which was issued in 2016. The association currently employs five people who are responsible for protecting and carefully developing the region. The management is jointly financed by the Republic of Austria, the Federal State of Lower Austria and the municipalities. For specific projects, it makes use of a wide variety of national and European grant schemes.

1.2. History and Context

Like any river in the world, the people living close to the Danube have witnessed a number of smaller and higher floods during their lives. Many towns and villages in the Wachau valley are located so that they are safe from flood risk, or at least from minor events, except for some villages which served as harbour cities which were therefore flooded more frequently.

Really big flood events were a rare occurrence. The biggest flood in recent history was the flood around 15

August 1501. Calculations from the 1930s estimated the peak flow of this event at around 14,000 m³/s in the town of Krems-Stein.¹ As a comparison: Currently, the average flow of water (MQ) in the Danube in the Wachau is at 1,880 m³/s, the average lowest flow during the last 10 years amounts to 812 m³/s.²

Around 1800, there were again a number of rather large floods, such as in 1787, 1830, and 1862, partly caused by ice jams (see fig. 2).³ At the same time, the use of the Danube followed the industrialisation of society, meaning the river should become more reliable for navigation and at the same time safer for the local people in the event of a flood. This is why the Danube in Austria was, as it was called, "regulated" (*reguliert*) during the second half of the nineteenth-century, which mostly meant cutting off side branches, putting the water into one rectified river bed and securing the banks with big rocks.

At some places, people became a little careless, building closer to the river than they should have. However, it soon became clear that floods would still be a regular part of their life. Both 1897 and especially 1899 saw large floods putting wide parts of the newly built areas under water. The next huge flood only took place in 1954, with the water levels rising to the same height as those in the nineteenth-century.



Fig. 2. M. Schimek, 2019, Flood marks at the house Oberarnsdorf 16





After that, circumstances changed once again. Between 1956 and 1998, a total of ten hydroelectric power dams were built in the Austrian Danube.⁴ There are now only two stretches of the Austrian Danube where the water is not dammed: The Wachau, now a UNESCO World Heritage, and the part between Vienna and Bratislava, now a National Park. Both the opportunities of the newly created retaining capacities behind the power dams and the necessities of proper gravel management – the rubble transport of the Danube is blocked by the power dams now and only takes place in the freely flowing river sections, resulting in gravel accumulation where the freely flowing river ends and the dammedup areas start – had to be tested out.

This is why the effects of the flood in August 1991 turned out to be more severe than expected in the case of the historic city of Stein. During the building of the downstream power dam at Altenwörth, along the city of Stein a wall had been erected which kept smaller floods away from the city. In this case, because of gravel accumulations and the late reduction of the water level at Altenwörth, they were almost a metre too low,⁵ though, so the flood severely damaged the historic city.

This is why the municipality of Krems (to which Stein belongs) decided to build a higher flood protection system following the role model of the City of Cologne in Germany, which had built a special form of flood protection infrastructure during the 1980s.⁶ In case of danger, aluminium panels can be mounted on top of relatively low walls following the riverbed and which have little influence on the perception of the townscape of the old town of Cologne. The new flood protection system for Krems and Stein was completed in 1996, at a cost of about €12 million (ATS165 million). It runs over a length of 1.69 km, out of which about half is constructed in the same way as the one in Cologne (the remaining part, aside from the historic city centre, is made up by dams and permanent walls).⁷

2. The Nature of the Impacting Event

2.1. The Hydrological Aspects of the Flood

The year 2002 brought a number of flood events all over Austria. In the case of the Wachau, in March there was a medium-sized flood which came close to the extent of the flood from 1991.⁸ But this was overshadowed by the enormous flood that hit parts of Austria – the same flood hit western Czech Republic and northeastern Germany – in August 2002.

In the end, it was two events within a week that caused the enormous impact of the flood in the Wachau in August 2002. The first event took place on 6 and 7 August. 2002. Extremely heavy rainfall north of the Danube – in some places there was almost three times as much rain in 48 hours than there usually was for the whole month of August⁹ – caused a 1000-yearly flood (fig. 3) in some places.



From top to bottom:

4

Fig. 4. The August 2002 flood on the Danube, in: Godina *et al.* 2004, 32 Fig. 5. Flood levels in August 2002 from the Wachau downwards, in: Godina *et al.* 2004, 33

Dams along the rivers broke, wide areas in the flatlands were flooded. Initially the situation seemed to improve, but then between 11 and 13 August there was again heavy rainfall, this time not only north of the Danube, but also in the Alps, especially in Salzburg, Upper Styria, and Upper Austria, causing extreme floods along the main tributaries of the Danube in this area, for example, Salzach, Traun, Enns, and Ybbs. This second flood wave built on the already high water levels from the first flood wave, causing the highest water levels in 200 years.

10.Aug

12 Aug

14.Aug

16.Aug

18.Aug

20 Aug

2000 • 2000 • 1000 • 06 Aug

08.Aug

For the Wachau, it proved crucial that the highest floods on the tributaries happened on rivers entering the Danube rather close to the valley. In many cases, floods on the Danube have to do with extreme precipitation events along the Bavarian Danube and its tributaries, for example particularly on the Inn River. In August 2002, the most extreme floods happened more to the east of Austria. The enormous influx from the Enns River showed that the water level rose from 5 m to more than 8 m within just a few hours on 12 August on the water level metre of the Danube at Mauthausen, opposite the mouth of the Enns into the Danube (fig. 4).

This is why a flood which was only classified as a 30-yearly event until Mauthausen had become a 100-yearly flood from Mauthausen to Vienna.¹⁰ For the Wachau, this meant the worst flood since 1954. Because of the nature of the event, the flood came relatively quickly. It only took about 36 hours from reaching basic flood level at a flow level of 5,150 m^3/s^{11} to the peak at 11,300 m^3/s (fig. 5).¹²

2.2. Lack of Practical Experience with a 100-yearly Flood

This meant relatively little time to prepare the villages for the unavoidable. Added to this was the fact that at that time, the official forecasts were only prepared for a few hours ahead, which meant that the anticipated peak level of the flood was constantly raised with any new forecast. There were unofficial reports that precisely forecast the final peak level, but they were not officially communicated, probably because of fear of liability issues. This meant that many people checking the forecasts themselves on the internet lost precious time to safeguard their properties since they first believed that they would not be affected at all.

Furthermore, as this was the first really big flood in almost 50 years, not many of the people in charge in 2002 had already witnessed the 1954 event. Operation plans for the blue light organisations had not been updated for a long time. People had become careless, using lower-lying parts of their house as living spaces or for storage of valuable items. Many house owners had installed central heating since 1954, usually in places that were flooded this time. In particular broken oil tanks proved to be an additional hazard.

2.3. Damage Witnessed

In the end, the flood waters rose as high as 3 metres or in some places even higher, which in these cases meant that the water reached the second floor of the houses (fig. 6). In most cases, though, the local residents could stay on the second floor of their houses but had to be supplied with food and drinking water from fire brigades on boats. None of the flooded houses collapsed, since generally speaking the historic buildings are built in a way that they survive a few days in the water – many old houses use Danube stones in the lower part of the wall construction, which means that they do not soak up the water, timber structures in the walls are extremely rare – but of course a lot of the interior fabric was severely damaged.

The most severe damage occurred to one of the most important features of the World Heritage cultural landscape, the traditional dry stone wall wine terraces, many of them dating back almost 1,000 years and still successfully maintained for wine production (fig. 7). Because of the extreme rainfall, 150,000 m² of them had been severely damaged or had even collapsed. Recovery of the terraces started immediately after the flood but, of course, this took longer than cleaning up the houses and streets.

The only town which was not flooded in 2002, though, was Krems-Stein, since they had already built a new flood protection facility after the flood of 1991. Although the aluminium panels screwed to the top of the base walls proved to be too low, the fire brigade and local people managed to put enough bags of sand on top of the aluminium walls to keep the water out of the city.

