Cura Aquarum in Israel II

Water in Antiquity

In Memory of
Mr. Yehuda Peleg
Prof. Ehud Netzer
Dr. David Amit

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Front cover: The six shafts tunnel at Sepphoris (photo: Alon Levite)

Taninim Dam – A Byzantine Flushing Mechanism*

Yehoshua (Yeshu) Dray (translated by Miriam Webber, edited by Ilana Gonen)

The Byzantine metropolis of Caesarea received its water supply from different sources, via long aqueducts that brought fresh spring water, as was customary in the ancient world (Fig. 1). One of these aqueducts termed the 'low level aqueduct', brought water to Caesarea from the artificial Taninim-reservoir that was built about 5 km north of the city. The quality of the reservoir water, and the exceptional proportions of this aqueduct, compared to the accepted proportions of "normal" aqueducts of the Roman–Byzantine period, arouses speculation regarding the nature of the reservoir, its size and the purpose of its construction.

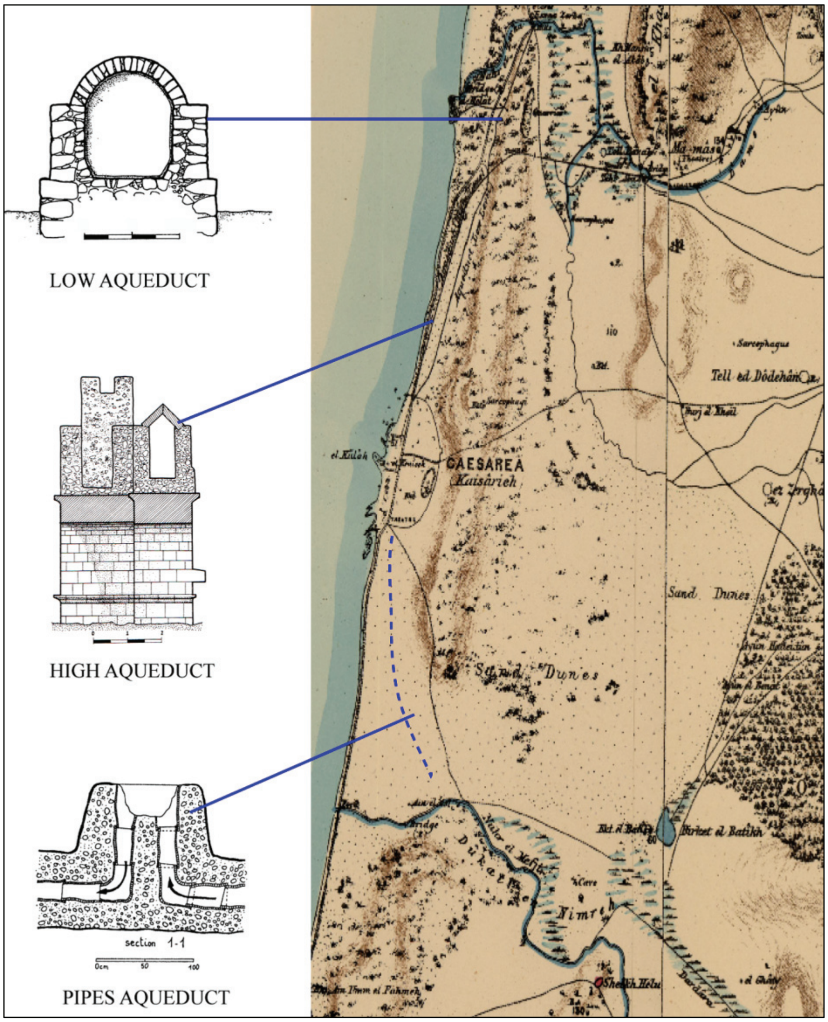

Fig. 1: Three aqueducts of Caesarea on a map of the Survey of Western Palestine, 19th century (Conder and Kitchener 1880; graphics – Y. Dray; low and high aqueducts' sections in Peleg 1989; pipes' aqueduct's section in Peleg 2011)

Data

The Kebara basin provided the most suitable natural conditions for the site of a reservoir, having natural topographical barriers on the one hand, and on the other hand two drains leading to the sea, which are outlets of Ada stream and Taninim stream to the west, and of Dalia stream to the north. All that had to be done was to dam the last in order to obtain a large efficient reservoir (Fig. 2):

To the north, Taninim-reservoir is bordered by an impressive dam that has been preserved for over 900 m, from the Kurkar ridge in the west to the foothills of the Carmel in the east. Near the railway-station of Zichron Ya'akov its remains reach a maximum height of 6.54 m ASL. (Porath, Gendleman and Arnon 2007).

