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Determination of flood inundation maps: a case study of Akyazı industrial zone

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ABSTRACT

Heavy and sudden rainfalls, snow melt, meteorological factors, human impact and climate change cause floods that lead to loss of life and property. Trend analysis shows that the number of floods has increased in recent years. The use of flood plains as a residental area or industrial area causes an increase in the potential impact of floods. Loss of life and property may ocur in a probable flood due to the presence of factories in the Akyazı industrial zone, which is one of the most affected zones by floods, and 1000-1500 people working actively in these factories.Therefore, flood protection wall was built by DSI for this zone. The aim of this study is to create a 1-D flood model both before and after rehabilitation of the creek. Kucucek Creek passes through the study area. Kucucek Creek consists of merging of 2 branches on the downstream of the industrial zone. These are called Kucucek Creek main branch and Karaca Creek. In the study, ArcGIS 10.2 program was used to digitize the zone. In the hydraulic analyzes performed with 8 return period flood flows, it was determined that the repetition years will not occur flood and the rehabilitation project will be effective.

Keywords: Flood, HEC-RAS, Kucucek Creek, Flow

1. INTRODUCTION

Floods creates 40% of all damage caused by natural disaster [1]. Therefore, it is seen as the biggest global threat considering the frequency, occurrence and economic losses caused by floods [2,3]. Last thirty-forty years frequency and severity of flood events depending on the increase, the loss of life and property is also large increased [2,4,5]. Floods caused by factors such as hydrology, meteorological and human impact, cause an average economic loss of US $ 100 million in Turkey every year. [6]. 820 floods occurred between 1975 and 2011. 660 people lost their lives in these floods and 799,758 hectares of agricultural land was flooded by flood waters [7]. Trend analysis, floods in recent years shows that the catastrophes and losses caused by them have increased considerably [8]. Figure 1 shows the percentage of natural disasters in the first half of 2017 shown.

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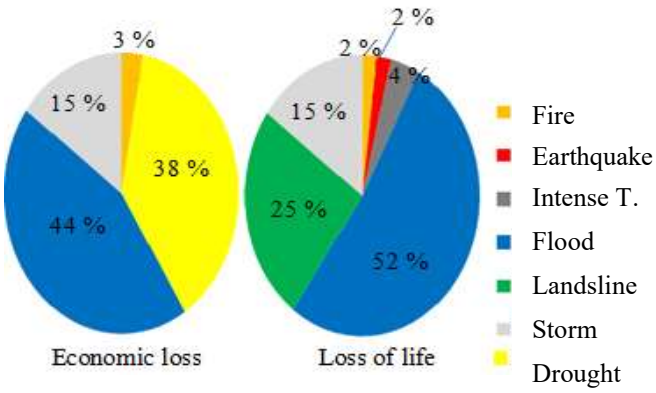

Figure 1. Percentages of natural disasters occurring in the first half of 2017.

In a study conducted by CRED on international disasters on a global scale, approximately 2.5 billion people were affected by flooding between 1994 and 2014 [9]. Today, with the development of meteorology and hydrology sciences have caused flooding risk predetermination of regions. Developed for this purpose hydrological analysis and risk maps using GIS systems it can be produced. Many studies were done in this way.

HEC-RAS for the first time in Turkey with the study carried out by the Yazıcılar and Önder (1998) the software was used. As a result of the study carried out in the Bartın Stream levels and floods in Bartın Stream in 1998 close to each other [10].

Özdemir (2007) transferred the data of Balıkesir Havran Stream to Hec-GeoRAS and Hydraulic analyzes were performed at HEC-RAS. In the results of working; flood due to different scenarios produced maps [11].

In a study by Amini (2010), Khoram-Abad in the northwest of Iran possible flood areas for the river in the city determined using image (IKONOS) and Digital Elevation Model (SYM) [12].

In the study conducted by Efe (2014), The New Malabadi bridge of Batman Stream AutoCAD Civil 3D for the region between Diyarbakır Batman Road Bridge and Flood risk analysis using HEC-Ras programs [13].

