

## **INVESTIGATING OF WATER DIVERSION STRUCTURES AND IRRIGATION NETWORK IN ANCIENT TIME OF SHUSHTAR CITY TYPICAL STUDY OF DAM, BRIDGE-DAM, CREEK**

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### **ABSTRACT**

Mizan dam, Shadorwan bridge-dam and Dariun creek which were constructed on Karoon river in Shushtar city are from old and ancient structures that are located in Khuzestan province. In this paper their technical and engineering specifications have been addressed.

Mizan dam was constructed in Sassanid Shahpur I reign in order to regulate and to divide Karoon river water between 2 tributaries; Gargar and Shotate. this dam has 9 entrances whose bottoms are a little lower than lowest water level of the river. Dariun Creek was dug out down stream of Mizan dam in the Achaemenid Darius I reign In order to irrigate Mianab plain. Shadorwan bridge-dam was built down stream of Dariun creek by sassanid Shahpur I for 2 purposes: 1- To connect either side of karoon river. 2- To raise water level for providing necessary head so that water rivers the Dariun creek.

### **INTRODUCTION**

Water has always played an important role in forming civilization as the most ancient human civilizations have been formed on banks or rivers. Karoon river in south of Iran has been the origin of many civilizations. Karoon, is the greatest and the longest river of Iran. After leaving Zagros mountains' straits, it enters Khuzestun plain and then flows in Shushtar city flat land, fertile soil accompanied by plenty of water of running rivers of Khuzestun province, it has made this region as one of most important agricultural pivot points of country during the history so that it always has attracted the attention of many rulers. In Achaemenids reign. Their economy which was dependent on agricultural revenues, had made the government to increase farmers' revenues and as a result, country's revenues by developing this sector.

Digging Gargar and Dariun hand – dug creek are probable activities of Achaemenids to develop agriculture. After Achaemenids, The Sassanids attempted to construct and

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develop water installations in Shushtar and managed to create the most unique irrigation network in ancient times.

Although the purpose in constructing these installations was irrigation, their constructors achieved other great purposes such as industrial, commercial, defensive, architectural and etc.

The set of Shushtar mills comprises more than 10 mills which is considered as the greatest industrial set prior to industrial revolution. Utilizing river all around the city, digging moats, accompanied by defensive fences and adopting defensive strategic positions made this city as impregnable in some junctions of history.

- Navigability of Gargar river made the Shushtar a considerable axis at international level in commercial and trade areas.
- Utilizing water in circumferential structures for living on basis of climatic conditions by creating subterranean network under ancient Shushtar city, has formed one of the smartest aquatic architectural forms.

Shadorwan dam and bridge which gained reputation in Iranian legends, were not only one of the most fundamental part of Shushtar irrigation network, but also one of few roads for crossing the Karoon river. Probably kingdom road passed this bridge.

Considering political and economical significance of Shushtar and its water installations, castle of this city served both as control center of these installations and residence of Khuzestan's ruler.

Shushtar served as a center of this province till the past century.

The followings can be mentioned as old aquatic structures of this city:

- |  |                                      |
|--|--------------------------------------|
| 1. Set of water falls and mills                    | 14. Suzangar spring                  |
| 2. Shadorwan dam                                   | 15. Shah ali bridge                  |
| 3. Mizan dam                                       | 16. Sharabdar bridge-dam             |
| 4. Lashkar bridge-dam                              | 17. Dariun creek's water distributor |
| 5. Dariun creek                                    | 18. Shahi creek, dam and mills       |
| 6. Gargar river                                    | 19. Dokhtar dam                      |
| 7. Khak dam  | 20. Dara dam                         |
| 8. Gargar dam                                      | 21. Chir dam                         |
| 9. Mostovfi and Bateni single –<br>entrance bridge | 22. Amir dam                         |
| 10. Borje Ayyar bridge                             | 23. Chah Anjiri water tank           |
| 11. Mahi Bazan dam                                 | 24. Gabri dam                        |
| 12. Magham dam                                     | 25. Gargar bridge-dam                |
| 13. Haj Khodaei bridge                             | 26. Boleiti tunnel                   |

## GEOGRAPHICAL LOCATION

Shushtar lies at longitude 48° 20' east, latitude 32° 30' north and is 150 meters high off sea level. Shushtar city is located 92 k.m. for off Ahwaz and 222 k.m. for off Persian Gulf and 831 k.m. for off Tehran, respectively.

