# Impact of hydropower reservoirs on floods: Evidence from large river basins in Austria

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**Keywords**: *Flood peak reduction, hydropower reservoirs, flood control*

## Abstract

Dams and hydropower reservoirs constructed in the headwaters of river basins alter the hydrological characteristics as well as other physical and biological conditions of rivers downstream. In this study the impact of reservoirs on floods is systematically assessed for 8 heavily modified river basins in Austria. Since discharge data prior to the construction is not available the natural unaffected annual peak discharges downstream of the reservoirs were estimated by transposing the peak runoff of an unaffected reference catchment by considering the spatial proximity, the catchment area and the precipitation conditions in both catchments. The potential impact is then calculated by comparing the estimated and the observed discharge peaks. The results show significant flood peak reductions not only at gauges directly affected by the reservoir but also further downstream at receiving rivers. The propagation of the flood peak reduction downstream is also related to the ratios (i) between the reservoir catchment and the total catchment area and (ii) between the storage capacity and the catchment area. This indicates the decrease of possible flood control further downstream. Considering the return periods, results indicated that flood peak reductions are most significantly for events with higher return periods. Extremer events with return periods larger than 30 years show a considerable flood peak reduction of over 33 % on average. These findings show that reservoirs foremost constructed for hydropower generation also contribute significantly to flood control and flood risk mitigation.

# 1 Introduction

Man-made lakes, created by the impoundment of rivers by dams, can be designed for several purposes, including irrigation, hydropower generation, flood control, navigation, domestic and industrial water supply, sediment control, sport and commercial fishing or recreation (Ackermann et al., 1973b). Today, over 58 000 large dams exist worldwide, of which 47 % are used for irrigation, 21 % for hydropower generation, 12 % for water supply, 9 % for flood control and 11 % for other purposes including navigation, recreation and others (ICOLD, 2021). Independent of single- or multi-purpose use of dams and impoundments they create a complex net of impacts (Ackermann et al., 1973a) and globally, over half of large river systems are impacted by dams (Nilsson et al., 2005). The reservoirs can strongly alter the hydrology and runoff conditions in the downstream reaches along with other river characteristics, including temperature, sediment transport, biological and physical characteristics, but also socio-economic aspects (e.g. Ackermann et al., 1973a; Butcher, 1973; Hoffman & Jonez, 1973; Mei, Van Gelder, Dai, & Tang, 2017; Taylor, 1973). Furthermore, dams are considered the main cause for fragmentation and declining river connectivity (Grill et al., 2019). Dam-induced hydrologic and hydrologic regime changes have been investigated by multiple authors (e.g. Catherine et al., 2011; Ely et al., 2020; Magilligan & Nislow, 2005; Moschen & Lauffer, 1977; Räsänen et al., 2012; Song et al., 2020). The impacts can reach such a level of severity that dams and reservoirs are removed (Habel et al., 2020).

A variety of studies analysed the effect of dams on flood risk and flood control, thereby not necessarily differentiating between single- or multi-purpose dams. Batalla et al. (2004) concluded that almost all rivers within the Ebro basin in Spain showed a flood reduction. The average ratio of pre-dam and post-dam flood peaks for a 2-year flood and a 25-year flood, is 0.69 and 0.58, respectively. Additionally, the ratio between reservoir capacity and mean annual runoff showed a significant association with the flood reduction. Based on the comparison of annual peak discharges in upstream unregulated river reaches and downstream regulated river reaches of 36 of the largest dams in the United States, Graf (2006) determined a reduction of flood peaks of 67 %, on average. The mean daily discharge of the analysed rivers was at the same time also reduced by 12 %. Another study carried out in California investigated the hydrological impacts of dams and it water diversions in the Sacramento and San Joauqin river basins and showed that flood peaks of a 2-year flood was reduced on average, by 53 % and 81 %, respectively (Mathias Kondolf & Batalla, 2005). Another study from the United States investigated 38 dam affected rivers. Based on pre- and post-dam annual peak discharge analysis, a flood peak reduction ranging from 7.4 % to 95.14 % could be found (Mei et al., 2017). At rivers in Quebec, Assani et al. (2006) determined that the construction of dams change various characteristics of the annual maximum flow including the magnitude, whereby the magnitude of these changes depends on the hydrological regime the catchment size. Verbunt et al. (2005) investigated the impact of hydropower storages and land cover changes in the highly anthropogenic influenced Rhine basin in Switzerland. This study also showed that the buffering capacity of reservoirs reduces small flood peaks. Hauenstein (2009) mentioned that in Switzerland the contribution of hydropower storage reservoirs to flood damage reduction should not be underestimated.

Hydropower has a long tradition in Europe and provides 41.7 % of the total renewable electricity generation in the EU (Wagner et al., 2019). As a consequence, the majority of large dams (39 %) are used for hydropower generation in Europe (ICOLD, 2021). In Central Europe, Austria is characterized by high precipitation sums and large gradients due to the dominating Alps. This natural setting provides ideal conditions for hydropower production and the contribution of hydropower to the overall electrical energy production is significant. The primary goal of storage hydropower schemes in Austria is power generation. Explicit drawdowns for providing flood control capabilities are not foreseen, with very few exceptions. Nevertheless, studies have shown that they also reduce flood peaks downstream. Alpine valleys with larger annual or seasonal storage reservoirs in place have rarely been affected by flood damages since their construction. (Pircher, 1990).

**Fehler! Verweisquelle konnte nicht gefunden werden.** exemplarily shows discharge data of the Zemmbach before and after the construction of the Schlegeis storage reservoir in Tyrol in the west of Austria (Hydropower scheme Zemm-Ziller; see Figure 1). The mean annual maximum discharge (16.8 m³/s, 1971-2017) is reduced by 59% compared to the mean annual maximum discharge before the completion of the reservoir in 1971 (54.8 m³/s, 1956 -1970).

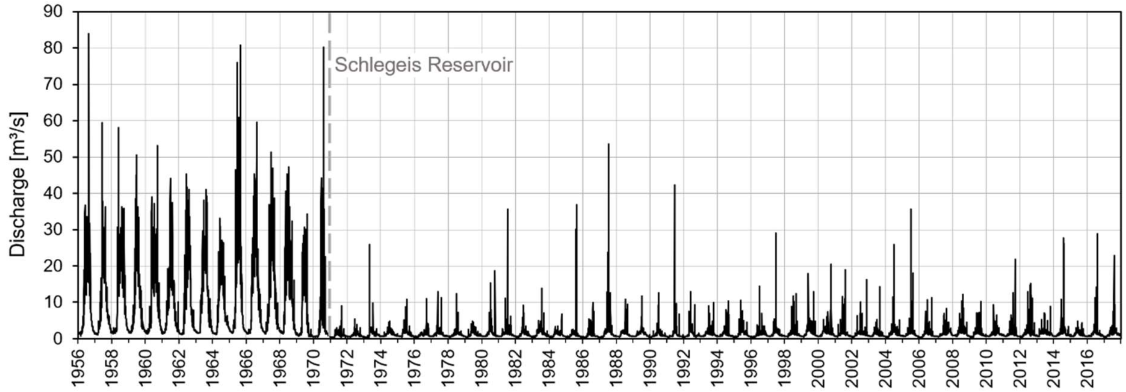


*Figure 1 Mean daily discharge time series at the gauge Sausteinaste from 1956 to 2017 showing the impact of the 1971 completed Schlegeis reservoir of the power plant group Zemm-Ziller on flood peaks.*

Consequently, also the flood peaks further downstream of reservoirs can be reduced after construction (Pircher, 1990). For instance, extreme flood peaks corresponding to a return period of 1,000 years are estimated to be reduced by about 40 - 50 % downstream due to the construction of the Kaprun hydropower scheme in Salzburg (Lauffer, 1975). Kugi & Weissel (1986) reported that the flood event of 1985 in the Malta Valley was reduced by 42 to 47 % downstream of the Kölnbrein reservoir, the largest reservoir in Austria with a capacity of 200 million m³. At other river basins in Austria influenced by reservoirs comparative reductions for single flood events of different magnitudes were observed (Ganahl, 1988; Hofer et al., 2013; Pircher, 1990)

Reservoirs constructed for hydropower generation generally affect the possible flood risk downstream. The downstream flood risk reduction potential of reservoirs depend on the share of catchment area controlled by the reservoir (Widmann, 1988, Pircher, 1990). Hence, the capacity of flood control decreases with the distance from the dam and with an increase in the catchment area downstream (Pircher, 1990; Schöberl, 2005). Additionally, the storage volume available at the time of the flood event plays a crucial role (Pircher, 1990). Drawdowns for the sake of flood control are not in place, with few exceptions.

Studies analysing the effects of hydropower reservoirs on flood peaks in Austria focused on single events. No systematic assessment exists. Additionally, most studies were done many years or even decades ago. Since that time, longer periods of observations have become available. Already in 1988, Widmann urged to analyse the peak flood reduction based on longer observation records in the future. Considering these limitations in our current knowledge, this study aims to investigate and systematically quantify the impact of the main hydropower reservoirs in Austria on floods. This allows for a more comprehensive understanding on the reduction of peak discharge, flood hazard and flood risk along the downstream reaches of a river basin influenced by a reservoir in its headwaters. The objectives of this research are:

(i) The estimation of the flood peak reduction, including the spatial distribution downstream of the reservoirs

(ii) The analyses of flood hazard mitigation due to the construction of reservoirs considering return periods

(ii) The evaluation of the relationship between the estimated flood peak reduction with catchment and reservoir features.

The focus thereby not only lies on selected extreme events (as has been done in the past), but also on annual peak discharges of long-term runoff records and floods of different return periods, thereby covering eight river basins, having areas of 955 – 9 310 km². This allows for a more holistic quantification of the influence of reservoirs on flood peaks and their impact on flood risk in the Alps.

# 2 Materials and Method

## 2.1 Study area

The study covers eight river basins in Austria influenced by storage hydropower plants (Figure 2). With the exception of the Kamp (Basin 8 in Figure 2), which is located in the north-east, the basins are located in the Alps and are, from west to east: Ill (1), Rosanna (2), Fagge (3), Ziller (4), Salzach (5), Drau (6, Drava) and Mur (7, Mura). The main storage power plants of Austria (Table 1) are covered within this study.

The topography in Austria is strongly dominated by the Alps and its adjoining alpine foothills. The Alps account for 65 % of the entire national area. Such elevated areas act as a barrier and govern large-scale weather and wind systems influencing precipitation characteristics and precipitation sums (Fürst et al., 2010). One of the general characteristics of precipitation is the altitudinal gradient with higher sums in elevated areas, which can however vary with local conditions. Mean annual precipitation ranges between 480 mm in eastern lowlands and over 2700 mm in the Alps (Lebiedzinski & Fürst, 2018). Most runoff in Austria is also affected by the alpine characteristics and is therefore strongly influenced by the snow accumulation in winter and the melting process in spring and summer (Herrnegger et al., 2018; Lebiedzinski & Fürst, 2018).

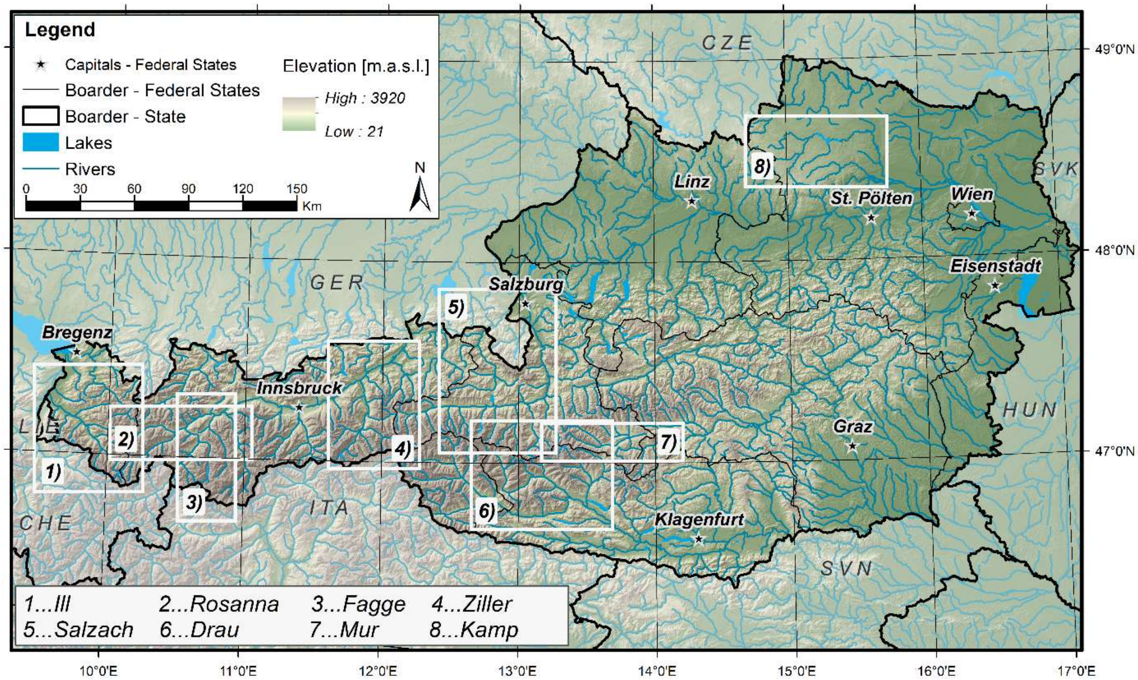


*Figure 2 Overview of the studied river basins*

Glacier melt processes can contribute significantly to runoff, however depending on the catchment size. Koboltschnig & Schöner (2011) showed that the glacier melt contribution to runoff has a logarithmic relationship with the relative glacierized catchment area. Hence, mean runoff regimes also show a clear spatial pattern influenced by the altitude. In alpine areas, runoff regimes are determined by (glacio-) nival characteristics. In the alpine foothills and lowlands in the north and east, pluvial runoff regimes dominate (Lebiedzinski & Fürst, 2018).

During the last two decades, major flood events took place in 2002, 2005, 2013 and 2018 (Leis & Kienberger, 2020). For example, during the flood event in the upper Danube catchment in June 2013, several tributaries (Saalach, Tiroler Ache, downstream reaches of the river Inn and Salzach) experienced runoff in the order of a 100-year return period. Peak discharge exceeded the largest observed floods in many parts of the Upper Danube catchment. The August 2002 flood event was most severe in the catchment of the river Kamp, which showed unusual high runoff coefficients due to antecedent saturated soils (Komma et al., 2007). This extraordinary event showed estimated return period in the order of 2000 to 10,000 years (Gutknecht et al., 2002). The June 2005 flood event was most severe in the western provinces of Vorarlberg and Tyrol. Here, the event runoff exceeded the maximum discharge records at several rivers. This led to substantial flooding and damages along major rivers in Tyrol including the river Inn. At the gauge in Innsbruck, the largest runoff (1511 $m^3/s$) since observations began was recorded. This runoff corresponded to an estimated 200-year event (BMLFUW, 2006). In October 2018, another flood event took place in the southern province of Carinthia, where gauges along tributaries showed discharge peaks exceeding return periods of 100 years (Moser et al., 2019).

The alpine topography does not only characterise spatio-temporal discharge and precipitation trends, but also provides the topographic gradients for hydropower generation. Over 90 % of large single purpose dams are hydropower dams (ICOLD, 2021). In Austria hydropower is a significant part of the energy system, providing about 65.7% of the national gross energy generation, whereas 28 % are produced by storage and pump-storage power plants (Wagner et al., 2015). The operation of these power plants also affects the downstream hydrology. About 80 % of large rivers (n = 52, > 500km²) are moderately to heavily affected by humans. 49 % of these rivers show hydrological alterations including impoundments (16 %), water diversions (19 %) and hydropeaking (14 %) (Muhar et al., 2000). Within the river basins covered in this study, power plant groups consisting of multiple water reservoirs are installed (Table 1). In total, these hydropower plants produce about 7400 GWh/a, which represents over 60% of all storage – and pump-storage plants in Austria (11,812 GWh/a) (ICOLD, 2021, Wagner et al., 2015). The main purpose of most water reservoirs is hydropower production and not flood control.

*Table 1 Storage water reservoirs and power plants within the study areas (ICOLD, 2021)*

| Nr. | River Basin | Power plant (group) | Reservoir Name | Reservoir Capacity [$10^3$ $m^3$] | Catchment area [$km^2$] | Purposes* | River | International Code | Year of Const. |
|---|---|---|---|---|---|---|---|---|---|
| 1) | ILL | OBERE ILL - LÜNERSEE | Kops | 44600 | 170 | H | Ill | I01000072 | 1965 |
| | | | Luenersee | 94000 | 10 | H | Ill | I01000089 | 1958 |
| | | | Silvretta | 39100 | 35 | H | Ill | I01000131 | 1948 |
| | | | Vermunt | 5700 | 75 | H | Ill | I01000151 | 1931 |
| 2) | ROSANNA | KARTELL | Kartell | 8000 | 15 | H | Moosbach | I01000066 | 2005 |
| 3) | FAGGE | KAUNERTAL | Gepatsch | 139000 | 108 | H/C | Faggenbach | I01000041 | 1964 |
| 4) | ZILLER | GERLOS | Durlassboden | 53500 | 75 | H | Gerlosbach | I01000018 | 1966 |
| | | | Gmuend | 850 | 108 | H | Gerlosbach | I01000043 | 1945 |
| | | ZEMM-ZILLER | Schlegeis | 129000 | 122 | H | Zemmbach | I01000128 | 1971 |
| | | | Zillergruendl | 89500 | 67 | H | Ziller | I01000169 | 1986 |
| | | | Stillup | 7900 | 61 | H | Stilluppe | I01000019 | 1968 |
| 5) | SALZACH | KAPRUN | Margaritze | 3800 | 64 | H | Moell | I01000091 | 1952 |
| | | | Mooserboden | 87000 | 99 | H | Kapruner Ache | I01000097 | 1955 |
| | | | Wasserfallboden | 86000 | 43 | H | Kapruner Ache | I01000086 | 1951 |
| | | STUBACHTAL | Tauernmoos | 55300 | 23 | H | Stubache | I01000143 | 1973 |
| | | | Weisssee | 16000 | 10 | H | Stubache | I01000160 | 1952 |
| 6) | DRAU | FRAGANT | Feldsee | 2450 | 3 | H | Fragant | I01000027 | 2008 |
| | | | Grosssee | 14400 | 3 | H | Moell | I01000053 | 1980 |
| | | | Haselstein | 43 | 9 | H | Kl. Fragantbach | I01000057 | 1968 |
| | | | Hochwurten | 12700 | 6 | H | Fragant | I01000061 | 1980 |
| | | | Innerfragant | 210 | - | H | Wurtenbach | I01000063 | 1967 |
| | | | Oscheniksee | 33000 | 3 | H | Fragant | I01000105 | 1979 |
| | | | Woella | 10 | 13 | H | Woellabach | I01000166 | 1984 |
| | | | Wurtenalm | 2800 | 10 | H | Wurtenbach | I01000167 | 1971 |
| | | | Zirmsee | 8650 | 4 | H | Moell | I01000170 | 1983 |
| | | REISSECK | Galgenbichl | 4800 | 51 | H | Malta | I01000038 | 1974 |
| | | | Goesskar | 2000 | 11 | H | Malta | I01000046 | 1975 |
| | | | Gr. Muehldorfersee[1] | 7850 | 2 | H | Malta | I01000050 | 1957 |
| | | | Koelnbrein | 205000 | 52 | H | Malta | I01000071 | 1977 |
| 7) | MUR | HINTERMUHR | Rotgueldensee | 15600 | 10 | H/C | Mur | I01000121 | 1991 |
| 8) | KAMP | KAMPTAL | Dobra | 21000 | 940 | H/R | Kamp | I01000016 | 1953 |
| | | | Ottenstein | 73000 | 889 | H/R/N/C | Kamp | I01000107 | 1956 |
| | | | Thurnberg | 2570 | 1012 | H/R/N | Kamp | I01000145 | 1952 |

[1] *including Kleiner Muehldorfersee, Hochalmsee, Radlsee* — *H…*Hydroelectricity*; R…*Recreation*; N…*Navigation*; C…*Flood Control*

A few reservoirs have secondary purposes covering flood control, recreation and navigation. Apart from hydropower generation, the reservoirs Gepatsch, Rotgueldensee and Ottenstein are additionally used for flood control and to mitigate flood risk. At the Gepatsch reservoir for instance, seasonal flood storage volumes were defined following the flood event of 2005. In August, 4 m retention space (10.2 mio $m^3$) is exempted from regular operation and in September 2 m (5.4 mio $m^3$) (Hofer et al., 2013).

## 2.2 Data and Methodology

Other studies investigate the impact of reservoirs on flood events by using (i) long-term discharge data up – and downstream of reservoirs (Graf, 2006), (ii) pre- and post-dam runoff data (Mei et al., 2017, Mathias Kondolf & Batalla, 2005) or (iii) other data including, discharge of diversions, reservoir inflow and outflow for detailed event-based analyses (Ganahl, 1988, Hofer et al., 2013). For the current study, (i) to (iii) are not an option, since the data is not available.

The basis for the analysis is the calculation of the ratio between observed runoff peaks after construction of a reservoir with an estimated peak representing the natural state. The estimation of the numerator in the ratio is a problem of runoff prediction in an ungauged setting, where several methods exist (Anctil et al., 1998; Assani et al., 2006; Blöschl et al., 2013; Hrachowitz et al., 2013; Ralf Merz, 2006; Wundt, 1949).

Here, flood estimates are derived through transposition or regionalisation of gauge records of catchments with undisturbed runoff conditions (reference catchments). As a measure of suitability and similarity, spatial proximity of the two catchments is used. Catchments close to each other act similar with respect to their flood responses, since it is expected that hydroclimatic and hydrogeological conditions only change smoothly in space (R. Merz & Blöschl, 2005). Additionally, the land cover of the catchments were analysed (see Table A5 and A6 in the Appendix) based on the CORINE land cover data set (European Union, 2021). The differences in catchment area is considered by multiplying the annual peak discharge from the reference catchment ($HQ_{ref}$) with the ratio of the catchment area of the affected gauge ($A_{aff}$) and the area of the unaffected catchment ($A_{ref}$). Thus, the estimated natural peak discharge downstream of the reservoirs ($HQ_{est}$) increases or decreases linearly with the catchment ratio.

Additionally, precipitation was included as a scaling factor for the estimation of the $HQ_{est}$. The SPARTACUS dataset (Hiebl & Frei, 2018), which is a gridded (1x1 km) daily precipitation dataset for Austria, was used to calculate the precipitation ratio between (i) the catchment of the reservoir (affected) and (ii) the reference (unaffected) catchment. Based on this dataset, the 3-day precipitation sum ($\sum_{t=1}^{3} P$) starting three days before the day of $HQ_{est}$, of the affected catchment ($P_{aff}$) is compared to the precipitation sums in the reference catchment ($P_{ref}$). Thus, the prevailing antecedent hydrological conditions (e.g. saturation) in the catchments prior to the annual peak discharge are considered in the estimation of the annual peak discharge. To avoid discharge estimations of $HQ_{est}$ with large differences in precipitation, e.g. due to very small-scale events, thresholds of the ratio were defined. If the precipitation ratio exceeds 1.3 or is below 0.7, the estimated $HQ_{est}$ was not used for further analysis. Similar to the catchment area ratio used in the estimation, the precipitation ratio increases or decreases the estimated annual peak flood linearly.

Figure 3 shows a schematic illustration for the estimation of the discharge peak at the affected catchment. On the left side, a hydrograph of the observed, reference and estimated flood schematically illustrated. The right side shows a schematic river basin and the water reservoir influenced gauges, also including the reference catchment.

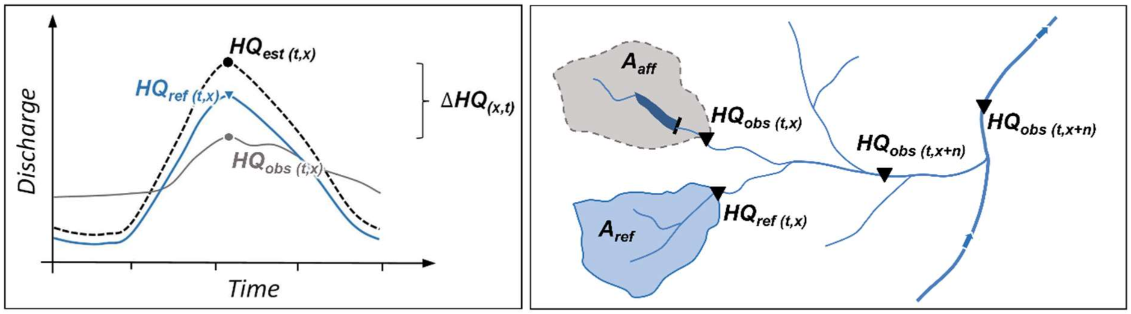


*Figure 3 Schematic illustration of hydrographs including the observed and estimated HQ based on records of a reference catchment (left); and a schematic map of a river basin influenced by a water reservoir (right).*

In a first step, the annual peak discharge ($HQ_{est}$) at the affected gauge (*x*), including the catchment area and precipitation conditions for the day per year (*t*) respectively, can be calculated based on equation (1).

$$HQ_{est}(t,x) = HQ_{ref}(t) * \frac{A_{aff}}{A_{ref}} * \frac{\sum_{t=1}^{3} P_{aff}}{\sum_{t=1}^{3} P_{ref}} \quad (1)$$

The next step is to actually calculate the potential impact of the reservoirs by comparing the estimated peak discharge ($HQ_{est}$) with the observed discharge ($HQ_{obs}$) at the affected gauges. Based on equation (2), the potential flood peak reduction (*FPR*) can be calculated for every location x and day per year t.

$$FPR(t,x) = \left(1 - \frac{HQ_{obs}(t,x)}{HQ_{est}(t,x)}\right) * 100 \quad (2)$$

For analysing the potential impact of reservoirs, not only at the gauges directly downstream (Eq. 1 & 2), but also their impact further downstream, it was necessary to propagate the estimated peak discharge $HQ_{est}$ of the directly affected gauge onto these downstream gauges (*x* + *n*). Since the day (*t*) of the annual peak discharge can vary considerably between a downstream gauge of interest (*x* + *n*) and the gauge (*x*) of the influenced catchment, the transposition formulated in equation (1) was applied at the day corresponding to the *recorded* $HQ_{obs}$ at the gauge *(x + n).* The estimated $HQ_{est}$ *(x)* and the observed $HQ_{obs}$ *(x)* were then used to compute the $HQ_{est}$ *(x+n)* at the respective day based on equation (3).

$$HQ_{est}(t, x+n) = HQ_{obs}(t, x+n) - HQ_{obs}(t, x) + HQ_{est}(t, x) \quad (3)$$

Following Eq. (2) the potential flood peak reduction at this gauge can then be calculated. For downstream gauges with more than one affected catchment in their headwaters the transformation (Eq. 1) was applied to all reservoir influenced catchments.

In Table 2 the affected and the used reference catchments and their gauging stations with other attributes including the location, altitude, area and the distance between the gauges are listed. Discharge data for the selected gauges was obtained from the hydrographic central office of Austria, which publishes mean daily discharge data at https://ehyd.gv.at/ (HZB, 2021). Depending on the gauge, the time series cover a period starting earliest from 1976 to 2017. The gauges selected for this study for each river basin can be found in the appendix.

