FACTORS INFLUENCING SEDIMENT LOAD TO GULLY POTS

Environmental and gully pot specific factors

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TU DELFT
Department of Water management

Summary

Phenomena like urbanization and climate change will increase flooding problems, making it clear that more research and investments are needed in sewer systems to improve urban flood prevention. This research was done to determine factors influencing the sediment load to gully pots. It was assumed that in the measurement period, the retaining efficiency of the gully pots remains unchanged. Sediment levels in gully pots for a period of 3 months after cleaning were measured in the fall/winter period, in the cities of Rotterdam and The Hague. A probabilistic approach was used, consisting of a deterministic and random part. For the deterministic part, a generalized linear model is constructed to determine the influence of chosen parameters from the surrounding environment and the gully pot itself. For the random part, a normal distribution is used. The factors which were deemed to be relevant ($p>0.05$) are the tree factor ($p=2{,}39E-06$), inlet structure ($p=2{,}05E-05$), sand trap volume ($p=9{,}52E-03$) and road surface ($p=1{,}28E-02$). Parameters deemed not to be relevant are connected surface area ($p=4{,}39E-01$) and traffic intensity ($p=3{,}33E-01$). In further research, rainfall intensities should be included as well.

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Introduction

Research validation

Urban flooding is an increasing problem in cities, causing damage (both tangible and intangible) to property and potential health risks (Post, Langeveld, & Clemens, 2017). Phenomena like urbanization and climate change will only increase this flooding problem, making it clear that more research and investments are needed in sewer systems to improve urban flood prevention. Through research in sewer induced flooding, it has been shown that gully pot blockages are the main cause of flooding (Cherqui et al., 2015; ten Veldhuis, Clemens, & van Gelder, 2011). In the research of ten Veldhuis & Clemens (2011), an average of 83% of the flooding was due to gully pot blockage.
In the Netherlands, the gully pot chambers are usually cleaned preventively once a year (RIONED Foundation, 2004)(vulnerable locations like market places 2 or 4 times yearly). Cleaning is also done reactively when complaints are made, usually within a maximum period of 1 or 2 weeks after the complaint was made (ten Veldhuis & Clemens, 2011). To improve this system (move from proactive and reactive based to risk based sewer asset management), research is needed on the sediment load that is received by gully pots in different environments to determine by which factors the sediment load is influenced. With this factors determined, a model that can give an estimation of the sediment load per gully pot can be constructed. This model may not be too complicated or require too much data, since this would drastically decrease the usefulness for municipalities and other possible users.
A lot of research has already been done on the sedimentation and resuspension mechanisms in gully pots (Tang, Zhu, Rajaratnam, & van Duin, 2016; Butler & Karunaratne, 1995), as well as on the blockage and equilibrium occurring in gully pots in the field (Post, et al., 2016) (Post, Langeveld, & Clemens, 2017). The research of (Post et al., 2016) shows that after 15 months (without cleaning), either an equilibrium state (95%) or blockage (5%) occurs. When equilibrium occurs, all the sediment that is collected after this point is flushed through the gully pot (0% trapping efficiency) and ends up in the sewer system.
This shows that blockage is not the only problem which needs to be considered when discussing the cleaning frequency of gully pots, the trapping of sediment also declines and stops after a certain time. A study in Almere (Stichting RIONED/STOWA, 2016) shows that when collecting the sediment every 2 months instead of once a year, three times as much sediment was collected. This validates that not only blockage frequency is of importance, but also the amount of sediment that is captured by the gully pot. When cleaning frequencies are not adapted to this, the utility of a sand trap would be greatly reduced and most of the sediment would still end up in the sewer as deposits.
Since the impact of this phenomenon on to the sewer system is usually hard to quantify and only experienced decennia later, the blockage problem which has an immediate impact has been the main focus of most research so far.

Sediment in sewer systems

To protect urban areas against flooding, collecting and transporting of run-off is needed so rainwater will not pond on the surface and cause nuisance, damage or even danger for the citizens. The street inlets collecting storm water are usually designed as gully pots, referring to the presence of a sand trap (Ashley et al., 2004; Butler et al., 1995). This sand trap is designed to capture the heavier fraction of particles suspended in run-off by gravity separation (Deletic, Ashley, & Rest, 2000; Karlsson & Viklander, 2008). Lighter particles are not captured but flushed through the gully pot into the sewer to the treatmentplant or receiving waterbody (CSO and separate system). They will not form deposits in the sewer because of their low settleability.

By capturing suspended particles in runoff, silting and wear of downstream sewer components are reduced (Ashley et al., 2004; Butler et al., 1995). In addition, solids and (heavier) sediment flushed into the sewer can form deposits in the sewer system when hydraulic conditions do not assure their transportation. Solids accumulated in sewer systems can affect discharge capacity, cause blockage in the sewer, increase flood risk and frequency of overflow spills (e.g. Arthur et al., 2009; ten Veldhuis et al., 2009; Butler, Xiao, & Karunaratne, 1995). The flushing of accumulated sewer sediment is one of the major sources of pollutants in urban wet-weather flow discharges (Rodríguez et al., 2010). Treatment plant efficiency is also safeguarded by trapping of solids by gully pots, since a large amount of solids and the pollutant they carry (like heavy metals) would disrupt the (biological)treatment processes (Butler and Karunaratne, 1995; Butler and Memon, 1999; Deletic et al., 2000; Memon and Butler, 2002).

Capturing part of the solids in the storm water also results in a lower pollution load to the receiving waterbody (Ashley et al., 2004; Butler et al., 1995), since a high amount of pollutants tend to adhere to sediment (US Environmental Protection Agency 1993).

These pollutants include heavy metals, salt, hydrocarbons, total nitrogen and total phosphorus, which pose a direct threat to aquatic life and the water quality.

Large amounts of sediment coming from the sewer can also contribute to higher turbidity which in turn limits sunlight penetration, thereby obstructing the growth of aquatic plants (Aryal & Lee 2009). In addition, sedimentation can clog fish spawning grounds and reduce the transportation capacity of the rivers receiving water from storm sewer system (US Environmental Protection Agency 1993).

A schematization of a gully pot and lateral connection can be found in Figure 1 below.

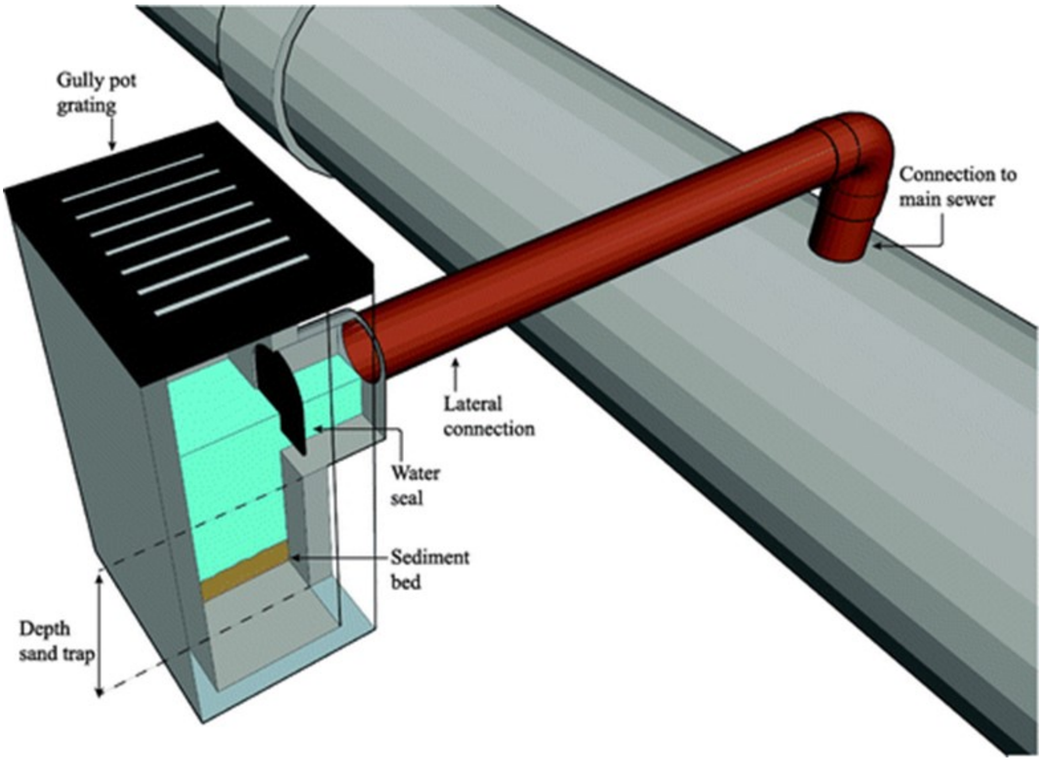

Figure 1: Schematization of a gully pot and lateral connection (Post, Langeveld, & Clemens, 2017)

Sediment capture of gully pots

Sediment supply

As has been mentioned in the previous paragraph, gully pots are designed to trap a part of the sediments entrained in stormwater. From empirical data it was shown that the characteristics of theses sediments are highly area-specific (Xanthopoulos & Augustin, 1992). In the same research it was shown that fine-grained solids are transported as suspended loads by the storm water runoff. This applies also to coarse-grained, non-mineral solids due to their low density (Xanthopoulos & Augustin, 1992).

The sediment layer in the gully pot is mainly formed by settleable solids sized between 250 and 500 µm. This range complies with the grain diameter of 350 µm which is the basis for the design of sediment-free sewer systems (Xanthopoulos & Augustin, 1992). This means that the sediment that is not captured by gully pots will not settle in the sewer but is transported to the receiving waterbody or treatment plant.

Threllfall et al. (1991) have reviewed the data from a number of UK catchments and many storm events did have a mean suspended solids concentration of 358 mg/l (as suggested by Binnie & Partners and Hydraulics Research, 1987 as average for Europe) but with a range of 53-2035 mg/l. Results from the comprehensive USEPA's National Urban Runoff Program (EPA, 1983), however, indicated that suspended solids event mean concentrations for all urban areas were 100 mg/l. These large variations may well be related to the substantial variation in grain size distributions of samples from different gully pots (Jartun et al., 2008).

Capturing efficiency

Laboratory studies of the capturing efficiency of gully pots report that gully pots can remove medium to coarse sands very efficiently (65 to 90%) over a wide range of flow rates. However, a negative capture efficiency can appear when the sand trap is filled over 40 to 50% of its total depth, which is mainly caused by scouring (Tang, Zhu, Rajaratnam, & van Duin, 2016). Early field based experiments in the US by Sartor and Boyd (1972) tend to confirm laboratory studies and show that virtually all particles > 246 µm are trapped compared with under 30% for solids < 43 µm. The capturing efficiency from field data ranges from 20 to 50% (Deletic et al., 2000; Pitt & Field, 2004).