This city is bounded on the north by Bakhtiary mountains and Dezful, on the west by Dezful and Susa, on the east by Masjed-e-Soleiman on the south by Ahwaz, on the south – east by ramhormoz. The mountains which are situated in this low city and their famous one are as follows:

- 1- Taft with height of 205 meters
- 2- Mamazade with height of 494 meters
- 3- Koohsiah with height of 606 meters

This city had 6 ingresses that are as follows:

- 1- Mafarian in north, opened facing Mizan dam.
- 2- Dezful gate was connected to Shadorwan bridge-dam in north – west which Dezful road passed it.
- 3- Adineh gate in west of city
- 4- Lashkar gate in west – south side, opened toward Askarmokram
- 5- Magham Ali gate was located over Gargar in south – east.
- 6- Gargar gate, opening in east side and crossing the Gargar

This city has an area of 3440 km<sup>2</sup> that old and historical Shushtar served as a center of it and is limited among Karoon river branches. This city is located in an island that is 2 k.m. wide and 8 k.m. long (**Figure 1**).

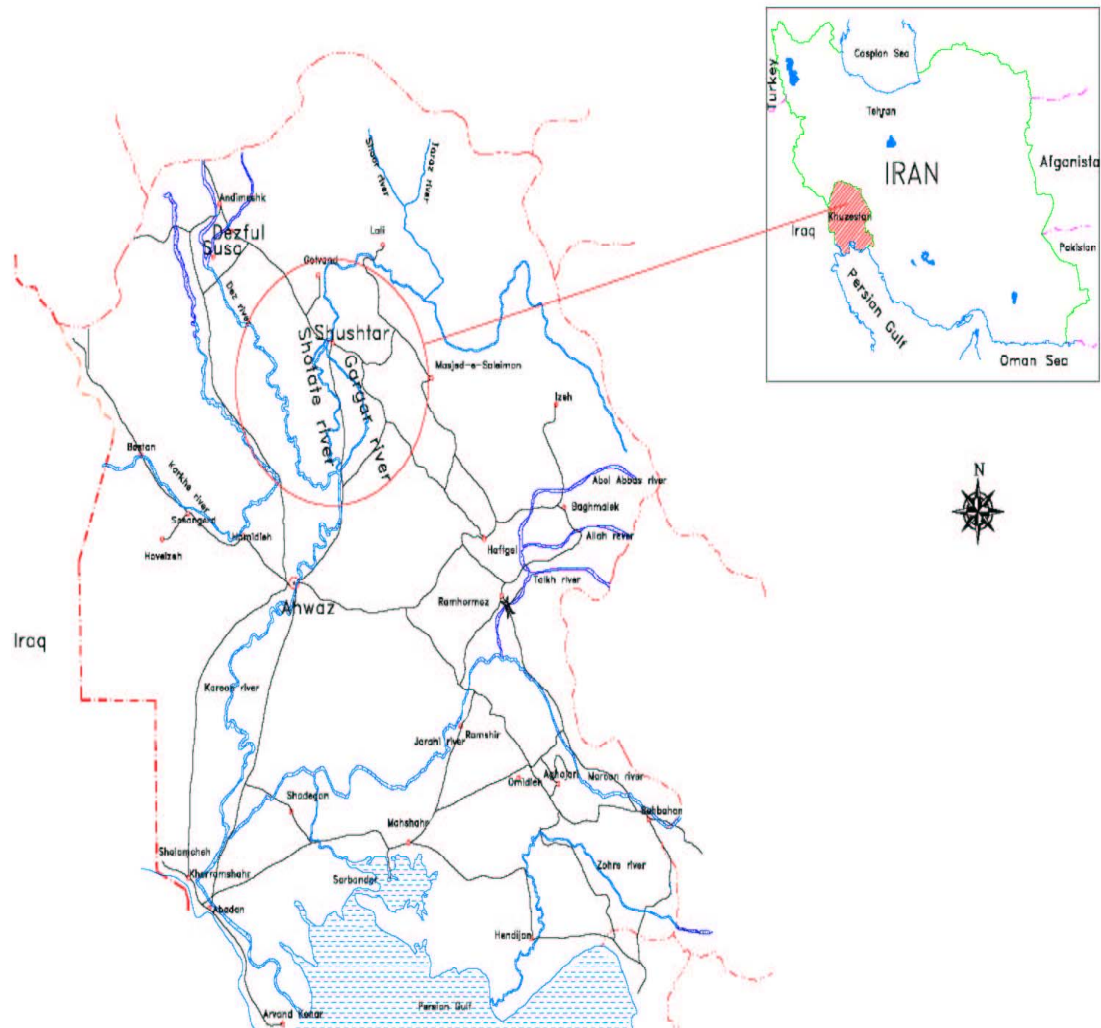


Figure 1.

## GARGAR RIVER

Gargar river is an artificial tributary of Karoon river. This tributary is separated from Karoon in north of Shushtar and after traveling a distance at a place called Ghirbaz rejoins the Karoon again. Length of Gargar course is about 82 k.m. and aerial distance from Mizan dam to Ghir dam is about 44 k.m. Though some historians ascribe digging this creek to Sassanid kings, Ardeshir and Shahpur, existence of Parthian sites such as stova city, Dates digging this creek prior to Parthians, to the Achaemenids. Gargar creek transfers 2 shares of 6 shares of Karoon river's water.

Gargar creek is the biggest hand – dug in Iran. In order to prevent creeks bed to be deepened, it has been cobbled with great rocks connected to one another by metal braces.

Passing these tunnels, Moving mills' spokes creek's water car cades off inside the mills.

Considering the difference of height among afore – mentioned tunnels and compared with surrounding gardens. Digging this canal is deemed as one of engineering