*Table 2 Affected and reference gauges* (marked with an asterix*) *used for the estimation of annual peak discharges*

| Nr | river basin | ID | Name | Latitude | Longitude | Altitude [m] | Area [km²] | Distance between gauges [km] |
|---|---|---|---|---|---|---|---|---|
| 1 | Ill | 231688 | Beschling | 47° 12´10,08´´N | 09° 40´48,54´´E | 489.2 | 1118.6 | 15.01 |
| | | *200105** | *Garsella* | *47° 13´36,54´´N* | *09° 52´34,23´´E* | *736.5* | *95.5* | |
| 2 | Rosanna | 201251 | St.Anton am Arlberg-Moos | 47° 07´23,16´´N | 10° 15´36,36´´E | 1386.9 | 130.6 | 31.29 |
| | | *200105** | *Garsella* | *47° 13´36,54´´N* | *09° 52´34,23´´E* | *736.5* | *95.5* | |
| 3 | Fagge | 202119 | Platz-Loch | 47° 03´24,12´´N | 10° 45´03,24´´E | 1227.1 | 191.5 | 17.58 |
| | | *230300** | *Gepatschalm* | *46° 53´55,54´´N* | *10° 44´18,90´´E* | *1891.9* | *55* | |
| 4 | Ziller | 201749 | Mayrhofen | 47° 10´09,48´´N | 11° 51´41,75´´E | 629.3 | 610.9 | 30.06 |
| | | *203034** | *Sulzau* | *47° 13´54,39´´N* | *12° 14´51,79´´E* | *885.8* | *80.7* | |
| | | 201970 | EW-Gmünd | 47° 12´41,03´´N | 12° 00´10,07´´E | 1193.0 | 141 | 18.68 |
| | | *203034** | *Sulzau* | *47° 13´54,39´´N* | *12° 14´51,79´´E* | *885.8* | *80.7* | |
| 5 | Salzach | 203554 | Uttendorf (Summenpegel) | 47° 16´02,63´´N | 12° 34´12,35´´E | 844.2 | 127.9 | 24.71 |
| | | *203034** | *Sulzau* | *47° 13´54,39´´N* | *12° 14´51,79´´E* | *885.8* | *80.7* | |
| | | 203109 | Kaprun | 47° 16´22,79´´N | 12° 45´34,91´´E | 767.5 | 88.6 | 39.01 |
| | | *203034** | *Sulzau* | *47° 13´54,39´´N* | *12° 14´51,79´´E* | *885.8* | *80.7* | |
| 6 | Drau | 213124 | Flattach | 46° 55´59,88´´N | 13° 08´00,60´´E | 692.9 | 705.3 | 6.39 |
| | | *212381** | *Mallnitz* | *46° 58´59,94´´N* | *13° 10´29,04´´E* | *1176.5* | *85.3* | |
| | | 212472 | Pflüglhof | 46° 59´31,91´´N | 13° 27´29,52´´E | 851.5 | 131.3 | 21.58 |
| | | *212381** | *Mallnitz* | *46° 58´59,94´´N* | *13° 10´29,04´´E* | *1176.5* | *85.3* | |
| 7 | Mur | 203745 | Muhr | 47° 06´11,87´´N | 13° 29´18,95´´E | 1121.2 | 75.7 | 18.35 |
| | | *203778** | *Weißpriach* | *47° 10´37,02´´N* | *13° 42´18,77´´E* | *1099.7* | *77.1* | |
| 8 | Kamp | 207985 | Rosenburg | 48° 37´53,40´´N | 15° 37´02,28´´E | 281.8 | 1150.2 | 32.71 |
| | | *207944** | *Zwettl-Bahnbrücke* | *48° 36´34,61´´N* | *15° 10´28,67´´E* | *519.1* | *621.8* | |

Some of the reference catchments used for the transposition define a sub-catchment of the affected catchment or are located within the same river basin. Other reference gauges are used for multiple reservoir influenced gauges (e.g. Garsella). The distance between the affected and the reference gauging station used ranges from about 6.4 km to 39.1 km.

# 3 Results

## 3.1 Impact of hydropower reservoirs on peak discharges, including their spatial characteristics

The possible role of water reservoirs in flood control and hence reducing flood risk downstream is investigated for eight river basins. In Table 3Table 1 the estimated median flood peak reduction ($FPR_{median}$) of all investigated gauges is summarized. The basis for the calculation of the $FPR_{median}$ are thereby the annual maximum floods of the period 1976-2017 (42 years). The data availability differs between the basins (see header in Figure 5 on data availability of the single gauges). Additionally, the observed and the estimated long-term mean annual peak discharge is shown.

*Table 3 Median flood peak reduction ($FPR_{median}$) and long-term mean annual peak discharge observed ($HQ_{obs}$) and estimated ($HQ_{est}$)*

| *River basin* | *ID* | *Gauge* | *River* | Area [km²] | *$FPR_{median}$ [%]* | *$HQ_{obs}$ [m³/s]* | *$HQ_{est}$ [m³/s]* |
|---|---|---|---|---|---|---|---|
| Ill | 231688 | Beschling | Ill | 1118.6 | 53.6 | 155 | 289 |
| | 200147 | Gisingen | Ill | 1281 | 36.1 | 233 | 341 |
| | 2437 (CH) | Diepoldsau | Rhein | 6119 | 8.4 | 910 | 1010 |
| Rosanna | 201251 | St. Anton am Arlberg-Moos | Rosanna | 130.6 | 59.7 | 17 | 42 |
| | 202036 | Landeck - Bruggen | Rosanna | 727 | 9.2 | 84 | 85 |
| | 201319 | Imst (Bahnhof) | Inn | 3842 | 0.1 | 372 | 370 |
| Fagge | 202119 | Platz-Loch | Fagge | 191.5 | 96.7 | 2 | 58 |
| | 201194 | Prutz | Inn | 2461.5 | 9.6 | 292 | 329 |
| | 201319 | Imst (Bahnhof) | Inn | 3842 | 6 | 423 | 453 |
| Ziller | 201749 | Mayrhofen | Ziller | 610.9 | 56.25 | 88 | 224 |
| | 201780 | Hart im Zillertal | Ziller | 1094.7 | 42.15 | 165 | 296 |
| | 201806 | Brixlegg | Inn | 8503.6 | 9.3 | 984 | 1083 |
| | 201889 | Kirchbichl | Inn | 9310 | 8.05 | 1061 | 1151 |
| | 201970 | EW-Gmünd | Gerlosbach | 141 | 73.45 | 14 | 50 |
| | 201772 | Rohr | Gerlosbach | 196.8 | 67 | 17 | 54 |
| Salzach | 203554 | Uttendorf | Stubache | 127.9 | 66.3 | 13 | 41 |
| | 203109 | Kaprun | Kapruner Ache | 88.6 | 77.85 | 9 | 31 |
| | 203125 | Bruck (Salzach) | Salzach | 1168.7 | 14.4 | 183 | 213 |
| | 204297 | Salzburg | Salzach | 4425.7 | 2.6 | 711 | 726 |
| Drau | 213124 | Flattach | Möll | 705.3 | 47.9 | 66 | 127 |
| | 212399 | Kolbnitz a.d. Tauernbahn AHP | Möll | 1043.8 | 32.95 | 114 | 171 |
| | 213199 | Drauhofen | Möll | 3674.4 | 11.2 | 450 | 510 |
| | 212472 | Pflügelhof | Malta | 131.3 | 76.75 | 10 | 27 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 212498 | Sandriesen | Malta | 266 | 22.6 | 30 | 38 |
| | 212530 | Spittal (Fasan) | Lieser | 1035.5 | 10.1 | 96 | 105 |
| | 213215 | Amlach | Drau | 4789.6 | 14.65 | 525 | 614 |
| Mur | 203745 | Muhr | Mur | 75.7 | 50.7 | 10 | 18 |
| | 203752 | St.Michael i. Lg. (Mur) | Mur | 289.2 | 14.35 | 34 | 41 |
| | 203794 | Mörtelsdorf | Mur | 366.9 | 14.75 | 39 | 46 |
| | 203976 | Kendlbruck | Mur | 955 | 5.9 | 108 | 114 |
| Kamp | 207985 | Rosenburg (EVN) | Kamp | 1150.2 | 70.2 | 39 | 80 |
| | 207993 | Stiefern | Kamp | 1493.3 | 22.2 | 69 | 79 |

Generally, the median of the calculated $FPR_{median}$ indicates a clear positive impact on annual floods at all stations. The $FPR_{median}$ values range from 96.7% at the Platz-Loch gauge along the Fagge to 0.1% in Imst (Inn river). The overall mean $FPR_{median}$ value is 27.4%, with a standard deviation of +/- 31.9 %. The $FPR_{median}$ shows high values of over 45 - 70% or more for gauges located in the proximity of reservoirs. Further downstream, the $FPR_{median}$ is reduced, but can still show values of 5 – 20%, e.g. at the Inn, Drau or Kamp.

Based on the median values calculated for each gauging station, Figure 4 shows the spatial trends of the $FPR_{median}$ values along the river reaches, including the reservoirs/hydropower groups and the affected catchment. The reduction of the $FPR_{median}$ along the stream between the gauges is derived by linearly interpolating the median values along the river stretch. The results show the clear decreasing trend of the $FPR_{median}$ with increasing distance from the reservoir. This is particular pronounced right after the confluence of tributaries.

At the most westerly located river basin, $FPR_{median}$ values range from 53.6 % at the closest gauge (231688, 1118.6 km²) to the reservoirs to 8.4 % at the gauge located at the river Rhein. The construction of the water reservoir Kartell in the Rosanna river basin, was only finished in 2005. Due to the short time series after the construction and the applied precipitation thresholds in the estimation only very few results are available. Therefore, results for this river basin are highly uncertain and should be seen with caution.

The largest $FPR_{median}$ value of 96.7 % can be found at the gauge 202119 Platz-Loch (191.5 km²), which is situated downstream of the Gepatsch reservoir. It is the second largest reservoir in Austria with a total capacity of 139 million m³. The high FPR translates further downstream to the next gauges. The Prutz gauge (201194), of which the catchment is over 12 times larger, still shows a median FPR of nearly 10 %. This gauge however is not located along the impacted river reaches, but right upstream of the confluence of the affected river (Fagge) and the receiving river (Inn).

The headwaters of the Ziller are influenced by two power plant groups. The power plant group Zemm-Ziller and its reservoirs (total capacity = 226 million m³) are located at several streams and rivers upstream of the gauge Mayerhofen (201749, 610.9 km²), where a $FPR_{median}$ of over 56 % is found. Between the gauges Mayerhofen and Hart im Zillertal, the Gerlosbach, which has another large reservoir in its headwaters, drains into the Ziller. The Durlaßboden reservoir has a capacity of 53.5 million m³ and strongly reduces annual flood peaks along the Gerlosbach. The influence on the Inn is in the range of 8% – 9%.

Multiple reservoirs in the headwaters of the Salzach river affect flood peaks, reducing them by about 15 % at the gauge Bruck (203125, 1168.7km²). The Stubache is influenced by two large reservoirs (71.3 million m³; Wesemann et al. 2018), which leads to a $FPR_{median}$ of 66.3 %. Likewise, in the valley running parallel to the east, the power plant group Kaprun decreases the annual floods by about 78 % due to the reservoirs Tauernmoos and Wasserfallboden (176.8 million m³). For the Salzach, the influence of the reservoirs in the headwaters is still visible in Salzburg, where a $FPR_{median}$ of around 3 % is still evident. Additionally, diversion from the Möll catchment in the south transfer water to the north towards Kaprun, also influencing discharge of the Möll.

The discharge at the Möll river is predominantly affected by a number of reservoirs of the power plant group Fragant (total capacity = 74.3 million m³). The $FPR_{median}$ at the Flattach gauge (213124, 664.5 km²) located downstream lies around 47 %. With a $FPR_{median}$ of over 11 % the influence is still evident at the Drauhofen gauge (213199, 3674.4 km²). At the Amlach gauge (213215, 4789.6 km²) further downstream at the river Drau, an increase of the $FPR_{median}$ can be seen. Here the Drau river is also influenced by the power plant group Kreuzeck in the headwaters of the Malta river, which is another tributary. In the headwaters of the Malta river the Kölnbrein reservoir is situated. With its overall reservoir capacity of 200 million m³ it is the largest reservoir in Austria. Annual flood peaks downstream are significantly reduced. At the gauge Pflügelhof (212472, 131.3 km²) and Sandriesen (212498, 266 km²) the median flood peak reduction is 76.65 % and 22.6 %, respectively.

360

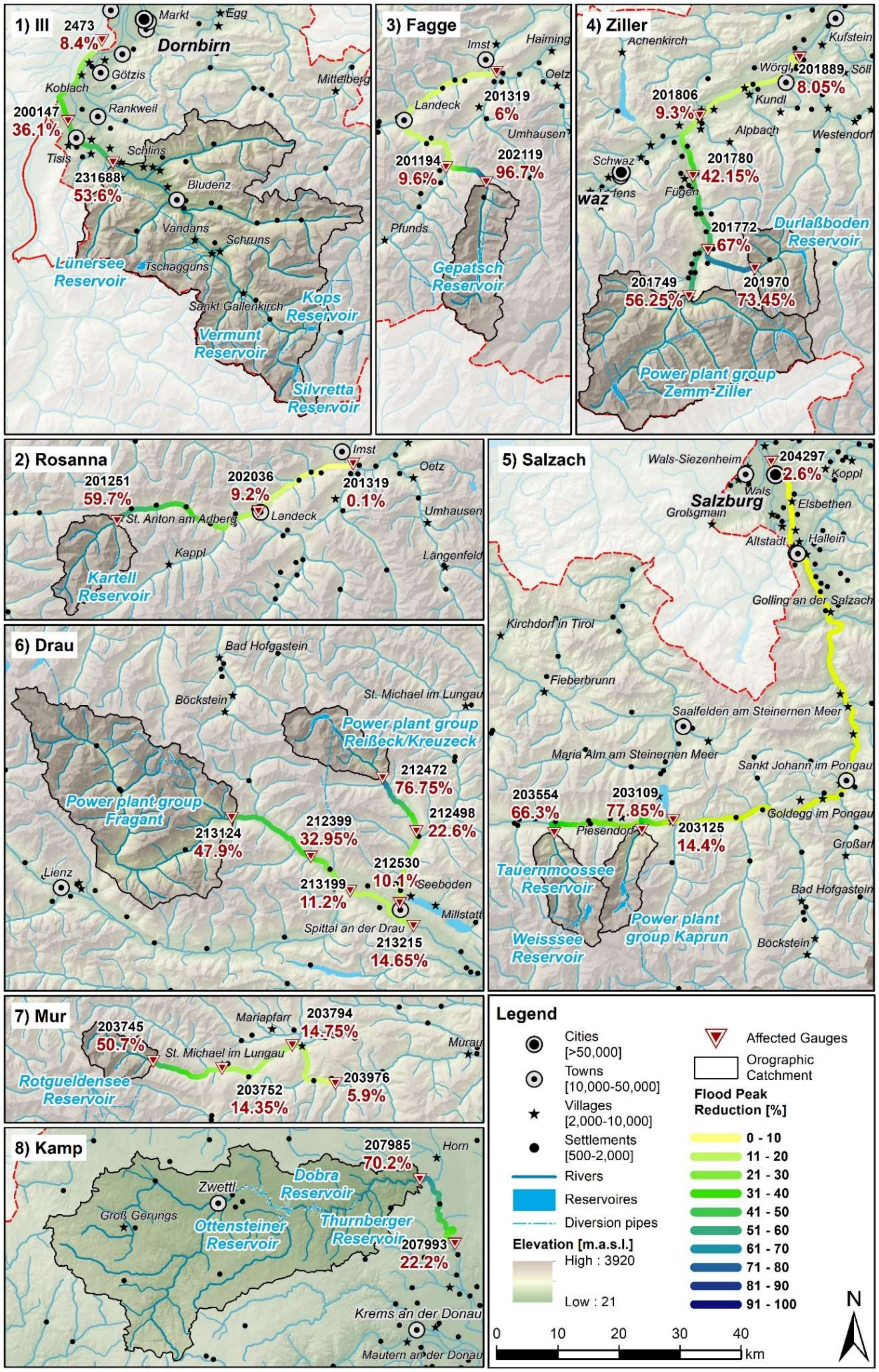


*Figure 4 Median Flood peak reduction (FPR) for the eight study basins.*

At the Mur river basin, $FPR_{median}$ values ranging from over 50 % (203745, 75.7 km²) to 5.9 % (203976, 955 km²) further downstream at the last gauge analysed, are found. $FPR_{median}$ values in at gauges in the mid-stretches of the Mur are over 14 %.

The impact of the Powerplant Kamptal significantly reduces flood peaks downstream at the Rosenburg gauge (FPRmedian = 70.2 %). This impact reduces to 22.2 % at the next gauge (207993, 1493.3 km²), which is located after the tributary Taffa confluences with the Kamp river.

Figure 5 shows the distribution of the estimated flood peak reductions based on the single annual flood peaks of the individual gauges in the eight river basins. The return periods of the single events are thereby plotted in different colours. In the headwaters of the Ziller and Drau river basin, reservoirs exist at different tributaries. Hence, the impact of the reservoirs along these tributaries is plotted individually and the location of the confluence is marked by an asterisk within the respective plots of the river basins.

The impact of the reservoirs is generally positive, leading to a reduction of the estimated annual peak discharge peak throughout all river basins. The $FPR_{median}$, plotted in red, shows the decreasing trend with increasing distance from the reservoir in all river basins with the exception of the Amlach gauge at the river Drau. The majority of all analysed flood peaks (n=838) show positive values (n=792), indicating reductions of the estimated flood peaks. Compared to the total analysed events at all gauging stations, around 5.5 % (n=46) show an increase of the respective maximum annual discharge.

On average, the flood peak reduction is strongest at the first gauges downstream of a reservoir. Here, the mean flood peak reduction is 63.5 %. At the second gauges after the reservoirs, mean flood peak reduction decreases to 26.5 %. Further downstream, at the third and fourth gauge included in the analyses, the mean FPR values further decrease to approximately 10 %.

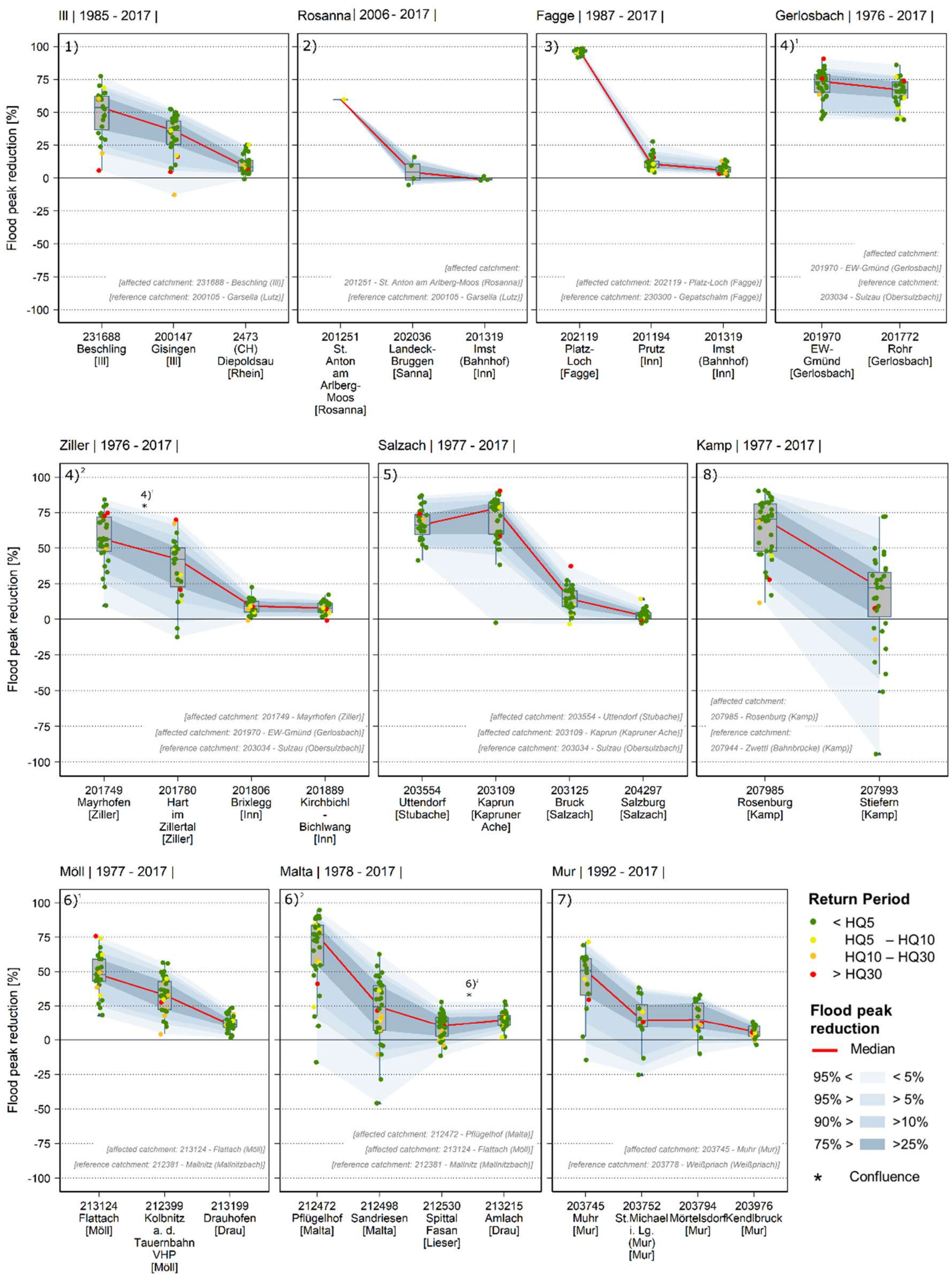


*Figure 5 Event based flood peak reduction and return periods at gauges affected by hydropower reservoirs*

### 3.2 Relating return periods and flood peak reduction

Figure 6 shows the relationship between return periods based on the Gumbel extreme value distribution and the FPR. Generally, floods with lower return periods (~<HQ10) show a larger flood peak reduction. On average, the FPR for these events lies around 31-35 %. For return periods between 10 and 30 years, the mean FPR is further reduced to about 23 %. For events with a lower probability (> $HQ_{30}$) a mean FPR of over 33 % can be found. It is clear that the sample size for this category is smaller, compared to the other categories.

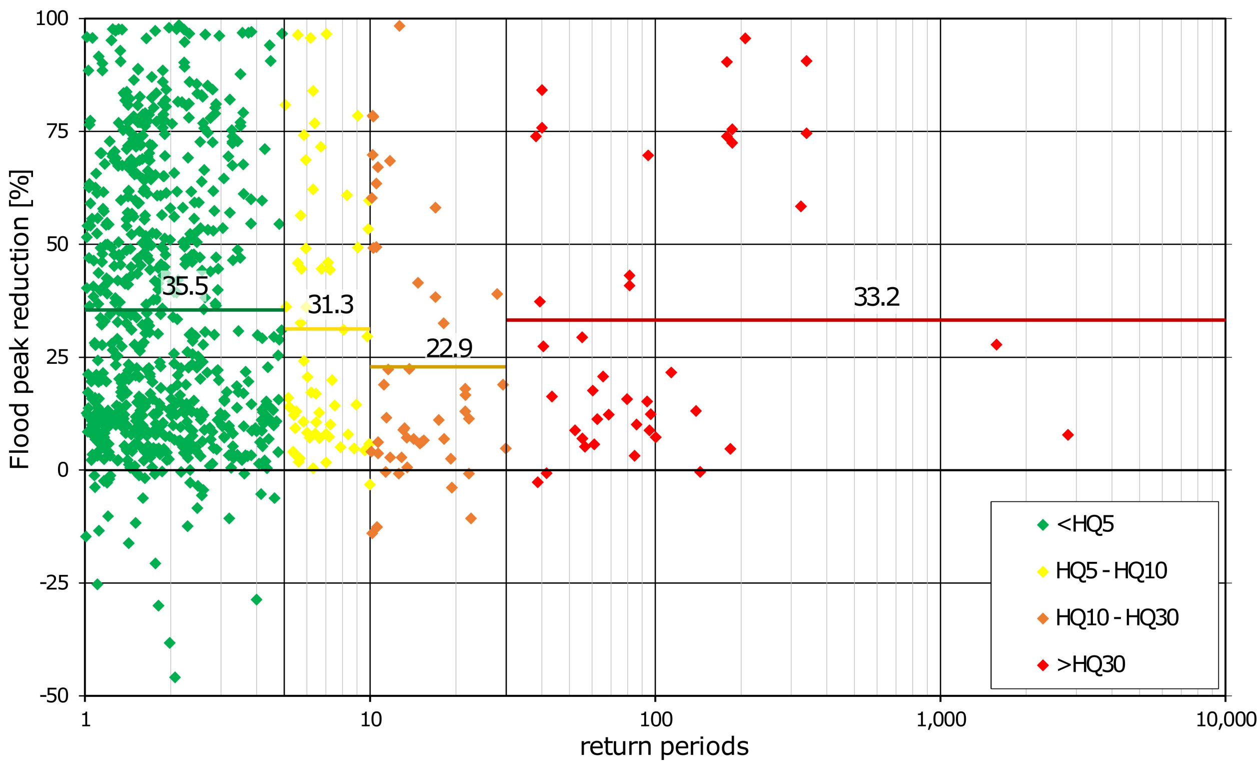


*Figure 6 Relationship of return periods and the flood peak reduction*

Negative flood peak reductions, indicating an increase of the discharge peak of the respective event due to the operation of storage reservoirs, were found at few river basins. Most events with negative ratios are thereby found at the river Kamp (Figure 5; Stiefern gauge (207993)). Generally, the majority of these events show low return periods (< $HQ_5$) and are therefore events exhibiting negligible flood risk. These events would not cause flooding along the river reaches. Generally, negative ratios decrease with increasing return periods. Only three extreme events with return periods larger than 30 years show small negative values (-2.7, -0.7, -0.4 %).

### 3.3 Flood Peak Reduction as a function of catchment and reservoir characteristics

Based on the results, a decreasing flood peak reduction with increasing distance and catchment area is apparent. Some studies focusing on single flood events also showed this effect (Ganahl, 1988; Hofer et al., 2013; Kugi & Weissel, 1986). Relative variables calculated based on various reservoir features, including the reservoir and catchment area, the total reservoir capacity and the mean annual discharge can be helpful to identify similar behaviours of reservoirs and their possible impact on flood events (Schöberl, 2005). Apart from the storage volume existing at the time of an event, the percentage of the entire catchment controlled by the reservoir contributes to the improved flood control at any location downstream (Pircher, 1990). Other relative variables used to describe the possible impact of reservoirs on floods are the ratio between mean annual discharge (recorded before the construction) and the reservoir size (Graf, 2006), the geographic location, operation rules and the ratio between the reservoir capacity and the drainage area (Graf, 2006; Mei et al., 2017)

In this study the ratio between the reservoir capacity and the catchment area of the respective gauges are related to the respective $FPR_{median}$ values. Additionally, the ratio of the reservoir catchment and total catchment area is related to the $FPR_{median}$. The scatter plots including all river basins are shown in Figure 7. $FPR_{median}$ values increase with increasing ratios between the reservoir capacity and the catchment area (Figure 7, left). Likewise, higher $FPR_{median}$ values are found when ratios between the reservoir catchment and the total catchment area increase (Figure 7, right). This indicates that catchment with high ratios have a stronger flood control potential and here reservoirs strongly reduce flood hazard and flood risks downstream. Thus, flood risk reduction is especially significant in the headwaters and the flood control potential of reservoirs decreases with increasing catchment area and distance from the reservoir.

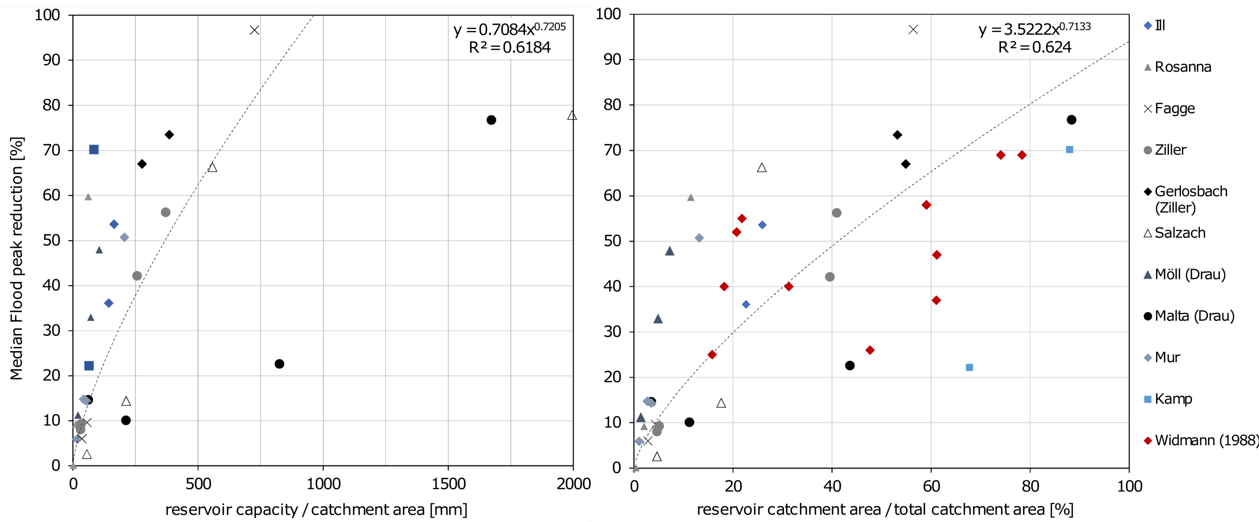


*Figure 7 Relationship of flood peak reduction with catchment and reservoir characteristics. left: Relationship between the reservoir capacity/catchment area ratio. Right: Relationship between the reservoir catchment /catchment area ratio*

On the right scatter plot, values provided by Widmann (1988), also covering the Ill, Salzach, Ziller and Fagge, are additionally shown. These flood peak reductions correspond to events with a return period of 100 years (Widmann, 1988). In general, the independent data shows a good agreement with our findings.

