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Assessing the Effects of Alluvial Transport in the Kizilirmak River on Dams with Local, Photogrammetric and Remote Sensing Methods

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Abstract: Naturally transported sand, clay, and gravel-like blocks by rivers cause a decrease in water flow and flow velocity. Additionally, uncontrolled disposal of waste materials into the riverbed increases adverse effects and endangers natural life. Over time, the alluvium generated by natural and external factors in river and creek beds leads to flood risks that pose a significant threat to life and property. These sediments, known as alluvium, accumulate in favorable locations in valleys and form alluvial beds with spread movement to broader areas. In Turkey, interventions in river branches and creek beds, as well as insufficient preventive measures, have kept floods a hot topic. To eliminate these issues, it is crucial for every organization to take comprehensive measures and increase environmental awareness by addressing similar areas in large projections. The Kızılırmak River, originating from the Kızıldag slopes in the İmranlı district of Sivas province and passing through the Çorum province before reaching the Black Sea at Bafra Cape, also harbors alluvial risks and adverse effects. It holds significant importance for energy production with 12 dams and hydroelectric power plants (HES) on the river. Additionally, the Pirinçli Hydroelectric Power Plant, with a transmission structure of 13,756 meters between Dodurga district of Çorum province and Güvercinlik and Kumbaba Villages, plays a vital role in electricity production in the region. The Pirinçli HES is located downstream of the Obruk Dam constructed by the State Hydraulic Works (D.S.I.) on the Kızılırmak River. It is known that a significant portion of the sediment accumulation between Güvercinlik Dam and Kumbaba Dam occurred before the construction of the Obruk Dam. Hence, preventing risks that could lead to environmental adversities is of paramount importance. In this study, a combined fieldwork was conducted using different methods to determine the areas where sediments accumulated and the alluvial material being transported cuts off the flow velocity of the Kızılırmak River and causes accumulations between the Güvercinlik Dam and Kumbaba Dam. For this purpose, terrestrial measurements, photogrammetric and remote sensing methods were combined and evaluated together to ensure the integrity of the obtained data.

Keywords: Drone photogrammetry, Risk assessment, HEPP, Environmental threats, Remote sensing

Introduction

Blocks such as sand, clay and pebbles carried naturally by streams cause the flow of water and the flow rate to decrease. In addition, waste materials left uncontrolled in the river bed increase the negativities and endanger the natural life.Flood risks caused by these alluviums, which arise from natural and external factors that form in river and stream beds over time, greatly threaten the safety of life and property. These sediments, called alluviums and accumulated in suitable places over time, occupy the ground floor in most of the valleys and form alluvial deposits by spreading to larger areas. Coastal erosion that occurs in waterways as a result of the

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construction of structures in coastal areas near estuaries, which are the source of sediment supply, can negatively affect the lives of local residents (Tak et al.,2020). In order to evaluate risks in rivers, a detailed analysis is required whether changes in the flow regime are associated with sudden climate changes. It is important to record hydrogeomorphological basin changes because these processes can occur very quickly and lead to flood events that affect the entire living environment (Salandra et al.,2022).

Floods in Turkey, which occur as a result of interventions in river branches and stream beds and inadequate precautions, always remain hot on the agenda. In order to eliminate the negative effects experienced, it is of great importance for each organization to consider similar areas in wide projections, to always take precautions and to increase environmental awareness. In this context, river bed composition needs to be regularly monitored and updated due to various factors For this purpose, to extract river bed features precisely, UAV-based orthophoto maps are created using photogrammetric techniques. (Liu,2023) .

The Kızılırmak River, which originates from the foothills of Kızıldağ in the İmranlı district of Sivas Province, passes through the borders of Çorum province and reaches the Black Sea from the Bafra cape, also contains alluvial risks and negativities. It has an important place with its energy production with 12 dams and HEPPs on the river. Obruk Dam in Dodurga district of Çorum province and Pirinçli Hydroelectric Power Plant (HEPP), which has a 13756 m long transmission structure located between Güvercinlik and Kumbaba Villages, plays an important role in the region in terms of electricity production. Pirinçli HEPP is located downstream of the Obruk Dam built by DSI on the Kızılırmak River. It is known that the majority of the conflicts between Güvercinlik Dam and Kumbaba Dam took place before the construction of the Obruk Dam. In this case, it is of great importance to prevent risks that may lead to environmental negativities.

