ANALYSIS OF HYDROLOGICAL DATA

THE GRADAŠČICA RIVER BASIN

UL FGG (PP 9)

WORK PACKAGE 4
ACTIVITY 4.3

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Stations locations

Data from two hydrological stations were analysed. Station Dvor on the river Gradaščica and station Razori on the river (stream) Šujica (also called Horjulščica) are part of the Sava river basin. Station Razori is located approximately 500 m upstream of the confluence of the Gradaščica and Šujica rivers. After the confluence of rivers the stream is called Mali Graben. Hydrological station Dvor lies near village Dvor pri Polhovem Gradcu which is located about 10 km east of Ljubljana. 57 years (1954-2010) of daily discharge data were available for station Razori. Stage gauge was used for water level observations (once a day by observer). Stage gauge was also used at station Dvor, however from the year 2000 hourly time scale discharge series were also available (limnigraph). Measurements in Dvor began in 1977; data is available from year 1981. Drainage area of station Dvor is 78,67 km^2 and drainage area of station Razori is 46,88 km^2 (Frantar and Hrvatin, 2008). Stations locations are presented in Fig. 1.

Gauging section of station Dvor is not well chosen, because at discharge values larger than 40 m^3/s water starts flooding and it goes around gauging section (Inženirng za vode, 2007). This means that extreme events are not measured correctly. Some mitigations were made in the last 5 years, but still this problem is not solved because extreme events are still not completely captured by gauging equipment.

Stream Šujica also starts flooding near the village Vrzdenec (Inženirng za vode, 2007), which means that measured extreme discharge values are also not completely captured in available data.

Figure 1: Stations locations (Scale 1:140000)

Daily time scale analysis

Table 1 shows some descriptive statistics values for both considered stations. Descriptive statistics for daily discharge values and annual maximums series are shown (Table 1). One can see that the river Gradaščica has larger mean daily discharge values as the stream Šujica. Gradaščica also has larger standard deviation, kurtosis and skewnees values.

Table 1: Descriptive statistics for daily time scale series and annual maximums (AM) samples

	Dvor (Gradaščica)		Razori (Šujica)	
	Daily values	AM	Daily values	AM
Mean value [m^3/s]	2,27	27,66	1,44	15,89
Standard error [m^3/s]	0,03	1,89	0,01	0,72
Standard deviation [m^3/s]	2,99	10,36	1,94	5,42
Variance [m^6/s^2]	8,96	107,43	3,75	29,42
Kurtosis	54,17	2,07	36,75	5,07
Skewness	5,75	1,22	4,74	1,49
Maximum value [m^3/s]	55,63	55,63	39,329	39,329