From left to right: Fig. 6. M. Schimek, 2019, Flood marks inside Gasthaus Reiböck in Spitz – the house itself is raised about a meter above street level Fig. 7. M. Schimek, 2006, Dry stone walls still are the backbone of wine production in the Wachau





3. Post-Event Appraisals

Apart from the immediate recovery and help to the affected people, thoughts centred around ideas on what to do in the future, if a similar event happened again.

A week after the flood, the head of the region and mayor of Spitz, Dr Hannes Hirtzberger, was invited onto a TV show where he postulated that the public sector had to accept floods like these and fully compensate all affected owners in the future. This was not very well received by a lot of the local people, but especially by the Governor of Lower Austria. Even though it was merely pure luck, the example of Krems-Stein avoiding devastation in their town by technical means, was perceived as a great success and a role model for the future.

Hirtzberger stressed the fact that technical infrastructure alone would never provide 100 per cent security, which means that people might become careless again, and he was afraid that the recently acquired World Heritage status might be jeopardised by major constructions significantly altering the landscape. Not all the other mayors in the Wachau held the same opinion. In particular, the mayor of Weißenkirchen publicly called for additional flood protection systems. The Lower Austrian government offered those who were ready to invest in such a system additional money - 50 per cent of the cost from the Republic of Austria, 37.5 per cent from the State of Lower Austria, and only 12.5 per cent from the municipalities,¹³ all of them small communities of between 1,500 and 3,000 inhabitants. Plans for a potential flood protection system had already been drafted in the 1990s for all the affected villages, so the calls for a more detailed planning and implementation of those plans became louder and louder.

In the end, Hirtzberger agreed on more detailed planning, but he made almost all of the other mayors agree on common rules for the future flood protection systems. If possible, they should all follow the example of Krems-Stein, i.e. construct a relatively low wall of about 80 cm in height which would in many cases replace the similarly high guard rails along the roads (fig. 8), and put aluminium panels on top only when they were needed (figg. 9, 10). Thus, the high water is kept behind the system in the riverbed creating a dry polder inside.¹⁴

Most of the infrastructure is not visible, though. The walls that show 80 cm above the surface need to be grounded some metres deep in order to prevent ground water from intruding into the polder (fig. 11). Since a certain amount of influx into the ground water body still needs to be possible, not all ground water can be blocked. The remaining water, therefore, has to be pumped out of the polder during the flood. For this a number of pump houses had to be built. The decision was taken to put all those pump houses underground, so that they did not intrude on the landscape. The only visible sign of the pump houses usually is a strange array of locks on the street surface (fig. 12).

All drafts should not only be done by technical planners, but also by a professional architect watching over the aesthetical appearance of the walls and additional infrastructure necessary, such as the storage halls for the aluminium panels. The final decision on the details of the planned devices was taken by an advisory board that was composed not only of technicians, politicians, and the architect, but also a delegate from ICOMOS Austria. Since every decision had to take into account different conditions, they could not be taken at the same time, and since the same people were not involved in every single project (e.g. it was a free decision of each municipality to decide on the architect in charge), there was an advisory board for each village respectively.

The discussion process in the advisory board meetings tried to ensure that all necessary decisions were supported by all members of the boards, so if any doubts were raised by any member of the board, the current drafts were worked over to make sure that everybody could agree on the final solutions in the end. Only in exceptional cases, a majority vote took place, in which each of the board members (also the ICOMOS delegate) had one vote, following standard legal procedures for public commissions in Austria.

The local people of the affected villages were informed on a number of occasions in public meetings and had the opportunity to discuss the plans with the planners and their municipality representatives.









Images, Clockwise from top left: Fig. 8. M. Schimek, 2019, The base walls of the flood protection systems should about equal the height of the guard rails along the main road Fig. 9. R. Schütz, 2012, Trial mounting of the flood protection system at Oberarnsdorf Fig. 10. P. Strobl, 2019, Trial mounting of the flood protection system near Melk Fig. 11. R. Schütz, 2011, Grounding of the walls near Rührsdorf Fig. 12. M. Schimek, 2019, Location of the pump house at Emmersdorf



They did not send any additional people to the advisory board, though. Since most of the affected municipalities have a population of around 1,500 people (the largest 5,500), the mayor and the other municipality representatives have a very close connection to their inhabitants and are, generally speaking, trusted by them. Since the mayors have no interest in public unrest, they tried to make sure that the ideas of the local people were taken into account as much as possible.

To allow for all necessary projects to be financed, the State of Lower Austria created a list of priorities for all municipalities. In this list, the projected costs were compared with the potential damage of a similar flood event like the one in 2002, thus creating a cost-utilityratio for each village. This number made clear which plans create the highest utility if implemented – if the costs of building a flood protection system were potentially already covered by preventing the damage stemming from one or two similar floods (so creating a ratio of below or slightly above 1), those plans were prioritised first. The villages with a higher ratio had to accept that their systems would come later. Since the different flood protection systems were built consecutively, each municipality learned from the examples erected before them. Some were luckier than others - since the rule was that the reconstruction of everything that had to be destroyed because of building underground - road surfaces, smaller green areas, but no valuable historic substance - was jointly financed by the Republic of Austria, the State of Lower Austria, and the municipality involved, some could do more for the new design of the affected places than others. It was the job of the architect to make sure that also these interventions are taken with respect to the World Heritage status of the region and the historic substance, in each case. In some cases, asphalted street surfaces were replaced by cobblestone. In any case, the modernised situation means that the public space is of a better quality in visual and useability terms for both the local people and visitors to the area.

As for the design of the walls, the decision was taken that they should be recognisable as a twenty-first-century intervention and not be designed in a historicising manner. This led to different aesthetic solutions, though, depending on which architect the municipality chose for the job (fig. 13).



Fig. 13. M. Schimek, 2019, Different wall designs

4. Response Actions, Timeframes, Resources and Costs

4.1. Immediate Action

4.1.1. Cleaning Up

As the flood waters recede, they leave millions of cubic metres of mud in the houses, gardens, and on the streets. It is crucial to get rid of the mud as quickly as possible, since it gets solid and hard as concrete when it is drying out. Since almost all the affected houses were still inhabited, people had a huge interest in quickly making their houses inhabitable again, so they started cleaning up immediately and tried to make sure that the walls dried quickly. Wheelbarrows, snow shovels and drying devices for houses were sold out within hours.

The local residents were supported by fire brigades from neighbouring villages and the Austrian army who were sent to the flooded areas to help. In addition, thousands of volunteers from all over Austria supported the local people, many equipped with their own shovels and carts. Special trains from Vienna for volunteers were organised in cooperation with radio stations. The result was overwhelming: On the first weekend after the flood, so many people had come that the mayors had to ask the people who had not arrived yet to stay at home, since there was no way of dealing with them properly. The number of volunteers even outnumbered the number of inhabitants in some of the villages.

This is how the immediate cleaning up job was done within a week of the end of the flood everywhere. Drying the walls took a little longer, of course. The local people cooperated a lot in sharing machinery and supporting each other.

4.1.2. Financing the Recovery of Damaged Houses and Furniture

The Republic of Austria has set aside some of its revenue from income and corporate tax in a so-called Catastrophe Fund. It may be paid out to private households who have suffered from natural disasters.¹⁵ The fund is administered by the federal states, which also have the right to issue procedures on how the money is assigned.¹⁶

In Lower Austria, money from the catastrophe fund is

mainly paid out for damage to houses, agricultural land, and forests. For these cases, each municipality has to form commissions straight after the event who visit each affected household and record the amount of damage. These commissions include the mayor of the municipality, the head of the second largest political party delegation in the municipality council, and a number of certified experts, depending on the kind of properties affected. The commission agrees on the amount of damage and notes how much may be covered by private insurance.

