B.C.S. Levering

S1841807

Drinking water: Liquid Gold of the City

An urban archaeological study of the cisterns in Early Modern Amsterdam (1650-1850)

Image on cover: Binnenplaatsje, Andreas Schelfhout, 1820-1830. SK-A-3887. (https://www.rijksmuseum.nl/nl/zoeken/objecten?q=SK-A-3887&p=1&ps=12&st=Objects&ii=0#/SK-A-3887,0).

Contact: B.C.S. Levering

Diamantplein 39

2332 HT, Leiden

Email: bcs.levering@gmail.com

Tel.: 06-11204996

Drinking water: Liquid Gold of the City

An urban archaeological study of the cisterns in Early Modern Amsterdam (1650-1850)

B.C.S. Levering

S1841807

Bachelor Thesis

Supervisor: Dr. R.M.R. van Oosten

Specialisation: Urban Archaeology

Archaeology of North-western Europe

University of Leiden

Faculty of Archaeology

Leiden, 17th of June 2019

Final Version

Contents

1 Introduction

The discipline of archaeology knows many faces. One of these is the brick face of the urbanised (post-)medieval environment. Many themes have been researched in urban archaeology, from house plans to fortifications, burials and cesspits. One aspect of urban life is however often overlooked: fresh drinking water. As no urbanised society can function without a constant supply of clean water, obtaining drinking water is vital for the existence and preservation of a healthy population. Water was not only used for consumption, but also in many household activities, such as washing, cooking and cleaning. Furthermore, large quantities of clean water are needed for many industries, for example beer brewing. Of course, this water had to be stored somewhere. Traditionally, wells and rain barrels were used. However, in the course of the 17th century a new invention arose: cisterns.

1.1 Research problems

Little research has yet been conducted on cisterns. In 2007, Gawronski and Veerkamp published an article on eighty cisterns in Amsterdam. In this article, the architectural aspects and methods of construction of cisterns are described (Gawronski and Veerkamp 2007, 60-64). Furthermore, great emphasis is placed on the size of floor surfaces and, when sufficient data was available, the maximum capacity of cisterns. From their analysis, Gawronski and Veerkamp concluded a standardisation is present in the construction of their eighty cisterns in Amsterdam.

In their publication, Gawronski and Veerkamp briefly establish that differences in the functional application of the stored water influence the size of a cistern (Gawronski and Veerkamp 2007, 68). However, besides mentioning a handful of examples, the writers do not elaborate on the topic of cistern size vs. functional application, which could also be called the cistern's context. It would be expected different functions require varying amounts of water, for example, in theory a brewery would need more water than a domestic residence. When contexts are divided into categories, patterns in cistern sizes and their maximum capacities might stand out. Therefore, in this thesis emphasis lies with the context of cisterns in Amsterdam, building upon the results acquired in the research conducted by Gawronski and Veerkamp.

In addition to the lack of attention spent on the context of cisterns, the spatial distribution of cisterns in Amsterdam was not treated in the publication by Gawronski and Veerkamp. Plotting the cisterns on a map might however shed light on the use of cisterns, as, for example, it will become clear whether these subterranean structures were mostly constructed in neighbourhoods associated with industrial practices, or in residential areas of Amsterdam as well. Also, considering the spatial developments of the city, a higher density of cisterns might be expected in the neighbourhoods that were constructed and developed just before, or after the initial employment of cisterns in Amsterdam in the 17th and 18th century.

Furthermore, the dating of cisterns is tenuous, as datable finds are rarely made in cistern chambers. Gawronski and Veerkamp established a distinction between a 17th century, or early, and 18th, or late generation, based on architectural differences (Gawronski and Veerkamp 2007, 61). In their article, the writers also mention when cisterns first came into use, and when they were no longer used. However, since many new cisterns have been recorded since 2007, their initial conclusion may be enhanced or specified.

Finally, both in modern publications as in period texts different terms are used to indicate cisterns. Most commonly, the terms *waterkelder* and *versch-waterbak* are used. However, other terms, such as *regenbak,* are also used. It is often not specified whether these structures are similar, architecturally different from each other, or actually exactly the same. This mixed terminology results in embroiling definitions, as it is not always clear what type of structure exactly is meant with each term. Therefore, it is deemed useful to revise used terms, and specify what is meant with the word *cistern*.

1.2 Research goals & questions

Above a number of issues about the conducted research on cisterns are mentioned. In this thesis, these issues are tackled by answering a number of subquestions:

1. What exactly is meant with cisterns; what do they look like, how are they made, and how do they function? In addition, how can cisterns be differentiated from other subterranean structures?
2. When are cisterns first introduced in Amsterdam, and why?
3. When is the use of cisterns abandoned in Amsterdam, and why?

Importantly, besides the defining and temporal characteristics of cisterns, their spatial distribution will be mapped. This way, it is easily recognised where cisterns are located, and what context can be assigned to specific cisterns. In order to gain an understanding of spatial and contextual characteristics of cisterns, an important subquestion is formulated:

4. Are there any patterns in the location of cisterns of different contexts? Furthermore, are cisterns only located in post-17th century neighbourhoods, or can they be found in older parts of Amsterdam as well?

The division into categories of functional application, or context, will be the main focus of this thesis. Besides mapping their spatial distribution, floor surfaces and maximum capacities of cisterns of each category of context will be looked into, and compared to each other. Also, besides the categories of context, public cisterns will be compared with private cisterns. The results gained from this analysis, in combination with the results from subquestion 4 will be used to answer the research question for this thesis:
"*How are varying sizes of cisterns explained by their functional application?*".

1.3 Materials

In order to answer the research questions, a number of sources are used. First of all, the article by Gawronski and Veerkamp forms the backbone of this thesis. Their results will be built upon, supplementing their research with new angles and perspectives. In addition to the article by Gawronski and Veerkamp, publications on the history of Amsterdam, its water management and subterranean structures by, i.a. Abrahamse, Groen and Van Oosten, will be used.

Besides literature, the *Amsterdamse Archeologische Rapporten*, or AAR, published by the bureau of Monuments & Archaeology, will provide the primary data for this research. In these reports, ninety-one cisterns have been documented. These were collected, and stored in a database (appendix 1). In addition to this created database, J. Gawronski has shared his own database, used for his article from 2007, featuring eighty-six cisterns (appendix 2). As with their article, the database by Gawronski and Veerkamp was used as the backbone for the created database, and complemented with new data and features from the AAR.

1.4 Reader's guide

Chapter 2 provides a historical framework and context of the city of Amsterdam. In chapter 3, a more detailed history of water management in Amsterdam is described. Chapter 4 treats the concept of cisterns, and how to differentiate them from other subterranean structures. Chapter 5 provides the analysis of the dataset of ninety-one cisterns and their categories of functional application, treating cistern sizes and capacities. Chapter 6 discusses the dating and commissioning of cisterns, and their spatial distribution in Amsterdam. Chapter 7 provides the conclusions.

2 History of Amsterdam

A historical and contextual background is important in order to fully understand any process. In this chapter, the genesis of Amsterdam is described. Furthermore, specification of a number of important events in the political, religious and urban history of Amsterdam is given. Ultimately, the goal of this chapter is to create an image of the character and urban development of the city of Amsterdam, which is used as a backdrop for the following chapters on water management and the location of cisterns.

2.1 1200-1850 AD: City of Amsterdam

The origins of the city of Amsterdam lie with a pre-urban village of fishermen and craftsmen called *Amestelledamme*, mentioned in Medieval texts first in 1275 AD (Gawronski 2008, 44). In this year, the count of Holland granted the inhabitants of this village toll rights. In the 13th century, small wattle & daub constructions were built on the raised riverbank of the Amstel. After the dykes had been built along the water, both sides of the Amstel were inhabited.

It was only in the 14th century that the settlement acquired a number of typical urban characteristics; defensive canals, quays, and an increasing number in brick structures, such as the Oude Kerk (fig. 2.1). Furthermore, Amsterdam officially gained its city rights in 1342. Besides the developments in the urban structures of the city, its function also developed, as craftsmen started to specialise and involve in international commerce in the 15th century. This commerce mostly took place at the Baltic Sea, transporting goods between the Baltic states, Germany and Flanders (Gawronski 2008, 53). The conditions in the landscape around Amsterdam became too wet for arable farming due to draining and consequently sinking of the peat lands (De Gans 2013, 356). Consequently, grain had to be imported from other places, mostly the Baltic. In this trade, Amsterdam became a *stapelmarkt*, which implies many different goods were shipped to this central location, from where it would be shipped on to the rest of Europe. For Amsterdam, this meant an influx of different cultures, ideas, but most importantly: wealth. By now, in the late 15th century, Amsterdam had expanded until the *Singel*, and newly constructed brick walls encircled the town centre (fig. 2.2; Abrahamse 2014, 26).

It is in the 16th and 17th century that Amsterdam truly became a centre of worldly importance. The city joined in the Dutch Revolt in 1578, which accelerated its economic growth, as well as population increase. In 1602, the *Vereenigde Oostindische Compagnie*

(VOC), or Dutch East India Company, was established, followed by the *Geoctroyeerde Westindische Compagnie* (WIC), or Chartered West India Company, in 1621 (Gawronski 2008, 53). These corporations were the leading drive in worldwide trade relationships, introducing luxury goods from China and India, such as spices, tea and porcelain to the European market. In the West, the WIC participated in the Atlantic slave trade, which resulted in prosperity for the city. Consequently, the harbour of Amsterdam ended up too small for the amount of ships that needed to dock in the IJ. The harbour was therefore expanded, first in 1592 and again in 1650 (Abrahamse 2014, 28).

As mentioned above, Amsterdam joined in the Dutch Revolt by the end of the 16th century. In this political and religious dispute, the Dutch cities fought for their independence as well as religious freedom. Religious freedom did not exist in most of Europe, as Catholicism was traditionally the official state religion. In 1585, during the Revolt, many cities in the Southern part of the Netherlands, such as Antwerp, Ghent and Brussels, had fallen to the Spanish army (Abrahamse 2010, 31). However, the Protestant population of a conquered city was given the opportunity to leave within four years after the conquest. Therefore, Northern Dutch cities became a mayor attraction to many foreigners; Protestants from the Southern Netherlands, Jews from Portugal and Spain, and Huguenots from France fled to the free Dutch cities (Gawronski 2008, 53). Consequently, this large number of refugees significantly increased the number of inhabitants of Amsterdam, as well as many other cities, and resulted in an influx of new ideas and wealth, thus stimulating cultural and economic prosperity. This era, the 17th century, is also known as the Dutch Golden Age. It is during this age Amsterdam has its

Fig. 2.1: Amsterdam in 1350 (map made after Rutte and Abrahamse 2016, 27).

Fig. 2.2: Amsterdam in 1500 (map made after Rutte and Abrahamse 2016, 27).

peak of growth and importance, and truly becomes a centre of the world.

Besides the expansions of the harbour, urban extensions were planned, as the city had reached its residential capacity in the beginning of the 17th century due to said immigration (Abrahamse 2014, 26). In the final decades of the 16th century, a large part of the newcomers found no place to live in the city, which resulted in the formation of suburbs outside the city walls (Abrahamse 2010, 32). Officially, building outside the city walls was not allowed, since the fortifications needed clear sight in times of siege, however, the suburbs continued to grow as the population of Amsterdam increased.

It was only in 1609, during the Twelve Years' Truce, a period of peace between Habsburg and the Dutch Republic, that the States General approved the city's request for the expansion of Amsterdam. According to these plans the city would grow up to the *Singelgracht*, and the illegal suburbs would finally be demolished in order to make space for new neighbourhoods, as well as a modernised and upgraded fortification (Abrahamse 2010, 39). The designing process did not go without obstacles and delay; the water board, or regional government managing waterways, of Rhineland protested against the expansion of Amsterdam, as it would bring trouble to the dyke at the *Haarlemmerbuurt* (Abrahamse 2010, 44). Furthermore, no official fortification architect was hired. Instead, this job was shared by carpenter Staets, mason Danckerts and stone cutter Hendrick de Keijser (Abrahamse 2010, 45). This resulted in a poor design, which had to be corrected by Stadtholder Maurice of Orange, as he was a man of military experience and knew a proper fortification when he saw one.

Although urban practice and development had been highly continuous up to the 17th century, several changes and innovations took place in the development and design of cities and/or city parts (Rutte and Abrahamse 2016, 24). For example, city parts were designed with a predetermined function, such as residence, labour or industry. This deliberate segregation of the urban landscape is recognisable in street plans, which became very linear and symmetrical. In the expansion of Amsterdam, symmetrical features are enhanced by the parcel landscape in the peat, which can be seen best in the street plan of the *Jordaan*. Most recognisable in the street plan of the expansion is the iconic crescent shaped canal belt; the *Herengracht*, *Keizergracht* and *Prinsengracht*. These streets, which were designed for residential purposes and would become the most luxurious living area of the city, lie outside the *Singel*.

In 1613 the construction of the expansion had finally started. The canal belts were completely designed on the drawing table, resulting in a well-structured urban landscape, whereas the *Jordaan* was built following the existing structure of the suburbs and polder, thus transforming an existing situation (Abrahamse 2010, 75). The character of the *Jordaan* did not change; it remained an area for the poorest of the city, and was mainly used for minor industries and crafts, as well as residence. It was decided to execute only half of the crescent shaped expansion, up to the *Leidsegracht* (fig. 2.3; Abrahamse 2014, 28). Within six years the expansion had been filled up, but the suburbs outside the new city walls continued to grow. In 1663 the expansion was continued, only after the remaining suburbs had been demolished, as another unstructured neighbourhood like the *Jordaan* was not wished.

The Disaster Year of 1672, when the Franco-Dutch and third Anglo-Dutch wars started, followed by another invasion by Münster, put an end to the expansion as all construction work at the canal belt had to be stopped in order to focus on finishing the fortifications, which had a priority during wartime (Abrahamse 2010, 194). This year marks the end of the Golden Age of Amsterdam, and is the beginning of a long period of stagnation (Abrahamse 2014, 28). The seemingly endless stream of immigration also came to a hold by the end of the 17th century, and many parcels in the expansion remained unsold for a long time. In order to make profit out of this area, the city council decided to adapt its function; instead of living quarters, allotment gardens and depositories for wood were constructed here (Abrahamse 2010, 203). This new part of the city became known as the *Plantage*. It was only in 1850, about 170 years later, that

Fig. 2.3: Amsterdam in 1650 (map made after Rutte and Abrahamse 2016, 27).

Fig. 2.4: Amsterdam in 1850 (map made after Rutte and Abrahamse 2016, 27).

urban development continued where it had stopped in the 1670s. Parcels in the *Plantage* were sold, and the first 19th century neighbourhood of Amsterdam became a fact (fig. 2.4).

2.2 Conclusion

In this chapter a general historical description of the city formation and growth of Amsterdam is presented.

Between 1265 and 1275 AD a dam was built in the mouth of the Amstel, along which the earliest settlement, known as *Amestelledamme*, was consequently built. Since arable farming was no longer possible in the 15th century, the city had to import its grain from elsewhere, resulting in the mercantile character Amsterdam attained. This character increased when the city joined the Dutch Revolt in 1578, for it created the opportunity for many refugees, mainly protestants and Jews from the Southern Netherlands, France and the Iberian peninsula, to settle in Amsterdam, resulting in an influx of ideas, capital and new relationships.

Over time, the city reached its maximum capacity of inhabitants, and extensions were needed. First in 1613, when Amsterdam was enlarged from the *Singel* all the way to the *Singelgracht*. Luxurious canal houses were constructed along the iconic canal belt, whereas the *Jordaan*, a new living and working area, followed the organised parcels of the peat reclamation landscape. Construction was stopped when the *Leidsegracht* was reached, and the other half of the crescent shaped extension was turned into gardens, known as the *Plantage*. This area of the city was only filled up with living quarters in the course of the 19th century.

Based on the spatial developments of the city, and assuming cisterns were a typical phenomenon from the 17th century onwards, a higher density of cisterns might be expected in the city extensions from 1613 onwards, in neighbourhoods such as the *Jordaan*, the canal belts, and the parcels of the former *Plantage*. However, cisterns were possibly also installed beneath already existing structures, which makes it difficult to predict where the highest density of cisterns could be expected. This will be discussed in further detail below.

