HPASS Survey of a Roman Bridge, Maastricht, The Netherlands

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Introduction

In May this year, the Netherlands Institute of Ship Archaeology (NISA) requested the assistance of the Department of Archaeology for the deployment of the HPASS (High Precision Acoustic Survey System) as part of a survey of a third century AD Roman bridge site in Maastricht, the Netherlands. This presented an opportunity to use the system in a situation with poor visibility for which an acoustic survey system is ideally suited. In a collaboration with the City of Maastricht, Rijkswaterstaat and ROB/NISA, a diving survey was carried out by the archaeological diving team of NISA, on the remains of the Roman bridge in the river Maas, just south of the St. Servaas bridge. (Refer Map, Appendix 1)

This project was a continuation of a survey initiated in 1999 which covered an area of c. 400 square metres revealing three different structures which are tentatively associated with three phases of the bridge's construction. After utilising the SHARPS system in the 1999 campaign, NISA requested the use of HPASS. The primary aim of the project was to accurately locate and map the remains of the bridge. A multi-beam sonar mapping of the Maas bed carried out in 1998 was a prelude to the diving survey in 1999 and 2000.

Fig 1 Multi-beam images 1998

The remains of the bridge were discovered in 1915 as a result of extremely low water levels in the river Maas. The then city archivist W. Goosen published the statement that these were the remains of a bridge from the late Roman Period. In 1963, ROB were informed of a site known as "de fundering" (the foundation [piles]) which was a navigational hazard for shipping. It was concluded that it was the remains of a late third to fourth century AD Roman Bridge after the identification of the engraved stones removed as part of this process. The stones, previously used in architectural contexts, had been used as foundation material and possibly as bridge piles. The rest of the remains consisted of heavy oak piles seemingly arranged in regular networks, rammed into the riverbed and capped with iron pile shoes.

Site History

The Name of Maastricht

The name Maastricht recalls the first bridge crossing by the Romans in the first century BC. It was the only fixed crossing over the river in the region. The name is of Latin derivation literally meaning where the River Maas was crossed although it is not known what the bridge was called in the Roman period. Maastricht was probably first mentioned by Tacitus in 69-70 BC. A bridge described as "Pontem Mosae Fluminus" is translated as "bridge over the Maas" from his text. Maastricht was founded by Julius Caesar when he chose the town as the most suitable for wintering his troops after the campaigns against Galle and Germany. Roman bridge architecture was as equally developed as the building architecture, although there are less remains of the former to evidence this. The remains have been less accessible or have been totally destroyed as a result of canalisation of European river systems in the nineteenth and twentieth centuries. It is interesting that the remains of the bridge at Maastricht have never been mentioned in historical sources for example, as an obstruction to canal shipping.

Roman Bridge Types

1. Temporary timber piled, yoke (cross-beam) bridge. An example of this type of bridge constructed over the Rhine, had been described by Caesar.
2. Temporary ship pontoon bridge. This consisted of several boats of the same fleet arranged next to each other with a wooden deck joining them together creating access across the river. No remains of this type of bridge have been discovered.
3. Wooden Pillar bridge consisting of a heavy wooden upper structure with a maximum life of one hundred years.

4. Pillar bridge with stone piles and a wooden upper construction. When properly maintained this bridge could last several centuries.

Fig 2 Roman Bridge reconstructions

5. Permanent stone arch bridge consisting of several arches.

Remains of bridges are not usually impressive. They consist of remains of stone piles, triangular bridge footings (used as breakwaters on the upstream side except in the case when piles could be attached to the rock bottom). Heavy oak piles were arranged in regular networks, in a pentagon pattern and rammed into the riverbed. Other remains consist of iron pile shoes, grid network of beams,

Fig 3 Iron pile shoes

remains of caissons contemproary with the piles, stone blocks including those originally from architectural and breakwater contexts.

The majority of finds from Roman bridges were from the nineteenth century when scientific methods of age determination such as dendrochronology were not

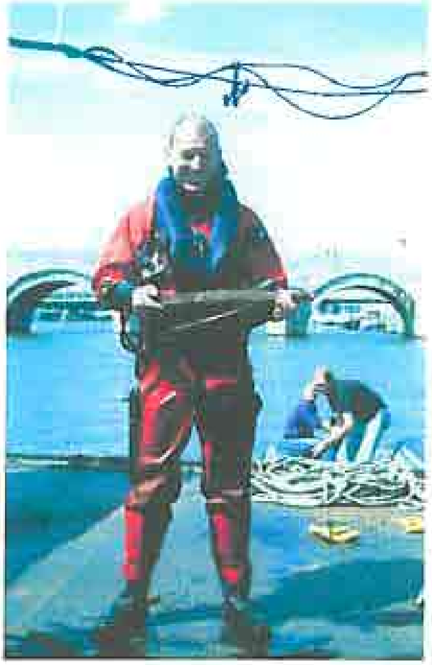

Fig 4 Arent Vos with recovered pile shoe

available. Many of these samples have also perished so modern archaeological excavation plays as important part in providing new samples.

