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FLOODS IN THE TERRITORY OF THE REPUBLIC OF AZERBAIJAN AND COUNTER MEASURES AGAINST THEM

A.SH. MAMMADOV, A.A. BAYRAMOV, E.B. JAVADZADE, G.H. HUSEYNOV

"HYDROLOG" Limited Liability Company, AZ1102, Baku city, Tbilisi Ave.

*e-mail:*ahmad.m@hidrolog.az

S.A.Velieva associate professor (Azerbaijan University of Architecture and Construction)

e-mail:velieva-sevda@mail.ru

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ABSTRACT

The article is devoted to mudflow activities that caused destruction on the territory of the Republic of Azerbaijan, the socio-economic problems they caused and their elimination. It also provides extensive information on the causes of floods and their hydraulic regime, devices used in global practice for managing flood waters, and sound recommendations for taking measures to reduce the damage caused by floods to the country's economy. Mudflow floods are caused by high steepness of river slopes, accumulation of large amounts of erosive material in river basins, heavy downpours and prolonged rains, intensive melting of snow cover accumulated in river basins due to a sharp increase in air temperature, and human economic activity . The mountainous and foothill regions of Azerbaijan, especially the southern slopes of the Greater Caucasus, are considered one of the regions with the largest number of mudflows in the world.

If earlier in our country mudflows occurred every 5-10 years, in recent years, under the influence of climate change and socio-economic development, the intensity, frequency and duration of floods have been observed (even on some rivers they repeat every year, and sometimes several times a year).

Introduction. Flood (an Arabic word for strong river currents) is a stony-muddy stream that suddenly appears in the bed of mountain rivers as a result of intense rains.Floods easily move stones weighing 100 tons by creating a flow with a speed of 3 m/s, and sometimes 10-15 m/s. Sometimes the amount of dependent materials he brings with him is several million. The sound, roar and roar of the approaching floods can be heard from a distance of a hundred meters or even several kilometers. The average height of flood waters reaches 3-5 meters, and rarely 8-10 meters.The main reason for the occurrence of floods is the physical-geographical conditions of the area, including the orographic-geomorphological structure - climate, soil, vegetation and hydrometeorological processes. A short-term (sometimes within a few hours) destructive muddy-stone flow of mountain rivers is called a flood. Intense torrential rains, rapid melting of glaciers and seasonal snow cover wash debris from the slopes and fill it into the river bed (channel) /1/.In most cases, floods occur 2-3 hours after heavy rains or after intensive melting of snow cover accumulated in river basins. The flood flow in the river lasts from several minutes to several hours. 80-90 percent of floods in Azerbaijan are caused by rainwater.The volume of

debris materials in flood flows is from 20-25% to 70-80% of the mass of the flow. Therefore, in a short period of time, a large amount of waste material is transported to the delivery cones of rivers through floods. The high flow of a flood increases its destructive power, which distinguishes it from ordinary floods. It is necessary to distinguish flood and flood flows.

Floods is the phase of the hydrological regime that occurs in rivers depending on the physical-geographical and climatic conditions of the river basin. Floods occur throughout the year mainly in spring and autumn seasons. Compared to floods, the amount of discharge in flood flows does not exceed 2-5% of the total flow. Flood flows in rivers are considered an expected event, and the times of its observation are informed by the population in advance. Since floods occur unexpectedly, in an instant, it is impossible to predict them in advance. The main cause of floods in dry valleys is sudden heavy downpours. The water runoff from the rains creates a rapid flow in the valleys with large slopes, which is collected in the river causes its materials to be washed and transported to the lower parts. The resulting rapid and destructive flow causes serious damage to communication lines and agricultural fields located along the road in a short period of time. The main mass of the flood is made up of large-sized sediments accumulated on the steep mountain slopes. These sediments are washed to the surface as a result of erosion on the mountain slopes and fall into the river valleys after being washed by small spurs. As a result of the tectonic processes occurring in the mountainous areas, rock splitting and the formation of small pieces of stone also occur. The formation of floods in rivers is closely related to landscape zones. In the Gobustan zone of the republic, sometimes muddy floods occur after heavy rains. Such floods are observed in Jeyrankechmez, Sumgayitchay, Takhtakorpu, Atachay and Gilgilchay basins /2, 3, 4/.

At the edges of the riverbeds, the detrital material from the erosion of the steep slopes is washed away by the currents when the floods pass through the river valley, causing the floods to take a more powerful form. Such cases are often found in Kishchay, Shinchay, Demiraparanchay, Girdimanchay and Valvalechay basins. Floodplains are mainly located in the highlands of the Big, Small Caucasus and Zangezur ranges. Debris materials collected at the foot of steep slopes and in the subsoil of river beds are also considered potential flood sources /3,4/. Currently, the alpine and subalpine meadow landscape has become an area of rapid erosion due to irregular use as summer pastures. Such areas can be found in the Hekari, Tartar, Ordubad, Girdiman, Pirsaat, Kish and Shin river basins. Flood flows are divided into 3 parts according to their composition /1,8/:

- Watery and stony floods;

- *Watery Muddy floods;*

- *Rocky-muddy floods*

According to the hydraulic structure of the flow, floods are divided into 2 places: Turbulent and laminar floods;

Turbulent floods. This flood is characterized by heavy flow and irregular movement of flow elements and intensive mixing of flow layers. Solids make up about 30-40% of the entrained materials in turbulent flows. These floods are weaker than other floods due to their destructive power.

Laminar or structured floods. Structurally in these floodsthe flow moves in parallel layers. Laminar or structural floods are stony-muddy, gravel-muddy or muddy. These floods are characterized by a large amount of silt in the flow, moving mainly in a straight direction and with itselfteabrings out a large amount of materials to its bed.Such floods are found mainly in Girdiman, Shin and Kish rivers. Such floods cause great destruction.Combating laminar or structural floods requires the construction of large-scale hydrotechnical facilities.

Floods are observed in almost all mountainous and foothill areas of the Republic of Azerbaijan.Out of 1700 rivers in the republic, 170 are considered to be flooded rivers. 67 of these rivers are considered more dangerous. 16 of the dangerous rivers (Balakenchay, Katekhchay, Talachay, Mukakhchay, Kapychay, Kurmukchay, Dashagylchay, Kishchay, Shinchay, Alijanchay, Turyunchay, Tikanilichay, Agchay, Bumchay, Demiraparanchay, Hamzalichay), 4 (Goychay, Girdimanchay, Agsuchay, Pirsaat)) are in mountainous Shirvan, 12 (Gusarchay, Guruchay, Gudyalchay, Agchay, Karachay, Chagachugchay, Valvelachay, Shabranchay, Devechichay, Gilgilchay, Atachay, Tughchay) are located in Guba-Khachmaz. 12 of the rivers with a high risk of flooding belong to the Nakhchivan Autonomous Republic, 6 to Ganja-Kazakh, 4 to Lachin-Kalbajar, 6 to Upper Karabakh, 5 to Lankaran-Astara region, and 2 to Absheron. Flooded rivers located in the territory of Azerbaijan have been a constant object of research. On the Kish River, where devastating floods are often observed, extensive research work has been carried out and embankment devices have been built. From 1772 to 1916, destructive floods passed through the Kish River 10 times, from 1926 to the present time, 43 times. Due to the economic damage they cause, floods are ahead of other natural disasters /6,7,9/.

