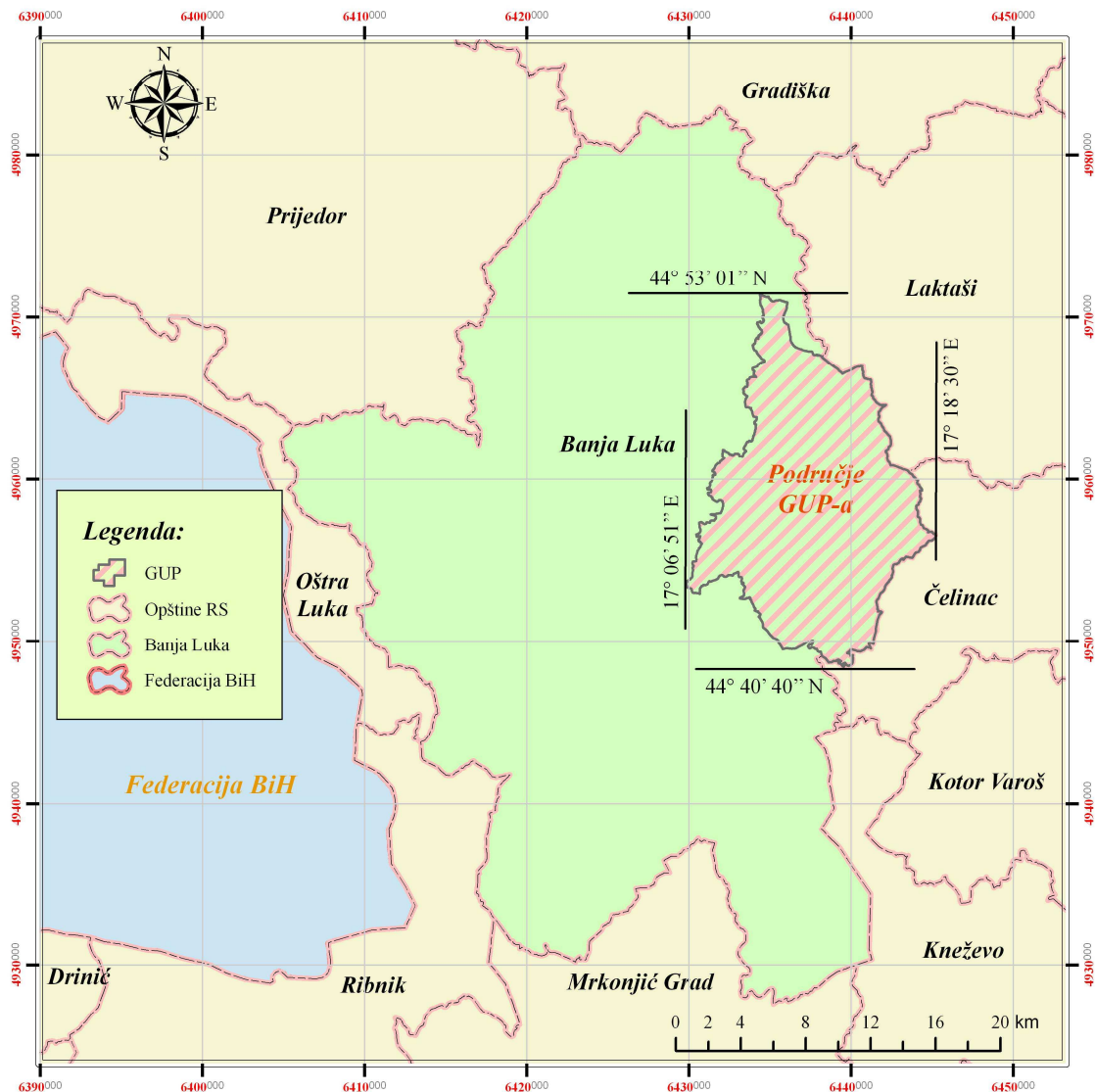


STORM WATER SEWERAGE SYSTEM

TEHNICAL REPORT INTRODUCTION

Urban area of city of Banja Luka is situated inside: 44°40'40" N, 17°06'51" E and 44°53'01" N, 17°18'30" E, in range of total area of 18.347 ha.

Geographical position of CUA Banja Luka



Banja Luka CUA is 183.47 km² and makes 14,81 % of total area of Municipality of Banja Luka that is 1239 km².

With current urbanistic plan narrower urban area of the city is increased from 895 ha (4,4%), to 5510 ha, and makes app 30% of total area of CUA.

City area is made of 14 settlements of which are 2 settlements partly in coverage of CUA. Settlements from CUA area are on area of 40 cadastral municipalities.

Settlements from range of CUA of BL

Number	Settlement	Settlement area [km ²]
1	Banja Luka	88.75
2	Bastasi	9.20
3	Debeljaci	8.65
4	Drakulić	5.53
5	Jagare	11.45
6	Kola Donja (dio)	10.96
7	Kuljani	4.05
8	Pavlovac	5.06
9	Ponir	7.95
10	Priječani	9.76
11	Ramići	6.69
12	Rekavice (dio)	5.30
13	Šargovac	6.13
14	Zalužani	3.99
Total area CUA:		183.47

Total area of CUA BL is divided into 61 catchment areas, in urban part of the city, from which storm water is collected and drained away by independent precipitation sewage systems.

In morphological terms Banjaluka's neogene basin can be divided into 7 basic terraces (according to S.Pavičić) while the Basic geological map can single out two main terraces, higher and lower terrace.

Higher terrace is built by clay, sandy clay, gravelly-sandy clay and gravel.

Lower terrace is built by gravel and sandy gravel.

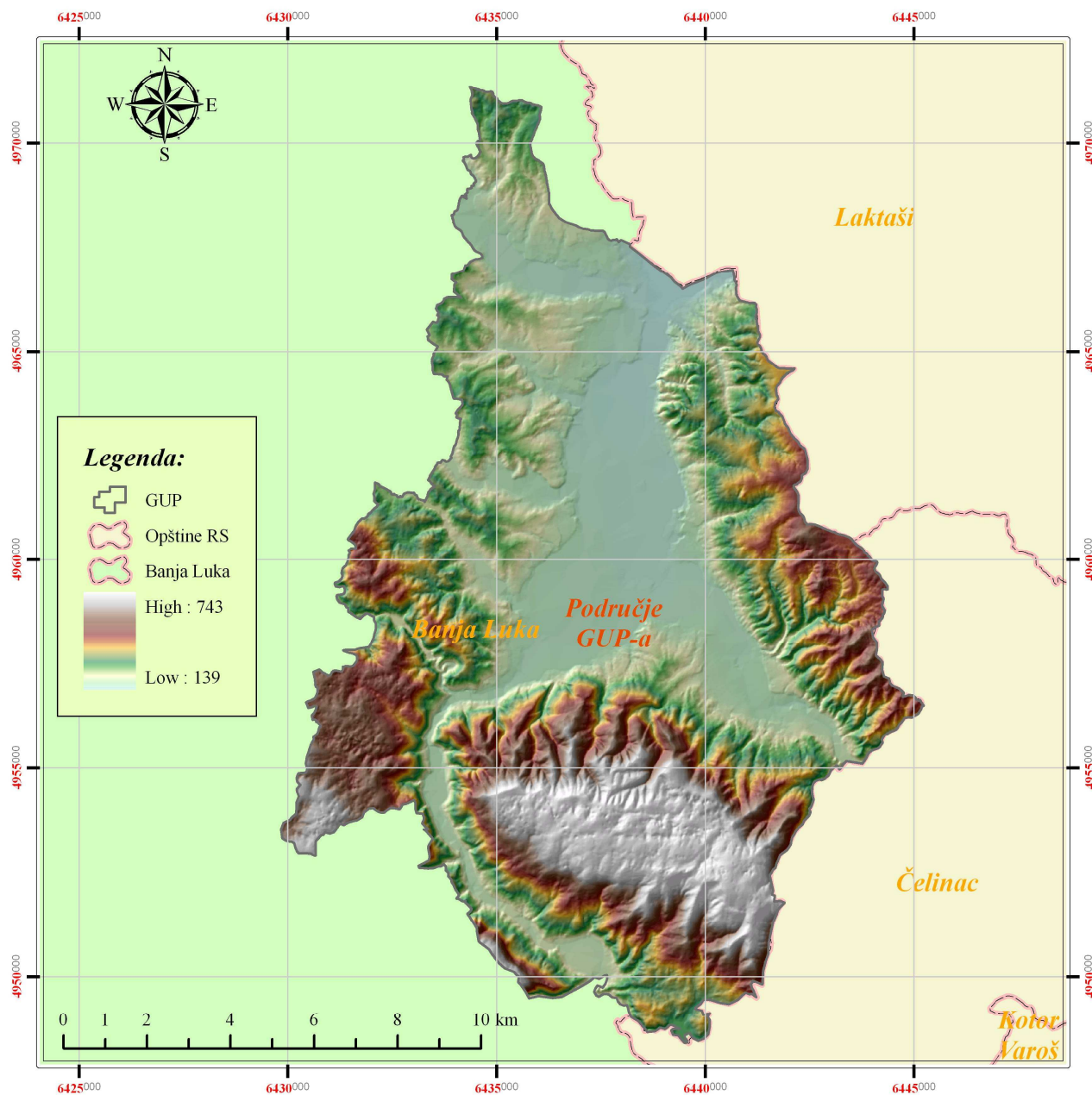
Hydrographic network in CUA area is developed, main recipient of surface water is Vrbas river and its right tributary Vrbanja river into which it flows around 25 fewer and bigger streams in CUA area, characterized by extremely torrent character.

River Vrbas in CUA area, during high water levels, floods riverside in three locations because of natural low shores in that areas, or because of unregulated riverbed of Vrbas river. Areas exposed to floods are: Begin road, Kumsale and Trapisti (Village of Delibaša).

Floods caused with torrent flows (mountain water) are given in areas between stream Močila 1-Crkvena, Crkvena-Podstranac, Podstranac-Široka river and Đurđevački stream-Jularac.

Floods of mountain water often occur in areas where these streams are introduced into rain collectors, that can not receive storm water in big return period.

Elevation model of CUA Banja Luka



Most of the CUA Banja Luka is flat with terrain elevation of 139-165 m.n.m. (center of Borik area and Hanište), and the rest is mountainous with terrain elevation of 165-743 m.n.m. Average terrain elevation for whole area of CUA is 29 meters above sea level.

Average field falls in flat part of CUA are in the range of 1,2-2,0 m/km.