Objective

Detection of areas where the sediment accumulated between Güvercinlik Dam and Kumbaba Dam and the alluvial material being transported interrupt the flow rate of the Kızılırmak River and cause accumulations.In this study, a composit fieldwork was conducted using varied methods to determine the areas where sediments accumulated and the alluvial material being transported cuts off the flow velocity of the Kızılırmak River and causes accumulations between the Güvercinlik Dam and Kumbaba Dam. For this purpose, terrestrial measurements, photogrammetric and remote sensing methods were combined and evaluated together to ensure the integrity of the obtained data.

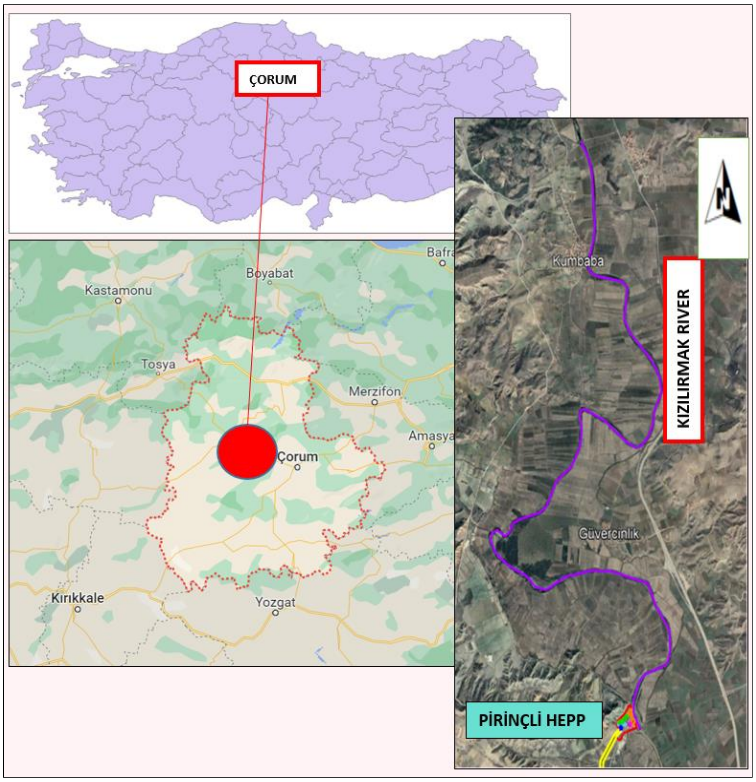

Figure 1. Location of the study area

Study Area and Assessment of Current Situation

The length between Güvercinlik Weir, built next to Pirinçli HEPP, and Kumbaba Weir is around 13 km. In the examinations carried out on this area along the river flow, it was observed that the excessive alluvial material formed in places especially filled the stream beds and blocked the water flow. While the existing Kızılırmak River capacity (Obruk Dam Maximum production capacity) is on average 400 m3/sec, it is estimated that it cannot even carry 100 m3/sec of water due to the fullness of alluvial material. The study area, which was created for the purpose of measuring and determining the depths of the areas where this flow obstacle is concentrated in its current state, is on the Kızılırmak River line in Dodurga District of Corum Province; In the geographical coordinates of 40.51'29.24"N, 34.51'27.98"E Güvercinlik Weir and 40.55'22.04"N, 34.50'52.13"E Kumbaba Weir, it covers the Güvercinlik and Kumbaba settlement areas and the river areas on the tail water side of the Pirinçli HEPP power plant pointed at the satellite image (Figure 1).

Method

Terresterial, Photogrammetric and Remote Sensing

Various methods were used in field studies and the integrity of the data obtained was ensured. For this purpose, terrestrial measurements were evaluated using photogrammetric and remote sensing methods. The work program including all methods is shown in the flow chart (Figure 2).