Due to the effect of global climate change in the world, more intensive rains have been observed in the territory of the Republic in recent years. In 2022-24, more floods began to be observed in the territory of the republic. As a result of the floods that occurred in April-June 2024, up to 120 bridges located in the territory of the Republic were seriously damaged. Strong depth deformations occurred around the supports of the bridges. Bridges and other communications that suffered the most damage are mainly located on rivers in the Guba-Khachmaz zone. One of the main reasons is the removal of large amounts of sand and gravel from the channels of these rivers. Figures 1 and 2 show that the guard rail of the "Baku-Khachmaz" road bridge located on the Valvala River and the "Shollar-Baku" water pipeline crossing the river were washed away by the flood waters and fell into an accident.

Figure 1. Opening of guard rail of "Baku-Khachmaz" road bridge by washing.

Figure 2. Opening by washing the "Shollar-Baku" aqueduct crossing from the Velvele river

As can be seen from the photos, a very strong depth deformation is taking place in the river channel, and the river channel has created a 15-20 m wide deep gorge in the washed soil. The main stone-gravel alluvial soils that formed the channel were excavated and the river channel began to re-form on structurally weaker soil. In the newly formed river channels, depth deformations started to occur faster than the effect of floods. The area of the bringing cone of Mukhakhchay, which brings floods, is 310 km2, Balakenchay 255 km2, Kurmukchay 220 km2, Kish river 210 km2, and Shin river 185 km2. Hundreds of thousands of hectares of agricultural land in the catchment area of these rivers have become unusable by being covered with stones, gravel and clay brought by the flood. Many areas in Balakan, Zagatala, Gakh, Sheki, Oguz, Gabala, Ismayilli regions have been eroded by floods. S.Q.Rustamov summarized the

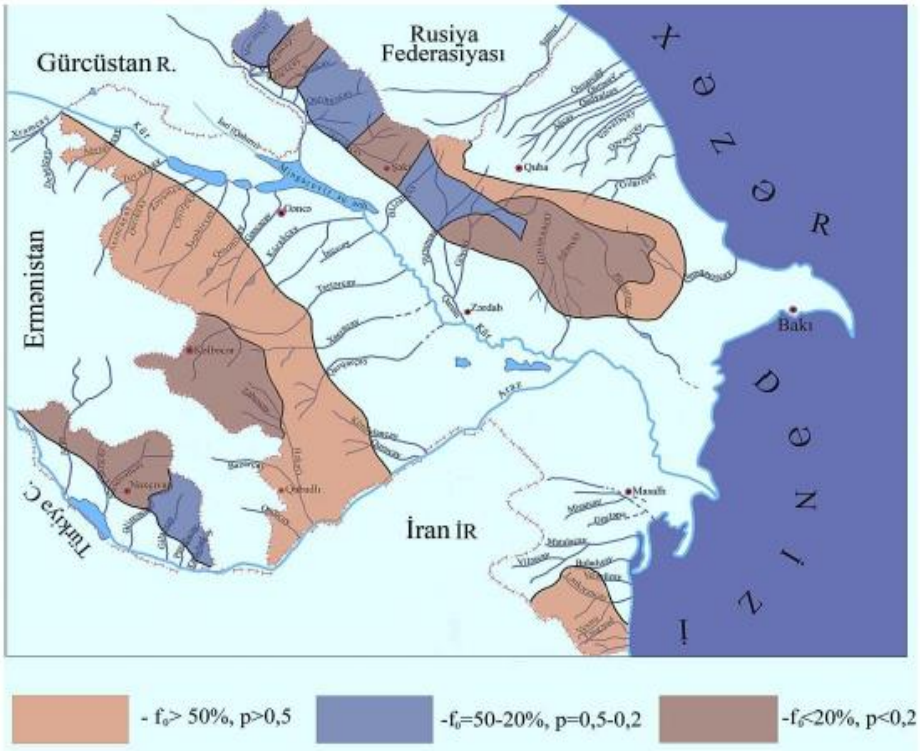
information about rivers that bring floods flowing from the southern slope of the Great Caucasus Mountains (table 1). As it can be seen, up to 40-50% of the catchment areas of Kish, Dashağıl and Girdiman rivers are floodplains /4/.

Table 1. Information about rivers that bring floods

Rivers	The average slope of the river until it brings the cone	The catchment area of the river until it reaches the cone, km2	Area of flood prone areas, km2	The ratio of the area of flood-prone areas to the total area in %
Mazymchay	0.128	117	20	17.1
Balakenchay	0.108	178	22	18.7
Katekhchay	0.118	334	51	15.3
Talachay	0.106	153	46	30.1
Mukhachay	0.088	287	92	32.1
Gurmukhchay	0.091	289	105	35.4
Gashkachay	0.113	66	10	15.2
Gumchay	0.056	108	7	6.5
Shinchai	0.092	223	91	41.0
Kishchay	0.117	165	75	45.5
Kunqutchay	0.103	166	46	27.7
Dashagilchay	0.092	259	106	40.9
Alijanchay	0.116	340	56	16.5
Turyanchay	0.081	898	280	31.2
Goychay	0.046	687	215	31.3
Girdimanchay	0.065	451	232	51.5
Agsuchay	0.071	321	96	30.0

In recent years, as a result of the expansion of settlement in the mountainous and foothill areas of the republic, anthropogenic effects on the environment have become stronger. Anthropogenic effects in all cases lead to the destruction of forest cover located in the catchment areas of rivers. The measures taken to mitigate the negative impact of anthropogenic factors in the water catchment parts of the rivers have not yet yielded significant results and the erosion areas are expanding rapidly.

Intermittent flow of floods through the channels of mountain rivers - in a wave-like hydraulic mode - causes their destructive power to be great. Depending on the physical and mechanical properties of the rocks that make up the river valleys, the river channel has a wide and narrow canyon-like cross-section. Sometimes the narrow parts of the channel are blocked by large pieces of rock and stone, creating traffic jams. A large amount of fetching material is collected behind these plugs from small floods. In cases of strong floods in the river, these plugs are broken and debris collected there is spread over a wider area of the channel with great speed. The large number of narrow areas along river valleys leads to an increase in the number of traffic jams and the creation of more destructive flood flows. The rivers of the Big, Little Caucasus and Zangezur ranges are characterized by the alternation of narrow and wide cross-sectional channels. The flood map on the territory of Azerbaijan is given in figure 3 /10/.