masterpieces of ancient Iran. This creek is known as Mosraghan in Bandahesh Book. Askar Mokram is a city which existed prior to Islam advent and after it. This city is in debt of Gargar creek for its economical briskness.

### MIZAN DAM

This dam is one of high importance building in historical – aquatic Shushtar buildings that bisects Karoon tributaries: 1-Shotate 2- Gargar

The dam construction record dates Sassanid reign as its time of construction. This dam registered in national monuments list by No. 2331 (**Figure 2,3**).

According to present evidences, this dam was found in Sassanid Shahpur reign. Mizan dam is located in east – west direction, in the north of Shushtar, hear to seyed Mohammad Giahkhar mausoleum on the location of this dam, Karoon river is bisected to 2 tributaries: 1- Shotate or Chahardange 2-Gargar or Dodange



**Figure 2.**



**Figure3.**

As some claimed the distance between this dam to Shadorwan is cobbled by hewn stones and lead braces. Since in Mohammad Ali Mirza reign, this dam was repaired, it is called by this name. In fact, this dam divides the Karoon river's water in 2/6 and 4/6 shares, so that 4 shares flow in Shotate course that is known as chehar dange and the rest 2 shares flow in east direction that is known as Dodange or Gargar. In historical texts, Nothing has been mentioned on the construction of this dam directly, unless in some parts in indirect ways.

### **MIZAN DAM ARCHITECTURE**

Mizan dam has 10 watercourses 9 out of 10 opening inlets of dam are in eastern part and one is in western part. Each of the opening inlets is 215 meters long and has a specialized name. The total length of dam is 423 meters. Dams' opening inlets surfaces are a little lower than river's water level. This dam has been constructed in 2 oblique sides. These 2 sides are in forms of 2 semicircle arms. The width of water courses' opening inlets are different from one another, but the width of their pillars are all but the same.