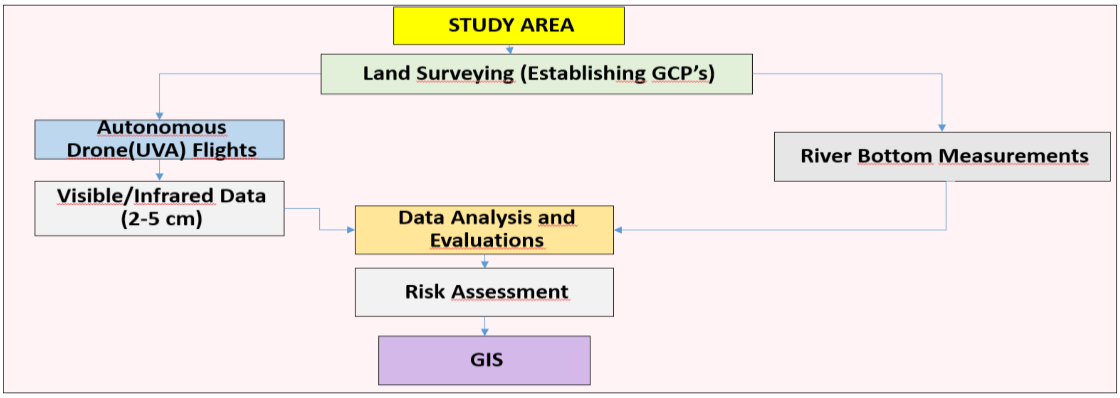

Figure 2. Flow chart of the work schedule

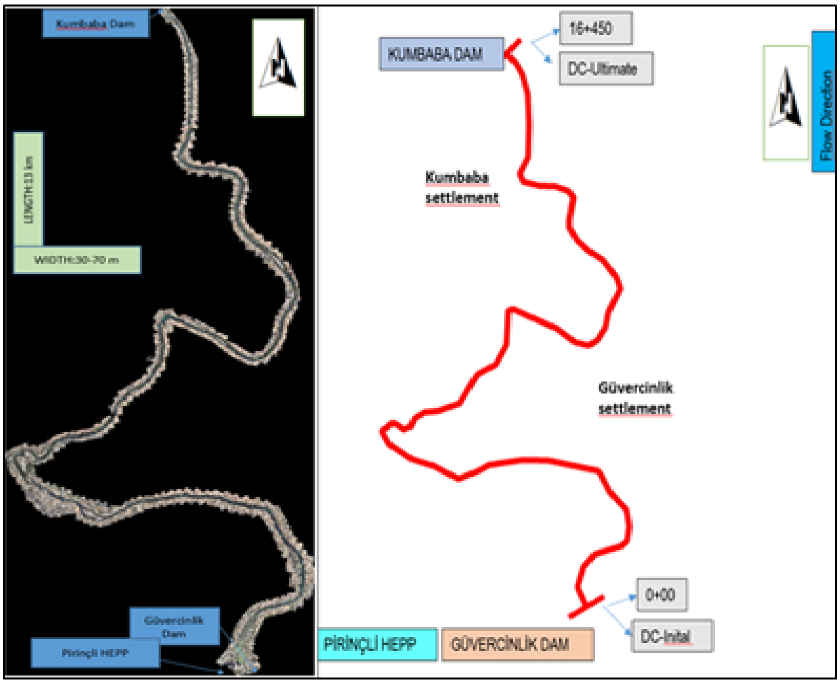

Figure 3. Mosaic image and sattelite image of the study area

Drone Mapping

The length of the Kızılırmak River between Güvercinlik and Kumbaba dams is 13 km, and its width varies between 30-70 m. Orthophoto map production of the study area was made with the 3D drone mapping method as dsm_ortho (Figure 3). 11 planned flights were made for the 13 km area, 27 GCPs (Ground Control Points) were established and coordinate measurements were carried out on a 3D plane, in the TUSAGA Active system. In addition, the study was designed to form a basis for the cadastral map of the region.

River Bottom Measurements

River depth measurements were obtained as DCP (Depth Control Points) in the form of a test point every 50 meters. Test measurements were carried out at 236 DCPs each measuring point for 0+050 to 13+000 is coordinated in three dimensions (Table 1). Measurements were started by taking the Pirinçli HEPP power plant tailwater and completed at the Kumbaba Dam. The depth was measured as 2.40 m at the initial point and 1.20 m at the ultimate point (Figure 4).