3 “A beautiful virgin with a smelly breath”

The previous chapter introduced a general history of Amsterdam. This chapter provides more in-depth information on water management in the city. This includes not only maintenance and pollution of the canals, but also supply of fresh drinking water. This background information may shed light on why, and when, cisterns were employed throughout the city.

3.1 Pollution of the canals

As described in chapter 2, Amsterdam is a city that had to deal with water since its very beginning. In the early stages of the city formation, Amsterdam only had to deal with discharge of the Amstel into the IJ. Since the settlement was built upon the elevated riverbanks of this peat river, flooding was no serious threat. Only in later times, when the peat had begun to shrink and the seawater level continued to rise measures had to be taken to ensure the city’s safety during peak tides.

A much greater problem, and harder to deal with, was the pollution of canals. Up to the end of the 15th century, the water of the Amstel was used for drinking, cleaning and beer brewing (Groen 1979, 11). That the canal water was still clear by the end of the 14th century can be derived from a warrant by the city council from 1394, in which fishing in the canals is declared illegal (Groen 1979, 9). This warrant might seem unimportant, however, it does indicate there was still a diverse fish population in the late 14th century canals; the city council would not declare fishing illegal were it not for a large number of people fishing here on a regular basis, thus indicating a fair amount of fish was present in the canals.

However, as the number of inhabitants continued to grow, it did not take long before the canals became polluted with all sorts of domestic refuse, but also industrial waste. Furthermore, the water in the Amstel became increasingly brackish because of the rising IJssel. Therefore, the brewers of Amsterdam decided in 1480 to get water from the Haarlemmermeer instead (Groen 1979, 11). A large number of barges were used in this process, making the collection of water an expensive, but necessary, undertaking. In 1514, using canal water in beer production even became illegal, in order to protect its reputation (Abrahamse 2010, 293). In the 16th century the water in Amsterdam was truly polluted, and dumping domestic refuse, faeces, urine and dead animals became illegal by official decree in 1530 (Groen 1979, 12).

As the collection of water from elsewhere was a costly undertaking, different solutions were looked for. For example, in 1505 the city council ordered for the construction of nine large *regenbakken*, or rain tanks, throughout the city[1] (Groen 1979, 12). Groen does not specify on the nature of these tanks. Although the term *regenbak* is also used by Gawronski to refer to the cistern of the Portuguese synagogue, usually cisterns are mentioned as *verschwaterbak* (Gawronski and Jayasena 2012, 7). As a result, a lack of clarity of terms arises, as it is vague what exactly Groen means by *regenbak*.

In addition to these public tanks, according to Groen, patricians started constructing tanks beneath their cellars in the early 16th century as well. This statement is supported by Abrahamse, according to whom *regenbakken* were constructed in the 16th century[2] (Abrahamse 2010, 294). Again, it is unclear whether or not these *regenbakken* were similar structures to 17th and 18th century cisterns. Whilst these rain tanks were constructed around 1505, the first known cisterns in Amsterdam arose in the second half of the 17th century. Therefore, it seems dubious these tanks were similar to cisterns. Below it is discussed whether or not mentioned rain tanks are possibly the earliest examples of cisterns in Amsterdam.

Even though many laws were adopted on keeping the canals as clean as possible, results were mediocre. The many industries of Amsterdam, i.e. tanning, pig farming, paint and glue production, brewing, sugar refinery, distillery and white lead fabrication, kept disposing their waste into the canals. In the second half of the 17th century, specific industries were addressed on the seriousness of the situation, but often in vain (Abrahamse 2010, 295). It were not only the industries that were established in the city centre that were causing trouble to public health; large parts of the area outside the city were also affected by industry that was already banished from the centre, such as the *traanbranderij*, the production of whale oil, in the Watergraafsmeer (Abrahamse 2010, 295). This oil production not only worsened the water quality, it polluted the air as well. Therefore, many people opposed to the construction of such a *traanbranderij*. It was however built, although not allowed to produce any oil during east wind.

[1] Groen 1979, 12: "In 1505 besloot het stadsbestuur de mogelijkheden tot het verkrijgen van zuiver water uit te breiden door het plaatsen van negen regenbakken op diverse punten in de stad. De rijke Amsterdammers, die over een eigen huis beschikten verzamelden het via hun dakgoten aangevoerde regenwater in bakken in hun kelders, waar het zuinig werd bewaard."

[2] Abrahamse 2010, 294: "Het overgrote deel van het drinkwater kwam uit ondergrondse gemetselde regenbakken, die voor huizen lagen. Deze werden in de zestiende eeuw ingevoerd, toen het stadswater te smerig werd om nog als drinkwater te dienen. In ieder huis was minstens één regenbak te vinden."

Besides industrial waste and privies, the construction of a sewage system in the 1660s caused major problems to the water quality of the canals (Abrahamse 2010, 298). While it would seem the installation of a sewage system would increase the sanitation of the city at first thought, it actually only worsened the situation, as its contents were directly disposed into the canals through dozens of pipes at the waterfront. This is a peculiar choice, since the decree of 1530, mentioned above, explicitly forbids the disposal of faeces and urine into the canals. Therefore, this new sewage system completely disregards laws made by the city council only about a century earlier.

3.2 The search for solutions

The city council started to become desperate for solutions, as all plans thus far had failed (Abrahamse 2010, 318). A number of individuals tried coring down up to 65 metres beneath the street level, hoping to reach a layer or vein of clear water, but unsuccessfully so (Abrahamse 2010, 306, 319). As mentioned above, a number of water tanks were spread throughout the city. Already in 1681 Marcus Meyboom stated his concern about the cleanliness of the water in the tanks, as he thought it was polluted by the lead supply pipes, and lime from the mortar with which the troughs were constructed (Abrahamse 2010, 320). In 1688, Jan de Bray proposed his plans to construct a massive freshwater storage of 205 x 171 metres, including cisterns underneath. This storage would be filled with water from the Vecht, supplied by no less than 48 ships. Brewers and painters would be able to pump up water from this trough, and separate taps would be installed for private individuals. Furthermore, De Bray suggested underground pipes could transport water from said unit to a number of prominent city squares, on which fountains and taps would have to be built. Not surprisingly, the city council rejected De Bray’s plans, as the costs of such an undertaking were way too high.

In the 18th century, the age of stagnation, innovations and suggestions on the field of freshwater supply and sanitation were scarce (Groen 1979, 35). Ultimately, all ideas had been tried, and all proved unsuccessful. In 1730 an anonymous writer described Amsterdam as *“een schoone maagd met een stinkenden adem”*; a beautiful virgin with a smelly breath (Abrahamse 2010, 329). The only solution that was of any help were cisterns, as the construction of these was affordable, water could be stored in these for a longer time than in troughs and wells, and the chance of their content getting polluted was smaller (Gawronski & Veerkamp 2007, 60).

In the first half of the 18th century, drinking water was predominantly brought into the city by barges from the Vecht. Although this solution worked, water had to be paid for, whereas collecting rainwater was considerately cheaper since only the cisterns had to be built. In 1761, it was suggested to install cisterns at large structures, such as churches, warehouses and other public facilities. The rainwater collected in these cisterns was to be saved for periods of drought and paucity, when it was sold at a small price.

This plan was further developed by brewer Isaäc Decker in 1784, who proposed the construction of fifty-two large cisterns throughout the city, which could be used by both brewers and citizens (Groen 1979, 38-39). Even though city architect Abraham van der Hart initially disapproved, thirty-three of the cisterns were constructed between 1790 and 1824, of which twelve were reserved for brewers only.

3.3 Water pipes

New ideas regarding the fresh drinking water problem in Amsterdam arose in the course of the 19th century. These mainly focussed on the installation of water pipes. Cornelis Lanckamp, for example, proposed to channel water to Amsterdam from the dunes northwest of Haarlem in 1816 (Groen 1979, 43). However, this would be a very expensive undertaking, resulting in only the upper class being able to afford the dune water. Since the upper class already owned estates with their own wells and pumps, outside the city walls where the water was not as polluted, the construction of such a piping system would be redundant, as the common man would still have to buy barge water from the Vecht.

The situation changed in 1853, when the *Koninklijke Amsterdamsche Waterleiding Maatschappij* installed a water supply system from the Kennemerland dunes to Amsterdam (Groen 1979, 55). From Monday the 12th of December 1853 the *Duinwater-Maatschappij* (which became *Gemeentewaterleidingen* in 1896) opened their first tapping point at the Willemspoort (Groen 1979, 78). Here people were welcomed to fetch two buckets of fresh water per person, for a cent per bucket. As this system turned out to be a great success, the network was expanded rapidly, and in 1866 fifty-six tapping points were spread throughout the city.

In the second half of the 19th century, Amsterdam once more saw a massive population increase, doubling its total population. As a result, water supply was to be doubled as well. Furthermore, by this time most houses in Amsterdam were connected directly to the water piping system (Groen 1979, 104). In order to meet the increased demand, another network of water pipes was installed to the river Vecht. This water was deemed less suitable for consumption than the clear dune water, therefore it was used mostly in household tasks. Meanwhile the barges continued to supply water; in 1844 twenty-three were still in service (Abrahamse 2010, 328). In the course of the 19thcentury, the use of barges deceased. Cisterns were no longer constructed either, as the pipe networks were able to comply with the requirements of the late 19th century.

3.4 Conclusions

In this chapter, a brief history of water management in Amsterdam is presented. By the end of the 15th century, the water in the Amsterdam canals was so polluted, the city brewers decided to send barges to the Haarlemmermeer and the river Vecht. This practice continued into the 19th century. However, since this was a costly undertaking, different, more direct solutions were looked for. In the second half of the 17thcentury a sewage system was installed throughout the city. Though seemingly a good solution, the contents of this system were directly emptied into the canals, thus only worsening the initial problem.

In 1784 another development took place; the construction of a large number of cisterns was proposed. Thirty-three of these were actually installed, in prominent places throughout the city. These cisterns were free to use for civilians, although twelve were reserved specifically for brewers.

Even though it was a step in the right direction, the construction of large public cisterns never solved the drinking water problem in Amsterdam. By the end of 1853 the situation changed, as the first water pipe connection supplied the city with fresh water from the dunes. This invention was expanded rapidly; by the end of the 19thcentury most houses in Amsterdam accessed a direct connection to the water pipe system.

Regarding cisterns, it can be concluded they were introduced to reduce the freshwater problem in Amsterdam. It is clear there was a peak of construction in the end of the 18th century. However, this only covers large public cisterns. From textual sources it remains unclear when exactly private cisterns were first constructed in Amsterdam. It is, however, more evident when cisterns were no longer constructed. This must have been around the introduction of dune water through a pipe system by the *Duinwater-Maatschappij*, halfway the 19th century.

4 On Cellars, Cesspits & Cisterns

In the previous chapter cisterns have been mentioned on multiple occasion. However, what is exactly meant with this term? Furthermore, how are cisterns distinguished from other subterranean structures in the urban landscape? This chapter specifies on the concept of cisterns, their architectural characteristics, as well as differentiation between cisterns and other subterranean structures; cellars, cesspits, and wells. These structures are described first.

4.1 Cellars

Even though the water level was fluctuating and unreliable due to the many storm surges in Amsterdam in the 17th and 18th century, many people wanted to have a cellar constructed beneath their houses (De Roon 2007, 162). As the city grew and many new inhabitants moved to Amsterdam, all available space was sought-after. Cellars provided a solution to lack of space, as they are simply constructed beneath a building, acting as another storey without swallowing up more space at the surface. A common and recurring issue with cellars, however, was the formation of cracks and leaks in the floor due to disproportionate pressure of the rising water during or after a storm or tidal peak. As this damaged many stored goods, people were desperately looking for solutions.

Therefore, in 1674, renowned architect Philips Vingboons designed a cellar which would not be fixed to the main structure of the house, but floated on the fluctuating water level instead (fig. 4.1). Because the fluctuating water level did not have to be considered, these cellars could be made deeper; if the water would rise, the cellar would simply rise along, rather than crack. Fixed cellars could not be made as deep, since they did not possess this flexibility and as a result would be damaged by rising water if built too deep. This new type of cellar was adopted occasionally throughout the city, but most cellars remained fixed. Floating cellars were tailor-made, and therefore expensive to construct, resulting in their adoption by only the upper classes of society (De Roon 2007, 167). After the sluices were constructed in the IJ in 1871 and the Zuiderzee was kept out of the city, fluctuating groundwater level was no longer of concern.

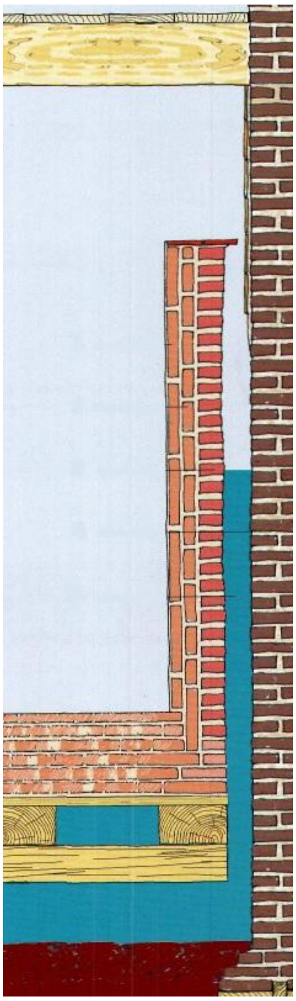


Fig. 4.1: Section of a floating cellar (after De Roon 2007, 163).

Therefore, many floating cellars were now fixed in place, and no new ones were constructed (De Roon 2007, 174).

When differentiating cellars and cisterns, floating cellars are most important; as regular cellars are fixed to their superstructure, they are easily distinguished from cisterns, which are constructed separately from their superstructure, just as floating cellars. Important to note about floating cellars, are their architectural elements. The floor was constructed of thick oaken beams and planks, covered with up to eight layers of brick, put in such a manner all seams were covered by another layer, thus making sure the entire structure was as watertight as possible. Moreover, the weight of so many layers of brick made sure the cellar would lay deep enough, thus not crashing into the superstructure at times of a high groundwater level. The side walls consisted of three layers of brick; a stretcher bond layer on the outside, covered with two *klamplagen*, a layer of bricks applied on their largest side, called the bed, on the inside. Again, the bricks were put in such a manner all seams would be sealed off. The inside would finally be covered with red glazed tiles or white glazed tiles (De Roon 2007, 172). The sizes of cellars varied, but they are usually larger than a few metres in width and length, easily differing them from cisterns, which are usually much smaller (fig. 4.2; De Roon 2007, 168).

Of further importance is the use waterproof hydraulic trass mortar. Trass is grind tuff from the Eifel region. By adding trass to the lime mortar it acquired the characteristic of hardening in water, thus making it suitable for subterranean structures, which came into contact with groundwater.

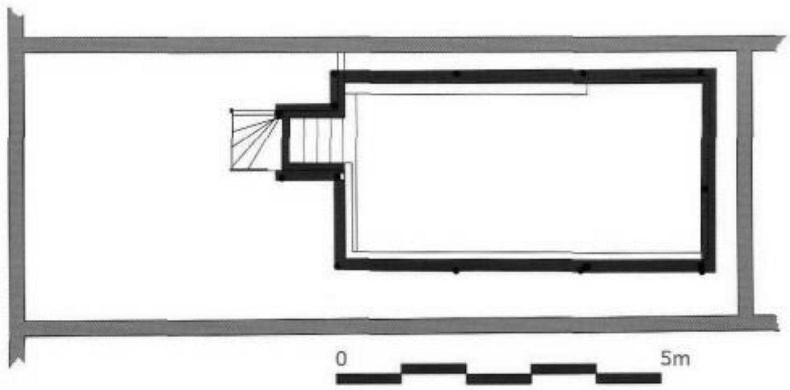


Fig. 4.2: Floating cellar beneath *Herengracht* 354 (after De Roon 2007, 166).

4.2 Cesspits

The most occurring subterranean structure in the urban archaeology of the Netherlands are cesspits (Van Oosten 2017, 22). Cesspits are underground reservoirs for both faeces and waste.