The Maastricht Bridge in History

The road between Ardennen and Eifel avoided the lowlands which incorporated the Maas and the Rhine. It crossed the Maas north of the Sint Pietersberg mountain near the mouth of the Jeker river. At the widening of the valley and riverbed, pebble banks made it possible to cross the river at this point by foot. In this area settlements were established and trade across the river with neighbours was possible. However, the road required continual maintenance after high water and often carts needed extra assistance to cross the pebble banks. Very high tides prevented crossing and traders needed to be lodged in the area of Maastricht while the waited for the water to drop. This is turn activated an economic centre.

The First Bridge

Caesar captured Galle up to the Rhine between 57-51BC. Agrippa, began his role as Governor of Galle in 39BC with the creation of a centralised administration, establishment of districts, founding of towns and building of roads. He was particularly active in the Maastricht district in the first half of the second decenium BC. It was probably during this period the road from Northern France (Bavai) to the Rhine at Cologne was built. Towns such as Tongeren and villages such as Maastricht and Heerlen were founded. The road building of Roman engineers was an artistic process with a military and administrative use. A bridge was required as the Maas could not be reliably crossed due to fluctuating water level, determined by rainfall. It is conceivable that the first bridge at Maastricht was built at the same time as the road to Cologne. Evidence of this early bridge has not been found. The oldest datable timber structure is from the first half of the first century AD. Only one text from the Roman period is thought to have referred to the bridge. Tacitus refers to *Pons Mosae* when he chronicles the Bavarian rebellion in 69-70 AD. Since 1963, there have been archaeological indications in Maastricht for the existence of the bridge in this period and the following centuries.

The next mentioning of a bridge was by Gregorius Van Tours from c.590AD who writes about the death and funeral of the Bishop of St Servatius Van Tongeran in 389 AD *"iuxta ipsum pontem agerris publici"* (close to the bridge on the public road.) The text refers to the existence of a bridge in the fourth and maybe sixth century AD. Written sources are scarce for centuries proceeding this.

A bridge was intensively maintained in the ninth century when Maastricht was a busy trade centre. The bridge appears several times in archival texts. An Act in which Keiser Otto III, the Bishop of Liege (Luik) specifically mentions the bridge and references to tolls for ships and the bridge. In 1139, Romes king Conrad III passes the ownership, maintenance and toll over to the church administration of St Servaas and after that the bridge is mentioned regularly in church archival texts.

In the meantime, the western end point of the old Roman road had changed from Bavai to the Flemish towns with the metropolitan Brugge, as the centre. Many technical improvements in relation to transport resulted in intensive traffic developments. The road became politically important in the demarcation of provinces and states due to its position and the bridge was repeatedly destroyed during this period. The thirteenth century brought hardship to the bridge owner and eventually the bridge disintegrated in 1275 during a procession where hundreds of people lost their lives.

The question of whether this medieval bridge stood on the piles of the preceding Roman example cannot be discerned.

Servaas Bridge

The rebuilding of the old bridge after the collapse of 1275 was not possible. In 1280, the church of St Servaas began with the building of a stone bridge with one timber arch at the Wykse site. The bridge was finished in 1298. This bridge with nine stone arches was well maintained until the beginning of the seventeenth century when the maintenance became a burden for the church. They passed the responsibility and ownership with some additional funding to the city in 1646.

The city carried out repairs between 1683 and 1716 under the Dominican brother Franciscus Romanus. Almost all building materials were replaced in time, although the medieval bridge is still there. Until 1856, the Servaas bridge was still the only bridge across the Maas.

The Wilhelmina Bridge was built 1930-32, the Kennedy Bridge in 1968 and the Noorder Bridge in 1984.