Georgia, Russian Federation, Armenia, Turkey, Iran I.R., Caspian Sea

Figure 3. Flood map of the territory of Azerbaijan

Flood control measures: More than 1.5 million people live in the valleys of flooded rivers in the territory of Azerbaijan. More than 200 settlements of 18 districts of the republic are located in flood-prone areas. According to statistics, 300 km of railways, more than 1000 km of highways, hundreds of bridges and other communications are located in flooded areas. In the world the measures to combat handworms are mainly carried out in two directions: active and passive methods. Active control measures are aimed at preventing natural and anthropogenic factors that cause floods. These control measures are carried out by carrying out phytomeliorative works in mountain-meadow and forest zones, as is the case all over the world. Among these measures, it is important to protect the forest zone in the catchment basin and to completely ban cattle grazing in the forests. Determining the norms of animal grazing in alpine-subalpine meadows, where the main floodplains are formed and used as summer pastures, is one of the important issues. In the world experience and very little active control measures in Azerbaijan show that the restoration of the forest-forest-shrub ecosystem has a greater effect in high-altitude and medium-altitude areas subject to intense erosion. These fighting measures should be carried out on a larger scale at the state level.

Passive methods include engineering facilities built in riverbeds where floods pass, embankments for the protection of settlements and economic facilities in the flow cones of rivers, flood catcher-level-raising partitions built along the length of the channel (walls with a height of 2-3 m and barriers with holes and meshes that are higher). and include clauses that leave the relatively dry part while keeping the flow of the flood /1, 8/. The general classification of this type of devices is given in table 2.

Table 2. Devices used in the engineering protection of areas against floods

Possible actions and type of device	Purpose of the device and conditions of application
Flood-catcher devices	
Concrete, reinforced concrete and stone dams:	Keeping the flood flows in the upper bay and letting the relatively smooth flow in the lower bay by taking the mains
Dams with irrigation	
Porous-mesh dams	
Deaf soil-stone embankments	
2. Flood release devices	
Channels	Ensuring discharge of flood flows through or bypassing the area
Flood gutters	
Bridges that release floods	
3. Directing flood waters	
Flow diverting dams	
Spurs	
4. Regulatory devices	
Adjustment teeth in the form of a cascade	Actions related to retention of flood waters in the catchment area or weakening of the power of the flow
Retaining walls	
Drainage facilities	
Creation of terraces on slopes	
Forestry measures	
5. Flood prevention devices	
Flood control dams	
Water throwing near reservoir dams	
6. Organization - technical works	
Monitoring and warning service	Forecasts on the occurrence of flood flows

In order to partially extinguish the energy of the flow and deposit large-sized stones in the channel in the streams that bring floods, thresholds of concrete elements are built along the length of the channel. These calming-regulatory thresholds should be designed to release 2% of the flood flows generated in the valley. The material and height of the device -H, spacing -L are calculated based on the fractional composition of the probable flow of the flood (Figure 4).

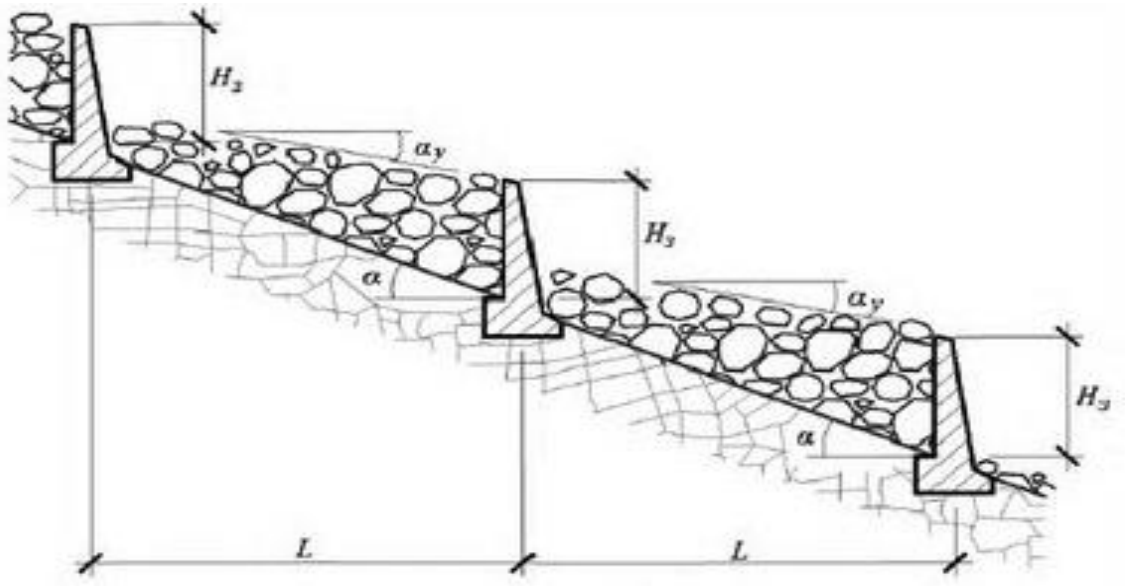


Figure 4. Placement of regulatory thresholds along the length of the duct

In some cases, it is necessary to release the flood flows over roads and railways, water channels. For this purpose, bridge-type tributary devices are built on these devices. Floodwaters are diverted through troughs made of concrete or steel sheets placed on special supports (Fig. 5 a). In order to protect the roads built along the channels of the rivers from the influence of flood waters, spurs (spurs) are placed along the bank of the channel, directing a stream at a certain distance (Fig. 5 b).

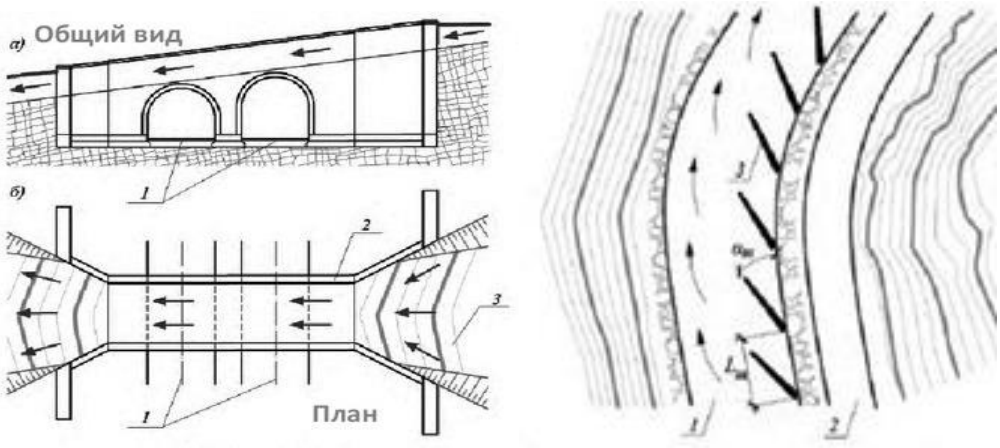


Figure 5. Flood release device

a) The device that releases the flood over the road and channel; 1-motorway, 2-flood discharge device, 3- torrent channel.

b) Flood directing device; 1-flood channel, 2-protected highway, 3-rivers.