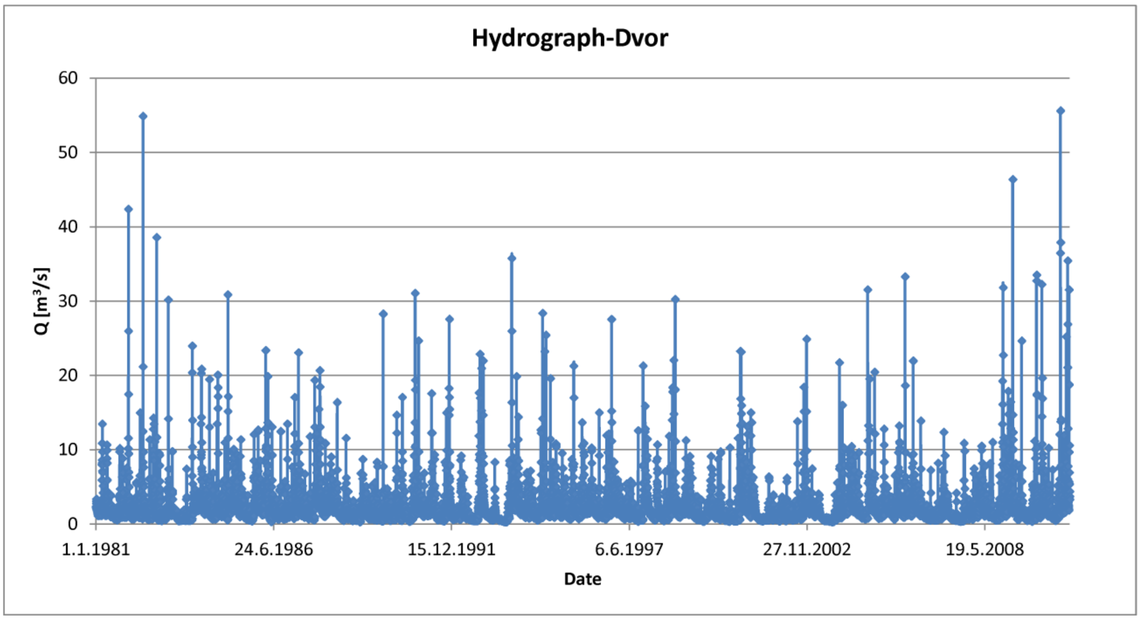

Figure 2: Hydrograph for gauging station Dvor for the period 1981-2010

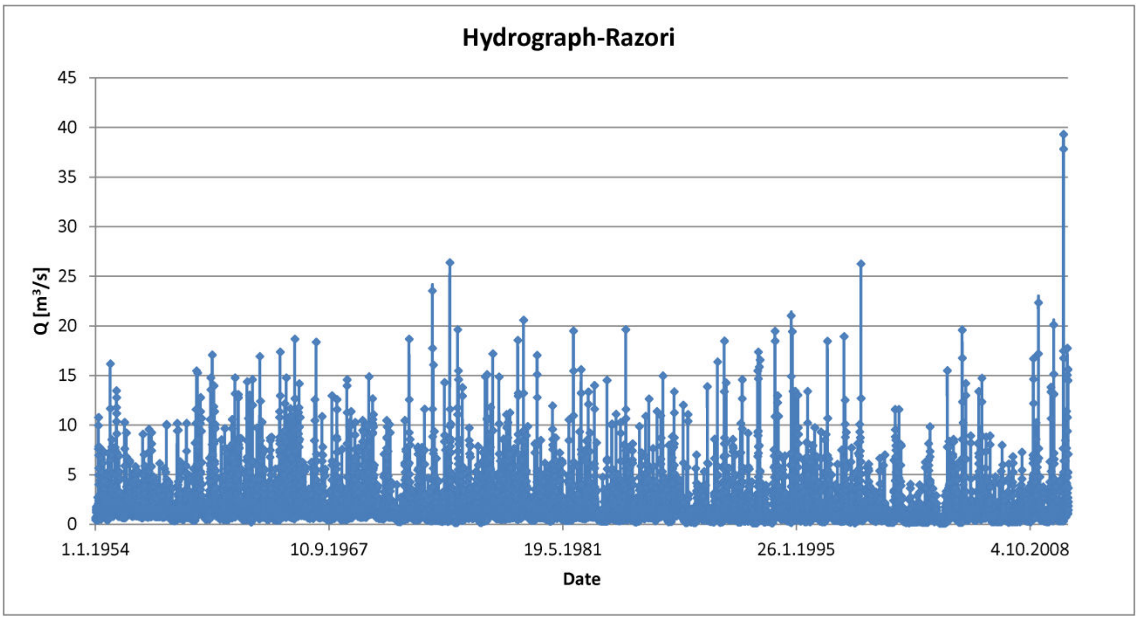

Figure 3: Hydrograph for gauging station Razori for the period 1954-2010

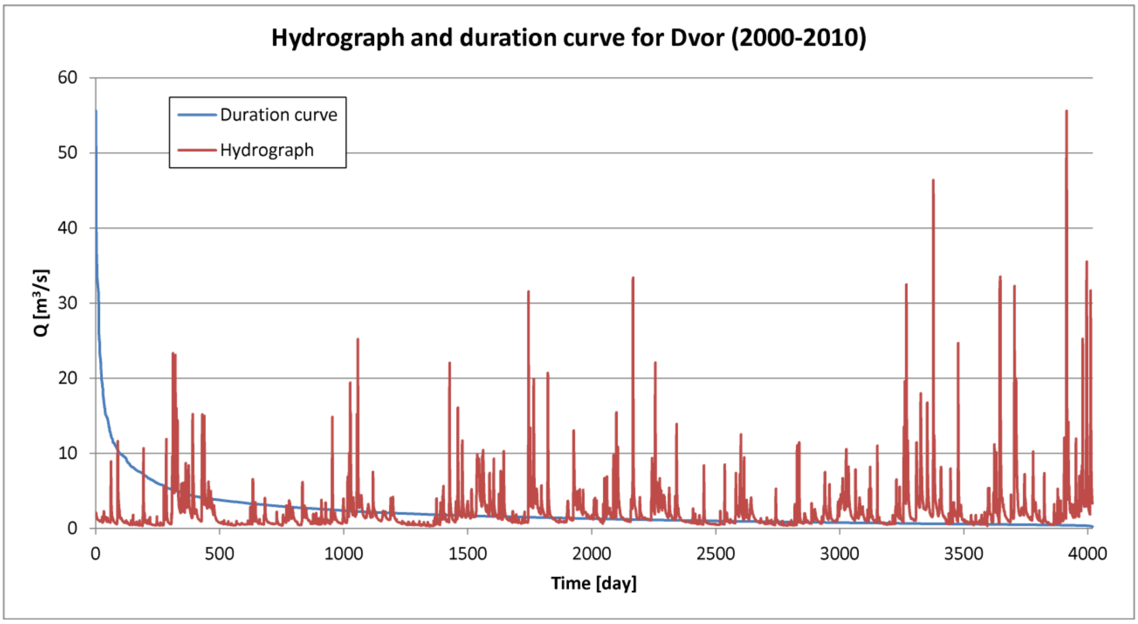

Figure 4: Hydrograph and duration curve for station Dvor for the period 2000-2010

In Fig. 2 and 3 hydrographs for daily discharge series are shown for stations Dvor and Razori at streams Gradaščica and Šujica, respectively. Maximum discharges at both stations occurred in September 2010 when large flood happened. Linear regression and Mann-Kendall test for detecting trends were also used and both tests for station Razori were suggesting negative trend (also statistically significant). Also for station Dvor both