Passing the opening inlets, 9 arcs are stretched west ward with 25° curvature and form 3 circle quarters. This stone wall stretches until it reaches kohlah Farangi tower. This tower is built thoroughly by stone and mortar grout on the end of Mizan dam corner, kohlah. Farangi building is located. This tower is at the top of the hill which overlooks the Mizan dam. The afore-mentioned tower is an octagonal tower. The sides of its base have a length of 1.10 to 1.18 meters. According to some people, this tower was built as a watch tower for supervising on Mizan dam construction process. It also seems that this tower was an indicator for measuring river's water. By the end of 1971, the length of afore – mentioned tower was 4 meters. At the side facing the dam, there is a trap door that is covered by brick and stone. It seems that there used to be an inscription in this place.

In building this tower, only brick and stones were applied. The stone are of hewn sand stones. Plaster was used to caulk the stones. Tower's height from ground surface is about 7 meters. The height was more in the past, but has decreased due to passage of time. Need less to say that application of this tower was only for the dam. This tower had 4 function:

- 1- As a watchtower for supervising on construction process of dam.
- 2- As an indicator for measuring water
- 3- As a lantern or a guidance light.
- 4- As an inscription which had illustrated Sassanid Shahpur actions on it (the inscription is annihilated now)

“In Sassanid Shahpur reign, the defeated army of Roman valerianus, consisted of 70000 soldiers was captured by Iranians. Shahpur used the captives for erecting some buildings in Iran one of these buildings was Shadorawan dam in Shushtar. Shushtar located on eastern bank of Karoon river, has been considered as a principal city since Elamites and Sassanid dynasty. For elevating water level so that it reaches city's surface, they had built a dam on the river. As it is apparent, the primitive dam was not

satisfactory in elevating water level. As a result, Roman captives were exploited to remove defects. Probably, in addition to labor forces, several engineers were present in Roman army. The first step was to dig Gargar river for conducting Karoon river's water. This dam, after undergoing some repairs, now is called Mizan dam. Dam's facade is of hewn stones. These stones are joined by application of grout and metal braces which are in lead. Dam has water flows that would offload additional water. Dam is 10 to 12 meters wide. It took 3 to 7 years to build this dam. When its construction was over, Gargar river entrance was chute down with another dam. That Chutting dam is called Kaiser. This dam which has left from that time, has been constructed by big rocks which are made firm by metal braces. In order to control river's water, overflows were built on the dam. Traveling 40.23 K.m. toward south, Gargar rejoins the Karoon again. Present signs suggest digging other streams on this canal for irrigation, It seemed it was the first time in dam building history that for building a dam, a diversionary canal was built. In particular, from engineering view, considering Karoon water amount, this project was of high importance.”<sup>6</sup>

### SHADORWAN BRIDGE-DAM

Shadorwan dam is built on Shotate tributary and is one of most fundamental aquatic installations of Shushtar. This dam is registered in national monuments list by No. 78.

The construction record of this dam is related to Sassanid Shahpur. According to some evidences, it was found and constructed in Sassanid Shahpur reign. Shadorwan dam is built on main tributary of Karoon in a distance 300 meters far off Mizan dam in north – west Shushtar. At the present time, its relics has left next to Azadegan bridge. Shadorwan dam – bridge has designed as an exit sluice and regulator of water height in west end of this aquatic set in order to connect Shotate water to Dariun creek and making it possible to cross Karoon in east west main road. “It is adverted in Shahnameye Ferdousi (A legendary epic book of Iranians) that the engineer and the constructor of Shadorwan dam was a person called Branush. Shadorwan construction was finished in 280 A.D. After 3 constructional operations. In order to add to stability of dam, granite stones were applied”<sup>6</sup> (**Figure 4,5**).