From research it was derived that the capturing efficiency is independent from the solids concentration (Butler and Karunaratne, 1995), decreases as sediment bed levels increase (Memon and Butler, 2002; Post et al., 2016), reduces with increasing flow rate and decreasing particle size (Butler & Karunaratne, 1995) and the effects of erosion and re-suspension inside the pot are very limited (Bolognesi et al., 2008).

Equilibrium and blockage

In research (Post et al., 2016) it was reported that in the field, two silting evolutions were identified. Approximately 5% of all gully pots experienced progressive silting, which eventually resulted in a blockage. The other gully pots (95%) showed stabilising sediment bed levels after several months after cleaning. In field measurements from Butler and Clark (1995), equilibrium sediment bed levels were reached at the level of the outlet pipe. Conradin (1990) reported similar results, equilibrium depths were generally reached in 6 months and sediment bed levels did not exceed the level of the outlet pipes.

Resuspension

In research Bolognesi et al. (2008) and Butler & Karunaratne (1995) it is shown that contribution to the outflow of solids due to re-suspension of bed sediments is not quantitatively significant. It is limited to the first 20-40 seconds of the event, and only occurs on a previously disturbed bed. After a few minutes operation it was conceptualized that the bed became graded and released no more material into suspension. A continuous erosional output (at low level) was only observed for the smallest particle tested at the highest flow and bed depth. Fletcher and Pratt (1981) mentioned that the majority of solids discharged from gully pots are due to a lack of sedimentation rather than re-suspension.

Method

Measuring of sediment depth

In order to quantify the influence of different parameters on the sediment supply to gully pots, measurements of sediment depth were taken in the city of Rotterdam and The Hague, The Netherlands. The measuring was done in the following streets:
The Hague: Kanaalweg, Keukenhoflaan, Leuvensetraat, Paul Krugerlaan, van Stolkweg.
Rotterdam: Ludolf de Jonghstraat, De Lugt.
Before measuring, all gully pots were cleaned out. A similar measuring device was used by Post et al. (2016), it consists of a punctured disk attached to a shaft, with a retractable rod in the middle. The disk rests on the sediment bed, while the rod is driven through until the bottom of the gully pot is reached. The rod is equipped with a tapeline, enabling the operator to determine the height of the bed. Measurements were taken with a precision of usually 0.5 cm, but can be worse when large amounts of organics are part of the sediment. These sediment beds were compressed during measuring, until no more air came out. This enlarged the error that was made, since the compressing was not the same for every measurement and sediments slipped away to the sides. Another problem influencing the measurements were the shape of the bottom of the gully pots. Some rounded of, resulting in the disk of the device getting stuck on the sides of the gully pot before reaching the sediment bed level, in case of low sediment bed levels.
Since the measuring device which was originally used wat too large for gully pots in the Paul Krugerlaan and the Keukenhoflaan, a second device was ordered with a smaller disc. Due to communication errors, this device got a square plate instead of a round one. However, the same device was used to measure a gully pot in every time step, so this should not have influenced the measurements.
Measurements were taken in week 0, 4, 8 and 12 of the research. Due to the problems with the measuring device mentioned before, the Paul Kugerlaan and Keukenhoflaan were only measured three times. The measurements were done between end-October/start-November and mid-January, this period was chosen so that the effects of trees (losing their leaves) could be investigated.
Gully pots which were inaccessible due to cars during a measuring round are still part of the model. Only gully pots inaccessible due to blockage at some time are not used, since the flow to the gully pot was altered during some time. At last it ought to be mentioned that one street, Ludolf de Jonghstraat, had severe blockage issues. In the last measurement round, 19 of the 58 gully pots were blocked. This appeared to be the result of damage to lateral connections (since there was almost no sediment in the measurable blocked gully pots), which could be explained by the type of traffic (loaded trucks) on a road not build to support this (local road, bricks).

Assumption

It is assumed that the retaining efficiencies of the gully pots will not change over time in the period the measuring takes place. Research from Post et al. (2016) has shown that the sediment growth decreases in time after cleaning, showing a decreased retaining efficiency. However, this decrease is assumed negligible in the first few months after cleaning.
In addition, a study by Butler & Karunaratne (1995) reported that the depth of the accumulated material did not have a significant effect until the level reached 40% of the total depth of the sand trap. Since the volume of gully pots used are not equal, this research cannot be used as proof but does add credibility to the assumption. Further study will show whether this was a reasonable assumption.

Method of data analyses

As mentioned before, there is a large variation in sediment loads received by gully pots. To do this, a generalized linear model is constructed. In this model, certain parameters from the surrounding environment and the gully pot itself should be taken into account. Several parameters will be examined to validate whether they have an clear influence on the amount of sediment received by the gully pot. An overview is given in Table 1 at the end of the chapter.

Environmental parameters

Trees

The influence of trees on the solid deposition has been taken into account via a tree factor per street:

$$\mathrm{Tf} = \frac{1}{L_{street}} \; \Sigma_{\,\mathrm{i}}\, h_{tree}(i) \cdot D_{tree}(i)$$

In which L_{street} is street length, h_{tree} is the height of the tree and D_{tree} is the diameter of the crown of the tree. The data for the height of the trees was obtained using the site of 'Actueel Hoogtebestand Nederland' (Provinces, Waterboards & the Government). The diameters of the crowns for the trees in the city of Rotterdam were supplied by the municipality of Rotterdam. For the trees in the city of Den Hague, only the diameters of the trunk were available using the tree application, 'Haagse Bomen App' (Municipality Den Hague) made available to citizens by the municipality of Den Hague. Using the relation between the trunk diameter and crown diameter for semidetached trees (Hasenauer, 1997), these could be recalculated as crown diameters. The length of the street was determined using the site 'afstandmeten.nl'.
Interesting enough, this factor has not been considered priory by other research. Even though peaks in the material supply in June, autumn and after snowmelt were mentioned by Pratt et al. (1987), indicating seasonal variation, which in turn could suggest influence from vegetation.
Please note that this tree factor does not consider seasonal variation yet, since measurement were only done in the autumn/winter period.

Connected surface area

The connected surface area is determined by means of the eight-direction flow approach described in Jenson and Domingue (1988), as done in (Post et al., 2016).
The digital elevation model (DEM) used to deduct these flow patterns is based on the 'Actueel hoogtebestand Nederland', which has a maximal systematic error of 5 cm and maximal standard deviation of 5 cm. Usually these are respectively 3 and 4 cm. This data is obtained by airborne laser scanning, and has a spatial resolution of 0.5 * 0.5 m (van der Zon, 2013). The elevation data for Rotterdam and The Hague are from the first quarter of 2008.
Confounding objects (e.g. cars and trees) were filtered from the DEM and were interpolated from the surrounding data. Ordinary Kriging was applied to interpolate the DEM, as in (Post et al., 2016).

Traffic intensity

The traffic intensity (cars/day) has been determined for 9 road pieces, varying from 500 to 10.000 cars/day. Only for the two streets in the city of Rotterdam was information available on traffic intensity, estimations were made based on road type and observations during measuring practices for the other roads. It was reported by (Xanthopoulos & Augustin, 1992) that street runoff is more polluted by solids than other components of surface runoff. This makes road related parameters interesting to look into.

Road surface (asphalt or bricks)

The pavement of parking spaces and the sidewalks have not been taken into account, only the part of the road used for transport by cars was considered. Since the type of road surface and the amount of cars using it are strongly correlated, one should not be used without the other in a model (using only one could lead to false results, if only traffic intensity was used and it was found to have a large influence this could also be due to the type of road surface).

Gully pot specific parameters

Depth of the sand trap

Memon and Butler (2002) found that the depth of the sand trap is an important parameter for the capture efficiency of a gully pot. When the depth decreases due to sedimentation, the retaining capacity decreases. Lager et al. (1977) reported that the depth of the accumulated material was found not to have a significant effect until the level reached 40% of the total depth of the sand trap (Butler & Karunaratne, 1995). Since this was done in North America and the gully pot properties are unknown, this cannot be taken as a certain value thought it has some value as indication.

Size of the sand trap

Most studies use the depth of the sand trap and not the volume, presumably because the length and width are kept constant. However, since in this research gully pots of different sizes are used, the total volume is included as well as a parameter. It will have to show of the depth or total volume has more influence.

Type of inlet (side, top or combi)

In the researched area, three types of inlets appeared, namely side, top and combined. From the first side visits it was observed that top inlets appeared to catch much more sediment than side inlets.
It was then decided to add this as parameter to the model, as 'side inlet or no side inlet', 'top inlet or no top inlet' and 'combi inlet or no combi inlet'.

Variable	Index	Type	Unit	Range
Connected surface area	x1	continuous	(m^2)	[671.75 - 6.75]
Tree factor	x2	street specific	(m)	[14.16 - 0.39]
Traffic intensity	x3	street specific	(cars/day)	[10,000 - 500]
Road surface	x4	categorical	-	asphalt/bricks
Depth sandtrap	x5	continuous	(cm)	[30.5 - 16.5]
Size sandtrap	x6	continuous	(cm^3)	[47170.5 - 8100.0]
Top inlet	x7	categorical	-	top/not top
Side inlet	x8	categorical	-	side/not side
Combi inlet	x9	categorical	-	combi/not combi

Table 1: Variables deterministic part

Probabilistic approach

Deterministic part

The linear predictor η contains the deterministic part of the model, which is a linear function of k explanatory variables and is given by:

$$\eta_{i,t} = \beta_0 + \beta_1 x_{t,i,1} + \beta_2 x_{t,i,2} + \ldots\ldots + \beta_k x_{t,i,k}$$

Where t represents the observation number and *i* the gully pot, *β* refers to the weights assigned to the respective explanatory variables, β_0 is the intercept.

Structure of the random part

A normal distribution is fitted to the data, as can be seen in Figure 2 below. This is not a very good fit, but that is not the focus of this paper. The mean μ and standard deviation σ are determined by Matlab, determining the best fit (least square fit). Than the *β*-values and p-values of the factors are determined.

Normal distribution function: $f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}(\frac{\eta_{i,t}-\mu}{\sigma})}$

With p giving an indication whether the factor gives a significand difference. It was chosen to assume that factors with a p-value larger than 0.05 are not proven to be relevant.
The fit of the model to the data is shown in the Figure 2 below. As can be observed, the fit is not very accurate. However, little time was available to determine a more proper model.