## 4 Discussion

More complex methods exist to calculate the flood peak reduction FPR. For example, given the knowledge of inflow and other boundary conditions, the application of a hydraulic model to simulate the retention within a reservoir and the following deformation of the flood wave downstream would allow for a more detailed analysis. This approach would be feasible for single events and hydropower stations, given the availability of necessary data. The objective of this contribution is however to analyse the general characteristics of FPR by reservoirs for a larger domain and the application of detailed models would not be feasible.

The assumption of spatial proximity for the reference catchment, the scaling of peak discharge events based on the catchment area and precipitation ratios are important factors for the estimation of a possible flood in the affected catchment prior to the setup of the dam. It is thereby assumed that hydrological processes are comparable between the different catchments. The applied methodology and its assumptions are clearly subject to some degree of uncertainty. Plausibility checks and comparison of our findings with published data are therefore important.

In the Montafon Valley (Ill River Basin) flood peaks from a 33 year period have been reduced by 26 to 82 %, due to hydropower reservoirs (Pircher, 1990). Downstream of the Montafon Valley, at the Beschling gauge, FPR values presented in this study range from 5.7 % to 77.3 %. With 53.6 %, the $FPR_{median}$ is well within the range of the published values. Results from the Rosanna river basin are highly uncertain due to the short time series available. The uncertainty is also obvious, when comparing mean annual peak discharges from pre- and post-dam construction. At the gauge St. Anton (201251), a mean flood peak reduction of about 31 % is found, which is lower compared to the calculated $FPR_{median}$ (59.7 %) value.

At the gauge Platz-Loch (202119) downstream of the Gepatsch reservoir, the estimated $FPR_{median}$ is 96.7 %. Pircher (1990) reports a flood peak reduction of the flood in July 1987 of 90 % and 92 %. Analysing the flood of August 2005, Hofer et al. (2013) mentions a discharge reduction from 37.3 m³/s to 8.2 m³/s, which corresponds to a FPR of 78 %. Following the flood event of 2005, flood storage volumes were defined for the Gepatsch reservoir and the single-purpose character (hydropower generation) of the reservoir was changed to include flood control (Hofer et al., 2013). The higher values found in our results may therefore also be explained by the consideration of flood storage volumes.

The impacts of the power plant group Zemm-Ziller and the Durlaßboden reservoir was investigated by Ganahl (1988) based on single flood events from 1973 to 1987. Flood peak reductions at the Hart im Zillertal (201780) range from 26 to 40 %. In the past, the largest reduction of 40 % was determined for the flood event in August 1987, reducing the peak from a possible 852 m³/s to 507 m³/s. At this gauge the estimated $FPR_{median}$ is 42.15 %, a value well in the range of previously published data.

The flood of 1985 in the Malta valley was analysed by Kugi & Weissel (1986). They stated that the flood peak was reduced at the Pflügelhof (212498) and the Sandriesen (212498) gauge by 42 % and 45 %, respectively. Based on the comparison of mean annual peak discharges, derived from the comparison of pre and post-dam discharge records, the reduction at the Pflügelhof and Sandriesen gauges is 74 % and 58 %, respectively. Here, results from this study suggest a similar $FPR_{median}$ of 76.75 % at the Pflügelhof gauge. At the same time, the resulting FPR values seem to be underestimated at the Sandriesen gauges ($FPR_{median}$ = 22.6 %). For other gauges in the study areas literature values are lacking.

In general, the comparison of our data with the published data (e.g.Ganahl, 1988; Kugi & Weissel, 1986; Pircher, 1990) shows that the estimated FPR values for most gauges are in the same range. At some gauges, e.g. St. Anton the estimated reductions might however be overestimated. For other gauges, the strong influence could be confirmed (e.g. Platz-Loch).

Published data also indicate the decreasing trend of the possible flood peak reduction downstream. This is also indicated by the relationship of the estimated $FPR_{median}$ values in this study with the ratio of the reservoir catchment and the total catchment area. By comparing the results from this study to event-based investigations from the past (Widmann, 1988), a comparable decrease of the flood reduction with decreasing catchment ratios is found. At the same time our results show that the influence and peak reductions due to the hydropower reservoirs can strongly influence densely populated downstream areas and thus reduce flood risk. Examples here are the Inn, Salzach or Drau, where flood peak reductions of up to around 15% are found.

Results also indicate that flood events with lower return periods ($HQ_{10}$ - $HQ_{30}$) are less reduced compared to events with higher return periods (< $HQ_{10}$). Extremer events, with return periods larger than 30 years show a mean flood peak reduction of over 33 %. Most hydropower companies operate inflow forecasting systems, which are based on a hydrological model driven by precipitation and temperature forecasts. The strong reduction of possible extreme floods might therefore result from an anticipatory preparation and lowering of reservoir levels, providing more retention space. Results from Widmann (1988) also indicate strong flood peak reductions ranging from 26 to 69 % of extreme events ($HQ_{100}$).

## 5 Summary and Conclusion

Generally, most dams and reservoirs in Austria serve to generate hydropower (ICOLD, 2021). Storage and pump- storage facilities provide about 28 % of the national hydropower generation (Wagner et al., 2015), but such reservoirs also alter the hydrological conditions downstream (e.g.Magilligan & Nislow 2005, Catherine et al. 2011, Moschen & Lauffer 1977). Internationally, the impact on peak flows has been studied by various authors (e.g. Batalla et al. 2004, Verbunt et al. 2005, Graf, 2006). In Austria, the effect of hydropower reservoirs has been studied in the past, however only for single events and reservoirs(e.g. Ganahl, 1988; Hofer et al., 2013; Pircher, 1990; Widmann, 1988).

In this study, the aim was to systematically quantify the general reduction of flood peaks based on long-term annual peak discharges as suggested by Widmann (1988) for all main storage hydropower schemes in Austria, thereby covering eight rivers basins. Due to the lack of discharge data recorded prior to dam construction in most river basins, unaffected (natural) annual peak flows were estimated by the transposition of data from reference catchments. This approach assumes similar hydroclimatic and hydrogeological conditions and hydrological processes in the reference and the affected catchment.

Along all reservoir influenced rivers and streams, a reduction of annual peak discharges could be found. They range from over 96 % to 47.9 % at affected gauges close to the reservoirs and from 14.6 % to 0.1 % at gauges further downstream. On average, the reduction of estimated unaffected flood peaks at gauges directly downstream of the reservoirs is 63.5 %. Those results correspond quite well with previous event-based investigations (e.g. Hofer et al., 2013).

Results also indicate that the peak discharge reduction decreases with increasing catchment size and the distance from the water reservoir. This is also shown by relating the reduction with the ratio of the reservoir catchment and the total catchment area. The results align well with previous investigations from Widmann (1988). On the other hand, single events showed negative FPR´s, leading to an increase of the respective annual peak discharge. These events mostly show low return periods smaller than five years and do therefore not lead to increased flood risk or flood damages along the riparian and downstream communities. Events with return periods between 10 and 30 years show a mean FPR of 22.9 %. Another result is that rare maximum annual discharges with low return probabilities (> $HQ_{30}$) are reduced by 33 % on average. Hence, potential flooding due to these events may have been prevented. Overall, the results show that reservoirs in the headwaters of a river basin can considerably reduce peak discharges within the entire basin, also contributing to mitigate flood risk downstream.

Diversions and inter-basin water transfer can lead to reduction of flood peaks (e.g. Bui et al., 2020; Hofer et al., 2013) but was not considered in the current study. Further research investigating the impact of hydropower reservoirs on flood risk should therefore also include diverted streams. Generally, the analysis with higher temporal resolution discharge data or the application of detailed hydraulic models might also lead to an improved quantification of the flood reduction potential of water reservoirs. These approaches however are more data intensive and the question of the feasibility for the application on a larger domain remains.

Man-made lakes have distinct hydrological, biological or social impacts. Here, we analysed the effect of reservoirs on flood peaks downstream. Although the reservoirs were mostly built for the single purpose of hydropower generation, clear positive effects and a downstream reduction of flood hazard are found. A higher flood peak reduction potential is available, if operation rules would be adopted to explicitly consider a flood storage volume. This however contrasts the interests of the hydropower plant operators and does, at least in Austria, not have a legal basis for implementation. At the same time, further investigations could evaluate the overall potential in flood hazard reduction, if the reservoirs were operated in a manner, which puts more weight in the retention of floods.

## 6 Author contributions

MH, KL and GS designed the study, established the methodological framework and performed all analyses. GS prepared the figures. GS and MH drafted and compiled the manuscript with contributions by KL.

## 7 Competing interests

The authors declare that they have no conflict of interest.

## 8 Acknowledgment

Discussions with Dr. Klaus Hebenstreit and Dr. Willibald Kerschbaumsteiner helped in understanding operation procedures of storage hydropower plants in Austria. This is highly acknowledged. We also acknowledge the work of DI Katharina Lebiedzinski in the context of this paper.

## 9 Data Availability Statement

The study was performed using openly available primary input data. All intermediate and final data that were generated in this study are available in the appendix and upon request to the corresponding author.

## 10 Funding

This work was funded by the Earth System Sciences (ESS) research program of the Austrian Academy of Sciences (ÖAW) within the project “Integrated Flood Risk Management in Mountain Areas: Assessing Sectoral Interdependencies, Conflicts and Options for Policy Coordination” (PoCo-FLOOD). Open access funding was provided by the University of Natural Resources and Life Sciences Vienna (BOKU).

## 11 References


Ackermann, W. C., White, G. F., Worthington, E. B., & Ivens, J. L. (1973a). *Man-made Lakes: Their Problems and Environmental Effects* (W. C. Ackermann, G. F. White, E. B. Worthington, & J. L. Ivens (eds.); Vol. 17). American Geophysical Union. https://doi.org/10.1029/GM017

Ackermann, W. C., White, G. F., Worthington, E. B., & Ivens, J. L. (1973b). Summary of Symposium and Recommendations. In W. C. Ackermann, G. F. White, E. B. Worthington, & J. L. Ivens (Eds.), *Man-Made Lakes. Their Problems and Environmental Effects* (pp. 3–40). American Geophysical Union. https://doi.org/10.1029/GM017P0003

Anctil, F., Martel, N., & Hoang, V. D. (1998). Analyse regionale des crues journalieres de la province du Quebec. *Canadian Journal of Civil Engineering*, *25*, 125–146.

Assani, A. A., Stichelbout, É., Roy, A. G., & Petit, F. (2006). Comparison of impacts of dams on the annual maximum flow characteristics in three regulated hydrologic regimes in Québec (Canada). *Hydrological Processes*, *20*(16), 3485–3501. https://doi.org/10.1002/hyp.6150

Batalla, R. J., Gómez, C. M., & Kondolf, G. M. (2004). Reservoir-induced hydrological changes in the Ebro River basin (NE Spain). *Journal of Hydrology*, *290*(1–2), 117–136. https://doi.org/10.1016/j.jhydrol.2003.12.002

Blöschl, G., Sivapalan, M., Wagener, T., Viglione, A., & Savenije, H. (2013). Runoff Prediction in Ungauged Basins. In G. Bloschl, M. Sivapalan, T. Wagener, A. Viglione, & H. Savenije (Eds.), *Runoff Prediction in Ungauged Basins: Synthesis Across Processes, Places and Scales*. Cambridge University Press. https://doi.org/10.1017/CBO9781139235761

BMLFUW. (2006). *Hochwasser 2005 - Ereignissdokumentation*.

Bui, D. T., Asl, D. T., Ghanavati, E., Al-Ansari, N., Khezri, S., Chapi, K., Amini, A., & Pham, B. T. (2020). Effects of inter-basinwater transfer on water flow condition of destination basin. *Sustainability (Switzerland)*, *12*(1), 338. https://doi.org/10.3390/SU12010338

Butcher, D. A. P. (1973). Sociologic Aspects of Fishery Development on Volta Lake. In W. C. Ackermann, G. F. White, E. B. Worthington, & J. L. Ivens (Eds.), *Man-Made Lakes. Their Problems and Environmental Effects* (pp. 108–113). American Geophysical Union. https://doi.org/10.1029/GM017P0108

Catherine, F., Ali A, A., Mhamed, M., & Andre G., R. (2011). Comparison of the interannual and interdecadal variability of heavy flood characteristics upstream and downstream from dams in inversed hydrologic regime: case study of Matawin river (Quebec, Canada). *River Research and Applications*, *30*(January), 132–133. https://doi.org/10.1002/rra

Ely, P., Fantin-Cruz, I., Tritico, H. M., Girard, P., & Kaplan, D. (2020). Dam-Induced Hydrologic Alterations in the Rivers Feeding the Pantanal. *Frontiers in Environmental Science*, *8*(December), 1–17. https://doi.org/10.3389/fenvs.2020.579031

European Union. (2021). Copernicus Land Monitoring Service. *European Environment Agency*.

Fürst, J., Nachtnebel, H. P., Kling, H., & Hörhan, T. (2010). Beobachtete Veränderungen in der Wasserbilanz Österreichs. In *Auswirkungen des Klimawandels auf Hydrologie und Wasserwirtschaft in Österreich* (pp. 101–115). ÖWAV (Österreichischer Wasser- und Abfallwirtschaftsverband).

Ganahl, P. (1988). Retention of a 100 years event by the Zillertal reservoirs. *Internationales Symposium INTERPRAEVENT*, *Band 4*(Tagungspublikation), 43–54.

Graf, W. L. (2006). Downstream hydrological and geomorphoc effects of large dams on American rivers. *Geomorphology*.

Grill, G., Lehner, B., Thieme, M., Geenen, B., Tickner, D., Antonelli, F., Babu, S., Borrelli, P., Cheng, L., Crochetiere, H., Ehalt Macedo, H., Filgueiras, R., Goichot, M., Higgins, J., Hogan, Z., Lip, B., McClain, M. E., Meng, J., Mulligan, M., … Zarfl, C. (2019). Mapping the world's free-flowing rivers. *Nature*, *569*(7755), 215–221. https://doi.org/10.1038/s41586-019-1111-9

Gutknecht, D., Reszler, C., & Blöschl, G. (2002). Das Katastrophenhochwasser vom 7. August 2002 am Kamp — Eine erste Einschätzung (The 7 August 2002 – flood of the Kamp – a first assessment). *Elektrotechnik Und Informationstechnik*, *119*, 411–413. https://doi.org/10.1007/bf03161354

Habel, M., Mechkin, K., Podgorska, K., Saunes, M., Babiński, Z., Chalov, S., Absalon, D., Podgórski, Z., & Obolewski, K. (2020). Dam and reservoir removal projects: a mix of social-ecological trends and cost-cutting attitudes. *Scientific Reports*, *10*(1), 19210. https://doi.org/10.1038/s41598-020-76158-3

Hauenstein, W. (2009). Wasserkraft und Klimawandel. *Stromwirtschaft Im Klimawandel. Auswirkungen Der Klimaver{{}{ä}{}}nderung Auf Die Erzeugung von Strom.*, 33–50.

Herrnegger, M., Senoner, T., & Nachtnebel, H.-P. (2018). Adjustment of spatio-temporal precipitation patterns in a high Alpine environment. *Journal of Hydrology*, *556*, 913–921. https://doi.org/10.1016/j.jhydrol.2016.04.068

Hiebl, J., & Frei, C. (2018). Daily precipitation grids for Austria since 1961—development and evaluation of a spatial dataset for hydroclimatic monitoring and modelling. *Theoretical and Applied Climatology*, *132*(1–2), 327–345. https://doi.org/10.1007/s00704-017-2093-x

Hofer, B., Schöber, J., & Perzlmaier, S. (2013). *Flood control: Principles for the operation of existing and the planning of new storage power plants*. 1–8.

Hoffman, D. A., & Jonez, A. R. (1973). Lake Mead, A Case History. In W. C. Ackermann, G. F. White, E. B. Worthington, & J. L. Ivens (Eds.), *Man-made Lakes: Their Problems and Environmental Effects* (pp. 220–233). American Geophysical Union. https://doi.org/10.1029/gm017p0220

Hrachowitz, M., Savenije, H. H. G., Blöschl, G., McDonnell, J. J., Sivapalan, M., Pomeroy, J. W., Arheimer, B., Blume, T., Clark, M. P., Ehret, U., Fenicia, F., Freer, J. E., Gelfan, A., Gupta, H. V., Hughes, D. A., Hut, R. W., Montanari, A., Pande, S., Tetzlaff, D., … Cudennec, C. (2013). A decade of Predictions in Ungauged Basins (PUB)—a review. *Hydrological Sciences Journal*, *58*(6), 1198–1255. https://doi.org/10.1080/02626667.2013.803183

HZB. (2021). *Federal Ministry of Agriculture Regions and Tourism – Hydrographic Central Office*. https://ehyd.gv.at/

ICOLD. (2021). The World Register Dams (WRD). *International Commission on Large Dams (Last Update: April 2021)*. https://www.icold-cigb.org/

Koboltschnig, G. R., & Schöner, W. (2011). The relevance of glacier melt in the water cycle of the Alps: The example of Austria. *Hydrology and Earth System Sciences*, *15*(6), 2039–2048. https://doi.org/10.5194/hess-15-2039-2011

Komma, J., Reszler, C., Blöschl, G., & Haiden, T. (2007). Ensemble prediction of floods – catchment non-linearity and forecast probabilities. *Natural Hazards and Earth System Sciences*, *7*(4), 431–444. https://doi.org/10.5194/nhess-7-431-2007

Kugi, W., & Weissel, G. (1986). Das Augusthochwasser 1985 im Maltatal. *Carinthia II, Klagenfurt 1986*, *176/96 Jah*, 311–319.

Lauffer, H. (1975). Die Auswirungen der Speicherkraftwerke auf die Umwelt. *Österreichische Wasserwirtschaft*, *Jahrgang 2*(Heft 5/6), 101–118.

Lebiedzinski, K., & Fürst, J. (2018). Entwicklung der alpinen Abflussregime in Österreich im Zeitraum 1961–2010. *Österreichische Wasser- Und Abfallwirtschaft*, *70*(9–10), 474–484. https://doi.org/10.1007/s00506-018-0499-z

Leis, J. L., & Kienberger, S. (2020). Climate risk and vulnerability assessment of floods in Austria: Mapping homogenous regions, hotspots and typologies. *Sustainability (Switzerland)*, *12*(16). https://doi.org/10.3390/su12166458

Magilligan, F. J., & Nislow, K. H. (2005). Changes in hydrologic regime by dams. *Geomorphology*, *71*(1–2), 61–78. https://doi.org/10.1016/j.geomorph.2004.08.017

Mathias Kondolf, G., & Batalla, R. J. (2005). Chapter 11 Hydrological effects of dams and water diversions on rivers of Mediterranean-climate regions: examples from California. *Developments in Earth Surface Processes*, *7*(C), 197–211. https://doi.org/10.1016/S0928-2025(05)80017-3

Mei, X., Van Gelder, P. H. A. J. M., Dai, Z., & Tang, Z. (2017). Impact of dams on flood occurrence of selected rivers in the United States. *Frontiers of Earth Science*, *11*(2), 268–282. https://doi.org/10.1007/s11707-016-0592-1

Merz, R., & Blöschl, G. (2005). Flood frequency regionalisation - Spatial proximity vs. catchment attributes. *Journal of Hydrology*, *302*(1–4), 283–306. https://doi.org/10.1016/j.jhydrol.2004.07.018

Merz, Ralf. (2006). *Wiener Mitteilungen Band 197: Methoden der hydrologischen Regionalisierung*. 109–130.

Moschen, H., & Lauffer, H. (1977). Der Einfluss der Speicher und Überleitungen auf die Wasserführung des Inn in Tirol. *Österreichische Wasserwirtschaft*, *Jahrgang 2*(Heft 5/6), 88–95.

Moser, J., Kopeinig, C., Gutschi, E., Malle, H., Eder, M., Koboltschnig, G., Schober, S., Kulterer, K., Schabus, V., Hofer, W., & Scherz, W. (2019). *Hochwasserereregnis an der Drau, Möll, Gail und Zubringern 28 - 31.10.2018*.

Muhar, S., Schwarz, M., Schmutz, S., & Jungwirth, M. (2000). Identification of rivers with high and good habitat quality: Methodological approach and applications in Austria. *Hydrobiologia*, *422–423*(1994), 343–358. https://doi.org/10.1007/978-94-011-4164-2_28

Nilsson, C., Reidy, C. A., Dynesius, M., & Revenga, C. (2005). Fragmentation and flow regulation of the world's large river systems. *Science*, *308*(5720), 405–408. https://doi.org/10.1126/science.1107887

Pircher, W. (1990). The contribution of hydropower reservoirs to flood control in the Austrian Alps. *Hydrology in Mountainous Regions. Artificial Reservoirs;Water and Slopes*, *194*, 3–10.

Räsänen, T. A., Koponen, J., Lauri, H., & Kummu, M. (2012). Downstream Hydrological Impacts of Hydropower Development in the Upper Mekong Basin. *Water Resources Management*, *26*(12), 3495–3513. https://doi.org/10.1007/s11269-012-0087-0

Schöberl, F. (2005). *Hochwasserschutz durch Hochwasserrückhalt*. *1988*, 115–128.

Schönlaub, H., & Hofer, B. (2009). Die Hochwassersituation bei abgeleiteten Bächen. *WasserWirtschaft*, *99*(9), 23–29. https://doi.org/10.1007/bf03241567

Song, X., Zhuang, Y., Wang, X., Li, E., Zhang, Y., Lu, X., Yang, J., & Liu, X. (2020). Analysis of Hydrologic Regime Changes Caused by Dams in China. *Journal of Hydrologic Engineering*, *25*(4), 05020003. https://doi.org/10.1061/(asce)he.1943-5584.0001891

Taylor, B. W. (1973). People in a Rapidly Changing Environment: the First Six Years of Volta Lake. In W. C. Ackermann, G. F. White, E. B. Worthington, & J. L. Ivens (Eds.), *Made Lakes. Their Problems and Environmental Effects* (pp. 99–107). American Geophysical Union. https://doi.org/10.1029/GM017P0099

Verbunt, M., Groot Zwaaftink, M., & Gurtz, J. (2005). The hydrologic impact of land cover changes and hydropower stations in the Alpine Rhine basin. *Ecological Modelling*, *187*(1 SPEC. ISS.), 71–84. https://doi.org/10.1016/j.ecolmodel.2005.01.027

Wagner, B., Hauer, C., & Habersack, H. (2019). Current hydropower developments in Europe. *Current Opinion in Environmental Sustainability*, *37*(i), 41–49. https://doi.org/10.1016/j.cosust.2019.06.002

Wagner, B., Hauer, C., Schoder, A., & Habersack, H. (2015). A review of hydropower in Austria: Past, present and future development. *Renewable and Sustainable Energy Reviews*, *50*(2015), 304–314. https://doi.org/10.1016/j.rser.2015.04.169

Wesemann, J., Herrnegger, M., & Schulz, K. (2018). Hydrological modelling in the anthroposphere: predicting local runoff in a heavily modified high-alpine catchment. *Journal of Mountain Science*, *15*(5), 921–938. https://doi.org/10.1007/s11629-017-4587-5

Widmann, R. (1988). Einfluss von alpinen Speichern auf den Abfluss von Hochwässern. *Die Talsperren Österreichs, 16. Talsperrenkongress in San Francisco*, *Q.63*, *R.85*, 137–144.

Wundt, W. (1949). Die größten Abflussspenden in Abhängigkeit von der Fläche. *Die Wasserwirtschaft*, *40*, 59–64.

# 12 Appendix

*Table Appendix 1 Gauges used in this study*

| River basin Nr. | ID | Name | River | Catchment area [km²] |
|---|---|---|---|---|
| 1 | 231688 | Beschling | Ill | 1118.6 |
| | 200147 | Gisingen | Ill | 1281 |
| | 2473 | Diepoldsau (CH) | Rhein | 6119 |
| 2 | 201251 | St. Anton am Arlberg-Moos | Rosanna | 130.6 |
| | 202036 | Landeck-Bruggen | Sanna | 727 |
| | 201319 | Imst | Inn | 3842 |
| 3 | 202119 | Platz-Loch | Fagge | 191.5 |
| | 201194 | Prutz | Inn | 2461.5 |
| | 201319 | Imst | Inn | 3842 |
| 4 | 201749 | Mayerhofen | Ziller | 610.9 |
| | 201780 | Hart | Ziller | 1094.7 |
| | 201806 | Brixlegg | Inn | 8503.6 |
| | 201889 | Kirchbichl-Bichlwang | Inn | 9310 |
| | 201970 | EW-Gmünd | Gerlosbach | 141 |
| | 201772 | Rohr | Gerlosbach | 196.8 |
| 5 | 203554 | Uttendorf | Stubache | 127.9 |
| | 203109 | Kaprun | Kaoruner Ache | 88.6 |
| | 203125 | Bruck | Salzach | 1168.7 |
| | 204297 | Salzburg | Salzach | 4425.7 |
| 6 | 213124 | Flattach | Möll | 705.3 |
| | 212399 | Kolbnitz a.d. Tauernautobahn | Möll | 1043.8 |
| | 213199 | Drauhofen | Drau | 3674.4 |
| | 212472 | Pflügelhof | Malta | 131.3 |
| | 212498 | Sandriesen | Malta | 266 |
| | 212530 | Spittal (Fasan) | Lieser | 1035.5 |
| | 213215 | Amlach | Drau | 4789.6 |
| 7 | 203745 | Muhr | Mur | 75.7 |
| | 203752 | St.Michael i. Lg. | Mur | 289.2 |
| | 203794 | Mörtelsdorf | Mur | 366.9 |
| | 203976 | Kendlbruck | Mur | 955 |
| 8 | 207985 | Rosenburg | Kamp | 1150.2 |
| | 207993 | Stiefern | Kamp | 1493.3 |

*Table Appendix 2 Topographic features of the affected and reference catchment/gauge*

| ID | Name | Catchment Topography min. altitude [m] | max. altitude [m] | mean altitude [m] | Gauge altitude [m] | Diff. Gauge altitude [m] | Diff. Mean catchment altitude [m] | Centroid catchment distance (ref/aff) [km] |
|---|---|---|---|---|---|---|---|---|
| 231688 | Beschling | 485,9 | 3301,3 | 1661,6 | 489,2 | -247 | 56 | 16.27 |
| *200105* | *Garsella* | *729,6* | *2701,3* | *1606,1* | *736,5* | | | |
| 201251 | St.Anton am Arlberg-Moos | 1306,6 | 3145,3 | 2257,1 | 1386,9 | 650 | 651 | 25.99 |
| *200105* | *Garsella* | *729,6* | *2701,3* | *1606,1* | *736,5* | | | |
| 202119 | Platz-Loch | 1227,2 | 3526,8 | 2502,7 | 1227,1 | -665 | -309 | 7.94 |
| *230300* | *Gepatschalm* | *1876,7* | *3526,8* | *2811,9* | *1891,9* | | | |
| 201749 | Mayrhofen | 623,6 | 3500,6 | 2133,4 | 629,3 | -257 | -165 | 30.05 |
| *203034* | *Sulzau* | *884,8* | *3656,1* | *2298,1* | *885,8* | | | |
| 201970 | EW-Gmünd | 1192,9 | 3281,9 | 1960,9 | 1193,0 | 307 | -337 | 16.50 |
| *203034* | *Sulzau* | *884,8* | *3656,1* | *2298,1* | *885,8* | | | |
| 203554 | Uttendorf (Summenpegel) | 786,2 | 3425,7 | 1974,3 | 844,2 | -42 | -324 | 25.83 |
| *203034* | *Sulzau* | *884,8* | *3656,1* | *2298,1* | *885,8* | | | |
| 203109 | Kaprun | 766,0 | 3534,2 | 2052,7 | 767,5 | -118 | -245 | 34.86 |
| *203034* | *Sulzau* | *884,8* | *3656,1* | *2298,1* | *885,8* | | | |
| 213124 | Flattach | 688,6 | 3793,4 | 1995,7 | 692,9 | -484 | -45 | 20.95 |
| *212381* | *Mallnitz* | *1175,4* | *3318,7* | *2040,6* | *1176,5* | | | |
| 212472 | Pflüglhof | 848,7 | 3343,0 | 2224,6 | 851,5 | -325 | 184 | 13.55 |
| *212381* | *Mallnitz* | *1175,4* | *3318,7* | *2040,6* | *1176,5* | | | |
| 203745 | Muhr | 1121,0 | 3061,5 | 2048,1 | 1121,2 | 22 | 230 | 21.96 |
| *203778* | *Weißpriach* | *1099,0* | *2610,7* | *1818,1* | *1099,7* | | | |
| 207985 | Rosenburg | 262,8 | 1051,1 | 672,0 | 281,8 | -237 | -76 | 11.51 |
| *207944* | *Zwettl-Bahnbrücke* | *508,0* | *1051,1* | *747,8* | *519,1* | | | |

