

WP8, Deliverable D25 End-user test report



Summary:

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Appendices:

Respective end-user partners



***CARE-S - Computer Aided
REhabilitation of Sewer networks***



COMPUTER AIDED REHABILITATION OF SEWER NETWORKS
RESEARCH AND TECHNOLOGICAL DEVELOPMENT PROJECT OF EUROPEAN COMMUNITY

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CARE – S

**Computer Aided REhabilitation of Sewer networks.
Decision Support Tools for Sustainable Sewer Network Management**

WP8 - Testing and validation of CARE-S Rehab Manager

Report D25

**REPORT ON END-USER TEST RESULTS OF THE CARE-S
SOFTWARE**

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End-user reports:

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Trondheim, November 2005

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1 Introduction

The aim of CARE-S has been the development of an integrated suite of tools, which provides the most cost-efficient system for maintenance, repair and rehabilitation of sewer networks, with the aim to guarantee security of sanitary sewage collection and storm water drainage in order to meet social, health, economic and environmental requirements. The tools will enable engineers to establish and maintain an effective management of their sewer network.

The project is organised in the following Working Packages (WP):

WP 1: Construction of a control panel of performance indicators (PI) for rehabilitation

WP 2: Description and validation of structural condition

WP 3: Description and validation of hydraulic performance

WP 4: Rehabilitation technology information system

WP 5: Socio-economic consequences

WP 6: Multi-criteria decision support

WP 7: Wastewater network rehabilitation manager

WP 8: Testing and validation

WP 9: Result presentation and dissemination

WP 10: Project management

SINTEF is responsible for WP8, but the actual testing has been carried out by 8 partners for different end-users spread all over Europe.

The testing of the *CARE-S Rehab Manager* (in the proposal the term *Prototype* was used) and all the tools contained within it, is the final part of the *CARE-S* project, but one of the most important. It allows each software component to be thoroughly evaluated using data from different end-users – data that are diverse in terms of quantity and quality, as well as in geographic origin. It also permits the whole rehabilitation procedure to be tried, and facilitates the establishment of a recommended best practice, based on data availability and the utility's objectives. This report outlines the testing procedure and presents the results from the testing. The aim of this WP in the *CARE-S* project is to test the various tools in the *CARE-S* toolkit within the main framework of the *CARE-S* software (*CARE-S Rehab Manager*). In addition to the testing of the integrated *CARE-S Rehab Manager*, the individual tools have also been tested separately. The testing phase addresses both the ease of use of the *CARE-S* software and tools as well as the relevance of the analysis that has been undertaken.

Besides aiding removal of software bugs, such broad testing provides many benefits:

The opportunity to examine data availability in different regions and countries with

- a view to determining the “most appropriate use of *CARE-S*” for each;
- A chance to determine how “*CARE-S - the Rehab Manager*” can fit into and improve the existing rehabilitation management of end-users;
- Identification of extra functionality requirements and needs for further research.

The testing phase for the *CARE-S* project officially began at the end of March 2005, version 1.0.0 of the *CARE-S* software was issued. Since then, several versions of the software have been released, being 2.6.0.13 the current one. After finalisation of the project, the final version 3.0.0.0 will be released.

2 Overview of the testing

This Working Package has been broken down in two tasks as follows:

Task 8.1. System for testing: the toolkit was tested for 8 real cases reflecting different European conditions, including geographical location, size and water/wastewater management organisation.

The testing has been carried out in three steps, according to the *CARE-S Description of Work* document:

1. Identification of the current state-of-art
2. Comparative studies of programmes for pipe condition grades and Service reliability
3. Testing, including evaluation, of the *Rehab Manager*.

Task 8.2. Analysis: A synthesis of the case studies is extracted from the testing to support further business development and implementation of the *CARE-S Rehab Manager*. This synthesis comprises a critical view of the tools and methods and will also include sensitivity and feasibility analyses.

Table 1 gives an overview of the test cities, including some properties of water network and management.

The testing phase carried out in this penultimate work package involves all partners and end-users participating within the project. The focus is on testing all tools within the CARE-S Rehab Manager environment rather than as stand alone software. Testing has been performed at several levels by the end-users. Some tools have only been applied towards data transfer and functionality with an artificial data set, whilst others have been analysed more thoroughly, including evaluation of reliability of results. These testing details can be retrieved in the respective test reports in the appendix.

For most of the test cases there is an end-user report providing feedback and suggestions for further improvement of the software. The individual test reports from the end-users are given as appendices of this document.

