SLUICE GATES IN ROMAN AQUEDUCTS

May I introduce to you a question in aqueduct studies which is not often addressed: was there any control in Roman aqueducts between the source and the castellum divisorium? One always presents a static picture: a source, a channel, one or more tunnels, bridges and/or a siphon and at the end the distribution basin. But what happened in a period of abundance of supply or in the case of maintenance or repair? How to deactivate an aqueduct?

Control is related to human intervention. The common factor in dynamic control is time dependency. So we are in search of elements in Roman aqueducts which position(s) can be changed over time, such as in reservoirs and in distribution basins.

When we look into the ancient literature we encounter Vitruvius, Pliny the Elder and Frontinus who are indeed were referring to dynamic elements. There is also some evidence in epigraphical sources: inscriptions including a small map! In general: all are hinting on dynamic control en control elements, but without any details about nature nor location.

From the research literature I collected a series of examples of dynamic control elements in ancient aqueducts including taps, wedges and plugs, one way valves and mostly sluice gates and put these in typology schemes. The 25 sluice gates – mainly in single setting but some one behind the other - led me to some conclusions, although we have to keep in mind that those 25 can hardly be representative for the 600 – 1200 known Roman aqueducts.

Given the fact that we were confronted with partly inconsistent, incomplete, or sometimes (too) general descriptions, our *tentative* conclusions are:

1. The aqueducts of which the sluice gates were part of, were mainly built in the **1st and 2nd century**. But we have to bear in mind that it is possible that some control elements were added later
2. A major part of the described sluice gates (**11**) were **found in France**, 3 in Spain and 4 in North Africa
3. Some 12 were applied in the *main* water course of which 1 in a double setting (Uzès / Pont du Gard); 19 were used in a *side* branch of which 4 in a double setting (Ars, Reims, Uzès / Pont du Gard and Calahorra).
4. Of this group of 25 elements 10 were used to **regulate the water flow** and 9 played a role **to split the water course**. Only three were related to a storage basin (Tigava, Bararus, and Burnum) and two to a distribution basin (Nimes and Shivta).

Our overall conclusions:

- There must have been control in (some) Roman aqueducts
- Major questions keep unanswered: who regulated the water flow, when were these persons active, what was their goal, who gave the orders etc.

Wilke D. Schram
w.d.schram@uu.nl
http://www.romanaqueducts.info

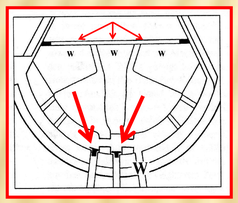
Sluice Gates in Roman Aqueducts I

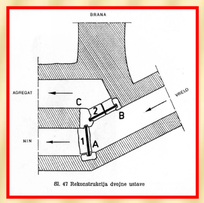
Wilke D. Schram (NL) w.d.schram@uu.nl or www.romanaqueducts.info

Dynamics in aqueducts?

Many aqueduct studies present a static view: the water source, the main conduit with tunnels, bridges, and sometimes siphons, with at the end the water distribution in the town.
In ancient times one may suppose that a more dynamic environment existed: seasonal fluctuations in the supply, day and night rhythm on the demand side, temporarily closing of a section for maintenance and major interventions e.g. extra supply or users. In response to these external stimuli one would expect a need for control.
The main question in this study is: **was there any control in Roman aqueducts** between the source and the main distribution point near the city?

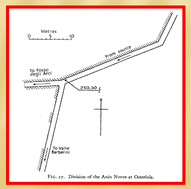
The common factor of dynamic control is human intervention , closely related to **time dependency**. So we are in search for elements – often enclosed in basins – whose position can change over time io control the water flow.
Is there any literary or epigraphic evidence about these actions, which mechanisms were used, which functions did the Romans execute, and was there any systematic approach in Roman times? Basically: **how did the Romans control an aqueduct?**
First two examples of control elements: in the distribution basin of Pompeii and a splitting in the aqueduct of Aenona (present Nin, Croatia).





Missing control elements?

A remarkable example of a seemingly *missing* control element is at *Osteriola* at the start of the Tivoli loop were the water flow of the *Anio Novus* was divided, see Ashby's 'solution'.
Another example: at Porta Maggiore the Arcus Neroniana branches of from the Aqua Claudia, but without a trace of control?



Ancient sources

In 8.6.7 **Vitruvius** recommends: "*… to apply a castellum every 200 actus [24.000 Roman feet; 7,1 km] so in case of emergency, there is no need to deactivate the whole system and to be able to find the place of trouble easily*" (translation from gutenberg.org)

In open cast mining, to crush and wash away the overburden, reservoirs were used for 'hushing', according to **Pliny the Elder**: "*Five sluices about a yard across occur in the walls. When the reservoir is full, the sluices are knocked open so that the violent down rush is sufficient to sweep away rock debris*" (NH 33.75, Lewis and Jones 1970).