*Table Appendix 3 Detailed results of the flood peak estimations for all gauges, (*)…Precipitation ratio outside the defined thresholds for transfer; (-) … No precipitation in the affected or reference catchment*

**231688 Beschling [Ill]**

| *year* | *date* | $FPR_{Ratio}$ | $HQ_{obs}$ | $HQ_{est}$ | $P_{Ratio}$ | *Return Period* |
|---|---|---|---|---|---|---|
| 1985 | 06.08.1985 | 53.6 | 165.0 | 355.5 | 0.98 | 2.5 |
| 1986 | 19.05.1986 | 57.4 | 84.9 | 199.5 | 0.53* | 2.8 |
| 1987 | 01.07.1987 | 39.0 | 186.0 | 304.8 | 0.55* | 27.9 |
| 1988 | 20.05.1988 | 54.4 | 105.0 | 230.1 | 0.85 | 1.2 |
| 1989 | 01.08.1989 | 70.2 | 63.0 | 211.7 | 0.83 | 1.1 |
| 1990 | 08.07.1990 | 64.6 | 96.3 | 272.1 | 0.71 | 3.1 |
| 1991 | 17.06.1991 | 47.7 | 160.0 | 305.9 | 0.86 | 2.4 |
| 1992 | 29.11.1992 | 67.8 | 58.9 | 183.2 | 0.61* | 1.4 |
| 1993 | 15.07.1993 | 58.1 | 102.0 | 243.3 | 0.7* | 2.2 |
| 1994 | 25.05.1994 | 55.7 | 85.2 | 192.3 | 0.65* | 1.4 |
| 1995 | 01.06.1995 | 52.3 | 148.0 | 310.4 | 0.87 | 2.3 |
| 1996 | 28.05.1996 | 57.0 | 87.0 | 202.5 | 0.68* | 1.4 |
| 1997 | 06.07.1997 | 44.2 | 155.0 | 277.7 | 0.76 | 2.6 |
| 1998 | 17.09.1998 | 55.7 | 58.4 | 131.8 | 0.57* | 1.1 |
| 1999 | 22.05.1999 | 18.9 | 375.0 | 462.6 | 0.83 | 29.2 |
| 2000 | 06.08.2000 | 30.4 | 226.0 | 324.8 | 0.91 | 2.4 |
| 2001 | 05.09.2001 | 75.3 | 62.7 | 254.2 | 0.66* | 3.3 |
| 2002 | 11.08.2002 | 68.7 | 111.0 | 354.4 | 0.81 | 5.9 |
| 2003 | 09.10.2003 | 59.7 | 134.0 | 332.6 | 0.82 | 4.2 |
| 2004 | 03.06.2004 | 62.6 | 63.0 | 168.7 | 0.77 | 1.0 |
| 2005 | 23.08.2005 | 5.7 | 445.0 | 472.1 | 0.77 | 61.0 |
| 2006 | 29.05.2006 | 49.1 | 143.0 | 280.9 | 0.64* | 5.9 |
| 2007 | 19.01.2007 | 77.4 | 37.3 | 165.1 | 0.73 | 1.0 |
| 2008 | 14.07.2008 | 39.1 | 146.0 | 239.7 | 0.89 | 1.2 |
| 2009 | 18.07.2009 | 59.8 | 90.1 | 223.9 | 0.78 | 1.3 |
| 2010 | 06.08.2010 | 34.2 | 157.0 | 238.7 | 0.78 | 1.5 |
| 2011 | 18.06.2011 | 61.7 | 90.2 | 235.8 | 0.79 | 1.4 |
| 2012 | 10.10.2012 | 29.1 | 153.0 | 215.8 | 0.76 | 1.3 |
| 2013 | 02.06.2013 | 23.9 | 204.0 | 268.0 | 0.81 | 1.8 |
| 2014 | 11.07.2014 | 64.4 | 86.7 | 243.2 | 0.76 | 1.7 |
| 2015 | 03.05.2015 | 61.7 | 84.1 | 219.4 | 0.64* | 2.1 |
| 2016 | 17.06.2016 | 47.0 | 196.0 | 369.8 | 0.94 | 3.5 |
| 2017 | 26.07.2017 | 60.3 | 147.0 | 370.6 | 0.77 | 10.1 |

**200147 Gisingen [Ill]**

| *year* | *date* | $FPR_{Ratio}$ | $HQ_{obs}$ | $HQ_{est}$ | $P_{Ratio}$ | *Return Period* |
|---|---|---|---|---|---|---|
| 1985 | 07.08.1985 | 29.2 | 281.0 | 397.1 | 0.93 | 4.2 |
| 1986 | 22.05.1986 | 23.6 | 220.0 | 288.1 | 0.76 | 2.1 |
| 1987 | 01.07.1987 | 29.9 | 278.0 | 396.8 | 0.55* | 4.0 |
| 1988 | 20.05.1988 | 37.8 | 206.0 | 331.1 | 0.85 | 1.8 |
| 1989 | 01.08.1989 | 49.9 | 149.0 | 297.7 | 0.83 | 1.2 |
| 1990 | 10.07.1990 | 43.5 | 188.0 | 332.8 | 0.81 | 1.5 |
| 1991 | 17.06.1991 | 36.9 | 250.0 | 395.9 | 0.86 | 2.9 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1992 | 16.05.1992 | - | 176.0 | - | - | 1.4 |
| 1993 | 20.07.1993 | 31.1 | 182.0 | 264.2 | 0.73 | 1.5 |
| 1994 | 07.07.1994 | 37.1 | 163.0 | 259.0 | 0.98 | 1.3 |
| 1995 | 01.06.1995 | 42.1 | 223.0 | 385.4 | 0.87 | 2.1 |
| 1996 | 11.07.1996 | 35.2 | 168.0 | 259.2 | 0.71 | 1.3 |
| 1997 | 06.07.1997 | 37.7 | 203.0 | 325.7 | 0.76 | 1.7 |
| 1998 | 12.06.1998 | 38.4 | 124.0 | 201.2 | 0.87 | 1.1 |
| 1999 | 22.05.1999 | 16.3 | 449.0 | 536.6 | 0.83 | 43.4 |
| 2000 | 06.08.2000 | 25.4 | 291.0 | 389.8 | 0.91 | 4.8 |
| 2001 | 19.06.2001 | 12.6 | 228.0 | 261.0 | 0.65* | 2.2 |
| 2002 | 12.08.2002 | -12.6 | 350.0 | 310.8 | 0.76 | 10.6 |
| 2003 | 09.10.2003 | 52.2 | 182.0 | 380.6 | 0.82 | 1.5 |
| 2004 | 11.06.2004 | 34.4 | 175.0 | 266.6 | 1.19 | 1.4 |
| 2005 | 23.08.2005 | 4.7 | 548.0 | 575.1 | 0.77 | 183.3 |
| 2006 | 29.05.2006 | 40.0 | 207.0 | 344.9 | 0.64* | 1.8 |
| 2007 | 10.07.2007 | 10.0 | 164.0 | 182.2 | 0.84 | 1.3 |
| 2008 | 14.07.2008 | 28.6 | 234.0 | 327.7 | 0.89 | 2.4 |
| 2009 | 18.07.2009 | 45.2 | 162.0 | 295.8 | 0.78 | 1.3 |
| 2010 | 06.08.2010 | 26.2 | 230.0 | 311.7 | 0.78 | 2.3 |
| 2011 | 10.10.2011 | 47.7 | 162.0 | 309.9 | 0.88 | 1.3 |
| 2012 | 04.06.2012 | 7.4 | 256.0 | 276.4 | 0.74 | 3.1 |
| 2013 | 02.06.2013 | 16.9 | 314.0 | 378.0 | 0.81 | 6.5 |
| 2014 | 31.07.2014 | 44.8 | 207.0 | 374.8 | 0.89 | 1.8 |
| 2015 | 06.05.2015 | 47.7 | 168.0 | 321.4 | 0.90 | 1.3 |
| 2016 | 17.06.2016 | 36.1 | 308.0 | 481.8 | 0.94 | 6.0 |
| 2017 | 26.07.2017 | 52.5 | 202.0 | 425.6 | 0.77 | 1.7 |

**2473 Diepoldsau(CH) Rhein**

| *year* | *date* | $FPR_{Ratio}$ | $HQ_{obs}$ | $HQ_{est}$ | $P_{Ratio}$ | *Return Period* |
|---|---|---|---|---|---|---|
| 1985 | 26.08.1985 | 7.2 | 1079.2 | 1163.1 | 0.76 | 3.1 |
| 1986 | 22.05.1986 | 13.4 | 896.7 | 1035.1 | 1.06 | 2.0 |
| 1987 | 19.07.1987 | 7.0 | 2027.6 | 2180.5 | 0.91 | 55.5 |
| 1988 | 06.07.1988 | 12.3 | 708.3 | 808.0 | 1.09 | 1.4 |
| 1989 | 12.07.1989 | 9.4 | 493.1 | 544.3 | 0.88 | 1.1 |
| 1990 | 06.06.1990 | 23.3 | 662.4 | 864.0 | 0.86 | 1.3 |
| 1991 | 17.06.1991 | - | 1560.4 | - | - | 12.6 |
| 1992 | 16.05.1992 | 11.8 | 763.2 | 865.3 | 0.84 | 1.5 |
| 1993 | 13.10.1993 | 3.3 | 1159.3 | 1199.2 | 1.16 | 3.8 |
| 1994 | 15.09.1994 | 5.4 | 781.5 | 826.4 | 0.87 | 1.6 |
| 1995 | 01.06.1995 | 12.4 | 838.0 | 956.4 | 0.75 | 1.7 |
| 1996 | 08.07.1996 | 20.1 | 731.1 | 915.5 | 1.04 | 1.4 |
| 1997 | 30.06.1997 | 4.8 | 858.2 | 901.2 | 0.90 | 1.8 |
| 1998 | 08.06.1998 | 9.9 | 612.3 | 679.6 | 0.83 | 1.2 |
| 1999 | 22.05.1999 | 6.6 | 1624.6 | 1739.1 | 0.87 | 15.4 |
| 2000 | 07.08.2000 | -0.8 | 1138.8 | 1129.6 | 1.07 | 3.6 |
| 2001 | 11.06.2001 | 3.6 | 1281.9 | 1329.2 | 0.76 | 5.4 |
| 2002 | 12.08.2002 | 11.1 | 1188.7 | 1337.1 | 1.34* | 4.2 |
| 2003 | 09.05.2003 | 6.8 | 505.3 | 542.3 | 0.82 | 1.1 |
| 2004 | 09.07.2004 | 8.6 | 813.7 | 890.3 | 0.77 | 1.7 |
| 2005 | 23.08.2005 | -2.7 | 1914.1 | 1864.5 | 0.64* | 38.7 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2006 | 29.05.2006 | 25.2 | 660.9 | 883.4 | 0.84 | 1.3 |
| 2007 | 10.07.2007 | 4.0 | 618.5 | 644.1 | 0.89 | 1.2 |
| 2008 | 14.07.2008 | 5.3 | 1104.5 | 1166.9 | 0.78 | 3.3 |
| 2009 | 18.07.2009 | 20.7 | 822.9 | 1037.6 | 1.06 | 1.7 |
| 2010 | 13.06.2010 | 4.3 | 721.6 | 754.4 | 0.82 | 1.4 |
| 2011 | 19.06.2011 | 12.9 | 613.1 | 703.9 | 0.74 | 1.2 |
| 2012 | 04.06.2012 | 3.3 | 1142.3 | 1180.9 | 0.81 | 3.7 |
| 2013 | 02.06.2013 | 13.5 | 970.0 | 1121.2 | 1.08 | 2.3 |
| 2014 | 14.08.2014 | 8.2 | 715.8 | 779.9 | 0.93 | 1.4 |
| 2015 | 20.05.2015 | 18.3 | 697.9 | 854.2 | 0.94 | 1.4 |
| 2016 | 17.06.2016 | 7.2 | 1580.6 | 1703.0 | 0.81 | 13.4 |
| 2017 | 01.09.2017 | 25.3 | 671.0 | 898.0 | 1.13 | 1.3 |

**201251 St. Anton am Arlberg-Moos [Rosanna]**

| *year* | *date* | $FPR_{Ratio}$ | $HQ_{obs}$ | $HQ_{est}$ | $P_{Ratio}$ | *Return Period* |
|---|---|---|---|---|---|---|
| 2006 | 29.05.2006 | 1,4 | 27,5 | 27,9 | 0,55* | 5,9 |
| 2007 | 19.01.2007 | 74,3 | 10,5 | 40,9 | 1,55* | 1,0 |
| 2008 | 14.07.2008 | 20,9 | 17,2 | 21,7 | 0,69* | 1,2 |
| 2009 | 18.07.2009 | 55,0 | 10,2 | 22,7 | 0,67* | 1,3 |
| 2010 | 06.08.2010 | 17,2 | 13,8 | 16,7 | 0,47* | 1,5 |
| 2011 | 18.06.2011 | 26,9 | 11,4 | 15,6 | 0,45* | 1,4 |
| 2012 | 10.10.2012 | 4,1 | 21,6 | 22,5 | 0,68* | 1,3 |
| 2013 | 02.06.2013 | 31,4 | 12,7 | 18,5 | 0,48* | 1,8 |
| 2014 | 11.07.2014 | 42,5 | 13,5 | 23,5 | 0,63* | 1,7 |
| 2015 | 03.05.2015 | 57,8 | 11,4 | 27,0 | 0,67* | 2,1 |
| 2016 | 17.06.2016 | 17,8 | 25,0 | 30,4 | 0,66* | 3,5 |
| 2017 | 26.07.2017 | 59,7 | 17,1 | 42,4 | 0,76 | 9,9 |

**202036 Landeck [Sanna]**

| *year* | *date* | $FPR_{Ratio}$ | $HQ_{obs}$ | $HQ_{est}$ | $P_{Ratio}$ | *Return Period* |
|---|---|---|---|---|---|---|
| 2006 | 19.05.2006 | -5,3 | 133,0 | 126,4 | 1,13 | 4,1 |
| 2007 | 30.08.2007 | -0,3 | 94,5 | 94,3 | 1,14 | 1,9 |
| 2008 | 29.05.2008 | - | 131,0 | - | - | 4,0 |
| 2009 | 24.05.2009 | 38,9 | 92,4 | 151,3 | 4,55* | 1,8 |
| 2010 | 11.06.2010 | -12,8 | 96,2 | 85,3 | 0,43* | 1,9 |
| 2011 | 08.08.2011 | 15,8 | 44,5 | 52,8 | 0,96 | 1,1 |
| 2012 | 04.06.2012 | -8,4 | 116,0 | 107,1 | 0,58* | 2,8 |
| 2013 | 20.06.2013 | -19,2 | 104,0 | 87,2 | 0,19* | 2,2 |
| 2014 | 14.08.2014 | 9,2 | 62,0 | 68,3 | 1,25 | 1,2 |
| 2015 | 08.06.2015 | 9,4 | 131,0 | 144,6 | 2,3* | 4,0 |
| 2016 | 17.06.2016 | 4,9 | 104,0 | 109,4 | 0,66* | 2,2 |
| 2017 | 31.05.2017 | 15,5 | 78,1 | 92,4 | 1,69* | 1,4 |

**201319 Imst (Bahnhof) [Inn]**

| *year* | *date* | $FPR_{Ratio}$ | $HQ_{obs}$ | $HQ_{est}$ | $P_{Ratio}$ | *Return Period* |
|---|---|---|---|---|---|---|
| 2006 | 19.05.2006 | -1.8 | 379.0 | 372.4 | 1.13 | 1.6 |
| 2007 | 10.07.2007 | -1.2 | 285.0 | 281.7 | 0.75 | 1.1 |
| 2008 | 30.05.2008 | 3.8 | 533.0 | 554.1 | 1.99* | 6.0 |
| 2009 | 25.05.2009 | 16.3 | 422.0 | 504.3 | 6.39* | 2.2 |
| 2010 | 11.06.2010 | -2.3 | 482.0 | 471.1 | 0.43* | 3.7 |
| 2011 | 19.06.2011 | 0.6 | 249.0 | 250.5 | 0.51* | 1.0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2012 | 04.06.2012 | -2.0 | 455.0 | 446.1 | 0.58* | | 2.9 |
| 2013 | 18.06.2013 | -4.2 | 436.0 | 418.6 | 0.11* | | 2.5 |
| 2014 | 14.08.2014 | 1.4 | 451.0 | 457.3 | | 1.25 | 2.8 |
| 2015 | 08.06.2015 | 2.4 | 544.0 | 557.6 | 2.3* | | 6.6 |
| 2016 | 17.06.2016 | 0.9 | 591.0 | 596.4 | 0.66* | | 10.7 |
| 2017 | 31.05.2017 | 4.4 | 314.0 | 328.3 | 1.69* | | 1.2 |

**202119 Platz (Loch) [Fagge]**

| *year* | *date* | *$FPR_{Ratio}$* | *$HQ_{obs}$* | *$HQ_{est}$* | *$P_{Ratio}$* | | *Return Period* |
|---|---|---|---|---|---|---|---|
| 1986 | 05.08.1986 | 98.7 | 1.0 | 71.9 | 1.35* | | 1.4 |
| 1987 | 19.07.1987 | 95.6 | 4.5 | 102.6 | | 0.84 | 207.0 |
| 1988 | 03.08.1988 | 98.4 | 1.2 | 77.2 | | 0.89 | 12.7 |
| 1989 | 08.07.1989 | 94.1 | 3.9 | 65.7 | | 0.90 | 4.4 |
| 1990 | 01.07.1990 | 91.6 | 3.3 | 39.5 | | 0.86 | 1.1 |
| 1991 | 14.07.1991 | 96.7 | 1.8 | 55.4 | | 0.88 | 2.3 |
| 1992 | 08.08.1992 | 97.3 | 1.2 | 43.9 | | 0.86 | 1.3 |
| 1993 | 24.08.1993 | 97.7 | 1.3 | 53.3 | | 1.03 | 1.3 |
| 1994 | 10.08.1994 | 97.7 | 0.9 | 38.1 | | 0.76 | 1.3 |
| 1995 | 22.07.1995 | 93.2 | 2.6 | 37.6 | 0.67* | | 1.6 |
| 1996 | 29.07.1996 | 95.9 | 1.4 | 33.1 | | 0.86 | 1.0 |
| 1997 | 08.08.1997 | 95.7 | 2.0 | 45.7 | | 1.06 | 1.1 |
| 1998 | 04.08.1998 | 97.6 | 1.4 | 55.7 | | 0.89 | 2.2 |
| 1999 | 06.07.1999 | 95.6 | 2.4 | 54.7 | | 0.96 | 1.6 |
| 2000 | 25.07.2000 | 95.2 | 1.9 | 40.4 | | 0.81 | 1.2 |
| 2001 | 10.08.2001 | 96.5 | 2.2 | 62.9 | | 0.97 | 2.6 |
| 2002 | 24.06.2002 | 96.9 | 2.1 | 68.2 | | 0.97 | 3.7 |
| 2003 | 29.08.2003 | 98.6 | 0.8 | 61.2 | | 0.99 | 2.1 |
| 2004 | 09.07.2004 | 96.6 | 2.3 | 67.2 | | 0.85 | 7.0 |
| 2005 | 30.07.2005 | 97.6 | 1.1 | 45.9 | | 0.88 | 1.3 |
| 2006 | 28.06.2006 | 96.2 | 2.1 | 56.3 | | 0.84 | 3.0 |
| 2007 | 21.07.2007 | 99.8 | 1.5 | 601.7 | 12.52* | | 1.2 |
| 2008 | 07.07.2008 | 96.7 | 2.0 | 62.0 | | 0.84 | 4.9 |
| 2009 | 17.07.2009 | 97.7 | 1.1 | 49.1 | | 0.80 | 2.1 |
| 2010 | 13.06.2010 | 97.1 | 2.1 | 71.6 | | 1.01 | 3.8 |
| 2011 | 22.08.2011 | 98.0 | 1.0 | 51.7 | | 0.86 | 2.0 |
| 2012 | 03.07.2012 | 96.9 | 1.7 | 54.7 | | 0.78 | 3.6 |
| 2013 | 21.06.2013 | 94.5 | 2.6 | 47.3 | 0.64* | | 4.7 |
| 2014 | 13.08.2014 | 95.7 | 3.1 | 72.8 | | 0.94 | 6.2 |
| 2015 | 08.06.2015 | 92.9 | 3.1 | 44.5 | | 0.86 | 1.3 |
| 2016 | 12.07.2016 | 96.4 | 2.6 | 72.0 | | 0.95 | 5.6 |
| 2017 | 09.08.2017 | 97.3 | 2.0 | 72.3 | | 1.24 | 1.8 |

**2011 94 Prutz [Inn]**

| *year* | *date* | *$FPR_{Ratio}$* | *$HQ_{obs}$* | *$HQ_{est}$* | *$P_{Ratio}$* | | *Return Period* |
|---|---|---|---|---|---|---|---|
| 1986 | 22.05.1986 | 11.9 | 305.0 | 346.2 | 1.52* | | 2.5 |
| 1987 | 19.07.1987 | 15.7 | 551.0 | 653.6 | | 0.84 | 79.5 |
| 1988 | 14.07.1988 | 27.7 | 198.0 | 273.9 | | 0.93 | 1.1 |
| 1989 | 08.07.1989 | 21.2 | 244.0 | 309.7 | | 0.90 | 1.4 |
| 1990 | 02.07.1990 | 11.1 | 231.0 | 259.7 | | 0.83 | 1.3 |
| 1991 | 17.06.1991 | 9.3 | 429.0 | 473.0 | | 0.82 | 13.2 |
| 1992 | 03.06.1992 | 6.1 | 298.0 | 317.2 | | 0.72 | 2.3 |

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|---|---|---|---|---|---|---|
| 1993 | 14.10.1993 | 2.5 | 254.0 | 260.4 | 0.54* | 1.5 |
| 1994 | 15.09.1994 | 4.2 | 250.0 | 261.0 | 0.76 | 1.5 |
| 1995 | 22.06.1995 | 7.9 | 278.0 | 301.9 | 0.99 | 1.9 |
| 1996 | 29.08.1996 | 5.9 | 207.0 | 219.9 | 0.79 | 1.1 |
| 1997 | 30.06.1997 | 6.9 | 350.0 | 375.8 | 0.74 | 4.4 |
| 1998 | 08.06.1998 | 7.9 | 249.0 | 270.3 | 0.75 | 1.5 |
| 1999 | 03.06.1999 | 10.7 | 371.0 | 415.2 | 0.91 | 5.8 |
| 2000 | 25.07.2000 | 12.3 | 288.0 | 328.4 | 0.81 | 2.1 |
| 2001 | 28.06.2001 | 7.4 | 386.0 | 416.8 | 0.84 | 7.2 |
| 2002 | 06.06.2002 | 8.5 | 256.0 | 279.7 | 0.80 | 1.5 |
| 2003 | 05.06.2003 | 16.4 | 239.0 | 285.8 | 1.08 | 1.3 |
| 2004 | 09.07.2004 | 18.9 | 289.0 | 356.2 | 0.85 | 2.1 |
| 2005 | 23.08.2005 | 9.4 | 312.0 | 344.2 | 0.99 | 2.7 |
| 2006 | 19.05.2006 | 8.3 | 204.0 | 222.6 | 0.90 | 1.1 |
| 2007 | 10.07.2007 | 13.7 | 174.0 | 201.5 | 0.98 | 1.0 |
| 2008 | 30.05.2008 | 7.2 | 418.0 | 450.3 | 0.62* | 11.3 |
| 2009 | 25.05.2009 | 7.6 | 300.0 | 324.7 | 0.96 | 2.4 |
| 2010 | 11.06.2010 | 4.0 | 371.0 | 386.6 | 0.3* | 5.8 |
| 2011 | 27.05.2011 | 12.1 | 170.0 | 193.3 | 0.92 | 1.0 |
| 2012 | 22.06.2012 | 17.8 | 284.0 | 345.6 | 0.97 | 2.0 |
| 2013 | 18.06.2013 | - | 304.0 | - | - | 2.5 |
| 2014 | 14.08.2014 | 11.5 | 350.0 | 395.3 | 0.91 | 4.4 |
| 2015 | 08.06.2015 | 10.7 | 371.0 | 415.5 | 0.86 | 5.8 |
| 2016 | 17.06.2016 | 5.8 | 409.0 | 434.0 | 0.91 | 9.9 |
| 2017 | 06.06.2017 | 10.9 | 194.0 | 217.8 | 0.82 | 1.1 |

**201319 Imst (Bahnhof) [Inn]**

| *year* | *date* | *$FPR_{Ratio}$* | *$HQ_{obs}$* | *$HQ_{est}$* | *$P_{Ratio}$* | *Return Period* |
|---|---|---|---|---|---|---|
| 1986 | 22.05.1986 | 8.3 | 422.0 | 460.4 | 1.52* | 2.2 |
| 1987 | 19.07.1987 | 13.0 | 659.0 | 757.1 | 0.84 | 21.6 |
| 1988 | 15.06.1988 | 4.5 | 302.0 | 316.3 | 0.94 | 1.1 |
| 1989 | 12.07.1989 | 13.9 | 343.0 | 398.3 | 1.12 | 1.3 |
| 1990 | 10.07.1990 | 12.6 | 344.0 | 393.6 | 1.17 | 1.3 |
| 1991 | 17.06.1991 | 7.2 | 536.0 | 577.8 | 0.82 | 6.1 |
| 1992 | 03.06.1992 | 3.8 | 423.0 | 439.6 | 0.72 | 2.2 |
| 1993 | 27.05.1993 | 7.3 | 313.0 | 337.8 | 1.08 | 1.2 |
| 1994 | 07.07.1994 | 9.3 | 349.0 | 384.9 | 0.79 | 1.4 |
| 1995 | 22.06.1995 | 4.5 | 429.0 | 449.1 | 0.99 | 2.3 |
| 1996 | 29.08.1996 | 3.5 | 277.0 | 287.1 | 0.79 | 1.1 |
| 1997 | 30.06.1997 | 4.9 | 452.0 | 475.1 | 0.74 | 2.8 |
| 1998 | 08.06.1998 | 5.8 | 323.0 | 342.9 | 0.75 | 1.2 |
| 1999 | 03.06.1999 | 6.2 | 591.0 | 630.2 | 0.91 | 10.7 |
| 2000 | 07.08.2000 | 3.9 | 405.0 | 421.5 | 0.94 | 1.9 |
| 2001 | 11.06.2001 | 2.1 | 498.0 | 508.9 | 0.97 | 4.3 |
| 2002 | 06.06.2002 | 5.4 | 383.0 | 404.7 | 0.80 | 1.7 |
| 2003 | 06.06.2003 | 10.1 | 353.0 | 392.9 | 0.96 | 1.4 |
| 2004 | 12.06.2004 | 7.8 | 392.0 | 425.1 | 0.91 | 1.8 |
| 2005 | 23.08.2005 | 3.2 | 788.0 | 814.0 | 0.99 | 84.5 |
| 2006 | 19.05.2006 | 4.1 | 379.0 | 395.0 | 0.90 | 1.6 |
| 2007 | 10.07.2007 | 8.1 | 285.0 | 310.1 | 0.98 | 1.1 |

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|---|---|---|---|---|---|---|
| 2008 | 30.05.2008 | 5.2 | 533.0 | 562.2 | 0.62* | 6.0 |
| 2009 | 25.05.2009 | 5.1 | 422.0 | 444.9 | 0.96 | 2.2 |
| 2010 | 11.06.2010 | 2.7 | 482.0 | 495.5 | 0.3* | 3.7 |
| 2011 | 19.06.2011 | 8.5 | 249.0 | 272.2 | 0.91 | 1.0 |
| 2012 | 04.06.2012 | 4.6 | 455.0 | 477.1 | 0.90 | 2.9 |
| 2013 | 18.06.2013 | - | 436.0 | - | - | 2.5 |
| 2014 | 14.08.2014 | 8.5 | 451.0 | 493.2 | 0.91 | 2.8 |
| 2015 | 08.06.2015 | 7.1 | 544.0 | 585.4 | 0.86 | 6.6 |
| 2016 | 17.06.2016 | 3.7 | 591.0 | 613.4 | 0.91 | 10.7 |
| 2017 | 31.05.2017 | 8.2 | 314.0 | 341.9 | 1.12 | 1.2 |