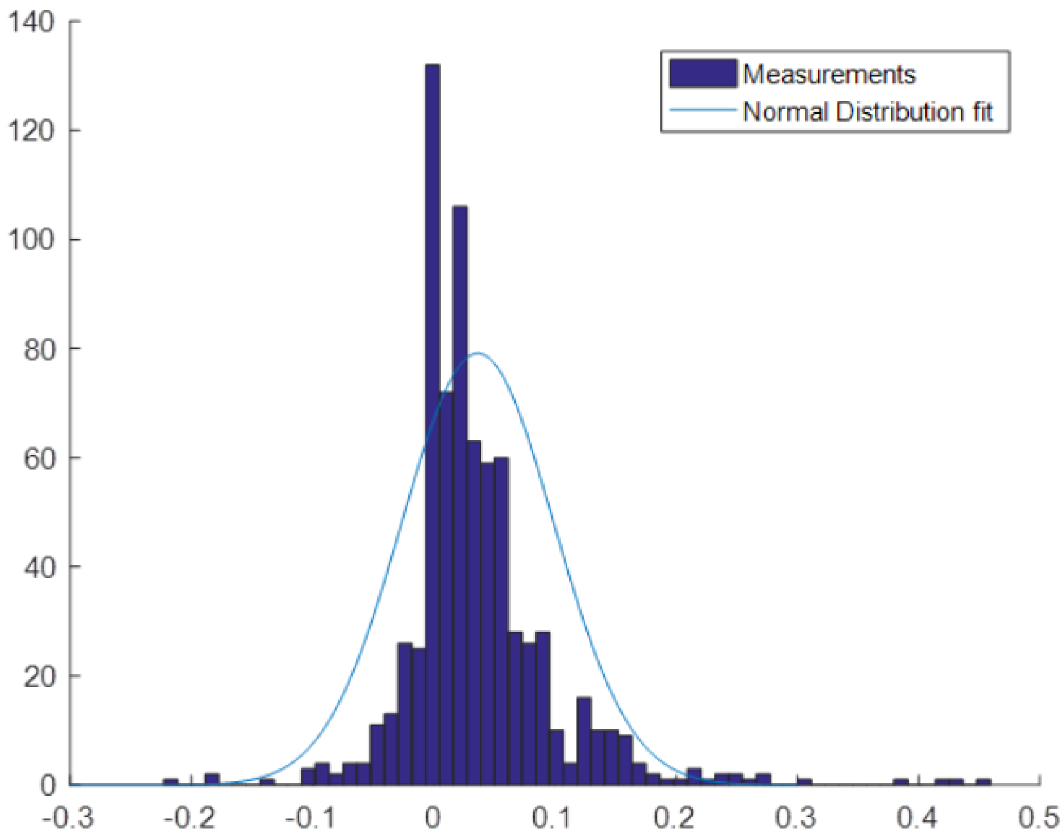

Figure 2: Comparison between the link function and the actual data

Data processing

For the model discussed above, the data obtained by measuring the sediment depth every 4 weeks has to be converted into a daily growth. This was done using the following method: $\frac{(m_i - m_{i-1})}{t}$

In which m_i is the sediment depth at measuring round *i*, m_{i-1} is the sediment depth the measuring round before *i*, and *t* the time in days between the measurements.
This results in 850 total data points, assumed not to be correlated. Even though data from the same gully pot is probably correlated, this is neglected in this research.
When a measurement is missing, the next measurement point is taken and t becomes 8 weeks instead of 4 (exact number of days variates some days per measurement).
The measurement data was first screened manually, data of blocked gully pots were removed, as well as gully pots in which stones or a broken water seal were observed in the sand trap.
Outliers were not removed, since there was no probable cause. A sensitivity study could be done to assess the impact on the model, thought this is not expected to be very significant.
In one street (van Stolkweg), cleaning was done between measuring round 2 and 3, presumably reactive cleaning resulting from blockage complains. Another street (De Lugt) was partially cleaned between measuring round 1 and 2. This has been taken into account and the growth between 2 and 3 for van Stolkweg and 1 and 2 for De Lugt (partially) are removed. All the screening actions combined leave 761 usable data points.

Results

Model 1

The model will be run two times, the first time is to determine between some variables which are the relevant ones and the second run with adapted variables is the end result. This is where the results will be briefly reviewed. An overview of the results from Model 1 can be found in Table 2 below.

Variable	β value	P value
Connected surface area	1,73E-05	4,48E-01
Tree factor	2,10E-03	7,18E-06
Traffic intensity	-9,10E-07	3,46E-01
Road surface	1,77E-02	1,36E-02
Depth sandtrap	1,43E-04	9,05E-01
Size sandtrap	1,49E-03	9,28E-03
Top inlet	-4,77E-03	6,98E-01
Side inlet	-2,43E-02	3,84E-02
Combi inlet	0	NaN

Table 2: Results Model 1

No results were obtained for variable x_9, since not enough data was available for the model. It was chosen to combine combination inlets with top inlets, inlets because of their more similar physical characteristics. It is also observed that the p-value of the sand trap volume is a lot lower than that of the sand trap depth. This answers the question whether the depth or the total volume of a sand trap influences the retaining capacity. As such, it was chosen to remove sand trap depth as a variable.

Model 2

The discoveries made after the first modelling round result in some changes in the variables, which can be viewed in the table below. With these variables, the model was run a second time.

Variable	Index	Type	Unit	Range
Connected surface area	x1	continuous	(m^2)	[671.75 - 6.75]
Tree factor	x2	street specific	(m)	[14.16 - 0.39]
Traffic intensity	x3	street specific	(cars/day)	[10,000 - 500]
Road surface	x4	categorical	-	ashphalt/bricks
Depth sandtrap	x5	continuous	(cm)	[30.5 - 16.5]
Size sandtrap	x6	continuous	(cm^3)	[47170.5 - 8100.0]
Side inlet	x7	categorical	-	side/other

Table 3: New variables deterministic part

Variable	B value	P value
Connected surface area	1,76E-05	4,39E-01
Tree factor	2,13E-03	2,39E-06
Traffic intensity	-9,31E-07	3,33E-01
Road surface	1,78E-02	1,28E-02
Size sandtrap	1,55E-04	9,52E-03
Side inlet	-2,04E-02	2,05E-05

Table 4: Results Model 2

From the results, it appears that the connected surface area is not a relevant factor, this seems somewhat odd and will be further evaluated in the discussion section.
On the opposite, the tree factor seems to be very relevant and has a strong positive relation with sediment load to the gully pot. This is quite interesting, since it is usually not taken into account by models determining sediment load to gully pots.
Traffic intensity seems to not play a role of importance, while the road surface does seem to be relevant with the assumption ($p<0.05$ is relevant) that was chosen here. It suggests that the presence of asphalt would lead to faster growth of the sediment level within a gully pot.
As has been shown in Model 1, the size and not the depth of the sand trap in relevant for sediment capture in a gully pot. Interesting to note is that the p-value of the parameter 'side inlet' decreases drastically with the new category that was chosen, giving very good results.

Discussion

According to our model, the connected surface area does not have a significant effect on the sediment growth in a gully pot. However, Post et al (2016) found this to be a quite relevant factor, as well as Pratt and Adams (1984) and Butler & Karunaratne (1995).

The different results could be explained by the computer model and the data used to determine the contributing surface area of each gully pot. While the same model was used as by Post et al (2016), the elevation data of AHN2 of the investigated area is already 10 years old. Therefore, it might nolonger represent the current elevation profile of the research area

The tree factor gives very strong results, suggesting it could be a very useful parameter when trying to model the sediment load to gully pots. The only research found relating trees to sediment growth is by Chen, Cowling, Polack, Remde, & Mourdjis (2017), reporting that analysis of real-world gully pot maintenance records shows that most complains (>50%) are in fall, suggesting leaffall causes gully pot blockages.

Post et al (2016) found a relationship between road type and sediment growth, with a higher growth rate for main roads than local roads. To determine if this was due to higher traffic intensities or the difference in road surface, those two parameters were both included in this model. It appears that not traffic intensity, but road surface is a relevant factor. It is usually suggested that because of sand washout between the bricks, a brick surface would result in a higher sediment growth rate. However, in this research asphalt was determined to lead to a faster sediment growth. According to Pratt and Adams (1984) and Post et al (2016), the shear force required to suspend material is limiting, rather than the availability of material. This could explain why asphalt leads to a higher sediment growth, since the smooth surface gives less resistance to flow than a brick surface, meaning that the force of the flow remains larger. However, the p-value of the variable road surface was just below the maximum of 0.05. More research should be done to validate this, with a more proper research area for this purpose (our own area was chosen mainly on the tree factor).

As was shown in Model 1, the volume and not the depth of a sand trap is a relevant factor. Since in most laboratory researches, like Memon and Butler (2002), the volume is increased by increasing the depth, it was important to check whether the depth or the volume change had the biggest influence.

Another factor beside the tree factor that is not usually considered, is the type of inlet structure. The difference between a side inlet and a top or combination inlet were very significant. Far less sediment is captured with a side inlet, resulting in a lower sediment growth rate. In practice, this would mean that with more side inlets instead of top inlets, less cleaning activities are needed.To actually implement this, other factors (like blockage of the inlet structure) need to be taken into account as well.

A factor which was not considered in this research was rainfall intensity. The data required had a time lag, making it only available months after recording. A large amount of studies relate rainfall intensity to sediment growth in gully pots, like Ellis and Harrop (1984), Lager et al. (1977) and Butler & Karunaratne (1995). These studies show that rainfall in a very important parameter, worthwhile to include in a model. Following this, rainfall intensity will be included in further research.