Pliny again reports in *NH 18.51* a system, based on the principle of time-division of waters from a constant source in the oases of Tacape (Qabès): "*It is only at certain hours that its waters are distributed among the inhabitants*".

In his work **Frontinus** describes many splittings (19.8, 20.3, 21.2, and 66.2) where decisions had to be made which part of the water flow should be diverted, however without any detail. The same counts for transfer from one aqueduct into another (67 - 69), mixing (90 – 92), and the arrangements around the Aqua Augusta (14.3), the Aqua Crabra (9.5) and the Aqua Alsietina (11.2).

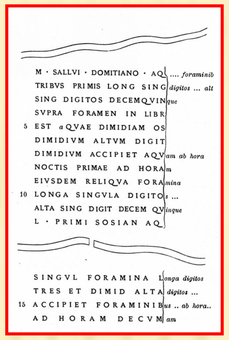
Conclusion

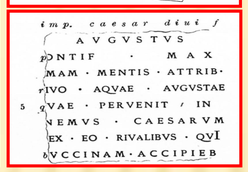
We may conclude that Vitruvius, Pliny and Frontinus make mention of time-dependant – so dynamic - control elements, although in quite different settings. **Locations and nature of the necessary devices remain unclear**.

Epigrafica

The epigraphical sources below, more or less related to the aqueducts of Rome, present only indirect evidence for control elements.

CIL 6.1261 is the well-known image of a plan plus related text depicting an aqueduct, branches, and on certain places interruptions, which seem to represent sluice gates. The text gives some names and hours owners may count on water supplied to their properties.





The inscription ***CIL 8.448*** = *CIL 14.3676* describes regulations for the use of water in the area of Tibur, setting sizes of channels and length of time for access .
A text was found on a slab of travertine excavated in 1887 15 miles outside Rome (Bruun 1991), and used as a cover upon a modern branch of the Acqua Paola (***CIL 6.31566*** = *CIL 11.3772a*), describing the distribution of Alsietina water by allotment of time: "…so that from it [the Aqua Alsietina] the water might flow continuously to those consumers who once received water at fixed hours only".
CIL ***8.18587*** (=CIL 8.4440 = ILS 5793) is a decree that records in detail the arrangements for time dependant irrigation of a large number of agricultural plots in the region of the ancient town of Lamasba (present Ain Merwana, Algeria).

Workforce

Bruun (1991) lists, based on epigraphical sources, the names of 19 workmen from the *familia aquaria* in Rome, of which one may derive that some (if not all) were attached to (only?) one of the aqueducts.
Unfortunately we are **ignorant** of the exact duties of these castellarii: were they watchmen, cleaners, observers, or - when necessary - operators of control devices?

Types of control and control elements

Basically there are two types of dynamic control: on/off and adjustable.
Based on this difference, the following **control elements** can be ascertained:

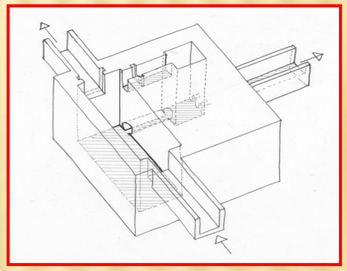
On/off type
- Plug in a pipe
- Single wedge in a slit
- One way valve in a pipe

Adjustable type
- Stopcock and tap
- Sluice gate
- In-steam vertical board pivoting horizontally
- Multiple plug system
- Multiple wedge system

Functions

At several places along the aqueducts specific functions were executed, but not all were time dependant. Some examples:

Time dependent examples:
- To store water: often in a storage basin (cistern, reservoir)
- To distribute the water among (groups of) users within a city: often in a distribution basin
- To split the water flow extra urbem
- To regulate the flow and to get rid of excess water: often in a regulation basin
- To settle impurities: often in a settling basin.



Complex regulation and settling basin in the Grüngürtel in Köln / Cologne (Germany)

From the literature we compiled a series of dynamic control elements and sorted them out for functions.

Neither **plugs** nor **wedges** were archeologically attested; where surmised they were related to main distribution basins (e.g. Nimes, Pompeii, Apamea).
The number of **one way valves** as described in the literature, was too small to present a reliable statement (e.g. Sepphoris, Israel).
The number of extra urbem **stopcocks** were also too few and mostly related to storage basins (e.g. Carthage and other North African cities, Humeima, Jordan).

Sluice gates

We have concentrated on a sample of **25 sluice gates** related to one or more of the functions described above. However, this number is a **not-representative** sample, given the fact that over 600 Roman and Greek aqueducts are described in the literature.