**201749 Mayrhofen [Ziller]**

| *year* | *date* | *$FPR_{Ratio}$* | *$HQ_{obs}$* | *$HQ_{est}$* | *$P_{Ratio}$* | *Return Period* |
|---|---|---|---|---|---|---|
| 1976 | 28.07.1976 | 69.5 | 46.4 | 152.1 | 1.15 | 1.2 |
| 1977 | 21.07.1977 | 72.6 | 54.8 | 200.0 | 1.20 | 1.5 |
| 1978 | 08.08.1978 | 41.1 | 69.6 | 118.2 | 0.75 | 1.4 |
| 1979 | 26.06.1979 | 28.3 | 103.0 | 143.6 | 0.81 | 1.6 |
| 1980 | 06.08.1980 | 65.5 | 76.7 | 222.2 | 1.4* | 1.4 |
| 1981 | 18.07.1981 | 9.8 | 123.0 | 136.4 | 0.88 | 1.4 |
| 1982 | 12.06.1982 | 37.2 | 83.1 | 132.4 | 0.92 | 1.3 |
| 1983 | 02.08.1983 | 33.0 | 75.6 | 112.9 | 0.96 | 1.2 |
| 1984 | 12.07.1984 | - | 78.5 | - | - | 1.3 |
| 1985 | 06.08.1985 | 22.7 | 173.0 | 223.9 | 0.96 | 2.5 |
| 1986 | 24.06.1986 | 56.4 | 66.0 | 151.5 | 0.85 | 1.6 |
| 1987 | 25.08.1987 | 74.6 | 199.0 | 785.0 | 1.14 | 339.4 |
| 1988 | 12.07.1988 | 74.4 | 56.2 | 219.5 | 1.09 | 1.9 |
| 1989 | 09.07.1989 | 79.0 | 54.4 | 258.8 | 1.04 | 2.9 |
| 1990 | 10.07.1990 | 51.0 | 106.0 | 216.3 | 0.96 | 2.3 |
| 1991 | 17.06.1991 | 49.4 | 173.0 | 342.1 | 0.91 | 10.5 |
| 1992 | 08.08.1992 | -223.2 | 42.5 | 13.1 | 0.09* | 1.4 |
| 1993 | 23.06.1993 | 67.9 | 49.9 | 155.6 | 0.99 | 1.4 |
| 1994 | 21.06.1994 | 58.3 | 42.7 | 102.5 | 0.64* | 1.4 |
| 1995 | 03.07.1995 | 55.5 | 83.2 | 187.0 | 1.05 | 1.6 |
| 1996 | 08.07.1996 | 56.8 | 76.3 | 176.5 | 1.09 | 1.5 |
| 1997 | 12.06.1997 | 46.6 | 74.4 | 139.4 | 0.76 | 1.7 |
| 1998 | 03.07.1998 | 52.9 | 65.1 | 138.3 | 0.80 | 1.6 |
| 1999 | 03.06.1999 | 51.3 | 76.9 | 157.8 | 0.79 | 1.9 |
| 2000 | 08.07.2000 | 80.3 | 45.8 | 232.8 | 1.24 | 1.7 |
| 2001 | 29.06.2001 | 64.4 | 80.3 | 225.3 | 1.26 | 1.6 |
| 2002 | 12.08.2002 | 52.0 | 93.3 | 194.4 | 0.86 | 2.4 |
| 2003 | 01.08.2003 | 97.1 | 12.5 | 428.1 | 2.09* | 2.0 |
| 2004 | 09.07.2004 | 67.7 | 103.0 | 319.0 | 1.17 | 3.6 |
| 2005 | 11.07.2005 | 74.0 | 143.0 | 550.4 | 1.5* | 9.3 |
| 2006 | 29.06.2006 | 72.5 | 93.5 | 339.9 | 1.4* | 2.7 |
| 2007 | 09.07.2007 | 58.7 | 51.9 | 125.8 | 0.68* | 1.7 |
| 2008 | 08.08.2008 | 66.5 | 89.2 | 266.5 | 1.11 | 2.6 |
| 2009 | 04.09.2009 | 59.5 | 71.4 | 176.2 | 0.65* | 3.5 |
| 2010 | 11.06.2010 | - | 81.9 | - | - | 2.7 |
| 2011 | 23.06.2011 | 64.0 | 57.9 | 160.7 | 0.68* | 2.6 |
| 2012 | 22.06.2012 | 56.1 | 94.5 | 215.4 | 1.02 | 2.1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2013 | 19.06.2013 | - | 89.6 | - | - | 1.9 |
| 2014 | 31.07.2014 | 72.5 | 129.0 | 469.2 | 0.74 | 186.2 |
| 2015 | 07.06.2015 | 84.3 | 34.2 | 218.5 | 1.08 | 1.9 |
| 2016 | 12.07.2016 | 47.1 | 109.0 | 206.0 | 0.82 | 2.9 |
| 2017 | 19.08.2017 | 73.9 | 56.7 | 217.7 | 0.82 | 3.3 |

**201780 Hart im Zillertal [Ziller]**

| *year* | *date* | $FPR_{Ratio}$ | $HQ_{obs}$ | $HQ_{est}$ | $P_{ratio}$ (Mayrhofen) | $P_{ratio}$ (Gerlosbach) | *Return Period* |
|---|---|---|---|---|---|---|---|
| 1976 | 14.09.1976 | 8.5 | 115.0 | 125.7 | 1.01 | 0.57* | 1.3 |
| 1977 | 01.08.1977 | 31.1 | 215.0 | 311.9 | 0.98 | 1.14 | 8.1 |
| 1978 | 05.07.1978 | 21.8 | 179.0 | 228.9 | 1.22 | 1.04 | 3.7 |
| 1979 | 21.05.1979 | 49.2 | 168.0 | 330.5 | 2.13* | 1.54* | 2.9 |
| 1980 | 09.07.1980 | -6.2 | 190.0 | 178.9 | 0.74 | 0.78 | 4.6 |
| 1981 | 18.07.1981 | 13.0 | 198.0 | 227.5 | 0.88 | 0.93 | 5.5 |
| 1982 | 24.05.1982 | -12.4 | 155.0 | 137.9 | 0.99 | 0.86 | 2.3 |
| 1983 | 03.08.1983 | 27.8 | 128.0 | 177.3 | 1.00 | 1.11 | 1.5 |
| 1984 | 15.06.1984 | 33.8 | 118.0 | 178.3 | 1.55* | 1.55* | 1.3 |
| 1985 | 06.08.1985 | 20.7 | 303.0 | 382.0 | 0.96 | 1.04 | 65.6 |
| 1986 | 22.05.1986 | -9.4 | 123.0 | 112.4 | 0.45* | 0.52* | 1.4 |
| 1987 | 25.08.1987 | 69.7 | 318.0 | 1049.9 | 1.14 | 1.01 | 94.4 |
| 1988 | 14.07.1988 | 42.0 | 110.0 | 189.8 | 0.83 | 0.91 | 1.2 |
| 1989 | 03.07.1989 | 32.2 | 136.0 | 200.5 | 1.00 | 0.93 | 1.7 |
| 1990 | 10.07.1990 | 50.5 | 153.0 | 309.2 | 0.96 | 1.09 | 2.2 |
| 1991 | 17.06.1991 | 49.3 | 220.0 | 434.0 | 0.91 | 0.81 | 9.1 |
| 1992 | 03.06.1992 | 44.0 | 130.0 | 232.3 | 1.30 | 0.55* | 1.5 |
| 1993 | 20.07.1993 | 49.3 | 112.0 | 220.8 | 0.96 | 0.92 | 1.2 |
| 1994 | 05.07.1994 | 82.9 | 102.0 | 596.7 | 4.9* | 1.31* | 1.1 |
| 1995 | 14.07.1995 | 16.9 | 137.0 | 164.9 | 0.75 | 0.93 | 1.7 |
| 1996 | 08.07.1996 | 54.3 | 107.0 | 234.2 | 1.09 | 0.97 | 1.2 |
| 1997 | 28.06.1997 | 38.2 | 161.0 | 260.5 | 1.27 | 0.62* | 2.6 |
| 1998 | 08.06.1998 | 42.3 | 123.0 | 213.2 | 1.22 | 1.14 | 1.4 |
| 1999 | 03.06.1999 | 39.3 | 150.0 | 246.9 | 0.79 | 0.77 | 2.1 |
| 2000 | 11.05.2000 | 4.7 | 141.0 | 147.9 | 0.88 | 0.58* | 1.8 |
| 2001 | 11.06.2001 | 12.2 | 162.0 | 184.6 | 0.81 | 0.81 | 2.6 |
| 2002 | 12.08.2002 | 46.8 | 154.0 | 289.2 | 0.86 | 1.06 | 2.2 |
| 2003 | 18.06.2003 | 68.8 | 106.0 | 339.5 | 1.8* | 1.23 | 1.2 |
| 2004 | 12.06.2004 | 46.1 | 157.0 | 291.1 | 0.87 | 0.96 | 2.4 |
| 2005 | 11.07.2005 | 62.4 | 294.0 | 782.8 | 1.5* | 1.59* | 52.7 |
| 2006 | 29.06.2006 | 69.2 | 131.0 | 424.7 | 1.4* | 0.99 | 1.6 |
| 2007 | 18.09.2007 | 26.6 | 113.0 | 154.0 | 0.73 | 0.83 | 1.3 |
| 2008 | 16.08.2008 | 49.7 | 156.0 | 310.3 | 1.4* | 1.27 | 2.3 |
| 2009 | 04.08.2009 | 60.6 | 124.0 | 314.4 | 0.83 | 1.02 | 1.4 |
| 2010 | 06.08.2010 | 44.4 | 123.0 | 221.1 | 1.4* | 1.20 | 1.4 |
| 2011 | 08.08.2011 | 54.8 | 108.0 | 238.9 | 0.82 | 0.90 | 1.2 |
| 2012 | 22.06.2012 | 51.0 | 147.0 | 299.8 | 1.02 | 1.00 | 2.0 |
| 2013 | 20.06.2013 | 63.0 | 127.0 | 342.9 | 1.47* | 0.55* | 1.5 |
| 2014 | 31.07.2014 | 67.1 | 227.0 | 690.3 | 0.74 | 1.11 | 10.6 |
| 2015 | 10.06.2015 | 50.7 | 125.0 | 253.6 | 1.38* | 0.92 | 1.4 |
| 2016 | 05.08.2016 | 46.5 | 174.0 | 325.0 | 1.17 | 1.10 | 3.3 |

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|---|---|---|---|---|---|---|---|
| 2017 | 06.08.2017 | 67.0 | 129.0 | 391.2 | 1.41* | 1.07 | 1.5 |

**201806 Brixlegg [Inn]**

| *year* | *date* | $FPR_{Ratio}$ | $HQ_{obs}$ | $HQ_{est}$ | $P_{ratio}$ *(Mayrhofen)* | $P_{ratio}$ *(Gerlosbach)* | *Return Period* |
|---|---|---|---|---|---|---|---|
| 1976 | 30.09.1976 | 6.5 | 565.0 | 604.4 | 1.59* | 1.01 | 1.0 |
| 1977 | 15.06.1977 | 5.2 | 921.0 | 971.5 | 0.84 | 1.31* | 2.4 |
| 1978 | 10.06.1978 | 5.1 | 929.0 | 978.5 | 0.78 | 0.98 | 2.5 |
| 1979 | 31.05.1979 | 59.2 | 965.0 | 2365.6 | 11.73* | 0.59* | 2.9 |
| 1980 | 15.06.1980 | 12.1 | 989.0 | 1124.7 | 1.14 | 1.43* | 3.2 |
| 1981 | 19.07.1981 | 3.3 | 986.0 | 1019.2 | 0.89 | 1.00 | 3.2 |
| 1982 | 12.06.1982 | 6.7 | 888.0 | 951.5 | 0.92 | 0.90 | 2.1 |
| 1983 | 10.06.1983 | 3.5 | 859.0 | 890.5 | 1.06 | 0.97 | 1.8 |
| 1984 | 22.06.1984 | 2.2 | 782.0 | 799.9 | 0.90 | 0.88 | 1.4 |
| 1985 | 07.08.1985 | -0.8 | 1345.0 | 1334.3 | 0.97 | 1.03 | 22.2 |
| 1986 | 22.05.1986 | -1.2 | 875.0 | 864.3 | 0.45* | 0.51* | 2.0 |
| 1987 | 19.07.1987 | 11.3 | 1525.0 | 1719.8 | 1.22 | 0.94 | 62.5 |
| 1988 | 15.07.1988 | -5.2 | 698.0 | 663.3 | 0.63* | 0.76 | 1.2 |
| 1989 | 12.07.1989 | 14.3 | 848.0 | 989.3 | 1.35* | 1.41* | 1.8 |
| 1990 | 10.07.1990 | 14.7 | 903.0 | 1059.1 | 0.96 | 1.09 | 2.2 |
| 1991 | 18.06.1991 | 5.1 | 1160.0 | 1222.1 | 0.90 | 0.83 | 7.9 |
| 1992 | 03.06.1992 | 10.4 | 881.0 | 983.3 | 1.30 | 0.55* | 2.0 |
| 1993 | 20.07.1993 | 13.9 | 675.0 | 783.8 | 0.96 | 0.92 | 1.1 |
| 1994 | 07.07.1994 | 11.9 | 690.0 | 782.8 | 0.71 | 1.03 | 1.1 |
| 1995 | 04.07.1995 | 6.8 | 955.0 | 1024.9 | 0.89 | 0.71 | 2.8 |
| 1996 | 07.06.1996 | 65.2 | 563.0 | 1616.3 | 7.97* | 8.91* | 1.0 |
| 1997 | 30.06.1997 | 12.9 | 921.0 | 1057.5 | 1.09 | 0.98 | 2.4 |
| 1998 | 08.06.1998 | 10.8 | 743.0 | 833.3 | 1.22 | 1.14 | 1.3 |
| 1999 | 03.06.1999 | 6.9 | 1310.0 | 1406.9 | 0.79 | 0.77 | 18.2 |
| 2000 | 07.08.2000 | 15.0 | 895.0 | 1052.6 | 1.19 | 1.00 | 2.1 |
| 2001 | 11.06.2001 | 2.2 | 1008.0 | 1030.6 | 0.81 | 0.81 | 3.6 |
| 2002 | 21.06.2002 | 31.4 | 772.0 | 1125.2 | 2.3* | 1.16 | 1.4 |
| 2003 | 06.06.2003 | 11.6 | 709.0 | 802.0 | 0.74 | 1.6* | 1.2 |
| 2004 | 09.07.2004 | 22.6 | 901.0 | 1164.3 | 1.17 | 0.95 | 2.2 |
| 2005 | 23.08.2005 | 8.8 | 1494.0 | 1638.5 | 1.12 | 1.10 | 52.3 |
| 2006 | 19.05.2006 | 5.2 | 749.0 | 790.3 | 0.59* | 0.69* | 1.3 |
| 2007 | 10.07.2007 | 6.7 | 647.0 | 693.4 | 0.68* | 0.80 | 1.1 |
| 2008 | 30.05.2008 | -3.8 | 1079.0 | 1039.5 | 0.25* | 0.25* | 5.1 |
| 2009 | 25.05.2009 | 1.7 | 864.0 | 878.6 | 0.63* | 0.70 | 1.9 |
| 2010 | 14.06.2010 | 9.0 | 928.0 | 1019.7 | 0.78 | 0.46* | 2.4 |
| 2011 | 19.06.2011 | 12.6 | 565.0 | 646.6 | 0.81 | 0.81 | 1.0 |
| 2012 | 04.06.2012 | 11.1 | 967.0 | 1088.1 | 1.14 | 1.19 | 2.9 |
| 2013 | 20.06.2013 | 18.1 | 1003.0 | 1224.9 | 1.51* | 0.55* | 3.5 |
| 2014 | 14.08.2014 | 9.3 | 1092.0 | 1203.5 | 0.88 | 0.84 | 5.5 |
| 2015 | 09.06.2015 | 15.0 | 982.0 | 1154.7 | 1.48* | 0.83 | 3.1 |
| 2016 | 17.06.2016 | 14.5 | 1049.0 | 1226.5 | 1.14 | 0.92 | 4.4 |
| 2017 | 11.08.2017 | 21.5 | 844.0 | 1074.6 | 1.81* | 1.21 | 1.7 |

**201889 Kirchbichl - Bichlwang [Inn]**

| *year* | *date* | $FPR_{Ratio}$ | $HQ_{obs}$ | $HQ_{est}$ | $P_{ratio}$ *(Mayrhofen)* | $P_{ratio}$ *(Gerlosbach)* | *Return Period* |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1976 | 30.09.1976 | 6.5 | 564.0 | 603.4 | 1.59* | 1.01 | 1.0 |
| 1977 | 01.08.1977 | 8.1 | 1104.0 | 1201.0 | 0.98 | 1.14 | 3.3 |
| 1978 | 11.06.1978 | 4.3 | 1029.0 | 1074.9 | 0.70 | 0.89 | 2.5 |
| 1979 | 14.06.1979 | 4.9 | 1018.0 | 1070.2 | 0.83 | 0.71 | 2.4 |
| 1980 | 15.06.1980 | 11.9 | 1004.0 | 1139.7 | 1.14 | 1.43* | 2.2 |
| 1981 | 19.07.1981 | 2.6 | 1229.0 | 1262.2 | 0.89 | 1.00 | 5.7 |
| 1982 | 27.06.1982 | 5.0 | 1012.0 | 1064.9 | 0.93 | 0.96 | 2.3 |
| 1983 | 14.06.1983 | 4.3 | 946.0 | 988.9 | 1.07 | 1.34* | 1.8 |
| 1984 | 22.06.1984 | 2.1 | 821.0 | 838.9 | 0.90 | 0.88 | 1.3 |
| 1985 | 07.08.1985 | -0.7 | 1648.0 | 1637.3 | 0.97 | 1.03 | 41.6 |
| 1986 | 22.05.1986 | -1.2 | 919.0 | 908.3 | 0.45* | 0.51* | 1.7 |
| 1987 | 19.07.1987 | 11.4 | 1519.0 | 1713.8 | 1.22 | 0.94 | 22.2 |
| 1988 | 15.07.1988 | -4.9 | 749.0 | 714.3 | 0.63* | 0.76 | 1.1 |
| 1989 | 12.07.1989 | 13.7 | 890.0 | 1031.3 | 1.35* | 1.41* | 1.5 |
| 1990 | 10.07.1990 | 12.6 | 1079.0 | 1235.1 | 0.96 | 1.09 | 3.0 |
| 1991 | 18.06.1991 | 4.4 | 1343.0 | 1405.1 | 0.90 | 0.83 | 9.6 |
| 1992 | 03.06.1992 | 10.0 | 922.0 | 1024.3 | 1.30 | 0.55* | 1.7 |
| 1993 | 20.07.1993 | 11.4 | 843.0 | 951.8 | 0.96 | 0.92 | 1.4 |
| 1994 | 07.07.1994 | 11.3 | 728.0 | 820.8 | 0.71 | 1.03 | 1.1 |
| 1995 | 04.07.1995 | 6.5 | 1010.0 | 1079.9 | 0.89 | 0.71 | 2.3 |
| 1996 | 09.07.1996 | 8.3 | 734.0 | 800.1 | 0.96 | 1.06 | 1.1 |
| 1997 | 30.06.1997 | 12.7 | 938.0 | 1074.5 | 1.09 | 0.98 | 1.8 |
| 1998 | 08.06.1998 | 10.2 | 796.0 | 886.3 | 1.22 | 1.14 | 1.2 |
| 1999 | 03.06.1999 | 6.3 | 1441.0 | 1537.9 | 0.79 | 0.77 | 15.2 |
| 2000 | 07.08.2000 | 13.9 | 976.0 | 1133.6 | 1.19 | 1.00 | 2.0 |
| 2001 | 11.06.2001 | 1.9 | 1166.0 | 1188.6 | 0.81 | 0.81 | 4.3 |
| 2002 | 12.08.2002 | 12.6 | 940.0 | 1075.2 | 0.86 | 1.06 | 1.8 |
| 2003 | 06.06.2003 | 11.2 | 739.0 | 832.0 | 0.74 | 1.6* | 1.1 |
| 2004 | 12.06.2004 | 12.1 | 973.0 | 1107.0 | 0.87 | 0.96 | 2.0 |
| 2005 | 23.08.2005 | 7.3 | 1827.0 | 1971.5 | 1.12 | 1.10 | 100.2 |
| 2006 | 19.05.2006 | 4.8 | 821.0 | 862.3 | 0.59* | 0.69* | 1.3 |
| 2007 | 10.07.2007 | 5.8 | 752.0 | 798.4 | 0.68* | 0.80 | 1.1 |
| 2008 | 30.05.2008 | -3.6 | 1148.0 | 1108.5 | 0.25* | 0.25* | 4.0 |
| 2009 | 27.05.2009 | 5.6 | 882.0 | 934.6 | 0.78 | 0.71 | 1.5 |
| 2010 | 14.06.2010 | 8.3 | 1007.0 | 1098.7 | 0.78 | 0.46* | 2.3 |
| 2011 | 08.08.2011 | 17.2 | 629.0 | 759.9 | 0.82 | 0.90 | 1.0 |
| 2012 | 04.06.2012 | 10.1 | 1081.0 | 1202.1 | 1.14 | 1.19 | 3.0 |
| 2013 | 02.06.2013 | 3.1 | 1038.0 | 1070.8 | 0.77 | 1.08 | 2.5 |
| 2014 | 14.08.2014 | 8.0 | 1276.0 | 1387.5 | 0.88 | 0.84 | 7.0 |
| 2015 | 09.06.2015 | 14.2 | 1040.0 | 1212.7 | 1.48* | 0.83 | 2.6 |
| 2016 | 17.06.2016 | 13.8 | 1112.0 | 1289.5 | 1.14 | 0.92 | 3.4 |
| 2017 | 11.08.2017 | 19.9 | 930.0 | 1160.6 | 1.81* | 1.21 | 1.7 |

**201970 EW Gmünd [Gerlosbach]**

| *year* | *date* | *$FPR_{Ratio}$* | *$HQ_{obs}$* | *$HQ_{est}$* | *$P_{Ratio}$* | *Return Period* |
|---|---|---|---|---|---|---|
| 1976 | 28.07.1976 | 70.0 | 10.0 | 33.1 | 1.08 | 1.2 |
| 1977 | 21.07.1977 | 59.8 | 12.3 | 30.6 | 0.80 | 1.5 |
| 1978 | 08.08.1978 | 71.8 | 8.4 | 29.8 | 0.82 | 1.4 |
| 1979 | 26.06.1979 | 74.5 | 16.9 | 66.2 | 1.62* | 1.6 |
| 1980 | 06.08.1980 | 81.4 | 11.5 | 61.7 | 1.68* | 1.4 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1981 | 18.07.1981 | 48.7 | 17.0 | 33.1 | 0.93 | 1.4 |
| 1982 | 12.06.1982 | 47.2 | 15.9 | 30.1 | 0.90 | 1.3 |
| 1983 | 02.08.1983 | 67.8 | 9.4 | 29.2 | 1.08 | 1.2 |
| 1984 | 12.07.1984 | - | 9.6 | - | - | 1.3 |
| 1985 | 06.08.1985 | 50.5 | 27.5 | 55.6 | 1.04 | 2.5 |
| 1986 | 24.06.1986 | 79.1 | 9.6 | 46.0 | 1.11 | 1.6 |
| 1987 | 25.08.1987 | 90.6 | 15.1 | 161.0 | 1.01 | 339.4 |
| 1988 | 12.07.1988 | 77.4 | 9.9 | 43.9 | 0.95 | 1.9 |
| 1989 | 09.07.1989 | 80.3 | 8.0 | 40.8 | 0.71 | 2.9 |
| 1990 | 10.07.1990 | 81.2 | 10.6 | 56.3 | 1.09 | 2.3 |
| 1991 | 17.06.1991 | 63.5 | 25.8 | 70.6 | 0.81 | 10.5 |
| 1992 | 08.08.1992 | 11.9 | 13.3 | 15.1 | 0.44* | 1.4 |
| 1993 | 23.06.1993 | 77.1 | 8.2 | 36.0 | 1.00 | 1.4 |
| 1994 | 21.06.1994 | 68.4 | 10.5 | 33.2 | 0.90 | 1.4 |
| 1995 | 03.07.1995 | 62.3 | 13.1 | 34.8 | 0.85 | 1.6 |
| 1996 | 08.07.1996 | 74.5 | 9.2 | 36.2 | 0.97 | 1.5 |
| 1997 | 12.06.1997 | 78.7 | 9.0 | 42.1 | 1.00 | 1.7 |
| 1998 | 03.07.1998 | 68.6 | 9.7 | 31.0 | 0.78 | 1.6 |
| 1999 | 03.06.1999 | 45.0 | 19.6 | 35.6 | 0.77 | 1.9 |
| 2000 | 08.07.2000 | 84.6 | 9.0 | 58.3 | 1.34* | 1.7 |
| 2001 | 29.06.2001 | 76.2 | 10.1 | 42.4 | 1.03 | 1.6 |
| 2002 | 12.08.2002 | 61.7 | 21.2 | 55.4 | 1.06 | 2.4 |
| 2003 | 01.08.2003 | 93.2 | 6.4 | 93.7 | 1.99* | 2.0 |
| 2004 | 09.07.2004 | 79.2 | 12.4 | 59.7 | 0.95 | 3.6 |
| 2005 | 11.07.2005 | 60.4 | 53.3 | 134.4 | 1.59* | 9.3 |
| 2006 | 29.06.2006 | 85.2 | 8.2 | 55.4 | 0.99 | 2.7 |
| 2007 | 09.07.2007 | 68.6 | 10.5 | 33.5 | 0.79 | 1.7 |
| 2008 | 08.08.2008 | 75.7 | 14.6 | 60.2 | 1.09 | 2.6 |
| 2009 | 04.09.2009 | 77.0 | 10.9 | 47.4 | 0.76 | 3.5 |
| 2010 | 11.06.2010 | - | 9.5 | - | - | 2.7 |
| 2011 | 23.06.2011 | 82.7 | 7.7 | 44.4 | 0.81 | 2.6 |
| 2012 | 22.06.2012 | 65.8 | 16.6 | 48.5 | 1.00 | 2.1 |
| 2013 | 19.06.2013 | - | 10.4 | - | - | 1.9 |
| 2014 | 31.07.2014 | 75.5 | 40.1 | 163.3 | 1.11 | 186.2 |
| 2015 | 07.06.2015 | 61.0 | 9.7 | 24.7 | 0.53* | 1.9 |
| 2016 | 12.07.2016 | 81.1 | 8.3 | 44.2 | 0.77 | 2.9 |
| 2017 | 19.08.2017 | 72.4 | 14.4 | 52.1 | 0.85 | 3.3 |

**201772 Rohr [Gerlosbach]**

| *year* | *date* | *$FPR_{Ratio}$* | *$HQ_{obs}$* | *$HQ_{est}$* | *$P_{Ratio}$* | *Return Period* |
|---|---|---|---|---|---|---|
| 1976 | 28.07.1976 | 65.5 | 12.2 | 35.4 | 1.08 | 1.5 |
| 1977 | 21.07.1977 | 53.4 | 16.0 | 34.3 | 0.80 | 9.9 |
| 1978 | 08.08.1978 | 60.8 | 13.8 | 35.2 | 0.82 | 1.8 |
| 1979 | 26.06.1979 | 64.5 | 27.1 | 76.4 | 1.62* | 3.3 |
| 1980 | 06.08.1980 | 75.9 | 15.9 | 66.1 | 1.68* | 4.1 |
| 1981 | 18.07.1981 | 45.9 | 19.0 | 35.1 | 0.93 | 5.6 |
| 1982 | 12.06.1982 | 44.4 | 17.8 | 32.0 | 0.90 | 1.7 |
| 1983 | 02.08.1983 | 65.4 | 10.5 | 30.3 | 1.08 | 1.8 |
| 1984 | 12.07.1984 | - | 12.9 | - | - | 1.4 |
| 1985 | 06.08.1985 | 46.0 | 33.0 | 61.1 | 1.04 | 7.1 |