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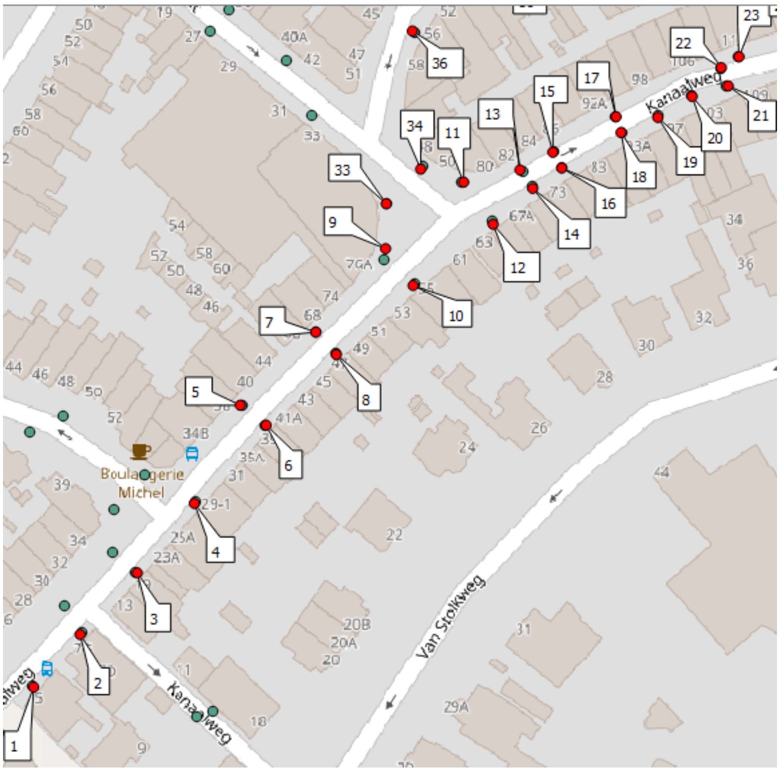
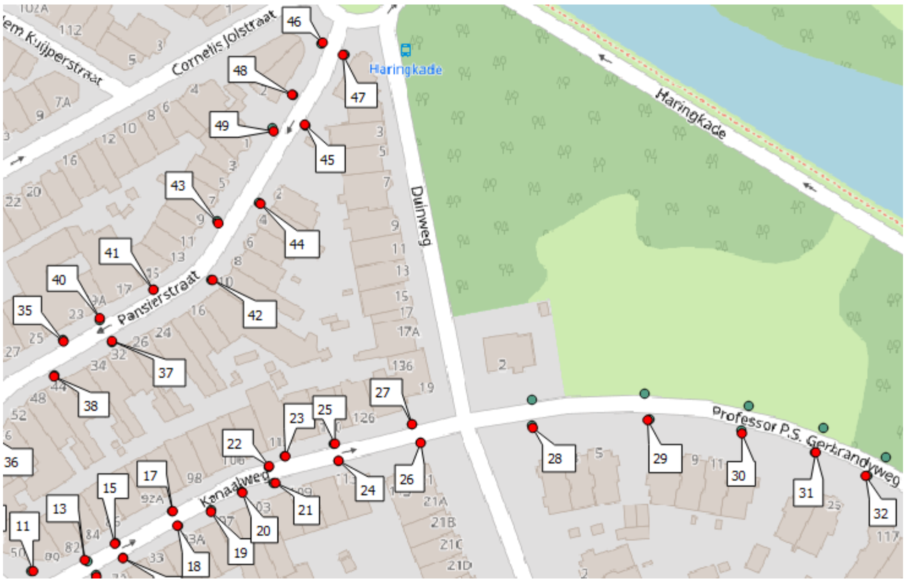
Version 1.3