PURPOSE OF WORK

Primary aim of making sewage system of waste water of CUA of city of Banja Luka is resolving about collecting, treatment and discharging purified rainwater of city area, or defining next important question in this domain.

- Total (optimal) number of draining rain water sewage into surface water that provides fulfillment of conditions for draining rainwater of settlements into surface watercourses in accordance with the law about water of RS (and suitable bylaws), as well as Europe water framework directive.
- Location of rain water drain and routes of precipitation collectors, because of reserving locations and passages for building this kind of objects, or purposeful reserving of space in Spatial plan of the city, Spatial plan of RS and necessary modifications of city master plan to reserve locations of future objects of sewage system.
- Evaluations of total necessary finances funds (resources) and evaluations of economic price 1 m³ of purified water, which provides coverage of all costs of the proposed system. (operational and exploitation costs).
- Possible phases of building objects and systems for timely planning of execution activities and providing necessary budget and credit funds, or defining basic components of dynamic plan executing activities and finance plan (construction) for realizations of proposed activities.

Activities to strategic questions is possible to give only through analysis of storm sewers in order to define the optimal solution.

Designer's task is to provide enough technical and financial indicators to investor for selecting the most profitable (optimal) variant, or to suggest variant that besides economical justification has to fulfill condition of safe drive system.

Analysed variants must deal with two basic conceptual approaches to the problem, covering next two basic concepts:

- Common treatment of storm water for reported catchment areas, before discharging into watercourses, for whole area of CUA, by building retentions for accepting contaminated rainwater for each catchment from which contaminated surface water is drawn by pumping stations and purifies by separators of grease and oil capacity of 20-50 l/s
- Combined purification of rainwater, applying retentions and separate separators of grease and oil for parts of catchment, where is possible that kind of configuration of sewage system.

In terms of making General project of city sewage network, designer's task is hydraulic dimensioning of city rainwater sewage network, with simulation of several – hour work of system to prove necessary capacity of city network in terms of accepting of all rainwater in CUA Banja Luka.

DESCRIPTION OF CURRENT SITUATION

The city of Banja Luka has partly built sewage system for collecting rainwater. Construction of sewage system began in 1912. but until today city doesn't have complete coverage of sewage system.

Most of the existing sewage systems are mixed type, while in some regulatory units built sewage system is separate type. Collected rainwater gravitationally by the shortest route drains to surface streams. In city area rainwater is embarking on the two largest recipients: Vrbas river and Vrbanja river, as well as in few streams that then flow into Vrbas river. Over the past few years was worked on locating all places of discharge rainwater and waste water, so today we know their locations. It should be borne in mind that the City of Banja Luka supplies with drinking water from Vrbas river and because of that priority is protection of Vrbas river upstream from water intake source Novoselija. Protection of water quality of Vrbas river will achieve besides building of sewage system of used water and with building sewage system of rainwater, whose drains end up with appropriate units for purifying rainwater before discharging into surface water.

Built sewage system in CUA Banja Luka is approximately 50% of mixed type and 50% of separate type. Besides that in built separate part of sewage system exists certain number of wrong and irregular parts of waste water on rainfall sewage so that parts need to be separated. Also was observed large number of illegal connections that are usually done incorrectly. These and similar cases before the detailed design is needed to track and predict solution.

Since year 2008. AD "Vodovod" (water supply) Banja Luka is working hard to locate the recording and registration of the existing sewerage system. Recording is done with modern vehicle which is intended specifically for this purpose, and vehicle has video camera so it is possible to review sewer visually which is very important for determining the condition of the sewer, as well as in most cases determining the profile, diameter and material of sewers. Based on existing recordings some sewers are completely covered with various materials, and it is necessary to clean them, but also there are sewers that are in good state and they could be used for future sewerage system. So far is recorded about 220km of sewage system.

It is necessary to locate and record complete system for investigating the possibilities for integration of existing systems in the future sewerage system.

Given the age of the sewer materials are the most common as asbestos cement and AB concrete, but also ceramic as well as plastic (PVC, PE). Sewer profiles are circular and egg – shaped. Circular profiles are represented from Ø300 to Ø600, egg – shaped profiles: Ø300/450, Ø400/600, Ø500/750, Ø600/900, Ø650/1000, Ø700/1050, Ø800/1200, Ø900/1350, Ø1500/2000, Ø1700/2200.

Current sewers for collecting and draining rainwater by capacity are mostly satisfactory for draining rain that lasts 20 minutes with return period of 2 years. Only small part of sewers is necessary to replace because of insufficient capacity.

Estimated total length of the sewer is 405km.

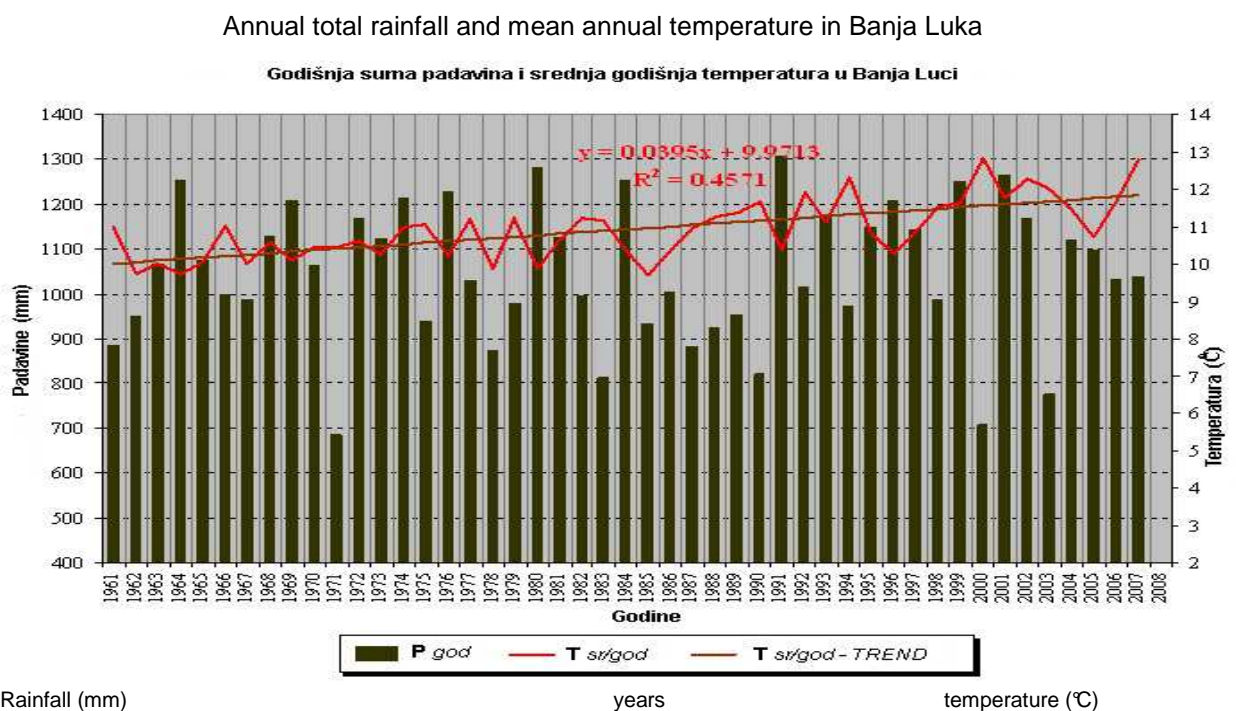
Based on the current terrain configuration, using the principle of gravitational drainage of rainwater, is defined by a total of 61 catchment area, with which the storm water drains through independent sewerage systems.

Total length of the main rain sewer is around 150km, while the length of secondary sewers is around 255km, of which approximately 50% sewerage system is completed.

Climate and morphological characteristics of the terrain

CUA Banja Luka belongs to the temperate continental climates with the following climatic characteristics:

Chart: Climatic characteristics of CUA Banja Luka



Average annual temperatures are in range from 10 to 12°C. CUA is characterised mostly with northern and north – westerly winds speeds up to 20m/s. The strongest winds are northern.

Geological and hydrogeological characteristics

Geological structure of CUA consists of Neogene sedimentary formations and Quaternary sediments of river terrace and they have the largest distribution on CUA.

With hydrogeological point, CUA belongs to hydrogeological reon reflected in the great abundance of source water in the alluvial sediments of the Vrbas river, which in principle consists of two lithological members:

- Upper layer (terrace) thickness 6.0 – 8.0m, that is consisted of clay, clayey sands, gravelly sandy clay and less gravel.
- Lower layer (terrace), layer of thickness 4.0 – 6.0m, that is consisted of gravel and sandy gravel.

- Groundwater level (GWL), according to available data mostly goes from 6 – 8m below surface terrain, depending on water level of the Vrbas river.

Hydrological substrate
Rainfall in the CUA Banja Luka

Basis for the analysis of rainfall are data for Banja Luka weather station. Available data RHMZ Banja Luka were analyzed, as well as available data from water Agency for river basin of Sava river from Bijeljina.

According to available meteorological data, RHMZ Banja Luka for MS Banja Luka, rainfall in CUA of Banja Luka have next characteristics:

Table: Average number of days with rainfall

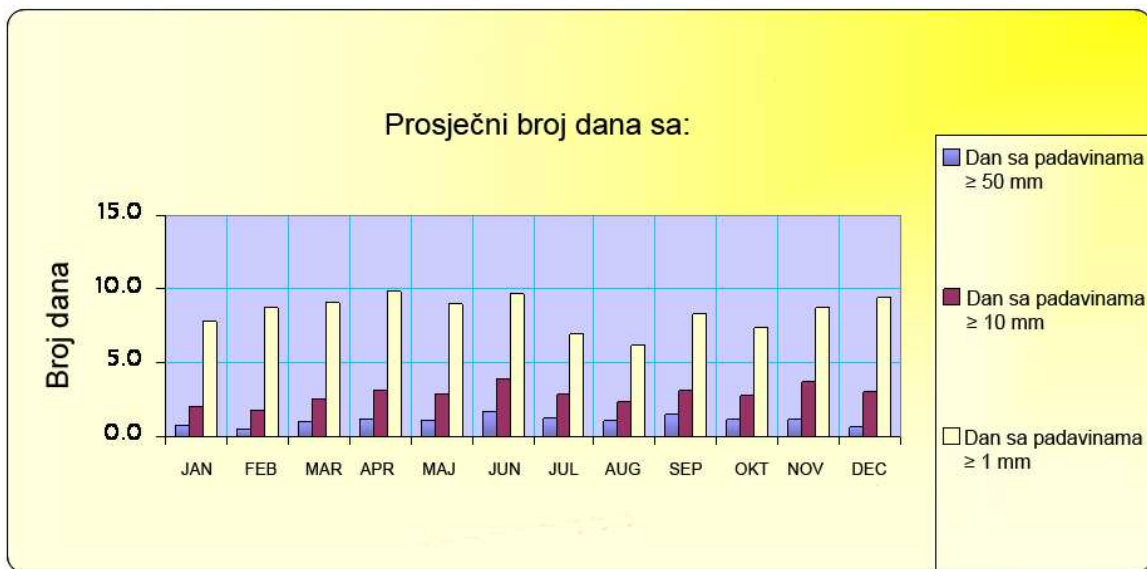


Table: Maximum daily rainfall

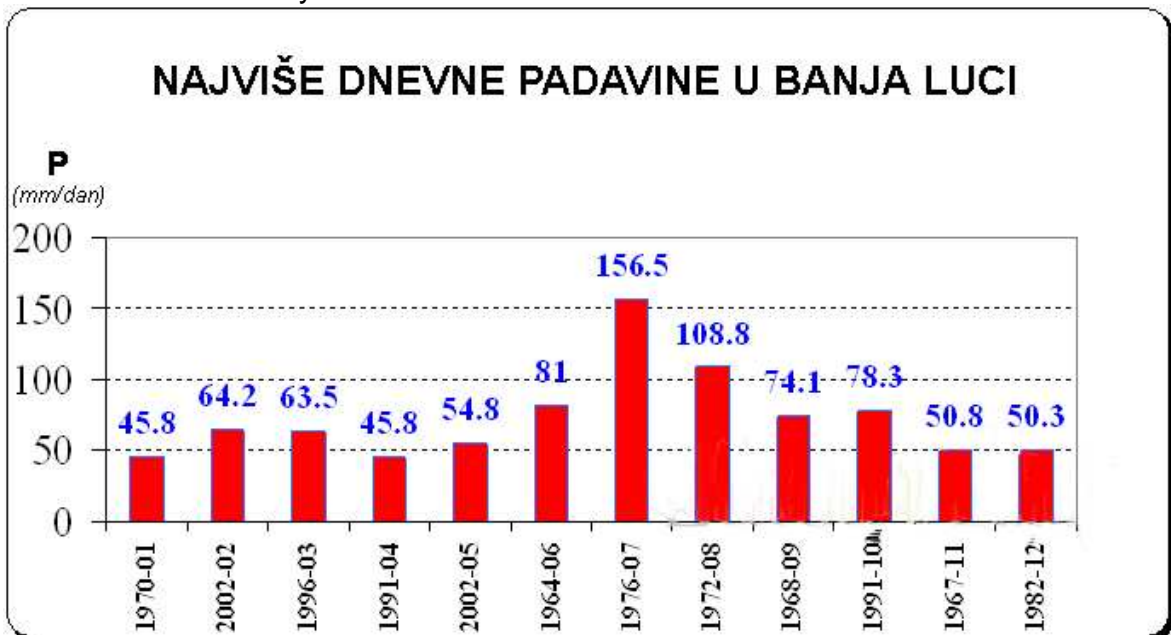
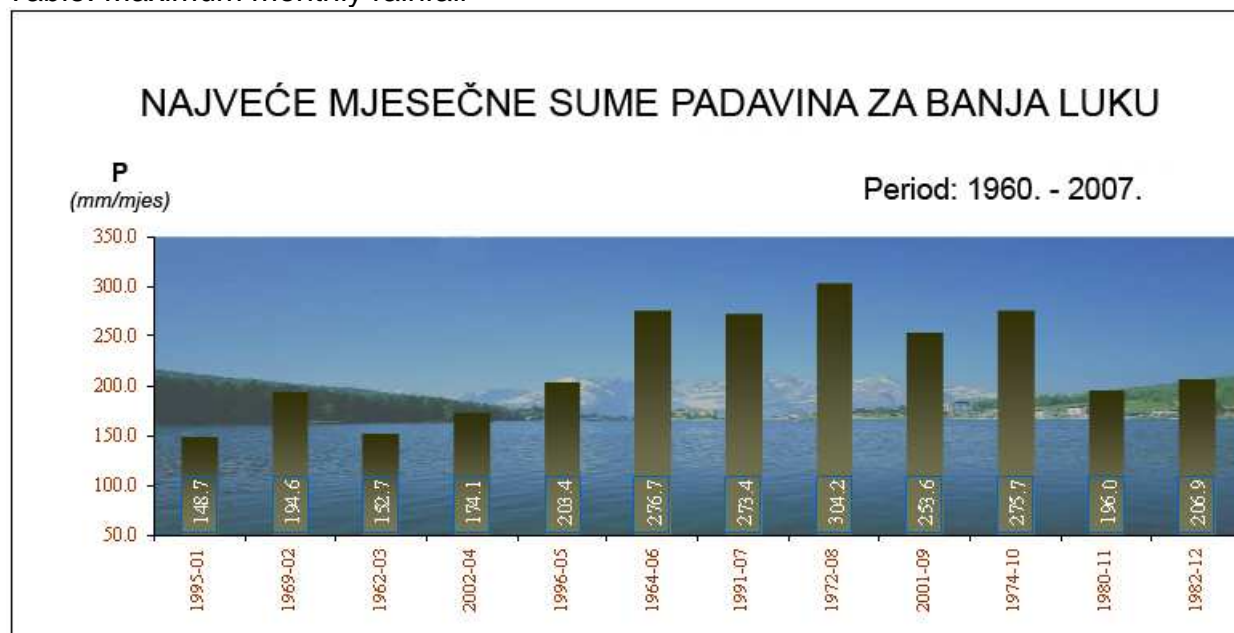


Table: Maximum monthly rainfall



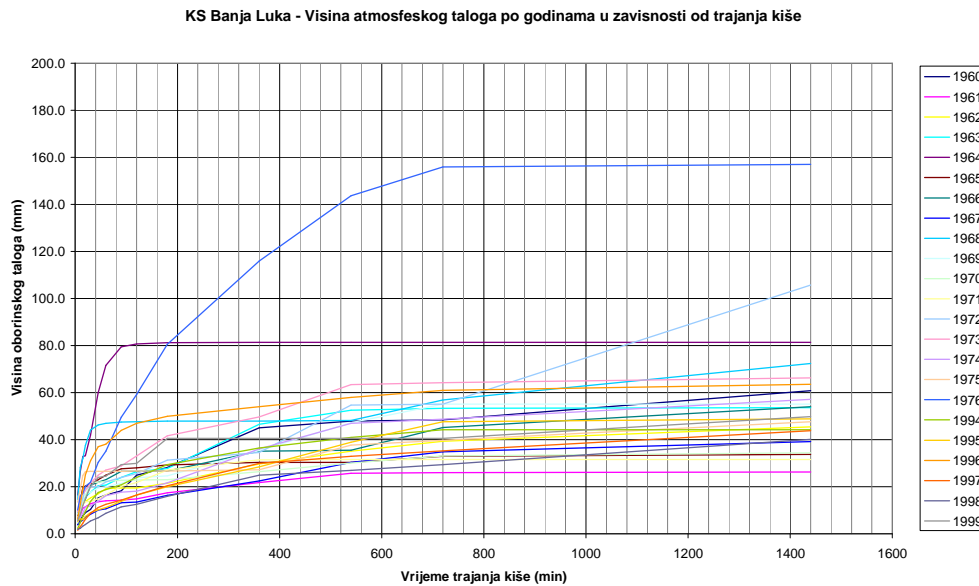
Data of water Agency for river basin of Sava river about short – term rainfall in the area of CUA Banja Luka are given in the following table.

Table: Table for rainfall duration from 5min to 24h (1440min)

God	MS Banja Luka – Rainfall duration (min)													
	5	10	15	20	30	45	60	90	120	180	360	540	720	1440
Rainfall height (mm)														
1960	4.0	6.0	7.6	8.9	10.4	15.2	16.5	18.2	25.0	28.2	45.0	48.0	48.4	60.8
1961	6.4	7.9	11.0	11.5	12.9	13.6	14.0	14.3	14.9	17.4	21.8	25.7	26.0	26.3
1962	8.3	11.0	12.7	13.8	15.2	17.1	19.2	19.4	19.4	21.5	29.6	35.2	39.3	45.5
1963	8.8	11.3	13.0	15.5	17.7	20.4	20.7	24.0	26.4	27.7	46.5	52.5	53.4	53.6
1964	16.5	26.4	32.8	33.2	41.9	60.0	71.6	79.4	80.7	81.2	81.3	81.3	81.4	81.4
1965	7.9	14.2	19.6	20.3	21.2	23.1	24.9	27.6	28.1	29.3	30.4	30.4	32.9	33.7
1966	9.0	11.3	12.7	14.8	20.7	21.9	23.0	26.5	26.6	26.7	35.1	35.6	45.2	54.1
1967	3.8	5.1	5.9	7.0	8.4	10.1	10.6	13.2	13.5	16.4	22.5	30.3	34.8	39.2
1968	14.6	28.2	32.0	37.6	44.1	46.2	47.0	47.5	47.6	47.9	48.0	48.1	56.9	72.4
1969	8.4	13.7	15.5	16.8	17.7	19.4	20.0	21.3	23.8	24.7	35.4	47.2	55.1	55.1
1970	4.5	8.9	12.6	16.1	21.8	21.9	22.3	22.8	22.9	23.0	26.4	30.1	33.1	34.5
1971	5.7	10.1	13.5	13.6	13.7	14.9	16.6	20.2	21.8	27.1	31.5	31.6	31.6	31.6
1972	6.2	11.0	15.1	19.3	20.0	20.0	22.0	23.9	25.6	31.4	34.6	54.7	55.1	105.7
1973	9.4	15.5	17.2	18.4	21.5	25.0	27.1	28.9	33.1	41.7	49.7	63.4	64.2	66.3
1974	5.5	7.1	8.7	11.3	11.9	13.9	16.2	17.7	18.1	21.6	36.0	46.9	48.7	57.1
1975	13.5	19.2	24.8	26.4	26.6	26.6	26.6	26.6	26.7	26.7	27.2	37.7	39.8	47.6
1976	10.1	16.1	17.3	20.2	21.9	30.3	35.1	49.6	59.2	80.6	116.0	143.7	155.9	157.1
1994	2.4	4.8	7.4	9.6	13.7	17.5	18.8	20.8	24.0	29.5	36.5	41.0	44.2	44.2
1995	5.3	6.5	6.0	7.3	9.0	10.3	11.1	13.7	16.5	20.0	28.5	39.0	47.6	48.8
1996	6.3	12.6	19.0	25.1	31.0	37.0	38.1	44.0	47.0	50.0	54.0	58.0	60.9	63.5
1997	1.5	3.0	4.5	6.1	8.7	11.2	12.5	14.3	16.5	20.5	30.0	33.0	35.3	43.8
1998	2.0	2.4	3.3	4.0	5.5	6.8	8.7	11.4	12.5	16.0	25.0	27.0	29.4	40.2
1999	5.6	8.3	12.0	15.0	20.0	24.0	24.5	29.4	30.0	40.5	40.5	40.5	40.5	49.9