It is then the job of the federal state administration to decide on the final amount of money paid out to the individual households. The general rule is that 20 per cent of the costs remaining after the deduction of private insurance payments are covered by the public. In case of socially disadvantaged people or other special circumstances, the amount may be raised to 50 per cent of the remaining costs.

One problem was that some of the house owners who live close to the river that are flooded more regularly, or suffer other minor events, no longer had private insurance since they could not afford the high annual insurance rates. This was one of the reasons for discussing ways of dealing with the situation in the case of similar floods in the future (see chapter 3).

4.1.3. Recovery of the Dry Stone Wall Terraces

Immediately after the catastrophic loss of the dry stone terraces because of the heavy rainfall, negotiations for additional public funding of their restoration started.

it was necessary to restore the terraces not only from a World Heritage point of view, but also to maintain the worldwide fame of wine growing in the Wachau. Luckily, the economically healthy and prosperous wine economy of the Wachau managed to afford the necessary restoration works.

So, by 2004, almost all of the collapsed or damaged walls had been rebuilt in the traditional dry stone style, using the original materials and technique which has proven to be the best possible way to build such terraces in order to grow wine on them. Most of the work was done by the wine growers themselves, in many cases supported by volunteers who were actively recruited by the region.

4.2. Preventive Actions from 2002 to 2013

4.2.1. Provisions for Civil Protection

Apart from the catastrophic nature of the flood itself in 2002, some of the problems arose from the fact that the Wachau had not witnessed a similar event for almost 50 years and the general circumstances had changed tremendously in between because of the building of the power dams upstream and downstream and the general alteration of the surroundings of the river that simply happen over a span of 50 years. This is why all the institutions involved thoroughly recorded all the shortcomings of the civil protection plans from 2002 and created significantly improved disaster response plans for the local people, the municipalities, the blue light organisations, especially the volunteer fire brigades run by the local people themselves, and the Austrian army specialises in helping out with inland disasters.

At the same time, the public authorities agreed on investing in a better forecasting model that would also provide the affected people with a forecast on the maximum height of a pending flood. The minor events following the 2002 flood showed that the new forecasting models were very accurate and significantly improved the response of the public authorities. Generally speaking, floods along the Danube take two to three days to reach their peak, so if anticipated early and precisely, this leaves enough time for everybody to prepare properly for the event.

4.2.2. Nature Protection Projects

Another large project had additional positive effects on the flooding situation in parts of the Wachau valley. The regional development authorities had been granted an EU-funded LIFE Nature project from 2003 to 2008.¹⁷ A major part of the project dealt with reconnecting cut-off side branches of the Danube to the main river, making them part of the natural regime of the river again, mainly for ecological reasons.

During the works, a significant amount of gravel that had previously accumulated there was dug out of the side branches and relocated in the riverbed. After the 2009 flood event, the fire brigades in Dürnstein, opposite the largest reconnection project site, witnessed that the water flow measured during the flood should have resulted in a 20 cm higher water level, according to measurements recorded at former events.¹⁸

4.2.3. Flood Protection Systems

4.2.3.1. Luberegg (fig. 14)

The first new flood protection system that was built happened without any involvement of the regional level and without the support of the local municipality. It was privately erected by the owners of Luberegg castle, the Pichler family.

The late baroque castle of Luberegg, at the outermost fringe of the World Heritage area, had been built around 1780 by an early industrial entrepreneur,



Fig. 14. Google Maps, cartography M. Schimek, 2019, Flood protection system at Luberegg



Images, Clockwise from top left:

Fig. 15. M. Schimek, 2019, Luberegg castle and the flood protection wallFig. 16. M. Schimek, 2019, The flood wall replaced the garden wallFig. 17. M. Schimek, 2019, Flood gate at Luberegg

Joseph Freiherr von Fürstenberg, as the logistical hub for his timber trading company. It was severely impacted during the 2002 flood.¹⁹

In 2003, Josef Pichler, owner of a number of hotels in the municipality of Emmersdorf, bought the estate and directly after that started to look for funding for protecting the castle from future floods. He was supported by the Republic of Austria and the federal state of Lower Austria. The protection infrastructure was designed in the style of most of the other public protection systems later (fig. 15), in this case replacing the garden walls of the castle by a low concrete wall on which aluminium panels can be screwed for the final height of the system (fig. 16). Only in the westernmost corner and to the side of the already existing Landhof Hotel were higher walls erected (fig. 17).

The aluminium panels are privately stored and mounted in case of emergency. The system was finished in 2006.²⁰ The whole infrastructure is about 500 m long.²¹



Images, Clockwise

from top: Fig. 18. Google Maps, cartography M. Schimek, 2019, Flood protection system at Hundsheim Fig. 19. M. Schimek, 2019, Hundsheim chapel and the flood protection solution around Fig. 20. M. Schimek, 2019, Upper corner of the flood protection at Hundsheim



4.2.3.2. Hundsheim (fig. 18)

The small village of Hundsheim belongs to the town of Mautern, opposite the town of Krems-Stein. In this case, the municipality council of Mautern started their plans to build a flood protection system without discussing it with the regional board. Thus, everybody was very surprised when they presented a draft which planned to build only fixed walls, most of them 3 to 5 m high.

The personal effort of the officer-in-charge of the Federal Monument Protection Authority (Bundesdenkmalamt) made those plans public and caused a redesign of the initial draft. In front of the historic chapel of Hundsheim, the fixed wall was replaced by the lower wall and aluminium panel version (fig. 19).

The infrastructure served as a role model for the ones coming after. It became clear however, that it was necessary for static reasons to build a fixed concrete wall at the beginning and end of the systems (fig. 20).

The construction of the flood protection system at Hundsheim started in 2006.²² It was officially opened in February 2008.23 The whole infrastructure cost €6.95 million²⁴ and is about 700 m long.²⁵

4.2.3.3. Weißenkirchen, Joching, and Wösendorf (fig. 21)

The first flood protection system that was built following public discussion was also the longest so far. It protects the three villages Wösendorf, Joching, and Weißenkirchen in the municipality of Weißenkirchen.

Since there is no clear limit between the built structure of the three villages, the decision was taken not to erect three discrete polders, but one single long infrastructure. The wall was built on the Danube side of the main road, replacing the guard rails, so that the main road can be used for maintenance of the system in the event of a flood. The walls are between 80 cm and 100 cm high (fig. 22). There was some criticism of the fact that the height of the wall does not follow a certain water level but is instead kept constant despite some minor level differences along the road.

Because of this design method, the whole system only requires a single, relatively small flood gate at Wösendorf (fig. 23). At the other end, in Weißenkirchen, the street rises high enough so that the wall can simply end there.

A very good solution could be found for the enormous storage capacity that is needed for the aluminium panels. A new storage hall was erected between Wösendorf and Joching. It is not visible from the main road and is built into the wine hills, thus only a relatively small front stands out into the landscape and most of the building is hidden (fig. 24).



-

Images, Clockwise from top left:

Fig. 21. Google Maps, cartography M. Schimek, 2019, Flood protection system at Weißenkirchen, Joching, and Wösendorf
Fig. 22. M. Schimek, 2019, Flood wall in the relatively open land near Joching
Fig. 23. M. Schimek, 2019, The flood gate at Wösendorf
Fig. 24. M. Schimek, 2019, Aluminum panel storage hall near Joching

At the time of the planning, the Republic and the federal state made it clear that only those parts of the protection system that were absolutely needed would be publicly financed. This is why Weißenkirchen missed the chance to redesign its connection between the village and the Danube, and the area between the road and the Danube stayed more or less unchanged.

The discussions in Weißenkirchen took some years, so building was officially started in March 2008.²⁶ The construction site was therefore once flooded by a medium high flood in June 2009. It was opened in 2010.²⁷ The whole infrastructure cost about €25 million²⁸ (€27 million in other online sources²⁹) and is 3 km long.³⁰

4.2.3.4. Spitz (fig. 25)

Likewise, in the municipality of Spitz, there were lengthy discussions on the construction of a flood protection system. Once Weißenkirchen had successfully started building its system however, similar plans were also enforced in Spitz.