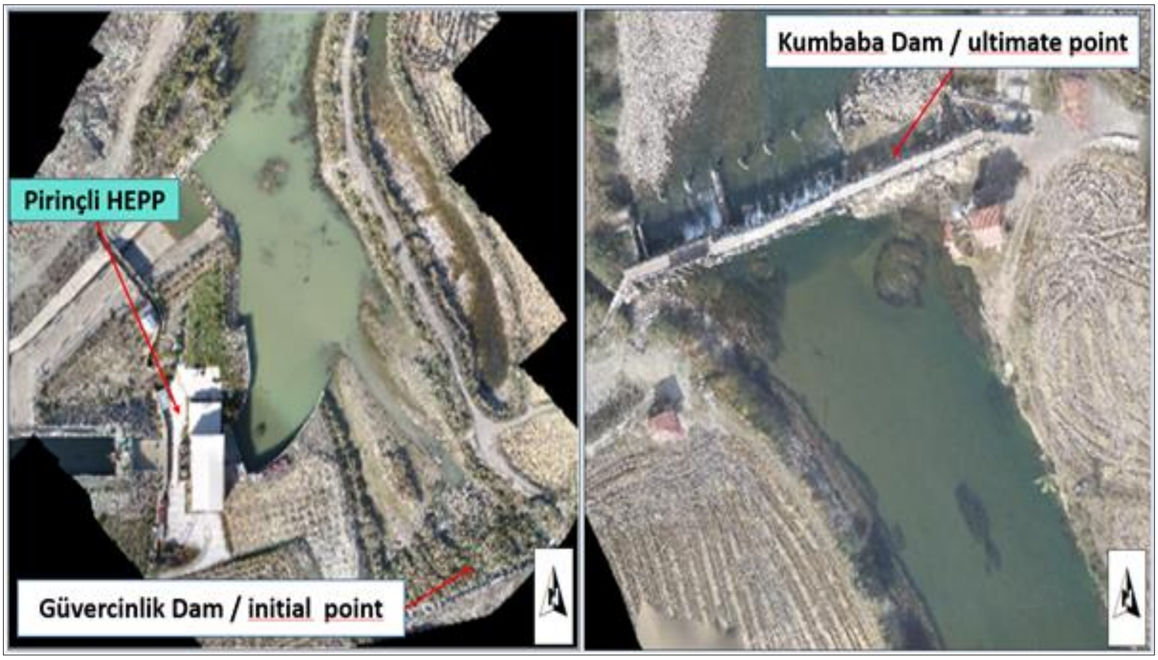

Figure 4. Rendered drone images of initial and ultimate points

Table 1. Brief of the DCPs

4+950	20	5+000	30	3+150	40	0+100	50	3+100	60	0+600	70	0+450	80	0+150	85	4+800	90	1+050	100	0+850	110	0+400	120	0+700	130	1+000	140	0+800	150
5+150	20	4+950	30	3+200	40	0+500	50	3+350	60	4+800	70	1+650	80			5+500	90	1+300	100	3+400	110	0+650	120	1+150	130	1+200	140	0+950	150
5+200	20	5+000	30	3+250	40	0+550	50	4+500	60	4+600	70	2+650	80			6+750	90	1+350	100	4+450	110	1+100	120	1+900	130	1+250	140	1+700	150
		5+100	30	3+300	40	1+600	50	5+350	60	5+700	70	2+700	80			7+200	90	2+500	100	4+650	110	2+600	120	2+550	130	8+700	140	1+750	150
		6+450	30	5+050	40	4+850	50	5+400	60	6+100	70	4+750	80			7+250	90	3+500	100	5+600	110	3+450	120	7+350	130	9+700	140	1+800	150
		6+500	30	5+250	40	4+900	50	5+650	60	6+350	70	4+450	80			7+550	90	3+550	100	6+700	110	3+600	120	9+400	130	9+800	140	1+850	150
		12+70(	30	5+300	40	4+900	50	6+000	60	8+400	70	4+550	80			7+600	90	4+650	100	8+650	110	3+650	120	10+650	130	9+900	140	2+750	150
				6+200	40	5+450	50	6+550	60	8+550	70	4+700	80			8+500	90	4+700	100	9+550	110	3+700	120	10+700	130	13+200	140	3+050	150
				6+400	40	5+850	50	6+950	60	8+600	70	4+750	80			9+500	90	4+850	100	9+600	110	4+400	120	11+400	130			3+750	150
				6+650	40	5+900	50	7+700	60	10+150	70	5+750	80			10+000	90	7+900	100	9+650	110	4+600	120	12+050	130			6+600	150
				7+650	40	6+150	50	8+000	60	10+400	70	5+800	80			10+300	90	8+150	100	9+750	110	6+250	120	12+450	130			7+750	150
				7+950	40	9+000	50	9+250	60	10+500	70	5+950	80			11+100	90	8+900	100	9+850	110	6+800	120	13+300	130			8+850	150
				8+450	40	9+150	50	12+25(	60	11+150	70	6+050	80			11+300	90	10+100	100	10+250	110	7+100	120	13+450	130			9+450	150
				8+950	40	9+200	50			11+200	70	8+200	80			12+900	90	10+450	100	11+050	110	7+150	120					9+950	150