Chart No.1: Graphical representation of data from table given below

KS BANJA LUKA – Amount of atmospheric sludge per year, depending on the duration of the rain

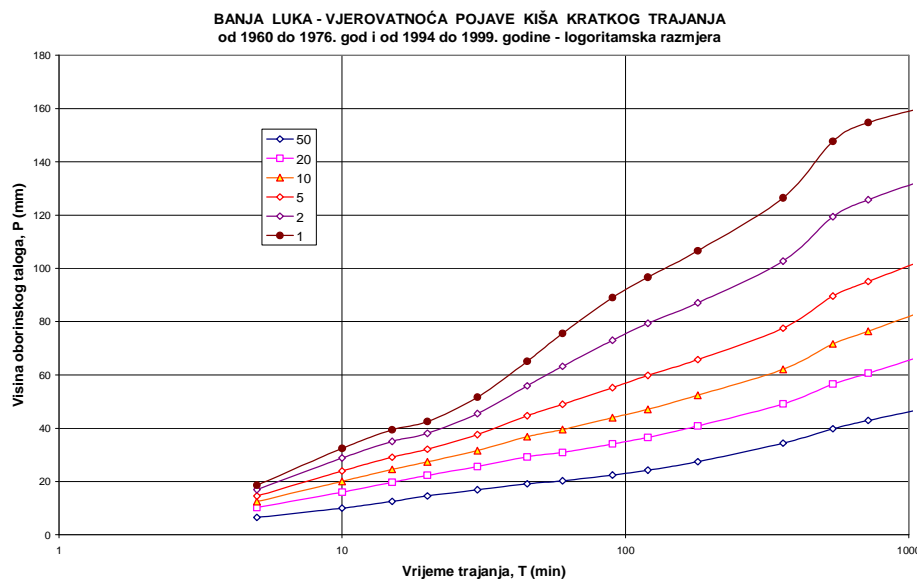


Amount of rainfall sludge (mm) rain duration time (min)

Based on data from table above, for period from 1960 – 1999., the analysis of the probability of occurrence of rainfall duration from 1 – 24h was performed, and then extrapolated on duration shorter than one hour. Graph of the amount of rainfall return period (probability) of their occurrence, is shown in logarithmic scale in chart No. 2, and in minute scale in chart No.3.

Chart No.2: Rainfall depending on the return period and duration
Logarithmic scale for duration

Banja Luka – probability of occurrence of rain of short durations since 1960 until 1976, and since 1994 until 1999. logarythmic scale



Amount of rainfall sludge, P (mm) duration time, T (min)

By processing of HMZ from Sarajevo for the purpose of making Study – Conceptual design of draining waste water and rainfall for Banja Luka city, in 1975., data for short – term rainfall in the CUA Banja Luka are given for observed data, in the following table.

Table: Table for rainfall of short – duration HMZ Sarajevo (1975.)

Probability of occurrence (%)	Return period [year]	Rainfall duration (minutes)													
		5	10	15	20	30	40	50	60						
		Rainfall height (mm)													
100	1	-	9.7	-	13.2	15.5	17.2	18.9	19.4						
50	2	-	10.1	-	16.2	18.0	20.4	22.5	22.8						
33	3	-	11.4	-	20.4	21.6	22.8	27.0	25.2						
25	4	-	12.0	-	21.6	23.4	24.0	27.0	27.0						

Calculation of short – term rainfall KS Banja Luka

KS Banja Luka – Processing of daily values

Table: Characteristic of rainfall KS Banja Luka

T	1 day	2 days	3 days
50	51,7	72,3	79,7
20	73,2	102,4	111,9
10	87,4	122,5	133,3
5	101,1	141,7	153,8
1	132,1	185,1	200,2

KS Banja Luka – Analysis of rainfall on the basis of hourly and daily values

Processor were available sequences of hourly (minute and hourly) values of rainfall in the KS Banja Luka in period from 1960. to 1976. and from 1994. to 1999. Maximum annual 5, 10, 15, 20, etc., until 1440 min rainfall are shown in previous attachment.

Complete results of budget of maximum annual hourly rainfall are shown in table for adopted probability in this attachment:

KS BANJA LUKA													Attachment 4.	
PROBABILITY OF OCCURENCE OF MAXIMUM ANNUAL MINUTE RAINFALL (mm)														
With an appropriate test by Kolmogorov - Period 1960 - 1976 and 1994 - 1999 year – adopted Log Pirson distribution														
	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka
	5 min	10 min	15 min	20 min	30 min	45 min	60 min	90 min	120 min	180 min	360 min	540 min	720 min	1440 min
	L Pirson	L Pirson	L Pirson	L Pirson	L Pirson	L Pirson	L Pirson	L Pirson	L Pirson	L Pirson	L Pirson	L Pirson	L Pirson	L Pirson
	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK
	100.0	100.0	98.2	100.0	99.2	100.0	100.0	99.8	99.8	97.2	100.0	99.8	100.0	100.0
99.9	0.6	1.1	1.5	2.0	3.3	4.9	6.6	8.9	9.8	12.7	20.2	24.4	26.3	24.3
90	2.8	4.4	5.7	7.0	8.8	10.5	11.8	13.8	15.1	17.8	24.5	28.8	31.2	33.6
50	6.6	10.0	12.6	14.7	17.0	19.2	20.3	22.5	24.3	27.5	34.5	39.9	43.1	49.9
20	10.3	16.1	19.8	22.4	25.7	29.3	31.0	34.2	36.7	41.0	49.3	56.8	60.8	71.0
10	12.5	20.1	24.6	27.4	31.7	36.9	39.6	44.1	46.9	52.5	62.3	71.8	76.6	88.2
5	14.6	24.0	29.2	32.2	37.7	44.8	49.1	55.4	58.6	65.9	77.7	89.8	95.3	107.6
1	18.6	32.5	39.5	42.6	51.7	65.2	75.7	89.2	93.3	106.9	126.7	148.0	155.1	163.6
0.5	20.2	36.0	43.7	46.8	58.0	75.2	89.7	108.0	112.3	130.1	155.5	182.7	190.3	193.9
0.1	23.4	44.0	53.5	56.5	73.1	101.3	129.6	165.0	169.6	202.3	248.3	296.2	304.4	283.2

KS BANJA LUKA

PROBABILITY OF OCCURENCE OF MAXIMUM ANNUAL MINUTE RAINFALL (mm)

With an appropriate test by Kolmogorov - Period 1960 - 1976 and 1994 - 1999 year

	5 minutes				10 minutes				15 minutes				20 minutes			
	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka
	5 min	5 min	5 min	5 min	10 min	10 min	10 min	10 min	15 min	15 min	15 min	15 min	20 min	20 min	20 min	20 min
	Galton	Gumbel	Pirson	L Pirs.	Galton	Gumbel	Pirson	L Pirs.	Galton	Gumbel	Pirson	L Pirs.	Galton	Gumbel	Pirson	L Pirs.
	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK
	96.0	86.0	100.0	100.0	99.3	85.4	100.0	100.0	90.3	92.5	100.0	98.2	98.5	97.9	100.0	100.0
99.9	1.0	-0.2	-0.6	0.6	1.5	-1.3	0.2	1.1	2.1	-0.9	0.0	1.5	2.7	0.1	0.4	2.0
90	2.9	3.1	2.8	2.8	4.5	4.2	4.2	4.4	5.8	5.7	5.5	5.7	7.2	7.2	6.8	7.0
50	6.2	6.6	6.7	6.6	9.6	10.3	10.2	10.0	12.1	12.9	12.9	12.6	14.2	14.9	15.0	14.7
20	10.2	10.0	10.2	10.3	16.0	16.0	16.2	16.1	19.7	19.7	19.9	19.8	22.3	22.1	22.5	22.4
10	13.2	12.2	12.3	12.5	20.8	19.8	20.0	20.1	25.3	24.1	24.3	24.6	28.1	26.9	27.2	27.4
5	16.3	14.3	14.2	14.6	25.8	23.4	23.5	24.0	31.1	28.4	28.4	29.2	34.2	31.6	31.5	32.2
1	24.4	19.1	18.1	18.6	38.9	31.6	31.3	32.5	45.9	38.1	37.1	39.5	49.2	42.0	40.6	42.6
0.5	28.3	21.2	19.7	20.2	45.2	35.2	34.5	36.0	53.0	42.3	40.7	43.7	56.2	46.5	44.4	46.8
0.1	38.3	25.9	23.2	23.4	61.5	43.3	41.8	44.0	71.1	51.9	48.7	53.5	74.0	56.8	52.7	56.5

KS BANJA LUKA

PROBABILITY OF OCCURENCE OF MAXIMUM ANNUAL MINUTE RAINFALL (mm)