Initially, the system in Spitz seemed to be especially fragile, since the village lies in the outside corner of a 45° Danube bend, which means that the system has to take a higher kinetic force than other devices inside the bends of the river. In the end, the system looks very similar to the one in Weißenkirchen, though, only the flood gate on the upper end at the village part of Hinterhaus was built using a double wall of aluminium panels to be mounted over the main road (fig. 26). On the other hand, from the ferry port downwards and opposite the historic building of the Danube Navigation Company ("Agentiegebäude"), the walls were built even a little lower in order to allow ship passengers to have a good view on the building. The soccer field of the local football club was not integrated into the system but got a dam of its own towards the Danube.

On the lower end, along the mouth of the Mieslingbach creek, Spitz decided on a massive wall, since the maintenance of the aluminium panels would be rather difficult there, and the place needs to be kept safe since the storage halls for the panels are also located there. ICOMOS Austria took a particular interest in the site and architecture of the storage halls. Initially it was planned to build the halls in the hinterland, some kilometres away from the Danube, but then the municipality managed to acquire a plot of land near the Mieslingbach, at the lower entrance to the village, and decided to relocate the storage halls without further discussion (fig. 27). ICOMOS Austria reported its disagreement with the solution but had to accept the majority decision of the advisory board. No further action was taken by the World Heritage committee.

Another particular element of the flood protection system is the mouth of the Spitzer Bach creek, the largest tributary in the inner Wachau, which had to be made safe as well. This is why in addition to the walls near the Danube, another circular wall had to be built around the creek. In this case also, a decision was taken to use the wall-aluminium panel solution (fig. 28).

Unlike Weißenkirchen, Spitz used the opportunity of the flood protection building to redesign the public space between the wall and the Danube. A number of leisure elements were integrated into the wall (fig. 29); a new service house replaced the former ship cruise ticketing shed, and the design of the waiting zones for the public buses was similar to the other new buildings along the Danube. The area around the storage halls was turned into visitor parking for people coming to Spitz – an added benefit as there was previously a severe shortage of parking spaces.

In addition, Spitz implemented a number of contemporary works of art along the Danube with the support of the Lower Austrian initiative for Arts in Public Space. Near the centre of the village, the "Spitz von Spitz" by Gottfried Bechtold, a slim golden needle, marks the peak of the 2002 flood, giving an impression of the incredible height of the water at the time. Near the storage halls, Anita Leisz built a landscape art intervention called "HWS Wiese", commenting on the typical elements of the newly designed Danube landing.³¹ And all along the landing, Siegrun Appelt created a system of streetlamps specifically designed for the spot, which minimise light pollution and light the Danube landing in a reduced way, thus allowing to keep a visual connection between the river and the land also at night.

Building the system in Spitz started in 2010³² and took two years.³³ It cost about €28 million³⁴ and is 1.8 km long.³⁵



Images, Clockwise from top left:

Fig. 25. Google Maps, cartography M. Schimek, 2019, Flood protection system at Spitz
Fig. 26. M. Schimek, 2019, The double planked flood gate at Hinterhaus
Fig. 27. M. Schimek, 2019, Storage halls at Spitz
Fig. 28. M. Schimek, 2019, Flood walls surrounding the Spitzer Bach mouth
Fig. 29. M. Schimek, 2019, New design of the Spitz landing

4.2.3.5. Oberarnsdorf (fig. 30)

Oberarnsdorf is the lowest lying village in the whole Wachau, which means that it was affected by the 2002 flood the worst. Many houses were flooded up to the second floor, making them uninhabitable for quite some time.

The solution for Oberarnsdorf had to take into account building a safe flood protection system while not changing the typical townscape of the old houses lying next to the Danube to any great extent (fig. 31).

The usual wall-aluminium solution was chosen for the front of the village centre. To the side of the village, though, they are somewhat removed from the Danube and in fact quite big in places. The bonus for the village is that the area between the old houses and the Danube was widened a little, thus creating a kind of new village square which may be used for a variety of purposes, like charity fests for the local firefighters or the annual summer solstice celebrations, which is a huge traditional event in the Wachau (fig. 32).

The storage facility for the aluminium panels was located in the backyard of one of the old village houses. It was built into a steep gradient from the main road, so that the building looks modest from the street side (fig. 33). The real extent is only visible when driving down the hill – this view is obstructed from the village and the Danube, though, so it does not have any impact on the visibility of the World Heritage site.

Building the system in Oberarnsdorf started in 2011 and was finished in 2012. It cost about €9.7 million³⁶ and is 870 m long.³⁷



Images, Clockwise from top left:

Fig. 30. Google Maps, cartography M. Schimek, 2019, Flood protection system at Oberarnsdorf
Fig. 31. M. Schimek, 2019, Center part of the Oberarnsdorf flood protection
Fig. 32. M. Schimek, 2019, Part of the new "village square" along the Danube in Oberarnsdorf
Fig. 33. M. Schimek, 2019, Storage hall seen from the main road

From top to bottom:

Fig. 34. Google Maps, cartography M. Schimek, 2019, Flood protection system at Rührsdorf Fig. 35. M. Schimek, 2019, Walls are needed deep into the vineyards because of the flat land surrounding Rührsdorf



4.2.3.6. Rührsdorf (fig. 34)

Rührsdorf, another village of the municipality of Rossatz-Arnsdorf, started to build its flood protection system at the same time as Oberarnsdorf.

The situation in Rührsdorf is significantly different to Oberarnsdorf. The village is larger and lies on a flat area to the inside of a large Danube bend. It is not directly located on the Danube, but on a side branch which was recently reconnected to the main river. This is why it floods relatively late, but when it does flood a very large area is affected.

The initial discussions centred on whether to build the whole structure as a dam or to only have very high walls. The final decision was to erect the central part of the structure using the wall-aluminium scheme. At the northern end of the structure, an existing dam was used to keep the waters away and this was supplemented by a fixed wall in the vineyards. East of the village rather high walls are needed because of the flat nature of the land surrounding the village (fig. 35).

Since the aluminium panel section at Rührsdorf is rather short, not a lot of storage space is needed. The existing firefighter station in the village was therefore adapted for storage in historicising style.

As in Oberarnsdorf, construction of the system started in 2011 and was finished in 2012. It cost €9.85 million³⁸ and is about 1,100 m long.³⁹

4.2.3.7. Krems-Stein

Since the original flood protection system proved to be too low during the 2002 flood, the city of Krems invested in upgrading the existing schemes. The walls were left unchanged, but the aluminium panel add-ons were made taller so that there would be no need to add sand bags to the top in case of a major flood.

In addition, the Austrian Waterway Authorities agreed to dig out more gravel than planned from the Danube, since during the 2002 event they discovered that more gravel than expected had accumulated in the riverbed in front of the city. This was due to the significantly reduced flow of water at Krems-Stein because of the effects of the next hydropower dam downstream at Altenwörth. Therefore the normal water level of the Danube could be additionally reduced, providing more space for the water in case of a flood event.

4.2.3.8. Maintenance of the flood protection infrastructures

A big issue for the functionality of the flood protection systems is maintenance. In order to work properly, the aluminium panels are filled with Danube water after mounting. When the flood recedes, sand and mud stay in the panels. They must be cleaned as quickly as possible after a flood event, to remove the mud before it dries. Two teenage students from the Technical Secondary School in Hollabrunn – one from

Weißenkirchen - developed a machine which allows the fire brigade to clean the panels in an automatised way, using only a fraction of the time and resources, such as water, usually necessary.⁴⁰ The device is still used and frequently tested by the fire brigade and the Austrian army in joint practice sessions (fig. 36).41

4.3. The Giant Flood of 2013

Only 11 years after the catastrophe of 2002, another similar huge flood event hit the Wachau between 3 and 9 June 2013.