				12+65(	40	10+200	50			12+850	70	8+250	80			14+200	90	10+550	100	11+650	110	7+500	120					11+800	150
				14+50(	40	12+600	50			13+850	70	9+300	80					10+900	100	11+700	110	10+350	120					13+250	150
						14+000	50					9+350	80					11+350	100	12+950	110	10+600	120					13+550	150
												10+050	80					12+200	100	13+400	110	11+250	120					13+600	150
												11+750	80					12+400	100	15+300	110	13+000	120					13+800	150
												12+300	80					12+550	100	15+750	110	14+450	120					13+900	150
												12+350	80					12+750	100	15+800	110	15+450	120					14+650	150
												12+500	80					13+350	100	15+850	110	15+650	120					14+850	150
TOTAL:236 test points												13+950	80					14+150	100	15+900	110	15+700	120					14+900	150
												14+050	80					15+350	100			15+950	120					15+150	150
												14+100	80					15+400	100			16+000	120					15+250	150
												14+550	80									16+450	120					15+500	150
																												15+600	150
																												16+150	150
cm	20		30		40		50		60		70		80		85		90		100		110		120		130		140		150
sum	3		7		16		17		13		16		26		1		15		24		23		26		13		8		28

In the study, which was carried out to identify risky areas where the alluvial material accumulated and sedimented between the Güvercinlik and Kumbaba dams of the Kızılırmak River disruption of the flow rate and the water level was high. The km-depth/measurements obtained as 50 m intervals at DCPs which are considered as test points including 150 cm depths. Distribution of Depth Control Points of test points measured every 50 m is graphed (Figure 5).

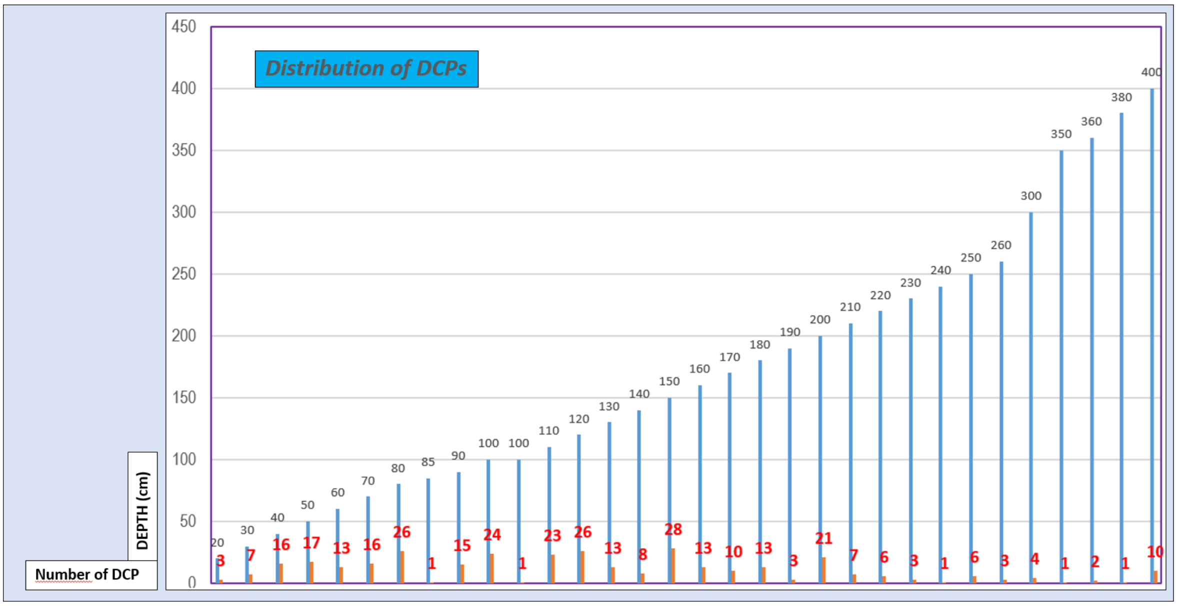

Figure 5. Distribution of the depth control points

Drone images of the lowest and highest depth obtained from the model created for the study area (Figure 6).