tests showed that there is negative trend present in the data (statistically significant for Mann-Kendall test and statistically non-significant for linear regression).

In Fig. 4 hydrograph and duration curve for station Dvor (period 2000-2010) are shown.

Hourly time scale analysis

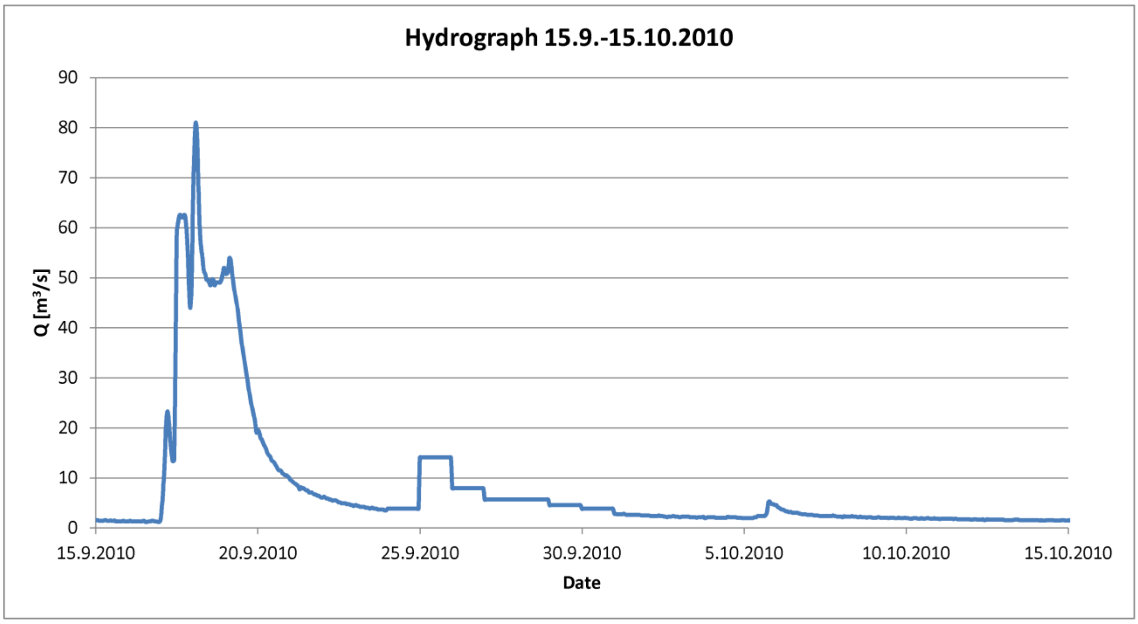

Figure 5: Hydrograph for the maximum event for gauging station Dvor

In Fig. 5 maximum event in the observed period for hydrological station Dvor is shown. As earlier mentioned, from the year 2000 there are also hourly discharge values available. These values are shown in Fig. 5. Very step discharge increase was characteristic of the maximum event from the September 2010. These kinds of events are characteristics of flash floods (Gradaščica is flashy stream).