Appendix

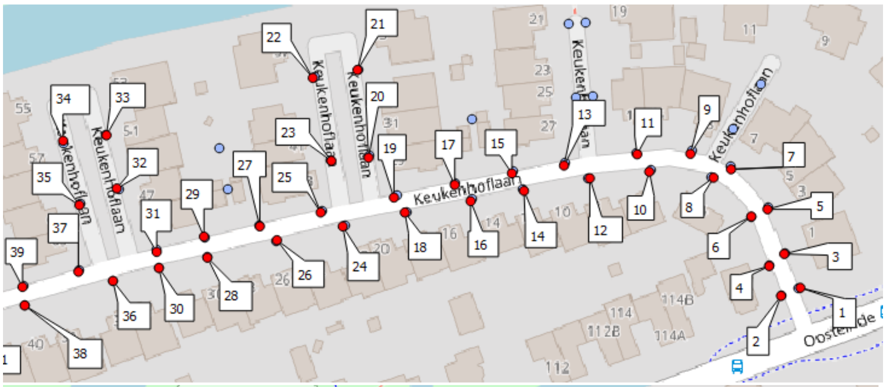
Streets with gully pot locations

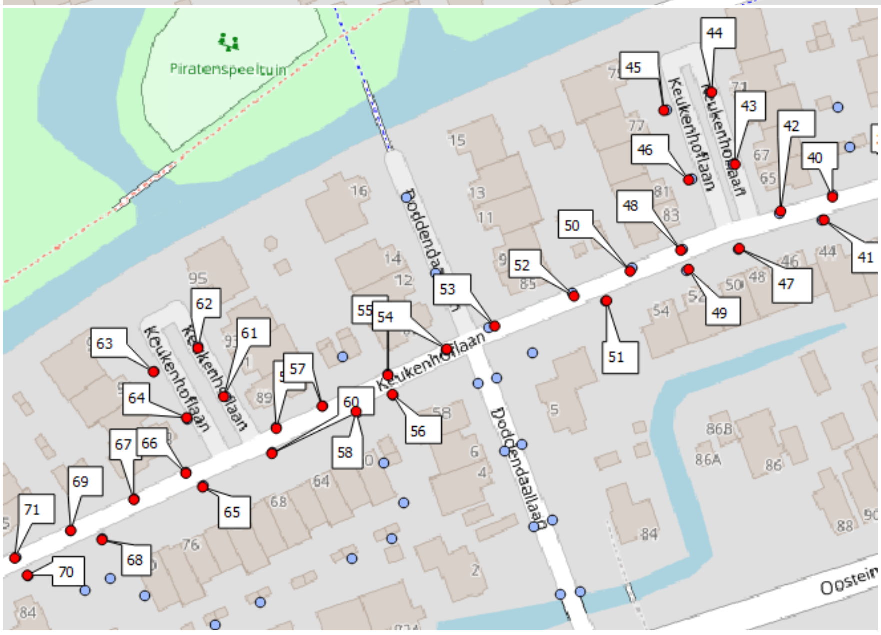
Kanaalweg



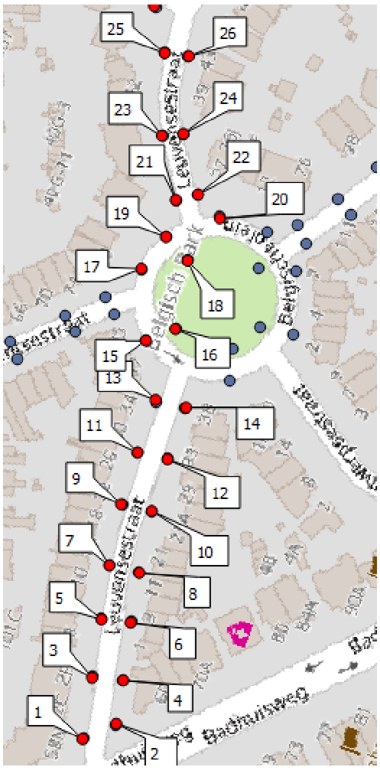


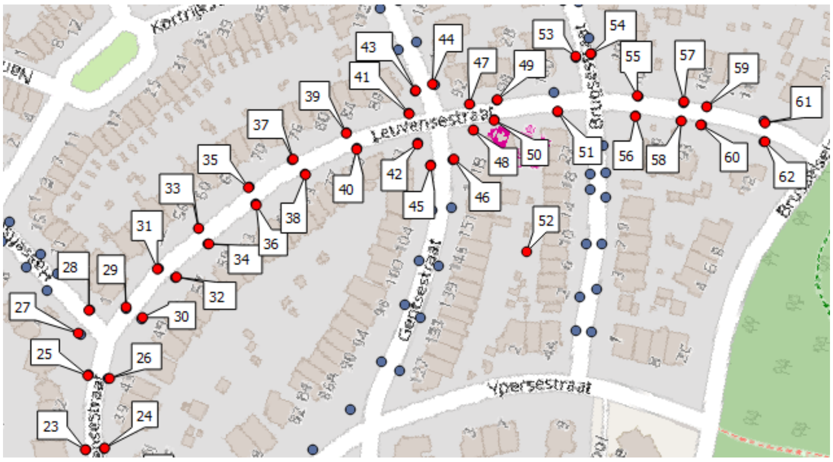
Keukenhoflaan



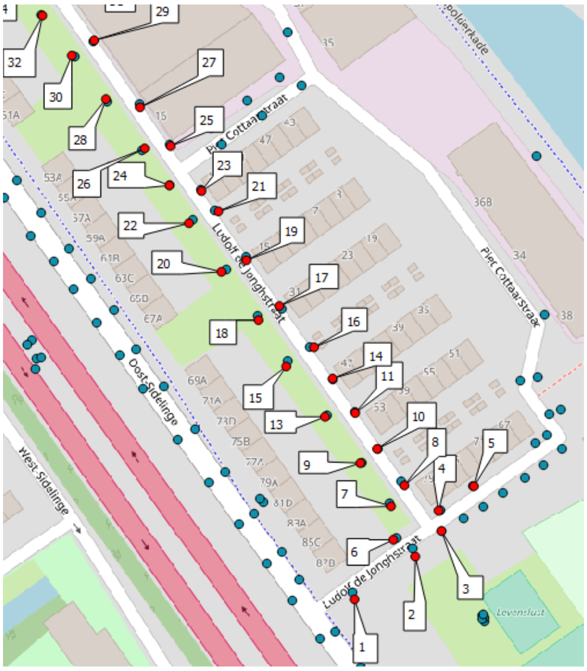


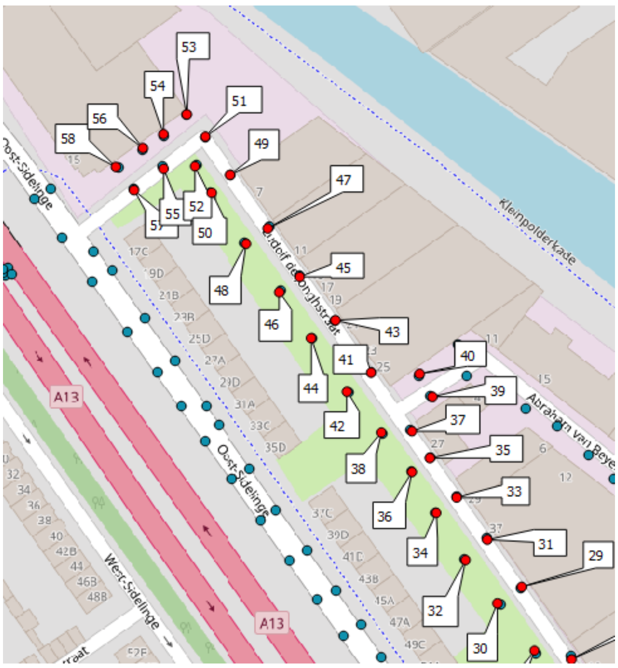
Leuvensestraat



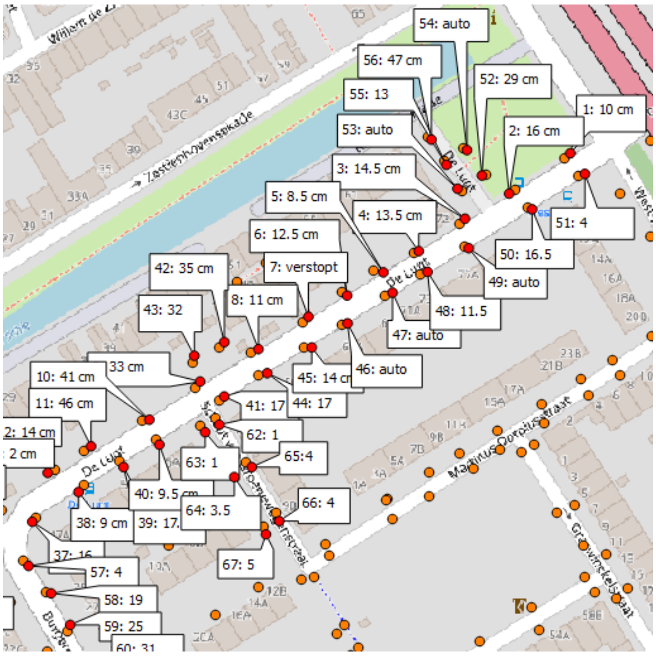


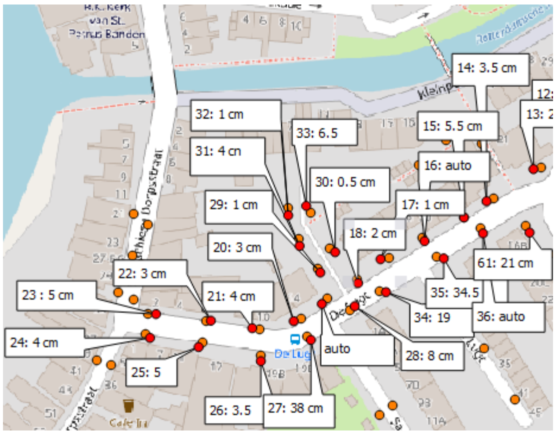
Ludolf de Jonghstraat



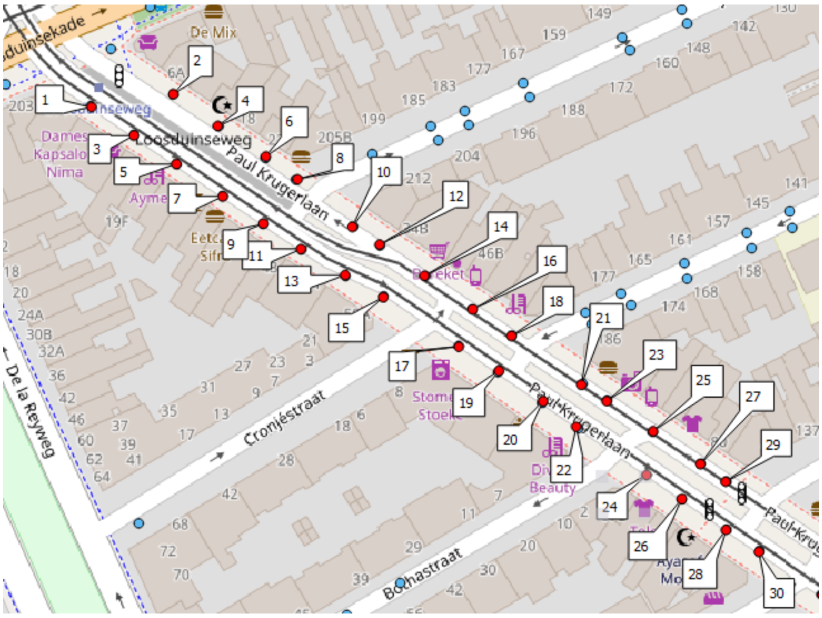


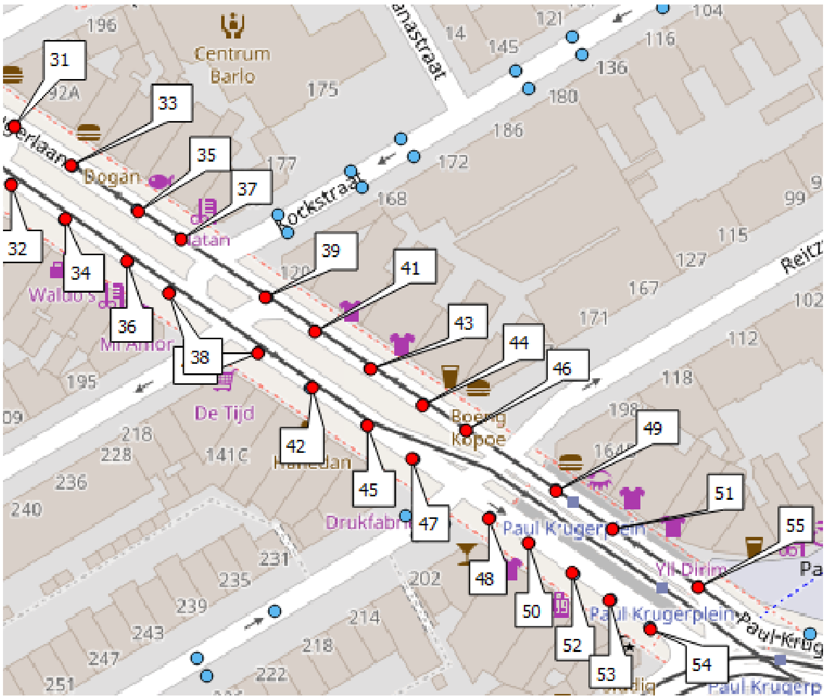
De Lugt





Paul Krugerlaan





van Stolkweg

Measurement data

Kanaalweg

Kanaalweg			Road surface:	Asphalt, exept bricks for 28-32			1 t/m 27	Gebiedsontsluitingsweg			3000 mvt/etm	
							28 t/m 47	Erftoegangsweg			1000 mvt/etm	
nummer	breedte	lengte	Waterlevel	type	zij/boven/combi	uitlaat	Height sandtrap	Volume sandtrap	meting 1	meting 2	meting 3	meting 4
1	35	35	31,5	Aquaway zijinlaat	zij	achter	22,0	26950,0	3	4	4	5
2	34,5	36	35	TBS zijinlaat	zij	achter	25,5	31671,0	0,5	0,5	2	2,75
3	34	37,5	35	TBS zijinlaat	zij	achter	25,5	32512,5	0,5	0,5	1,25	1,5
4	34	38,5	35	TBS zijinlaat	zij	achter	25,5	33379,5	0,5	1	2,5	3,75
5	34	38,5	35	TBS zijinlaat	zij	achter	25,5	33379,5	0,5	1	1,5	3
6	34	38,5	35	TBS zijinlaat	zij	achter	25,5	33379,5	2	0,5	3	3
7	34	38,5	35	TBS zijinlaat	zij	achter	25,5	33379,5	2	2	4	2,5
8	34,5	37,5	35	TBS zijinlaat	zij	achter	25,5	32990,6	0	0,5		
9	34	38	35	TBS zijinlaat	zij	achter	25,5	32946,0	0	0,5		2
10	34	37,5	35	TBS zijinlaat	zij	achter	25,5	32512,5	1	1,5	2,25	2,5
11	34	38	35	TBS zijinlaat	zij	achter	25,5	32946,0	1		1,75	
12	34,5	38	35	TBS zijinlaat	zij	achter	25,5	33430,5	1		2,75	
13	28	28	40	weegels boveninlaat	boven		30,5	23912,0			7,5	8,5
14	28	28	40	Weegels boveninlaat	boven		30,5	23912,0		3	4,25	4,75
15	30	34		TBS boveninlaat	boven						3,5	
16	30,5	35	35	TBS boveninlaat	boven		25,5	27221,3	2			
17				TBS boveninlaat	boven							
18				TBS boveninlaat	boven							
19	30,5	35	35	TBS boveninlaat	boven		25,5	27221,3	4,5	4,5	5	4,75
20	30,5	35	35	TBS boveninlaat	boven		25,5	27221,3	1	1	2,25	3
21	34	38,5	29	TBS zijninlaat	boven		19,5	25525,5			1,5	1,5
22	30	34,5	35	TBS boveninlaat	boven		25,5	26392,5	3		4,5	15
23	30	35	35	TBS boveninlaat	boven		25,5	26775,0			4,5	
24	34	37,5	33	TBS zijinlaat	zij	achter	23,5	29962,5	0,5	0,5	1,5	1
25	30	35	35	TBS boveninlaat	boven		25,5	26775,0			2,75	2
26	34,5	38,5	28	TBS zijinlaat	zij	achter	18,5	24572,6	1	0,5	1,25	1,25
27	34,5	38	28	TBS zijinlaat	zij	achter	18,5	24253,5	1	1	1,5	1,5
28	32	35	29	Weegels weert zijinlaat	zij	achter	19,5	21840,0	0,5	1,5	2,5	2,25
29	32	35	29	Weegels weert zijinlaat	zij	achter	19,5	21840,0	1,5	2	3	3,5
30	32	35	29	Weegels weert zijinlaat	zij	achter	19,5	21840,0	1,5	1,5	3	3
31	32	35	29	Weegels weert zijinlaat	zij	achter	19,5	21840,0	1,5	1,5	2	2,5
32	32	35	29	Weegels weert zijinlaat	zij	achter	19,5	21840,0	1,5	1,5	2	1,75
33	34	38,5	35	zijinlaat	zij	achter	25,5	33379,5	0,5	0,5	2,5	
34	34	38	35	zijinlaat	zij	achter	25,5	32946,0		0,5	1	2
35	34	38,5	35	zijinlaat	zij	achter	25,5	33379,5	0,5	1	3	3,75
36	34	38,5	35	zijinlaat	zij	achter	25,5	33379,5	0,5	1	1,5	1,5
37	34	38	35	zijinlaat	zij	achter	25,5	32946,0	0,5	1	2	5,5
38												
39	34	38,5	35	zijinlaat	zij	achter	25,5	33379,5	0,5	0,5	4	7,5
40	34	37,5	35	zijinlaat	zij	achter	25,5	32512,5	0,5	1,75	1	3
41	34	38	35	zijinlaat	zij	achter	25,5	32946,0	0,5	0,5	1,5	3,5
42	34,5	38	35	zijinlaat	zij	achter	25,5	33430,5	0,5	0,75	1	2
43	33,5	38	35	zijinlaat	zij	achter	25,5	32461,5	0,5	0,5	1	3,5
44	34	38	35	zijinlaat	zij	achter	25,5	32946,0	0,5	1,5	3	6,5
45	34	38	35	zijinlaat	zij	achter	25,5	32946,0	0,5	1,5	2	5,75
46	35	38,5	35	zijinlaat	zij	achter	25,5	34361,3	0,5	0,5	1,5	2,5
47	34	37,5	35	zijinlaat	zij	achter	25,5	32512,5	0,5	0,5	1,25	1,75
48	34,5	39	35	zijinlaat	zij	achter	25,5	34310,3	0,5	1,5	1	1
49	34,5	38	35	zijinlaat	zij	achter	25,5	33430,5	0,5	0,5	1,75	6,5