The unusually high amount of precipitation in the Austrian and Bavarian Alps was the cause of the flood. In the Wachau itself, almost no rainfall was recorded this time. The precipitation initially fell as snow in the higher Alpine regions. Shortly after, temperatures rose again, making the snow melt. In 2013, the flood waves of the Bavarian Danube and the Inn cumulated, as in 1954. The water peak was aggravated by the influx from the Traun and Enns river.42

Because of the "modified release" of the precipitation that first fell as snow, the whole flood event lasted for six days this time, similar to the flood of 1954 (fig. 37). The maximum amount of water passing through the Wachau was calculated at 11,450 m³/s, which was even slightly more than in 2002. Nevertheless, the maximum



Fig. 36. M. Schimek, 2019, Aluminum plank washing machine at work during a practice with the Austrian army in Weißenkirchen

Fig. 37. The June 2013 flood on the Danube, in: Godina *et al.* 2014, 32



peak of the flood was recorded at 10.81 m at the measuring station in Kienstock, which was 12 cm less than in 2002. $^{\rm 43}$

Of course, all the villages not so far protected were flooded again as in 2002. Where a flood protection system already had been built, however, the devices fully functioned and kept the water and the mud out of the inhabited areas. Furthermore, the new forecasting models and disaster response plans proved to be extremely well done and helped relieve the impact on those affected significantly. Since there was no catastrophic event in the hinterland this time, all the fire brigades from around were available to assist the local blue light organisations and the army in handling the event.

4.4. Actions from Around 2013 to 2019

4.4.1. Additional Financial Means for the Remaining Projects

Since the already existing flood protection systems proved ultimately successful during the 2013 flood, the public authorities agreed that implementing the remaining flood protection projects needed to be done with a higher priority than originally planned. This is why the Republic of Austria and the federal states signed the "15a agreement" ruling on efforts to be financed by the republic and the federal states jointly according to Article 15a of the Austrian Constitution. As before, the Republic of Austria would contribute 50 per cent of the necessary finances to the scheme; 30 per cent would come from the federal states and 20 per cent from the municipalities. It is possible however that there might be a problem with this; the Republic of Austria basically guaranteed 50 per cent of the costs, but also explicitly capped the maximum expenses at 50 per cent of the total costs reported by the federal states in 2013, with no way of extending its share. So where projects prove to be more expensive than projected, the difference has to be covered by the federal states and the municipalities without the support of the republic, which was of course not really good news for the municipalities and the federal state but a rule which, at least at the moment, is not discussed.⁴⁴

4.4.2. Implemented Additional Flood Protection Projects

4.4.2.1. Melk

Melk, the second largest city of the Wachau region, world famous for its magnificent baroque monastery, had already started building their flood protection in February 2013,⁴⁵ making use of the financial rules from 2002 to 2013 (additional 7.5 per cent of the costs taken over by the federal state of Lower Austria). Unfortunately, the 2013 flood came too early in this case, as the city was still unprotected, and the construction site was badly damaged by the event. The flood protection itself is 540 m long and all constructed in the wall-aluminium version.⁴⁶ It cost €10.1 million.⁴⁷ The aluminium panels are stored in the new fire brigade house which was built some kilometres from the city at the motorway exit, outside the World Heritage area.

One particular issue with the flood protection in Melk is that the Weierbach creek runs straight through the city in a tube. This tube, partly located under century-old houses, had to be renewed. Therefore, the construction site was not only right at the Danube, but also quite far inside the historic city centre, so a lot of care had to be taken not to damage the historic substance. The City of Melk took the opportunity to invest another €4.1 million⁴⁸ into redesigning the Danube landing and into a total reconstruction of the Hauptplatz (Main Square) and the Kremser Straße and Linzer Straße, which had to be totally dug up because of the Weierbach creek issue.

Cables and canal were renewed underground, car traffic and parking were reduced, asphalted street surfaces were replaced by cobblestone, and the main square was turned into a "meeting point"⁴⁹ which can be used in multiple ways for events, presentations and cultural purposes (fig. 38). A special feature implemented is the so-called "World Heritage Lens", a platform partly built above the water providing visitors to the city with an improved viewpoint to the front of the baroque abbey (fig. 39). The lens was additionally funded from the World Heritage budget of the republic in order to ensure that the protection system is more aligned with the World Heritage status of the city.⁵⁰ The flood of 2013 caused damage amounting to €5.5 million.⁵¹ So, technically speaking the new protection system will have paid for itself after two to three more floods in the future. The finishing of the project was celebrated with a weekend-long festival in September 2014.⁵²

4.4.2.2. Oberloiben, Unterloiben, and Dürnstein

Both Oberloiben and Unterloiben have a similar location to Rührsdorf – rather high up, but on flat land, where the water may reach far into the land. This is why for both villages some longer side walls had to be planned.

The flood protection in Oberloiben was built in the usual style – walls plus aluminium panels on the outside of the main road towards the Danube, flood gates at either end, plus a third flood gate on a crossing leading down to the river. The upper flood gate is constructed like the one in Spitz so that two panels walls can be inserted into the gate. All the walls were built in the same style as in Spitz and Weißenkirchen.

The protection schemes in Unterloiben differ quite a lot from most of the other ones so far erected. In Unterloiben, the decision was taken to integrate the walls into existing garden and vineyard walls, on the inner side of the main road, seen from the village. This is why the main road remains flooded in case of an event and cannot be used for maintenance of the system in an emergency. Downstream from the parish church, houses of private landowners are located



From left to right: Fig. 38. M. Schimek, 2019, Design elements along the main square in Melk Fig. 39. M. Schimek, 2019, The "World Heritage Lens" enhances the visibility of the baroque abbey from the Danube landing From top to bottom: Fig. 40. M. Schimek, 2019, Emergency lane at Unterloiben Fig. 41. M. Schimek, 2019, Massive walls at the upstream part of the flood protection in Unterloiben



further away from the Danube. This is why they agreed on an emergency lane to be built inside the walls on their land (fig. 40), which allowed the municipality to follow the usual concept of walls and aluminium panels, though on higher base walls than usual, since the wall was integrated into an existing vineyard wall at the lower end of the village.

Upstream from the parish church, there was less space between the road and the houses, so here the whole protection was built as a very tall wall, which led to a lot of public discussion. People had forgotten, though, that there had been a similar wall here previously, but because it was overgrown with ivy it had not been perceived as a tall wall. The new wall was in fact, only about a metre higher than the previous one, which was clearly marked out by the new design (fig. 41). It was agreed that the new wall would also be covered with vegetation. However, the new bushes were planted in the extremely hot summer of 2015, and not all of them survived, so it will probably take a bit more time before the wall looks as it did before 2013. Since the base walls downstream from the parish church were meant to look like the vineyard walls they were integrated into, most of these walls were, as in Krems-Stein, covered with brick stones.

A positive effect of the tall wall solution is that the storage facility for the aluminium panels could be kept very modest. It was built inside the village of Unterloiben, next to the kindergarten, and does not detract from the townscape of the village. Another reason for reducing the number of aluminium panels is that Dürnstein, unlike the other municipalities on the left bank of the Danube, has no road into its hinterland, which makes it difficult for fire brigades from the hinterland to support the local people in building the scheme, so maintenance of the system has to be undertaken by the currently less than 850 inhabitants of the municipality themselves.

Building in Oberloiben and Unterloiben started in 2014, the protection system was finished in 2015. The projected costs amounted to \leq 14.75 million. The whole system is 1.7 km long.⁵³

An additional short protection wall for some of the houses upstream from the old town of Dürnstein was erected in 2016. This wall was also covered with brick stones, like the walls in the downstream part of Unterloiben.