Different from cellars and cisterns, cesspits were not supposed to be watertight. In order for liquids to flow out, most brick cesspits were stacked rather than laid with mortar (Van Oosten 2015, 53). Since the groundwater level fluctuated heavily, as mentioned above, the contents of a cesspit would rise too. As can be imagined, this would create an unpleasant smell. For this reason, most cesspits in Amsterdam were provided with a plank floor (Gawronski *et al.* 2017, 10). Emptying was done by breaking down the top, or crown, of the pit, which would either be a barrel vault on a square cesspit, or domed vault on a round cesspit (Van Oosten 2015, 56). In some cases, a chimney-like funnel was constructed on top or to the side of the chamber, through which waste could be removed more easily, though less efficiently.

4.3 Wells

Before the use of cisterns, wells were the standard installation for drinking water. Wells were easily dug, and therefore much cheaper to install than cisterns. Usually, a well was constructed of a hole, depths in which a wooden barrel without top and bottom was placed (Gawronski *et al.* 2017, 11). Sometimes, in the case of deeper wells, up to four barrels were used to construct a well. The bottom of a well was either the perforated bottom of a barrel, or sometimes a layer of shells, in order to purify the groundwater (Gawronski *et al.* 2017, 11). On top of a well, a low brick wall was constructed to prevent things and people from falling in. This wall follows the round structure of the well.

Because of the simple construction, and porous material, wells are easily polluted, for example by oozing fluids from nearby cesspits, thus less reliable in the long term. Furthermore, the groundwater in Amsterdam became increasingly brackish as the seawater level rose, thus making it less suitable for consumption. Therefore, this may be one motive for the deployment of cisterns in the 17th century, as ground water would no longer be the main supply of drinking water.

4.4 Cisterns

A cistern is an underground reservoir for rainwater. In Dutch, cisterns are mentioned with different terms. Since this mixed terminology can lead to disorder, in this research only the terms *waterkelder* and *verschwaterbak* are taken into account when documenting cisterns, as it is certain both terms are used to indicate the same type of structure (Gawronski and Jayasena 2012, 7). It is unclear if different terms, for example *regenbak*, as mentioned by Groen, indicate to same structure. Therefore, structures indicated with terms other than *waterkelder* and *verschwaterbak* shall not be recorded as identical to previously mentioned.

The architectural elements and construction of cisterns are quite similar to those of floating cellars. For example, as cisterns had to be heavy enough to stay at a certain level underground as well, they also were comprised of a heavy oaken beam bottom, whereupon multiple layers of brick were lain (Gawronski and Veerkamp 2007, 61). Furthermore, cisterns of course had to be watertight, both to keep water in and to keep groundwater out. Therefore, trass mortar was used in the construction of cisterns. The same goes for the application of *klamplagen* of hard fired bricks, so called *klinkers* (Gawronski and Veerkamp 2007, 60). Whereas the inside of the chamber could be covered with glazed tiles, the outside of cisterns was usually either left crude, or covered with a layer of trass cement, which would make the whole more waterproof. In contrast to cesspits and wells, cisterns were rectangular in shape (Gawronski *et al.* 2017, 10). The chamber would be covered with a flattened barrel vault, which was often supported by a division wall. Often, there would be an opening in this wall so that the water could flow freely from one side of the chamber to the other. Sometimes, however, division walls were closed.

Like cesspits, cisterns often have a chimney-like shaft attached as well. Usually constructed in one of the corners and closed off with a slab of natural stone, this shaft granted necessary access to the chamber, since it was recommendable to enter the chamber and clean the inside of the chamber thoroughly from time to time. Furthermore, the shaft could be used to retrieve water from the cistern by pumps or buckets. As mentioned above, sometimes division walls were closed off, creating two separated chambers. In this case, two shafts were constructed on top of the cistern, indicating two neighbouring households used the same cistern (fig. 4.3).

Another important aspect of cisterns is the supply of water; how did water enter the chamber? One way to fill a cistern is manually, by emptying buckets of water down the shaft. As this would take a lot of time and effort, a more efficient way was found: lead supply pipes would transport water from the gutter down to the chamber (Gawronski and Veerkamp 2007, 64). Sometimes pipes were also constructed between cisterns and kitchens. In this case water was pumped up from the cistern directly into kitchen (Gawronski *et al.* 2017, 12).

Fig. 4.3: Cistern at Elandstraat 103-105, equipped with two shafts in the centre (Gawronski *et al*. 2010, 23).

4.5 Conclusion

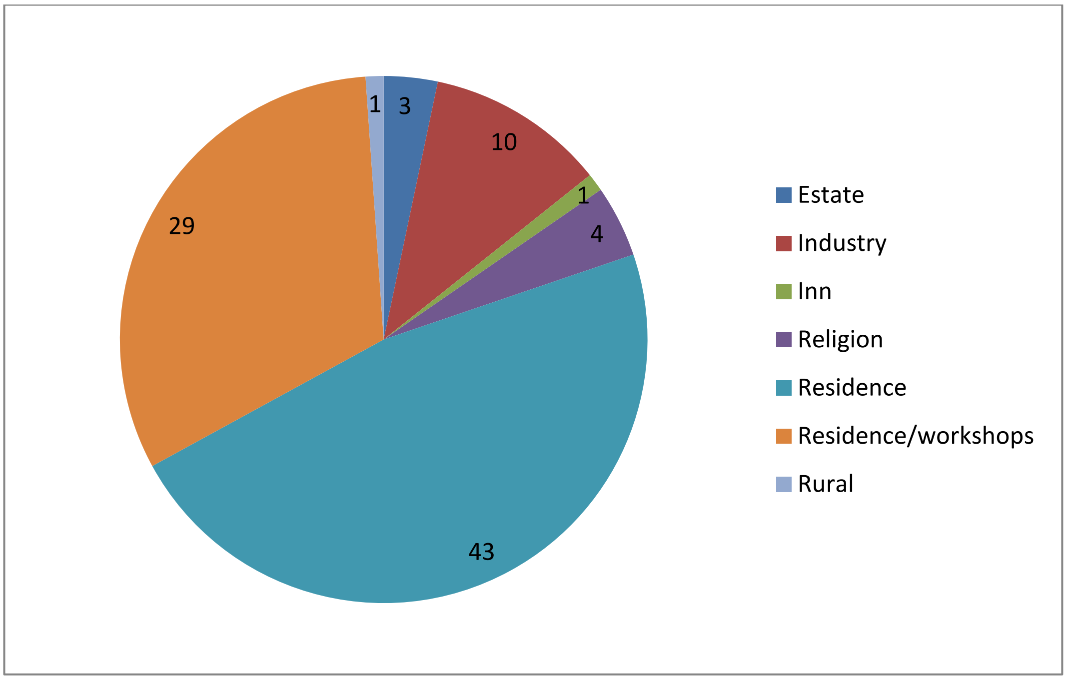
The main aspects that distinguish a cistern from (floating) cellars, cesspits and wells are their rectangular shape and flattened barrel vault, as cellars do not have these vaults, and cesspits and wells are most often circular or square. In addition, the walls of cisterns are laid of brick with trass mortar, whereas cesspits are constructed of stacked rather than mortared bricks. Furthermore, distinguishing cisterns from cellars can be done by looking for shafts, division walls and lead supply pipes. Finally, cisterns are almost always smaller than cellars.

5 The Cisterns of Amsterdam

In this research the relationship between superstructures and functional application of cisterns is focused upon. Therefore, the dataset has been divided into seven categories of functional application; estates, industrial, inns, religious, residential, residential/workshops and rural buildings (tab. 5.1).

In this chapter, first a general description of each category of functional application is given, highlighting some outstanding objects. Then, floor surfaces are looked upon and compared, since the measurements of sixty-two (n=62), out of ninety-one (n=91) cisterns are sufficiently described in the AAR. Furthermore, the maximum capacity of a number of cisterns (n=16) will be calculated and compared. In addition to the private cisterns recorded in the database (appendix 1) used for this research, public cisterns are discussed. Do these differ from private cisterns in size or architectural characteristics?

Tab. 5.1: Number of cisterns per category of functional application (appendix 1).



5.1 Estates

Three cisterns (n=3) are found in the context of estates, or country houses. Two of these were excavated at *Frankendael*, a mansion from 1660, outside the old city centre. As the cisterns from *Frankendael* were found in the vicinity of an orangery, or greenhouse, they are likely to have served the gardeners with a supply of rainwater to water the plants (Gawronski and Veerkamp 2008, 12). Cistern nr. 2 (appendix 1) stands out with its small size: 0.50 x 0.50 metres, making it the smallest object of the dataset. This small size is likely to be related to horticultural use, as cisterns used for other functional applications, such as drinking water or production, tend to be of larger size, as is discussed below.

Another cistern, nr. 5, was found at the former estate of *Rust en Werk*, which was situated along the Amstel but demolished in 1887 (Fig. 5.1; Gawronski and Veerkamp 2009, 10). This cistern was of large proportions: 4 x 2.60 metres. With a capacity of around 27,000 litres of rainwater, this cistern is one of the largest cisterns of the dataset. The use of this cistern will probably have varied from practices both indoors and outdoors, such as cooking, cleaning, bathing, as well as gardening.

Fig. 5.1: *Rust en Werk* along the *Amsteldijk* in 1885 (Gawronski and Veerkamp 2009, 9).

5.2 Industry

A number of cisterns (n=10) were found in the context of industrial buildings. The type of industrial use varied from glue production at the *Tweede Kostverlorenkade*, to shipbuilding at the *Oostenburgervoorstraat*. The latter, cistern nr. 11, is a special cistern in the dataset, as it is comprised of three compartments, which are all subdivided into two parts (Gawronski *et al.* 2017, 23). Its proportions, 4.20 x 2.25 metres, stand out, as this cistern is twice as large as the average cistern of industrial context. Its situation at the gatehouse of a shipyard might explain its size. This is explored further in the discussion below. In general, the cisterns related to industrial buildings tend to be relatively large, with an average floor surface area of 4.3 m².

5.3 Inn

One cistern, nr. 14, found beneath the lot of *Dam* 2, was of extraordinary proportions; at least 4 x 4 metres, making it the largest cistern of the dataset. This cistern most likely belonged to the inn "*De Bisschop*", which was established here in the second half of the 19th century (Fig. 5.2; Gawronski and Veerkamp 2012, 8).

Fig. 5.2: "*De Bisschop*" in 1899 (after Gawronski and Veerkamp 2012, 9).

5.4 Religious

Four cisterns (n=4) were found in the context of religious buildings. The average floor surface of cisterns with a functional application related to religious buildings is 4.4 m². An outstanding cistern of religious context is the cistern of the Portuguese Synagogue on the *Mr. Visserplein* 3 (fig. 5.3). This cistern, nr. 18, was quite large, 3.10 x 2.82 x 2.50 metres (Gawronski and Jayasena 2012, 10). It had a capacity of 11,000 litres, making it one of the largest cisterns in the

Fig. 5.3: The Portuguese synagogue in 1694 (Gawronski and Jayasena 2012, 8).

dataset. Interestingly, the construction of this cistern and its surrounding structures are mentioned in a construction bill, and therefore it is possible to be dated to 1674 exactly; one of the earliest known examples of cisterns in Amsterdam. The dating of cisterns is discussed further below.

5.5 Residence

Cisterns are most commonly found in residential contexts (n=43). These are common houses, owned by all layers of society. Unfortunately, only twenty (n=20) out of the total of forty-three cisterns of residential context were described in enough detail to calculate the average floor surface, which is 3.6 m². One cistern, nr. 44, excavated at *Singel* 97 had a floor surface of 7.5 m², which is remarkably large in comparison to the other residential cisterns (Gawronski *et al.* 2017, 63). Another, even larger object, nr. 61, was discovered at *Nieuwe Keizersgracht* 92. With a floor surface of 12.18 m², this object is the second largest in the dataset. The average of cisterns of a residential context was calculated without this cistern, since it is so much larger than the others, thus can be treated as an anomaly. Residential cisterns have an average floor surface of 3.2 m².

In general, cisterns found beneath residential structures have most likely been used for domestic activities, such as washing, cooking and consumption.

5.6 Residence/workshops

A large number (n=29) of cisterns was found in the context of workshops. In Amsterdam, many buildings functioned as both workshops and living quarters. Especially the *Jordaan* was designed as the new working and living neighbourhood in the 17th century expansion of Amsterdam (Gawronski and Veerkamp 2011, 5). Many small industries, for example tanneries, were no longer wanted in the centre of the city and moved to the *Jordaan*.

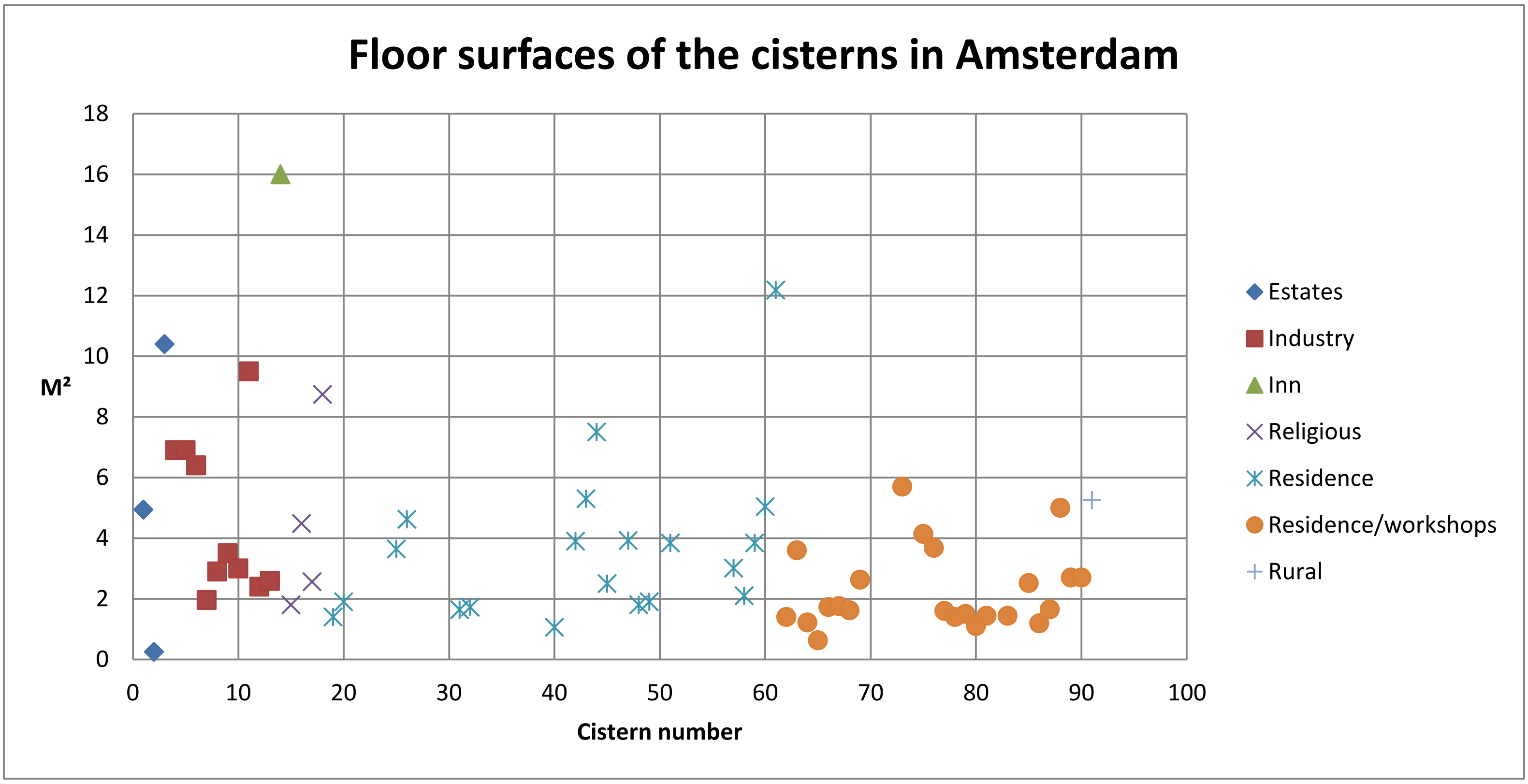
Since water is involved in many crafts, cisterns and wells are expected in neighbourhoods associated with production. However, in most cases it is difficult to indicate the specific use to a cistern, as well as the function of individual buildings. For example, it is likely a number of objects assigned to the category of residence were actually used in production activities as well, and vice versa, although in most cases there is not enough contextual evidence to prove such statements.