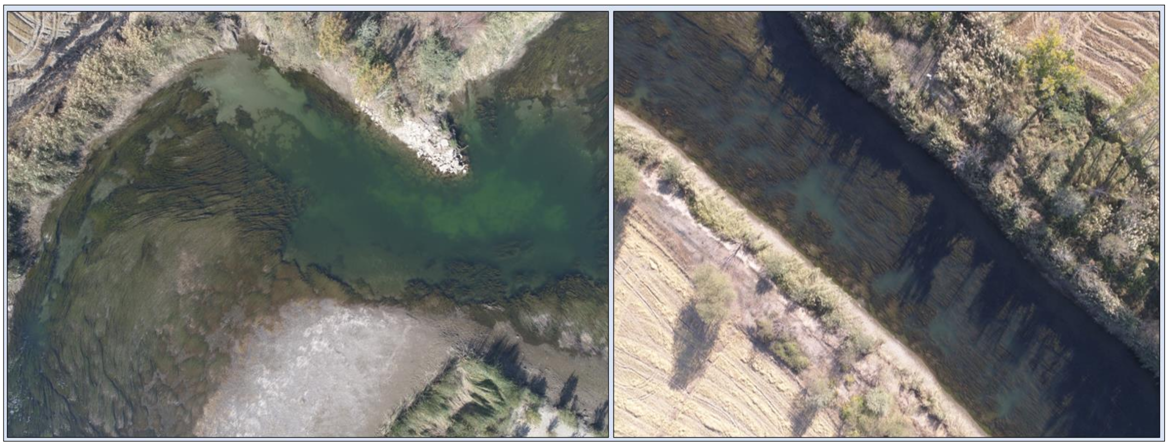

Figure 6. Lowest and highest depths among the dams

Images of sand islands formed by alluvial materials in the region are shown as examples of risk areas (Figure 7)

Figure 7. Risky areas with high potential for impact on the environment

Results and Discussion

Data Analysis and Evaluations

The lowest depth between the dams measured as 20 cm with 3 test points are at the 5th km.The highest depth measured 4 m with 10 test points where it exceeded the limit were determined at 1.5 and 3 km and at 10, 11 and 12 km The scatter plot of the measurements are generated (Figure 8).