In the study of Yaylak (2016), ArcGIS and HEC-Ras package of Bitlis Creek he used his programs. HEC-RAS produced water surface profiles, it was transferred to HecGeoRAS to identify flood risk areas [14].

Areas at risk before floods occur and risk to prevent possible damage to floods maps need to be created. In this direction in our study, the industrial zone of Akyazı District of Sakarya have been taken. In this study, 1-D flood model was analyzed before and after rehabilitation of the creek. In this way, it was determined whether the rehabilitation project would be efficient or not. Hydraulic analyzes using different return period flood flows were used in 1-D flood modeling in HEC-RAS.

2. STUDY AREA

Kucucek, where Kucucek stream is located, is connected to Akyazı District of Sakarya. Kucucek Creek, Mudurnu Stream is a branch and its geographical location is 40º 40’ 18’’ North and 30º 35’ 8’’ East. It is located the 40.671 latitude and 30.614 longitude coordinates. Kucucek is located 6.2 km from the southwest of Akyazı. The altitude of the region is 50 meters [15]. Figure 2 shows the study area.

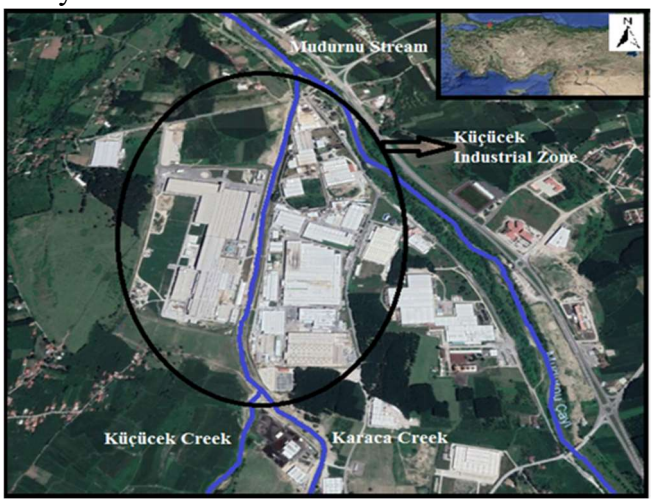

Figure 2. Study Area

Kucucek Creek is formed by the joining of 2 branch on the downstream side of the industrial zone. These are called Kucucek Creek main branch and Karaca Creek. Studying area has a clayey soil structure in general. The hottest month of the region; August and coldest month December. Major factory and industrial establishments in the region: Orthaus Trailers Vehicle Equipment Factory, Çak Textile Factory, Baysan Paint Factory, Asaş Aluminum Factory, AsaşPen Factory. 1000-1500 people actively working in factories in Kucucek Industrial Zone [16]. In this study, between 0 + 150 and 1 + 560 km of Kucucek stream, which is an industrial zone, was investigated.

3. MODEL& APPLICATION

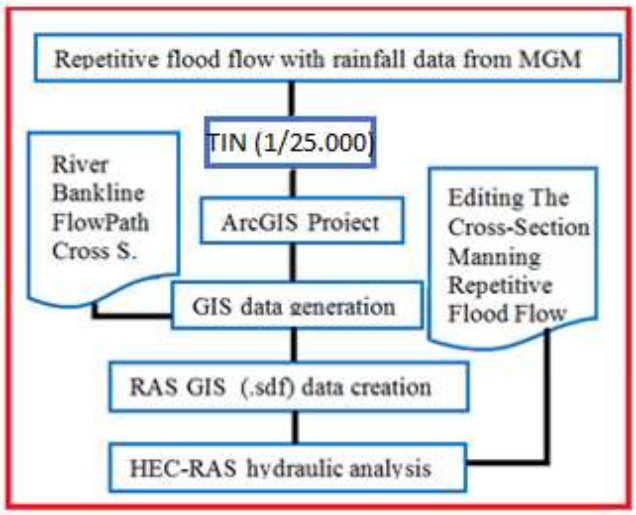

Figure 3. Working scheme

Many hydraulic models in the world to protect against the destructive effects of floods is used. Flood inundation maps can be produced in 1-D and 2-D. The rehabilitation project was evaluated by using 1-D hydraulic model for the study area.