Fig 5 Contemporary image of 1275 procession

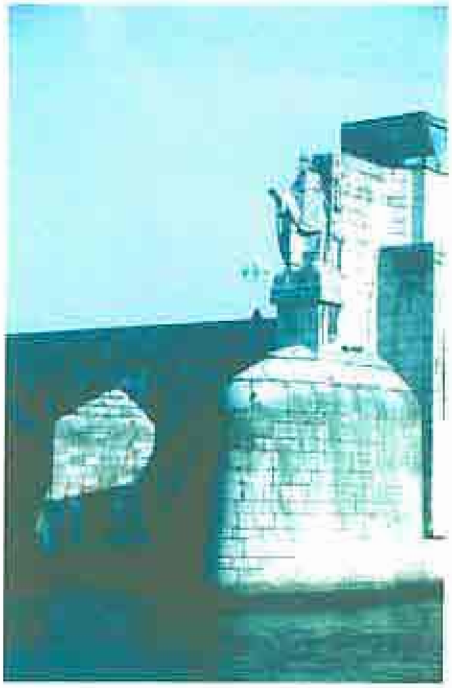

Fig 6 St Servaas Bridge (post WW2 reconstruction)

Archaeology

1923

The first archaeological find- a Roman coin treasure along the Maas, was discovered in 1923. The historian M. van Heylerhoff first studied the Roman sites in the nineteenth century and the first Roman archaeological investigation was the bath house on Stokstraat in 1840.

The first scientific hypothesis of Roman prehistory was by Goossens who excavated 1918-1926. In his 1923 article, *Over the Roman Castellum* he was the first scholar to state the position of the Roman bridge before it was discovered some forty years later.

Fig 7 1963 operation

Fig 8 Lion Sculpture

1963

ROB were informed of stones dredged from the Maas, 100-125 metres south of the St Servaas bridge, east of the area around Stokstraat. With the highest point situated at 2.4m under the present water level of the Maas, it was planned to dredge and remove this obstacle. Many stones were removed as part of this process and it was concluded that they had the bridge.

The Stones

These stone finds extended the dutch history of art another millenium and have been termed *Spolia* (recycled objects used in a new architectural context). It is a unique find in Holland, however, similar finds were more common in neighbouring countries. The third and fourth centuries were a politically unstable period with war and economic recession. Efforts to restore many buildings and monuments as well as fortifications utilised such stone. First to Third Century grave stones were used as foundations and this is seen throughout Europe, for example, in Sens, south of Paris, sculpture dating from a second century AD bath house was used in a fourth century town wall.

In 270 AD, a fortification was hastily erected in Maastricht and for this reason, many of the surrounding monuments were demolished. To connect the large

Fig 9 Raising an inscribed stone, May 2000

stones, holes were cut which wooden double "swallow tails" could be pushed into. After 333 AD the Roman military built a completely new bridgehead (military fortification for bridge) flattening the old fortifications and reusing the stones again in and around the piles of the renovated bridge. In this context, this is a tertiary use of the sculptured stones. It has also been suggested that some of the stones may have been dumped on the river bed to change the river current or perhaps to break the ice during Winter.

The stones were originally from grave monumental sculpture and consecrated architecture. The oldest of this type of architecture were massive monumental towers up to 15 metres high. The findings from the Maas suggest they date to the first century AD. Four of these large structures and possibly more, existed along the roads through the settlement. One grave monument could have been made from hundreds of blocks. The monuments were erected during the life of the owners who were colonists and war veterans, many who had made a career in the Rhine army. These people were raised in the late republican tradition of the municipal town culture of northern Italy and southern France. They possessed land in the Limburg hills, with many holding honorary jobs in the towns of the provinces. Proud immigrants expressing their Roman burgher rights through their impressive mauseleums, they were planning a heroic future in the afterlife.

Sculptured scenes depicted fights of Roman horseman and barbarians. Scenes of weapons point to military fame. The clothes, toga and tunica depicted on these stones

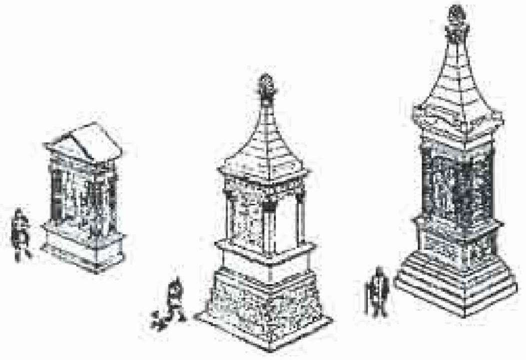

Fig 10 1st century AD Roman funarary monuments

Fig 11 Gladiator stone 190-220 AD

emphasised the social position of the burghers. References to Greek mythology and Elysium (heaven) suggests intellectualism of the deceased and a positive outlook on the afterlife.