4.4.2.3. Emmersdorf

The flood protection in the municipality of Emmersdorf, opposite Melk, should have been built later, since the village lies about a metre higher than the affected parts of Spitz and Weißenkirchen. In 2013, however, the whole historic village centre of Emmersdorf was severely flooded, necessitating the speeding up of plans.

So far, the protection for the villages of Emmersdorf and the small settlement of Seegarten have been finished. In Emmersdorf, the scheme is 650 m long.⁵⁴ Except for a short part at the camping site, which is built as a tall wall, all other parts were constructed in the wall-aluminium style, with flood gates on both ends. The storage halls were built next to the camping site. A public toilet and an ATM desk were also integrated into the building. Since the walls in Emmersdorf were built on the outer side of the main road from the village, it was not possible to plant bushes, due to the steep gradient towards the Danube and the fact that the so-called Treppelweg, the maintenance road for the waterways authorities, is located between the Danube and the flood protection walls (fig. 42).

The protection system for the settlement of Seegarten is 460 m long.⁵⁵ The storage hall for the aluminium panels was built into an existing dam close to the alluvial forest.

In some corners, tall walls were chosen, the rest of the structure is the usual wall-aluminium design, in order to keep a connection to the river and one of the best viewpoints on the Abbey of Melk from the other side of the Danube.

At Seegarten, the opportunity of building the flood protection system was used to create a proper turnaround for the public buses that go from Emmersdorf to Seegarten before returning to Emmersdorf and then on to Melk. Previously, the buses had to reverse on the main road. A particular feature of the flood protection in Emmersdorf are the specially designed waiting zones for the public buses, which were integrated into the design of the flood protection (fig. 43).

Both parts of the flood protection in Emmersdorf were started at the end of 2015 and took about three years. They cost €16.7 million.⁵⁶

4.4.3. Not yet Finished Protection Projects

4.4.3.1. Schönbühel-Aggsbach

The largest flood protection system in a single municipality has just been started. The infrastructure in the municipality of Schönbühel-Aggsbach will consist of five single polders, at Schönbühel, Aggsbach Dorf, at the historic Aggsteinerhof and the two separate parts of the village of Aggstein. In total, these protection elements will cost almost €45 million, financed by the new treaty between the republic and the federal states.⁵⁷



From left to right:

Fig. 42. M. Schimek, 2019, Location of the flood protection walls in Emmersdorf directly at the Danube Fig. 43. M. Schimek, 2019, Newly designed bus waiting zone at Seegarten

Fig. 44. The World Heritage region Wachau, in: Zech *et al.* 2017, 24-25, cartography M. Schimek, 2019, Overview over all flood protection projects



Currently, the two polders around Schönbühel and Aggsbach Dorf are under construction. The walls in Schönbühel will run along the village from its upstream end until the rock on which Schönbühel castle is situated using the wall-aluminium panel design and be similar in look to the schemes at Spitz and Weißenkirchen. The storage halls are being built off the main road.

Aggsbach Dorf needs a shorter wall along the Danube. On the other hand, the walls have to follow the Aggsbach creek almost a kilometre inland, since the area there is rather flat. The municipality will use the opportunity to erect a new village centre building, including storage facilities for the panels, a new municipality office and public housing, near the creek.

The other remaining polders have not yet been started, except for the storage hall, which is needed because all necessary panels were bought at the same time, reducing the price per item.⁵⁸ The storage hall is built into the mountain opposite the Aggsteinerhof, some metres away from the main road.

4.4.3.2. Remaining projects (fig. 44)

In the municipality of Rossatz-Arnsdorf, the next construction site, at the village of Rossatzbach, is scheduled for 2020 if the bidding process yields acceptable results.⁵⁹ The projects at Bacharnsdorf, Mitterarnsdorf, and Hofarnsdorf, and at Rossatz have all been launched with planning and bidding. The two tiny villages of St. Johann im Mauerthale and St. Lorenz, both with historically very interesting churches, will remain unprotected, though.⁶⁰

In Emmersdorf, the village of Schallemmersdorf is still not protected. During the bidding phase some problems with higher costs than expected arose; but they should be cleared soon.⁶¹

The last municipality which might start building is the small municipality of Aggsbach Markt, opposite Aggsbach Dorf. The bidding procedure there did not yield the expected number of valid bids, and those which were submitted were far beyond the calculated costs. In case of implementation, the village of Aggsbach Markt will be protected by a wall similar to the one in Schönbühel.⁶²

5. The Outcomes and Effects

In the end, all the flood protection systems in the World Heritage region Wachau that were built after the flood of 2002 were planned and implemented following common rules that were discussed on a regional level. Some exceptions are justifiable, looking at the various local circumstances and environments which vary from village to village.

All flood protection systems that were already finished by 2013 fully functioned during the huge flood of June 2013. This experience stopped almost all discussions about the feasibility of the infrastructures and forced the public authorities to speed up implementation of the remaining flood protection schemes.

The involvement of a wide range of local stakeholders, including ICOMOS Austria and skilled architects, assured that all flood protection schemes were, in as far as possible, built with a lot of respect for the World Heritage landscape. Decisions were taken at a local level and based on widespread agreement. All projects so far have been implemented without becoming subject of a State of Conservation Report or causing the official involvement of UNESCO. The fact that a number of historic buildings are now safe from being flooded frequently - something which would, taking into account the ongoing discussion about the effects of climate change, be rather likely - strengthens the World Heritage status of the cultural landscape and is a major relief to the private house owners in the region. This effect definitely creates more of an asset to the World Heritage than the loss of significance the unavoidable slight alteration of the landscape caused.

Even though many villages are protected now, there will never be 100 per cent security. This is why disaster management plans still include the necessity of evacuating people. If a similar situation to what occurred in 2002 were to happen, it is still unclear if the support of other fire brigades from the hinterland, as laid down in the disaster management plans, would really be available. Trainings on mounting the aluminium panels to the walls and checking the functionality of the disaster management plan are carried out every year, in order to ensure those involved (most of them volunteers) are fully aware of what to do in the face of a possible future disaster. Furthermore, the newly acquired high level of security helps landowners to obtain insurance for their property, something which was without the flood protection systems. The flood of 2013 showed that the costs of building and maintaining the flood protection systems will be amortised over the prevention of two to three floods at the most.

So far, the follow-up costs of maintaining the flood protection infrastructures are moderate and amount to around €10,000 to 20,000 a year per municipality.⁶³ Of course, after a certain period the municipalities will have to face additional costs for the replacement of elements of the infrastructures, like pumps or aluminium panels, but so far the follow-up costs are far below the initially (2004) anticipated 1 per cent of the building costs. The municipalities are, in addition, financially supported by the federal state of Lower Austria in covering these costs.

Of course, the building of the flood protection systems means a certain alteration of the traditional protected landscape of the World Heritage region Wachau. The older examples, for example in Luberegg or Weißenkirchen, show however, that aging and the growth of vegetation will help to relieve the visual impact of the infrastructures on the landscape. It is still the traditional townscapes and the magnificent views on the cultural landscape that are in the foreground for people passing through the valley.

6. Additional Comments

Uncredited details of the events from 2002 until today come from the personal experience of the author, who served as the World Heritage site manager from May 2002 to September 2018 and therefore witnessed all developments described personally.

7. Details of the Expert Completing the Case Study

Michael Schimek, Dipl.-Ing. MA was born in Vienna, Austria in 1972. He studied Spatial Planning at the Technical University of Vienna, Austria, from 1992 to 1998. He then studied Landscape Architecture, at the Swedish Agricultural University at Alnarp, Sweden from 1996 to 1998. He studied Music Management, at Danube University Krems, Austria from 2014 to 2017.

He gained professional experience as a planner for municipalities (local development plans, zoning plans, expertise on townscape and landscape issues) from 1998 to 2002. From May 2002 to September 2018, he was manager of the regional development agencies for the World Heritage cultural landscape Wachau, Austria, and was thus in charge of World Heritage site management. He is editor-in-charge for the current site management plan.