Keukenhoflaan

Keukenhoflaan			Road surface:	Bricks	Erftoegangsweg		500 mvt/etm			
nummer	breedte	lengte	Waterlevel	type	zij/boven/combi	Height sandtrap	Volume sandtrap	meting 1	meting 2	meting 3
1	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	14		15,5
2	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	11	12	12,5
3	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9		3	4
4	35,5	20,5	30	Weegels weert boven	boven					
5	35,5	20,5	30	Weegels weert boven	boven					8,5
6	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9		18,5	
7	35	35	29	Weegels weert zij	zij	19,5	23887,5	2	1,5	1,5
8	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9		12	12
9	35	35	29	Weegels weert zij	zij	19,5	23887,5	1,5	5	5
10	35	35	29	Weegels weert zij	zij	19,5	23887,5	1,5	1,5	1,5
11	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	4,5	4,5	
12	35	35	29	Weegels weert zij	zij	19,5	23887,5	1,5	2	2
13	35	35	29	Weegels weert zij	zij	19,5	23887,5	2	1,5	2
14	35	35	29	Weegels weert zij	zij	19,5	23887,5	1,5	1,75	1,5
15	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	2	3	3
16	35	35	29	Weegels weert zij	zij	19,5	23887,5	1,5	1,75	2
17	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	6		
18	35	35	29	Weegels weert zij	zij	19,5	23887,5	1,5	1,75	3
19	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	5		6,5
20	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	1	1,25	1,25
21	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	1,5	1	1,5
22	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	1	0,5	1,25
23	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	5,5	5,5	5,25
24	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	1,5	1,75	2,25
25	35	35	29	Weegels weert zij	zij	19,5	23887,5	2	2,5	3,25
26	35	35	29	Weegels weert zij	zij	19,5	23887,5	2	2	2
27	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	0,5	1	1,5
28	35	35	29	Weegels weert zij	zij	19,5	23887,5	1,5	2	1,75
29	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	4,5	5	5,25
30	35	35	29	Weegels weert zij	zij	19,5	23887,5	1,5	1,5	1,5
31	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9		1	
32	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	2	1,5	2
33	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	0,5	0,5	1
34	35,5	20,5		Weegels weert boven	boven					4,5
35	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	1,5	1,75	2,75
36	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	1,5	2	3,5
37	35,5	20,5		Weegels weert boven	boven					
38	35	35	29	Weegels weert zij	zij	19,5	23887,5	1,5	2	2
39	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	7	8,5	6,75
40	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	1	1,5	
41	35	35	29	Weegels weert zij	zij	19,5	23887,5	1,5	1,75	1,75
42	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	2		1,75
43	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	3,5	3,5	3,25
44	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	3,5	3,5	4
45	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	0,5	2,5	4,75
46	35,5	20,5		Weegels weert boven	boven					3
47	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	15,5	19	21
48	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	6,5		
49	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	1,5	1,5	1,75
50	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	12,5	12,5	12,5
51	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	0,5	1	3
52	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	8	7	6,75
53	35	35	29	Weegels weert zij	zij	19,5	23887,5	1,5	2	2,5
54	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	5,5		6,75
55	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9		11	10,25
56	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	3	3	3,25
57	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	2,5	4,5	5,25
58	35	35	29	Weegels weert zij	zij	19,5	23887,5	0,5	1,5	2,75
59	35,5	20,5		Weegels weert boven	boven					
60	35	35	29	Weegels weert zij	zij	19,5	23887,5	1,5	1,5	4
61	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	3	2,5	3,25
62	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	3	3	3
63	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	6,5	7,5	
64	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	10	11	12
65	35,5	20,5	30	Weegels weert boven	boven	20,5	14918,9	3	11,75	7,75
66	35,5	20,5		Weegels weert boven	boven					
67	35,5	20,5		Weegels weert boven	boven					
68	35	35	29	Weegels weert zij	zij	19,5	23887,5	1,5	1,75	3,75
69	35,5	20,5		Weegels weert boven	boven					
70	35	35	29	Weegels weert zij	zij	19,5	23887,5	2	1,5	3,25
71	35,5	20,5		Weegels weert boven	boven					11,25

Leuvensestraat

Leuvensestraat				Erftoegangsweg	<1000 mvt/etm		Road surface:	Bricks				
nummer	breedte	lengte	Waterlevel	type	Height sandt	Volume sandtrap	zij/boven/combi	uitlaat	meting 1	meting 2	meting 3	meting 4
1												7
2	35,5	35	27	Weegels zijinlaat	17,5	21743,8	zij	achter	1,5			5,5
3	35	35	27	Weegels zijinlaat	17,5	21437,5	zij	achter	1,5	1,5	2,5	4,75
4	35,5	33	29	TBS zijinlaat	19,5	22844,3	zij	achter	1	1,5	3,5	5
5	35	35	27	Weegels zijinlaat	17,5	21437,5	zij	achter			3,25	5,25
6	35	35	27	Weegels zijinlaat	17,5	21437,5	zij	achter	2	2,5		5
7	34,5	38,5	29	TBS zijinlaat	19,5	25900,9	zij	achter	0,5	1,5	2	
8	35	35	27	Weegels zijinlaat	17,5	21437,5	zij	achter	2	3	2,5	3,5
9	36	33	29	TBS zijinlaat	19,5	23166,0	zij	achter	0,5	1	2,25	
10	35	35	27	Weegels zijinlaat	17,5	21437,5	zij	achter	1,5	2		2,5
11	36,5	33	29	TBS zijinlaat	19,5	23487,8	zij	achter	0,5	2		
12	35	35	27	Weegels zijinlaat	17,5	21437,5	zij	achter	1,5	2,25	6,75	5
13	36	33	32	zijinlaat	22,5	26730,0	zij	achter	0,5	1	2	2,75
14	35	35	27	Weegels zijinlaat	17,5	21437,5	zij	achter	2	2,5	3	2
15	36	33	29	TBS zijinlaat	19,5	23166,0	zij	achter	1	1,5	3	2
16	36,5	33,5	29	TBS zijinlaat	19,5	23843,6	zij	achter	1,5	2,5	5	6
17	36,5	33	35	zijinlaat	25,5	30714,8	zij	achter	1,5	2	2,75	1,5
18	36,5	32,5	35	zijinlaat	25,5	30249,4	zij	achter	1	0,25	3	1,25
19	36,5	34	29	TBS zijinlaat	19,5	24199,5	zij	achter	5	6	6,5	5
20	37	33	29	TBS zijinlaat	19,5	23809,5	zij	achter	2,5	4	3	3,25
21	38	34	35	zijinlaat	25,5	32946,0	zij	achter	0,5	2	2,5	2,5
22	38,5	34,5	35	zijinlaat	25,5	33870,4	zij	achter	0,5	2	9,25	9,25
23	38,5	34	35	zijinlaat	25,5	33379,5	zij	achter	0,5	2	2,75	4
24	38,5	34,5	35	zijinlaat	25,5	33870,4	zij	achter	0,5	1,5	2,25	2
25	39	34,5	35	zijinlaat	25,5	34310,3	zij	achter	1	3	2,75	2,5
26	38,5	34,5	35	zijinlaat	25,5	33870,4	zij	achter	0,5	1	2	1,25
27	35	35	27	Weegels zijinlaat	17,5	21437,5	zij	achter	8	9,5	1	9,75
28	35	35	34	zijinlaat	24,5	30012,5	zij	achter	3	5,5	4,5	4
29	35	35	26	Aquaway zijinlaat	16,5	20212,5	zij	achter	4	5	5	4,5
30	35	35	26	Aquaway zijinlaat	16,5	20212,5	zij	achter	4	4	4	4,75
31	35	35	26	Aquaway zijinlaat	16,5	20212,5	zij	achter	3,5	5	5,5	5,25
32	D = 24		35	Aquaway zijingang	25,5	11535,9	zij	achter		3		7
33	35	35	26	Aquaway zijinlaat	16,5	20212,5	zij	achter	4		6,5	4,25
34	35	35	26	Aquaway zijinlaat	16,5	20212,5	zij	achter	4	7	7	5
35	35	35	26	Aquaway zijinlaat	16,5	20212,5	zij	achter	4	4,5	5	
36	35	35	26	Aquaway zijinlaat	16,5	20212,5	zij	achter	4		4	4
37	35	35	26	Aquaway zijinlaat	16,5	20212,5	zij	achter		5		4
38	35	35	26	Aquaway zijinlaat	16,5	20212,5	zij	achter	5	6	7	6,5
39	35	35	26	Aquaway zijinlaat	16,5	20212,5	zij	achter	4	4	4,5	4,5
40	35	35	26	Aquaway zijinlaat	16,5	20212,5	zij	achter	4	4,5	5	
41	35	35	26	Aquaway zijinlaat	16,5	20212,5	zij	achter	4	4	4,25	5
42	35	35	26	Aquaway zijinlaat	16,5	20212,5	zij	achter	4,5	9	8,5	5,25
43	39	34	33	zijinlaat	23,5	31161,0	zij	achter	2,5	3	4,25	3,25
44	39	34	33	zijinlaat	23,5	31161,0	zij	achter	8	10	11	13
45	35	35	27	Weegels zijinlaat	17,5	21437,5	zij	achter	2,5		4,75	2,5
46	35	35	26	Aquaway zijinlaat	16,5	20212,5	zij	achter	5,5	7	7,5	5
47	38	34	33	zijingang	23,5	30362,0	zij	achter	0,5	1,5	2	2,25
48	35	35	26	Aquaway zijinlaat	16,5	20212,5	zij	achter	3,5	6	6,75	5,5
49	35	35	27	Weegels zijinlaat	17,5	21437,5	zij	achter	2	2	2,25	2,75
50	34,5	34,5	26	Aquaway zijinlaat	16,5	19639,1	zij	achter		7	8,5	10
51	35	35	26	Aquaway zijinlaat	16,5	20212,5	zij	achter	4		5,5	5,25
52	35	35	26	Aquaway zijinlaat	16,5	20212,5	zij	achter	4	5	5	6,75
53	35	35	34	zijinlaat	24,5	30012,5	zij	achter	2	3	3	2,5
54	35	35	34	zijinlaat	24,5	30012,5	zij	achter	2,5	3	3	2,25
55	41	38,5	32	Budems zijinlaat	22,5	35516,3	zij	voor	0,5	2	1,5	1,25
56	40	39	32	Budems zijinlaat	22,5	35100,0	zij	voor	0,5	0,5	2,5	2,5
57	35	35	27	Weegels zijinlaat	17,5	21437,5	zij	achter	1,5	2	2	1,75
58	35	35	27	Weegels zijinlaat	17,5	21437,5	zij	achter	1,5		4,5	6,5
59	41	39	32	Budems zijinlaat	22,5	35977,5	zij	voor	1	1,75	2	3,75
60	40,5	38	32	Budems zijinlaat	22,5	34627,5	zij	voor		1	2	3
61	40,5	38	32	Buderus zijinlaat	22,5	34627,5	zij	voor	0,5	1	2	1,5
62	41	39	39	Globe zijinlaat	29,5	47170,5	zij	voor	1	2	1,25	1,5