Concrete channels designed under special conditions are used to safely carry floodwaters through cities and villages. The hydraulic capacity of these troughs should be calculated to safely release the maximum floodwater. Sometimes there is a need to build different-purpose facilities in the river channel (electric poles, various-purpose supports, etc.). for the protection of this type of facilities from flood waters, walls are used that cut off the flood flow and direct the debris to the outside (picture 6).

Artificial concrete chanel

flood, protected object

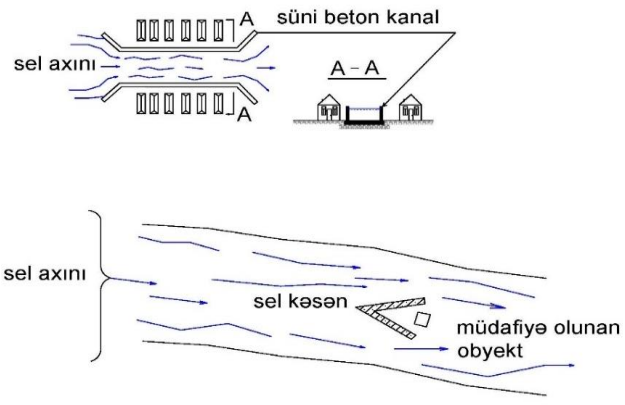


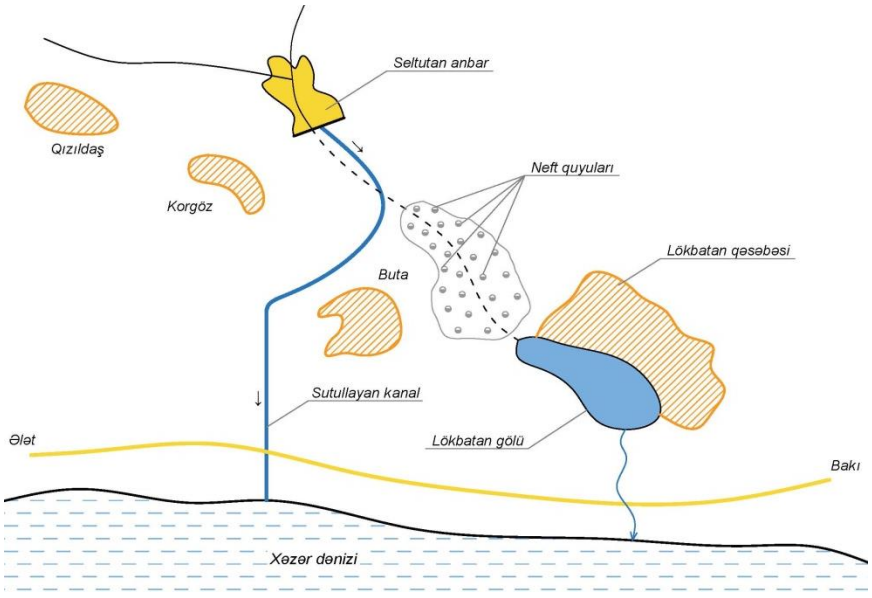
Figure 6. Floodwater management within the city and around facilities

It should be noted that until now in the Republic of Azerbaijan, flood control measures in river basins have been mainly carried out by passive methods. In the territory of the Republic, the protection of settlements, roads, agricultural fields and other infrastructures from flood waters is carried out mainly by strengthening the banks of rivers and directing flood waters. In the rivers where more floods occur in the territory of the republic action plan and corresponding projects of combat measures have been prepared. In the rivers, embankment and sewerage works are carried out, concrete, stone-concrete and gabion dams are built. At present, there are 22 kilometers of stone-concrete dams in the upper parts of mountain and foothill rivers, and 23 kilometers of protection dams made of prefabricated reinforced concrete elements in the middle parts. Experience shows that the amount of funds spent to eliminate the consequences of floods and floods is more than to prevent them in advance. is many times more than the funds needed for the measures to be taken. Flood prevention projects include protection of residential areas, industrial facilities, engineering and technical communications and agricultural fields from the harmful effects of floods in Balaken, Zagatala, Gakh, Sheki, Oguz, Gabala, Ismayilli, Goychay, Agsu, Gusar regions and the most dangerous parts of the rivers passing through the territory of Nakhchivan AR. construction of concrete dams with a total length of up to 95.0 km is planned.In recent years, reinforced concrete retaining walls with a length of 4.5 km and a height of 4-6 m were built along the right bank of the Demiraparan river in order to protect newly created recreation centers and other facilities from flood waters in Gabala. In order to protect the city of Sheki from flood waters, a 2.5 km long coastal protection embankment was built along the left bank of the Kish River /9/.

In the territory of Azerbaijan, some settlements are located at the exits of dry valleys with a large catchment area. During heavy downpours, short-term but large mud floods are observed in Buderas, which causes serious consequences. An example of such flood events is the floods that occurred in 1957 in Kendelenchay, Gargabazarchay, Cherakenchay, Jabrayilchay and Chakhmagchay, which caused great destruction. On October 18 and 27, 1957, the torrential rains that fell on Chakmag and Jabrayil rivers caused a strong flood. The flood that occurred in the valley of the tributary of the Chakhmag river, the Guruagac branch, damaged up to 30 houses in the village of Hovuslu, and some yards and roads were covered with stones and mud 1.5-2.0 m high. On October 27, the flood that passed through the Jabrayil River caused more damage, the floodwaters came out of the river channel and spread to the main central street of the city and destroyed the cocoon receiving station. After a short flood, the yards of the houses on the main street of the city and around the Chinar river were filled with mud and 1.0-1.5 m diameter stones. After the flood that passed through the river valley, grass and tree branches were left hanging on telephone and electric wires with a height of 3-3.5 m. The river channel with a width of 20.0 m and a depth of 3.0 m was filled with silt during 2-3 hours. The flood in Kondalanchay lasted for 5 hours, and at that time the maximum water consumption was 220.0 m3/sec, which did not pass through the silting device of the water reservoir built in the course of the river (up to this time, the maximum flood consumption in the river was 15.0 m3/sec) and as a result, the right bank of the dam was washed away by the flood. destroyed. The flood from the Çerakan river, which is mainly a dry river valley, caused serious destruction in the city of Fuzuli. The floodwaters came out of the Cheraken river and flooded the courtyards of private houses and public buildings located in the city. In October, a short-term flood occurred from the Gargabazar river located in the territory of Fuzuli region, and the village area was seriously damaged. This river was flooded twice with a break of 3 hours, and after the flood, a layer of sand and gravel 3 m high was formed in the river valley /5, 7/.