Since 2018 he has been a freelance consultant in regional development, with a focus on cultural management and World Heritage issues.

Notes

- ¹ https://de.wikipedia.org/wiki/Hochwasser_in_Mitteleuropa_1501.
- ² http://www.noe.gv.at/wasserstand/#/de/Messstellen/Details/207357/ DurchflussPrognose/48Stunden.
- ³ comp. Strasser 2017, 9; flood marks on house Oberarnsdorf 16, own photgraphy.
- ⁴ https://de.wikipedia.org/wiki/%C3%96sterreichische_Donaukraftwerke
- ⁵ Strasser 2017, 25.
- ⁶ https://www.steb-koeln.de/hochwasser-und-ueberflutungsschutz/hochwasser/Hochwassergeschichte/ Hochwassergeschichte.jsp
- ⁷ Strasser 2017, 37.
- ⁸ http://www.noe.gv.at/wasserstand/#/de/Messstellen/Details/207357/ DurchflussPrognose/48Stunden
- ⁹ Godina *et al*. 2004, 15.
- ¹⁰ Godina *et al*. 2004, 34.
- ¹¹ http://www.noe.gv.at/wasserstand/#/de/Messstellen/Details/207357/ DurchflussPrognose/48Stunden.
- ¹² Godina *et al*. 2004, 33.
- ¹³ http://krems.vpnoe.at/startseite/news-detail/article/hochwasserschutz-in-spitz-an-der-donau.html
- ¹⁴ For the functionality of those systems comp. the following YouTube video: https://www.youtube.com/ watch?v=VhIV9ivrJ9w [accessed 28 Sep. 2019].
- ¹⁵ https://www.ris.bka.gv.at/Dokumente/Bundesnormen/NOR11005084/ NOR11005084.pdf
- ¹⁶ http://www.noe.gv.at/noe/Landwirtschaft/Richtlinien_Katastrophenschaeden.pdf
- ¹⁷ https://www.weltkulturerbe-wachau.at/naturschutz/life-projekte/life-wachau.
- ¹⁸ personal information by Barbara Schwarz, mayor of Dürnstein 2004-2011, in 2010.
- ¹⁹ https://de.wikipedia.org/wiki/Schloss_Luberegg.
- ²⁰ https://www.bmvit.gv.at/verkehr/schifffahrt/hochwasserschutz/15aBVG.html
- ²¹ Measured in Google Maps.
- ²² https://www.hydro-ing.at/hws-hundsheim.html
- ²³ https://www.bmvit.gv.at/verkehr/schifffahrt/hochwasserschutz/15aBVG.html
- ²⁴ https://www.hydro-ing.at/hws-hundsheim.html
- ²⁵ Measured in Google Maps.
- ²⁶ https://www.ots.at/presseaussendung/OTS_20080305_OTS0291/spatenstich-fuer-hochwasserschutz-weissenkirchen
- ²⁷ https://www.bmvit.gv.at/verkehr/schifffahrt/hochwasserschutz/15aBVG.html
- ²⁸ http://www.wasseraktiv.at/resources/files/2012/3/14/2160/15-tag2-vortrag-bodenstein-brandstetter.pdf
- ²⁹ https://austria-forum.org/af/AustriaWiki/Wei%C3%9Fenkirchen_in_der_Wachau
- ³⁰ Measured in Google Maps.
- ³¹ Traditionally, along the Austrian Danube, ships didn't land in a harbour area, but all along the riverbank. This is why the roads along the riverbank in Austrian German are called "Lände". There isn't a really proper English translation for this word, so "landing" was used (since it also has the same meaning and similar language roots).
- ³² https://porr.at/projekte/hochwasserschutz-spitz-an-der-donau/
- ³³ https://www.bmvit.gv.at/verkehr/schifffahrt/hochwasserschutz/15aBVG.html
- ³⁴ personal information by Norbert Notz, manager of the municipality office of Spitz, 22 Aug. 2019.
- ³⁵ Measured in Google Maps.
- ³⁶ https://www.hydro-ing.at/hws-oberarnsdorf.html
- ³⁷ Measured in Google Maps.
- ³⁸ https://www.hydro-ing.at/hws-ruehrsdorf.html
- ³⁹ Measured in Google Maps.
- ⁴⁰ https://www.jugendinnovativ.at/projekt-teams/projekte/projekt/projekt/dammbalkenreinigungsanlage-fuer-denhochwasserschutz-weissenkirchen/

- ⁴¹ https://www.noen.at/krems/rekruten-trainierten-mobilen-hochwasserschutzaufbau-in-noe-4354649
- ⁴² Godina *et al*. 2014, 31–32.
- ⁴³ Godina *et al.* 2014, 32.
- ⁴⁴ https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen& Gesetzesnummer=20008613
- ⁴⁵ http://www.melk.gv.at/de/Spatenstich_Hochwasserschutz_Melk
- ⁴⁶ NÖN 2014, 2.
- ⁴⁷ NÖN 2014, 4.
- ⁴⁸ NÖN 2014, 4.
- ⁴⁹ NÖN 2014, 8.
- ⁵⁰ NÖN 2014, 10.
- ⁵¹ NÖN 2014, 3.
- ⁵² NÖN 2014, 2.
- ⁵³ Schopf 2014.
- ⁵⁴ Schweiger 2018.
- ⁵⁵ Schweiger 2018.
- ⁵⁶ Schweiger 2018.
- ⁵⁷ Butter 2019.
- ⁵⁸ Personal information by Erich Ringseis, mayor of Schönbühel-Aggsbach, 05 Sep. 2019.
- ⁵⁹ personal information by Mayor Erich Polz, January 2020.
- ⁶⁰ personal information by Robert Schütz, manager of the municipality office of Rossatz-Arnsdorf, September 2019.
- ⁶¹ personal information by Josef Kronsteiner, mayor of Emmersdorf, September 2019.
- ⁶² personal information by Hannes Ottendorfer, mayor of Aggsbach, September 2019.
- ⁶³ personal information by Norbert Notz, manager of the municipality office of Spitz, and Robert Schütz, manager of the municipality office of Rossatz-Arnsdorf, 22 Aug. 2019.