From the beginning of the second century the Maastricht monuments appeared more modest and noticeably simpler. This was the result of the formation of a new elite, romanised neo-burghers of native origin. Elsewhere in Europe, grave monuments located in the villas superseded the "grave streets" of monumental mausoleums. The scenes depicted and the lettering used

Fig 12 Sculpture from Sint Jangsgeleen 3rd century AD

signified the status of the deceased. For example, a magistrate could use capital letters and illustrate a bull sacrifice where a common burgher could not. The downfall of the opulent grave monuments in the second century did not appear in all of the Roman empire, only in this area. The new Romanised elite of this period consisting of traders and large land owners and the existence of artisans produced a demand for private assignments. Burgher tastes were based on riches, opulence and achievements of daily life. Again, tower like monuments were built, one example was 25 m high, but this time covered in scenes illustrating the life and functions of the deceased. These monuments stood near the villas and vicis of the landowners, like brightly painted advertisements. The fragments from Maastricht consist of the remains from at least eight funerary pillars. The deceased are dressed in full regalia as well as ordinary

Fig 13 Trading Scene 125-150 AD

native dress. Some scenes also contain mythological and allegorical symbolism. For example, a Roman she wolf as a symbol victory, or of conquest over death or as a sign of attachment to Rome. More typical are scenes which depict the family home life, family meal and local traders.

Fig 14 Woman in Roman dress 170-190 AD

Site Description

The Maas river bed consists of fairly solid mud which quickly silts up the water when disturbed. Even the slightest contact with the riverbed results in visibility loss. Visibility ranged from 0-80cm. Water temperature varied from 15 to 19 degrees Celsius with depths between 3 to 6 metres. The topography was generally uniform with the major Z variations occurring to the east of the site, in the main shipping channel. A rope grid 14 (NS) x 28 (EW) metres was placed on the site to aid in orientation. Each of the squares was 2 by 4 metres and was numbered from A1 (SW) to G7 (NE).

Fig 15 Expedition dive platform

HPASS Survey

The primary aim of the survey was to re-measure the bridge section surveyed in the 1999 campaign. It was then intended to survey an area similar in size, to the north east, mapping a series of large stones noted during the expedition. Traditional tape trilateration was carried out in an area immediately north of the 1999 site, providing a comparison of techniques.

Transponders were initially located on river bed to encompass the area of 1999 survey. A survey of the transponder positions was undertaken first to test the geometry of this network. The best accuracy is obtained when the angles between the datum being surveyed and the transponders is approximately 90 degrees. Angles less than 30 degrees or more than 150 degrees result in inaccurate fixes.

Fig 16 Deploying the transponders

Fig 17 Tripods built by NISA for holding the transponders

The aim, in positioning the transponders, is always to try to meet this condition for as many pairs of ranges as possible over the survey area. The initial results from the transponder positions surveyyielded high error residuals. It was conceivable that this problem was the result of surface reflection due to the shallow water depth. Shallow water can reduce the number of good ranges from the transponders and is most pronounced when the water surface is flat. Quite small waves such as wind generated ripples of boat wash can reduce, but not necessarily eliminate the problem. The effects of surface reflection are arbitary and therefore difficult to pinpoint and correct for. It was suggested that changing the height of the probe on a fix by fix basis would help if this became a major limitation (Duncan, A. pers comm). In light of this, the transponders were lowered to a depth of approximately 3.5m to compensate for possible surface reflection.

Some hardware problems were encountered at the beginning of the survey; T1 and the diver unit transponder cable were faulty, probably the result of damage sustained by the unit during freighting. These problems were easily

Fig 18 Repairing Transponder 1

identified in the relatively simple circuitry and fixed by the archaeologists on site. This survey of the 1999 area was successfully accomplished with many RS residuals as low as 30mm.

With the completion of the survey of the 1999 area, three transponders, T3, T4 and T5 were moved to incorporate the new stone area discovered NE of the 1999 grid, approximately 12-15 metres from T2. In the Site Surveyor project these were renamed accordingly; T3 = T7; T4 = T8; T5 = T9. In any one survey, no pair of transponders should be more than about 40m apart. If the survey needs to be extended, as in this case, at least three transponders need to remain in their original position and be re-surveyed. These points should be as far apart as is feasible, while still being able to be surveyed with good geometry. The newly positioned transponders were levelled between 3.5-4 metres, slightly deeper than the initial survey as this site was in the shipping channel. T2, T1 and T6 remained in their original positions but were turned around to face the new survey area. The new stone area was delineated by two tapes approximately 25m in length extended in a NS orientation The ends of each of these tapes was buoyed and the transponders placed at these positions. Deployment of the system in this area was relatively expeditious with up to 60 points or 400 measurements acquired in a dive. Initial results post processing not only indicated that HPASS can determine the relative positions of the stones, but demonstrated that it can also successfully plot the four corners of individual blocks. These macro survey capablities were made possible due to the relatively small inter-transponder distances and good geometry between the targets and transponders.