Flood frequency analysis

Normal (N), log-normal (LN), Pearson 3 (P3), log-Pearson 3 (LP3), Gumbel (G) and generalized extreme value (GEV) distributions were used for flood frequency analysis. Distributions parameters were estimated with the method of moments (MOM) and the method of L-moments (LM). Flood frequency analysis results are shown in Fig. 6 and 7. In Fig. 6 we can see that frequency curves do not fit the maximum three events. These events are larger than 40 m^3/s. Cross-section inappropriateness (stations locations) was probably the reason for this phenomenon. Also flashy stream like Gradaščica should have more step increase of curve that connects return period and estimated discharge values (Inženirng za vode, 2007). In Fig. 7 frequency curves for station Razori are shown. In case of this gauging station just one event could be declared as outlier (September 2010). Because of flooding also estimated discharge values for station Razori are probability underestimated (Fig. 7).

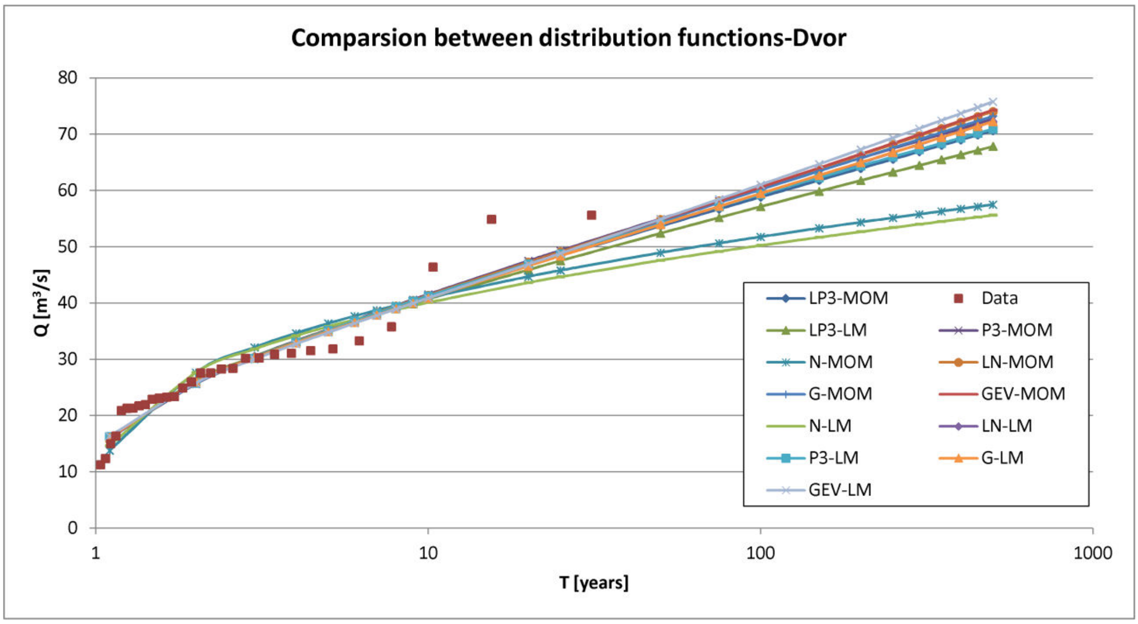

Figure 6: Flood frequency analysis results for station Dvor (1981-2010)