Table 1 Properties of the test zones in the cities

City	Brno	Dresden	Oeiras/ Anadora	UK	Oslo	Reggio Emilia	Barcelona	Palermo
Country	CZ	D	P	UK	N	I	ES	I
Location in Europe	CE	CE	SW	N	N	S	SW	S
Type of entity	P	M	M	P	M	P	P	M
Tourist area	N	N	Y	N	N	N	Y	Y
Electronic records	Y	Y	Y	Y	Y	Y	Y	Y
CCTV	M	A	M	M	A	M	M	M
GIS	Y	Y	Y	Y	Y	Y	Y	Y
Network length (km)	26	139	4	80	13,7	92,7	3	80
Average pipe age (years)	40	80	25		42	30		10
Hydraulic model	M	S	M	I	M	I		S

Explanation:

1. Location: S,E,N,W,C= south, east, north, west, central
2. Type of entity: P=private, M=municipal
3. Tourist area: Y=yes, N=no, P=partly

4. Electronic records: Y=yes, N=no
5. CCTV: imported M = Manually, A = Automatically
6. GIS: Y=yes, N=no
7. Hydraulic Model: M = MOUSE, I = InfoWorks, S = SWMM

The size of networks (or test zones within the network) varied considerably. In some cases it was possible to use the whole network for one or more of the tools, whilst in other regions, small zones within the network, already identified as problematic, were tested. This variety was important in assessing the suitability of each tool given the number of pipes present. For example, failure prediction tools require as many pipes as possible (i.e. a suitably large sample) to ensure statistical significance, whilst large networks will lead to long computational times for hydraulic reliability models.

Table 2 shows which tool groups have been in focus for testing at the various utilities.

Table 2. Summary of main testing sites including tools tested

<i>Test Network</i>	<i>Size of network / main test zone (km)</i>	<i>CARE-S PI</i>	<i>CARE-S Structural</i>	<i>CARE-S Hydraulic</i>	<i>CARE-S Socio-economic</i>	<i>CARE-S Multicriteria</i>
Brno, Czech Republic	26	x	x	x		x
Correggio, Italy	92,7	x	x	x	x	x
Dresden, Germany	139			x		
UK, United Utilities	80			x	x	
Oslo, Norway	13,7	x	x	x		
Clabsa, Barcelona	3	x	x	x		
LNEC	3,668	x	x	x		
Palermo	80 ²	x	x	x	x	x

Following figures give an overview of number of PI calculated by users, CCTV availability and tools tested. The number of PI that have been tested was not given by all end-users even they have applied this tool. Figure 1 contents therefore no information of number of applications. The same applies for figure 2 where only few end-users gave a percentage of available CCTV data for their network.