The HPASS Data was processed using Peter Holt's Site Surveyor 2.1.2. One of the ultimate aims of this survey is to integrate acoustic data with geodetic information, with constructional detail then projected into this. (Maarleveld T, pers com). These results, used in conjunction with terrestrial surveyed positions of the bridge remains and will be eventually used to illustrate where the bridge hypothetically projected over the river. The final graphic presentation was created by exporting the Site Surveyor data as a dxf file to Freehand so that it could be combined with the manual measurements.

Fig 19 Selecting stones from sketch survey for HPASS work

Processing in the Field

In the field it was more practical to process each days data in a single project. This was done on site after the dive giving immediate results. This showed the relative positions of targets more clearly without the confusion of several layers of points. It also enabled the operators to identify potential problems in the survey and to re-measure if necessary. Experimentation with RMS residuals for individual distances was necessary in the Site Surveyor processing to counter high error margins This was probably the result of multiple pathways interference. Results indicate that the main errors are multi-paths, because there are almost no negative residuals in distance. All measurements over 100 mm were ignored.

One interesting issue is that all the depth readings had a slight negative residual, but there seems to be very few positive residuals in the depth. One explanation may relate to the density of water/seawater is an issue here. The HPASS programme corrects for salinity and in this case, we were operating in fresh water with a salinity measurement of zero ppK. At this stage the HPASS program does not account for density.

Fig 20 Processing HPASS data on site

Conclusions

The deployment of HPASS in the Netherlands further proved the system's capabilities in poor visibility. In its present form, HPASS presents an interesting alternative solution to conventional underwater surveying techniques. The system has a number of advantages in that it is fast; accurate and can be operated in low visibility and on relatively deep sites. The speed of operation, once the transponders have been deployed, is at least as fast as a three-tape trilateration system and it gives an accurate and a more reliable z-co-ordinate than the three-tape system. There is also a considerable saving on post-dive processing and reliable assessment of errors.

Acknowledgements

The author would like to acknowledge the Australian Federal Government's grant establishing the Australian National centre of Excellence in Maritime Archaeology, which made the development of the HPASS system and a wide variety of projects possible. Under the leadership of Dr John Penrose, the CMST has been responsible for the technical development of the system, Alec Duncan and Malcolm Perry developed the software and hardware for the system and were a constant source of advice with technical problems. Peter Holt, of 2H surveying assisted in the development of software to enable the system to work with Site Surveyor.

I would also like to thank the NISA archaeological diving unit, co-ordinated by Thijs Maarleveld and Arent Vos, for the invitation to participate on the Maastricht project. A special thanks to Roel Mulkens for logistical and diving support throughout the expedition. Titus A.S.M. Panhuysen, Maastricht county archaeologist, has provided all the historical information for this report and Marit van Huystee and Juliette Pasveer of WA Maritime Museum have provided the translations of these works.

Finally, I would like to thank Jeremy Green for training and continuous support with the application of the HPASS system; and for giving me the opportunity to take part in Maastricht project.