3.1. Return Period Flood Flows Calculation

Historical flow data with flood frequency analysis flood flow of different recurrences can be calculated. Current for these analyzes the longer a record is covered, return period flood flows to be calculated will be realistic. Accurate detection of return period flood flow and accuracy of the result is of great importance [2,17-20]. Within the scope of the study, annual maximum rainfall data of Sakarya Meteorology Regional Directorate, Sakarya / 17069 MGI was used. The irregular rainfall causes many hydrological data to be irregular. Statistical methods were used to calculate extreme rainfall due to the presence of precipitation records dating back many years. Using the 81-year rainfall records of this region, statistical approaches and 24-hour rainfall-time-repetition values were calculated. Because in the FEMA 17/B bulletin, it was stated that Log-Pearson Type III distribution should be used in the calculation of flood flow. It was determined that Log-Pearson Type III probability distribution function was suitable as a result of L-Moment test applied to 81-year rainfall data. There are no flow records belonging to Akyazı Kucucek Industrial Zone which is determined as study area. Therefore, flow calculations methods based on deterministic approaches were used instead of statistical methods. Table 1 shows deterministic methods and conditions of use.

Table 1 Deterministic Methods and Contions of use

Deterministic Methods	**Conditions Of Use**
DSI Synthetic Method	$A \leq 1000$ km^2 $T_p > 2$ h
Mockus Method	$A \leq 1000$ km^2 $Tc < 30$ h
Snyder Method	$A > 1000$ km^2
Rational Method	$A < 1.0$ km^2 rural area $A < 0.5$ km^2 city area

The basin area of Kucucek Creek is 38.43 km^2. For Kucucek Creek; T_P is 3.13 h and T_C is 1.88 h. The basin area of Karaca Creek is 16.26 km^2. For Karaca Creek; T_P is 2.04 h and T_C is 1.30 h. Therefore, when the status of the deterministic

methods above can be examined, the methods that can be applied for both branches of the stream; DSI Synthetic and Mockus Methods has been identified. In Table 2, the DSI Synthetic and Mockus Methods of Kucucek Creek flow calculations are shown. In Table 3, the DSI Synthetic and Mockus Methods of Karaca Creek flow rates are shown.

Table 2. Comparison of calculation methods for Kucucek Creek Main Branch

Methods	**Return Periods**							
	2	**5**	**10**	**25**	**50**	**100**	**200**	**500**
DSI Synthetic	7.45	18.68	28.49	43.38	56.03	69.77	84.49	98.33
Mockus	9.09	22.8	34.78	52.96	68.4	83.90	103.15	117.89

Table 3. Comparison of calculation methods for Karaca Creek

Methods	**Return Periods**							
	2	**5**	**10**	**25**	**50**	**100**	**200**	**500**
DSI Synthetic	4.48	11.47	17.62	26.95	34.89	43.56	52.86	61.51
Mockus	5.26	13.45	20.67	31.60	40.93	50.27	61.99	70.76

Flow data to be used for hydraulic analysis were calculated and compared with different methods for streams and it was decided to use flow data obtained by mockus method. The reason for the selection of this method is that in case of absence of long-term flow records, the climate better reflect the physical properties of the basin and calculated by this method has higher values. In this way, extreme events such as floods is aimed to stay on the safe side in taking the necessary precautions. As the Kucucek Creek consists of a combination of two branchs, the hydraulic analyzes were performed with the sum of the flow calculated by the Mockus Method for the two branchs. Used in hydraulic analyzes in Table 4 flow rates are shown.