With an appropriate test by Kolmogorov - Period 1960 - 1976 and 1994 - 1999 year

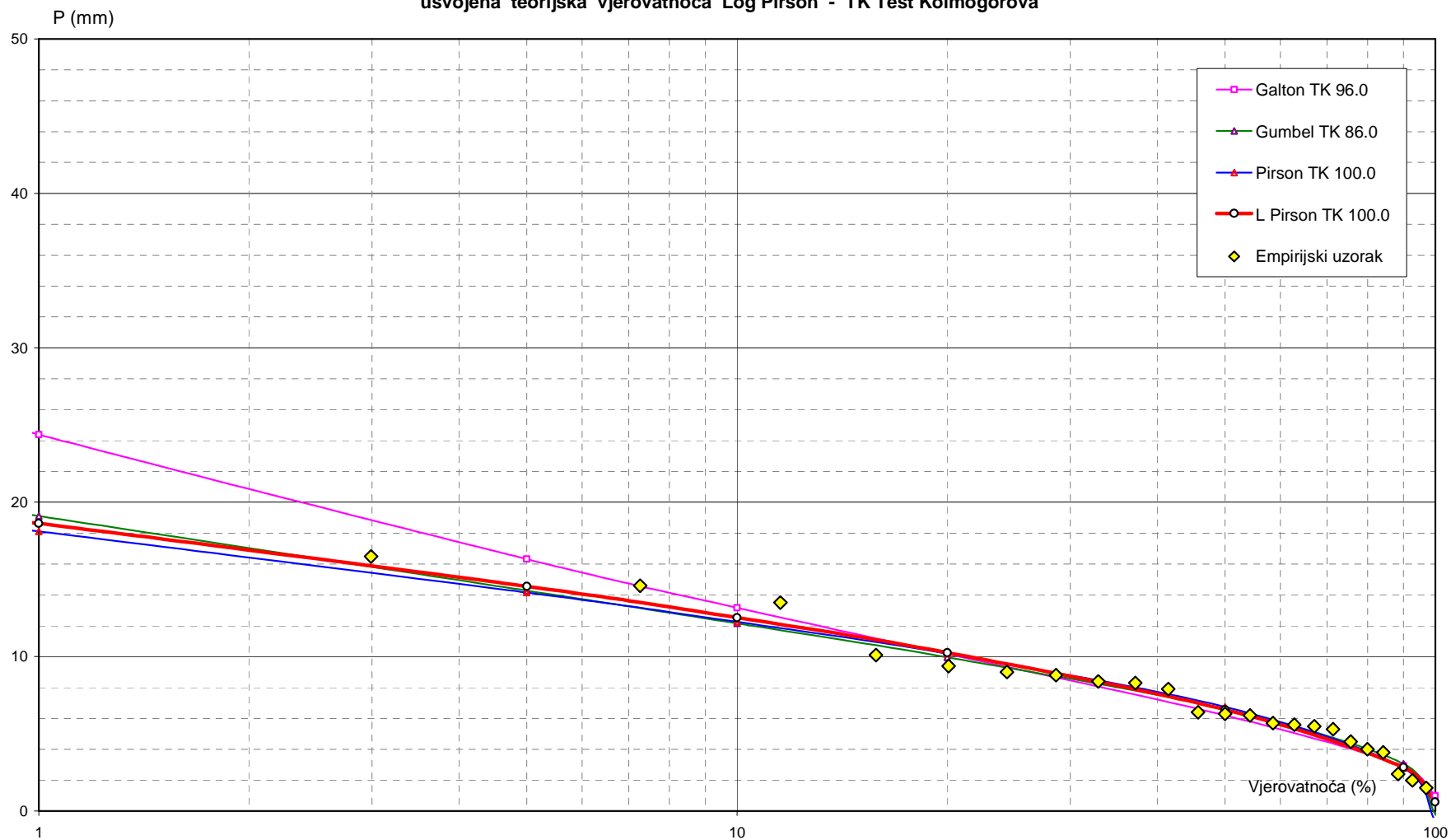
	30 minutes				45 minutes				60 minutes				90 minutes			
	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka	B Luka
	30 min	30 min	30 min	30 min	45 min	45 min	45 min	45 min	60 min	60 min	60 min	60 min	90 min	90 min	90 min	90 min
	Galton	Gumbel	Pirson	L Pirs.	Galton	Gumbel	Pirson	L Pirs.	Galton	Gumbel	Pirson	L Pirs.	Galton	Gumbel	Pirson	L Pirs.
	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK
	98.4	51.6	96.3	99.2	100.0	66.9	100.0	100.0	99.4	34.7	98.0	100.0	93.1	20.9	97.7	99.8
99.9	3.6	0.1	2.9	3.3	4.3	-1.3	7.2	4.9	4.8	-2.7	10.4	6.6	5.7	-3.0	11.4	8.9
90	8.9	8.4	8.4	8.8	10.4	8.9	10.2	10.5	11.5	9.0	11.7	11.8	13.1	10.1	13.0	13.8
50	16.8	17.4	17.2	17.0	19.5	20.1	19.1	19.2	21.1	21.6	19.8	20.3	23.8	24.3	22.3	22.5
20	25.6	25.9	26.1	25.7	29.5	30.7	30.1	29.3	31.5	33.6	31.9	31.0	35.1	37.7	36.0	34.2
10	31.9	31.5	31.8	31.7	36.5	37.7	37.8	36.9	38.9	41.5	41.1	39.6	43.0	46.6	46.3	44.1
5	38.3	37.0	37.2	37.7	43.7	44.4	45.3	44.8	46.2	49.1	50.5	49.1	50.9	55.1	56.7	55.4
1	53.9	49.2	49.0	51.7	61.0	59.6	62.7	65.2	64.0	66.3	72.8	75.7	69.9	74.4	81.4	89.2
0.5	61.0	54.4	53.9	58.0	69.0	66.1	70.2	75.2	72.1	73.7	82.7	89.7	78.5	82.7	92.3	108.0
0.1	79.0	66.5	65.0	73.1	88.8	81.1	87.8	101.3	92.2	90.7	106.3	129.6	99.6	101.8	118.2	165.0

KS BANJA LUKA																
PROBABILITY OF OCCURENCE OF MAXIMUM ANNUAL MINUTE RAINFALL (mm)																
With an appropriate test by Kolmogorov - Period 1960 - 1976 and 1994 - 1999 year																
	120 minutes				180 minutes				360 minutes				540 minutes			
	B Luka Galton	B Luka Gumbel	B Luka Pirson	B Luka L Pirs.	B Luka Galton	B Luka Gumbel	B Luka Pirson	B Luka L Pirs.	B Luka Galton	B Luka Gumbel	B Luka Pirson	B Luka L Pirs.	B Luka Galton	B Luka Gumbel	B Luka Pirson	B Luka L Pirs.
	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK
	83.5	20.2	97.0	99.8	60.2	15.1	85.4	97.2	74.6	30.4	99.8	100.0	98.7	37.6	99.0	99.8
99.9	6.3	-2.1	11.7	9.8	7.6	-1.5	12.9	12.7	11.3	0.3	22.4	20.2	13.3	-0.7	25.1	24.4
90	14.4	11.4	14.0	15.1	16.8	13.5	16.0	17.8	22.7	18.0	24.0	24.5	26.5	20.3	29.5	28.8
50	25.7	26.2	24.4	24.3	29.4	29.8	28.0	27.5	37.2	37.2	33.7	34.5	43.2	43.1	38.2	39.9
20	37.6	40.1	38.7	36.7	42.4	45.3	43.9	41.0	51.5	55.5	51.5	49.3	59.6	64.7	58.3	56.8
10	45.9	49.3	49.2	46.9	51.3	55.5	55.4	52.5	61.0	67.5	66.0	62.3	70.5	78.9	75.8	71.8
5	54.1	58.2	59.7	58.6	60.1	65.3	66.9	65.9	70.3	79.0	81.1	77.7	81.0	92.6	94.7	89.8
1	73.6	78.2	84.4	93.3	80.9	87.5	93.6	106.9	91.5	105.2	118.5	126.7	105.1	123.6	142.7	148.0
0.5	82.5	86.8	95.2	112.3	90.2	96.9	105.2	130.1	100.8	116.4	135.4	155.5	115.6	136.9	164.9	182.7
0.1	104.1	106.6	120.9	169.6	112.9	118.9	132.6	202.3	123.0	142.3	176.3	248.3	140.8	167.5	219.4	296.2

KS BANJA LUKA								
PROBABILITY OF OCCURENCE OF MAXIMUM ANNUAL MINUTE RAINFALL (mm)								
With an appropriate test by Kolmogorov - Period 1960 - 1976 and 1994 - 1999 year								
	720 minutes				1440 minutes			
	B Luka Galton	B Luka Gumbel	B Luka Pirson	B Luka L Pirs.	B Luka Galton	B Luka Gumbel	B Luka Pirson	B Luka L Pirs.
	TK	TK	TK	TK	TK	TK	TK	TK
	99.8	36.0	81.3	100.0	100.0	55.0	93.0	100.0
99.9	14.6	-0.2	25.8	26.3	15.9	3.4	31.9	24.3
90	28.8	22.1	32.9	31.2	32.0	27.0	33.9	33.6
50	46.5	46.3	40.7	43.1	52.6	52.7	48.4	49.9
20	63.8	69.2	61.5	60.8	72.9	77.0	72.7	71.0
10	75.2	84.3	80.2	76.6	86.5	93.0	91.7	88.2
5	86.2	98.9	100.6	95.3	99.6	108.5	111.3	107.6
1	111.3	131.8	153.5	155.1	129.8	143.4	159.1	163.6
0.5	122.2	145.9	178.1	190.3	143.0	158.3	180.5	193.9
0.1	148.3	178.4	239.1	304.4	174.6	192.9	231.9	283.2

Results of calculations are shown in following attachments:

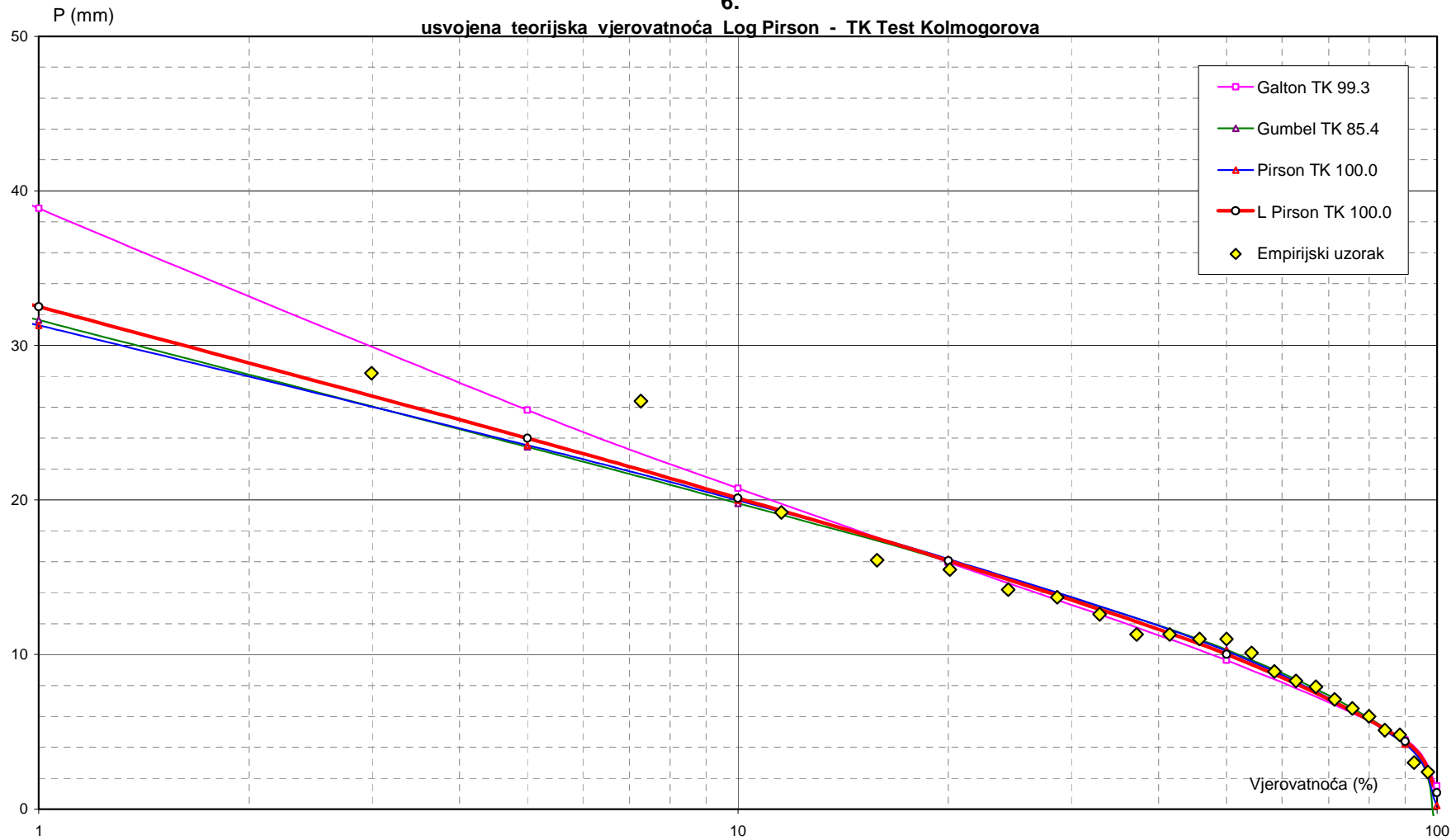
KS BANJA LUKA - VJEROVATNOĆE POJAVA KIŠA TRAJANJA 5 min (60 - 76, 94 - 99 god) Prilog 5.
 usvojena teorijska vjerovatnoća Log Pirson - TK Test Kolmogorova