Fig 21 Roel Mulkens, NISA

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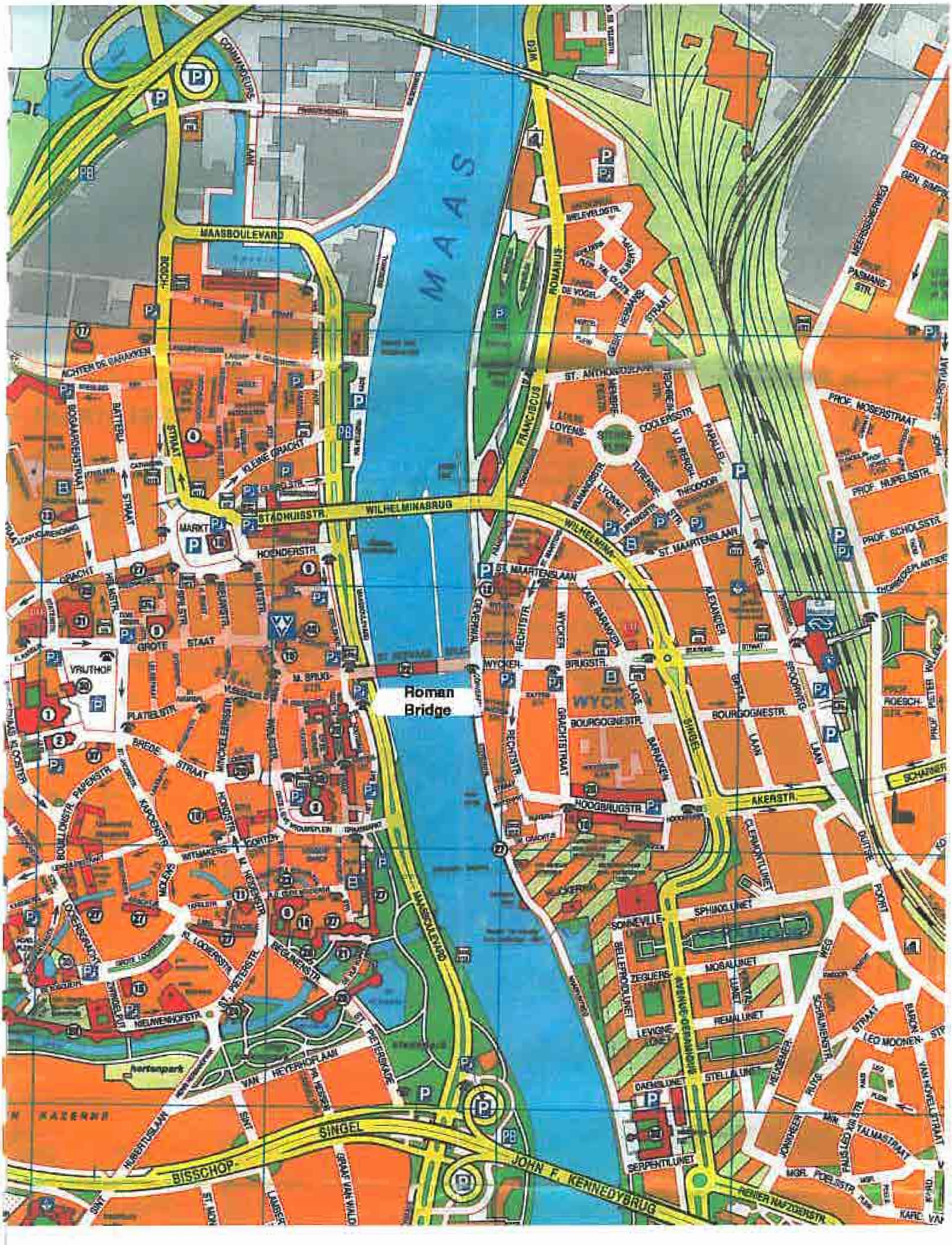
Bonnefantenmuseum, 1999 Archeologisch CentrumDe Wiebengahal. Bonnefantenmuseum, Maastricht/Van Gorgum, Assen.

Appendix 1 Maastricht Area Map


MAAS
Roman
Bridge
MAASBOULEVARD
WILHELMINABRUG
STADHUISSTR.
MARKT
GROTE STAAT
VRIJTHOF
HOENDERSTR.
KLEINE GRACHT
ACHTER DE BARAKKEN
BOSCHSTRAAT
BATTERIJ
BREDE STRAAT
PLATIELSTR.
PAPENSTR.
KAPOENSTR.
WITMAKERS
HOGESTR.
ST. PIETERSTR.
BEGIJNENSTR.
NIEUWENHOFSTR.
VAN HEYERHOFLAAN
BISSCHOP-SINGEL
JOHN F. KENNEDYBRUG
ROMANUS
FRANCISCUS
ST. ANTHONIUSLAAN
ST. MAARTENSLAAN
WILHELMINA-SINGEL
WYCK
WYCKER
BRUGSTR.
RECHTSTR.
BOURGOGNESTR.
HOOGBRUGSTR.
AKERSTR.
ALEXANDER
SPHINXLUNET
SCHNEVILLE
MOSALUNET
REMALUNET
LEVIGNE LUNET
STELLALUNET
SERPENTLUNET
DUITSE PORT
PROF. MOSERSTRAAT
PROF. SCHOLSSTR.
PROF. HUPELSSTR.
LEO MOONEN-
TALMASTRAAT
MGR. POELSSTR.
GEN. SIMPR.
PASMANS-STR.

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F220500_24	-5.151	4.909	3.402	0.018	0.016	110	0.02		282
F220500_25	-4.901	5.465	3.257	0.017	0.014	270	0.02		258
F220500_26	-4.661	5.559	3.087	0.024	0.019	135	0.02		257
F220500_27	-4.112	5.599	3.015	0.017	0.014	96	0.02		240
F220500_28	-4.34	6.738	2.936	0.018	0.014	264	0.02		250
F220500_29	10.704	12.966	3.236	0.041	0.02	249	0.056		264
F220500_6	0.908	-0.226	2.765	0.11	0.031	250	0.02	Stone 4	
F220500_7	-0.156	-0.582	3.365	0.021	0.019	129	0.02	Stone 1	
F220500_8	-0.582	-0.462	3.424	0.018	0.014	120	0.019	Stone 12	
F220500_9	3.684	1.534	3.238	0.021	0.013	118	0.019		220
F230500_10	-3.412	-3.021	7.999	10	10	0	1		451
F230500_11	-1.95	1.588	3.681	0.02	0.015	116	0.019		452
F230500_12	-2.623	1.802	3.563	0.019	0.014	118	0.019		228
F230500_13	-1.059	2.423	3.62	0.016	0.014	136	0.019		453
F230500_14	-0.092	5.043	3.044	0.034	0.015	142	0.019		233
F230500_15	0.759	6.319	3.043	0.023	0.015	144	0.019		454
F230500_16	0.966	5.172	3.155	0.025	0.019	154	0.019		455