Table 4. Flow rates used in hydraulic analysis for Kucucek Creek

Methods	**Return Periods**							
	2	**5**	**10**	**25**	**50**	**100**	**200**	**500**
Mockus	14.35	36.25	55.45	84.56	109.33	134.78	165.14	188.65

3.2. Digitalization of Geometric Data

Hec-Georas provides the necessary geometry file for HEC-RAS to perform hydraulic analysis. At this stage, which is the preliminary step for HEC-RAS river, bankline, flow paths and cross sections are indicated. This step is called digitization. It is shown on Figure 4. The geometric data digitized by ArcGIS software was transferred to HEC-RAS program with Hec-GeoRAS interface module.

Figure 4. Digitalization of geometric data

3.3. Hydraulic Analysis of Kucucek Creek with HEC-RAS

HEC-RAS is a computer program that performs the required hydraulic calculations of rivers for a one-dimensional (1D) steady and unsteady flow. The geometric data of the file produced by ArcGIS is regulated by HEC-RAS. Figure 5 shows an exemplary cross section of the creek prior to rehabilitation. After, In the HEC-RAS, the rehabilitation project to be done in the creek were taken into consideration and the necessary cross-sectional revision were made. Figure 6 shows an the same exemplary cross section revision in the scope of the rehabilitation project.

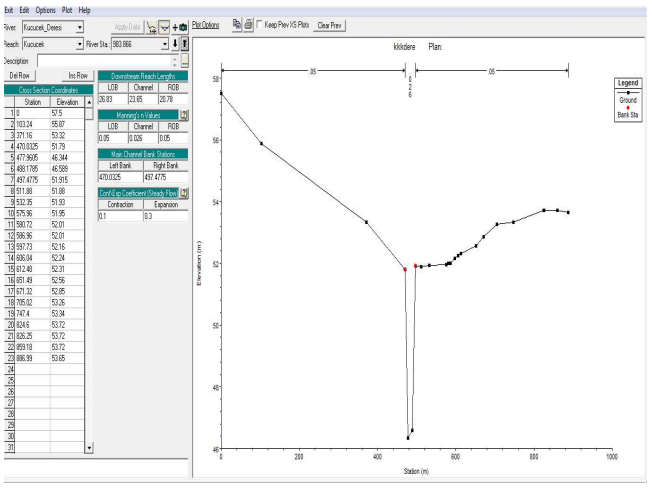

Figure 5. Exemplary cross section of the creek prior to rehabilitation

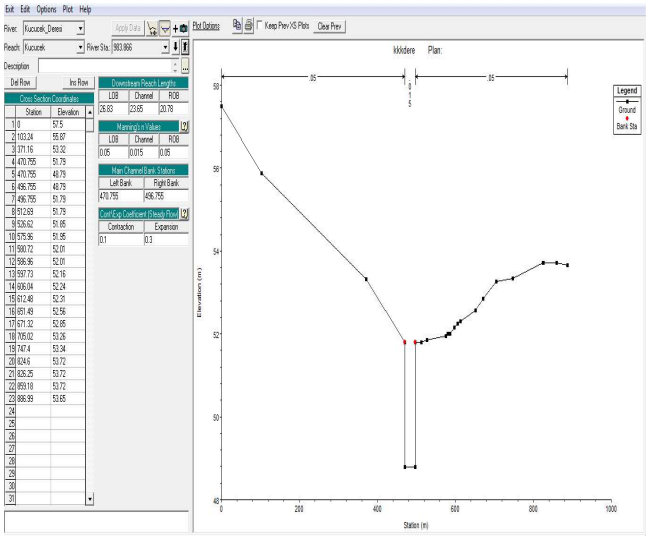

Figure 6. The same exemplary cross section revision in the the rehabilitation project scope of

Manning roughness values used in the study: 0.026 inside of the creek prior to rehabilitation. Post rehabilitation, 0.015 inside the creek, for the parts where the factories are located; 0.05 and 0.04 for planting areas in floodplain. Flood analysis with probable return period floods were analyzed. As a result of the hydraulic analysis, the resulting flood inundation is shown in Figure 7 and Figure 8.