KS – BANJA LUKA OCCURRENCE PROBABILITY OF RAIN DURATION 5min (60 – 76, 94 – 99 year) Attachment 5.
 Adopted theoretical probability Log Pirson – TK Kolmogorov's test

KS BANJA LUKA - VJEROVATNOĆE POJAVA KIŠA TRAJANJA 10 min (60 - 76, 94 - 99 god) Prilog

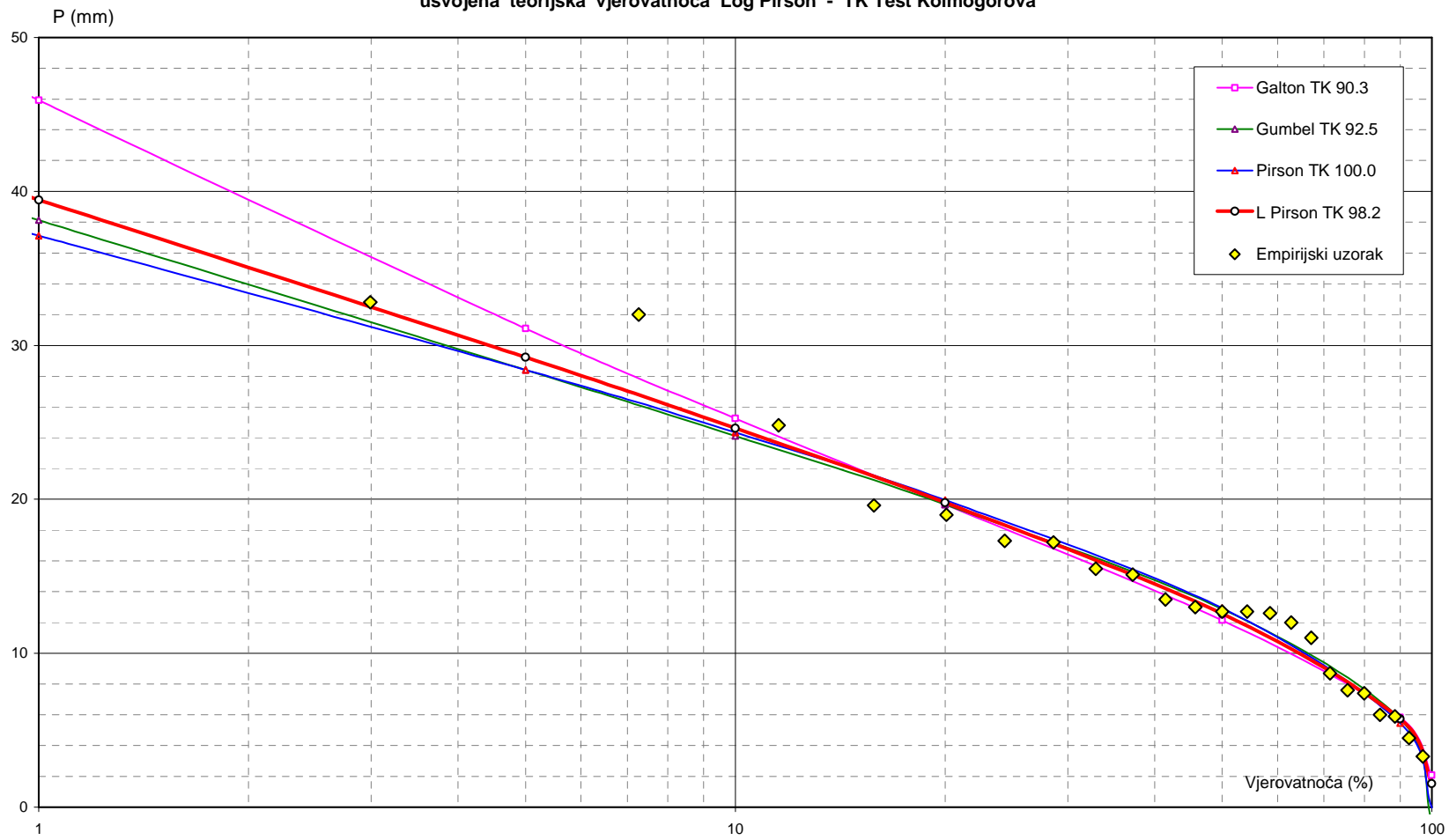
6.



KS – BANJA LUKA OCCURRENCE PROBABILITY OF RAIN DURATION 10min (60 – 76, 94 – 99 year)
 Adopted theoretical probability Log Pirson – TK Kolmogorov's test

Attachment 6.

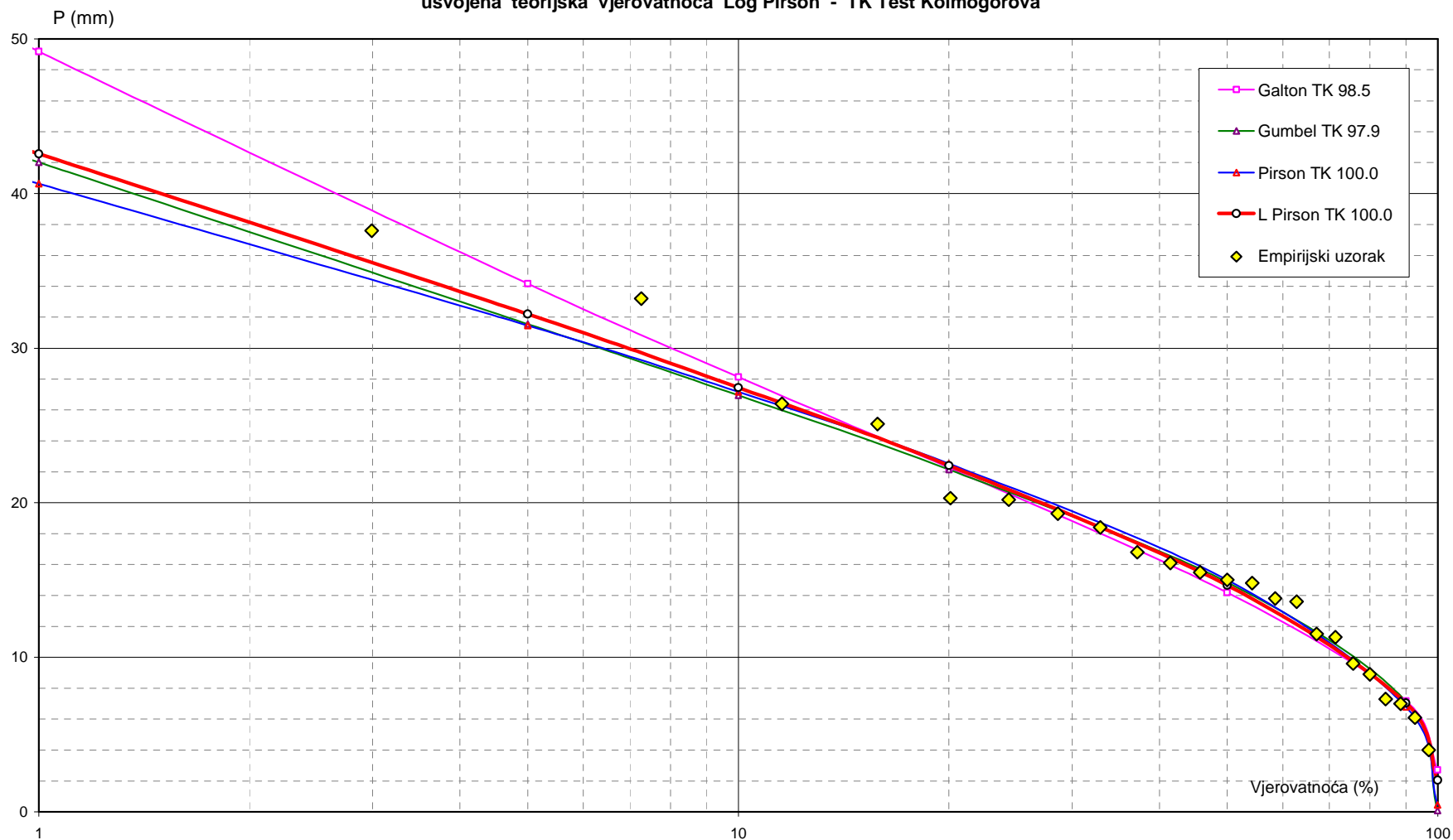
KS BANJA LUKA - VJEROVATNOĆE POJAVA KIŠA TRAJANJA 15 min (60 - 76, 94 - 99 god) Prilog 7.
 usvojena teorijska vjerovatnoća Log Pirson - TK Test Kolmogorova



KS – BANJA LUKA OCCURRENCE PROBABILITY OF RAIN DURATION 15min (60 – 76, 94 – 99 year)
 Adopted theorological probability Log Pirson – TK Kolmogorov's test

Attachment 7.