In general, more floods and floodings were observed in the territory of Azerbaijan in the 1950s. Sumgait and Jeyrankechmez rivers, located on the Absheron peninsula, experienced floods in 1952, 1953, 1958 and 1963, which seriously damaged some infrastructure facilities and oil fields /2/. The floods that occurred in 1952-53 caused serious damage to the oil fields and the railway located around Lokbatan settlement. The floodwaters coming from the direction of Korgoz and Gizildash caused the level of Lokbatan lake to rise sharply and surrounding houses were flooded. Taking into account the situation, a project was developed and construction works were carried out, which envisages the capture and regulation of the flood waters of the stream flowing in the direction of Lokbatan and bypassing this area and transferring it to the Caspian Sea. According to the project, in the east of Korgoz settlement, the front of the stream was cut with a 20.0 m high earthen embankment, and a reservoir with a total volume of up to 4.2 million cubic meters was created for the regulation of flood waters. In order to direct the flood waters collected in the reservoir to the Khakhar Sea, a 7.8 km long, maximum water consumption of 12.0 m3/s channel was built. By bypassing the direction of Lokbatan, this channel allowed flood waters to flow from the western part of Buta settlement to the sea. Unfortunately, during the heavy rains in this area on April 23, 1966, the flood dam was washed away and collapsed /6, 7/.

During heavy rains, it is likely that more than 60.0 m3/sec of flood flow is observed in the creek entering the reservoir (393.0 m3/sec of flood flow was observed in the Jeyrankechmez River during this rain) /2/. There is an urgent need to rebuild this system taking into account the current climate change. If the rains that occurred in 1966 are repeated, there is a possibility that a part of Lokbatan settlement, Bina trade center and many strategically important infrastructures will be flooded. At present, the 5.2 km section of the water throwing channel of this hydrotechnical facility system is partially operational and is used for the purpose of diverting rainwater generated in the direction of Buta settlement (Fig. 7).



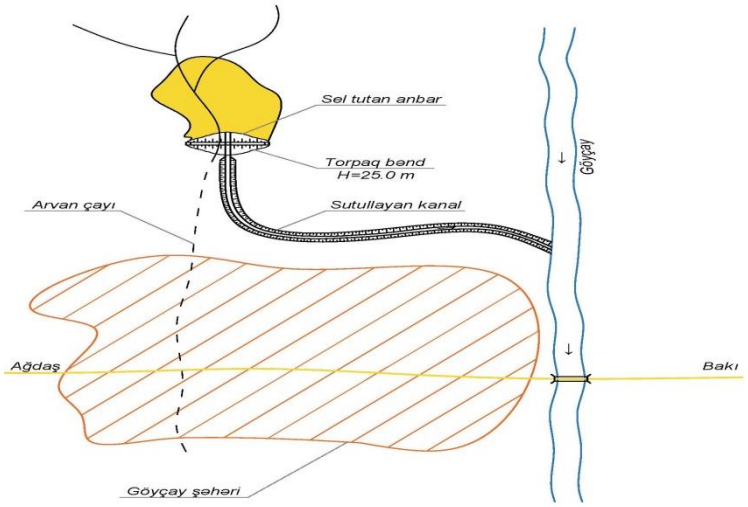
Kizildash, Korgoz, Alat, Buta, Flood catchment reservoir, oil wells, Lokbatan settlement, water catchment canal, Lokbatan lake, Baku.

Figure 7. Plan of the facilities built to protect Lokbatan settlement and oil fields from flood waters

The same catastrophic natural event occurred during the flood in the Arvan river passing west of Goychay city. The length of 12.0 km, the catchment area is mostly bare mountains, the

river Arvan river is currently located in the western part of Goychay city. At one time, the course of this river passed beyond the western boundary of the city. The city expanded rapidly to the west, and now the course of the river remains within the city. In this river, which has a catchment area of up to 2100 hectares, mud floods are observed during heavy rains. The last flood that caused greater destruction occurred on the Arvan River on April 25, 1973. As a result of the flood, the basements and courtyards of up to 200 houses located in the western part of the city were filled with mud 0.5-1.0 m high. The flood has completely paralyzed the traffic on the main streets of the city. Equipment and people from neighboring regions have come to help clean the mud accumulated on the streets. In order to prevent the situation from happening again, a special reservoir of flood catchment was built in the course of the Arvan river. In the upper part of the city, in the narrow part of the river channel, a system of hydrotechnical devices was built and put into use in 1977, which allows to catch and regulate the flood waters and partially throw them into the channel of the Blue River. An earth dam with a height of 25.0 m and a length of 230 m was built in the course of the river, and a 2.0 km long, concrete-lined channel with a maximum water consumption of 30.0 m3/sec was built to allow the flood waters to flow into the course of the Goychay River.

The total volume of the created flood catchment reservoir was 3.8 million cubic meters. In the body of this dam, a tower intake device with open windows (3x3 m in size) was built, which takes water from 4 different levels and transfers it to the canal. The flood waters entering the reservoir are partially regulated in this reservoir, and after a part of the silt settles, it is pumped into the course of the Goychay River through the siltation channel. The Seltutan reservoir created in this way ensured the complete protection of the city of Goychay from flood waters. 45-50 m3/sec of flood water in the Arvan River first enters this reservoir, and from here it is discharged into the Goychay River with a consumption of 15-20 m3/sec. It should be noted that in 2021, during our inspection of this flood catchment storage, it was found that the two windows of the subaqueous tower located below were covered with silt deposits. This flood catchment reservoir on the Arvan river is the only magnificent facility of this type in working condition in the territory of Azerbaijan (photo 8).



Arvan river, Agdash, Goychay city, flood catchment reservoir, earth embankment, flood catchment canal, Goychay city, Baku.

Figure 8. Facilities built to protect the city of Goychay from flood waters

Flood control measures in world practice: Serious engineering facilities are being built to protect large cities and strategically important industrial areas from the effects of destructive floods. These facilities were built primarily for the purpose of disrupting the structure of flood waters along the river channels and reducing its strength. In the territories of Turkey, Kazakhstan and Georgia, devices that destroy the flow structure of the flood, mainly concrete, stone-concrete and steel structures, are widely used in the course of mountain rivers. Barriers made of metal construction are used to reduce the speed of the flood and mainly to keep pieces of stones /6, 8, 11/. Barriers of this type are built in several characteristic places in the channel, and periodically the sediments collected in their upper reaches are excavated and used as construction material (Figure 9).