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* Dedicated to Yehuda Peleg – a friend and a colleague.

Fig. 2: The Taninim-reservoir area, looking west (photo and graphics – Y. Dray)

To the south, Taninim-reservoir is bordered by raised ground and sand-dunes that stretch from the north of the area to the industrial-zone of Or Akiva, and in the east to the southern edges of the Carmel, at the foothills of "Chotem Ha'carmel". To the west, the reservoir is bordered by a dam that was built to the width of Taninim strean and Ada stream, from the Kurkar ridge of Ma'agan Michael in the north, to the Kurkar ridge of Jisr az-Zarqa in the south. The length of the existing remains of the dam is 193 m (its original length was apparently over 300 m, see Fig. 3), and the maximum height of the remains is 7.17 m ASL. During excavations by the Israel Antiquities Authority, the construction of the dams was dated to the 4th century AD (they were built in stages) (Sa'id and Ad 2004; Porath, Gendleman and Arnon, 2007).

The reservoir, which spread over an area of about 10,000 dunam, contained winter run-off water from the Nadiv valley, Ada stream, Taninim stream and the southern Carmel, as well as brackish water from hundreds of springs found in its territory, termed collectively 'Crocodile springs' (Fig. 4).

In the western dam, built at the outlet of Ada stream and Taninim stream, a large regulation device is preserved, having four openings, 1.60 m - 1.90 m wide, in which wooden sluice gates have been fixed, that moved up and down in the vertical slots. In the upper part of the dam, above each of these openings, wooden winches were fixed as a mechanism for lifting the sluice gates (Fig. 5) (Ad and Sa'id 2011).

The 'low level aqueduct' starts out southward, toward Caesarea, from the regulating device of the dam, at an initial height of 4.50 m ASL. Its length is about 4.5 km, its width 1.80 m and its height (in the preserved sections) 2.20 m, and it is built as a massive pressure pipe.[1] In cross section, the aqueduct measured 3.96 m^2, which allowed the flow of a greater volume of water. Moreover, there is a considerable difference in height between its departure from the reservoir, to the highest point in the base of the aqueduct, more or less at its center (5.45 m ASL). From this point on, its base slopes, and the water flows faster toward its destination (Fig. 6).

[1] This is in comparison to "normal" aqueducts that were open, occasionally having a curved covering, with air-holes for cleaning purposes, and of a very gradual incline, to overcome topographical difficulties and differences of distance and to feed the destination point as high as possible. When it was necessary to use pipes, they took care to release the pressures and air bubbles that had collected by the use of special devices. It should be noted that earlier researchers explained the curved covering of the 'low level aqueduct' as the need to maintain the cleanliness of the water in sandy areas, and not as a technical function fundamental to the purpose of the aqueduct and the way it is operated.

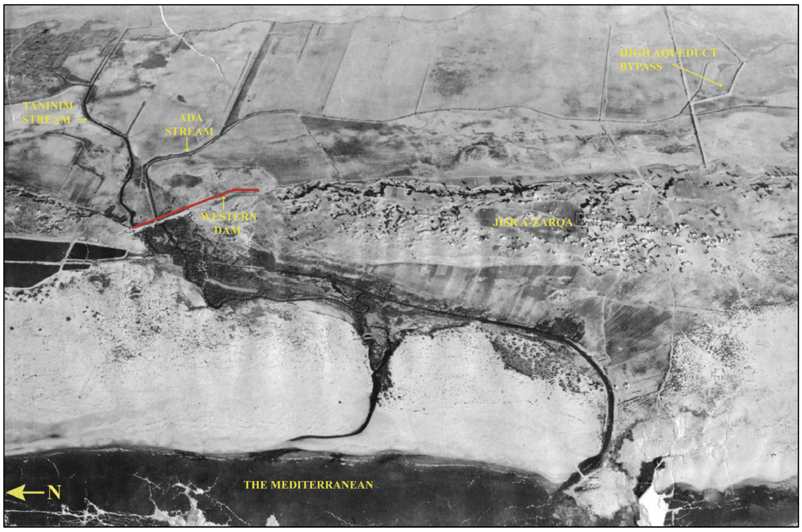

Fig. 3: British Mandate aerial photo (courtesy of Ma'agan Michael archive) in which the original length of the Taninim western dam can be seen (graphics – Y. Dray).