Ludolf de Jonghstraat

Ludolf de Jonghstraat				Road surface:	Bricks		Erftoegangsweg		<1000 mvt/etm		
nummer	breedte	lengte	Waterlevel	type	zij/boven/combi	Height sandtrap	Volume sandtrap	meting 1	meting 2	meting 3	meting 4
1	35	35	34	TBS zijinlaat	zij	24,5	30012,5	4,5	6	6,5	7,5
2											
3	35	35	34	TBS zijinlaat	zij	24,5	30012,5	2	6,5	6	6,5
4	35	35	34	TBS zijinlaat	zij	24,5	30012,5	11	7	9,5	11
5	35	35	34	TBS boveninlaat	boven	24,5	30012,5	1,5	1	13,5	1,5
6				TBS zijinlaat	zij						
7	35	35	34	TBS boveninlaat	boven	24,5	30012,5		4	8	
8	35	35		TBS boveninlaat	boven				3,5		
9	35	35	34	TBS boveninlaat	boven	24,5	30012,5	4	4	3,75	4,25
10	35,5	35,5								36	
11	35	35	34	TBS zijinlaat	zij	24,5	30012,5	4	4	4,25	4,5
13	35	35	34	TBS boveninlaat	boven	24,5	30012,5	4,5	6,5	7	12,5
14	35	35		TBS boveninlaat	boven						
15	35	35	34	TBS boveninlaat	boven	24,5	30012,5	2	4	5	8
16	35	35	31	zijinlaats	zij	21,5	26337,5	4,5	4	4	6,5
17	35	35	34	TBS boveninlaat	boven	24,5	30012,5	31		33	
18	35	35	34	TBS boveninlaat	boven	24,5	30012,5	4,5	6	6,5	9,75
19	35	35	34	TBS boveninlaat	boven	24,5	30012,5	19,5	20,5	21,5	22
20	35	35	34	TBS boveninlaat	boven	24,5	30012,5	7	9	12	15,5
21	35	35	34	TBS boveninlaat	boven	24,5	30012,5	4,5	6,5	7	9,25
22	35	35	34	TBS boveninlaat	boven	24,5	30012,5		2	1,75	2,5
23	35	35	34	TBS zijinlaat	zij	24,5	30012,5	4	3,5	4	4,25
24	35	35	34	TBS zijinlaat	zij	24,5	30012,5	5	4,5	4,75	6
25	35	36	34	TBS zijinlaat	zij	24,5	30870,0			2,75	
26	35	35	34	TBS boveninlaat	boven	24,5	30012,5	5	8	9	13,5
27	35	35	34	TBS boveninlaat	boven	24,5	30012,5	6	4,5	5,75	5,5
28	35	35	34	TBS boveninlaat	boven	24,5	30012,5	5	12,5	9	11
29	35	35	34	TBS boveninlaat	boven	24,5	30012,5	2	3,5	2,75	3,5
30	35	35	34	TBS boveninlaat	boven	24,5	30012,5	5	5,5	5,75	8
31	35	35	34	TBS boveninlaat	boven	24,5	30012,5	3		4,75	5,75
32	35	35	34	TBS boveninlaat	boven	24,5	30012,5	3	5,5	6	5,5
33	35	35	34	TBS boveninlaat	boven	24,5	30012,5	5,5		3	
34	35	35	34	TBS boveninlaat	boven	24,5	30012,5	4,5		7	
35	35	35	34	TBS boveninlaat	boven	24,5	30012,5	3		4	
36	35	35	34	TBS zijinlaat	zij	24,5	30012,5	4		3	
37	35	35	34	TBS boveninlaat	boven	24,5	30012,5	3	1,5	2,5	
38	35	35	34	TBS boveninlaat	boven	24,5	30012,5	6	9,5	10,75	14
39	35	35	34	TBS boveninlaat	boven	24,5	30012,5	1	3,5		3,25
40	35	35	34	TBS boveninlaat	boven	24,5	30012,5	4	4,5	6,75	10
41	35	35	34	TBS boveninlaat	boven	24,5	30012,5	1,5	3,5	6,5	4
42	35	35	34	TBS boveninlaat	boven	24,5	30012,5	4,5	4	7,25	9
43	35	35	34	TBS boveninlaat	boven	24,5	30012,5	4	4,5	5	5
44	35	35	34	TBS boveninlaat	boven	24,5	30012,5	2			3,5
45	35	35	34	TBS boveninlaat	boven	24,5	30012,5	4	5	6	7,75
46	35	35	34	TBS boveninlaat	boven	24,5	30012,5	5	7	7,5	8,25
47											
48											
49	35	35	34	TBS boveninlaat	boven	24,5	30012,5	4	7,5	9	9,5
50	35	35	34	TBS boveninlaat	boven	24,5	30012,5	2	4,5		
51	35	35	34	TBS boveninlaat	boven	24,5	30012,5	3,5	4,5	6	6,5
52	35	35	29	Wegels zijinlaat	zij	19,5	23887,5	3,5	3,5	3	1,5
53	35	35	34	TBS boveninlaat	boven	24,5	30012,5	4,5	8,5	8	11,5
54	35	35	34	TBS boveninlaat	boven	24,5	30012,5	5	8,5	9	9,5
55				zijinlaats	ziji						
56											
57											
58	35	35	34	TBS boveninlaat	boven	24,5	30012,5		3,5		

De Lugt

De Lugt				Road surface:	Bricks	Gebiedsontsluitingswegen			6000 mvt/etm		
						Erftoegangsweg			1000 mvt/etm		
						Gebiedsontsluitingswegen			6000 mvt/etm		
nummer	breedte	lengte	Waterlevel	type	zij/boven/combi	Height sandtrap	Volume sandtrap	meting 1	meting 2	meting 3	meting 4
1	35	35	34	TBS zijinlaat	zij	24,5	30012,5	10	4	4,5	4,5
2	35	35	34	TBS zijinlaat	zij	24,5	30012,5	16	4	4,5	6
3	35	35	34	TBS zijinlaat	zij	24,5	30012,5	14,5	4	3,75	4,5
4	35	35	34	TBS zijinlaat	zij	24,5	30012,5	13,5	5	4,5	5,25
5	35	35	34	TBS boveninlaat	boven	24,5	30012,5	8,5	4,5	5	5,25
6	35	35	34	TBS boveninlaat	boven	24,5	30012,5	12,5	5	7	9
7	35,5	36		TBS zijinlaat	zij	achter				4,5	
8	35	35	34	TBS zijinlaat	zij	24,5	30012,5	11	2,5	3,5	2,75
9	35	35	34	TBS zijinlaat	zij	24,5	30012,5	33	10,5	18	16
10	35	35	40	Weegels Weert boven	boven	30,5	37362,5	41	43	44,5	44,5
11	35	35	40	Weegels Weert boven	boven	30,5	37362,5	46	8,5	11	12
12	35	35	34	TBS boveninlaat	boven	24,5	30012,5	14	3,5	4,5	5
13	35	35	34	TBS zijinlaat	zij	24,5	30012,5	2	2	1,5	2
14	35	35	34	TBS zijinlaat	zij	24,5	30012,5	3,5	3,5	4,5	5
15	35	35	34	TBS zijinlaat	zij	24,5	30012,5	5,5	6	5,5	6,5
16				TBS boveninlaat	boven					45,5	
17	26		30,5	MBI rond	zij	21,0	11149,5	1	1,5	3	3,25
18	35	35	34	TBS boveninlaat	boven	24,5	30012,5	2	2,5		2,25
19	35	35	34	TBS boveninlaat	boven	24,5	30012,5		17,5	18,5	
20	35	35	34	TBS zijinlaat	zij	24,5	30012,5	3	3	2,75	2,5
21	35	35	34	TBS zijinlaat	zij	24,5	30012,5	4	4,5	5	6,5
22	35	35	34	TBS zijinlaat	zij	24,5	30012,5	3	3	4,5	5,5
23	35	35	34	TBS zijinlaat	zij	24,5	30012,5	5	5	5,5	5,5
24	35	35	34	TBS zijinlaat	zij	24,5	30012,5	4	4,25	4	4,75
25	35	35	34	TBS zijinlaat	zij	24,5	30012,5	5	5	6,5	6,5
26	35	35	34	TBS zijinlaat	zij	24,5	30012,5	3,5	3,5	3,5	3,5
27	35	35	34	TBS boveninlaat	boven	24,5	30012,5	38	37	43	
28	35	35	34	TBS zijinlaat	zij	24,5	30012,5	8	9	10	10
29	35	35	34	TBS boveninlaat	boven	24,5	30012,5	1	2,5	6	3,5
30	35	35	34	TBS boveninlaat	boven	24,5	30012,5	0,5		1,5	
31	35	35	34	TBS boveninlaat	boven	24,5	30012,5	4	5	6,5	6,5
32	35	35	34	TBS boveninlaat	boven	24,5	30012,5	1	2,5	3,5	3,5
33	35	35	34	TBS zijinlaat	zij	24,5	30012,5	6,5		6,5	2,5
34	35	35	34	TBS zijinlaat	zij	24,5	30012,5	19	20,5	21,5	20,5
35	35	35	34	TBS zijinlaat	zij	24,5	30012,5	34,5	35,5	36,5	36
36	35,5	36	34	TBS zijinlaat	zij	24,5	31311,0		14,5		14,5
37	35	35	34	TBS zijinlaat	zij	24,5	30012,5	16	6,5	9	11,25
38	31	31	31	MBI rond	zij	21,5	20661,5	9	2	4	4
39	35	35	40	weegels zijinlaat	zij	30,5	37362,5	17,5	3	3,5	4
40	35	35	40	weegels zijinlaat	zij	30,5	37362,5	9,5	2,5	3,5	3,5
41	35	35	34	TBS zijinlaat	zij	24,5	30012,5	17	8	9,5	9,5
42	35	35	34	ten cate boven	boven	24,5	30012,5	35	2,5		3
43	35	35	34	ten cate boven	boven	24,5	30012,5	32	1,5		6,5
44	35	35	32	tbs combi	combi	22,5	27562,5	17			4,5
45	35	35		tbs combi	combi			14			
46	34,5	34,5	34	TBS zijinlaat	zij	24,5	29161,1		10,5	11	11
47	34,5	34,5	34	TBS zijinlaat	zij	24,5	29161,1			29,5	
48	35	35	34	tbs combi	combi	24,5	30012,5	11,5	4,5	5	
49	34,5	34,5	34	TBS zijinlaat	zij	24,5	29161,1		15,5	16,5	15,75
50	35	35	34	TBS zijinlaat	zij	24,5	30012,5	16,5	3,5	4	5,5
51	35	35	34	TBS zijinlaat	zij	24,5	30012,5	4	3,5	3,75	4,5
52	35	35	34	TBS boveninlaat	boven	24,5	30012,5	29	3		5,5
53	40	40,5	32	W ten Cate boveninlaa	boven	22,5	36450,0		1,5		2
54	40	40,5	14,5	W ten Cate boveninlaa	boven	5,0	8100,0		12		
55	35	35	34	tbs boveninlaat	boven	24,5	30012,5	13	5,5		7,5
56	35	35	34	TBS boveninlaat	boven	24,5	30012,5	47	4		6,5
57	35	35	34	TBS zijinlaat	zij	24,5	30012,5	4	5	5	5
58	35	35		weegels boven	boven						
59	35	35		weegels boven	boven						
60	35	35		weegels boven	boven						
61	35	35	40	zijinlaat	zij	30,5	37362,5	21	4,5	5,5	7,25
62	35	35	34	TBS zijinlaat	zij	24,5	30012,5	1		1,5	0,5
63	35	35	34	TBS boveninlaat	boven	24,5	30012,5	1		4	4,25