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|---|---|---|---|---|---|---|
| 1986 | 24.06.1986 | 72.8 | 13.6 | 50.0 | 1.11 | 1.2 |
| 1987 | 25.08.1987 | 86.0 | 23.8 | 169.7 | 1.01 | 2.3 |
| 1988 | 12.07.1988 | 70.2 | 14.4 | 48.4 | 0.95 | 1.1 |
| 1989 | 09.07.1989 | 67.9 | 15.5 | 48.3 | 0.71 | 1.5 |
| 1990 | 10.07.1990 | 70.6 | 19.0 | 64.7 | 1.09 | 1.3 |
| 1991 | 17.06.1991 | 61.2 | 28.4 | 73.2 | 0.81 | 3.6 |
| 1992 | 08.08.1992 | 13.7 | 11.4 | 13.2 | 0.44* | 1.3 |
| 1993 | 23.06.1993 | 67.4 | 13.4 | 41.2 | 1.00 | 1.3 |
| 1994 | 21.06.1994 | 61.4 | 14.3 | 37.0 | 0.90 | 1.1 |
| 1995 | 03.07.1995 | 58.0 | 15.7 | 37.4 | 0.85 | 2.0 |
| 1996 | 08.07.1996 | 68.5 | 12.4 | 39.3 | 0.97 | 1.3 |
| 1997 | 12.06.1997 | 77.0 | 9.9 | 43.0 | 1.00 | 1.5 |
| 1998 | 03.07.1998 | 65.7 | 11.1 | 32.3 | 0.78 | 1.1 |
| 1999 | 03.06.1999 | 44.6 | 19.9 | 35.9 | 0.77 | 2.9 |
| 2000 | 08.07.2000 | 75.2 | 16.3 | 65.6 | 1.34* | 1.6 |
| 2001 | 29.06.2001 | 66.6 | 16.2 | 48.5 | 1.03 | 1.4 |
| 2002 | 12.08.2002 | 60.9 | 21.9 | 56.1 | 1.06 | 8.3 |
| 2003 | 01.08.2003 | 93.9 | 5.7 | 93.1 | 1.99* | 1.1 |
| 2004 | 09.07.2004 | 74.1 | 16.5 | 63.8 | 0.95 | 1.6 |
| 2005 | 11.07.2005 | 58.4 | 57.8 | 138.9 | 1.59* | 404.1 |
| 2006 | 29.06.2006 | 73.6 | 16.9 | 64.1 | 0.99 | 1.5 |
| 2007 | 09.07.2007 | 65.7 | 12.0 | 35.0 | 0.79 | 1.5 |
| 2008 | 08.08.2008 | 71.1 | 18.5 | 64.1 | 1.09 | 4.3 |
| 2009 | 04.09.2009 | 77.2 | 10.8 | 47.3 | 0.76 | 1.8 |
| 2010 | 11.06.2010 | - | 15.8 | 6.3 | - | 2.8 |
| 2011 | 23.06.2011 | 77.8 | 10.5 | 47.3 | 0.81 | 1.8 |
| 2012 | 22.06.2012 | 55.7 | 25.4 | 57.3 | 1.00 | 2.4 |
| 2013 | 19.06.2013 | - | 14.7 | - | - | 2.0 |
| 2014 | 31.07.2014 | 73.9 | 43.5 | 166.7 | 1.11 | 38.1 |
| 2015 | 07.06.2015 | 49.3 | 15.5 | 30.6 | 0.53* | 3.9 |
| 2016 | 12.07.2016 | 76.8 | 10.8 | 46.6 | 0.77 | 6.4 |
| 2017 | 19.08.2017 | 69.2 | 16.8 | 54.5 | 0.85 | 2.3 |

**203554 Uttendorf [Stubache]**

| *year* | *date* | $FPR_{Ratio}$ | $HQ_{obs}$ | $HQ_{est}$ | $P_{Ratio}$ | *Return Period* |
|---|---|---|---|---|---|---|
| 1977 | 21.07.1977 | 56.1 | 15.3 | 34.9 | 1.00 | 1.5 |
| 1978 | 08.08.1978 | 71.1 | 9.9 | 34.1 | 1.04 | 1.4 |
| 1979 | 26.06.1979 | 50.3 | 18.2 | 36.6 | 0.99 | 1.6 |
| 1980 | 06.08.1980 | 80.9 | 6.0 | 31.6 | 0.95 | 1.4 |
| 1981 | 18.07.1981 | 41.3 | 14.0 | 23.8 | 0.74 | 1.4 |
| 1982 | 12.06.1982 | 50.5 | 15.5 | 31.3 | 1.03 | 1.3 |
| 1983 | 02.08.1983 | 57.3 | 8.5 | 19.9 | 0.81 | 1.2 |
| 1984 | 12.07.1984 | - | 11.5 | - | - | 1.3 |
| 1985 | 06.08.1985 | 52.3 | 18.0 | 37.8 | 0.78 | 2.4 |
| 1986 | 24.06.1986 | 76.5 | 12.8 | 54.6 | 1.46* | 1.6 |
| 1987 | 25.08.1987 | 70.5 | 26.9 | 91.3 | 0.63* | 324.3 |
| 1988 | 12.07.1988 | 75.8 | 12.0 | 49.6 | 1.18 | 1.9 |
| 1989 | 09.07.1989 | 72.6 | 12.9 | 47.1 | 0.90 | 2.8 |
| 1990 | 10.07.1990 | 66.6 | 22.7 | 68.0 | 1.44* | 2.3 |
| 1991 | 17.06.1991 | 69.8 | 21.3 | 70.6 | 0.89 | 10.2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1992 | 08.08.1992 | 14.6 | 8.1 | 9.4 | 0.3* | 1.3 |
| 1993 | 23.06.1993 | 55.5 | 14.0 | 31.5 | 0.96 | 1.4 |
| 1994 | 21.06.1994 | 61.9 | 11.4 | 29.9 | 0.89 | 1.4 |
| 1995 | 03.07.1995 | 64.6 | 16.0 | 45.2 | 1.21 | 1.6 |
| 1996 | 08.07.1996 | 77.0 | 11.6 | 50.4 | 1.49* | 1.4 |
| 1997 | 12.06.1997 | 69.0 | 14.1 | 45.5 | 1.19 | 1.7 |
| 1998 | 03.07.1998 | 73.1 | 10.0 | 37.1 | 1.03 | 1.5 |
| 1999 | 03.06.1999 | 86.0 | 4.3 | 31.0 | 0.74 | 1.9 |
| 2000 | 08.07.2000 | 87.1 | 4.8 | 37.4 | 0.95 | 1.7 |
| 2001 | 29.06.2001 | 61.7 | 18.3 | 47.8 | 1.28 | 1.6 |
| 2002 | 12.08.2002 | 59.9 | 26.5 | 66.1 | 1.39* | 2.3 |
| 2003 | 01.08.2003 | 82.3 | 10.8 | 61.0 | 1.43* | 1.9 |
| 2004 | 09.07.2004 | 76.2 | 14.9 | 62.6 | 1.09 | 3.5 |
| 2005 | 11.07.2005 | 68.6 | 32.7 | 104.2 | 1.36* | 9.0 |
| 2006 | 29.06.2006 | 72.3 | 18.8 | 67.8 | 1.34* | 2.6 |
| 2007 | 09.07.2007 | 66.3 | 14.9 | 44.2 | 1.15 | 1.7 |
| 2008 | 08.08.2008 | 63.9 | 16.9 | 46.8 | 0.94 | 2.6 |
| 2009 | 04.09.2009 | 72.8 | 18.1 | 66.5 | 1.17 | 3.4 |
| 2010 | 11.06.2010 | 98.6 | 15.4 | 1135.4 | 22.46* | 2.6 |
| 2011 | 23.06.2011 | 71.8 | 18.5 | 65.6 | 1.32* | 2.5 |
| 2012 | 22.06.2012 | 80.0 | 12.7 | 63.5 | 1.44* | 2.0 |
| 2013 | 19.06.2013 | - | 17.8 | - | - | 1.9 |
| 2014 | 31.07.2014 | 73.9 | 31.8 | 121.8 | 0.92 | 178.4 |
| 2015 | 07.06.2015 | 65.1 | 16.2 | 46.4 | 1.10 | 1.9 |
| 2016 | 12.07.2016 | 61.8 | 16.2 | 42.4 | 0.81 | 2.8 |
| 2017 | 19.08.2017 | 82.1 | 9.2 | 51.6 | 0.93 | 3.2 |

**203109 Kaprun [Kapruner Ache]**

| *year* | *date* | *$FPR_{Ratio}$* | *$HQ_{obs}$* | *$HQ_{est}$* | *$P_{Ratio}$* | *Return Period* |
|---|---|---|---|---|---|---|
| 1977 | 21.07.1977 | 78.4 | 6.0 | 27.7 | 1.15 | 1.5 |
| 1978 | 08.08.1978 | 83.8 | 4.2 | 26.2 | 1.15 | 1.4 |
| 1979 | 26.06.1979 | 68.9 | 9.0 | 29.0 | 1.13 | 1.6 |
| 1980 | 06.08.1980 | 89.4 | 3.4 | 32.1 | 1.39* | 1.4 |
| 1981 | 18.07.1981 | 83.1 | 3.4 | 20.4 | 0.91 | 1.4 |
| 1982 | 12.06.1982 | 76.9 | 4.7 | 20.1 | 0.96 | 1.3 |
| 1983 | 02.08.1983 | -2.4 | 17.3 | 16.9 | 0.99 | 1.2 |
| 1984 | 12.07.1984 | - | 3.1 | - | - | 1.3 |
| 1985 | 06.08.1985 | 59.3 | 14.2 | 34.9 | 1.04 | 2.4 |
| 1986 | 24.06.1986 | 77.6 | 4.8 | 21.6 | 0.83 | 1.6 |
| 1987 | 25.08.1987 | 58.4 | 32.7 | 78.7 | 0.79 | 324.3 |
| 1988 | 12.07.1988 | 88.5 | 3.3 | 28.7 | 0.99 | 1.9 |
| 1989 | 09.07.1989 | 84.3 | 4.1 | 26.1 | 0.72 | 2.8 |
| 1990 | 10.07.1990 | 80.7 | 7.5 | 38.7 | 1.19 | 2.3 |
| 1991 | 17.06.1991 | 78.5 | 9.2 | 42.6 | 0.78 | 10.2 |
| 1992 | 08.08.1992 | -11.9 | 9.9 | 8.9 | 0.41* | 1.3 |
| 1993 | 23.06.1993 | 54.0 | 10.3 | 22.4 | 0.99 | 1.4 |
| 1994 | 21.06.1994 | 82.2 | 3.6 | 20.2 | 0.87 | 1.4 |
| 1995 | 03.07.1995 | 78.8 | 4.5 | 21.2 | 0.82 | 1.6 |
| 1996 | 08.07.1996 | 49.0 | 10.5 | 20.6 | 0.88 | 1.4 |
| 1997 | 12.06.1997 | 61.3 | 11.6 | 30.0 | 1.13 | 1.7 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1998 | 03.07.1998 | 80.8 | 4.6 | 23.8 | 0.95 | 1.5 |
| 1999 | 03.06.1999 | 81.2 | 5.3 | 28.1 | 0.97 | 1.9 |
| 2000 | 08.07.2000 | 82.5 | 5.5 | 31.4 | 1.15 | 1.7 |
| 2001 | 29.06.2001 | 66.2 | 12.9 | 38.2 | 1.47* | 1.6 |
| 2002 | 12.08.2002 | 78.1 | 8.0 | 36.7 | 1.12 | 2.3 |
| 2003 | 01.08.2003 | 61.4 | 14.8 | 38.4 | 1.29 | 1.9 |
| 2004 | 09.07.2004 | 87.7 | 4.1 | 33.0 | 0.83 | 3.5 |
| 2005 | 11.07.2005 | 78.5 | 10.7 | 49.7 | 0.93 | 9.0 |
| 2006 | 29.06.2006 | 38.2 | 23.4 | 37.9 | 1.08 | 2.6 |
| 2007 | 09.07.2007 | 69.4 | 8.4 | 27.3 | 1.02 | 1.7 |
| 2008 | 08.08.2008 | 83.1 | 5.5 | 32.5 | 0.94 | 2.6 |
| 2009 | 04.09.2009 | 48.8 | 18.6 | 36.3 | 0.92 | 3.4 |
| 2010 | 11.06.2010 | -4.9 | 10.2 | 9.7 | 0.28* | 2.6 |
| 2011 | 23.06.2011 | 72.7 | 9.2 | 33.6 | 0.97 | 2.5 |
| 2012 | 22.06.2012 | 76.7 | 9.1 | 38.9 | 1.28 | 2.0 |
| 2013 | 19.06.2013 | 58.3 | 18.3 | 43.9 | 1.52* | 1.9 |
| 2014 | 31.07.2014 | 90.4 | 10.5 | 109.9 | 1.19 | 178.4 |
| 2015 | 07.06.2015 | 85.3 | 6.7 | 45.5 | 1.55* | 1.9 |
| 2016 | 12.07.2016 | 53.0 | 16.4 | 34.9 | 0.96 | 2.8 |
| 2017 | 19.08.2017 | 57.0 | 17.4 | 40.5 | 1.06 | 3.2 |

**203125 Bruck [Salzach]**

| *year* | *date* | $FPR_{Ratio}$ | $HQ_{obs}$ | $HQ_{est}$ | $P_{ratio}$ *(Uttendorf)* | $P_{ratio}$ *(Kaprun)* | *Return Period* |
|---|---|---|---|---|---|---|---|
| 1977 | 01.08.1977 | 12.7 | 242.0 | 277.4 | 1.08 | 1.01 | 6.6 |
| 1978 | 19.07.1978 | 8.1 | 164.0 | 178.5 | 1.08 | 1.20 | 1.5 |
| 1979 | 10.07.1979 | 16.2 | 183.0 | 218.4 | 1.36* | 1.04 | 2.0 |
| 1980 | 15.06.1980 | 14.7 | 190.0 | 222.9 | 1.01 | 1.17 | 2.3 |
| 1981 | 19.07.1981 | 4.0 | 227.0 | 236.3 | 0.81 | 0.94 | 4.8 |
| 1982 | 27.06.1982 | 16.3 | 166.0 | 198.3 | 1.07 | 1.06 | 1.5 |
| 1983 | 14.06.1983 | 10.8 | 141.0 | 158.1 | 1.42* | 1.23 | 1.2 |
| 1984 | 21.05.1984 | 6.1 | 118.0 | 125.7 | 1.38* | 0.86 | 1.0 |
| 1985 | 07.08.1985 | 2.8 | 271.0 | 278.9 | 0.81 | 1.02 | 12.9 |
| 1986 | 24.05.1986 | 10.4 | 153.0 | 170.8 | 0.62* | 1.08 | 1.3 |
| 1987 | 25.08.1987 | 31.9 | 236.0 | 346.4 | 0.63* | 0.79 | 5.8 |
| 1988 | 30.08.1988 | 9.7 | 155.0 | 171.6 | 1.23 | 0.99 | 1.3 |
| 1989 | 03.07.1989 | 12.1 | 168.0 | 191.1 | 1.01 | 1.16 | 1.6 |
| 1990 | 10.07.1990 | 23.7 | 247.0 | 323.5 | 1.44* | 1.19 | 7.4 |
| 1991 | 18.06.1991 | 10.1 | 246.0 | 273.7 | 1.02 | 0.83 | 7.2 |
| 1992 | 03.06.1992 | 27.2 | 131.0 | 180.0 | 1.72* | 1.12 | 1.1 |
| 1993 | 20.07.1993 | 14.6 | 167.0 | 195.4 | 1.21 | 0.98 | 1.6 |
| 1994 | 21.06.1994 | 21.1 | 131.0 | 166.1 | 0.89 | 0.87 | 1.1 |
| 1995 | 26.06.1995 | 15.3 | 212.0 | 250.3 | 1.42* | 1.14 | 3.5 |
| 1996 | 08.07.1996 | 28.8 | 121.0 | 169.9 | 1.49* | 0.88 | 1.0 |
| 1997 | 19.07.1997 | 19.9 | 137.0 | 171.1 | 0.94 | 1.14 | 1.1 |
| 1998 | 14.07.1998 | 11.0 | 143.0 | 160.7 | 0.95 | 0.84 | 1.2 |
| 1999 | 03.06.1999 | 20.2 | 196.0 | 245.5 | 0.74 | 0.97 | 2.5 |
| 2000 | 08.07.2000 | 27.4 | 155.0 | 213.4 | 0.95 | 1.15 | 1.3 |
| 2001 | 11.06.2001 | 4.9 | 174.0 | 182.9 | 0.75 | 0.96 | 1.7 |
| 2002 | 12.08.2002 | 20.5 | 265.0 | 333.3 | 1.39* | 1.12 | 11.2 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2003 | 15.06.2003 | 24.3 | 133.0 | 175.6 | 0.90 | 1.09 | 1.1 |
| 2004 | 12.06.2004 | 24.0 | 197.0 | 259.1 | 1.01 | 1.12 | 2.6 |
| 2005 | 12.07.2005 | 15.7 | 356.0 | 422.4 | 1.34* | 0.95 | 98.4 |
| 2006 | 29.06.2006 | 25.4 | 186.0 | 249.5 | 1.34* | 1.08 | 2.1 |
| 2007 | 10.07.2007 | 9.1 | 175.0 | 192.5 | 1.11 | 1.04 | 1.8 |
| 2008 | 07.06.2008 | 17.0 | 164.0 | 197.5 | 1.4* | 0.97 | 1.5 |
| 2009 | 18.07.2009 | 18.6 | 211.0 | 259.1 | 1.29 | 0.98 | 3.4 |
| 2010 | 14.06.2010 | 21.0 | 186.0 | 235.5 | 1.09 | 1.04 | 2.1 |
| 2011 | 09.08.2011 | 8.7 | 176.0 | 192.8 | 1.11 | 1.11 | 1.8 |
| 2012 | 31.08.2012 | 0.9 | 200.0 | 201.8 | 0.89 | 0.86 | 2.7 |
| 2013 | 02.06.2013 | -3.2 | 260.0 | 252.1 | 0.90 | 1.20 | 10.0 |
| 2014 | 31.07.2014 | 37.3 | 318.0 | 507.4 | 0.92 | 1.19 | 39.3 |
| 2015 | 07.06.2015 | 27.7 | 180.0 | 249.0 | 1.10 | 1.55* | 1.9 |
| 2016 | 13.07.2016 | 15.6 | 206.0 | 244.0 | 0.93 | 0.98 | 3.1 |
| 2017 | 20.08.2017 | 14.4 | 158.0 | 184.5 | 0.95 | 1.08 | 1.4 |

**204297 Salzburg [Salzach]**

| *year* | *date* | *$FPR_{Ratio}$* | *$HQ_{obs}$* | *$HQ_{est}$* | *$P_{ratio}$ (Uttendorf)* | *$P_{ratio}$ (Kaprun)* | *Return Period* |
|---|---|---|---|---|---|---|---|
| 1977 | 01.08.1977 | 2.5 | 1384.0 | 1419.4 | 1.08 | 1.01 | 19.2 |
| 1978 | 09.09.1978 | 2.0 | 681.0 | 695.1 | 1.43* | 1.13 | 1.7 |
| 1979 | 10.07.1979 | 4.6 | 737.0 | 772.4 | 1.36* | 1.04 | 2.0 |
| 1980 | 15.06.1980 | 5.4 | 577.0 | 609.9 | 1.01 | 1.17 | 1.4 |
| 1981 | 21.07.1981 | 0.4 | 983.0 | 986.6 | 1.14 | 1.02 | 4.3 |
| 1982 | 24.05.1982 | 1.2 | 596.0 | 603.0 | 1.07 | 1.02 | 1.4 |
| 1983 | 14.06.1983 | 2.7 | 608.0 | 625.1 | 1.42* | 1.23 | 1.5 |
| 1984 | 07.08.1984 | 5.0 | 471.0 | 495.6 | 0.99 | 1.20 | 1.2 |
| 1985 | 07.08.1985 | 0.6 | 1292.0 | 1299.9 | 0.81 | 1.02 | 13.5 |
| 1986 | 29.05.1986 | 6.2 | 433.0 | 461.6 | 1.29 | 0.97 | 1.1 |
| 1987 | 09.07.1987 | 4.9 | 611.0 | 642.4 | 0.73 | 0.80 | 1.5 |
| 1988 | 30.08.1988 | 3.2 | 510.0 | 526.6 | 1.23 | 0.99 | 1.2 |
| 1989 | 03.07.1989 | 3.3 | 675.0 | 698.1 | 1.01 | 1.16 | 1.7 |
| 1990 | 10.07.1990 | 8.1 | 872.0 | 948.5 | 1.44* | 1.19 | 3.0 |
| 1991 | 03.08.1991 | 4.1 | 1043.0 | 1087.2 | 1.13 | 1.03 | 5.4 |
| 1992 | 23.11.1992 | -0.4 | 766.0 | 762.9 | 0.90 | 1.16 | 2.2 |
| 1993 | 20.07.1993 | 4.6 | 586.0 | 614.4 | 1.21 | 0.98 | 1.4 |
| 1994 | 19.05.1994 | 3.2 | 427.0 | 441.0 | 1.27 | 1.09 | 1.1 |
| 1995 | 26.06.1995 | 3.4 | 1096.0 | 1134.3 | 1.42* | 1.14 | 6.5 |
| 1996 | 22.10.1996 | 0.5 | 601.0 | 604.0 | 1.02 | 1.09 | 1.4 |
| 1997 | 19.07.1997 | 3.7 | 899.0 | 933.1 | 0.94 | 1.14 | 3.3 |
| 1998 | 06.09.1998 | 2.4 | 475.0 | 486.9 | 1.09 | 1.11 | 1.2 |
| 1999 | 23.07.1999 | 0.9 | 618.0 | 623.7 | 0.76 | 1.04 | 1.5 |
| 2000 | 10.03.2000 | -1.2 | 511.0 | 504.8 | 1.01 | 1.18 | 1.2 |
| 2001 | 19.06.2001 | -0.9 | 687.0 | 680.6 | 1.12 | 1.02 | 1.8 |
| 2002 | 12.08.2002 | 4.1 | 1588.0 | 1656.3 | 1.39* | 1.12 | 42.3 |
| 2003 | 12.09.2003 | -2.8 | 494.0 | 480.6 | 1.23 | 1.19 | 1.2 |
| 2004 | 12.06.2004 | 9.1 | 618.0 | 680.1 | 1.01 | 1.12 | 1.5 |
| 2005 | 12.07.2005 | 5.6 | 1123.0 | 1189.4 | 1.34* | 0.95 | 7.2 |
| 2006 | 07.08.2006 | 3.7 | 874.0 | 907.7 | 0.87 | 1.35* | 3.0 |
| 2007 | 07.09.2007 | 0.0 | 791.0 | 791.1 | 1.22 | 1.05 | 2.3 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2008 | 16.08.2008 | 5.7 | 616.0 | 653.4 | 1.29 | 0.92 | 1.5 |
| 2009 | 04.08.2009 | 7.5 | 732.0 | 791.0 | 0.94 | 1.08 | 2.0 |
| 2010 | 03.06.2010 | 0.4 | 1088.0 | 1092.2 | 1.03 | 1.27 | 6.3 |
| 2011 | 14.01.2011 | -1.2 | 634.0 | 626.7 | 0.84 | 1.09 | 1.5 |
| 2012 | 21.07.2012 | 4.6 | 692.0 | 725.6 | 1.10 | 1.02 | 1.8 |
| 2013 | 02.06.2013 | -0.4 | 1899.0 | 1891.1 | 0.90 | 1.20 | 143.7 |
| 2014 | 31.07.2014 | 14.3 | 1136.0 | 1325.4 | 0.92 | 1.19 | 7.5 |
| 2015 | 23.05.2015 | -1.9 | 495.0 | 485.9 | 0.79 | 1.54* | 1.2 |
| 2016 | 10.08.2016 | 2.7 | 785.0 | 806.6 | 1.15 | 1.02 | 2.3 |
| 2017 | 03.09.2017 | 0.6 | 679.0 | 683.3 | 1.18 | 0.94 | 1.7 |

**213124 Flattach [Möll]**

| *year* | *date* | *$FPR_{Ratio}$* | *$HQ_{obs}$* | *$HQ_{est}$* | *$P_{Ratio}$* | | *Return Period* |
|---|---|---|---|---|---|---|---|
| 1977 | 14.06.1977 | 47.7 | 62.4 | 112.4 | | 0.81 | 1.9 |
| 1978 | 22.05.1978 | 74.2 | 53.4 | 195.0 | | 1.10 | 5.8 |
| 1979 | 14.06.1979 | 59.1 | 61.7 | 142.2 | | 1.11 | 1.5 |
| 1980 | 10.07.1980 | 37.4 | 62.3 | 93.7 | 0.63* | | 2.5 |
| 1981 | 19.07.1981 | 43.1 | 140.0 | 231.6 | | 0.91 | 81.2 |
| 1982 | 12.06.1982 | 63.4 | 36.0 | 92.7 | | 0.97 | 1.0 |
| 1983 | 24.05.1983 | 40.3 | 53.6 | 84.6 | | 0.95 | 1.0 |
| 1984 | 22.06.1984 | 43.7 | 50.4 | 84.3 | | 0.79 | 1.1 |
| 1985 | 07.06.1985 | 52.3 | 54.0 | 106.6 | | 0.79 | 1.8 |
| 1986 | 22.05.1986 | 85.3 | 76.3 | 489.0 | 2.57* | | 8.8 |
| 1987 | 16.06.1987 | 44.1 | 65.3 | 110.1 | 0.64* | | 5.0 |
| 1988 | 13.10.1988 | 59.1 | 41.2 | 95.0 | | 0.98 | 1.0 |
| 1989 | 05.07.1989 | 43.1 | 81.8 | 135.4 | | 0.98 | 1.9 |
| 1990 | 10.07.1990 | 67.5 | 48.3 | 139.8 | | 0.88 | 3.3 |
| 1991 | 18.06.1991 | 38.3 | 122.0 | 186.2 | | 0.89 | 16.9 |
| 1992 | 03.06.1992 | 47.9 | 55.8 | 100.8 | | 0.92 | 1.1 |
| 1993 | 20.07.1993 | 51.9 | 69.2 | 135.5 | | 1.03 | 1.6 |
| 1994 | 14.09.1994 | 23.4 | 90.3 | 111.1 | | 0.89 | 1.4 |
| 1995 | 26.06.1995 | 56.8 | 35.5 | 77.4 | 0.6* | | 1.6 |
| 1996 | 08.07.1996 | 61.6 | 45.3 | 111.2 | | 1.01 | 1.2 |
| 1997 | 23.06.1997 | 53.2 | 64.4 | 129.6 | | 0.85 | 2.7 |
| 1998 | 11.06.1998 | 75.8 | 69.2 | 269.2 | | 1.15 | 40.0 |
| 1999 | 01.06.1999 | 19.9 | 49.4 | 58.1 | 0.53* | | 1.1 |
| 2000 | 13.10.2000 | 32.6 | 101.0 | 141.2 | | 0.80 | 5.7 |
| 2001 | 30.05.2001 | 13.9 | 71.4 | 78.1 | 0.47* | | 4.2 |
| 2002 | 12.08.2002 | 58.1 | 43.4 | 97.7 | 0.62* | | 3.1 |
| 2003 | 15.06.2003 | 53.6 | 26.2 | 53.2 | 0.57* | | 1.0 |
| 2004 | 02.11.2004 | 36.0 | 43.5 | 64.1 | 0.66* | | 1.7 |
| 2005 | 13.07.2005 | 0.8 | 44.7 | 42.5 | 0.41* | | 2.5 |
| 2006 | 21.06.2006 | 49.5 | 49.1 | 91.7 | | 0.79 | 2.2 |
| 2007 | 11.07.2007 | 43.6 | 51.5 | 86.0 | | 0.96 | 1.9 |
| 2008 | 30.05.2008 | - | 67.1 | - | | - | 2.7 |
| 2009 | 19.07.2009 | 62.2 | 54.2 | 135.2 | | 1.20 | 6.3 |
| 2010 | 15.06.2010 | 45.5 | 53.6 | 92.6 | | 1.07 | 1.3 |
| 2011 | 20.09.2011 | 18.2 | 40.9 | 47.1 | | 0.88 | 1.3 |
| 2012 | 22.07.2012 | 49.6 | 47.1 | 88.0 | | 1.14 | 1.7 |
| 2013 | 20.06.2013 | 81.0 | 65.4 | 324.2 | 2.25* | | 2.2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2014 | 07.11.2014 | 28.9 | 77.0 | 102.0 | 1.06 | 4.8 |
| 2015 | 08.06.2015 | 26.4 | 54.2 | 69.4 | 0.74 | 1.6 |
| 2016 | 18.06.2016 | 49.2 | 50.3 | 93.4 | 0.77 | 10.3 |
| 2017 | 12.08.2017 | 44.0 | 39.5 | 66.4 | 0.79 | 2.8 |