Out of the twenty-nine objects, twenty-three (n=23) cisterns were supplied with the measurements needed to calculate an average floor surface; 2.3 m², which is surprisingly small considering the semi-industrial functional application of this category of context. The largest cisterns of this context, nr. 73 and 88, with floor surfaces of 5.7 and 5 m², were built up in two compartments, meaning they were likely shared between two households or workshops. This would suggest even the large cisterns in this category would have had an individual floor surface of about 2.5 m².

5.7 Rural

One cistern, nr. 91, was excavated in the rural outskirts of Amsterdam. Associated with a small building, possibly a barn or stable, it can be assumed this cistern was used for agriculture or livestock (Gawronski and Jayasena 2010, 15). Its dimensions, 3 x 1.75 metres, with a floor surface of 5.25 m², are quite large; another indication this cistern was probably used for activities beyond the storage of drinking water.

Tab. 5.2: Floor surfaces of the cisterns in Amsterdam, based on category of functional application.



5.8 Floor surfaces

Above a figure (tab. 5.2) is provided showing the floor surfaces of the sixty-two cisterns of which dimensions were sufficiently described in the AAR. This figure shows a clear visual representation of the distribution and difference in sizes of cisterns. Most strikingly, it can be seen only nine (n=9) objects have a floor surface larger than 6 m². These are four (n=4) industrial cisterns, two (n=2) residential cisterns, and three cisterns belonging to an inn, estate and church.

Each category of context can be divided into clear clusters; the floor surfaces of industrial cisterns are between 2.5 and 4 m², with three (n=3) examples between 6 and 7 m² and one (n=1) anomaly of 9.5 m²: cistern nr. 11, at the *Oostenburgervoorstraat*. This cistern is described above, and will be discussed further below.

In addition to the industrial clusters, residential cisterns are clustered with floor surfaces between 1 and 5.3 m². Only two (n=2) out of a total of twenty (n=20) residential cisterns do not fall within this range. These cisterns, nr. 44 and 61, had a floor surface of 7.5 and 12.18 m², and are described above.

Contrary to the relatively large cisterns found in industrial and residential contexts, cisterns found in residence/workshops have relatively small floor surfaces; eighteen (n=18) out of twenty-three (n=23) cisterns in the residence/workshops category had a floor surface of less than 3m². The remaining five (n=5) cisterns were still smaller than 6m², with the largest cistern of this category being nr. 73, with a floor surface of 5.7m².

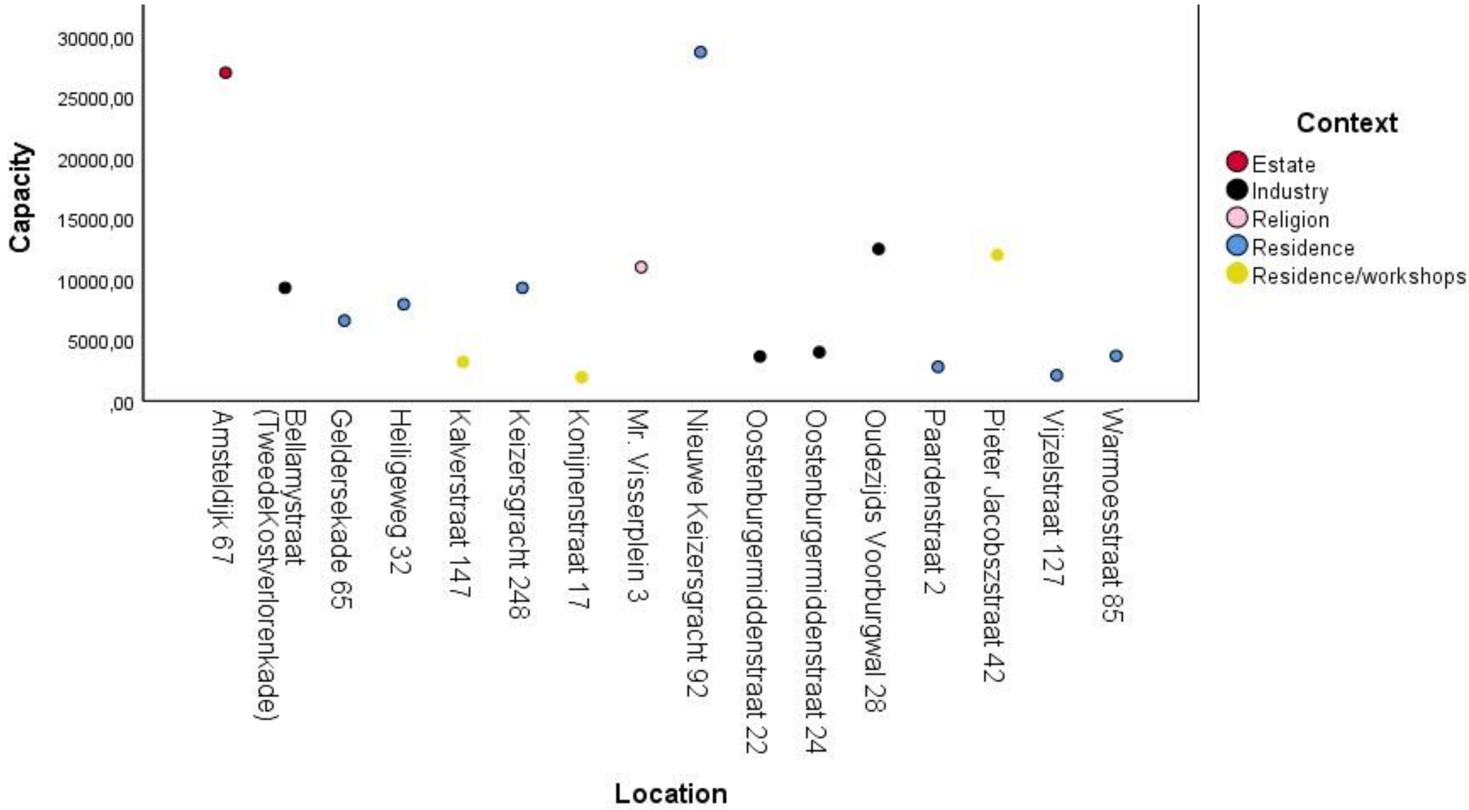
5.9 Maximum capacity

Of a number of cisterns (n=16) their maximum capacity could be calculated. Gawronski and Veerkamp appended a formula in their publication from 2007 (Gawronski and Veerkamp 2007, 133, note on page 67):

$$Maximum\ Capacity = \frac{(\pi r \times 2l)}{2} + (h - r) \times b \times\ l$$

Here, *r* stands for the radius of the barrel vault, which is half the width of the cistern, *l* stands for length, *h* stands for height, and *b* stands for width. In this formula, it is assumed a perfect half-cylinder barrel vault is present. In practice, these were often flattened (Gawronski and Veerkamp 2007, 61). The writers also mention they did not know whether or not cisterns were filled up all the way to the top. Even so, the calculated maximum capacities of sixteen cisterns will provide indications that can be compared, again based on category of context.

Tab. 5.3: Calculated maximum capacity per cistern.



As seen in table 5.3 (tab. 5.3), the calculated maximum capacities of cisterns vary greatly, with a minimum of 1,950 and a maximum of 28,700 litres. Three trends can be discovered here; first the smallest cisterns (n=7) with a capacity of 0-5,000 litres, a middle group with a capacity of 5,000-15,000 litres (n=7), and two (n=2) outstandingly large objects with a capacity of 25,000+ litres. Since these two cisterns, at *Amsteldijk* 67 and *Nieuwe Keizersgracht* 92, are so much larger than the other fourteen, they have been excluded for the calculation of an average, and are thus treated as anomalies. Without these two cisterns, an average capacity of 6,430 litres was calculated.

Based on category of functional application, no clear patterns are visible. Cisterns of all contexts are spread more or less evenly in the two main trends.

Interestingly, the two cisterns with the largest maximum capacity are found at locations of luxury, namely residential and estate contexts, whereas they might have been expected to belong to a large industrial or public institute, such as a wharf or church.

5.10 Public cisterns

In chapter 3, the installation of thirty-three public cisterns throughout Amsterdam between 1790 and 1824 was mentioned (Groen 1979, 39). In his publication, Groen provides a map of the spatial distribution of these cisterns, as well as a quantitative list of their capacities in *emmers*, or buckets (Groen 1979, 26, 38). One *emmer* is about 14.7 litres (www.meertens.knaw.nl). Interestingly, most cisterns mentioned on this list had the capacity of 8,000 *emmers*, which would be around an impressive 117,600 litres. Even the smallest cisterns of this list, with the capacity of 2,000 *emmers*, would contain around 29,500 litres, thus still more than the largest private cistern of which its capacity could be calculated, nr. 61, which would contain about 1,950 *emmers*.

These enormous capacities are explained by the architectural elements of the public cisterns; instead of one or two compartments, public cisterns can be divided in up to twelve compartments. Thus, there is a clear difference in size and construction between private and public cisterns.

5.11 Conclusions

In this chapter a number of aspects from the dataset are presented. First, each category of context was introduced by describing their general characteristics, such as the functional application of the water stored in cisterns, most outstanding objects, and average size based on floor surface. Noticeable were the large averages in floor size of cisterns of the religious and estate context. However, it should be noted that contexts with a large average floor surface also are the ones with least objects, thus making the average less significant. For example, the religious context has an average floor surface of 4.4 m², but also consists of only four (n=4) objects, of which one has a surface of 8.74 m². A similar situation is present at estates. Therefore, the floor surfaces with more objects, industrial, residential and residence/workshops, are more meaningful. Of these, it can be clearly said industrial cisterns are largest overall. The context of residence/workshops has the smallest cisterns, which contradicts the assumption more water would be needed in environments of production and crafts.

When analysing the averages, two large cisterns clearly stand out, the cistern of inn "*De Bisschop*", nr. 14, and the cistern at *Nieuwe Keizersgracht* 92, nr. 61. Of the inn it can be assumed much water was used both for consumption and tasks such as cleaning the floor, tankards and jugs. Why the residential building of *Nieuwe Keizersgracht* 92 possessed such a large cistern cannot be concluded from the analysis conducted in this research.

Maximum capacities of sixteen cisterns were calculated with the formula presented by Gawronski and Veerkamp. Whereas great variation is present between the individual cisterns, all but two outstandingly large objects, nr. 3 and nr. 61, have a maximum capacity of less than 15,000 litres. Seven objects had a capacity of less than 5,000 litres, and seven a capacity between 5,000-15,000. The average maximum capacity is 6,430. The two outstandingly large objects are excluded from this calculation.

In addition to the cisterns documented for this research, maximum capacities of public cisterns are presented. There clearly is a difference between private and public cisterns; public cisterns tend to contain enormous capacities of water, and although they are constructed similarly to private cisterns, they are significantly larger than even the largest private cistern.

6 Discussion

In this chapter, a number of statements made in the descriptive chapters above are revised, and the data from chapter 5 will be interpreted and discussed in a larger context. First of all, the dating of cisterns is treated, discussing their first and last use in Amsterdam. Then the spatial dispersion of cisterns throughout the city is discussed, analysing and explaining clusters. Finally, a number of the subquestions constructed in the introduction will be answered.

6.1 Dating cisterns

In the introduction a number of subquestions were asked. One of these is finding out when cisterns were first used, and why. A number of statements regarding the use and location of cisterns have been made throughout the chapters above. Here, with the data presented in chapter 5, some statements are nuanced.

Dating cisterns is mostly done relatively. The cisterns of Amsterdam can be divided into two generations; the first generation from the 17th century, and the second generation from the 18th and 19th century (Gawronski and Veerkamp 2007, 61). The first generation can be recognised by the presence of glazed tiles. These tiles, usually orange or brown and 22 x 22 cm, were applied on the inside of a cistern, on both the walls and floor (fig. 6.1). The second generation of cisterns can be recognised by the presence of *klamplagen*. As already mentioned above in chapter 4, these are layers of brick lain on their flat, in a diagonal line. Constructively, *klamplagen* are stronger and more watertight than the previously used tiles.

Fig. 6.1: Example of an early cistern at *Rozenstraat* 72, with glazed tiles on the walls and floor (Gawronski and Veerkamp 2011, 53).

6.1.1 Early cisterns

In the dataset used for this research, a number (n=11) of cisterns were constructed with tiled walls. Following the dating method of Gawronski and Veerkamp, these would be placed in the 17th century. Below a number of early examples of cisterns from the dataset are presented. First, the cistern found at the Portuguese Synagogue at *Mr. Visserplein* 3, nr. 18, can be precisely dated to 1674, as its installation was documented in a construction bill (Gawronski and Jayasena 2012, 7). In alignment with the description of first generation cisterns above, this cistern was finished with a layer of tiles on the floor and inside of the walls (fig. 6.2; Gawronski and Jayasena 2012, 10). In this case these were 21.5 x 21.5 cm, and red glazed.

Fig. 6.2: Inside of the cistern at *Mr. Visserplein* 3, with two compartments and red glazed tiles (Gawronski and Jayasena 2012, 12).

Another early example is cistern nr. 66, found at *Konijnenstraat* 5, which can be dated to the 17th century with certainty as well. In this case, the cistern was built on the same foundations as its neighbouring cesspit. Through its contents, the primary use of this cesspit was dated to 1615-1800 (Gawronski *et al.* 2007, 13). Since the cesspit and cistern share the same foundations, it is likely the cisterns was constructed in the first half of the 17th century as well, which is remarkably early in comparison to the other cisterns of Amsterdam.

Another roughly datable early cistern, nr. 81, was found at *Rozenstraat* 72 (fig. 6.1). Although the exact year in which this cistern was constructed is unclear, it must have been before 1692, as by then it was built over with a plank construction (Gawronski and Veerkamp 2011, 55).

In conclusion, it can be said cisterns only become a common phenomenon in Amsterdam in the 18th century, since the large majority of cisterns is dated to this century. Only eleven out of ninety-one objects, were finished with glazed tiles, which is typical for 17th century, or first generation cisterns. Furthermore, the only three objects were roughly datable, either by their context, or in case of the cistern of the Portuguese Synagogue by a construction bill. Considering the rest of the dataset, these can be regarded as the earliest examples of cisterns in Amsterdam.

With the conclusions made above, the statement by Groen about *regenbakken*, mentioned in chapter 3, can be revised. In his publication from 1979, Groen mentioned the installation of a number of *regenbakken* throughout Amsterdam in the beginning of the 16th century (Groen 1979, 12). However, above it is concluded the earliest cisterns in Amsterdam date to the end of the 17th century. Since this temporal difference is extensive, it can be assumed these *regenbakken* were either architecturally of a different nature than their late 17th century successors, or Groen was misinformed about the first installation of cisterns in Amsterdam.

6.1.2 Why cisterns?

Now that the first use of cisterns has been recognised, the reason why cisterns came into use in Amsterdam is looked into. In chapter 3, a number of solutions for the drinking water problem in the city have already been described, i.a. wells and barges. However, these solutions did not solve the insufficient supply of drinking water in Amsterdam. In chapter 4, in the description of some reoccurring subterranean structures in the urban archaeology of Amsterdam, an important problem of wells was presented; leakage. As wells are often built in the vicinity of cesspits, usually in courtyards, fluids tend to ooze through the walls and floors of the cesspits, thus polluting the groundwater around it. This polluted groundwater consequently ends up in the nearby well, and is pumped up later. In addition to pollution by cesspits, the groundwater beneath Amsterdam increasingly became brackish with the high tide of the salty IJ, thus only worsening the already poor situation (Abrahamse 2010, 320).