The sluice gates differ in function, in location, in the place within the aqueduct system (main course and/or side channel) and in design (single or double). Note: some sluice gates served a double function

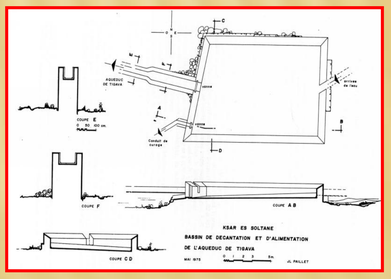
Tentative conclusions

Given the fact that we were confronted with partly inconsistent, incomplete, or sometimes (too) general descriptions, we come to the following **tentative conclusions**:

1. The aqueducts of which the sluice gates were part of, were mainly built in the **1st and 2nd century**. But we have to bear in mind that it is possible that some control elements were added later
2. A major part of the described sluice gates (**11**) were **found in France**, 3 in Spain and 4 in North Africa
3. Some 12 were applied in the *main* water course of which 1 in a double setting (Uzès / Pont du Gard); 19 were used in a *side* branch of which 4 in a double setting (Ars, Reims, Uzès / Pont du Gard and Calahorra).
4. Of this group of 25 elements 10 were used to **regulate the water flow** and 9 played a role **to split the water course**. Only three were related to a storage basin (Tigava, Bararus, and Burnum) and two to a distribution basin (Nimes and Shivta).

References

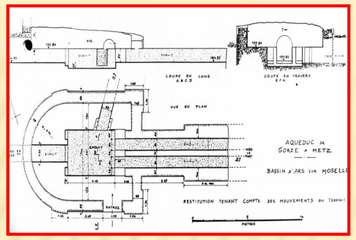
For literature sources about and drawings of the 25 sluice gates, see the poster annexed poster and http://www.romanaqueducts.info



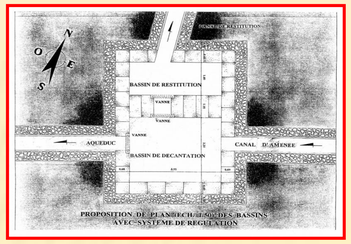
Settling basin of the aqueduct of Tigava (Algeria)

Sluice Gates in Roman Aqueducts II

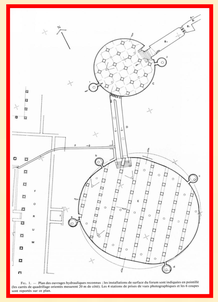
Wilke D. Schram
w.d.schram@romanaqueducts.info
www.romanaqueducts.info



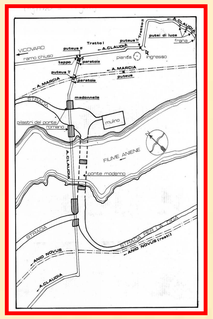
Ars-sur-Moselle (aqueduct of Metz) splitting + regulation basin



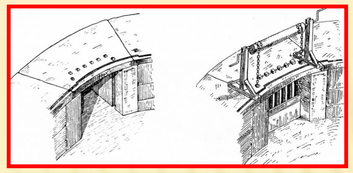
Regulation and settling basin in the aqueduct of **Reims** (France)



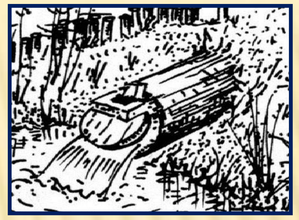
Three parallel sluice gates in a channel between the inlet and two cisterns of **Bararus** (Tunisia)



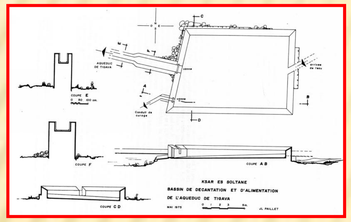
Aqua Claudia (**Rome**, Italy) Start of the Hadrians loop near Madonella. At ρ a splitting with a plug (3) in the old and a sluice gate (4) in the new channel.



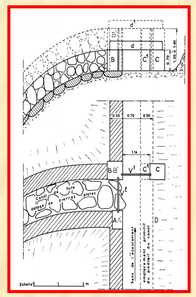
Circular distribution basin in, **Nîmes** (France) with at the inlet one set of grooves, also in the channel floor, possibly for a movable sluice gate



Example: **one way valve** (Roman drain pipe in Vlaardingen NL)

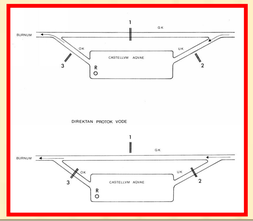


Settling basin in the aqueduct of **Tigava** (Algeria)

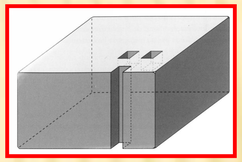


Regulation facility, near the source of the aqueduct of **Saint-Bertrand de Commignes** (France) to divert excess water.