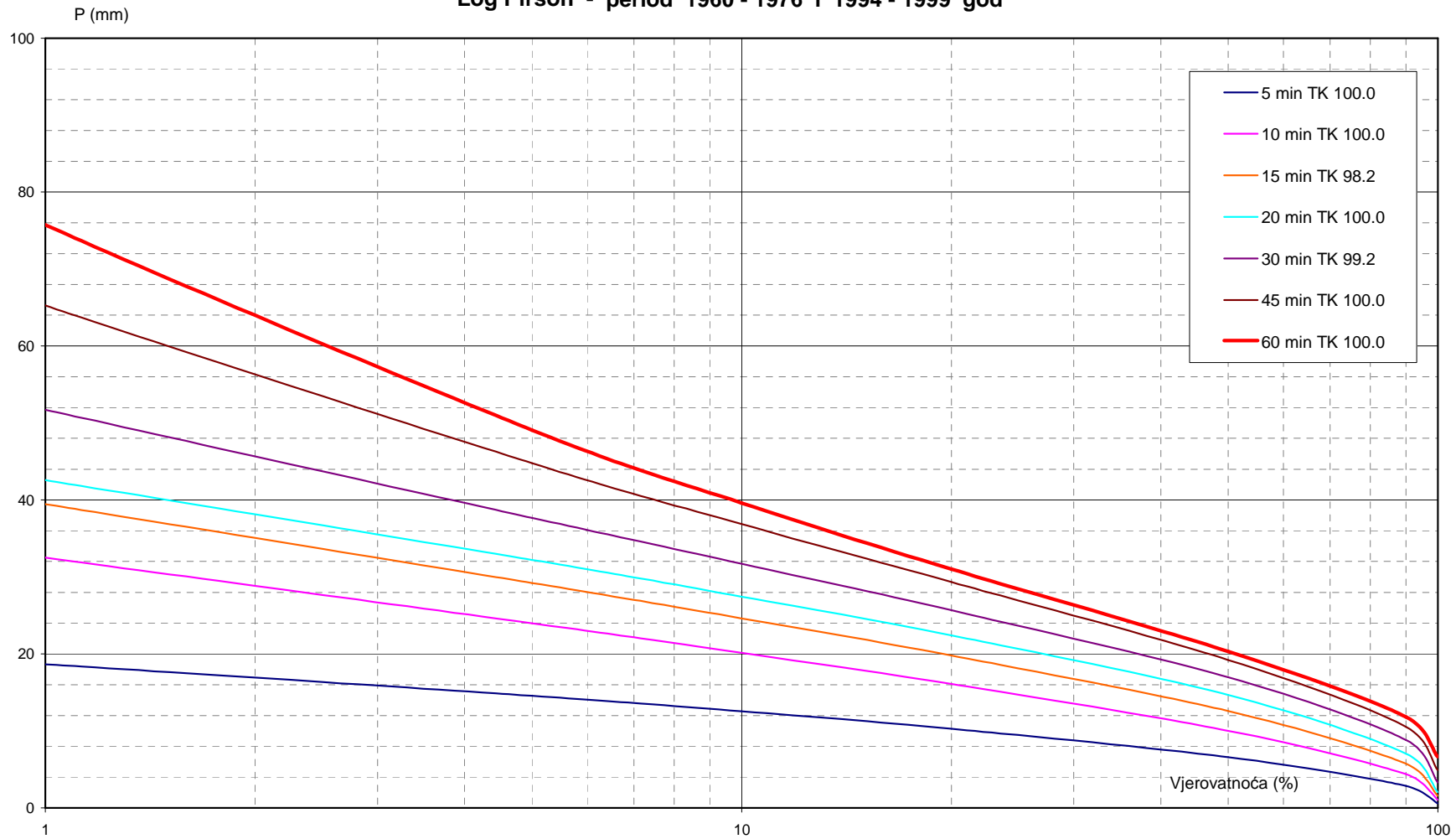
KS BANJA LUKA - VJEROVATNOĆE POJAVA KIŠA TRAJANJA 20 min (60 - 76, 94 - 99 god) Prilog 8.
 usvojena teorijska vjerovatnoća Log Pirson - TK Test Kolmogorova



KS – BANJA LUKA OCCURRENCE PROBABILITY OF RAIN DURATION 20min (60 – 76, 94 – 99 year)
 Adopted theorological probability Log Pirson – TK Kolmogorov's test

Attachment 8.

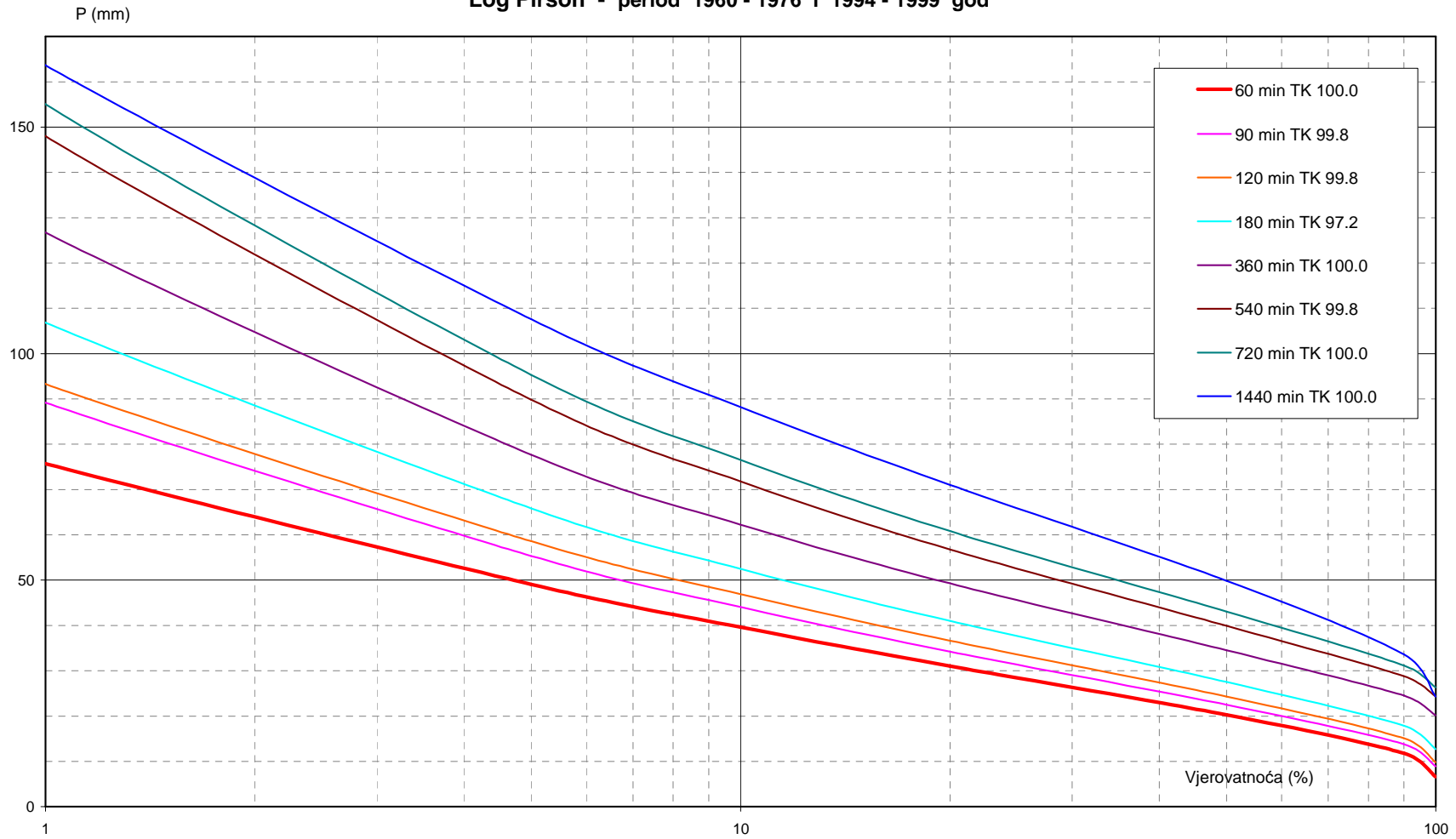
KS B LUKA - USVOJENE VJEROVATNOĆE MAKS. GOD. MINUTNIH PADAVINA Prilog 19.
 Log Pirson - period 1960 - 1976 i 1994 - 1999 god



KS BANJA LUKA – ADOPTED PROBABILITY OF MAXIMUM ANNUAL MINUTE RAINFALL
 Log Pirson – period 1960 – 1976 and 1994 – 1999 year

Attachment 19.

KS B LUKA - USVOJENE VJEROVATNOĆE MAKS. GOD. MINUTNIH PDAVINA Prilog 20.
 Log Pirson - period 1960 - 1976 i 1994 - 1999 god



KS BANJA LUKA – ADOPTED PROBABILITY OF MAXIMUM ANNUAL MINUTE RAINFALL
 Log Pirson – period 1960 – 1976 and 1994 – 1999 year

Attachment 20.

Table: Relevant rainfall for KS Banja Luka

KS BANJA LUKA														
PROBABILITY OF OCCURENCE OF MAXIMUM ANNUAL MINUTE RAINFALL (mm)														
With an appropriate test by Kolmogorov - Period 1960 - 1976 and 1994 - 1999 year														
Adopted Log Pirson distribution														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	5 min	10 min	15 min	20 min	30 min	45 min	60 min	90 min	120 min	180 min	360 min	540 min	720 min	1440 min
	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK	TK
Probability (%)	100.0	100.0	98.2	100.0	99.2	100.0	100.0	99.8	99.8	97.2	100.0	99.8	100.0	100.0
99.9	0.6	1.1	1.5	2.0	3.3	4.9	6.6	8.9	9.8	12.7	20.2	24.4	26.3	24.3
90	2.8	4.4	5.7	7.0	8.8	10.5	11.8	13.8	15.1	17.8	24.5	28.8	31.2	33.6
50	6.6	10.0	12.6	14.7	17.0	19.2	20.3	22.5	24.3	27.5	34.5	39.9	43.1	49.9
20	10.3	16.1	19.8	22.4	25.7	29.3	31.0	34.2	36.7	41.0	49.3	56.8	60.8	71.0
10	12.5	20.1	24.6	27.4	31.7	36.9	39.6	44.1	46.9	52.5	62.3	71.8	76.6	88.2
5	14.6	24.0	29.2	32.2	37.7	44.8	49.1	55.4	58.6	65.9	77.7	89.8	95.3	107.6
1	18.6	32.5	39.5	42.6	51.7	65.2	75.7	89.2	93.3	106.9	126.7	148.0	155.1	163.6
0.5	20.2	36.0	43.7	46.8	58.0	75.2	89.7	108.0	112.3	130.1	155.5	182.7	190.3	193.9
0.1	23.4	44.0	53.5	56.5	73.1	101.3	129.6	165.0	169.6	202.3	248.3	296.2	304.4	283.2

DESIGN CRITERIA

Basic principle of dimensioning the storm sewer in gravity drainage of rainwater wherever possible. Thanks to favorable terrain for CUA Banja Luka is possible to execute collection and storm water drainage without pumping. And then principle of individual drainage for each natural catchment area is adopted.