Figure 9. A flood catcher made of steel elements

In small streams, barriers made of metal mesh are used to reduce the speed of the flood and mainly to retain the pieces of rock. Metal nets in this type of barriers are connected with cables to supports built on the shore. In the channel with unstable banks, this type of devices are attached to concrete partition walls (photo 10).

Figure 10. A flood catchment device made of steel mesh

Depending on the local conditions and the nature of the flood, thresholds that turn off the power are built in the channel. These thresholds are made of concrete or masonry, depending on the speed of the flood. Thresholds are built 3-5 m high, depending on local conditions. Behind these thresholds, flood deposits collapse and the bottom slope of the channel decreases, which allows for a sharp decrease in the flow and the destructive power of the flood (Figure 11).

Figure 11. Sequential threshold flood dampers along the channel

Depending on the strength of the flood and local conditions, combined flood arresters are also widely used. In these installations, both the concrete dam and the steel construction flood catchment installations support each other by placing them at a certain distance. Holes of a special size are installed in the body of the concrete dam to release water (photo 12).

Figure 12. Combined flood catchment devices

In world practice, the practice of using large reservoirs is also used to manage floods with greater destructive power. The most dangerous floods in the world are in Austria (Alps), United States of America (California), Peru (Cordillera-Blanca mountains), Japan (Kobe port), Ukraine (Carpathians and Crimea), Turkmenistan (Ashgabad city), Uzbekistan (Fergana valley). and is observed in the territories of Kazakhstan (Zeylik Alatau). Many devastating floods occurred in these areas in the 18th and 20th centuries, which in many cases caused great loss of life. In order to fight against floods in Austria, more than 4400 km of embankments, 5540 levees and dams, and 700 hectares of upland forest were planted in 90 years (1884-1973). One of the cities most affected by floods is the city of Los Angeles in the United States. The city is located 80 km along the ocean coast at the foot of the 3000 m high San Gabriel Mountains. After the devastating flood in 1914, projects were developed to protect the city from flood waters. Construction works based on these projects were completed in 1970. During this period, 20 flood control dams, 105 flood catchment dams and 1033 km of channels of various sizes were built. These protective structures, which were built, mainly protected the city during the great floods that occurred in 1969. During this flood, a total of 12.4 million cubic meters of water was collected in the reservoirs. The Japanese city of Kobe is located at the foot of the Rocci Mountains in the south of Hongsyo

Island. This mountain system is made up of rapidly washed mountain rocks. The city is located around the cones of numerous rivers flowing through this rock. During the 1938 flood disaster, 616 people died in this city and the city suffered a lot of damage. In 1968, a project was implemented to protect the city from flood waters. According to this project, up to several million cubic meters of soil located in the mountains, prone to being washed away by floods, was cut and used for the expansion of the port /8, 11/.

Floodwaters in Ukraine are observed mainly in the rivers flowing from the Carpathian Mountains and the Crimean Peninsula. In both areas, numerous flood-regulating thresholds with a height of 3-5 m have been built. Rivers that bring floods in the territory of Uzbekistan are mainly located in the Fergana valley. In order to fight against floods, the construction of mainly small-volume flood catchment reservoirs has been given ample space. During the flood, the partially rinsed water collected in these reservoirs is used for irrigation. In the territory of Turkmenistan, the most floods occur in the Kopetdag range. The city of Ashgabat is most vulnerable to floods. From the direction of the Iranian border, 11 floods are directed towards the city of Ashgabat. In 2018-19, floodwaters entering from these valleys caused serious damage to the city. Taking this into account, a flood catchment channel was built at the end of these flooded valleys, and in several places, flood reservoirs were created with a volume that could be filled with silt for a period of 25 years.

The most floods in the territory of Kazakhstan are observed in the Zaylik Alatau region, which has been a constant source of danger for the city of Almaty. In 1887, 1910, 1921, 1956, 1963 and 1973, catastrophic floods occurred that seriously damaged the city of Almaty. The most dangerous of these floods occurred on July 8-9, 1921 in the Big and Small Almatinka rivers. During this flood, a total of 7-10 million cubic meters of stones and mud entered the city area from these rivers, a part of the city was destroyed in a short time, and 500 people died. One of the most destructive floods occurred on Sunday, July 7, 1963, and during 3-4 hours, up to 6-7 million cubic meters of stones and mud entered the city from these streams. The flood destroyed Lake Issyk in the highlands and tragically killed up to 150 tourists who were vacationing there. This flood showed a serious threat to the city of Almaty and the reliable engineer was the basis for the implementation of measures. In order to protect the city of Almaty from flood waters, the government of Kazakhstan has decided to build a 110 m high stone-soil dam (the volume of the dam is 3.0 million cubic meters) in the Medeo area of the Little Almatinka River (at an altitude of 1750 m above sea level) and create a large-scale flood storage reservoir.

The construction of this blast dam was started in 1964, and the reservoir was put into operation in 1972. Thus, after two directed explosions, a dam with a width of 500 m from the bottom, a width of 100 m from the top and a height of 85 m was created in the river valley. The upper and lower slopes of the soil mass poured into the river valley were relatively leveled and the height of the dam was increased to 107 m. By building this dam, a reservoir with a total volume of 6.2 million cubic meters was created. The severe flood that occurred on July 15, 1973 was the most difficult test for the Medeo reservoir. During this flood, up to 5.3 million cubic meters of stone and mud flowed from the Little Almatinka River. Since the newly built dam completely blocked the flood, the water level in the reservoir began to rise rapidly, and there was a danger of the water overflowing the dam and washing it away /8, 11/.

Large seepage flows from several directions were observed from the body of the dam. Considering the situation, hundreds of pumps were installed in the upper side of the dam and