Calahorra (Spain) An aqueduct sidebranch was equipped with **three** sets of grooves, problable a combination of two sluice gates and a filter screen

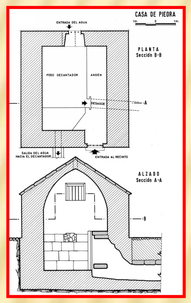


Drawing of a storage and stettling basin of the aqueduct of **Burnum** (Croatia), possibly hypothetical.

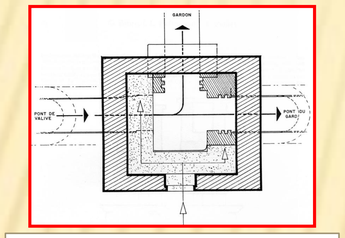


Near the original source of the aqueduct of **Fréjus** (France) in the area called La Foux, a bloc of stone was found iwith a groove referring to a regulation system with a sluice gate.

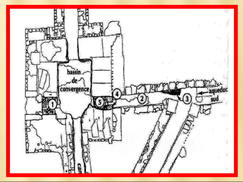
Example: modern **in-stream vertical board** in Saarburg (Germany) pivoting horizontally



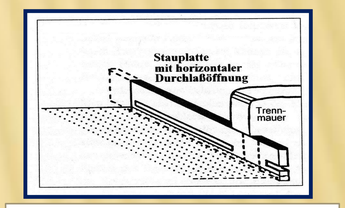
Settling and regulation basin (with some storage capacity) in **Segovia** (Spain)



At several places in the **Nîmes** aqueduct (France) regulation basins were present to divert excess water.



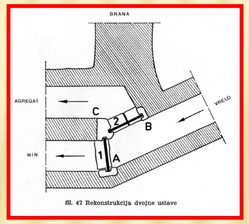
North of **Barbegal** (France) a basin with one inlet and three outlets with a complex history. At nr 4 “location of the valve placed at the partial reopening”.



Example: room for **wedges** in the horizontal openings in the flow control slabs of the castellum in Pompeii (It)

Just upstream of three bridges sluice gates were places in side branches as regulation mechanisms in the aqueduct of **Saintes** (France)

Grooves *in* the specus, probably part of a regulation facility in the **Arles** aqueduct (Caparon neuf)



Branch in the aqueduct of **Aeona** (present Nin, Croatia) to a reservoir of a mill complex

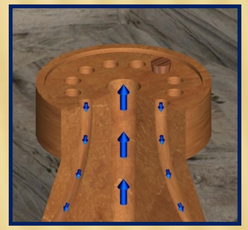
The Rio de la Acebeda water was partially diverted into the aqueduct channel towards **Segovia** (Spain) by means of a sluice gate.

Sitifis (Algeria): "Outflow from the (collecting) basin was through a lead pipe in the opposite wall, which could be shut off by a stone sluice gate sliding in a groove.“

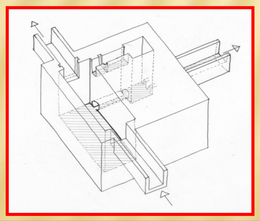
Before the [Byzantine] aqueduct enters **Shivta** (Israel) there is a basin with three openings / sluice gates. The sides of the openings are 25 - 28 cm high stones with grooves in which wooden boards could be inserted.

Just before the water of the Proserpina aqueduct (**Merida**) reached the 'Los Milagros' aqueduct bridge, a small building was constructed. By means of a sliding device one could interrupt the flow so that the water was diverted to one side.

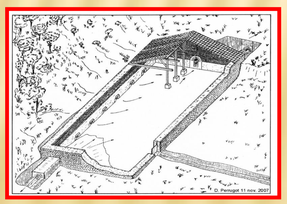
Olba (Turkey): single apertures at both sides of the aqueduct channel, equipped with simple grooves for boards (D. Murphy).



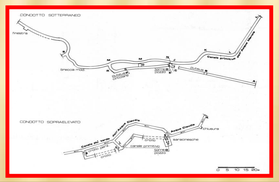
Example: **plugs** used in the water distribution (Apamea, Syria)



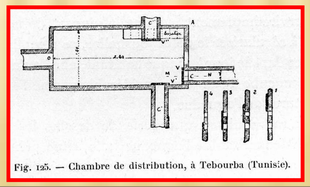
Complex regulation and settling basin just before the city of **Köln / Cologne** (Germany)



Sens (France), catchment basin in Noe with overflow. Arrow left under in the wrong direction.



Gorge of San Cosimato: ‘down-channel' to divert water from the Claudia aqueduct into the Marcia channel (**Rome**, Italy)



Basin of **Tebourba** (Tunisia) with one inlet and three outlets equipped with control sluices, two as usual, one more complex

Example: bronze **stopcock** at the outlet of the Nabataean reservoir in Auara / Humeima (Jordan)