Fig. 4: The Taninim-reservoir area simulation on an aerial photo (photo – Ofek, courtesy of Carmel Drainage Authority; graphics – Y. Dray).

Fig. 5: The regulation device at the Taninim western dam, before and after reconstruction, looking west (photo – Y. Dray).

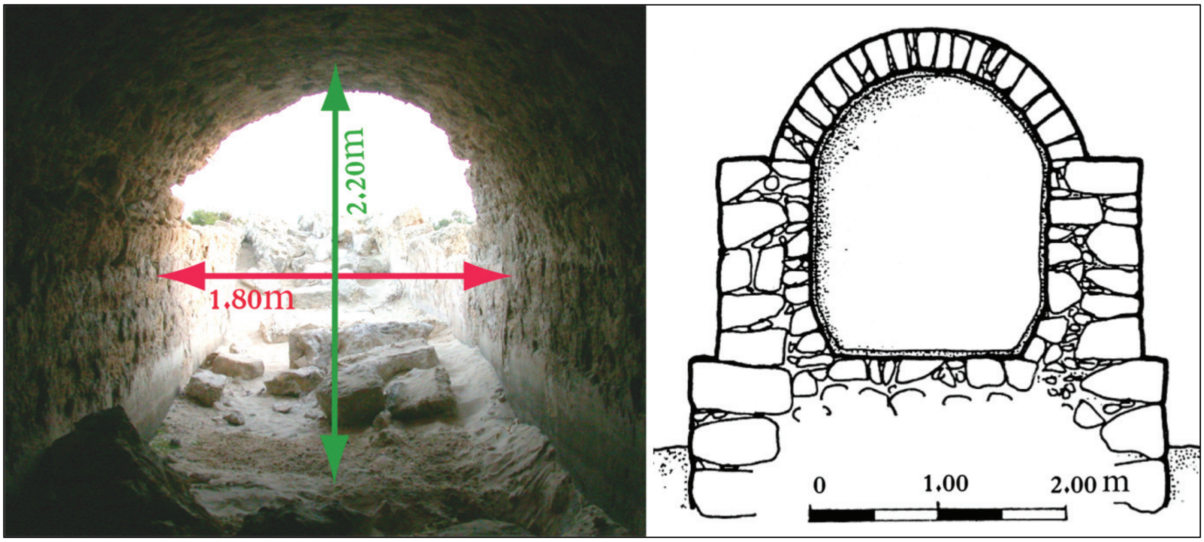

Fig. 6: The 'low level aqueduct' (photo – Y. Dray; graphics – Y. Dray; sketch of section – Peleg 1989, 122).

Proposal

What was then the destination of this water, considering the enormous scale of this official project, which enabled the conveyance of spring and rain water at volumetric flow rate and under high pressure, to the proximity of the city?

The cost and the effort invested in constructing the system and operating it was certainly meant to be justified in terms of cost-effectiveness. In the opinion of the writer, the only justification for such a great outlay, from an official point of view, was the renewed operation of Caesarea port, which was blocked by sand and silt.

Following here are some of the considerations behind this suggestion:

1. Marine trade was one of the sources of Caesarea's wealth during its existence, and this point to the importance of the port (Patrich 2002; Patrich 2006). Development activities carried out in the city in general (including the construction of a church and renovation of the temple platform vaults) and in the port in particular, during the Byzantine period, are recorded in historical sources and come to light in archaeological research. Clear evidence of renovation of the port appears in the letter of thanks sent by bishop of Gaza Procopius, to the Byzantine emperor Anastasius I, close to the year 500 AD, after his visit to the city, and evidence of this renovation was indeed disclosed during excavations by Raban's team in the northern section of the main port basin (Raban 2004):
"Back to what concerns us. About the city called after Caesar, her harbour had deteriorated with time and was exposed to all threats of the sea, and no longer preserved its condition in reality, but rather possessed the mere name of its ancient *tyche* <fortune>; you <Anastasius> have not overlooked her deprivation and her lamentations over the merchantmen that, after escaping the open sea, often were shipwrecked in the harbour, and those deprived of the cargoes suffered more piteously, for they would view the destruction of those (goods) of which they were in need, and the sight (of which) brought them no profit. But now by your will the city is rejuvenated and hopefully welcomes the ships, and is full of all its necessities".