“According, to eastern narrations, Shahpur I forced Roman empire to work on dam construction. This dam is 457 meters long and still in use to return Karoon's water to farms and is known as Kaiser dam. Probably Iranian king dam had deployed Roman captives in JondiShahpur region. Iranians emphasized high importance to Romans' skills and it is for sure that great bridge are great dam of Shushtar were built by Roman engineers.”<sup>3</sup>

“Shushtar bridge – dam is distinctive from 2 other important bridges of Khuzestan that its main axis is not in a direct line. Roguen guesses that Shahpur bridge constructor attempted to lay the foundation of the bridge on natural rocks. Consequently, Natural oscillation of beneath stones deviated bridge axis from mainline. Shadorwan bridge–dam had 40 opening inlets and was approximately long.”<sup>5</sup>

“Shushtar bridge was collapsed by river burst in winter of 1832 A.D. As far as I was there no measure was taken for repair the bridge any way, we had to transfer the artillery and people by raft.”<sup>1</sup>



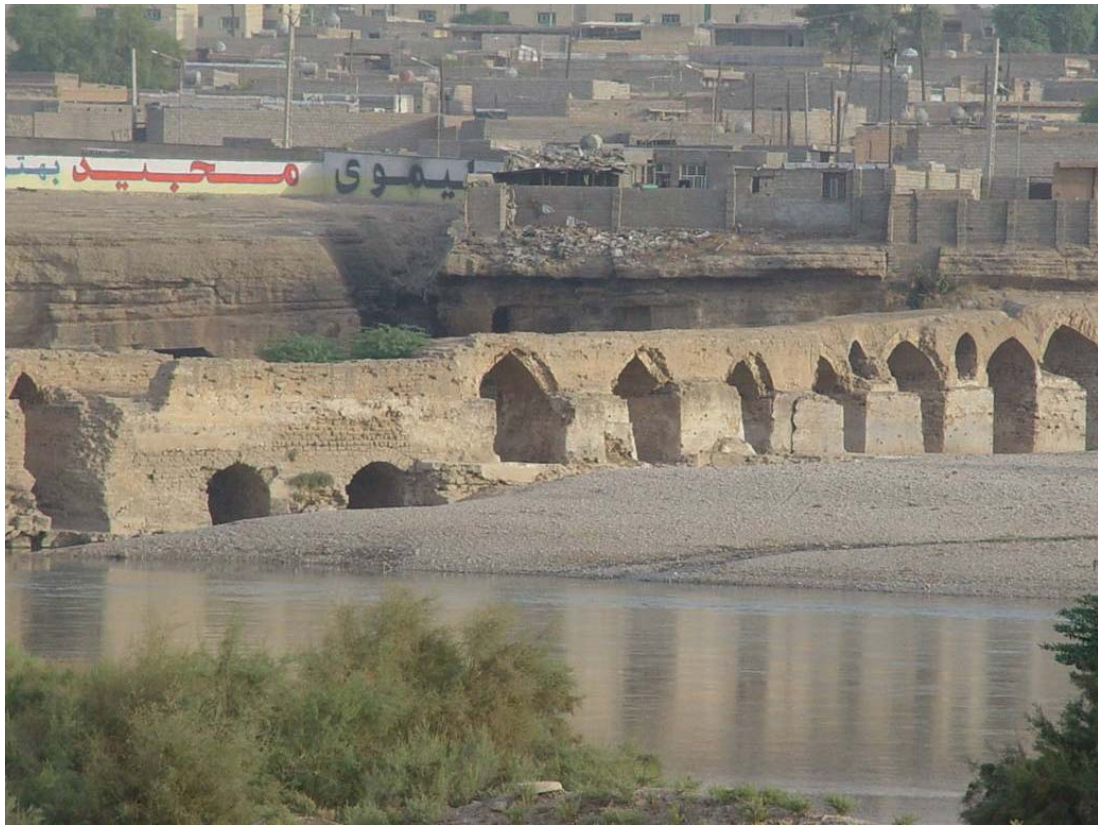


Figure 4.



Figure 5.