F240500_18	31.163	34.462	3.946	0.022	0.012	121	0.018	A4
F240500_19	31.502	33.885	3.989	0.021	0.012	118	0.018	B1
F240500_20	32.073	33.997	3.702	0.019	0.015	116	0.02	B2
F240500_21	31.745	34.845	3.824	0.02	0.013	121	0.018	B3
F240500_22	31.289	34.504	3.976	0.022	0.015	121	0.018	B4
F240500_23	24.328	29.66	3.779	0.037	0.013	114	0.02	58
F240500_24	24.861	30.276	3.842	0.029	0.012	116	0.019	57
F240500_25	25.681	31.269	3.327	0.032	0.013	100	0.02	Inscription Stone C1
F240500_26	26.395	31.056	3.254	0.026	0.013	109	0.02	Inscription Stone C2
F240500_27	26.373	31.041	3.751	0.028	0.015	97	0.02	Inscription Stone C3
F240500_28	25.746	29.462	3.764	0.027	0.012	107	0.02	Inscription Stone C4
F240500_29	25.005	29.693	3.846	0.027	0.011	113	0.019	Inscription Stone C5
F240500_30	25.798	29.909	3.589	0.029	0.013	111	0.02	Inscription Stone (CV)
F240500_31	28.695	37.7	3.394	0.019	0.012	122	0.02	66
F240500_32	27.992	37.342	3.446	0.019	0.012	124	0.02	65
F240500_33	27.098	32.779	3.529	0.023	0.018	109	0.02	59
F240500_34	25.709	29.494	3.712	0.03	0.015	119	0.02	Inscription Stone C7
F240500_35	22.177	23.043	4.079	0.025	0.013	111	0.019	29
F240500_36	23.326	22.355	3.863	0.026	0.016	118	0.02	28
F240500_37	24.643	22.171	3.898	0.03	0.012	121	0.02	25
F240500_38	23.504	20.997	3.858	0.028	0.012	108	0.02	27
F240500_39	22.505	21.012	4.022	0.026	0.017	113	0.02	24
F240500_40	22.818	20.358	4.246	0.022	0.013	112	0.019	23
F240500_41	21.518	20.846	5.526	10	10	0	1	25
F240500_42	20.95	21.966	4.595	0.034	0.015	99	0.019	30
F240500_43	21.862	20.658	4.776	0.024	0.019	117	0.02	26
F240500_44	22.027	18.965	4.579	0.021	0.016	121	0.019	31
F240500_45	22.403	18.404	4.585	0.021	0.015	122	0.019	36
F240500_46	22.636	17.905	4.449	0.023	0.018	113	0.019	34
F240500_47	23.136	17.92	4.107	0.02	0.013	114	0.019	35
F240500_48	23.262	18.301	3.97	10	10	0	1	Timber D1
F240500_49	23.664	16.42	4.656	0.02	0.017	115	0.019	Timber D2
F240500_50	23.061	16.694	4.099	0.029	0.017	93	0.02	Timber E1
F240500_51	23.347	16.387	4.72	0.027	0.014	107	0.018	Timber E2