2. The sea floor of Caesarea port undergoes morphological changes resulting from the regime of the sea currents and winter storms that attack the Israeli coast, in the present as in the past (Zviely 2006). As a result of this, the port is blocked by silt and sand, in addition to the sinking of the breakwater and its destruction (Galili, Zviely, Salamon and Rosen 2011). Already during the Roman period, flushing channels were found in the southern breakwater of Herod's port, for the purpose of conveying water from the high waves to anchorage areas of the ships, in an effort to prevent their blockage (Raban 2004).

3. The Byzantine government, as stated, worked to renovate the port for use. For this purpose they reverted, amongst other things, to the idea of washing out silt and sand from the port, but using a different system this time: by streaming sediment-free clean water, at pressure, from a high level, into the port. All they had to do was build a water channel of large dimensions, from the Taninim-reservoir to the northern part of Caesarea port, and activate it after, or during winter storms, by opening the dam sluice gates, thereby washing out the port with a strong flow, like an enormous rinsing facility. This purpose justifies the scale of the large sluice gates of the dam and the flow rate of the aqueduct. The fast flow of a large volume of water into the port created a channel in the sand that had accumulated at its entrance, thus enabling ships to enter (for this purpose, a channel was sufficient). The storms that damaged the port and blocked its entrance with sand occurred during the winter, the season during which the Taninim-reservoir filled up with run-off water.

During the rest of the year the reservoir water served flour mills that were built west of the dam (Fig. 7) and they are in fact a by-product of its construction (Oleson 1985). Thanks to their location, the Byzantine flour mills benefited from a permanent source of water and were able to function throughout the year, including during periods of low levels in the reservoir. Initially, they were fed by the regulation facility of the dam at a level of 4.50 m ASL and later, during the Byzantine period, the source of the flow was lowered to 3.50 m ASL at which level it was possible to get a trickle of water for working the mills during the summer also.

Fig. 7: Byzantine flour mills location west of Taninim western-dam (aerial photo – Ofek, courtesy of Carmel Drainage Authority; graphics – Y. Dray).

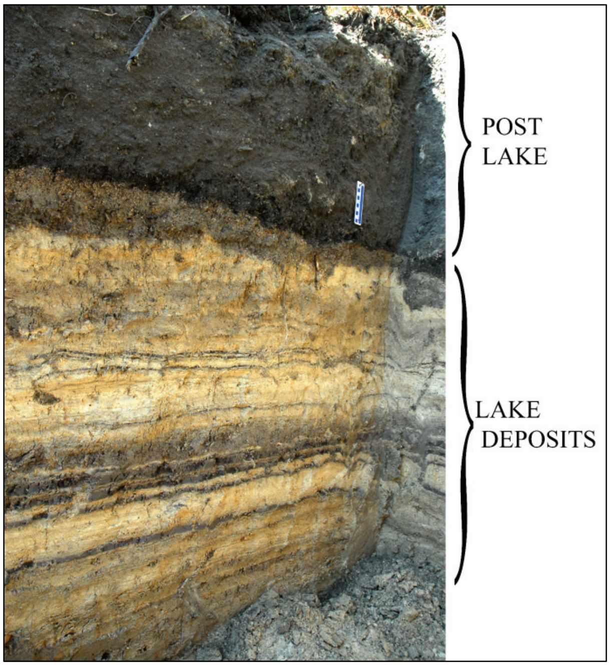

Fig. 8: Section of Taninim-reservoir lake-bed: the light-colored layers represent dehydrations (photo – Y. Dray).

This lowering of the level is evidence that the reservoir system of Taninim functioned only during the winter, when run-off water filled it (from over 5.50 m ASL to about 7.00 m ASL which is the height of the dam), a limited period during which the water was available for Caesarea.

Moreover, a large part of the area of the reservoir is based on Kurkar and sand dunes, so the loss of water was speedy, due to seeping and evaporation of about 12 cm per day. In addition, examination of the sediment in the area of the reservoir[2] clearly points to a picture of annual dehydration (Fig. 8).