## **SHADORWAN DESTRUCTION PERIODS AND THE MAIN REASONS FOR THE INFLICTED DAMAGES ON IT IN THE PAST**

- 1- Destruction by Hajjaje Yousef on account of Shaybe Khareji revolt
- 2- On basis of local researches, conducted by Mr. Sharafoldin and Abdolreza Farahi, Middle opening inlet destruction was done by Britain by explosives. Apparently, it was done to disconnect Shushtar from Dezful city and prevent low-paid labor force from escaping from this region and Masjede Soleiman to Dezful and other cities.

## **ARCHITECTURE**

Shadorwan bridge-dam is built at east-west direction on Shotate tributary. Shadorwan bridge-dam has 44 big opening inlets and 43 small opening inlets.

Bridge length is some longer than river's width and is approximately 500 meters. In the construction of this dam, there are 2 arcs:

- 1- A convex arc facing water stream and toward east direction.
- 2- A- concave arc facing the water stream. Though these arcs are caused by river's bed, they can be considered as arc dams.

Next to this bridge-dam, there were mills which water energy moved their wheels. Construction materials applied in constructing this bridge-dam are road metals, plaster grout and ash. Bridge's foundation width is 7 meters. Its water course opening inlet width is 8 meters.

The bridge height off its crest to its base is 10 meters. In constructing this bridge-dam hewn stones are applied which are connected to each other by metal braces.

There are different stories on construction of this bridge such as exploitation of Roman captives. These captives consisted of 70000 soldiers which were captured by Sassanid Shahpur. This colossal monument is considered as main principle of old irrigation network.

To construct this bridge-dam, river course was paved by arranged hewn stones. These stones were tightened to each other by metal braces.

Shadorwan mean carpet or decorated and precious layout literally. Since the distance from Mizan dam to Shadorwan river's bed is paved by arranged hewn stones, it is called Shadorwan. One of the reasons for constructing this bridge-dam was raising and quieting down the water stream by bridge dam foundation and its pillars and then to let this stream enter Dariun creek to irrigate farms.

## **DARIUN CREEK**

Dariun creek was dug out in Achaemenides Darius I reign. The purpose for digging this creek was to irrigate Mianab plain of Shushtar.

This creek is registered in national monuments list by No. 4141.

Some historical texts ascribe digging this creek to Achaemenides Darius I, that dates 500 B.C. Dariun creek is the second greatest hand – dug canal in Shushtar that irrigates those farmlands which are situated between Shotate and Gargar, tributaries due to height of these lands. Dariun is named after Darius I. This creek is the only Shushtar aquatic structure which still possesses its original name.

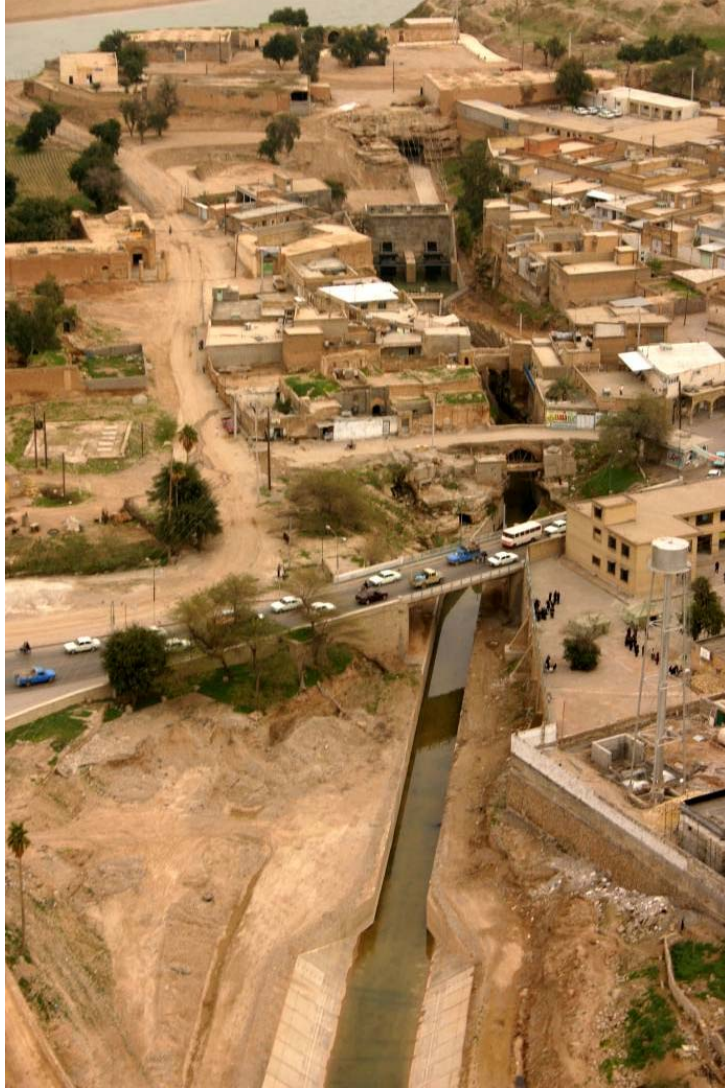
This creek not only supplies farmers sufficient water, but also through some tunnels conducts water to houses' basements. Although several historian recognize Shadorwan bridge–dam as of Sassanids aquatic structures, considering Dariun creek existence in Achaemenides and the position of Dariun creek basins at a higher distance off water level in water Shortages time, the existence of this bridge – dam can be verified definitely in Achaemenides reign.