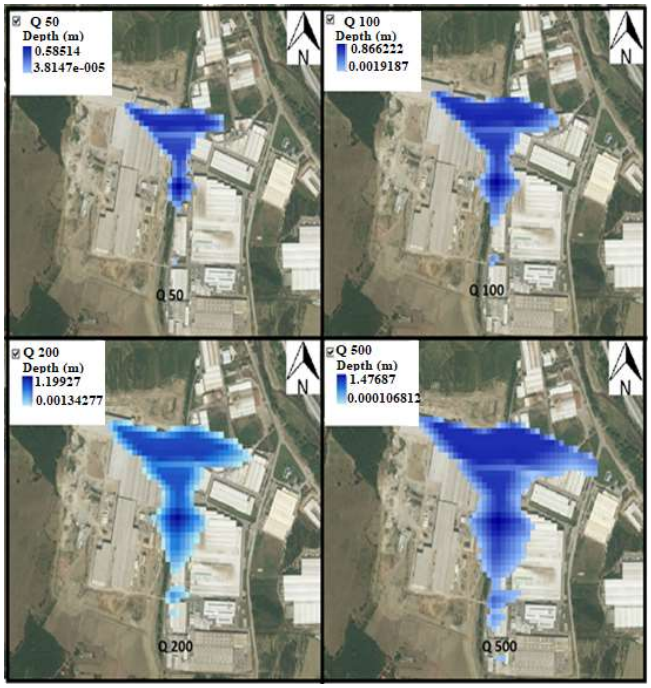

Figure 7. Flood inundation area for prior to rehabilitation

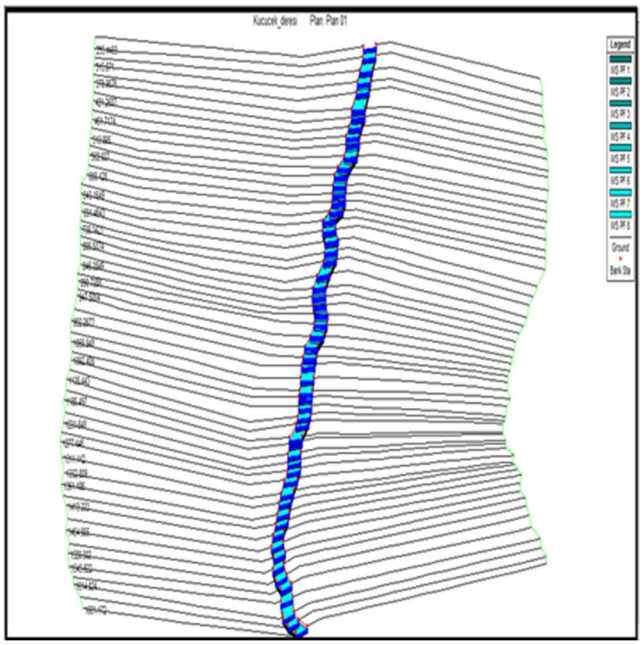

Figure 8. Flood inundation area for after rehabilitation

4.CONCLUSION AND EVALUATION

As in many regions of our country, Akyazı often floods events occur. Destructive size of floods in industrially developed areas it is larger than other regions. Since the Küçücek Creek passes through the industrial zone, this area is determined as the study area. An average of 1000-1500 people work in the factories on both sides of the creek. Possible floods are affected factories,heavy machinery and people. It was determined that 2, 5, 10 and 25 years return period did not exceed the creek bed for pre-rehabilitation. In addition, it has been determined that there will be 109.33 m^3 /s in the 50-year flood, 134.78 m^3/s in the 100-year flood, 165.14 m^3/s in the 200-year flood, and the flow of 500-year flood will be 188.65 m^3/s. Therefore, flood protection walls are planned to be constructed by DSI as a result of flood events. This within the scope of the study, the cross-sections have been made in HEC-RAS considering the dimensions (b = 26 m, h = 3 m) prescribed by DSI. In the hydraulic analyzes performed with 8 return period flood flows, it was determined that the repetition years will not occur flood and the rehabilitation project will be effective. In order to make flood risk management planning more accurate for the region, the study can be handled in 2 dimensions and the propagation map can be produced if it is exposed to flow rates above the capacity of the rehabilitation project.

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