4. The reservoir water that was transported to Caesarea through the 'low level aqueduct' was a cocktail of run-off water and brackish spring water, water that is unsuitable for drinking. It was the 'high level aqueduct' that supplied the city with large quantities of good spring water (Porath 2002). For agricultural and industrial needs, it was easy to obtain water from wells that utilized the high aquifer of Caesarea[3] whose water was similar in quality to that of Taninim-reservoir. Moreover, the height of the 'low level aqueduct' near the city (5.50 m ASL) is too low in relation to large areas of the city. From the upper height of 6.75 m ASL it was possible to supply water to only 10% of the households in Caesarea. On the other hand, the 'high level aqueduct' reached the city at almost 8.00 m ASL and could supply water to almost the whole of the city (Fig. 9).

Fig. 9: 'High level aqueduct' and 'low level aqueduct' on their way to Caesarea (photo – A. Izdarechet; graphics – Y. Dray).

[2] The examination was carried out in 2011 by Shmuel Marko and Oded Katz from the Geophysics Faculty of Tel Aviv University and the author of the article, on the discovery of evidence of a seismic event in ancient times (Marco, Kats and Dray 2014).

[3] For example, the Antilia well that replaced the main water supply system of the city in the Roman-Byzantine bath house (Porath 2011).

Fig. 10: A map of the Survey of Western Palestine, 19th century (Conder and Kitchener 1880; graphics – Y. Dray).

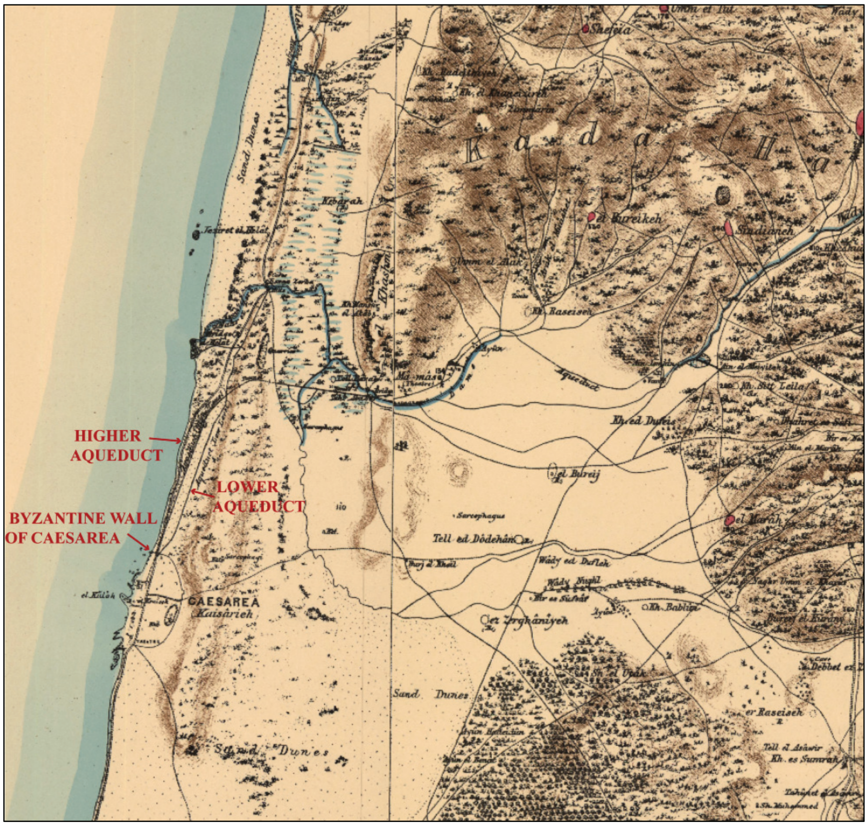

Fig. 11: The allocation facility of 'Pont du-Gard', Nimes, France (photo – Y. Dray).