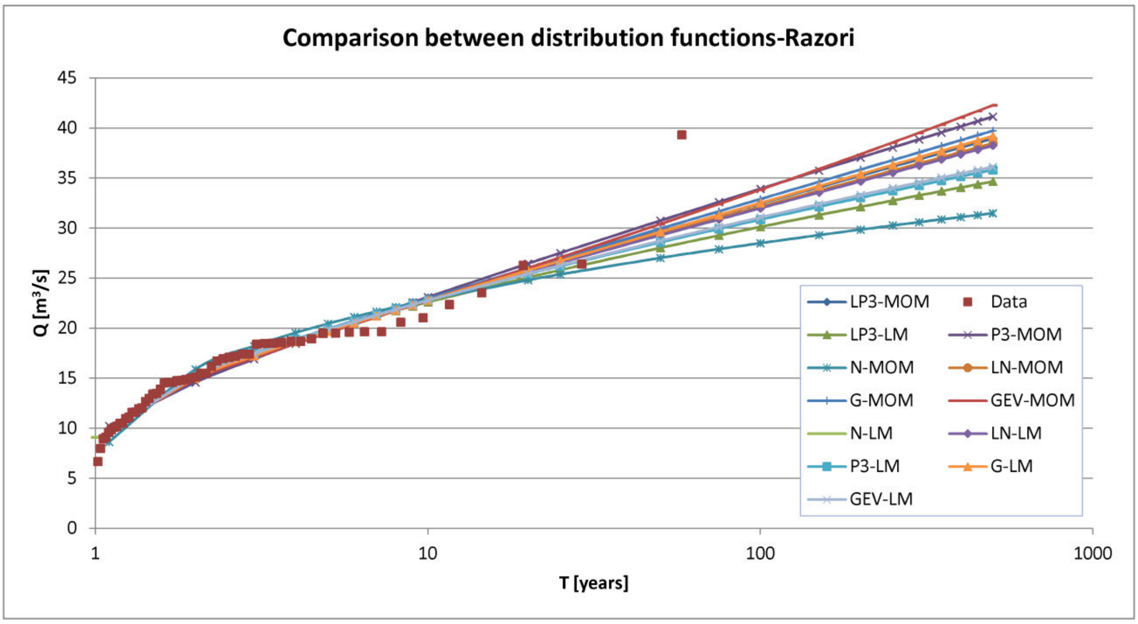

Figure 7: Flood frequency analysis results for station Razori (1954-2010)

Because of these problems Inženirng za vode (2006) made hydrological model HEC of analysed area. Estimated discharge values with return period 100 years were determined and comparison is shown in table 2. Topography (cross-sections) and precipitation data were used for calculation (model) of estimated discharge values (Inženirng za vode, 2007). Values calculated with model are compared with flood frequency analysis results of measured data (daily discharge data). Log-Pearson 3 and GEV distributions with parameters estimated with the method of moments and the method of L-moments were used for comparison.

Table 2: Comparison between estimated discharge values with return period 100 years

Estimated Q values	Dvor-Gradaščica	Razori-Šujica
Hydrologic model HEC (Inženirng za vode, 2007)	188	60
Log-Pearson 3 (MOM)	58,8	32,5
Log-Pearson 3 (L-moments)	57,2	30,1
GEV (MOM)	60,6	33,8
GEV (L-moments)	61,0	31,1

From table 2 one can see that estimated discharge values calculated with model HEC (Inženirng za vode, 2007) distinctly differ from estimated discharge values from the flood frequency analysis based on daily discharge values. For station Dvor this value is more than three times as GEV-LM (or any other) value and for station Razori model gave approximately two times larger values as GEV-LM. These differences could be explained with (frequent) flooding areas, which decrease peak discharge and also wave volume.

Seasonality analysis

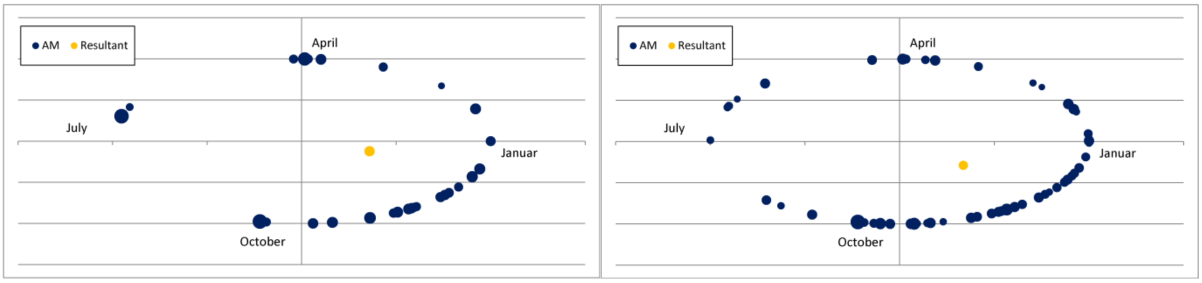

Figure 8: Display of seasonal behaviour of annual maximum series for stations Dvor and Razori, respectively