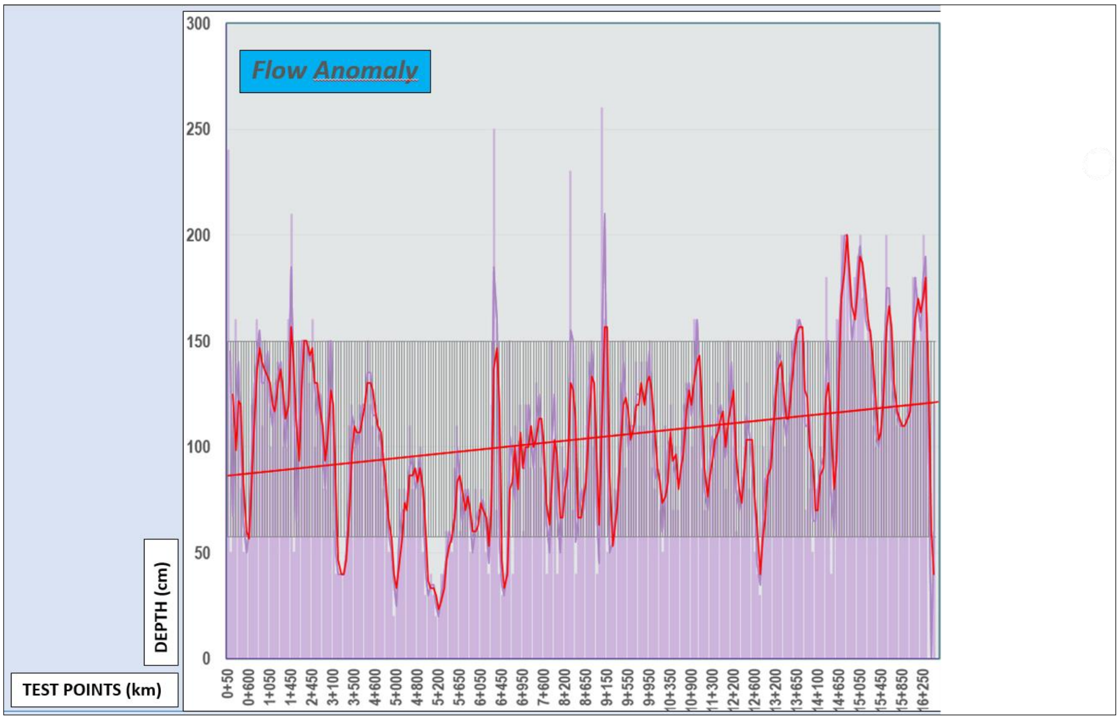

Figure 8. Scatter plot of the measurements generated

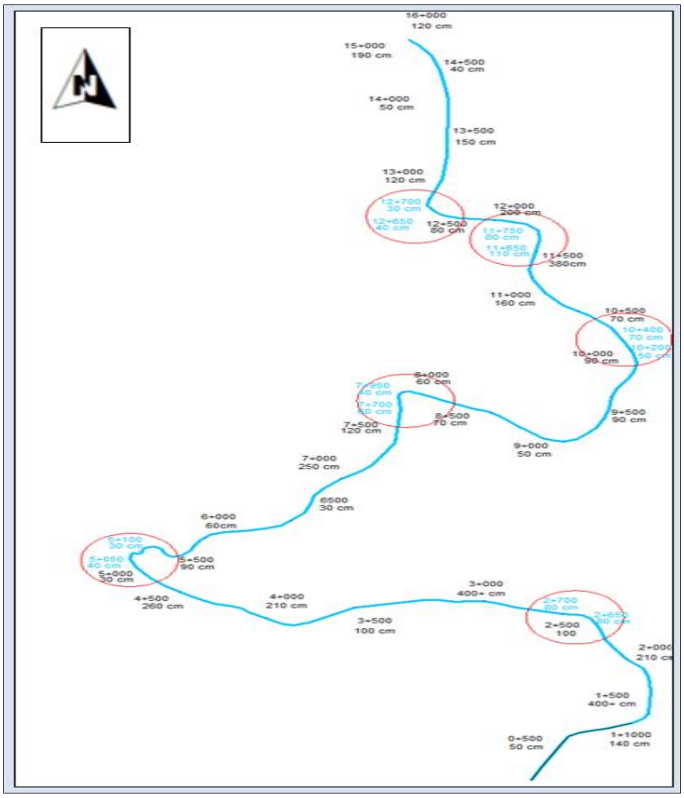

Figure 9. Risky areas on the depth measurement line

Depth values taken from depth measurements every 500 m, as well as risky areas where the depth falls to 50 cm or less are marked on the measurement line. As a result of the analysis carried out by processing and evaluating the data, areas that occurred in the six test regions and could pose a risk were identified (Figure 9). Orthophoto mosaics were created from images superimposed with depth measurements to define hydromorphological units marked risky areas on the ortophoto image and satellite image compared (Figure 10).