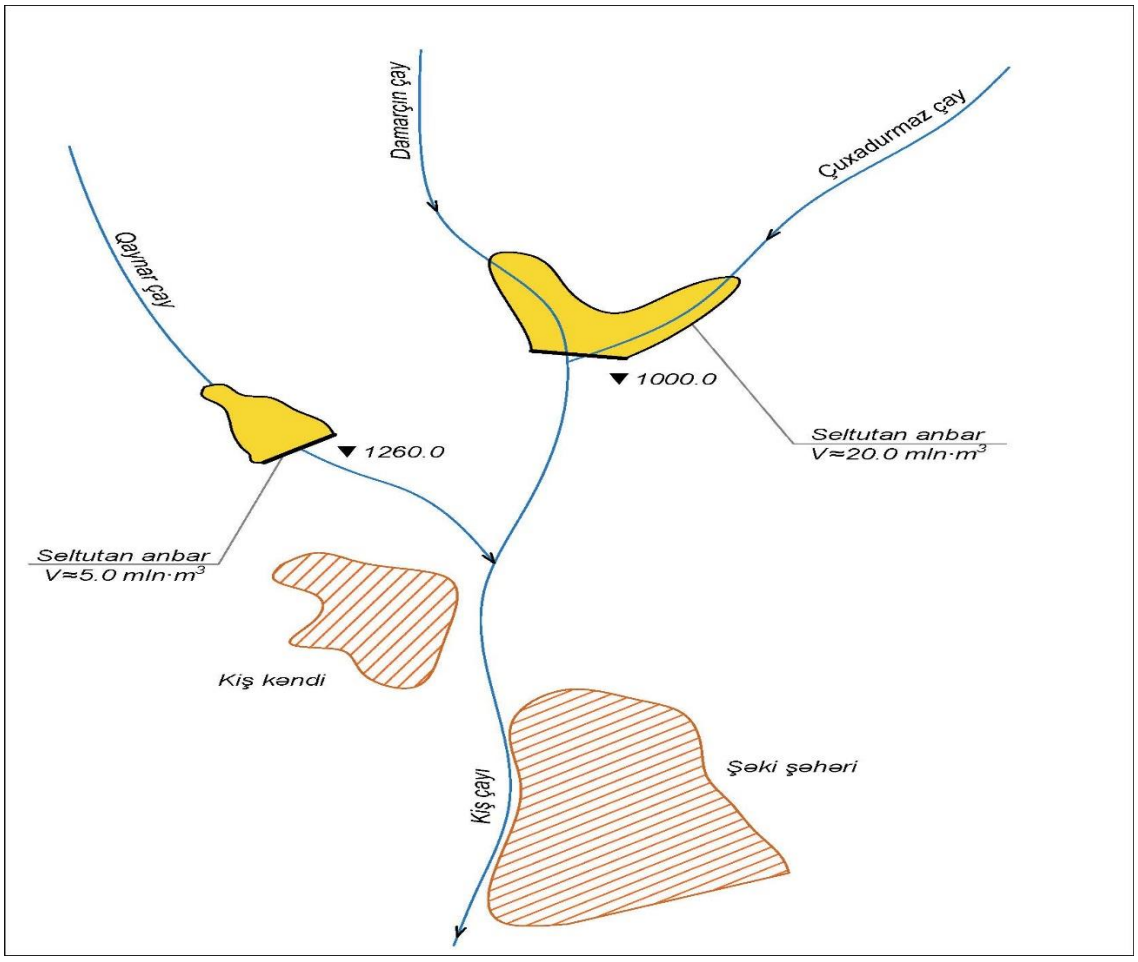
the water level was relatively lowered. After this catastrophic flood, the height of the dam was increased to 150 m, and the volume of the reservoir was 12.6 million cubic meters. The width of the dam is 20 m from the top, 800 m from the bottom, and the volume of soil and rock is 8.5 million cubic meters. This reservoir is one of the largest structures of this type in the world. A multi-window automatic water release device with a maximum consumption of 30.0 m3/sec has been built in the body of the dam, which can regulate the flood waters and release them to the lower bay. There are 35 water-releasing windows from the reservoir in three directions, allowing water to be taken at different levels and released into the lower bay. The alluvial sediments collected in the upper basin of the strategically important Medeo reservoir are used as construction material. A cable car was built around this warehouse and the area has become a favorite travel destination for tourists. The water collected in the reservoir is used in the water supply of the city of Almaty. For this purpose, a complex of water purification devices was built in the lower bay of the dam.

Necessary works against floods in the territory of the Republic: Destructive floods are often observed in the territory of the Republic of Azerbaijan. Floods wash the beds and banks of rivers, destroy obstacles, settlements, bridges, etc. It causes human casualties. Shin (1510), Kish (1901, 1982), Kurmuk (1921), Dashağıl (1656), Demiraparan (1963), Girdiman (1976), Pirsaat (1974), Mazım (1956), Kondalan, etc. floods with a great destructive force occurred in the rivers.

The conducted studies show that the area of floodplains in the river basins located on the southern slope of the Great Caucasus has increased by 15-20% on average compared to the data of 1961-1990. This increase is mainly observed in Shin, Kish, Demiraparan and Girdiman rivers. It was determined that floods cause great damage due to the lack of or very weak anti-flood devices in the river basins. For example, the flood that occurred in the Bum river in July 2015 (as a result, some houses in the village of Gamarvan were buried under a mass of mud), in the Kish river in July 2016 (as a result, the bridge connecting the village of Kish with the city of Sheki completely collapsed, the surrounding recreation centers under a thick layer of mud), in September 2016 in the Demiraparan river (as a result, several recreation centers in the city of Gabala were covered by a mass of mud), in June 2018 in the Goychay river flood (as a result of the flood, the district center of Galachiq and surrounding villages and the bridge connecting the city of Goychay with surrounding villages collapsed), the floods that occurred in Dashkasan and Gadabey in 2023, and in Goranboy and Zagatala in 2024 can be mentioned.If the flow cones of all flooded rivers and eroded land areas in Azerbaijan increase at this rate and serious measures against floods are not taken, 100-120 thousand ha of the most productive land areas of the republic may become unusable within the next 30-50 years /6, 7, 9 /.

There is a serious need to take substantial measures against floods in the Kish and Shin rivers, which bring the most floods and damage farms in the republic. The construction of dams of special construction to catch the floods in the channels of these rivers is considered to be the right option from the economic and ecological point of view. By building an earthen dam with a height of 50.0 m on the Gaynar tributary of the Kish river in the upper part of the Kish village, at the level of 1260 m in the river course, it is possible to create a reservoir with a volume of about 5 million cubic meters and regulate the river's flood flows, and use its water resources more efficiently. The silt reservoir to be built will allow to regulate the flow of the river and to use it as construction material. By placing a stone-sand quarry on the upper side of the flood catchment unit, it is possible to exclude and effectively use the river deposits that periodically settle there.

Seltutan reservoirs of the same type should be built at the junction of the Chukhadurmaz and Damarchin branches of the Kish river, at the level of 1000.0 m. Preliminary calculations show that it is possible to create a flood catchment reservoir with a volume of up to 20 million cubic meters by building a dam with a height of 65 m at the confluence of the rivers. It should be noted that the average price of the annual flow of the Kish River is about 100 million cubic meters. In these reservoirs designed to regulate flood waters, devices that can ensure that a part of it bypasses the dam and releases it into the lower bay when the floods come should also be provided. The location plan of the flood catchment reservoirs, which are planned to be built in the Kish river channel, is given in Figure 13.