F240500_52	22.814	16.717	4.58	0.026	0.014	111	0.019		37
F240500_53	23.142	15.579	4.539	0.037	0.022	98	0.02	F1	
F240500_54	22.735	14.443	4.275	0.019	0.017	109	0.019	F2	
F240500_55	23.36	14.834	4.771	0.025	0.017	105	0.018	F3	
F240500_56	23.478	15.589	4.736	0.031	0.018	127	0.02	F4	
F240500_57	22.751	15.451	4.582	0.019	0.017	101	0.019	Timber G1	
F240500_58	23.093	16.091	4.748	0.044	0.021	261	0.02	Timber G2	
F240500_59	21.831	10.798	4.709	0.024	0.021	93	0.019	H1	
F240500_60	21.461	10.591	4.83	0.024	0.017	104	0.019	H2	
F240500_61	21.387	10.419	5.193	0.017	0.015	132	0.033	H3	
F240500_62	21.774	9.534	4.771	0.024	0.017	111	0.019	H4	
F240500_63	21.93	9.864	5.046	0.02	0.017	267	0.046	H5	
F240500_64	22.258	10.115	4.438	0.024	0.019	110	0.02	H6	
F240500_65	22.648	10.113	5.014	0.018	0.017	17	0.018	H7	
F240500_66	21.84	10.646	5.125	0.02	0.015	117	0.036	H8	
F240500_67	25.864	23.1	3.777	0.024	0.011	113	0.02		50
F240500_68	26.569	24.335	3.945	0.028	0.011	108	0.02		48
F240500_69	25.261	23.984	4.035	0.025	0.012	112	0.019		46
F240500_7	25.52	36.128	4.105	0.038	0.023	96	0.019		55
F240500_70	25.214	23.681	4.097	0.029	0.012	106	0.019		47
F240500_71	21.352	24.158	4.535	0.026	0.012	114	0.019		39
F240500_72	21.082	22.037	4.554	0.024	0.015	113	0.019		30
F240500_73	21.369	19.351	4.787	0.022	0.014	120	0.018		32
F240500_74	21.989	19.014	4.534	0.029	0.015	106	0.019		31
F240500_75	21.373	17.847	4.533	0.02	0.014	120	0.019		33
F240500_8	26.972	36.926	3.366	0.029	0.019	136	0.02		67
F240500_9	27.705	35.886	3.51	0.02	0.013	140	0.02		56
F250500_10	26.951	39.496	3.679	0.024	0.015	109	0.02	A3	
F250500_11	27.577	39.328	3.457	0.023	0.012	105	0.02	A4	
F250500_12	31.023	24.872	4.055	0.02	0.012	113	0.02	B1	
F250500_13	30.234	24.802	4.107	0.021	0.012	113	0.02	B2	
F250500_14	30.188	25.633	3.899	0.021	0.011	112	0.02	B3	
F250500_15	31.035	25.6	3.864	0.021	0.012	109	0.02	B4	
F250500_16	28.202	21.739	4.152	0.022	0.012	111	0.02	C1	

F250500_17	27.628	21.906	3.828	0.024	0.013	120	0.02	C2	
F250500_18	27.651	22.786	3.884	0.023	0.013	118	0.02	C3	
F250500_19	27.765	22.937	4.026	0.233	0.018	128	0.02	C4	
F250500_20	25.65	22.249	4.091	0.023	0.011	113	0.019		44
F250500_21	25.644	21.544	4.177	0.026	0.012	107	0.019		43
F250500_22	25.147	20.38	4.097	0.022	0.011	113	0.019		42
F250500_23	25.555	19.601	4.304	0.021	0.012	112	0.019		40
F250500_24	25.933	20.201	4.226	0.022	0.011	113	0.019		41
F250500_25	24.437	22.32	3.892	0.024	0.013	110	0.02		45
F250500_26	22.492	20.067	4.351	0.033	0.015	98	0.019		22
F250500_27	22.767	19.262	4.089	0.023	0.013	114	0.019		18
F250500_28	23.224	18.943	4.025	0.021	0.014	115	0.019		17
F250500_29	23.401	19.405	4.09	0.021	0.012	113	0.019		19
F250500_30	23.616	19.888	4.149	0.023	0.013	110	0.019		20
F250500_31	23.254	19.954	4.163	0.031	0.013	102	0.02		21
F250500_32	20.551	20.907	4.799	0.027	0.014	110	0.018	D1	
F250500_33	20.366	20.138	4.72	0.022	0.012	116	0.018	D2	
F250500_34	19.654	20.412	4.914	0.022	0.012	115	0.018	D3	
F250500_35	19.952	21.135	4.978	0.031	0.013	103	0.018	D4	
F250500_7	29.156	37.089	3.451	0.019	0.014	127	0.02		64
F250500_8	27.233	38.676	3.269	0.023	0.015	120	0.02	A1	
F250500_9	26.624	38.85	3.528	0.023	0.015	101	0.02	A2	
T1	12.178	-0.054	2.595	0	0	0	0	F	
T2	12.535	6.437	1.584	0	0	0	0	F	
T3	9.469	-14.918	3.081	0	0	0	0	F	
T4	-0.28	-14.623	2.992	0	0	0	0	F	
T5	-5.929	-2.21	3.091	0	0	0	0	F	
T6	8.017	15.4	3.345	0	0	0	0	F	
T7	31.209	36.033	3.417	0	0	0	0	F	
T8	24.152	35.663	3.443	0	0	0	0	F	
T9	27.96	8.633	3.878	0	0	0	0	F	