As described above, another solution was found for the poor water quality of the canals and wells; barges. A large number of barges brought water into Amsterdam from the Vecht and nearby lakes for over three centuries, from the end of the 15th century up to the middle of the 19th century (Abrahamse 2010, 328). However, the collection of water by barges had a great disadvantage; since the undertaking of collecting water was very time and labour consuming, water had to be sold at a price. In addition to the undertaking being time and labour consuming, the weather also played a large role; when the canals were frozen the undertaking was troubled heavily. In case of a heavy winter it took two or more horses to pull the barges, resulting in an increased price per bucket in Amsterdam (Groen 1979, 22).

In the 18th century cisterns had become a common phenomenon in Amsterdam. In combination with the fresh water from the barges, cisterns provided a good reserve for brewers and other civilians alike (Groen 1979, 24). Cisterns had to be constructed and maintained afterwards, but compared to buying water by the bucket they are a much more sustainable answer to the drinking water problem. Furthermore, because of their watertight construction, water inside cisterns was not polluted by dirty groundwater.

6.1.3 Out with the old, in with the new

Above the reasons of employment of cisterns in Amsterdam are described. As mentioned in the introduction, the retirement of cisterns in Amsterdam is of importance as well; did cisterns no longer suffice the needs of the people of Amsterdam? Were cisterns replaced by a cheaper or more substantial alternative?

Important to note is the fact that even though cisterns proved a better alternative to wells, and were more sustainable than barges, they never completely solved the drinking water problem in Amsterdam, i.a. indicated by the continued use of barges.

A number of problems can be found with the use of cisterns. First of all, private cisterns had an average maximum capacity of 6,430 litres. This would be around 440 *emmers*, or buckets of 14.7 litres. Depending on the number and profession of the residents, this quantity of water would most likely not be enough to sustain a family with a constant supply of water.

Secondly, even if the capacity of a cistern would be sufficient to sustain a family, its content is dependent on the weather; as cisterns are filled with rainwater, replenishment is ceased during periods of drought.

Thirdly, the results of a quality inspection in 1794 were concerning; the level of lead in the water stored in cisterns was too high (Gawronski and Veerkamp 2007, 60). This high lead level was not only caused by the lead roof gutters, from which rainwater was collected, but also by the lead pipes used to conduct the water into the cistern. In addition to lead poisoning, the water in cisterns was polluted by filth from the roof gutters, for example animal’s faeces.

Regarding the abandonment of cistern, the introduction of a water piping system played a large role. The rise of a piping system is also seen in the use of barges, which declined in the second half of the 19th century, due to the supply of fresh water from the dunes by the *Amsterdamse Duinwaterleiding*. This development in the water management of Amsterdam most likely brought the construction of cisterns to a standstill as well. Even though cisterns remained a useful method for the storage of reserve water, in a number of cases they were re-used as cesspits. For example, the cistern at *Valkenburgerstraat* 132 was filled up with ceramics after it had lost its original function (Gawronski and Jayasena 2016, 84). Through typology, the ceramics could be dated between the end of the 18th and beginning of the 19th century. Another example is the cistern at *Elandsstraat* 109, which was used as a latrine after its use as a cistern, somewhere in the 19th century (Gawronski *et al.* 2012, 31).

Apart from a small amount of exceptions, in most cases it was not possible to date when the cistern had lost its original function, since either no evident secondary use was recognised, or no datable material was deposited. However, the little material that was found could be exclusively dated to the 19th century (Gawronski and Veerkamp, 2007, 60). Therefore, it can be concluded cisterns had lost their significance in Amsterdam in the 19th century, which is most likely connected with the arrival of a better alternative; the *Amsterdamse Duinwaterleiding.* Even though this water was not free, it was cleaner, and always available. It quickly became very popular in Amsterdam, and developments accelerated.

6.2 Locating cisterns

Besides the general age of cisterns, their location is of importance. Where are the cisterns located in Amsterdam? What neighbourhoods have the highest density of cisterns, and is there any relationship between the location of certain cisterns and their social context? Furthermore, is there an evident link between the age of neighbourhoods and their number of cisterns?

Fig. 6.3: Locations of all cisterns in the centre of Amsterdam, numbers correspond with the cistern numbers in appendix 1.

In figure 6.3 (fig. 6.3), the created map of Amsterdam in the 19th century and the spatial distribution of cisterns are combined, forming a general visual representation of all documented cisterns in Amsterdam. A number of interesting clusters of cisterns come forward in this map, which are presented in this chapter.

6.2.1 The Jordaan

First of all, all cisterns in the western part of the 17th century extensions of Amsterdam, the *Jordaan*, are found in a context of industry or residence/workshops (fig. 6.4). This is not surprising, since the *Jordaan* was designed as the new working and living area of the 17th century extensions, as mentioned above. Small industries that were no longer wanted in the city centre were moved here, for example skinning and tanning. Many street names in the *Jordaan* still remind us of industries practiced here, such as the *Elandsstraat* and *Konijnenstraat*, both associated with the fur and leather industry. Shortly after 1625, residential properties also arose here, which is why these cisterns are classified in the residence/workshops category, rather than industrial (Gawronski *et al.* 2007, 7). Not enough information about each individual house is available to determine what practices took place here exactly, and when. Therefore, it is very well possible a cistern in the *Jordaan*, classified in residence/workshops, was actually only used for residential purposes, e.g. cooking, cleaning and drinking.

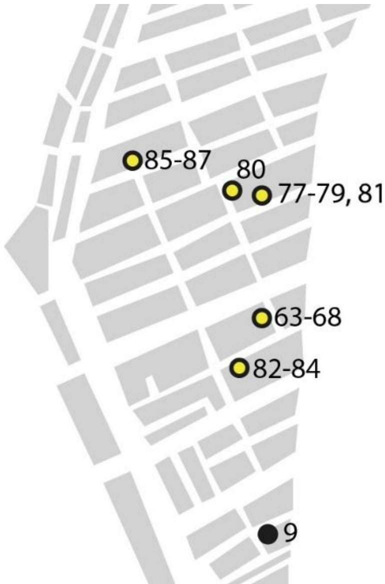


Fig. 6.4: Locations of cisterns in the *Jordaan*.

In chapter 5, the small average floor average of the residence/workshops context is mentioned. With the spatial data provided by figure 6.4, the small average floor surfaces might be explained. As described in chapter 2, the *Jordaan* developed from illegal slums, and followed the structure of the peat reclamation. Even after the redevelopment of the area in the 17th century, it remained the poorest part of Amsterdam. Therefore, the small cisterns found in the *Jordaan* might be related to the income of the people living here, which was not high. This hypothesis is supported by the large residential cisterns found in richer parts of Amsterdam, for example the *Nieuwe Keizersgracht*, *Singel* and *Keizersgracht*. These large cisterns were expensive to install, and therefore not likely to be found in poor parts of Amsterdam.

6.2.2 Valkenburgerstraat

Another striking cluster of cisterns can be found in the *Valkenburgerstraat*, where fifteen cisterns were found. Constructed in the 17th century extension, the island of *Marken* used to have an industrial function, linked with maritime activities (Gawronski and Jayasena 2016, 8). After 1663, the island acquired a residential function, as maritime industries moved to the islands *Kattenburg*, *Wittenburg* and *Oostenburg*. Considering the conclusions made about the dating of cisterns in Amsterdam, this large number of cisterns can be linked to the newly constructed residential neighbourhood rather than the industrial activities that took place on *Marken* in the first half of the 17th century.

6.2.3 Oostenburg

On *Oostenburg*, the most eastern island constructed in the IJ in the second half of the 17th century, a number of residential (n=9) as well as a number of industrial (n=3) cisterns were found (fig. 6.5). The island was constructed in the 1660s, when the maritime industry of Amsterdam had outgrown its previous location on the island of *Marken* and needed to move elsewhere. *Oostenburg* was designed for both maritime industry and residence (Gawronski *et al.* 2017, 5). The island was divided into three parts; living quarters on the most

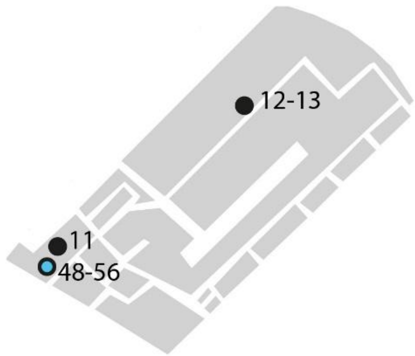


Fig. 6.5: Locations of cisterns on *Oostenburg*.

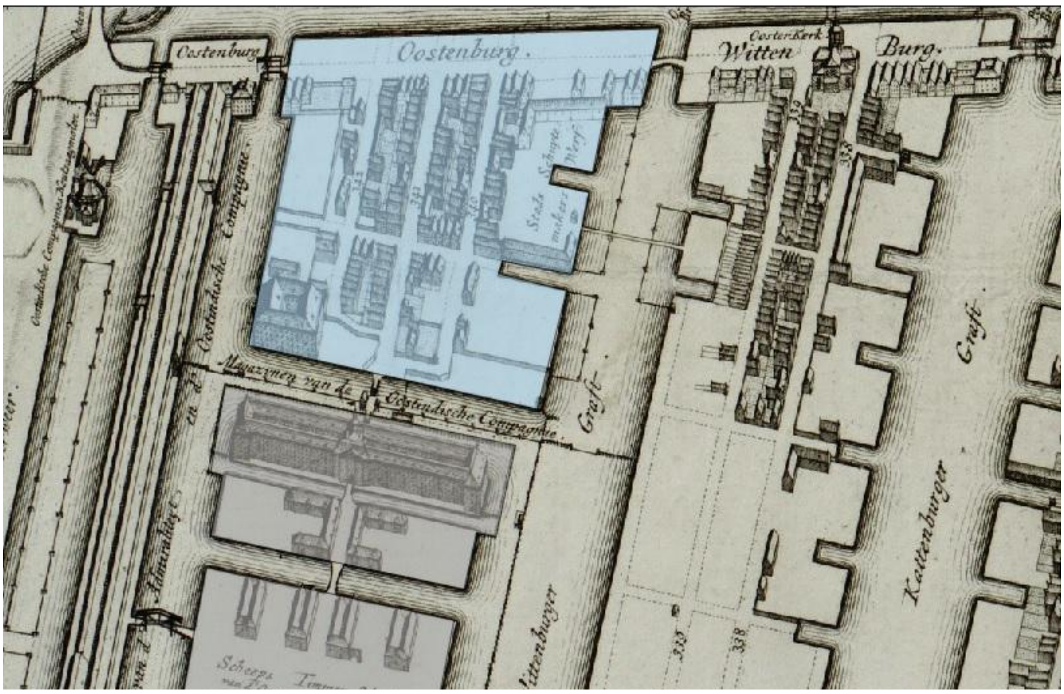


Fig. 6.6: *Oostenburg* with its functions; residence (blue) and industry (black). North is at the bottom (after www.upload.wikipedia.org).

southern part, the VOC wharf and depot on the middle part of the island, and another wharf with accessibility to the IJ on the northern section (fig. 6.6; Gawronski *et al.* 2017, 10). One cistern, nr. 11, is distinctive in this cluster, namely the only industrial cistern on found on the southern, thus residential, part of *Oostenburg*, at *Oostenburgervoorstraat* 29 (fig. 6.7). This large cistern of 4.20 x 2.25 metres, with a floor surface of 9.5 m², belonged to the gatehouse of the *Stadsschuitenmakerswerf*, a wharf where small ships were constructed and repaired. Interestingly, city historian C. Commelin wrote about this wharf in 1693;

"*Dese is gelegen op Oostenburg, daar niet als Vlot-schuyten, Modderschouwenen diergelijk slag gemaakt en herstelt werden. Alle deze boven genoemde StadsArbeyds-luyden; als mede die aan haar Heyen werken, genieten nevens de daghuurenvrydrank,en werden alhier des Zaterdags verscheydezoorten van Stadts Arbeyders betaalt*".

Thus, labourers received free drinks at this wharf in addition to their daily wages (Gawronski *et al.* 2017, 15). This might explain why the gatehouse of the wharf possessed such a large cistern. What drink was served at the *Stadsschuitenmakerswerf* is not specified, although beer and water were the most commonly drunk beverages in the 17th and 18th century. As beer was produced elsewhere in Amsterdam and unlikely to be stored in a cistern, cistern nr. 11 most likely supplied many labourers of drinking water during their breaks at work.

Fig. 6.7: The large cistern at *Oostenburgervoorstraat* 29 (Gawronski *et al.* 2017, 26).

6.2.4 Old centre

Besides these three notable clusters of cisterns at the *Jordaan*, *Valkenburgerstraat* and *Oostenburg*, twenty-nine (n=29) cisterns were found in the old, pre-17th century, centre of Amsterdam (fig. 6.8). This indicates that even though cisterns first came into use in the second half of the 17th century, they were also placed in older parts of the city. Cisterns of most contexts were found here, representing the varied practices that took place here; workshops, shops, churches, an inn at the *Dam*, and sugar industry at the *OudezijdsVoorburgwal* (Gawronski and Veerkamp 2012, 8; Gawronski and Jayasena 2010, 18). Even though these twenty-nine cisterns located in the old city centre are only about 30% of the total dataset, they show these subterranean structures were popular enough to take the effort of installing one beneath an already older superstructure as well, rather than merely beneath the newly constructed buildings from the 17th and 18th centuries.

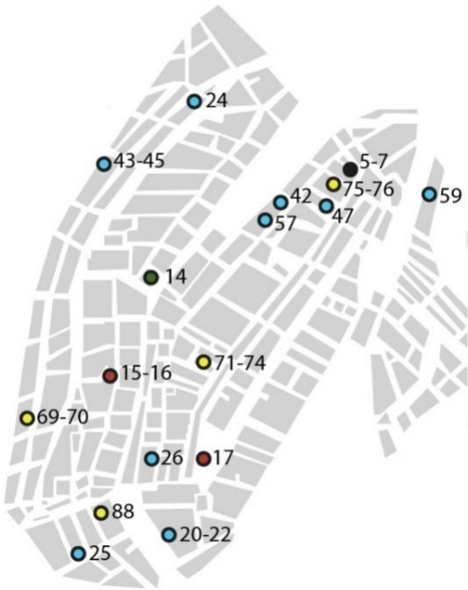


Fig. 6.8: Locations of cisterns in the old city centre.

However, it should be noted that not all superstructures in the old centre beneath which cisterns were constructed were constructed before the 17th century. For example, the cistern beneath the Portuguese Synagogue was newly constructed together with the rest of the building in the 1670s. The same goes for the cisterns of the catholic church at *Kalverstraat* 58, which was built only in 1710 (www.reliwiki.nl). Another example is the massive cistern beneath the inn "*De Bisschop*", which was likely built during rebuilding of its superstructure, somewhere in the 18th century (Gawronski and Veerkamp 2012, 26). Cistern nr. 24, at *Spuistraat* 3a, is located beneath a structure from the second half of the 17th century (www.wikipedia.org). The same goes for the cisterns, 43-45, at *Singel* 97 (www.onderdekeizerskroon.nl). One example of a cistern constructed in the vicinity a much older structure; the *Agnietenkapel* at *OudezijdsVoorburgwal* 229. This chapel was built in the 14th century (Gawronski and Jayasena 2008, 5). However, even in this case the cistern was constructed in association with a brick building from the 17th century, which was placed against the chapel. The cistern thus still belonged to this 17th century structure.

6.3 Conclusion

In this chapter, the results described in chapter 5 above are discussed. In the introduction, a number of aspects are listed on which the main focus lies in research. Whereas differences between each category of context are presented in chapter 5, this chapter provides an explanatory description of the dating, commissioning and location of cisterns.

Gawronski and Veerkamp recognized two generation of cisterns; 17th century cisterns, finished with a layer of tiles on their walls and floor, and 18th century cisterns, finished with *klamplagen*. Only three cisterns could be placed in the 17th century with complete certainty, making them the earliest examples of cisterns in Amsterdam. It can be concluded cisterns only become a common phenomenon in Amsterdam in the 18th century, since the vast majority of cisterns can be dated to this century rather than the 17th.