**212399 Kolbnitz a.d. Tauernautobahn VHP [Möll]**

| *year* | *date* | *$FPR_{Ratio}$* | *$HQ_{obs}$* | *$HQ_{est}$* | *$P_{Ratio}$* | *Return Period* |
|---|---|---|---|---|---|---|
| 1977 | 14.06.1977 | 36.7 | 98.3 | 155.2 | 0.81 | 1.6 |
| 1978 | 11.06.1978 | 56.5 | 104.0 | 239.1 | 1.18 | 1.9 |
| 1979 | 14.06.1979 | 47.5 | 98.7 | 187.9 | 1.11 | 1.7 |
| 1980 | 09.07.1980 | 21.7 | 111.0 | 141.8 | 0.69* | 2.2 |
| 1981 | 27.05.1981 | 18.0 | 182.0 | 221.9 | 1.04 | 21.5 |
| 1982 | 13.06.1982 | 36.3 | 63.0 | 98.9 | 0.92 | 1.0 |
| 1983 | 24.05.1983 | 32.2 | 76.3 | 112.5 | 0.95 | 1.1 |
| 1984 | 21.05.1984 | 32.5 | 90.2 | 133.7 | 1.20 | 1.4 |
| 1985 | 08.06.1985 | 43.1 | 92.5 | 162.5 | 0.87 | 1.5 |
| 1986 | 22.05.1986 | 77.8 | 126.0 | 568.7 | 2.57* | 3.4 |
| 1987 | 20.07.1987 | 35.6 | 117.0 | 181.5 | 0.86 | 2.6 |
| 1988 | 13.10.1988 | 46.4 | 69.0 | 128.6 | 0.98 | 1.1 |
| 1989 | 05.07.1989 | 31.0 | 138.0 | 199.9 | 0.98 | 4.9 |
| 1990 | 11.07.1990 | 55.8 | 72.9 | 165.0 | 0.88 | 1.1 |
| 1991 | 18.06.1991 | 27.4 | 200.0 | 275.6 | 0.89 | 40.5 |
| 1992 | 06.10.1992 | 34.3 | 92.2 | 140.3 | 1.08 | 1.4 |
| 1993 | 09.10.1993 | 12.1 | 123.0 | 140.0 | 0.78 | 3.1 |
| 1994 | 15.09.1994 | 13.4 | 133.0 | 153.6 | 0.89 | 4.2 |
| 1995 | 04.07.1995 | 42.5 | 79.7 | 138.6 | 0.95 | 1.2 |
| 1996 | 16.10.1996 | 50.3 | 111.0 | 223.3 | 1.64* | 2.2 |
| 1997 | 28.06.1997 | 49.4 | 104.0 | 205.5 | 1.15 | 1.9 |
| 1998 | 07.10.1998 | 41.5 | 171.0 | 292.5 | 1.29 | 14.7 |
| 1999 | 21.09.1999 | 32.2 | 96.9 | 142.9 | 0.96 | 1.6 |
| 2000 | 13.10.2000 | 22.4 | 169.0 | 217.8 | 0.80 | 13.7 |
| 2001 | 11.06.2001 | 21.6 | 118.0 | 150.6 | 0.85 | 2.7 |
| 2002 | 26.11.2002 | 4.1 | 160.0 | 166.9 | 0.83 | 10.1 |
| 2003 | 07.06.2003 | 65.0 | 53.3 | 152.5 | 1.57* | 1.0 |
| 2004 | 12.06.2004 | 33.4 | 109.0 | 163.7 | 1.12 | 2.1 |
| 2005 | 05.10.2005 | 22.3 | 164.0 | 211.0 | 1.17 | 11.6 |
| 2006 | 20.05.2006 | 33.7 | 75.2 | 113.4 | 0.79 | 1.1 |
| 2007 | 10.07.2007 | 45.0 | 92.3 | 167.7 | 0.96 | 1.5 |
| 2008 | 30.10.2008 | 20.9 | 94.2 | 119.0 | 0.79 | 1.5 |
| 2009 | 20.06.2009 | 44.6 | 143.0 | 258.2 | 1.08 | 5.7 |
| 2010 | 06.05.2010 | 22.1 | 91.1 | 117.0 | 0.79 | 1.4 |
| 2011 | 19.09.2011 | 32.0 | 99.5 | 146.3 | 0.88 | 1.7 |
| 2012 | 12.11.2012 | 9.5 | 110.0 | 121.6 | 0.89 | 2.2 |
| 2013 | 19.06.2013 | 72.9 | 104.0 | 383.2 | 2.25* | 1.9 |
| 2014 | 06.11.2014 | 32.5 | 177.0 | 262.1 | 1.06 | 18.1 |
| 2015 | 07.06.2015 | 40.9 | 78.4 | 132.6 | 0.74 | 1.2 |
| 2016 | 17.06.2016 | 29.6 | 159.0 | 225.8 | 0.77 | 9.8 |
| 2017 | 11.08.2017 | 50.0 | 80.3 | 160.7 | 0.79 | 1.2 |

**213199 Drauhofen [Drau]**

| *year* | *date* | *$FPR_{Ratio}$* | *$HQ_{obs}$* | *$HQ_{est}$* | *$P_{Ratio}$* | *Return Period* |
|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1977 | 14.06.1977 | 11.2 | 449.0 | 505.9 | | 0.81 | 2.5 |
| 1978 | 11.06.1978 | 23.4 | 441.0 | 576.1 | | 1.18 | 2.4 |
| 1979 | 01.06.1979 | 11.4 | 507.0 | 571.9 | | 1.04 | 4.4 |
| 1980 | 18.10.1980 | 12.0 | 529.0 | 600.9 | 1.47* | | 5.5 |
| 1981 | 19.07.1981 | 12.3 | 757.0 | 862.8 | | 0.91 | 68.6 |
| 1982 | 13.06.1982 | 10.9 | 294.0 | 329.9 | | 0.92 | 1.1 |
| 1983 | 24.05.1983 | 8.2 | 405.0 | 441.2 | | 0.95 | 1.8 |
| 1984 | 21.05.1984 | 10.7 | 363.0 | 406.5 | | 1.20 | 1.4 |
| 1985 | 07.08.1985 | 9.7 | 468.0 | 518.2 | | 0.77 | 3.0 |
| 1986 | 22.05.1986 | 44.8 | 546.0 | 988.7 | 2.57* | | 6.6 |
| 1987 | 20.07.1987 | 10.6 | 544.0 | 608.5 | | 0.86 | 6.5 |
| 1988 | 15.07.1988 | 13.5 | 318.0 | 367.4 | | 0.98 | 1.1 |
| 1989 | 05.07.1989 | 10.8 | 513.0 | 574.9 | | 0.98 | 4.7 |
| 1990 | 10.07.1990 | 20.6 | 385.0 | 485.1 | | 0.88 | 1.5 |
| 1991 | 18.06.1991 | 8.8 | 786.0 | 861.6 | | 0.89 | 95.4 |
| 1992 | 06.10.1992 | 10.5 | 412.0 | 460.1 | | 1.08 | 1.9 |
| 1993 | 09.10.1993 | 3.4 | 481.0 | 498.0 | | 0.78 | 3.4 |
| 1994 | 15.09.1994 | 4.7 | 413.0 | 433.6 | | 0.89 | 1.9 |
| 1995 | 04.07.1995 | 14.3 | 353.0 | 411.9 | | 0.95 | 1.3 |
| 1996 | 16.10.1996 | 21.0 | 423.0 | 535.3 | 1.64* | | 2.0 |
| 1997 | 28.06.1997 | 18.9 | 435.0 | 536.5 | | 1.15 | 2.3 |
| 1998 | 08.10.1998 | 18.9 | 595.0 | 733.9 | | 1.29 | 11.2 |
| 1999 | 21.09.1999 | 11.7 | 348.0 | 394.0 | | 0.96 | 1.3 |
| 2000 | 13.10.2000 | 8.3 | 537.0 | 585.8 | | 0.80 | 6.0 |
| 2001 | 31.05.2001 | 2.9 | 444.0 | 457.4 | 0.5* | | 2.4 |
| 2002 | 26.11.2002 | 1.4 | 501.0 | 507.9 | | 0.83 | 4.2 |
| 2003 | 12.06.2003 | 42.2 | 253.0 | 437.4 | 2.4* | | 1.0 |
| 2004 | 09.07.2004 | 14.7 | 408.0 | 478.1 | | 1.21 | 1.8 |
| 2005 | 05.10.2005 | 8.7 | 493.0 | 540.0 | | 1.17 | 3.8 |
| 2006 | 20.05.2006 | 10.3 | 332.0 | 370.2 | | 0.79 | 1.2 |
| 2007 | 10.07.2007 | 17.3 | 360.0 | 435.4 | | 0.96 | 1.3 |
| 2008 | 30.10.2008 | 7.6 | 300.0 | 324.8 | | 0.79 | 1.1 |
| 2009 | 20.06.2009 | 19.9 | 465.0 | 580.2 | | 1.08 | 2.9 |
| 2010 | 14.06.2010 | 15.7 | 401.0 | 475.5 | | 1.07 | 1.7 |
| 2011 | 19.09.2011 | 10.9 | 381.0 | 427.8 | | 0.88 | 1.5 |
| 2012 | 12.11.2012 | 2.8 | 398.0 | 409.6 | | 0.89 | 1.7 |
| 2013 | 20.06.2013 | 44.1 | 391.0 | 699.1 | 2.44* | | 1.6 |
| 2014 | 06.11.2014 | 14.0 | 523.0 | 608.1 | | 1.06 | 5.2 |
| 2015 | 07.06.2015 | 15.0 | 307.0 | 361.2 | | 0.74 | 1.1 |
| 2016 | 17.06.2016 | 12.9 | 450.0 | 516.8 | | 0.77 | 2.6 |
| 2017 | 25.07.2017 | 21.2 | 274.0 | 347.9 | | 1.19 | 1.0 |

**212472 Pflügelhof [Malta]**

| *year* | *date* | *$FPR_{Ratio}$* | *$HQ_{obs}$* | *$HQ_{est}$* | *$P_{Ratio}$* | | *Return Period* |
|---|---|---|---|---|---|---|---|
| 1977 | 14.06.1977 | 14.0 | 15.6 | 18.1 | 0.66* | | 1.9 |
| 1978 | 22.05.1978 | 24.2 | 24.8 | 32.7 | | 0.93 | 5.8 |
| 1979 | 14.06.1979 | 88.9 | 2.7 | 24.8 | | 0.97 | 1.5 |
| 1980 | 10.07.1980 | 47.1 | 17.0 | 32.2 | | 1.09 | 2.5 |
| 1981 | 19.07.1981 | 40.9 | 29.6 | 50.0 | | 0.99 | 81.2 |
| 1982 | 12.06.1982 | 76.5 | 3.7 | 15.6 | | 0.82 | 1.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1983 | 24.05.1983 | 51.6 | 8.9 | 18.4 | 1.05 | 1.0 |
| 1984 | 22.06.1984 | 83.1 | 2.4 | 14.1 | 0.67* | 1.1 |
| 1985 | 07.06.1985 | 83.5 | 4.0 | 24.4 | 0.91 | 1.8 |
| 1986 | 22.05.1986 | 90.1 | 5.6 | 56.2 | 1.5* | 8.8 |
| 1987 | 16.06.1987 | 80.9 | 6.5 | 34.1 | 1.00 | 5.0 |
| 1988 | 13.10.1988 | 54.1 | 7.4 | 16.1 | 0.83 | 1.0 |
| 1989 | 05.07.1989 | 65.1 | 9.8 | 28.1 | 1.03 | 1.9 |
| 1990 | 10.07.1990 | 72.7 | 9.3 | 34.0 | 1.08 | 3.3 |
| 1991 | 18.06.1991 | 58.1 | 15.9 | 37.9 | 0.92 | 16.9 |
| 1992 | 03.06.1992 | 90.1 | 2.2 | 22.3 | 1.03 | 1.1 |
| 1993 | 20.07.1993 | 32.1 | 18.6 | 27.4 | 1.05 | 1.6 |
| 1994 | 14.09.1994 | -16.2 | 23.8 | 20.5 | 0.83 | 1.4 |
| 1995 | 26.06.1995 | 77.0 | 6.4 | 27.9 | 1.09 | 1.6 |
| 1996 | 08.07.1996 | 10.0 | 18.3 | 20.3 | 0.93 | 1.2 |
| 1997 | 23.06.1997 | 74.7 | 8.4 | 33.2 | 1.10 | 2.7 |
| 1998 | 11.06.1998 | 84.2 | 8.5 | 53.8 | 1.16 | 40.0 |
| 1999 | 01.06.1999 | 88.5 | 2.0 | 17.7 | 0.82 | 1.1 |
| 2000 | 13.10.2000 | 56.4 | 14.6 | 33.5 | 0.96 | 5.7 |
| 2001 | 30.05.2001 | 98.6 | 5.2 | 369.2 | 11.21* | 4.2 |
| 2002 | 12.08.2002 | 17.3 | 29.7 | 35.9 | 1.15 | 3.1 |
| 2003 | 15.06.2003 | 88.5 | 2.0 | 17.2 | 0.93 | 1.0 |
| 2004 | 02.11.2004 | 71.9 | 5.2 | 18.5 | 0.96 | 1.7 |
| 2005 | 13.07.2005 | 83.4 | 2.9 | 17.6 | 0.87 | 2.5 |
| 2006 | 21.06.2006 | 89.3 | 2.9 | 27.1 | 1.18 | 2.2 |
| 2007 | 11.07.2007 | 82.0 | 3.4 | 18.7 | 1.05 | 1.9 |
| 2008 | 30.05.2008 | - | 3.1 | - | - | 2.7 |
| 2009 | 19.07.2009 | 84.0 | 4.2 | 26.4 | 1.19 | 6.3 |
| 2010 | 15.06.2010 | 90.5 | 1.7 | 17.7 | 1.03 | 1.3 |
| 2011 | 20.09.2011 | 67.5 | 3.7 | 11.4 | 1.07 | 1.3 |
| 2012 | 22.07.2012 | 77.3 | 3.6 | 16.0 | 1.05 | 1.7 |
| 2013 | 20.06.2013 | 94.8 | 1.7 | 33.0 | 1.16 | 2.2 |
| 2014 | 07.11.2014 | 54.5 | 7.5 | 16.5 | 0.87 | 4.8 |
| 2015 | 08.06.2015 | 82.7 | 2.4 | 13.7 | 0.74 | 1.6 |
| 2016 | 18.06.2016 | 78.3 | 5.0 | 23.0 | 0.96 | 10.3 |
| 2017 | 12.08.2017 | 78.0 | 3.1 | 14.2 | 0.85 | 2.8 |

**212498 Sandriesen [Malta]**

| *year* | *date* | $FPR_{Ratio}$ | $HQ_{obs}$ | $HQ_{est}$ | $P_{Ratio}$ | *Return Period* |
|---|---|---|---|---|---|---|
| 1977 | 07.05.1977 | -264.8 | 31.1 | 8.5 | 0.87 | 2,5 |
| 1978 | 22.05.1978 | 14.5 | 46.6 | 54.5 | 0.93 | 8,9 |
| 1979 | 15.10.1979 | -45.9 | 28.2 | 19.3 | 0.80 | 2,1 |
| 1980 | 09.07.1980 | -10.7 | 56.9 | 51.4 | 1.10 | 22,6 |
| 1981 | 19.07.1981 | 21.6 | 74.4 | 94.8 | 0.99 | 113,7 |
| 1982 | 13.06.1982 | 54.1 | 9.0 | 19.7 | 0.91 | 1,0 |
| 1983 | 24.05.1983 | 34.5 | 18.1 | 27.6 | 1.05 | 1,2 |
| 1984 | 21.05.1984 | -3.5 | 30.9 | 29.8 | 1.13 | 2,5 |
| 1985 | 06.08.1985 | -28.7 | 37.1 | 28.8 | 1.01 | 4,0 |
| 1986 | 22.05.1986 | 75.5 | 16.4 | 67.0 | 1.5* | 1,2 |
| 1987 | 25.08.1987 | 6.4 | 31.4 | 33.5 | 0.87 | 2,6 |
| 1988 | 13.10.1988 | 36.8 | 14.9 | 23.6 | 0.83 | 1,1 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1989 | 04.07.1989 | 29.7 | 30.6 | 43.5 | | 0.92 | 2,4 |
| 1990 | 02.07.1990 | 42.0 | 19.7 | 33.9 | | 1.11 | 1,3 |
| 1991 | 18.06.1991 | 39.9 | 33.1 | 55.1 | | 0.92 | 2,9 |
| 1992 | 05.10.1992 | 22.6 | 23.0 | 29.7 | | 0.87 | 1,5 |
| 1993 | 20.07.1993 | 17.2 | 42.4 | 51.2 | | 1.05 | 6,2 |
| 1994 | 14.09.1994 | -10.7 | 34.3 | 31.0 | | 0.83 | 3,2 |
| 1995 | 11.06.1995 | 39.7 | 15.6 | 25.9 | | 0.82 | 1,1 |
| 1996 | 08.07.1996 | 6.6 | 28.8 | 30.8 | | 0.93 | 2,2 |
| 1997 | 28.06.1997 | 41.9 | 25.6 | 44.1 | | 1.03 | 1,8 |
| 1998 | 12.09.1998 | 6.9 | 51.8 | 55.6 | | 1.29 | 14,2 |
| 1999 | 21.09.1999 | -4.4 | 31.5 | 30.2 | | 0.87 | 2,6 |
| 2000 | 13.10.2000 | 36.4 | 32.9 | 51.8 | | 0.96 | 2,9 |
| 2001 | 11.06.2001 | 49.2 | 15.6 | 30.7 | | 0.98 | 1,1 |
| 2002 | 26.11.2002 | 5.3 | 37.7 | 39.8 | | 0.96 | 4,2 |
| 2003 | 20.05.2003 | 47.0 | 10.4 | 19.6 | | 1.28 | 1,0 |
| 2004 | 30.10.2004 | 12.9 | 19.8 | 22.7 | | 0.84 | 1,3 |
| 2005 | 05.10.2005 | 8.6 | 37.1 | 40.6 | | 1.02 | 4,0 |
| 2006 | 20.06.2006 | 62.6 | 13.9 | 37.1 | | 1.18 | 1,1 |
| 2007 | 10.07.2007 | 46.8 | 23.1 | 43.4 | | 1.05 | 1,5 |
| 2008 | 30.10.2008 | 8.7 | 30.3 | 33.2 | | 0.91 | 2,4 |
| 2009 | 18.07.2009 | 36.2 | 40.0 | 62.7 | | 1.19 | 5,1 |
| 2010 | 06.05.2010 | 25.7 | 30.3 | 40.8 | | 1.12 | 2,4 |
| 2011 | 19.09.2011 | 30.6 | 31.7 | 45.7 | | 1.07 | 2,6 |
| 2012 | 05.11.2012 | 24.1 | 34.1 | 44.9 | 1.32* | | 3,2 |
| 2013 | 11.10.2013 | 37.1 | 14.7 | 23.4 | 1.41* | | 1,1 |
| 2014 | 06.11.2014 | 30.0 | 32.7 | 46.7 | | 0.87 | 2,8 |
| 2015 | 30.07.2015 | 46.1 | 16.0 | 29.7 | | 0.89 | 1,1 |
| 2016 | 17.06.2016 | 16.6 | 56.4 | 67.6 | | 0.96 | 21,6 |
| 2017 | 24.07.2017 | 56.5 | 19.9 | 45.7 | 1.32* | | 1,3 |

**212530 Spittal Fasan [Lieser]**

| *year* | *date* | *$FPR_{Ratio}$* | *$HQ_{obs}$* | *$HQ_{est}$* | *$P_{Ratio}$* | | *Return Period* |
|---|---|---|---|---|---|---|---|
| 1977 | 20.05.1977 | -5.6 | 96.8 | 91.7 | | 0.82 | 2.6 |
| 1978 | 22.05.1978 | 4.8 | 157.0 | 164.9 | | 0.93 | 29.9 |
| 1979 | 21.05.1979 | 22.2 | 108.0 | 138.8 | 1.75* | | 3.9 |
| 1980 | 09.07.1980 | -3.9 | 147.0 | 141.5 | | 1.10 | 19.4 |
| 1981 | 19.07.1981 | 10.1 | 181.0 | 201.4 | | 0.99 | 86.0 |
| 1982 | 24.05.1982 | 12.1 | 58.7 | 66.8 | | 1.27 | 1.1 |
| 1983 | 24.05.1983 | 9.9 | 86.7 | 96.2 | | 1.05 | 1.9 |
| 1984 | 21.05.1984 | -0.8 | 137.0 | 135.9 | | 1.13 | 12.6 |
| 1985 | 06.08.1985 | -11.7 | 78.9 | 70.6 | | 1.01 | 1.5 |
| 1986 | 30.04.1986 | 2.2 | 72.6 | 74.2 | | 1.03 | 1.3 |
| 1987 | 09.06.1987 | 22.7 | 93.6 | 121.0 | | 1.12 | 2.3 |
| 1988 | 15.07.1988 | 15.8 | 62.7 | 74.5 | | 0.92 | 1.1 |
| 1989 | 05.07.1989 | 16.6 | 91.5 | 109.8 | | 1.03 | 2.2 |
| 1990 | 26.11.1990 | -0.5 | 79.1 | 78.7 | | 1.03 | 1.5 |
| 1991 | 18.06.1991 | 17.3 | 105.0 | 127.0 | | 0.92 | 3.4 |
| 1992 | 11.05.1992 | 13.2 | 80.4 | 92.7 | | 1.17 | 1.6 |
| 1993 | 20.07.1993 | 5.9 | 141.0 | 149.8 | | 1.05 | 15.0 |
| 1994 | 15.09.1994 | 4.7 | 94.3 | 98.9 | | 0.83 | 2.4 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1995 | 11.06.1995 | 13.2 | 67.9 | 78.2 | | 0.82 | 1.2 |
| 1996 | 15.11.1996 | 2.4 | 88.5 | 90.7 | 1.33* | | 2.0 |
| 1997 | 23.06.1997 | 27.7 | 64.8 | 89.6 | | 1.10 | 1.1 |
| 1998 | 07.10.1998 | 8.7 | 110.0 | 120.5 | | 1.04 | 4.2 |
| 1999 | 21.09.1999 | -2.0 | 68.6 | 67.3 | | 0.87 | 1.2 |
| 2000 | 13.10.2000 | 14.5 | 111.0 | 129.9 | | 0.96 | 4.3 |
| 2001 | 11.06.2001 | 19.5 | 62.5 | 77.6 | | 0.98 | 1.1 |
| 2002 | 26.11.2002 | 1.7 | 123.0 | 125.1 | | 0.96 | 7.0 |
| 2003 | 02.11.2003 | 2.2 | 56.3 | 57.6 | | 0.97 | 1.1 |
| 2004 | 20.06.2004 | 19.3 | 73.9 | 91.6 | | 1.16 | 1.3 |
| 2005 | 05.10.2005 | 3.1 | 107.0 | 110.5 | | 1.02 | 3.7 |
| 2006 | 20.05.2006 | 19.4 | 74.2 | 92.1 | | 1.12 | 1.4 |
| 2007 | 10.07.2007 | 19.5 | 84.1 | 104.4 | | 1.05 | 1.7 |
| 2008 | 30.10.2008 | 2.7 | 104.0 | 106.9 | | 0.91 | 3.3 |
| 2009 | 20.06.2009 | 15.3 | 102.0 | 120.5 | | 0.90 | 3.1 |
| 2010 | 06.05.2010 | 9.2 | 103.0 | 113.5 | | 1.12 | 3.2 |
| 2011 | 19.09.2011 | 15.0 | 79.4 | 93.4 | | 1.07 | 1.5 |
| 2012 | 05.11.2012 | 8.3 | 119.0 | 129.8 | 1.32* | | 5.9 |
| 2013 | 03.05.2013 | 21.5 | 65.3 | 83.1 | | 1.28 | 1.2 |
| 2014 | 06.11.2014 | 14.0 | 86.5 | 100.5 | | 0.87 | 1.8 |
| 2015 | 30.07.2015 | 19.6 | 56.1 | 69.8 | | 0.89 | 1.1 |
| 2016 | 17.06.2016 | 9.8 | 103.0 | 114.2 | | 0.96 | 3.2 |
| 2017 | 24.07.2017 | 27.4 | 68.4 | 94.2 | 1.32* | | 1.2 |

**213215 Amlach [Drau]**

| *year* | *date* | *$FPR_{Ratio}$* | *$HQ_{obs}$* | *$HQ_{est}$* | *$P_{ratio}$ (Flattach)* | *$P_{ratio}$ (Pflügelhof)* | *Return Period* |
|---|---|---|---|---|---|---|---|
| 1977 | 14.06.1977 | 22.6 | 498.0 | 643.0 | 1.23 | 1.51* | 2.3 |
| 1978 | 05.07.1978 | 25.8 | 485.0 | 653.6 | 1.20 | 0.99 | 2.1 |
| 1979 | 01.06.1979 | 14.7 | 537.0 | 629.8 | 0.96 | 1.79* | 3.1 |
| 1980 | 18.10.1980 | -1.2 | 606.0 | 598.7 | 0.68* | 1.28 | 5.8 |
| 1981 | 19.07.1981 | 17.6 | 837.0 | 1015.4 | 1.10 | 1.01 | 60.4 |
| 1982 | 27.06.1982 | 17.4 | 326.0 | 394.6 | 0.99 | 0.67* | 1.0 |
| 1983 | 24.05.1983 | 10.3 | 464.0 | 517.1 | 1.05 | 0.95 | 1.8 |
| 1984 | 21.05.1984 | 2.1 | 449.0 | 458.5 | 0.83 | 0.89 | 1.6 |
| 1985 | 07.08.1985 | 21.3 | 457.0 | 580.6 | 1.30 | 1.04 | 1.7 |
| 1986 | 22.05.1986 | 3.9 | 524.0 | 545.5 | 0.39* | 0.67* | 2.8 |
| 1987 | 20.07.1987 | 19.6 | 558.0 | 693.9 | 1.16 | 1.19 | 3.7 |
| 1988 | 15.07.1988 | 16.0 | 357.0 | 424.8 | 1.02 | 1.09 | 1.1 |
| 1989 | 05.07.1989 | 12.8 | 571.0 | 654.9 | 1.02 | 0.97 | 4.2 |
| 1990 | 11.07.1990 | 28.0 | 399.0 | 554.2 | 1.14 | 0.96 | 1.2 |
| 1991 | 18.06.1991 | 15.2 | 879.0 | 1036.7 | 1.13 | 1.09 | 93.5 |
| 1992 | 06.10.1992 | 9.5 | 467.0 | 516.2 | 0.92 | 1.27 | 1.8 |
| 1993 | 09.10.1993 | 12.2 | 598.0 | 681.4 | 1.28 | 0.92 | 5.4 |
| 1994 | 15.09.1994 | 10.7 | 499.0 | 558.7 | 1.12 | 1.21 | 2.3 |
| 1995 | 04.07.1995 | 19.6 | 388.0 | 482.6 | 1.05 | 1.25 | 1.2 |
| 1996 | 16.10.1996 | 3.2 | 453.0 | 468.2 | 0.61* | 1.36* | 1.6 |
| 1997 | 28.06.1997 | 13.6 | 497.0 | 575.4 | 0.87 | 0.97 | 2.2 |
| 1998 | 08.10.1998 | 8.9 | 688.0 | 754.8 | 0.77 | 0.95 | 13.1 |
| 1999 | 21.09.1999 | 12.3 | 421.0 | 480.0 | 1.04 | 1.15 | 1.4 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2000 | 13.10.2000 | 19.9 | 630.0 | 786.0 | 1.25 | 1.04 | 7.3 |
| 2001 | 11.06.2001 | 15.4 | 506.0 | 597.9 | 1.17 | 1.02 | 2.4 |
| 2002 | 26.11.2002 | 8.1 | 616.0 | 670.3 | 1.20 | 1.04 | 6.4 |
| 2003 | 12.06.2003 | 4.0 | 267.0 | 278.0 | 0.42* | 0.49* | 1.0 |
| 2004 | 12.06.2004 | 7.6 | 453.0 | 490.1 | 0.90 | 0.70 | 1.6 |
| 2005 | 05.10.2005 | 1.8 | 602.0 | 613.3 | 0.86 | 0.98 | 5.6 |
| 2006 | 20.05.2006 | 20.2 | 413.0 | 517.4 | 1.26 | 0.89 | 1.3 |
| 2007 | 10.07.2007 | 18.2 | 470.0 | 574.8 | 1.04 | 0.95 | 1.8 |
| 2008 | 30.10.2008 | 16.3 | 418.0 | 499.4 | 1.27 | 1.10 | 1.3 |
| 2009 | 20.06.2009 | 16.0 | 593.0 | 706.1 | 0.93 | 1.11 | 5.2 |
| 2010 | 06.05.2010 | 15.6 | 448.0 | 530.6 | 1.26 | 0.90 | 1.6 |
| 2011 | 19.09.2011 | 15.8 | 482.0 | 572.7 | 1.14 | 0.93 | 2.0 |
| 2012 | 21.07.2012 | 14.1 | 451.0 | 525.2 | 0.88 | 0.95 | 1.6 |
| 2013 | 20.06.2013 | 4.4 | 433.0 | 453.1 | 0.41* | 0.86 | 1.5 |
| 2014 | 06.11.2014 | 13.3 | 580.0 | 669.1 | 0.95 | 1.15 | 4.6 |
| 2015 | 21.05.2015 | 10.0 | 344.0 | 382.3 | 1.19 | 0.95 | 1.1 |
| 2016 | 17.06.2016 | 25.8 | 552.0 | 743.8 | 1.3* | 1.05 | 3.5 |
| 2017 | 25.07.2017 | 12.1 | 353.0 | 401.6 | 0.84 | 0.78 | 1.1 |