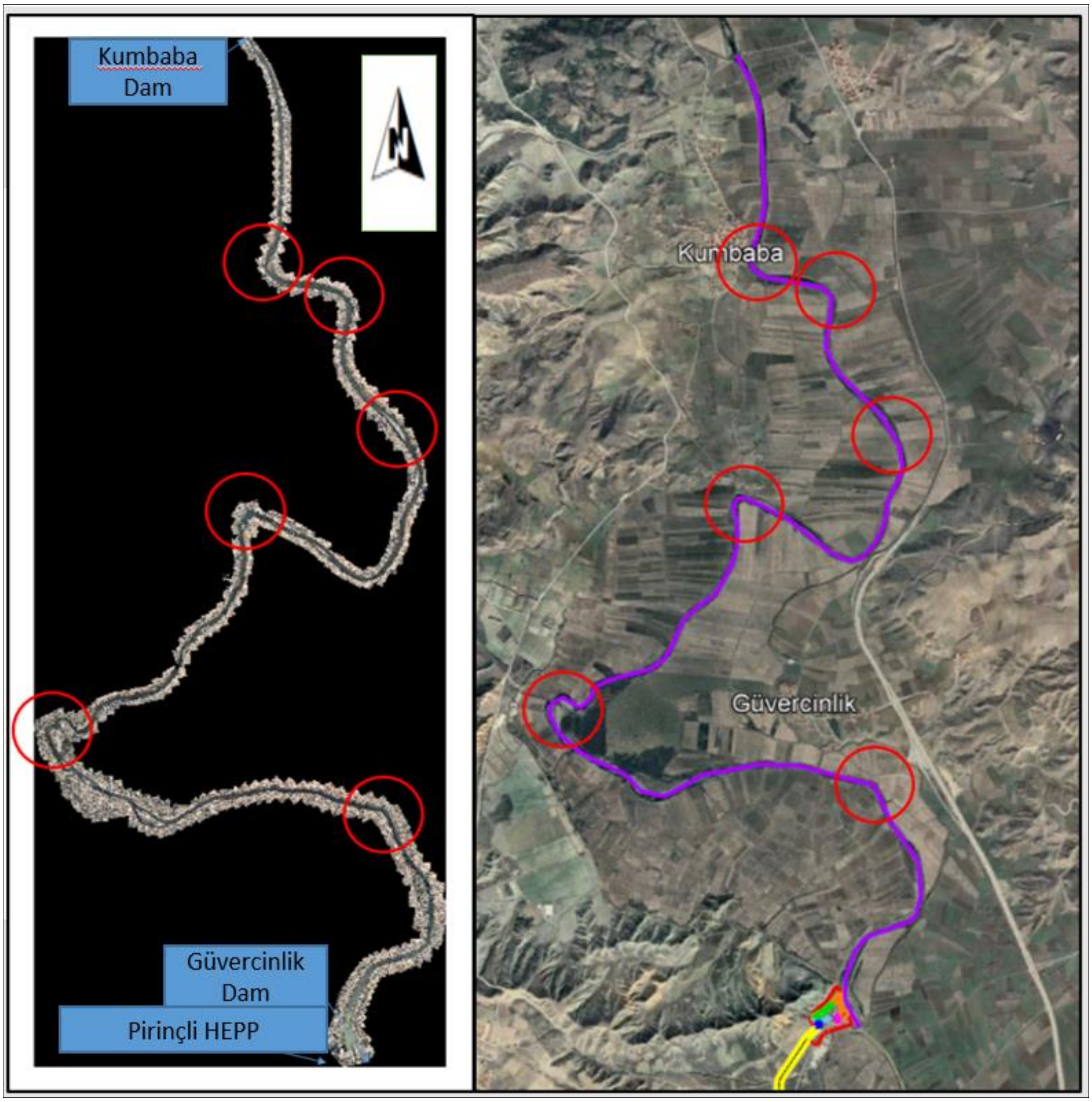

Figure 10. Mosaic image (Visible/infrared drone footage focusing on potential risk areas)

Conclusion

Of the depth measurements made at 341 points, 236 have a depth of 150 cm. It is seen that there are excessive alluvial accumulations in these areas. It has been observed that the values obtained from depth measurements between the dams are not distributed homogeneously in the anomaly graph, areas with high depth are located side by side with areas with low depth. These areas are considered to be particularly high risk. Considering that the average amount of water that Obruk Dam will release at its maximum production is 400 m3/sec, it is obvious that the river bed between Güvercinlik and Kumbaba Dams cannot carry this amount of water and that it will cause floods along with the connected streams on the side branches and threaten the safety of life and property.It is known that the alluvial material that forms the current situation was transported to the region before the construction of the Obruk Dam. Since the transports that may come from Obruk Dam will be detained/blocked by the existing dams.

Recommendations

When the study is evaluated in terms of its rich data, integrity of its methods and environmental quality It is anticipated that this planned work will be permanent in the long term.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the authors.

Acknowledgements or Notes

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