It is for sure that this bridge – dam was reconstructed in Sassanids reign (**Figure 6,7**).

In recent years, Dariun creek has been constructed by power department. Dariun creek by possessing various sluices, extremely accurate canals, water distributors, paved creeks and bridge was dug out for different complex purposes such as irrigating Minab Island, supplying potable water of Shushtar and providing specific accessibility to Salasel castle.



**Figure 6.** Turn out of Dariun creek



**Figure7.** Dariun creek

### **HISTORICAL TEXTS ON DARIUN CREEK**

“About 300 meters at upper position of Shushtar bridge – dam, beneath Salasel castle, 2 tunnels have been dug – out which join one another after traveling 100 meters. These tunnels form Dariun creek. Another name of this canal is Mianab or Darabian.”<sup>5</sup>

Ravelinson mentions in his travelogue on this creek as follows:

“It’s total length is 273 meters and it’s total width is about 14 meters”.<sup>1</sup>

To make irrigation of south Shushtar farms possible, at an upper distance off Polsangi and at a lower distance off Kaiser dam, a canal has been dug out in main branch.

Herodotus mentions Karoon river as Khuaseps and says “From Shaushtar dam, an area of 60 K.m. long and 36 K.m. wide is under cultivation that yields various crops the distance from this dam to Shushtar is 9650 meters.



## DARIUN CREEK ARCHITECTURE

Dariun creek basins which start flowing off beneath the Salasel castle, comprise 8 basins. Some of these basins have been blocked during successive years. Beneath Salasel castle, some stair cases were devised to use water so that in siege times, which castle doors would be shut down, they could access water easily.

8 afore-mentioned canals turn into two big canals leaving the castle, they join again and make a big canal that is conducted in format an open canal through Mianab plain. With the castle, there were various bath room which spent Dariun creek water using clay water pipes.

## SALASEL CASTLE

One of the most important parts of every ancient city which was involved in forming the initial core of every ancient city is its stronghold. Every city's stronghold is settlement of king or local governors considering historical importance of Shushtar as capital of province this city was very important. Besides political centralization, Shushtar stronghold was a base for supervising on the efficiency of aquatic structures through history, name of Shushtar always reminds us of Sassunid Shahpur I. Seemingly, during his reign, Shadorwan bridge – dam and the castle were reconstructed.

In addition to supplying castle resident water, Dariun creek irrigated Mianab plain which was a very important agricultural pivot point in that period. Within the castle, there were many staircases. Some of these staircases led to rocky rooms which were situated under the castle on the river bank this rocky rooms provided the castle with a pleasant climate in the summer. **(Figure 8)**



**Figure 8.** Salasel castle above the turn out of Dariun creek

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