5. Contrary to the prevalent technology of bringing drinking water to cities in the ancient world, the 'low level aqueduct' crosses the Byzantine wall of Caesarea (as shown on the SWP map – Fig. 10). It follows that at the point where the aqueduct reaches the walls of a city, an allocation facility will be built, usually with pipes, so that the aqueduct does not cross the wall, thereby creating a security hazard. A good example can be seen in the city of Nimes in France where such a facility was preserved, which gets the famous aqueduct 'Pont du-Gard' waters in the city (Fig. 11).
   In addition it should be mentioned that not only does the 'low level aqueduct' cross the wall, but its cross section is of a size that enables a man to walk inside it. Therefore, the purpose of the water brought by the aqueduct, that is to say the functioning of the port, constituted a consideration more important that the safety of the city.

6. It is appropriate to note that until now, the exit point of the 'low level aqueduct' within the area of the port has not been

Fig. 12: The 'high level aqueduct' by-pass (aerial photo – Ofek, courtesy of Carmel Drainage Authority; graphics – Y. Dray).

found (as would be expected according to the suggestion raised here), despite the archaeological excavations that have been carried out in the area (Porath 2006). However, at the same time no signs have been found of any other purpose for the use of the aqueduct, nor the southern end of it. The reason for this is attributable to the destruction of the northern coast, which, in addition to the 'low level aqueduct', contained the end of the 'high level aqueduct' and the north-western neighborhood of the city close to the port (Raban 2004). So at this stage it is only possible to estimate the approximate line of the 'low level aqueduct' toward the port, and in light of this to consider carefully the development of future excavations in this area.[4]

7. As a result of building the Taninim-reservoir, the 'high level aqueduct', which was the principal conveyer of drinking water to Caesarea, was damaged in the section between Beit-Hanania and the Kurkar ridge.
The fact that a bypass to the 'high level aqueduct' was built (Fig. 3 and Fig. 12) is proof that the 'low level aqueduct' conveyed water that was unfit for drinking, otherwise there would be no justification for such an enormous outlay (building the bypass) for conveying such a negligible volume of water (conveyed by the 'high level aqueduct').

Summary

First the author wants to express his gratitude to bishop of Gaza Procopius for writing Anastasius I a letter, in which he mentions the port's rehabilitation, and thus leaving us a dating testimony for the Taninim-project establishment at the end of 5th century or beginning of 6th century AD, according to the proposal presented here[5].

[4] In test excavations that were carried out close to the northern Herodian wall of Caesarea in 2005, a facility was found that could be the exit point of the aqueduct (as noted by Y. Porath in the above article). In addition, in the SWP map (Fig. 10), in which both aqueducts are shown entering the city, it can be seen that the route of the 'low level aqueduct' continues south up to the vicinity of the Crusader wall at the north-eastern edge of the port!

[5] Up until now the Taninim-dam dating was determined only by elimination: the north-western end of the dam blocks a tomb cave that was uncovered in the Israel Antiquity Authority excavation and dated to the end of the 3rd century or beginning of the 4th century AD (Ad and Sa'id 2011).

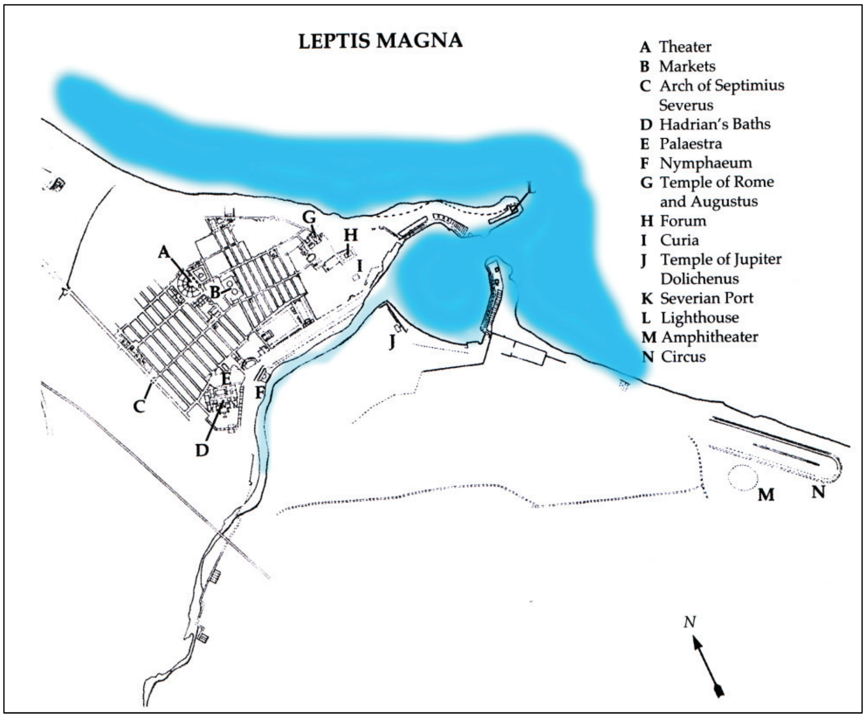

Fig. 13: Port of Leptis Magna, Libya (in Liberati 2004).