Paul Krugerlaan

Paul Krugerlaan		Road surface:	ashpalt					Gebiedsontsluitingswegen		10000 mvt/etm	
nummer	breedte	lengte	Waterlevel	type	zij/boven,	uitlaat	Height sandtrap	Volume sandtrap	meting 1	meting 2	meting 3
1	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	2,5	3	3,5
2	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	2,5	3,5	4
3	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	2,5	3	4
4	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4		3,5	4,25
5	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	2,5	3,5	4,5
6	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	3,5		3,75
7	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	2,5	4	10
8	35	35	27	AquaWay zij	zij	achter	17,5	21437,5	4,5	5	5,5
9	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	9,5	15	14,5
10	35	35	27	AquaWay zij	zij	achter	17,5	21437,5	4,5	4,75	4,5
11	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4		7	7
12	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	2,75	3,75	4,5
13	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	3,5	4,5	4,5
14	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	3		4,5
15	19,5	34,5		AquaWay boven	boven						
16	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	3	4,5	6
17	19,5	34,5		AquaWay boven	boven						
18	35	35	27	AquaWay zij	zij	achter	17,5	21437,5	4	5	5
19	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	2,5	4,5	6,5
20	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	3,5	4,5	4,5
21	35	35	27	AquaWay zij	zij	achter	17,5	21437,5	4	5	5
22	35	35	27	AquaWay zij	zij	achter	17,5	21437,5	4	5,5	5
23	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	2		3
24	35	35	27	AquaWay zij	zij	achter	17,5	21437,5	4	4,75	5,5
25	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4		3	5
26	19,5	34,5		AquaWay boven	boven						
27	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	2	3	4,5
28	35	35	27	AquaWay zij	zij	achter	17,5	21437,5	4	3,75	4
29	35	35	27	AquaWay zij	zij	achter	17,5	21437,5	4	4,5	3,75
30	35	35	27	AquaWay zij	zij	achter	17,5	21437,5	4	4,5	5,5
31	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	3,5	4,25	4,25
32	35	35	27	AquaWay zij	zij	achter	17,5	21437,5	4	4,25	4,5
33	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	3,5	4	4
34	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4		3,25	4
35	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	3,5	4	4
36	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4		12	12
37	35	35	27	AquaWay zij	zij	achter	17,5	21437,5	4	4	4,5
38	35	35	27	AquaWay zij	zij	achter	17,5	21437,5	4	4,25	4,75
39	35	35	27	AquaWay zij	zij	achter	17,5	21437,5	4	4	4,5
40	35	35	27	AquaWay zij	zij	achter	17,5	21437,5	4	4,75	6,25
41	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	2	2,5	4,25
42	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	2	3,75	4
43	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	3	4,25	10,75
44	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	3,5	4	5
45	19,5	34,5		AquaWay boven	boven						
46	19,5	34,5		AquaWay boven	boven						
47	35	35	27	AquaWay zij	zij	achter	17,5	21437,5	4	4,5	4,5
48	35	35	27	AquaWay zij	zij	achter	17,5	21437,5	3,5	5	5
49	19,5	34,5		AquaWay boven	boven						
50	19,5	34,5	30	AquaWay boven	boven	achter	20,5	13791,4	4	5	6
51	35	35	27	AquaWay zij	zij	achter	17,5	21437,5	4	7	7,5
52	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	13,5	17	
53	19,5	34,5	30	AquaWay boven	boven		20,5	13791,4	5	8	9,5
54	35	35	27	AquaWay zij	zij	achter	17,5	21437,5	1,5	4	4,5
55	35	35	27	AquaWay zij	zij	achter	17,5	21437,5	4	5	6,25

Van Stolkweg

van Stolkweg				Erftoegangsweg:	<1000 mvt/etm			Road surface:	Bricks			
nummer	breedte	lengte	Waterlevel	type	zij/boven/combi	uitlaat	Height sandtrap	Volume sandtrap	meting 1	meting 2	meting 3	meting 4
1	32	35	28	Weegels combi	combi	achter	18,5	20720,0	1,5	2	1,5	3,75
2	32	35	28	Weegels combi	combi	achter	18,5	20720,0	1,5	3	2	3,5
3	32	35	28	Weegels combi	combi	achter	18,5	20720,0	1,5	2	1,5	4
4	32	35	34	TBS combi	combi	achter	24,5	27440,0	3,5	4		
5	32	35	28	Weegels combi	combi	achter	18,5	20720,0	1,5	2,5	2,5	4,5
6	32	35	34	TBS combi	combi	achter	24,5	27440,0	3,5		3,75	6
7	32	35	28	Weegels combi	combi	achter	18,5	20720,0	2		1,5	3,5
8	32	35	28	Weegels zijinlaat	zij	achter	18,5	20720,0	1,5	2,5	1,5	5,25
9	32	35	28	Weegels zijinlaat	zij	achter	18,5	20720,0	2	2,5		3,75
10	32	35	28	Weegels combi	combi	achter	18,5	20720,0	2,5		2	4
11	32	35	34	TBS combi	combi	achter	24,5	27440,0		21	3,5	3,5
12	32	35	28	Weegels combi	combi	achter	18,5	20720,0	2	2	2	5
13	32	35	34	TBS combi	combi	achter	24,5	27440,0	3,5	3,5	3,5	3,5
14	32	35	28	Weegels combi	combi	achter	18,5	20720,0	1,5	2,5	4,5	9
15	32	35	28,5	zijinlaat	zij	achter	19,0	21280,0	1,5	1,5	1,5	1,5
16	32	35	28	Weegels combi	combi	achter	18,5	20720,0	1,5	4	2,5	4,5
17	28	31	32	TBS zijinlaat	zij	achter	22,5	19530,0	1,5	2,5	1,25	1,25
18	28	31	32	TBS zijinlaat	zij	achter	22,5	19530,0	2		1	
19	28	31	32	TBS zijinlaat	zij	achter	22,5	19530,0	1		0,5	
20	28	31	32	TBS zijinlaat	zij	achter	22,5	19530,0	1	11,5	1,5	5,5
21	28	32	30	zijinlaat	zij	achter	20,5	18368,0				
22	28,5	28,5	32,5	Aquaway boveninlaat	boven		23,0	18681,8		6,5	5	5,5
23	35	25,5	28	Aquaway zijinlaat	zij	achter	18,5	16511,3		8	7,5	7
24	28	31	32	TBS zijinlaat	zij	voor	22,5	19530,0	1	1	1,25	1,5
25	28	31	32	TBS zijinlaat	zij	achter	22,5	19530,0	1	1,5	1,75	2
26	28	31	32	TBS zijinlaat	zij	achter	22,5	19530,0	9,5	10,5	5	5,5
27	28	31	32	TBS zijinlaat	zij	achter	22,5	19530,0	1	1,5	1,5	2
28	28	31	32	TBS zijinlaat	zij	achter	22,5	19530,0	1	0,5	1,5	1,5
29	28	31	29,5	Konings zijinlaat	zij	achter	20,0	17360,0	1		1,5	1,5
30	28	31	32	TBS zijinlaat	zij	achter	22,5	19530,0	2	2,5	1	1,25
31	30	31	32	TBS zijinlaat	zij	achter	22,5	20925,0		1		1,5
32	32	35	34	TBS combi	combi	achter	24,5	27440,0	3,5	3,5	3,5	4,25
33	28	31	32	TBS zijinlaat	zij	achter	22,5	19530,0	1,5	1,5	0,5	2
34	32	35	34	TBS combi	combi	achter	24,5	27440,0	3,5	3,5	4,5	6,25
35	28	31	32	TBS zijinlaat	zij	achter	22,5	19530,0	1	1,5	1	1
36	31	34	32	TBS zijinlaat	zij	achter	22,5	23715,0	1	0,5		
37	28	31	32	TBS zijinlaat	zij	achter	22,5	19530,0	0,5	1	0,5	0,5
38	28	31	32	TBS zijinlaat	zij	achter	22,5	19530,0	2	2,5	1,5	2,75
39	28	31	32	TBS zijinlaat	zij	achter	22,5	19530,0	1,5	2,5	0,5	1,75
40	28	28	39	Weegels boveninlaat	boven		29,5	23128,0			4	6,5
41	28	31	29	zijinlaat	zij	achter	19,5	16926,0	1,5	1,5	1,5	5,5
42	30	31	32	TBS zijinlaat	zij	achter	22,5	20925,0			1,5	3,5
43	28	31	32	TBS zijinlaat	zij	achter	22,5	19530,0	1,5	2	1,5	3
44	28	31	32	TBS zijinlaat	zij	achter	22,5	19530,0	2,5	4	1,5	4,75
45	28	31	32	TBS zijinlaat	zij	achter	22,5	19530,0	2	2	1,75	2,75
46	28	31	32	TBS zijinlaat	zij	achter	22,5	19530,0	2	4	3,5	5,5
47	28	31	32	TBS zijinlaat	zij	achter	22,5	19530,0	1,5	2,5	6,5	12
48	28	31	32	TBS zijinlaat	zij	achter	22,5	19530,0	1,5	1,5	2	3,75
49	32	35	34	TBS combi	combi	achter	24,5	27440,0	4	9	3,75	7
50	32	35	28	Weegels zijinlaat	zij	achter	18,5	20720,0	1,5		3	6,75
51	32	35	28	Weegels combi	combi	achter	18,5	20720,0	1,5	3	4	7