In addition to indicating the time when cisterns were first introduced in Amsterdam, the initial reasons for their commissioning were looked into. It can be concluded cisterns were used as a possible solution for the drinking water problem that Amsterdam had been struggling with for centuries. Other methods of collecting fresh water, such as wells and barges, had proven less effective as water was easily polluted, or held undesirable expenses. Therefore, cisterns were deemed a more sustainable option. However, even though cisterns seemed to reduce the fresh drinking water problem in the city, they were no perfect solution. First of all, the capacity of most cisterns was most likely not sufficient to sustain a household constantly. Furthermore, cisterns were not resupplied continuously, since they are dependent on rainwater. In addition to these problems, water in cisterns had a high lead-level because of the lead roof gutters and supply pipes, and was easily polluted by filth left in the gutters, making it less suitable for consumption.

With the introduction of a water piping system by the *Duinwater-Maatschappij* in 1853, supplying Amsterdam with fresh water from the dunes, these problems were solved; a constant supply of fresh water could sustain any household, the supply was not dependent on weather conditions, the lead-level in the water was considerably lower since cast-iron pipes were used in this system, and pollution was less since the pipes were closed off. Therefore, cisterns lost their importance in Amsterdam in the second half of the 19th century.

As described in the introduction, an important aspect of this research is the spatial distribution of cisterns in Amsterdam. All cisterns are plotted in the map of 19th century Amsterdam, presenting easily recognisable clusters. For example, almost all cisterns of the residence/workshop context are found in the *Jordaan*, which can be explained by the nature of the neighbourhood; working and residence. The small sizes of cisterns in the residence/workshop context can also be explained by the nature of this neighbourhood; since it was the poorest part of Amsterdam, it is likely the people living here could not afford large cisterns, in contrast to people in the expensive residential parts of the city.

Many cisterns of the residential context are found in the *Valkenburgerstraat* on the island of *Marken*. Since a new residential neighbourhood was constructed here in the second half of the 17th century, it is likely the cisterns are connected to this development, considering the first cisterns were constructed in Amsterdam around this time. The island of *Oostenburg* is characterised by a large number of residential and industrial cisterns, which can be allocated to the VOC and *Stadsschuitenmakerswerf*. A number cisterns are located in the old city centre, pointing to the construction of cisterns not only in association with neighbourhoods and buildings from the late 17th century onwards, but also earlier ones. However, it should be noted many of the superstructures in the old centre have been replaced by new buildings in the course of the centuries, meaning many of the cisterns here are associated with late 17th and 18th century buildings after all.

7 Conclusion

In the introduction the following research question was formulated: “How are varying sizes of cisterns explained by their functional application?”. This question was answered by studying average floor surfaces and maximum capacities of ninety-one cisterns in Amsterdam, subdivided into categories of functional application, or context. These contexts are based on the function of specific superstructures and neighbourhoods cisterns are associated with. A number of subquestions were constructed in order to answer the research question, giving insight to the concept of cisterns, their period and reasons of use, and spatial distribution in Amsterdam. This research question is a valuable addition to the results by Gawronski and Veerkamp, since this topic was not fully explored in their research, and therefore provides interesting new insights into the concept of cisterns.

7.1 Question 1

“What exactly is meant with cisterns; what do they look like, how are they made, and how do they function? In addition, how can cisterns be differentiated from other subterranean structures?”

Cisterns are subterranean brick tanks, built for the storage of rainwater. They can be recognised by their rectangular shape, watertight brick structure, which is mortared with trass, a layer of tiles or *klamplagen* inside, and a barrel vault on top. In addition to these characteristics, cisterns can be recognised by shafts. These chimney-like funnels were constructed on top of each cistern, usually in a corner, to give entry to the chamber. Water was brought into, and pumped out of the chamber by lead supply pipes.

When conducting archaeological fieldwork in Amsterdam, different subterranean structures are faced; cellars, cesspits, wells and cisterns. A number of distinct features separate each structure from the others. Whereas cellars are constructed similarly to cisterns, cellars tend to be much larger. Furthermore, cellars are not constructed with a roof or top, whereas cisterns are closed off with a barrel vault on top. Cesspits in Amsterdam are mostly round or square, which makes them stand out against rectangular cisterns. Furthermore, as cesspits did not have to be watertight, bricks are stacked rather than lain, and no watertight trass mortar is used. Wells are most easily differentiated from cisterns, since these are always round holes in which a number, depending on the well's depth, of hollow barrels are placed. Bricks are only lain on the surface, in order to prevent things from falling down the well.

7.2 Question 2

"When are cisterns first introduced in Amsterdam, and why?"

Dating cisterns is done relatively by looking at certain features. Gawronski and Veerkamp recognised two generation; 17th century cisterns, and 18th-19th century cisterns. These generations are differentiated by the method of interior finishing. 17th century cisterns are recognised by a finishing of glazed tiles on both the floor and walls, whereas 18th/19th century cisterns are recognised by *klamplagen*.

Since no precise dating methods for cisterns are found yet, it has to be concluded cisterns only become a phenomenon in the second half of the 17th century, with only few objects representing this earliest generation. In the 18th century cisterns become more common.

It can be concluded cisterns were commissioned with the intention to reduce or solve the problems around fresh drinking water in Amsterdam. For centuries Amsterdam had been trying to cope with heavy pollution of the canals, from which the water had not been suitable for consumption already in the end of the 15th century. A number of alternative methods of water supply were employed, for example barges and wells. However, these had their disadvantages, such as expenses and groundwater pollution. With the introduction of cisterns, these issues were solved, since collecting rainwater was no costly undertaking, and water in cisterns was of a more stable quality, for the chambers were completely watertight, thus preventing the water from getting polluted by fluids in the groundwater.

7.3 Question 3

"When is the use of cisterns abandoned in Amsterdam, and why?"

In conclusion, it can be said cisterns were abandoned because of the introduction of a more attractive alternative; the water piping system in the second half of the 19th century. It can be assumed the construction of cisterns heavily decreased during this period, and eventually stopped completely.

Cisterns were outcompeted by this water piping system for a number of reasons. First of all, as the content of cisterns was not infinite, it was likely not possible to constantly sustain a household with it. In addition to the problem of sustainability, replenishment of a cistern's content was dependent on the weather, as it was rainwater that was stored here. Besides these problems, pollution played a role. Even though the water was not polluted from external fluids, the lead supply pipes and roof gutters caused a high lead-level in the water, making it less suitable for consumption. Furthermore, filth from roof gutters, such as animal's faeces, could end up inside a cistern, deteriorating the water quality. The introduction of a water piping system in the second half of the 19th century made the construction of cisterns redundant, as all downsides of cisterns were absent in this system; the supply of fresh groundwater from the dunes was infinite, and not dependent on weather conditions. Furthermore, as the supply pipes were not constructed of lead, the water quality was more stable. Finally, supply pipes were closed off, thus preventing filth polluting the water.

7.4 Question 4

"Are there any patterns in the location of cisterns of different contexts? Furthermore, are cisterns only located in post-17th century neighbourhoods, or can they be found in older parts of Amsterdam as well?"

It can be concluded clear patterns between functionality and location exist. Cisterns associated with industry and workshops are mostly found around areas known for their industrial character, such as the VOC wharfs and the *Jordaan*. Furthermore, residential cisterns are found in extensive numbers in newly constructed 17th century, more expensive, neighbourhoods.

Although cisterns are found in the pre-17th century neighbourhoods of Amsterdam, interestingly these are in many case associated with newly built, post-17th century buildings, thus suggesting cisterns were not customarily constructed beneath older buildings.

7.5 Research question

"How are varying sizes of cisterns explained by their functional application?"

It can be concluded a relationship exists between cistern size and functional application. Cisterns associated with industrial areas, religious buildings and estates, and one inn, tend to be larger than those found in the more private contexts of residence and residence/workshops. Interestingly, cisterns of a purely residential context tend to be larger than those of a residence/workshop context. In terms of functional application, this was unanticipated, for it was expected workshops utilise a larger amount of water than residential households, and therefore would need larger cisterns. However, as wealth probably played a role in the sizes of cisterns, the large cisterns of expensive canal houses are explained.

7.6 Limitations

Many conclusions could already be made with the results from this research. However, a number of obstacles have limited the possible results, or their usefulness. First of all, documentation of cisterns in the AAR was often poor, for construction methods and general sizes are often neglected. This was inconvenient for the calculation of average floor surfaces, since it was not possible to calculate these of a large number of objects, thus limiting the results of this research. In addition, no absolute dating methods are used when dating cisterns. Even though this is understandable, as such methods are a costly undertaking, ultimately it has caused less accurate results, and consequently less accurate conclusions. Furthermore, the mixture of terms used to indicate cisterns has lead to confusing situations in which it was unclear what kind of structure was meant. Finally, in many cases it was difficult to assign a specific functional application to a cistern, as it was unclear what original function the connected superstructure had. In those cases, the general function of the linked neighbourhood was assigned to these cisterns. This is, however, not a precise method, and it is likely a number of cisterns actually had a different functional application than the rest of the cisterns found in the same neighbourhood. For example, a neighbourhood predominantly characterised by residence might also contain a workshop.

7.7 Recommendations

In future research, it is deemed necessary to carefully and extensively document cisterns during archaeological excavations, and in archaeological reports, since all research conducted with these reports is heavily dependent on the primary data they provide. Most importantly, cistern sizes should always be documented. In addition to more careful documentation of cisterns, dating methods should be explored. As mentioned above, whereas relative dating methods can be used to some extent, absolute dating methods may provide different, more accurate results. However, it must be noted research on cisterns is an underdeveloped aspect of urban archaeology. Consequently, not much attention was spent on these structures before, making it only logical data is lacking.

Summary

This BA-thesis focuses on cisterns in early modern Amsterdam, building upon the research conducted by Gawronski and Veerkamp in 2007. In their research, a number of topics are treated, such as cistern sizes and capacities. However, little attention is spent to different functional applications of cisterns. Furthermore, spatial dispersion of cisterns in Amsterdam is completely left out. Therefore, in this thesis functional application of cisterns, divided into seven categories of context, and their spatial aspects are focused upon. Data was retrieved from the *Amsterdamse Archeologische Rapporten* (AAR), in which ninety-one cisterns are documented.

This thesis has emerged clear differences and relations between size and capacity, and different categories of context of cisterns. These differences are explained both by functional application of the cistern, as well as wealth of its owner. Spatially, clear clusters of cisterns are recognised in post-17th century neighbourhoods, such as the *Jordaan*, canal belts and the islands of *Marken* and *Oostenburg*. Even in pre-17th century neighbourhoods, many cisterns are located in association to newly built 17th-18th century structures. In order to make more detailed conclusions about the use and dating of cisterns, more extensive documentation, and new dating methods are needed.

Samenvatting

Deze BA-scriptie focust op waterkelders in vroegmodern Amsterdam, voortbouwend op het onderzoek door Gawronski en Veerkamp in 2007. Meerdere onderwerpen zijn behandeld in dit onderzoek, waaronder de groottes van waterkelders, en hun inhoud. Weinig aandacht is besteed aan verschillende functionele applicatie van de waterkelder. Verder is de ruimtelijke verspreiding van waterkelders in Amsterdam volledig onbehandeld gelaten. Hierom staan in deze scriptie de functionele applicatie, opgedeeld in zeven verschillende contextuele categorieën, en ruimtelijke aspecten van waterkelders centraal. De data voor dit onderzoek komt uit de Amsterdamse Archeologische Rapporten (AAR), waarin eenennegentig waterkelders zijn gedocumenteerd.

Deze scriptie heeft duidelijke verschillen en verbanden tussen de groottes en inhoud van waterkelders, en hun contextuele categorie weergegeven. Deze verschillen zijn te verklaren door de functionele applicatie van de waterkelder, evenals de welstand van de eigenaar. In ruimtelijk opzicht zijn duidelijke clusters van waterkelders te herkennen in post-17^{e}-eeuwse wijken, zoals de Jordaan, de grachtengordel en de eilanden Marken en Oostenburg. Ook in wijken van voor de 17^{e} eeuw zijn clusters van waterkelders te vinden, al zijn deze vaak in verband te brengen met nieuwe, post-17^{e}- en 18^{e}-eeuwse gebouwen. Gedetailleerdere documentatie van waterkelders, en specifiekere dateringsmethoden zijn nodig om betere, meer gecompliceerde conclusies te trekken in toekomstig onderzoek.

Bibliography

Abrahamse, J.E., 2010. *De grote uitleg van Amsterdam : stadsontwikkeling in de zeventiende eeuw*. Universiteit van Amsterdam.

De Gans, W., 2015. The geology of the Amstel river in Amsterdam (Netherlands): Man versus nature. *Netherlands Journal of Geosciences – Geologie en Mijnbouw* 94(4), 361-373.https://doi.org/10.1017/njg.2014.41

De Roon, D., 2007. Gedragen door water: Drijvende kelders in Amsterdam en omstreken. *Bulletin KNOB 4(5),* 162-178.

Gawronski, J., 2008. Amsterdam. *The Archaeological Journal*165(1), 44-60.https://doi.org/10.1080/00665983.2008.11771017

Gawronski, J. and J. Veerkamp, 2007. Water uit de kelder: De verdwenen waterkelders van Amsterdam in V. van Rossem, G. van Tussenbroek and J. Veerkamp (eds), *Monumenten & Archeologie 6*. Amsterdam: Uitgeverij Bas Lubberhuizen, 59-69.

Groen, J.A., 1979. Een *cent per emmer: het Amsterdamse drinkwater door de eeuwen heen*. Amsterdam: Gemeentewaterleidingen.

Rutte, R. and J.E. Abrahamse 2016. *Atlas of the Dutch Urban Landscape: A Millennium of Spatial Development*. Bussum: Uitgeverij Thot.

Van Oosten, R.M.R., 2014. The 'Great Sanitary Awakening' Questioned:Is There a Solid Argument in Favour of the'Filthy Medieval City' Hypothesis?.*Medieval and Modern Matters* 5, 95-116.https://doi.org/10.1484/J.MMM.5.109848

Van Oosten, R.M.R., 2015. *De Stad het Vuil en de Beerput: de opkomst, verbreiding en neergang van de beerput in stedelijke context*. Leiden: Sidestone Press.