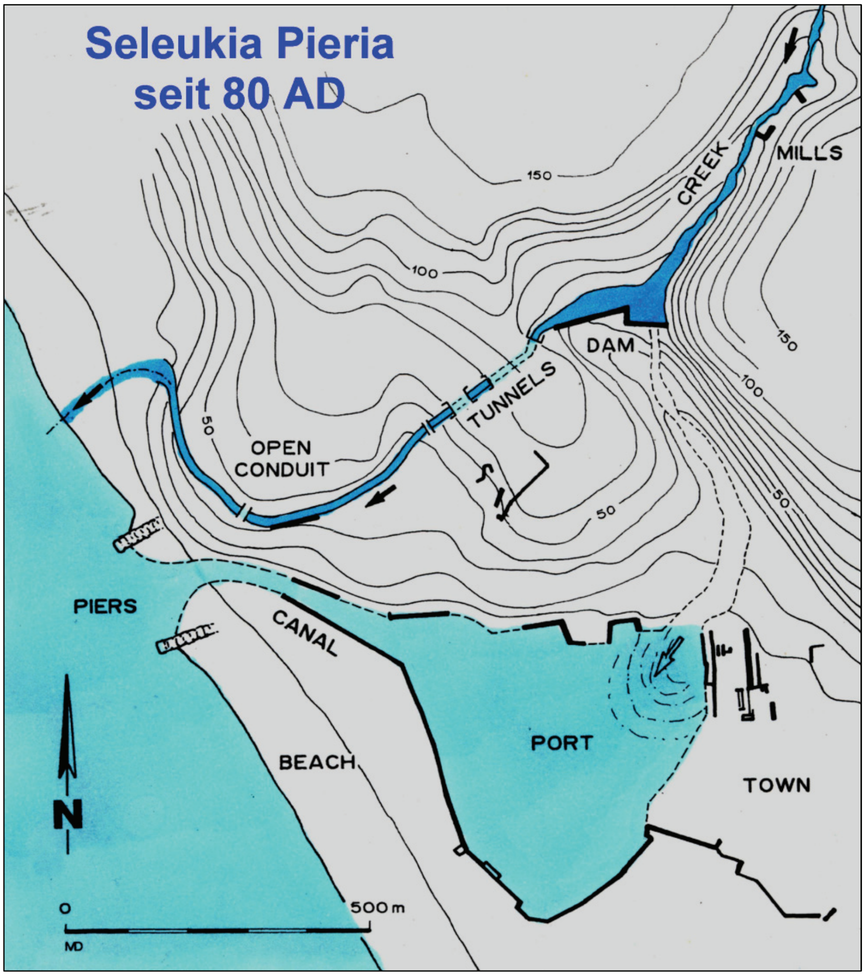

Fig. 14: Port of Antioch, Turkey (courtesy of Dr. Mathias Döring).