Bibliography

- austria-forum.org, 2019. *Weißenkirchen in der Wachau.* [online] Available at: https://austria-forum.org/af/AustriaWiki/ Wei%C3%9Fenkirchen_in_der_Wachau [accessed 7 October 2019]
- Bodenstein, A., Brandstetter, F., 2009. *Hochwasserschutz Donau mit Schwerpunkt Wachau*. [online] Bundesministerium für Nachhaltigkeit und Tourismus. Available at http://www.wasseraktiv.at/resources/ files/2012/3/14/2160/15-tag2-vortrag-bodenstein-brandstetter.pdf [accessed 7 October 2019]
- Butter, D., 2019. Teuerster Wasserschutz ist nun fertig finanziert. [online] Bezirksblätter. Available at: https://www. meinbezirk.at/melk/c-politik/teuerster-wasserschutz-ist-nun-fertig-finanziert_a3179730 [accessed 9 October 2019]
- de.wikipedia.org, 2019. *Hochwasser in Mitteleuropa 1501*. [online] Available at: https://de.wikipedia.org/wiki/ Hochwasser_in_Mitteleuropa_1501 [accessed 19 September 2019]
- de.wikipedia.org, 2019. *Österreichische Donaukraftwerke*. [online] Available at: https://de.wikipedia.org/ wiki/%C3%96sterreichische_Donaukraftwerke [accessed 19 September 2019]
- de.wikipedia.org, 2019. *Schloss Luberegg.* [online] Available at: https://de.wikipedia.org/wiki/Schloss_Luberegg [accessed 7 October 2019]
- Godina, R., Lalk, P., Lorenz, P., Müller, G., and Weilguni, V., 2004. *Die Hochwasserereignisse im Jahr 2002 in Österreich*. [online] Lebensministerium. Available at: https://www.bmnt.gv.at/dam/jcr:237b2ce8-a089-4cdb-adea-8652c628dd4d/Hochwasser2002.pdf [accessed 16 August 2019]
- Godina, R., Müller, G., *et al.*, 2014. *Hochwasser im Juni 2013 die hydrographische Analyse.* [online] Ministerium für ein lebenswertes Österreich. Available at: https://www.bmnt.gv.at/wasser/wasser-oesterreich/wasserkreislauf/hydrograph_charakt_extrema/hw2013hydroanalyse.html [accessed 16 August 2019]
- krems.vpnoe.at, 2010. *Hochwasserschutz in Spitz an der Donau*. [online] Volkspartei Niederösterreich. Available at: http://krems.vpnoe.at/startseite/news-detail/article/hochwasserschutz-in-spitz-an-der-donau.html [accessed 28 September 2019]
- NÖN, 2014. *Hochwasserschutz für die Stadt Melk.* [online] Niederösterreichische Nachrichten. Available at: http://www. melk.gv.at/de/LEBEN_in_MELK/ Hochwasserschutz [accessed 08 October 2019]
- porr.at, 2019. *Hochwasserschutz Spitz an der Donau.* [online] Porr. Available at: https://porr.at/projekte/ hochwasserschutz-spitz-an-der-donau/ [accessed 7 October 2019]
- Schopf, G., 2014. Schutzbau laut Plan. [online] Niederösterreichische Nachrichten. Available at: https://www.noen.at/ krems/schutzbau-laut-plan-donau-hochwasserschutz-spatenstich-4352604 [accessed 9 October 2019]
- Schweiger, D., 2018. Mega-Projekt: Angst vor den Fluten hat ein Ende. [online] Niederösterreichische Nachrichten. Available at: https://www.noen.at/melk/emmersdorf-mega-projekt-angst-vor-den-fluten-hat-ein-endehochwasserschutz-josef-kronsteiner-121978699 [accessed 9 October 2019]
- Strasser, W., 2017. *Modellstadt Hochwasserschutz Krems/Donau*. [online] Feuerwehr Krems. Available at: https://www. feuerwehr-krems.at/Berichte/0/1/0/ 3/0/9/1703061836_cc003970_Pr%C3%A4sentation%20Mobiler%20 Hochwasserschutz%20neu%202017.pdf [accessed 16 August 2019]
- www.blovsky.at, 2019. Hochwasserschutz. [online] Blovsky Geotechnik. Available at: https://www.blovsky.at/653_ Referenzen_Hochwasserschutz [accessed 09 October 2019]
- www.bmvit.gv.at, 2019. Nationaler Aktionsplan Donauschifffahrt (NAP). [online] Bundesministerium für Verkehr, Innovation und Technologie (BMVIT). Available at: https://www.bmvit.gv.at/service/publikationen/ verkehr/schifffahrt/nap.html [accessed 9 October 2019]
- www.bmvit.gv.at, 2019. Vorhaben der Vereinbarungen nach Artikel 15a Bundesverfassungsgesetz (B-VG). [online] Bundesministerium für Verkehr, Innovation und Technologie (BMVIT). Available at: https://www.bmvit. gv.at/ verkehr/schifffahrt/hochwasserschutz/15aBVG.html [accessed 28 September 2019]
- www.hydro-ing.at, 2019. *Donau-Hochwasserschutz Hundsheim.* [online] Hydro-Ingenieure. Available at: https://www. hydro-ing.at/hws-hundsheim.html [accessed 28 September 2019]

www.hydro-ing.at, 2019. *Donau-Hochwasserschutz Oberarnsdorf.* [online] Hydro-Ingenieure. Available at: https://www. hydro-ing.at/hws-oberarnsdorf.html [accessed 8 October 2019]

www.hydro-ing.at, 2019. *Donau-Hochwasserschutz Rührsdorf.* [online] Hydro-Ingenieure. Available at: https://www. hydro-ing.at/hws-ruehrsdorf.html [accessed 8 October 2019]

www.jugendinnovativ.at, 2013. Dammbalkenreinigungsanlage für den Hochwasserschutz Weißenkirchen. [online] Jugend innovativ. Available at: https://www.jugendinnovativ.at/projekt-teams/projekte/projekt/projekt/ dammbalkenreinigungsanlage-fuer-den-hochwasserschutz-weissenkirchen/ [accessed 8 October 2019]

www.melk.gv.at, 2013. *Spatenstich Hochwasserschutz Melk.* [online] Stadt Melk. Available at: http://www.melk.gv.at/de/ Spatenstich_Hochwasserschutz_Melk [accessed 8 October 2019]

www.noe.gv.at, 2019. *Kienstock – Durchfluss Prognose*. [online] Amt der NÖ Landesregierung. Available at: http://www. noe.gv.at/wasserstand/#/de/ Messstellen/Details/207357/DurchflussPrognose/48Stunden [accessed 19 September 2019]

www.noe.gv.at, 2020. *Richtlinien für die Gewährung von Beihilfen zur Behebung von Katastrophenschäden.* [online] Amt der NÖ Landesregierung. Available at: http://www.noe.gv.at/noe/Landwirtschaft/Richtlinien_ Katastrophenschaeden.pdf [accessed 9 January 2020]

www.noen.at, 2013. *Rekruten trainierten mobilen Hochwasserschutzaufbau in NÖ.* [online] Niederösterreichische Nachrichten. Available at: https://www.noen.at/krems/rekruten-trainierten-mobilen-hochwasserschutzaufbau-in-noe-4354649 [accessed 8 October 2019]

www.ots.at, 2008. Spatenstich für Hochwasserschutz Weißenkirchen. [online] Austria Presse Agentur (APA). Available at: https://www.ots.at/presseaussendung/OTS_20080305_OTS0291/spatenstich-fuer-hochwasserschutzweissenkirchen [accessed 7 October 2019]

www.ris.bka.gv.at, 2013. *Bundesgesetz über Maßnahmen zur Vorbeugung und Beseitigung von Katastrophenschäden (Katastrophenfondsgesetz 1996).* [online] Austrian Federal Law Gazette No. 201/1996. Available at: https://www.ris.bka.gv.at/Dokumente/Bundesnormen/NOR11005084/NOR11005084.pdf [accessed 9 January 2020]

www.steb-koeln.de, 2019. *Hochwassergeschichte*. [online] StEB Köln. Available at: https://www.steb-koeln.de/ hochwasser-und-ueberflutungsschutz/hochwasser/Hochwassergeschichte/Hochwassergeschichte.jsp [accessed 19 September 2019]

www.weltkulturerbe-wachau.at, 2019. *LIFE-Projekt WACHAU – lebendige Donau, Trockenrasen, Naturwald*. [online] Verein Welterbegemeinden Wachau. Available at: https://www.weltkulturerbe-wachau.at/naturschutz/ life-projekte/life-wachau [accessed 8 October 2019]

Zech, S., Bork, H., Klingler, S., Müllehner, S., and Schimek, M., 2017. Managementplan Welterbe Wachau. [online] Verein Welterbegemeinden Wachau. Available at: https://www.weltkulturerbe-wachau.at/fileadmin/Bibliothek/ projects/ _Projekte/WachauProjekte/ManagementplanWelterbeWachau_20170621.pdf [accessed 27 September 2019]

www.ris.bka.gv.at, 2013. Vereinbarung gemäß Artikel 15a B-VG zwischen dem Bund und den Ländern Niederösterreich, Oberösterreich und Wien über Vorhaben des Hochwasserschutzes im Bereich der österreichischen Donau. [online] Austrian Federal Law Gazette I No 201/2013. Available at: https://www.ris.bka.gv.at/ GeltendeFassung

wxe?Abfrage=Bundesnormen&Gesetzesnummer=20008613 [accessed 8 October 2019]