Van Oosten, R.M.R., 2017. Cesspits and the P-P-P-P-problem: The pitfall of the Pompeii premiseand the palimpsest. *Quaternary International* 460, 22-29.https://doi.org/10.1016/j.quaint.2016.08.020

Amsterdamse Archeologische Rapporten (AAR)

Gawronski, J., R. Jayasena and J. Veerkamp, 2006. Wonen aan een wagenplein: Archeologische Opgraving (AO) Haarlemmerplein Amsterdam. *Amsterdamse Archeologische Rapporten (AAR) 1*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J., R. Jayasena, 2006. Tweede Kostverlorenkade: Inventariserend veldonderzoek (IVO). *Amsterdamse Archeologische Rapporten (AAR) 2*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J., R. Jayasena, J. Veerkamp, 2007. Beerputten en bedrijvigheid: archeologische opgraving Konijnenstraat (2003). *Amsterdamse Archeologische Rapporten (AAR) 6*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J. and J. Veerkamp, 2007. Archeologische verkenning: Vijzelstraat (2004). *Amsterdamse Archeologische Rapporten (AAR) 14*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J., R. Jayasena and J. Veerkamp, 2008. Schuilkerk de Papegaai: Archeologische opgraving Kalverstraat (2004). *Amsterdamse Archeologische Rapporten (AAR) 16*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J., R. Jayasena, 2008. Het Purperhoedenveen: Archeologische opgraving Oudezijds Voorburgwal (2004). *Amsterdamse Archeologische Rapporten (AAR) 22*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J., and J. Veerkamp, 2008. Oranjerie in Frankendael: Archeologische opgraving Middenweg (2003). *Amsterdamse Archeologische Rapporten (AAR) 27*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J., R. Jayasena and J. Veerkamp, 2010. Van Amstelbocht tot Binnengasthuis: Archeologische opgraving Oude Turfmarkt, Amsterdam (2005). *Amsterdamse Archeologische Rapporten (AAR) 31*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J. and J. Veerkamp, 2009. Rust en Werk: Archeologische Begeleiding Amsteldijk 67 (2009). *Amsterdamse Archeologische Rapporten (AAR) 39*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J. and R. Jayasena, 2010. Zeis onder het maaiveld: Archeologische begeleiding Kolenkit Zuidelijk Veld Fase 1 (2009). *Amsterdamse Archeologische Rapporten (AAR) 42*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J. and J. Veerkamp, 2010. Spuistraat: Archeologische opgraving Spuistraat 256-258,Amsterdam-Centrum (2008). *Amsterdamse Archeologische Rapporten (AAR) 47*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J. and R. Jayasena, 2010. Sporen in de Suikerbakkerssteeg: Archeologische OpgravingOudezijds Voorburgwal / Suikerbakkerssteeg, Amsterdam (2007). *Amsterdamse Archeologische Rapporten (AAR) 48*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J. and R. Jayasena, 2010. Bewoning tussen Nes en stadswal: Archeologische opgraving Oudezijds Voorburgwal / Pieter Jacobszstraat, Amsterdam (2005). *Amsterdamse Archeologische Rapporten (AAR) 49*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J. and R. Jayasena, 2011. Van buitenpolder tot Uilenburg: Archeologische opgraving Oudeschans 5-11, Amsterdam (2008). *Amsterdamse Archeologische Rapporten (AAR) 59*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J. and R. Jayasena, 2011. Wonen achter de Oudezijds Voorburgwal: Archeologische opgraving Oudezijds Armsteeg, Amsterdam (2008). *Amsterdamse*

Archeologische Rapporten (AAR) 60. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J. and J. Veerkamp, 2011. Cluster Schievink: Archeologische Opgraving, Rozenstraat 68-76, Rozengracht 69-75, Amsterdam (2009). *Amsterdamse Archeologische Rapporten (AAR) 61*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J. and J. Veerkamp, 2012. Op ’t Water gewonnen: Archeologische Begeleiding Dam 2-4 (2009). *Amsterdamse Archeologische Rapporten (AAR) 65*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J. and R. Jayasena 2012. De waterkelder van de Portugese Synagoge: Archeologische Begeleiding Mr. Visserplein 3, Amsterdam (2010). *Amsterdamse Archeologische Rapporten (AAR) 66*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J., R. Jayasena, J. Veerkamp, 2012. ‘Ons Genoegen’: Archeologische Opgraving Elandsstraat 101, Amsterdam (2010). *Amsterdamse Archeologische Rapporten (AAR) 67*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J., R. Jayasena, 2013. Sporen van het 16^{e}-eeuwse landelijke gebied buiten het Singel: Archeologische Begeleiding Herengracht 74-78, Amsterdam (2010). *Amsterdamse Archeologische Rapporten (AAR) 70*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J., and J. Veerkamp, 2013. Tussen Nieuwezijds Voor- en Achterburgwal: Archeologische Begeleiding Spuistraat 3A / Nieuwezijds Voorburgwal 16, Amsterdam 2011. *Amsterdamse Archeologische Rapporten (AAR) 73*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J., R. Tousain and J. Veerkamp, 2013. Heiligeweg 32: Archeologische Begeleiding Heiligeweg 32, Amsterdam (2012). *Amsterdamse Archeologische Rapporten (AAR) 75*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J. and J. Veerkamp, 2015. Kerkhof Sint Mariaklooster: Inventariserend Veldonderzoek Nes 116, Amsterdam (2012). *Amsterdamse Archeologische Rapporten (AAR) 83*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J., and J. Veerkamp, 2016. BloemDwars: Archeologische Begeleiding binnenterrein Bloemgracht 143/Bloemstraat 150-154, Amsterdam (2015). *Amsterdamse Archeologische Rapporten (AAR) 86*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J., and R. Jayasena, 2016. Het eiland marken in Amsterdam: veranderingen in de stad 1592-1930; Archeologische Opgraving Valkenburgerstraat 130-146, Amsterdam (2011-2012). *Amsterdamse Archeologische Rapporten (AAR) 90*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J., R. Jayasena and J. Veerkamp, 2017. De stad in profiel: Archeologische Begeleidingen in het centrum van Amsterdam (2011-2016).*Amsterdamse Archeologische Rapporten (AAR) 94*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J. and T. Terhorst, 2017. Werken langs de Weespertrekvaart: Archeologische Begeleiding H.J.E. Wenckebachweg Amsterdam (2015). *Amsterdamse Archeologische Rapporten (AAR) 97*. Monumenten & Archeologie, gemeente Amsterdam.

Gawronski, J., R. Jayasena and T. Terhorst, 2017. Oostenburg: woningen en stadsschuitenmakerswerf (1660-1900); Archeologische Opgraving Oostenburgervoorstraat (Wiener & Co), Amsterdam (2013 en 2014). *Amsterdamse Archeologische Rapporten (AAR) 99*. Monumenten & Archeologie, gemeente Amsterdam.

Internet links

Schoonenberg, W., 2018. Singel 97, De Olyphant. Digitaal Grachtenboek, database van de Amsterdamse grachtengordel. https://www.onderdekeizerskroon.nl/database/grachtenboek_objecten.php?id=678, accessed on 17/04/2019, 14/05/2019.

https://upload.wikimedia.org/wikipedia/commons/1/1d/Gerrit_de_Broen_-_Amsterdam_%281737%29.jpg, accessed on 03/05/2019.

Meertens Instituut. De oude Nederlandse maten en gewichten. http://www.meertens.knaw.nl/mgw/plaats/44, accessed on 08/05/2019.

Reliwiki, 2018. Amsterdam, Kalverstraat 58 - Petrus en Paulus https://www.reliwiki.nl/index.php/Amsterdam,_Kalverstraat_58_-_Petrus_en_Paulus, accessed on 13/05/2019.

Wikipedia, 2019. Lijst van rijksmonumenten in de Spuistraat (Amsterdam). https://nl.wikipedia.org/wiki/Lijst_van_rijksmonumenten_in_de_Spuistraat_(Amsterdam), accessed on 14/05/2019.

List of figures

List of tables

Appendix 1

Number	Topo-code	Location	Length	Width	Height	Compartments
1	FKD1	Park Frankendael, Middenweg 72	2.60	1.90		1
2	FKD1	Park Frankendael, Middenweg 72	0.50	0.50		1
3	AMD2	Amsteldijk 67	2.60	4.00	1.60	1
4	TKK	Tweede Kostverlorenkade	3.00	2.30	2.35	2
5	OZV8	Oudezijds Voorburgwal 28	2.75	2.50		1
6	OZV8	Oudezijds Voorburgwal 28	3.90	1.64	2.00	1
7	OZV8	Oudezijds Voorburgwal 28	1.40	1.40		1
8	OS4	Oudeschans 7	2.15	1.35		1
9	ELS	Elandstraat 103/105	3.5	1.00		2
10	WTV	H.J.E. Wenckebachweg	2.82	1.06		1
11	OBV	Oostenburgervoorstraat 29	4.20	2.25		3
12	OBM	Oostenburgermiddenstraat 22	1.60	1.50	1.70	1
13	OBM	Oostenburgermiddenstraat 24	1.85	1.40	1.70	1
14	DAM4	Dam 2	4.00	4.00		1
15	KA8	Kalverstraat 58	1.16	1.55		1
16	KA8	Kalverstraat 58	3.20	1.40		1
17	OZV6	Oudezijds Voorburgwal 229	≈1.60	≈ 1.60		1
18	VIS1	Mr. Visserplein 3	3.10	2.82	2.50	2
19	VIJZ1	Vijzelstraat 127	1.20	1.20	1.10	1
20	OTM	Oude Turfmarkt 135-139	1.00	1.90		1
21	OTM	Oude Turfmarkt 135-139				1
22	OTM	Oude Turfmarkt 135-139				1
23	HE10	Herengracht 78				1
24	SP7	Spuistraat 3A		1.90	2.40	

Architectural attributes	Other	AAR	Context	Date	Spoorn	M2
thin pinewood floor		27	Estate	1725-1750	S6	10,4
	7 m from porter's lodge	27	Estate	1700-1800	S8	4,94
low barrel vault, collapsed		39	Estate	1620-1800	S5	0,25
two shafts (0.70 x 0.70 m)		2	Industry	1700-1800	S2	6.88
two shafts		48	Industry	1650-1850	S17	6.9
barrel vault		48	Industry	1650-1850	S18	9.45
square cistern		48	Industry	1650-1850	S2	6.40
stretcher bond, tile inside walls		59	Industry	1700-1900	S14	1.96
division wall between 103 and 105, central dubble shaft		67	Industry	1700-1800	S151	2.90
barrel vault	contained finds	97	Industry	1800-1850	S7	2.99
each compartment divided in two parts	associated with gatehouse	99	Industry	1700-1800	S65	3.5
			Industry			2.40
			Industry			2.59
	minimum dimensions: poss	65	Inn	1700-1800	S85	16
		16	Religious	1700-1900	S10	8.74
one shaft	two lead pipes	16	Religious	1700-1900	S8	1.8
stretcher bond, glazed tiles		22	Religious	1700-1800	S8	4.48
barrel vault, one shaft (0.48 x 0.48 m), glazed tiles	lead pipes found 5 cm	66	Religious	1674	S1	2.56
glazed tiles		14	Residence	1650-1800	S3	7.5
		31	Residence	1700-1800	S35	5.29
stretcher bond, tile inside walls		31	Residence	1700-1800	S57	2.48
stretcher bond, tile inside walls		31	Residence	1700-1800	S57	3.9
klamplaag		70	Residence	1700-1800	S14	1.90
klamplaag	partly destroyed	73	Residence	1700-1800	S17	

25	HEI1	Heiligeweg 32	2.84	1.28	1.90	1
26	NES12	Nes 116	3.30	1.40		1
27	VAL4	Valkenburgstraat 134				1
28	VAL4	Valkenburgstraat 134				1
29	VAL4	Valkenburgstraat 134				1
30	VAL4	Valkenburgstraat 132-146				1
31	VAL4	Valkenburgstraat 146	1.44	1.14		1
32	VAL4	Valkenburgstraat 132	1.62	1.06		1
33	VAL4	Valkenburgstraat 132				1
34	VAL4	Valkenburgstraat 134				1
35	VAL4	Valkenburgstraat 132				1
36	VAL4	Valkenburgstraat 146				1
37	VAL4	Valkenburgstraat 146				1
38	VAL4	Valkenburgstraat 146				1
39	VAL4	Valkenburgstraat 134				1
40	VAL4	Valkenburgstraat 136	1.56	0.68		1
41	VAL4	Valkenburgstraat 146				1
42	WA64	Warmoesstraat 64	2.05	1.90		1
43	SIN21	Singel 97	2.30	2.30		1
44	SIN21	Singel 97	2.50	3.00		1
45	SIN21	Singel 97	1.10	2.25		1
46	KRD	Korte Reguliersdwarsstraat 4				1
47	RO22	Lange Niezel 29	2.18	1.80		1
48	OBV	Oostenburgervoorstraat 19	1.50	1.20		1
49	OBV	Oostenburgervoorstraat 17	1.50	1.25		1
50	OBV	Oostenburgervoorstraat 35				1

barrel vault, one shaft (0.66 x 0.56 m), tile floor	lead pipe found 7 cm	75	Residence	1700-1800	S1	3.9
barrel vault, klamplaag		83	Residence	1700-1800	S2	3.84
	contained ceramics	90	Residence	1750-1850	S105	4.62
		90	Residence	1700-1800	S105	3.6
barrel vault		90	Residence	1700-1800	S113	1.88
one shaft, stretcher bond		90	Residence	1700-1800	S137	1.8
tiled walls	contained ceramics	90	Residence	1700-1800	S169	1.44
	contained ceramics	90	Residence	1800-1900	S17	1.64
	contained ceramics	90	Residence	1750-1825	S187	1.72
	contained ceramics	90	Residence	1800-1900	S267	1.06
		90	Residence	1700-1800	S268	
		90	Residence	1700-1800	S290	
		90	Residence	1700-1800	S295	
		90	Residence	1700-1800	S298	
	contained ceramics	90	Residence	1800-1900	S32	
	contained ceramics	90	Residence	1800-1900	S45	
		90	Residence	1700-1800	S48	
		94	Residence	1700-1800	S18	
klamplaag		94	Residence	1700-1800	S2	
klamplaag		94	Residence	1700-1800	S3	
tiled walls		94	Residence	1600-1700	S4	
stretcher bond, klamplaag		94	Residence	1700-1800	S7	
red tile walls		94	Residence	1650-1800	S9	
stretcher bond		99	Residence	1700-1800	S108	
stretcher bond		99	Residence	1700-1800	S110	
		99	Residence	1700-1800	S13	

51	OBV	Oostenburgervoorstraat 13-15	2.40	1.60		2
52	OBV	Oostenburgervoorstraat 35				1
53	OBV	Oostenburgervoorstraat 25				1
54	OBV	Oostenburgervoorstraat 33				1
55	OBV	Oostenburgervoorstraat 33				1
56	OBV	Oostenburgervoorstraat				1
57	WA18	Warmoesstraat 85	2.15	1.40	1.40	1
58	PA1	Paardenstraat 2	1.9	1.1	1.5	1
59	GEL1	Geldersekade 65	2.40	1.60	1.90	1
60	KG33	Keizersgracht 248	3.60	1.40	2.00	1
61	NKG2	Nieuwe Keizersgracht 92	4.20	2.90	2.50	2
62	HAP1	Haarlemmerplein 14	1.80	0.78		2
63	KON	Konijnenstraat 19	3.00	1.20		2
64	KON	Konijnenstraat 13	1.22	1.00		1
65	KON	Konijnenstraat 7	1.15	0.55		1
66	KON	Konijnenstraat 5	1.60	1.08		1
67	KON	Konijnenstraat 11	1.60	1.10		1
68	KON	Konijnenstraat 17	1.80	0.90	1.20	1
69	SP3	Spuistraat 256-258	1.35	1.95		1
70	SP3	Spuistraat 256-258	2.25			1
71	OZV7	Pieter Jacobszstraat 42				1
72	OZV7	Pieter Jacobszstraat 40				1
73	OZV7	Pieter Jacobszstraat 42	2.85	2.00	2.59	2
74	OZV7	Pieter Jacobszstraat 36				1
75	ARM	Oudezijds Armsteeg 16	2.30	1.80		1

each compartment 1.2 x 0.8 m		99	Residence	1725-1800	S136	
		99	Residence	1700-1800	S15	
		99	Residence	1710-1750	S151	
	contained ceramics	99	Residence	1710-1750	S33	
tiled walls		99	Residence	1700-1800	S35	
stretcher bond		99	Residence	1710-1750	S99	
			Residence			2.09
			Residence			3.84
			Residence			3.01
			Residence			5.04
			Residence			12.18
	Used as a cesspit	1	Residence, workshops		S29	5.7
two shafts		6	Residence, workshops	1700-1800	S1	5.0
		6	Residence, workshops	1600-1800	S24	2.63
one shaft (0.36 x 0.40 m), stretcher bond		6	Residence, workshops	1700-1800	S33	4.14
one shaft (0.54 x 0.54 m)		6	Residence, workshops	1700-1800	S40	2.7
one shaft (0.40 x 0.40 m), stretcher bond		6	Residence, workshops	1700-1800	S52	2.7
one shaft (0.55 x 0.53 m)		6	Residence, workshops	1700-1800	S7	3.60
stretcher bond, klamplaag, tile floor		47	Residence, workshops	1700-1800	S2	2.52
stretcher bond, klamplaag		47	Residence, workshops	1700-1800	S5	3.68
stretcher bond, tiled floor		49	Residence, workshops	1700-1800	S169	1.76
stretcher bond		49	Residence, workshops	1700-1800	S3	1.73
two shafts, barrel vault	lead pipe	49	Residence, workshops	1700-1800	S38	1.65
stretcher bond		49	Residence, workshops	1675-1800	S4	1.60
stretcher bond, glazed tiles		60	Residence, workshops	1700-1900	S13	1.50