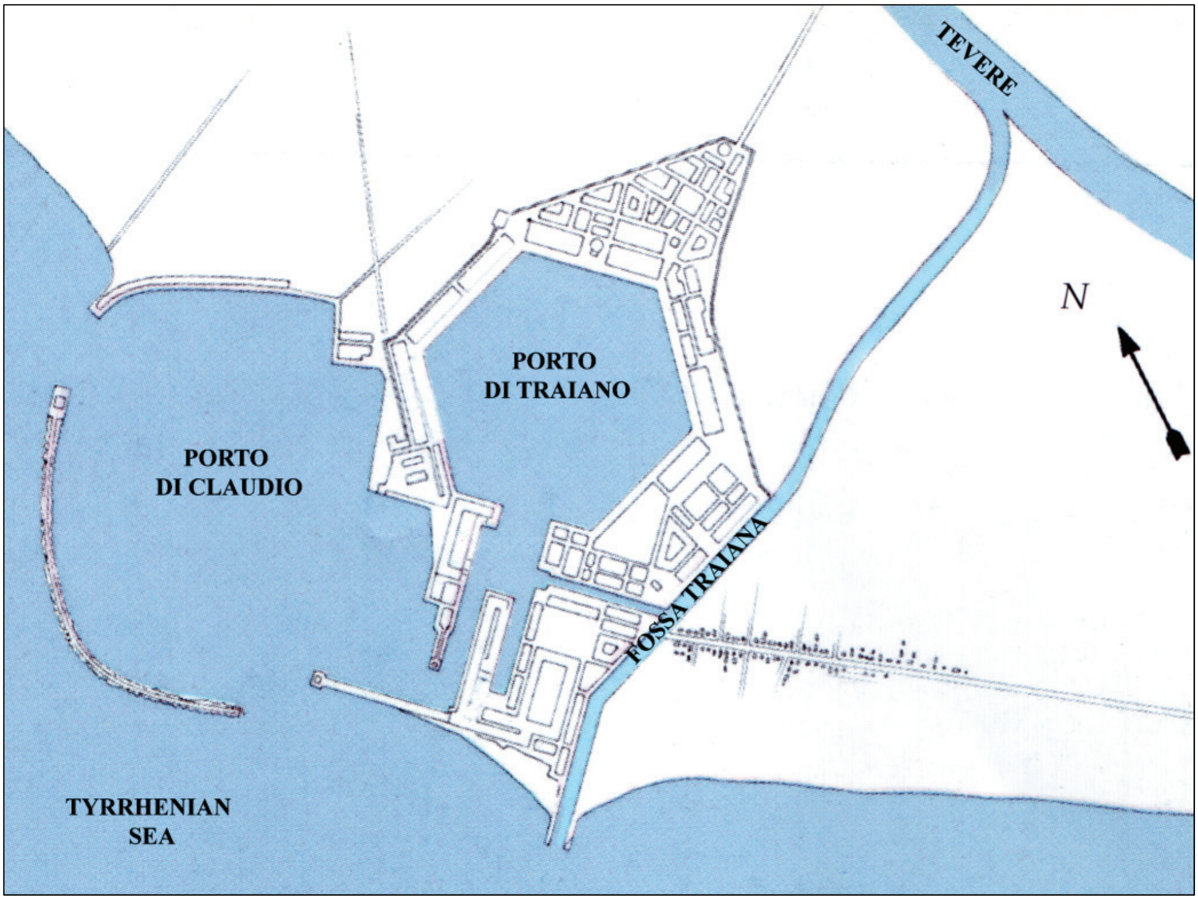

Fig. 15: Port of Ostia, Italy (in Liberati 2004).

The discussion of technical systems demands the meticulous gathering of data and identification of the stages of development, in addition to historical background and comparison with other systems, with the aim of examining their function and reconstructing their method of operation. In this article an approach has been presented that is different from the one accepted in research up to now, regarding the purpose of the Taninim-reservoir system, and this is based on deciphering its dimensions, understanding the stages of its construction, gathering data from the surveys and archaeological excavations, and precise examination of it; in addition to hydraulic data, geo-morphological data and the study of historical sources.

It seems that the facility of Taninim-dams expresses a technical solution accepted in the ancient world for washing out sand sediments from sea ports by means of a flow of rivers from the back of the port toward the sea opening. Likewise, at Caesarea, a seasonal artificial river was created, using the Taninim-reservoir to collect run-off waters from Ada stream and Taninim stream, and to divert them in a timed, fast-flowing stream, like a flushing mechanism to flush the sand out of the renewed port. Based on this assumption one can re-identify the role of natural, or artificial channels, existing at the back of large ancient cities' ports around the Mediterranean, such as Leptis-Magna in Libya (Fig. 13), Antioch in Turkey (Fig. 14) and Ostia in Italy (Fig. 15).

In conclusion – income from the commercial activity in the port of Caesarea provided financial coverage and the justification for investing in such a project. Up to the time of writing these lines, this, in the opinion of the author, is the only logical proposal that justifies the enormous outlay in setting up a project of this kind.[6]

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[6] The author wishes to mention that there is still place for research on this matter on the coast and underwater.