In Fig. 8, 9 and 10 seasonal behaviour of daily discharge series from stations Dvor and Razori is shown. Dinaric pluvial-nival regime is characteristic of the river Ljubljanica (Frantar and Hrvatin, 2008). Two fairly equal peaks in autumn and spring are characteristic of this regime (Frantar and Hrvatin, 2008). Summer water deficit is more expressive as winter (Frantar and Hrvatin, 2008). From Fig. 8, 9 and 10 we can see that for rivers Gradaščica and Šujica (also called Horjulščica) autumn peak is more expressive. Concentration of seasonality r was the largest for sample POT 1 from station Dvor (0,6). Other values of concentration of seasonality were around 0,4 or just below this value (AM, POT 3 for Dvor and AM, POT 1, POT 3 for Razori). From Fig. 8, 9 and 10 one can also see that at least extreme events occurred in summer time and the most events happened in autumn period.

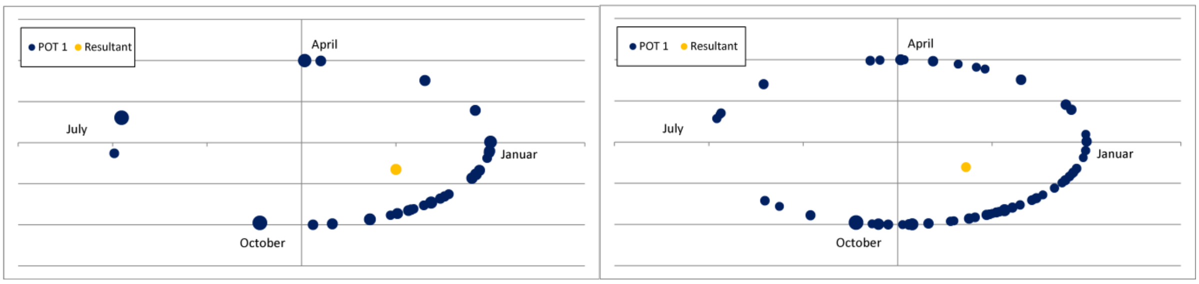

Figure 9: Display of seasonal behaviour of peaks over threshold series with an average of 1 event per year for stations Dvor and Razori, respectively

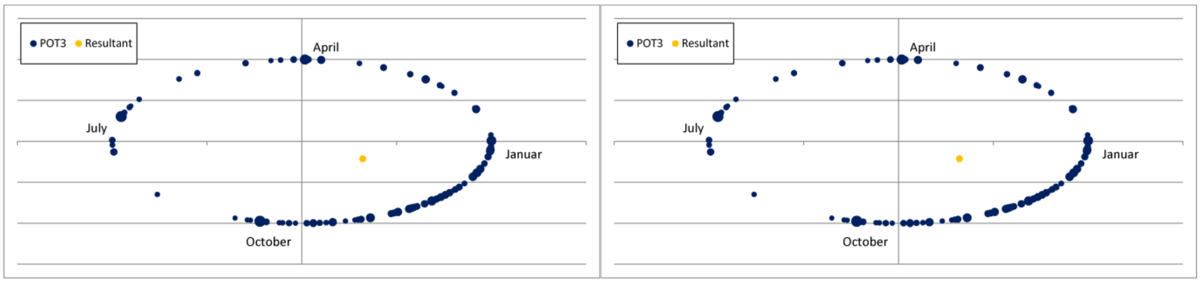

Figure 10: Display of seasonal behaviour of peaks over threshold series with an average of 3 events per year for stations Dvor and Razori, respectively

References

Frantar, P., Hrvatin, M., 2008. “Pretocni rezimi” in P. Frantar (ed.), Vodna bilanca Slovenije 1971–2000 = Water Balance of Slovenia 1971-2000. MOP ARSO, Ljubljana, 43–50.

Inženirng za vode, 2007. Določitev poplavne linije s povratno dobo 100 let za območje Gradaščice od naselja Gabrje do širšega območja Polhovega Gradca in Šujice ter potokov na območju Vrzdenca, Ljubgojno in Vovčne. Idejni projekt. Inženiring za vode, 13 f.