76	ARM	Oudezijds Armsteeg 12	3.20	1.15		2
77	RO22	Rozenstraat 74	1.60	1.00		1
78	RO22	Rozenstraat 72	1.40	1.00		1
79	RO22	Rozenstraat 72	1.50	1.00		1
80	RO22	Eerste Rozendwarsstraat 7	1.70	0.64		1
81	RO22	Rozenstraat 72	1.60	0.90		1
82	ELS	Elandsstraat 109				1
83	ELS	Elandsstraat 105	1.67	0.86		1
84	ELS	Elandstraat 107				
85	BL8	Bloemstraat 150	2.10	1.20		1
86	BL8	Bloemstraat 154	1.70	0.70		1
87	BL8	Bloemstraat 154	1.65	1.00		1
88	KA10	Kalverstraat 147	2.50	2.00	1.70	2
89	NO2	Noorderstraat 14	2.00	1.35		1
90	NO2	Noorderstraat 10	2.00	1.35		1
91	LDW	Leeuwendalersweg	3.00	1.75		1

red tile walls		60	Residence, workshops	1700-1897	S50	1.40
		61	Residence, workshops	1700-1800	S105	1.22
one shaft (0.36 x 0.41 m)		61	Residence, workshops	1700-1800	S111	1.62
stretcher bond, klamplaag		61	Residence, workshops	1700-1800	S131	1.44
		61	Residence, workshops	1700-1800	S40	1.44
stretcher bond, glazed tile floor		61	Residence, workshops	1650-1900	S95	1.4
	later used as latrine	67	Residence, workshops	1700-1800	S12	1.19
stretcher bond, tiles		67	Residence, workshops	1700-1800	S22	1.08
shaft only (0.38 x 0.38 m)		67	Residence, workshops	1700-1800	S28	0.63
klamplaag		86	Residence, workshops	1700-1800	S10	
barrel vault, one shaft		86	Residence, workshops	1700-1800	S24	
tiled walls		86	Residence, workshops	1650-1800	S25	
klamplaag		94	Residence, workshops	1700-1800	S18	
barrel vault		94	Residence, workshops	1700-1800	S4	
barrel vault, one shaft		94	Residence, workshops	1700-1800	S6	
one shaft		42	Rural	1700-1800	S4	5.25

Appendix 2

spoor	topo	beschrijving	interpretatie	AAR	dateringAAR
29	HAP1	waterkelder ten noorden van S 17, bevat beervulling	waterkelder	1	
34	HAP1	waterkelder, ten oosten van S 35, ten noorden van S 31	waterkelder	1	
1	KON	gemetselde bak, 300 x 120 cm, 2 compartimenten, dubbele vierkante tapmonding	waterkelder 1	6	
7	KON	gemetselde bak, 180 x 90 cm, koepel op 0.51 m ÷, vierkante tapmonding van 55 x 53 cm, funderingsvloer grenenhout 2 cm dik	waterkelder 2	6	
24	KON	gemetselde vloer (120 x 100 cm) met opstaande rand van een baksteen hoog	waterkelder 3	6	
33	KON	gemetselde bak van 115 x 55 cm, ½ steens, opening van 36 x 40 cm aan de zw-zijde. Onderzijde uit bruine steentjes, koepel uit gele steentjes	waterkelder 5	6	
37	KON	ronde put (ø 180 cm), in latere fase afgedekt met hout en voorzien van dubbele gemetselde tapmonding, putrand van oranje baksteen 18½/19 x 4 cm	waterkelder 6	6	
40	KON	gemetselde bak van 160 x 108 cm, met een koepel, met aan zw-zijde een vierkant tapgat van 54 x 54 cm.	waterkelder 7	6	
52	KON	gemetselde bak 160 x 110 cm, ½-steens wanden uit gele ijsselsteentjes, tapmonding aan NO-zijde, koepel ontbreekt	waterkelder 4	6	
13	JDM	waterkelder	waterkelder perceel 4	8	
14	JDM	waterkelder	waterkelder perceel 4	8	
3	VIJZ1	gemetselde bak van 120 x 120 cm van baksteen 21 x 21 x 3 cm, bekleed met plavuizen. Bevat S 4	waterkelder	14	1650-1800
8	KA8	gemetselde bak van 320 x 140 cm,afgesloten met een tongewelf, een vierkane opening in het noorden.	waterkelder 2	16	1700-1800
10	KA8	gemetseld grondvlak van 116 x 155 cm met een lage opstaande rand	waterkelder 3, Kalverstraat 58	16	1700-1800

8	OZV6	muurwerk 1,5 steens, paarse klinkers 18,5x8,5x3,5, onder sp. 3, ingebed in sp. 4. Binnenzijde bekleed met geglazuurde plavuizen	waterkelder	22	
6	FKD1	gemetselde bak (1.90 x 2.60 m) van harde klinkers (21,5/22 x 10/10,5 x 4 cm) op een dunne grenenhouten vloer	waterkelder 1	27	1725-1750
8	FKD1	gemetselde vierkante opening (50 x 50 cm) onder het maaiveld op 7.00 m achter de portierswoning	waterkelder 2	27	
35	OTM	tras gemetselde vierkante bak, ca 100 x 190cm.	waterkelder, fase C	31	1700-1800
57	OTM	halfsteens metselwerk aan de binnenzijde bekleed met plavuizen	waterkelder, fase C	31	1700-1800
58	OTM	halfsteens metselwerk aan de binnenzijde bekleed met plavuizen	waterkelder, fase C	31	1700-1800
5	AMD2	gemetselde bak van bruine geel geaderde klinkers, diepte 160 cm, met licht gebogen gewelf, binnen S 4	waterkelder 'Rust en Werk'	39	1600-1700
4	LDW	waterkelder, inlaat in zuidwesthoek	waterkelder	42	1700-1800
28	NJ	waterkelder ten Z van S 27, koepel aangesmeerd met gr klei, wp 1 vlak 3	waterkelder	44	
2	SP3	gemetselde bak, half- steens muurwerk van bruinpaarse klinkers met gele aders (19 x 9 x 3,5 cm), binnenzijde een klamplaag van zelfde baksteen, opp 135 x 195 cm, vloer van plavuizen	waterkelder 1	47	1700-1800
5	SP3	gemetselde bak, half-steens muurwerk van bruinpaarse klinkers met gele aders (18,5 x 9 x 4 cm), binnenzijde een klamplaag van zelfde baksteen, lengte 225 cm, doorsneden door damwand	waterkelder 2	47	1700-1800
2	OZV8	vierkante bak, halfsteens metselwerk, baksteen 17,5 x 8,5 x 3,5/4 cm, binnenzijde met cement aangesmeerd	waterkelder	48	1650-1850
17	OZV8	kelder met ingestorte koepel en twee inlaten, bruine baksteen 18 x 8 x 4 cm, vulling zand,puin, sintels en klei	waterkelder	48	1650-1850
18	OZV8	gemetselde bak met koepel gewelf, 164 x 360 cm. Beksteen is burin 17,5 x 8 x 3,5 cm	waterkelder	48	1650-1850
3	OZV7	halfsteensmuur, parallel aan muur S 1, gele klinkers 17 x 8,5 x 3,5 cm	waterkelder 1, Pieter Jacobszstraat 40	49	

4	OZV7	halfsteensmuur, binnenzijde bekleed met plavuizen, verticala planken tegen buitenzijde	waterkelder 2, Pieter Jacobszstraat 38	49	1675-1800
16	OZV7	rechthoekig gemetselde bak met plavuizenvloer, halfsteens metselwerk, ingegraven in ophoging S 5	waterkelder 3, perceel 4	49	1700-1800
38	OZV7	rechthoekig gemetselde bak, afgesloten door een tongewelf, toegang aan bovenzijde	waterkelder 4, Pieter Jacobszstraat 42	49	1675-1800
14	OS4	rechthoekige bak, plavuizen tegen binnenwand, kleimantel buitenzijde	waterkelder	59	1675-1800
40	RO22	halfsteens gemetselde bak	waterkelder 1	61	1730-1800
95	RO22	kelder bekleed met plavuizen op vloer 21,5 x 21,5 en aan wand 14,5 x 14,5 cm, bevat RO22-53	waterkelder 2 Rozenstraat 72	61	1675-1692
105	RO22	waterkelder, rechthoekige bak van oranje baksteen, achter gebouw S 101 (Rozenstraat 74)	waterkelder 3 Rozenstraat 74	61	1700-1800
111	RO22	waterkelder achter muur S 60, perceel Rozenstraat 72, rechthoekige bak met koepel en inlaat van 60 x 63 cm (buiten, 36 x 41 cm binnen), rode plavuizen aan binnenkant, kleine dichtgezette inlaat van 32 x 32 cm (buiten, 13 x 13 cm binnen)	waterkelder 4 Rozenstraat 72	61	1700-1800
131	RO22	waterkelder, hardgebakken paarse baksteen (18 x 8,5 x 3,5 cm)	waterkelder 5 Rozenstraat 72	61	1700-1800
85	DAM4	baksteenvloer van min. 4 x 4 m in NO-hoek bouwput, aan zuidzijde nog opgaandwerk met aan binnenzijde klamplaag van bruine klinkers	waterkelder	65	1700-1800
1	VIS1	waterkelder	waterkelder	66	1674
12	ELS	halfsteens, gele ijsselsteen (18,5 x 9 x 3 cm) met tras gemetselde bak, baksteenklamplaag, aangesmeerd aan binnenzijde, tegen S 10, ten N van S 11, opgevuld met vondstloze beer, buitenzijde omgeven door grijze klei	waterkelder 1, secundair BP 4	67	1600-1700
22	ELS	halfsteens gemetselde bak (167 x 86 cm) van ijsselsteentjes, binnenzijde klamplaag van plavuizen	waterkelder Elandsstraat 105 / WK 2	67	1650-1700
28	ELS	mond WK 3, roodbruine klinkers met tras afgesmeerd, binnenmaat 38 x 38 cm, ten Z van S 18, met dunne laag grijze putklei aan buitenzijde	waterkelder Elandsstraat 107 / WK 3	67	1650-1750
151	ELS	langgerekte gemetselde bak (3,5 x 1 m) met centraal een dubbele aaneengesloten opening	waterkelder	67	1650-1700

14	HE10	waterkelder, eensteenswand met klamplaag	waterkelder Herengracht 78	70	1700-1800
17	SP7	bakstenen reservoir met aan de binnenzijde een klamplaag van baksteen, opening tussen 12,7 en 13,2 m	waterkelder	73	1700-1800
1	HEI1	rechthoekige constructie van 1,28 x 2,84 m; diep 1,90 m, overkluisd tongewelf, gemetseld van klinkers, plavuizenvloer	waterkelder	75	1625-1700
2	NES12	gemetselde bak van 3,3, x 1,4 m, anderhalfsteens wand inclusief klamplaag aan binnenzijde, gewelf halfsteens, paarse klinkers, geel geaderd	waterkelder	83	1700-1800
10	BL8	gemetselde bak 2,1 x 1,2 m, halfsteens met klamplaag aan binnenzijde, bs paarsbruin, 17 x 8/9 x 4 cm	waterkelder 1	86	1700-1925
24	BL8	gewelfrestant en mangat	waterkelder 3	86	1700-1925
25	BL8	gemetselde bak 1 x 1,65 m uit gele baksteen 17 x 8 x 4 cm, met plavuizen aan binnenzijde	waterkelder 2	86	1650-1925
17	VAL4	waterkelder; perceel II; halfsteensmuren, tras gemetseld, bekleding van op zijkant gezette bs; bevat berige vulling S18; ge bs 18x8,2x4cm	waterkelder	90	1700-1800
17	VAL4	waterkelder; perceel II; halfsteensmuren, tras gemetseld, bekleding van op zijkant gezette bs; bevat berige vulling S18; ge bs 18x8,2x4cm	waterkelder	90	
32	VAL4	waterkelder; ge klinker 19x7,5x4cm; tegen S11 (perceel III)	waterkelder	90	1700-1800
45	VAL4	waterkelder; perceel IV; ligt achter achtergevel; paarse klinker 17,5x8x4cm	waterkelder	90	
45	VAL4	waterkelder; perceel IV; ligt achter achtergevel; paarse klinker 17,5x8x4cm	waterkelder	90	1700-1800
48	VAL4	waterkelder; perceel IV; ge bs 17,5x8x4cm	waterkelder	90	1700-1800
105	VAL4	waterkelder; tegen zw-hoek van muur S104	waterkelder	90	1700-1800
113	VAL4	rechthoekig eensteens waterkeldertje in zo-hoek S106; ten westen van stookplaat S81, met baksteen nog op vulling in n-helft: ingestorte koepel waterkeldertje; vulling geel zandig puin met vondsten en zoologisch materiaal	waterkelder	90	1700-1800

137	VAL4	gemetselde koker, halfsteens; inlaat waterkelder; gelijktijdig met S132	waterkelder	90	1700-1800
169	VAL4	waterkelder; bevat S170; aan buiten (west)kant bevat loden plaat met stop in de bodem (zie foto); ass. S137	waterkelder	90	
169	VAL4	waterkelder; bevat S170; aan buiten (west)kant bevat loden plaat met stop in de bodem (zie foto); ass. S137	waterkelder	90	1700-1800
187	VAL4	waterkelder	waterkelder	90	
187	VAL4	waterkelder	waterkelder	90	1700-1800
267	VAL4	waterkelder	waterkelder	90	1700-1800
268	VAL4	waterkelder, gevuld met puin	waterkelder	90	1700-1800
290	VAL4	waterkelder	waterkelder	90	1700-1800
295	VAL4	waterkelder	waterkelder	90	1700-1800
298	VAL4	waterkelder	waterkelder	90	1700-1800
7	KRD	uit gele ijsselsteen gemetselde bak in S 6	waterkelder	94	1700-1800
4	NO2	rechthoekige bak, tras gemetseld, 2 x 1,35 m	waterkelder	94	1675-1800
6	NO2	rechthoekige bak, tras gemetseld, 2 x 1,35 m	waterkelder	94	1675-1800
7	WTV	Waterkelder (2,82 x 1,06), tras gemetseld, tongewelf van op hun kant gemetselde rode bakstenen (22 x 10 x 3,5 cm), bekleed met bakstenen op hun plat	Waterkelder	97	1775-1825
7	WTV	Waterkelder (2,82 x 1,06), tras gemetseld, tongewelf van op hun kant gemetselde rode bakstenen (22 x 10 x 3,5 cm), bekleed met bakstenen op hun plat	Waterkelder	97	1775-1825
33	OBV	waterkelder gebouw achter 33-37, OK gat met loden plaat van 42 x 42 cm, gat d. 4,5 cm; gresbuis in mond, secundair gebruik beerput	waterkelder	99	1710-1750
108	OBV	rechthoekige halfsteens bak 1,5 x 1,2 m; paarse baksteen 18,5 x 8 x 3,5 cm; waterkelder Oostenburgervoorstraat 19	waterkelder	99	
110	OBV	rechthoekige halfsteens bak 1,5 x 1,25 m; paarse baksteen 18,5 x 8 x 3 cm; waterkelder Oostenburgervoorstraat 17	waterkelder	99	
136	OBV	waterkelder Oostenburgervoorstraat 13 en 15	waterkelder	99	1725-1800
151	OBV	waterkelder Oostenburgervoorstraat 25, tegen beerput S 77, rode baksteen 18,5 x 9 x 4 cm	waterkelder	99	1710-1750
35	OBV	waterkelder, bekleed met rode plavuizen	waterkelder Oostenburgervoorstraat 33	99	
13	OBV	waterkelder	waterkelder Oostenburgervoorstraat 35	99	
15	OBV	waterkelder, eensteensmuur, gewelf, 18,5 x 8 x 4 cm	waterkelder Oostenburgervoorstraat 35	99	1710-1750
65	OBV	waterkelder 4,40 m x 2,20 m, drie compartimenten onderverdeeld in ieder twee kamers met doorgangen	waterkelder poortdeel nr 29	99	
3	VAL2	gemetselde bak (1,8 x 1,7 m) ten oosten van S 1, ten Z van S 4	waterkelder		
89	VAL2	gemetselde bak, 177 x 124 cm binnenmaat, baksteen (paarsrood 18 x 8 x 4 cm), bodem schuin opgemetseld op helling talud, doorsnijdt S 82	waterkelder		