Methodology of work

For calculation and dimensioning of rainwater runoff sewer was used in the software package US EPA SWMM (Storm Water Management Modeling).

The program calculations are done for all the rainwater, the calculation of transformation of gross rainfall in the net outflow, to the sizing system sewage facilities.

Software package is tailored for the calculation of unsteady flow, as a dynamic model that solves the complete system Saint Venant's equations. In this way has enabled analysis of the occurrence of flooding (ponding) and full compliance with the sewer in which the program takes into account the free volume of the sewer as a volume space for the transformation of runoff hydrographs. Results of the budget are real because they show influence of retention capacity of sewers on maximum flows in sewers. This is particularly reflected in the final sections of sewers in the zone of discharge into the recipient.

Runoff analysis were performed assuming uniform distribution of rainfall throughout the Banja Luka CUA.

Transformation of gross rainfall in the net outflow was carried out by Horton model, which implies that part of rainfall infiltrates into soil, that part of rainfall retains on the surface without runoff, that part of rainfall retains in sewers, and the rest of rainfall creates discharge in sewers.

Parameters for Horton's model are chosen considering construction of intergrated catchment area, purpose of the catchment area, geological characteristics of terrain and slopes of catchment area.

Surface layer of soil has an important role in analyzing short – term rainfall, for CUA Banja Luka where are adopted high permeability soils.

Adopted the infiltration characteristics of soil are:

- Initial infiltration – 25mm/hour
- Final infiltration – 108mm/hour
- Maximum capacity of terrain for infiltration – 120mm
- Drying time of terrain – adopted 3 days
- Above the layer of water at which there is runoff
 - From non permeable areas – 2mm
 - From permeable areas – 5mm
- Manning's roughness coefficient
 - Non permeable areas – 0.11
 - Permeable areas – 0.4

Total catchment area, which was analyzed for the runoff was determined by purpose of space or degree of urbanization of the space.

Criteria for dimensioning

Basic concept of building sewerage system rainwater, for city areas in which there is no built sewerage is:

- Gravity drainage to the nearest recipient
- Retention of rainwater

Relevant rainfall, rainfall duration and return period

Relevant duration of rainfall is set based on time concentration on basin (flow) obtained from a model. Mostly obtained by time of concentration from 22 to 26 minutes, so they adopted the relevant rainfall of 20 minute duration.

2 – year return period is adopted, or relevant rainfall occurring once in 2 years.

Control of leakage made for control rainfall for 5 – year return period.

Model showed just smaller leakages in zone of sewer drainage in Vrbas river, and in terms of 50 – year flow in the recipient, because of terrain elevation that is lower or even with water level of 50 – year return period. At higher water levels comes to leakage in drainage zone because the terrain is mostly lower from 100 – year return period water level.

Longitudinal downs and sewer charging

Sewers are mostly projected to follow the slope, except in low parts, where falls of sewers are usually less.

Sewers are dimensioned so that the maximum compliance with the relevant rainfall of 2 – year return period are 60 – 70%, which ensures that there can be no leakage from the manhole and flooding the city urban area.

Storm water treatment

Storm water is also necessary to refine (clean up) before being discharged into the recipient, or surface watercourses. Minimum level of treatment is to remove grease and oil from storm water. It is known that the first storm water discharges are highly loaded with grease and oils that rainwater washes off from asphalt traffic areas.

To remove grease and oil from storm water to fewer streams, 100 – 200l/s, can be used prefabricated grease and oil separators. However, for larger flows that characterize almost all analyzed sewers, such a treatment would give a large number of separators connected in batteries, with very complicated structures for even distribution of water.

Additional problem is depth of installing separators by sewer drainages, due to the great depths of sewers, mainly 5 – 6m.

Because of that is proposed solution with the acceptance of the first wave of very dirty water in the reservoirs from which, after cessation of rainfall, pump draws the water with capacity of 20 – 50l/s on the separator, which mounted above or beside the object retention. Proposed solution is more expensive but more efficient in terms of the effects of treatment.

Retentions are dimensioned so they can accept first wave of muddy water for a period of time for concentration of the basin, or a period of 20 minutes.

Rainwater recipients

Rainwater is discharged into surface watercourses in the CUA Banja Luka, mostly straight into the river Vrbas, and partly in its tributaries.

In 2005. was made project documentation "Hydro – morphological analysis of the Vrbas River in the city of Banja Luka, from the border with the Municipality of Laktasi and upstream to the area of Tijesno with length of 26.00km and Vrbanja in length of 3.00km.

This documentation defines the relevant stimuluses and water levels for Vrbas river, and relevant stimuluses for its tributaries, as given in following tables.

Table: Hydrological characteristics of the tributaries of the Vrbas river

No.	Tributary of Vrbas	Catchment area of the tributary (km ²)	Area of corresponding chatchment (km ²)	Belonging area (km ²)
1	Rekavica	28,79	40,15	68,94
2	Svrakava	79,91	39,49	119,40
3	Surtolija	67,53	7,9	75,43*
4	Crkvina	23,30	14,39	37,69
5	Vrbanja	791,28	56,04	847,32*
6	Dragočaj	96,91	15,55	112,46*
7	Bukovica	75,43	23,19	98,62
8	Turjanica	190,47	0,00	190,47

Table: Typical stimuluses of high water in Vrbas routes

No.	Vrbas route	0,1% 1/1000	0,2% 1/500	1% 1/100	5% 1/20	10% 1/10	20% 1/5
1	To Rekavica	2037	1797	1299	902	763	625
2	Rekavica - Svrakava	2067	1824	1319	915	774	633
3	Svrakava - Surtolija	2120	1871	1353	938	792	648
4	Surtolija - Crkvina	2154	1990	1374	952	803	658
5	Crkvina - Vrbanja	2172	1915	1385	960	808	663
6	Vrbanja - Dragočaj	2559	2247	1628	1118	938	764
7	Dragočaj - Bukovica	2610	2293	1660	1137	957	777
8	Bukovica -Turjanica	2655	2333	1688	1154	973	789
9	Behind Turjanice	2743	2411	1743	1187	1002	812

ANALYSIS OF PIPE MATERIAL

In the analysis of the pipe material, in order to decide for the certain pipe material, we analyzed three types of pipe material:

- Concrete pipe with an integrated rubber with a razor, length 2.0m, manufacturer Binis Banja Luka, Republic of Srpska, BiH.
- PEHD spiral wound pipe with welded joints, length 6.0m, manufacturer KRAH Vrgorec – Croatia.
- Polyether pipes with polyester coupling and rubber with a razor, length 6.0m, manufacturer Hobas – Austria, representation Sarajevo.

Selection of pipe material is very important decision, for the total investment, and for the functionality of the sewage system as a whole.

In the evaluation of the proposed pipe material, it is necessary to score its next feature:

- Cost of material and utilization of domestic products
- Resistance to aggressive action on the sewage pipe material
- Stiffness of the pipe material, and sensitivity to external influences and traffic load
- Abrasion resistance
- Overall length pipes, and the total number of joints and method of connecting pipes to each other, as well as links to the manholes, and necessary fittings for sewer connections
- Pipe installation conditions and the necessary machinery for handling and lowering into the trench, as well as necessary equipment and time for the performance of pipe joints
- Speed of installation and water durability of compounds and environmental suitability and safety of the penetration of surface leachate water into constructed sewers.

Of all the listed conditions which pipe material to satisfy the most important are those relating to stability, resistance to the effects of waste water, security of joints and pipe material prices.

All piping materials to be analyzed generally meet above criteria, with certain advantages and disadvantages.

In the analysis of cost analysis are the following costs:

- Purchase price of pipe material loaded on the vehicle without transportation costs
- Transportation costs from factory to reconstruction area
- Unloading, local transport along the trench and lowering into the trench
- Installation of sewers.

Price calculations are made based on construction standards, and the results of price calculations are given in tables.

RECAP PROCUREMENT AND INSTALLATION OF SEWERS

Table: Costs of procurement and installation of concrete (BINIS), PEHD spiral wound (KRAH) and polyester (HOBAS) sewers + VAT

Pipe type / diameter	Ø200	Ø250	Ø300	Ø400	Ø500	Ø600	Ø700	Ø800	Ø1000	Ø1200	Ø1500	Ø1600
Concrete pipes	▪ -	▪ -	68.28	83.82	120.45	150.70	▪ -	251.12	337.60	489.97	694.43	788.30
PEHD spiral	▪ -	▪ -	45.36	76.34	98.20	149.16	199.64	243.13	403.97	695.31	1,232.85	▪ -
Polyester pipes	79.25	▪ -	126.06	177.98	242.28	312.41	373.58	465.20	693.65	940.56	1,374.48	▪ -

From this table, we can see that concrete pipes are cheaper for profiles above 500mm.

Basic reason for that is because pipe factory is in Banja Luka and transport costs are minor.

Therefore it is proposed for all fecal sewers who are not under the influence of ground water and all the rain sewers, concrete pipe diameters larger than 500mm.

FEEDBACK ANALYSIS OF PIPE MATERIAL

From tables we can conclude that, for depth of installation 3 – 6m, concrete pipes compared to PEHD spiral wounded pipes cheaper for sewers diameters above 600mm, and compared to polyester pipes for all sewers diameters.

Bearing in mind that the concrete pipe factory is in the center of the future reconstruction area for further analysis of the cost of building the sewage system is proposed to use the following pipe materials:

- For rainwater sewers nominal diameter 300 – 500mm, which are beyond the ground water, PEHD and PP corrugated drainage pipe
- For rainwater sewers 300 – 500mm, in contact with groundwater, PEHD spiral wound pipes with welded connection
- For rainwater sewers 600 – 1600mm, concrete vibrating portable pipes of 45MB

General rainfall sewers in CUA Banja Luka will be installed at depths of 3 – 6m, and ground water is expected to short strokes along the Vrbas River.