Kish village, flood catchment reservoir, Gaymalchay, Kish river, Sheki city, Darmarchin river, Chukadurmaz river, flood catchment reservoir,Sheki city

Figure 13. Location plan of flood catchment reservoirs, which are planned to be built on the Kish River

As we mentioned above, the Shin river located in this zone is also a river that brings a lot of floods. Several large villages of Sheki district are located in the catchment area of this river. The transport cone is crossed by the republic's strategically important Sheki-Kakh highway and the Baku-Balakan railway. Floods in the river cause serious damage to communication lines and agricultural fields located in the area every year. According to the section of the river near the village of Shin, the water catchment area is 119 km2, and it brings about 120 thousand cubic meters during the year. Preliminary calculations show that it is possible to create a flood catchment reservoir with a volume of up to 30 million cubic meters by building a dam with a

height of 75 m in the course of the river, at an absolute level of 1100 m. In this reservoir, which is intended to regulate flood waters, when floods come, special facilities should also be provided to release a part of it in transit, bypassing the dam, into the lower bay. The location plan of the flood catchment reservoirs, which are planned to be built in the course of the Shin river, is given in figure 14.

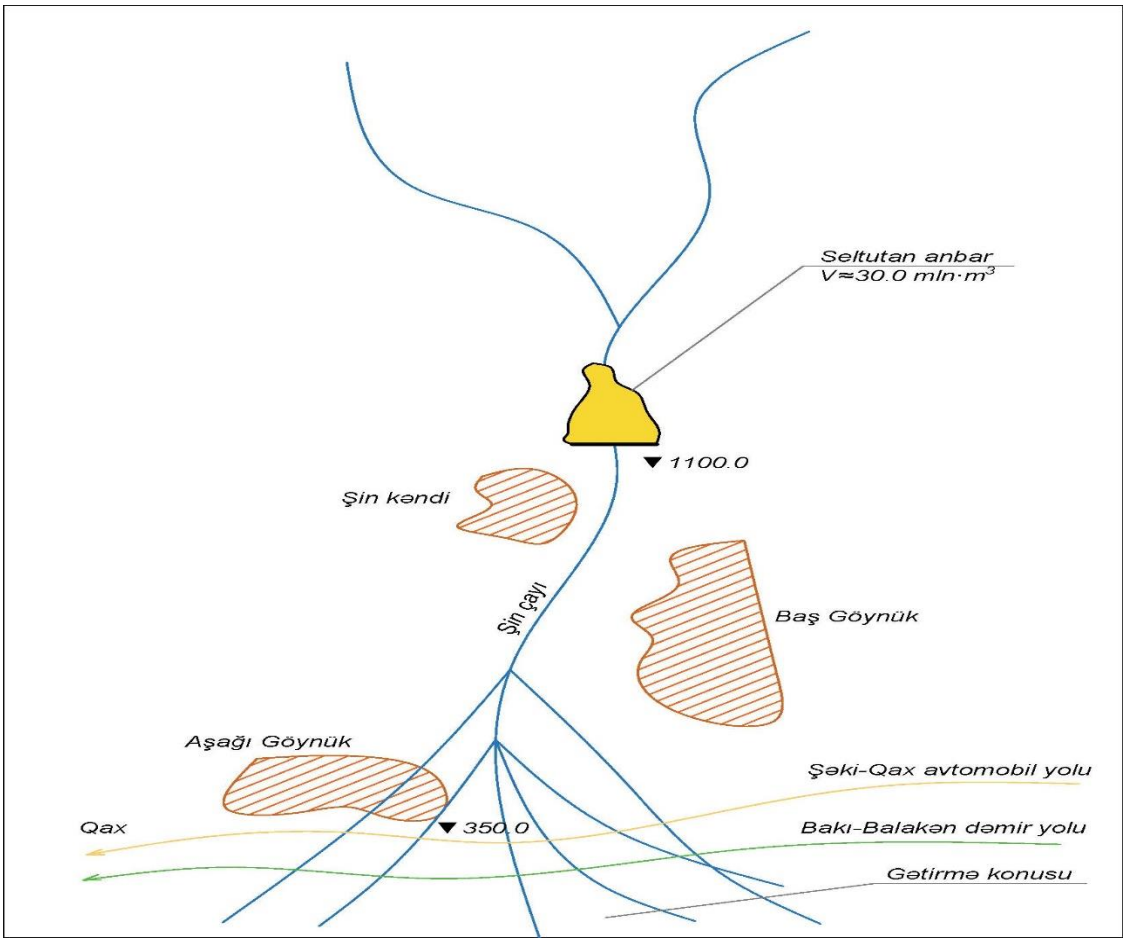


Figure 14. The location plan of the flood catchment reservoirs, which are planned to be built in the course of the Shin River

About 250-300 thousand cubic meters of sand-gravel material will be deposited in these flood catchment reservoirs to be built. By placing stone-sand processing quarries in the upper reaches of the flood catchment reservoirs, construction sites of the republic can be continuously supplied with construction material (sand, gravel, stone, clay). The sand-gravel material to be used here can be delivered cheaply and quickly to any construction site of the country by using the Baku-Balakan railway, which is located very close to the area.

There is a need to implement the following urgent measures against floods in the territory of the Republic:

- When designing settlements and other infrastructures, hydrological data related to destructive floods in the area should be extensively investigated;
- In cases where settlements are built along dry valleys and in the areas where they come out to the plain, not to interfere with the channels created by large floods that have historically passed through this area;

- During the design of residential areas built along river valleys, the level of flow resulting from the maximum floods that may occur must be taken into account and the construction of protective walls;
- In order to ensure the safety of the population living in the existing settlements, the creation of systems that detect the danger of flooding in advance along the river valleys;
- Preparation of special evacuation plans to quickly and safely remove the population from flood-prone areas;
- Reducing the volume of floods by carrying out forest and forest-shrub ecosystem restoration works in the highlands and mid-mountain areas that are subject to erosion in the catchment area of rivers;
- Determining animal grazing norms in alpine-subalpine meadows where the main floodplains are formed and used as summer pastures;
- Creation of special water reservoirs in the upper parts of these valleys in order to protect settlements built in the course of dry valleys from floods;
- Construction of canals diverting flood waters around flood-prone settlements, if the relief allows;
- By creating stone-sand quarries in the channels of larger rivers that bring floods (Kish, Shin, Girdiman, Tala, Gurmukh, etc.), deepening of their channels and preventing the spread of flood waters around;
- Cascading control devices should be built along the channels of small rivers where intense floods are observed.

Main results

1. **Taking into account the effects of global climate change, the hydrological regimes of flood-prone rivers located on the territory of the republic and the maximum possible water consumption should be determined.**
2. **Hydrological information about floods that may occur in dry valleys where large settlements are located should be clarified and appropriate engineering measures should be taken for the safety of the population.**
3. **Appropriate engineering measures should be taken to protect Lokbatan (Sadarak and Bina shopping centers), Buta, Sahil settlements and industrial facilities from flood waters in Garadagh district of Baku city.**
4. **It is considered appropriate to create large-scale silt reservoirs in the channels of rivers Kish, Shin, Girdiman, Tala, Gurmukh, etc.**
5. **In order to use in construction works, stone-sand quarries should be created in the channels of Kish, Shin, Girdiman, Tala and Gurmukh rivers, dredging of their channels and partial control of flood waters should be carried out.**

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