**203745 Muhr [Mur]**

| *year* | *date* | *$FPR_{Ratio}$* | *$HQ_{obs}$* | *$HQ_{est}$* | *$P_{Ratio}$* | *Return Period* |
|---|---|---|---|---|---|---|
| 1992 | 17.05.1992 | 71.6 | 5.9 | 20.9 | 1.14 | 6.7 |
| 1993 | 21.07.1993 | 52.4 | 5.2 | 11.0 | 0.91 | 1.1 |
| 1994 | 19.05.1994 | 69.1 | 3.7 | 11.8 | 0.87 | 1.3 |
| 1995 | 26.06.1995 | 44.4 | 13.4 | 24.1 | 1.04 | 7.2 |
| 1996 | 22.10.1996 | 49.0 | 4.1 | 8.0 | 0.71 | 1.9 |
| 1997 | 21.05.1997 | 60.0 | 8.6 | 21.5 | 1.09 | 3.8 |
| 1998 | 11.06.1998 | 40.7 | 6.9 | 11.7 | 1.29 | 1.1 |
| 1999 | 23.07.1999 | 2.2 | 11.4 | 11.7 | 0.85 | 1.9 |
| 2000 | 29.04.2000 | -155.8 | 3.5 | 1.4 | 0.08* | 9.0 |
| 2001 | 01.06.2001 | 59.3 | 8.5 | 21.0 | 1.25 | 2.5 |
| 2002 | 12.08.2002 | 29.4 | 25.2 | 35.7 | 1.00 | 55.4 |
| 2003 | 20.05.2003 | 70.8 | 3.4 | 11.5 | 1.31* | 1.0 |
| 2004 | 12.06.2004 | 56.8 | 15.7 | 36.3 | 1.43* | 6.0 |
| 2005 | 11.07.2005 | 55.3 | 17.9 | 40.0 | 1.32* | 4.7 |
| 2006 | 20.06.2006 | 22.8 | 14.8 | 19.2 | 0.88 | 4.4 |
| 2007 | 10.07.2007 | 33.8 | 14.1 | 21.3 | 1.01 | 1.5 |
| 2008 | 30.05.2008 | 97.3 | 8.2 | 307.8 | 17.71* | 3.8 |
| 2009 | 24.06.2009 | 54.6 | 6.9 | 15.2 | 0.83 | 3.8 |
| 2010 | 06.05.2010 | 68.6 | 10.7 | 34.1 | 1.49* | 1.9 |
| 2011 | 11.10.2011 | -14.7 | 7.7 | 6.7 | 0.80 | 1.0 |
| 2012 | 21.07.2012 | 2.0 | 13.0 | 13.3 | 0.68* | 3.3 |
| 2013 | 03.05.2013 | 60.8 | 9.8 | 25.1 | 1.24 | 1.8 |
| 2014 | 02.08.2014 | 57.7 | 4.3 | 10.2 | 1.44* | 1.2 |
| 2015 | 14.05.2015 | 69.6 | 3.1 | 10.3 | 0.65* | 1.5 |
| 2016 | 10.08.2016 | 57.9 | 7.6 | 18.0 | 0.96 | 1.2 |
| 2017 | 06.08.2017 | 59.8 | 3.9 | 9.8 | 0.7* | 3.7 |

**203752 St. Michael i. Lg. (Mur) [Mur]**

| *year* | *date* | *$FPR_{Ratio}$* | *$HQ_{obs}$* | *$HQ_{est}$* | *$P_{Ratio}$* | *Return Period* |
|---|---|---|---|---|---|---|
| 1992 | 17.05.1992 | 34.5 | 28.4 | 43.4 | 1.14 | 1.8 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1993 | 20.07.1993 | 9.9 | 38.6 | 42.9 | | 0.86 | 4.6 |
| 1994 | 15.09.1994 | -5.0 | 21.9 | 20.8 | 1.89* | | 1.2 |
| 1995 | 26.06.1995 | 20.6 | 41.3 | 52.0 | | 1.04 | 6.0 |
| 1996 | 08.07.1996 | -25.3 | 18.7 | 14.9 | | 0.96 | 1.1 |
| 1997 | 20.05.1997 | -13.0 | 30.5 | 27.0 | 0.38* | | 2.2 |
| 1998 | 08.10.1998 | 29.7 | 25.7 | 36.6 | 2.56* | | 1.5 |
| 1999 | 30.08.1999 | 7.5 | 28.9 | 31.2 | | 1.06 | 1.9 |
| 2000 | 13.10.2000 | 58.2 | 29.8 | 71.3 | 4.34* | | 2.1 |
| 2001 | 31.05.2001 | 23.1 | 32.0 | 41.6 | | 1.24 | 2.5 |
| 2002 | 12.08.2002 | 13.1 | 69.7 | 80.2 | | 1.00 | 138.9 |
| 2003 | 15.06.2003 | 5.9 | 17.3 | 18.4 | 2.03* | | 1.1 |
| 2004 | 12.06.2004 | 32.1 | 43.5 | 64.1 | 1.43* | | 7.6 |
| 2005 | 11.07.2005 | 30.7 | 50.0 | 72.1 | 1.32* | | 15.3 |
| 2006 | 20.06.2006 | 10.3 | 37.8 | 42.2 | | 0.88 | 4.2 |
| 2007 | 10.07.2007 | 15.6 | 39.0 | 46.2 | | 1.01 | 4.8 |
| 2008 | 20.05.2008 | 20.9 | 25.0 | 31.6 | 1.35* | | 1.5 |
| 2009 | 25.05.2009 | -28.2 | 32.6 | 25.4 | 0.42* | | 2.6 |
| 2010 | 06.05.2010 | 43.7 | 30.1 | 53.5 | 1.49* | | 2.1 |
| 2011 | 24.06.2011 | -13.4 | 19.1 | 16.8 | | 1.06 | 1.1 |
| 2012 | 21.07.2012 | 0.9 | 30.9 | 31.2 | 0.68* | | 2.2 |
| 2013 | 03.05.2013 | 33.9 | 29.7 | 44.9 | | 1.24 | 2.0 |
| 2014 | 14.06.2014 | -24.4 | 23.4 | 18.8 | 0.64* | | 1.3 |
| 2015 | 13.05.2015 | -7.3 | 19.8 | 18.5 | 0.51* | | 1.1 |
| 2016 | 17.06.2016 | 8.3 | 28.5 | 31.1 | 1.55* | | 1.9 |
| 2017 | 20.08.2017 | 38.1 | 22.5 | 36.4 | | 1.27 | 1.3 |

**203794 Mörtelsdorf [Mur]**

| *year* | *date* | *$FPR_{Ratio}$* | *$HQ_{obs}$* | *$HQ_{est}$* | *$P_{Ratio}$* | | *Return Period* |
|---|---|---|---|---|---|---|---|
| 1992 | 17.05.1992 | 32.8 | 30.7 | 45.7 | | 1.14 | 1.7 |
| 1993 | 20.07.1993 | 7.9 | 49.9 | 54.2 | | 0.86 | 8.4 |
| 1994 | 19.05.1994 | 28.2 | 20.7 | 28.8 | | 0.87 | 1.1 |
| 1995 | 26.06.1995 | 21.9 | 38.2 | 48.9 | | 1.04 | 2.9 |
| 1996 | 18.11.1996 | 16.8 | 22.1 | 26.6 | 1.47* | | 1.1 |
| 1997 | 20.05.1997 | -13.7 | 29.2 | 25.7 | 0.38* | | 1.5 |
| 1998 | 08.10.1998 | 28.7 | 27.0 | 37.9 | 2.56* | | 1.3 |
| 1999 | 30.08.1999 | 6.4 | 34.3 | 36.6 | | 1.06 | 2.1 |
| 2000 | 13.10.2000 | 59.9 | 27.8 | 69.3 | 4.34* | | 1.4 |
| 2001 | 31.05.2001 | 23.0 | 32.3 | 41.9 | | 1.24 | 1.8 |
| 2002 | 12.08.2002 | 12.4 | 74.1 | 84.6 | | 1.00 | 96.3 |
| 2003 | 20.05.2003 | 28.8 | 20.1 | 28.2 | 1.31* | | 1.1 |
| 2004 | 12.06.2004 | 33.0 | 41.9 | 62.5 | 1.43* | | 4.0 |
| 2005 | 11.07.2005 | 30.2 | 51.1 | 73.2 | 1.32* | | 9.4 |
| 2006 | 20.06.2006 | 9.7 | 40.8 | 45.2 | | 0.88 | 3.6 |
| 2007 | 10.07.2007 | 11.1 | 57.3 | 64.5 | | 1.01 | 17.4 |
| 2008 | 20.05.2008 | 19.4 | 27.5 | 34.1 | 1.35* | | 1.4 |
| 2009 | 20.06.2009 | 1.4 | 42.2 | 42.8 | | 0.78 | 4.1 |
| 2010 | 06.05.2010 | 38.0 | 38.1 | 61.5 | 1.49* | | 2.9 |
| 2011 | 24.06.2011 | -10.2 | 24.4 | 22.1 | | 1.06 | 1.2 |
| 2012 | 21.07.2012 | 0.6 | 41.9 | 42.2 | 0.68* | | 4.0 |
| 2013 | 03.05.2013 | 30.0 | 35.5 | 50.7 | | 1.24 | 2.3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2014 | 03.09.2014 | 17.1 | 27.8 | 33.5 | 1.25 | 1.4 |
| 2015 | 13.05.2015 | -6.3 | 22.6 | 21.3 | 0.51* | 1.1 |
| 2016 | 17.06.2016 | 7.0 | 34.1 | 36.7 | 1.55* | 2.1 |
| 2017 | 20.08.2017 | 30.2 | 32.0 | 45.9 | 1.27 | 1.8 |

**203976 Kendlbruck [Mur]**

| *year* | *date* | *$FPR_{Ratio}$* | *$HQ_{obs}$* | *$HQ_{est}$* | *$P_{Ratio}$* | *Return Period* |
|---|---|---|---|---|---|---|
| 1992 | 17.05.1992 | 12.6 | 104.0 | 119.0 | 1.14 | 2.5 |
| 1993 | 20.07.1993 | 2.8 | 150.0 | 154.3 | 0.86 | 11.8 |
| 1994 | 19.05.1994 | 11.1 | 65.2 | 73.3 | 0.87 | 1.1 |
| 1995 | 26.06.1995 | 9.9 | 97.1 | 107.8 | 1.04 | 2.0 |
| 1996 | 18.11.1996 | 5.6 | 74.7 | 79.2 | 1.47* | 1.3 |
| 1997 | 20.05.1997 | -4.5 | 82.0 | 78.5 | 0.38* | 1.4 |
| 1998 | 11.06.1998 | 6.6 | 66.9 | 71.6 | 1.29 | 1.1 |
| 1999 | 30.08.1999 | 2.4 | 95.8 | 98.1 | 1.06 | 2.0 |
| 2000 | 24.04.2000 | 40.6 | 88.1 | 148.3 | 3.93* | 1.6 |
| 2001 | 31.05.2001 | 9.9 | 87.2 | 96.8 | 1.24 | 1.6 |
| 2002 | 12.08.2002 | 5.2 | 192.0 | 202.5 | 1.00 | 56.7 |
| 2003 | 20.05.2003 | 12.2 | 58.4 | 66.5 | 1.31* | 1.1 |
| 2004 | 12.06.2004 | 15.8 | 110.0 | 130.6 | 1.43* | 3.0 |
| 2005 | 05.10.2005 | -0.4 | 149.0 | 148.4 | 1.08 | 11.3 |
| 2006 | 20.06.2006 | 4.0 | 104.0 | 108.4 | 0.88 | 2.5 |
| 2007 | 10.07.2007 | 4.8 | 142.0 | 149.2 | 1.01 | 8.8 |
| 2008 | 30.05.2008 | 78.6 | 81.4 | 381.0 | 17.71* | 1.4 |
| 2009 | 20.06.2009 | 0.5 | 113.0 | 113.6 | 0.78 | 3.3 |
| 2010 | 06.05.2010 | 18.6 | 102.0 | 125.4 | 1.49* | 2.3 |
| 2011 | 24.06.2011 | -3.8 | 62.2 | 59.9 | 1.06 | 1.1 |
| 2012 | 21.07.2012 | 0.2 | 165.0 | 165.3 | 0.68* | 20.5 |
| 2013 | 03.05.2013 | 13.2 | 100.0 | 115.2 | 1.24 | 2.2 |
| 2014 | 01.09.2014 | 7.5 | 85.8 | 92.8 | 1.03 | 1.5 |
| 2015 | 14.05.2015 | 9.7 | 66.7 | 73.8 | 0.65* | 1.1 |
| 2016 | 10.08.2016 | 8.9 | 106.0 | 116.4 | 0.96 | 2.6 |
| 2017 | 06.08.2017 | 5.5 | 101.0 | 106.9 | 0.7* | 2.3 |

**207985 Rosenburg [Kamp]**

| *year* | *date* | *$FPR_{Ratio}$* | *$HQ_{obs}$* | *$HQ_{est}$* | *$P_{Ratio}$* | *Return Period* |
|---|---|---|---|---|---|---|
| 1977 | 04.03.1977 | 41.8 | 46.7 | 80.3 | 1.15 | 2.0 |
| 1978 | 18.06.1978 | 83.5 | 4.7 | 28.2 | 0.99 | 1.4 |
| 1979 | 28.04.1979 | 45.6 | 40.1 | 73.8 | 1.20 | 1.8 |
| 1980 | 01.05.1980 | 47.4 | 39.8 | 75.7 | 1.33* | 1.8 |
| 1981 | 12.03.1981 | 81.6 | 10.6 | 57.7 | 0.78 | 2.1 |
| 1982 | 06.01.1982 | 25.3 | 31.5 | 42.1 | 0.64* | 1.9 |
| 1983 | 05.01.1983 | 81.9 | 4.6 | 25.6 | 0.85 | 1.4 |
| 1984 | 17.09.1984 | 86.4 | 5.3 | 38.5 | 0.99 | 1.5 |
| 1985 | 07.08.1985 | 29.5 | 96.5 | 136.9 | 1.03 | 4.6 |
| 1986 | 20.01.1986 | 59.2 | 13.0 | 31.8 | 0.73 | 1.5 |
| 1987 | 27.03.1987 | 81.5 | 11.8 | 63.9 | 0.83 | 2.2 |
| 1988 | 26.03.1988 | 45.6 | 34.9 | 64.2 | 0.81 | 2.2 |
| 1989 | 01.05.1989 | 75.3 | 7.6 | 30.9 | 1.09 | 1.4 |
| 1990 | 26.05.1990 | 32.8 | 13.3 | 19.8 | 0.89 | 1.3 |
| 1991 | 03.08.1991 | 69.5 | 31.7 | 104.1 | 0.98 | 3.2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1992 | 22.03.1992 | 72.6 | 9.2 | 33.6 | 0.92 | 1.5 |
| 1993 | 18.03.1993 | 85.5 | 9.2 | 63.3 | 0.73 | 2.5 |
| 1994 | 18.04.1994 | 69.6 | 21.9 | 72.1 | 1.12 | 1.9 |
| 1995 | 25.12.1995 | 51.1 | 18.7 | 38.3 | 0.77 | 1.6 |
| 1996 | 14.05.1996 | 11.6 | 163.0 | 184.4 | 0.95 | 11.4 |
| 1997 | 13.02.1997 | 78.8 | 10.5 | 49.4 | 0.78 | 1.9 |
| 1998 | 18.03.1998 | 68.8 | 10.0 | 31.9 | 0.88 | 1.5 |
| 1999 | 10.07.1999 | 90.3 | 7.2 | 73.7 | 0.94 | 2.2 |
| 2000 | 30.03.2000 | 48 | 19.0 | 36.6 | 0.77 | 1.6 |
| 2001 | 18.09.2001 | 75.6 | 7.6 | 31.3 | 0.97 | 1.4 |
| 2002 | 13.08.2002 | 27.8 | 338.0 | 468.3 | 0.93 | 1572.5 |
| 2003 | 13.03.2003 | 82.3 | 4.9 | 27.5 | 0.79 | 1.4 |
| 2004 | 04.06.2004 | 64.2 | 16.4 | 45.8 | 0.96 | 1.6 |
| 2005 | 11.07.2005 | 44.6 | 80.1 | 144.5 | 0.91 | 6.8 |
| 2006 | 29.03.2006 | 68.5 | 58.6 | 185.9 | 0.95 | 11.7 |
| 2007 | 07.09.2007 | 90.6 | 11.8 | 126.2 | 0.96 | 4.5 |
| 2008 | 16.08.2008 | 70.2 | 14.1 | 47.4 | 0.91 | 1.7 |
| 2009 | 24.06.2009 | 17 | 95.3 | 114.8 | 0.99 | 3.6 |
| 2010 | 03.08.2010 | 47.8 | 34.8 | 66.7 | 0.79 | 2.4 |
| 2011 | 14.01.2011 | 80.5 | 10.0 | 51.2 | 0.79 | 1.9 |
| 2012 | 13.06.2012 | 76.8 | 19.3 | 83.2 | 0.92 | 2.6 |
| 2013 | 04.06.2013 | 53.6 | 42.8 | 92.3 | 0.90 | 3.0 |
| 2014 | 29.05.2014 | 71.6 | 11.1 | 39.1 | 0.96 | 1.5 |
| 2015 | 11.01.2015 | 73.4 | 9.1 | 34.1 | 0.90 | 1.5 |
| 2016 | 03.07.2016 | 72.4 | 12.2 | 44.2 | 1.00 | 1.6 |
| 2017 | 23.02.2017 | 88.7 | 4.1 | 36.1 | 0.84 | 1.5 |

**207993 Stiefern [Kamp]**

| *year* | *date* | *$FPR_{Ratio}$* | *$HQ_{obs}$* | *$HQ_{est}$* | *$P_{Ratio}$* | *Return Period* |
|---|---|---|---|---|---|---|
| 1977 | 05.03.1977 | 9.3 | 102.0 | 112.4 | 1.19 | 4.0 |
| 1978 | 22.02.1978 | -94.3 | 18.2 | 9.4 | 1.02 | 1.6 |
| 1979 | 29.04.1979 | 9.3 | 57.1 | 62.9 | 1.17 | 2.3 |
| 1980 | 30.04.1980 | 27.8 | 66.9 | 92.7 | 1.28 | 2.6 |
| 1981 | 10.01.1981 | -34.2 | 26.9 | 20.0 | 0.56* | 1.7 |
| 1982 | 31.01.1982 | 25.2 | 63.3 | 84.6 | 0.88 | 2.5 |
| 1983 | 03.04.1983 | 34.8 | 22.0 | 33.7 | 1.02 | 1.6 |
| 1984 | 15.11.1984 | - | 16.7 | - | - | 1.6 |
| 1985 | 07.08.1985 | 30.8 | 91.0 | 131.4 | 1.03 | 3.5 |
| 1986 | 14.03.1986 | 87.1 | 20.3 | 157.2 | 11.55* | 1.6 |
| 1987 | 11.04.1987 | -8.4 | 62.6 | 57.7 | 0.86 | 2.5 |
| 1988 | 26.03.1988 | 39.4 | 45.0 | 74.3 | 0.81 | 2.1 |
| 1989 | 19.06.1989 | 14.7 | 20.6 | 24.2 | 0.93 | 1.6 |
| 1990 | 26.05.1990 | 27.6 | 17.0 | 23.5 | 0.89 | 1.6 |
| 1991 | 04.08.1991 | -2.8 | 57.3 | 55.8 | 1.01 | 2.3 |
| 1992 | 09.04.1992 | 93.3 | 18.0 | 267.2 | 15.79* | 1.6 |
| 1993 | 25.03.1993 | 22.6 | 24.0 | 31.0 | 0.70 | 1.7 |
| 1994 | 19.04.1994 | 49.8 | 26.2 | 52.2 | 1.11 | 1.7 |
| 1995 | 25.12.1995 | 47.3 | 21.8 | 41.4 | 0.77 | 1.6 |
| 1996 | 15.05.1996 | -14 | 173.0 | 151.7 | 0.96 | 10.2 |
| 1997 | 08.07.1997 | 35.8 | 35.5 | 55.3 | 0.91 | 1.9 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1998 | 20.03.1998 | 8.5 | 17.8 | 19.4 | | 0.89 | 1.6 |
| 1999 | 01.04.1999 | -50.7 | 28.3 | 18.8 | | 0.92 | 1.7 |
| 2000 | 06.04.2000 | -20.7 | 29.6 | 24.5 | | 0.73 | 1.8 |
| 2001 | 22.04.2001 | 30.3 | 20.6 | 29.5 | | 0.92 | 1.6 |
| 2002 | 08.08.2002 | 7.8 | 562.0 | 609.7 | | 0.94 | 2800.8 |
| 2003 | 28.01.2003 | -30 | 32.4 | 24.9 | | 0.73 | 1.8 |
| 2004 | 26.03.2004 | -38.3 | 41.6 | 30.1 | | 0.93 | 2.0 |
| 2005 | 12.07.2005 | 22.2 | 77.0 | 99.0 | | 0.91 | 2.9 |
| 2006 | 02.04.2006 | 14.6 | 99.4 | 116.4 | | 0.82 | 3.8 |
| 2007 | 06.09.2007 | 41.4 | 32.1 | 54.8 | | 0.95 | 1.8 |
| 2008 | 17.08.2008 | 45.4 | 16.5 | 30.2 | | 0.94 | 1.6 |
| 2009 | 24.06.2009 | 15.2 | 109.0 | 128.5 | | 0.99 | 4.3 |
| 2010 | 07.08.2010 | 6.2 | 105.0 | 111.9 | | 1.19 | 4.1 |
| 2011 | 14.01.2011 | 71.9 | 16.1 | 57.3 | | 0.79 | 1.6 |
| 2012 | 13.06.2012 | 72.1 | 24.7 | 88.6 | | 0.92 | 1.7 |
| 2013 | 08.06.2013 | -73.3 | 59.2 | 34.2 | 0.65* | | 2.4 |
| 2014 | 14.09.2014 | 30.5 | 24.6 | 35.4 | | 1.03 | 1.7 |
| 2015 | 13.01.2015 | -6.2 | 18.4 | 17.3 | | 0.87 | 1.6 |
| 2016 | 13.07.2016 | 22.2 | 21.8 | 28.0 | | 0.98 | 1.6 |
| 2017 | 03.01.2017 | -176.9 | 15.3 | 5.5 | 0.67* | | 1.6 |

*Table Appendix 4 Flood peak (HQ100) reduction based on (Widmann, 1988)*

| | | | *Catchment area* | | | *$HQ_{100}$* | | |
|---|---|---|---|---|---|---|---|---|
| River | Gauge | Reservoir | Reservoir [km²] | Gauge [km²] | Ar/Ag [-] | pre-dam [m³/s] | post-dam [m³/s] | reduction [%] |
| Seeache | Jaßsteg | Achensee | 105 | 172 | 0.61 | 88 | 55 | 37 |
| Kapruner Ache | Kaprun | Wasserfallboden<br>Mooserboden | 42 | 88.1 | 0.48 | 90 | 67 | 26 |
| Ziller | Mayrhofen | Schlegeiß | 127 | 612 | 0.21 | 579 | 280 | 52 |
| | Zell am Ziller | Stillup | | 696.9 | 0.18 | 630 | 377 | 40 |
| | Straß (Hart) | Durlaßboden | 173 | 1095 | 0.16 | 700 | 527 | 25 |
| Möll | Ranigroß | Margeritze | 44 | 74.5 | 0.60 | 103 | 43 | 58 |
| Ill | Partenen | Partenen | 63 | 103 | 0.61 | 264 | 140 | 47 |
| Faggenbach | Platz | Gepatsch | 150 | 191.5 | 0.78 | 58 | 18 | 69 |
| Finstertal | Kühtai | Finstertal | 6 | 8.1 | 0.74 | 7 | 2 | 69 |
| Malta | Gmünd | Kölnbrein | 58 | 266 | 0.22 | 300 | 165 | 55 |
| Gerlos | Gmünd | Durlaßboden | 45 | 144 | 0.31 | 101 | 101 | 40 |

*Table Appendix 5 Distribution of CORINE land cover classes (Level 1) for the affected and reference catchments [%]*

| | | ARTIFICIAL SURFACES | AGRICULTURAL AREAS | FOREST AND SEMI NATURAL AREAS | WETLANDS | WATER BODIES |
|---|---|---|---|---|---|---|
| AFFECTED CATCHMENTS | Beschling | 5.2 | 5.8 | 88.3 | 0.2 | 0.5 |
| | St. Anton | 1.2 | 0.2 | 98.0 | 0.3 | 0.2 |
| | Platz-Loch | 0.2 | 1.9 | 96.5 | 0.0 | 1.4 |
| | Mayerhofen | 1.5 | 4.9 | 92.9 | 0.0 | 0.7 |
| | EW Gmünd | 4.9 | 7.9 | 85.7 | 0.1 | 1.3 |
| | Uttendorf | 0.1 | 5.5 | 92.4 | 0.0 | 2.0 |
| | Kaprun | 3.5 | 3.1 | 90.0 | 0.0 | 3.4 |
| | Flattach | 1.2 | 6.6 | 91.8 | 0.0 | 0.4 |
| | Pflügelhof | 0.0 | 0.4 | 97.6 | 0.0 | 2.1 |
| | Muhr | 1.4 | 5.0 | 93.4 | 0.0 | 0.2 |
| | Rosenburg | 2.6 | 48.7 | 48.0 | 0.1 | 0.6 |
| REFERENCE CATCHMENTS | Garsella | 0.4 | 5.6 | 94.0 | 0.0 | 0 |
| | Gepatschalm | 0.0 | 0.0 | 100.0 | 0.0 | 0 |
| | Sulzau | 0.0 | 1.2 | 98.8 | 0.0 | 0 |
| | Mallnitzbach | 1.8 | 2.8 | 95.3 | 0.0 | 0 |
| | Weißpriach | 1.5 | 3.1 | 94.7 | 0.7 | 0 |
| | Zwettl (Bahnbrücke) | 2.9 | 48.6 | 48.3 | 0.2 | 0 |

*Table Appendix 6 Differences of CORINE land cover classes (Level 1) between the affected and reference catchments [%]*

| AFFECTED CATCHMENT | REFERENCE CATCHMENT | ARTIFICIAL SURFACES | AGRICULTURAL AREAS | FOREST AND SEMI NATURAL AREAS | WETLANDS | WATER BODIES |
|---|---|---|---|---|---|---|
| Beschling | Garsella | 4.8 | 0.2 | -5.7 | 0.2 | 0.5 |
| Rosanna | Garsella | 0.8 | -5.3 | 4.0 | 0.3 | 0.2 |
| Platz-Loch | Gepatschalm | 0.2 | 1.9 | -3.5 | 0.0 | 1.4 |
| Mayrhofen | Sulzau | 1.5 | 3.7 | -5.8 | 0.0 | 0.7 |
| EW Gmünd | Sulzau | 4.9 | 6.7 | -13.0 | 0.1 | 1.3 |
| Uttendorf | Sulzau | 0.1 | 4.3 | -6.4 | 0.0 | 2.0 |
| Kaprun | Sulzau | 3.5 | 1.9 | -8.8 | 0.0 | 3.4 |
| Flattach | Malnitz | -0.6 | 3.8 | -3.6 | 0.0 | 0.4 |
| Pflügelhof | Malnitz | -1.8 | -2.5 | 2.2 | 0.0 | 2.1 |
| Muhr | Weißpriach | -0.1 | 1.9 | -1.3 | -0.7 | 0.2 |
| Rosenburg | Zwettl (Bahnbrücke) | -0.3 | 0.1 | -0.3 | -0.1 | 0.6 |