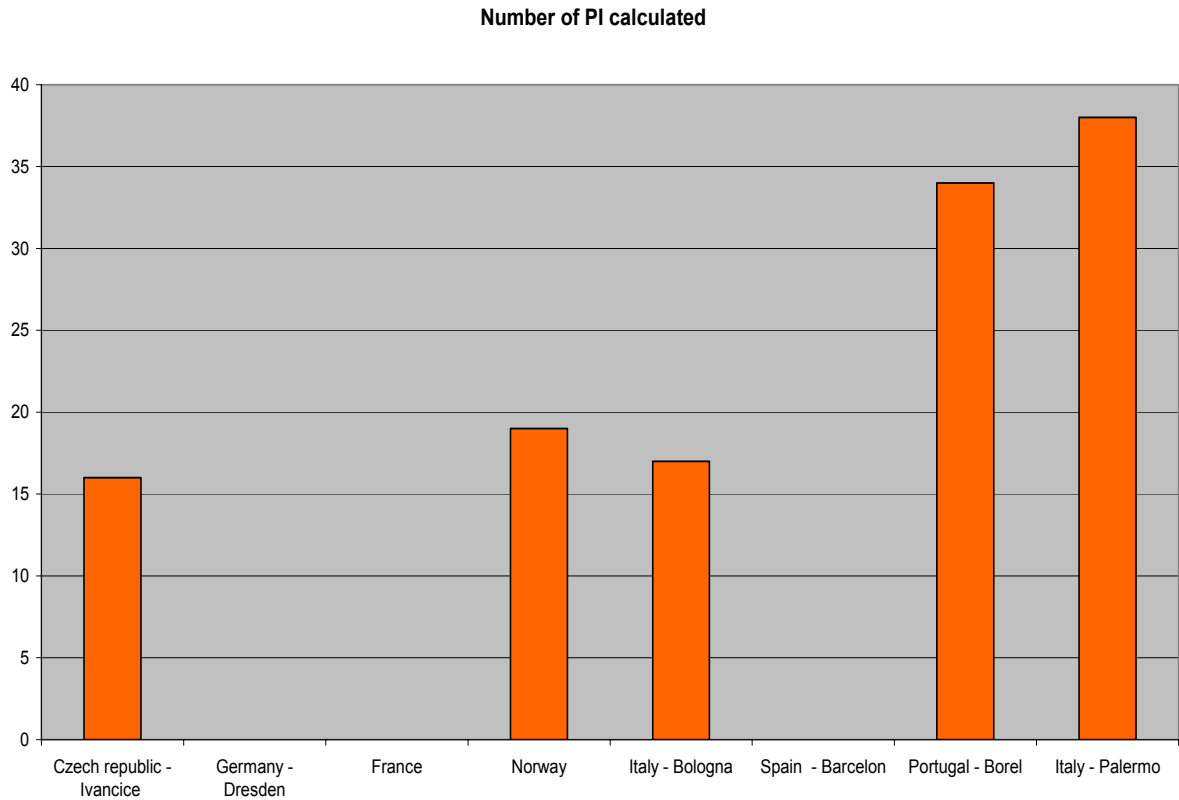


Figure 1: Number of PI calculated per user (if known)

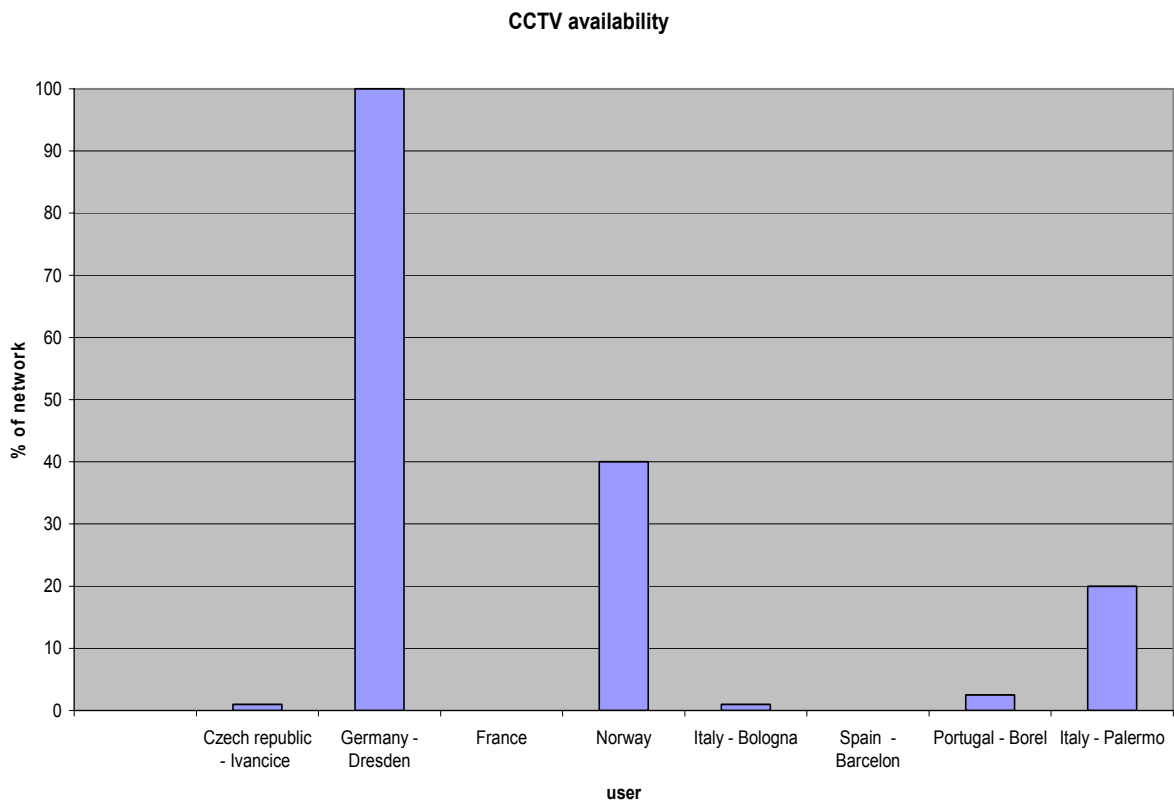


Figure 2: CCTV availability in % of network

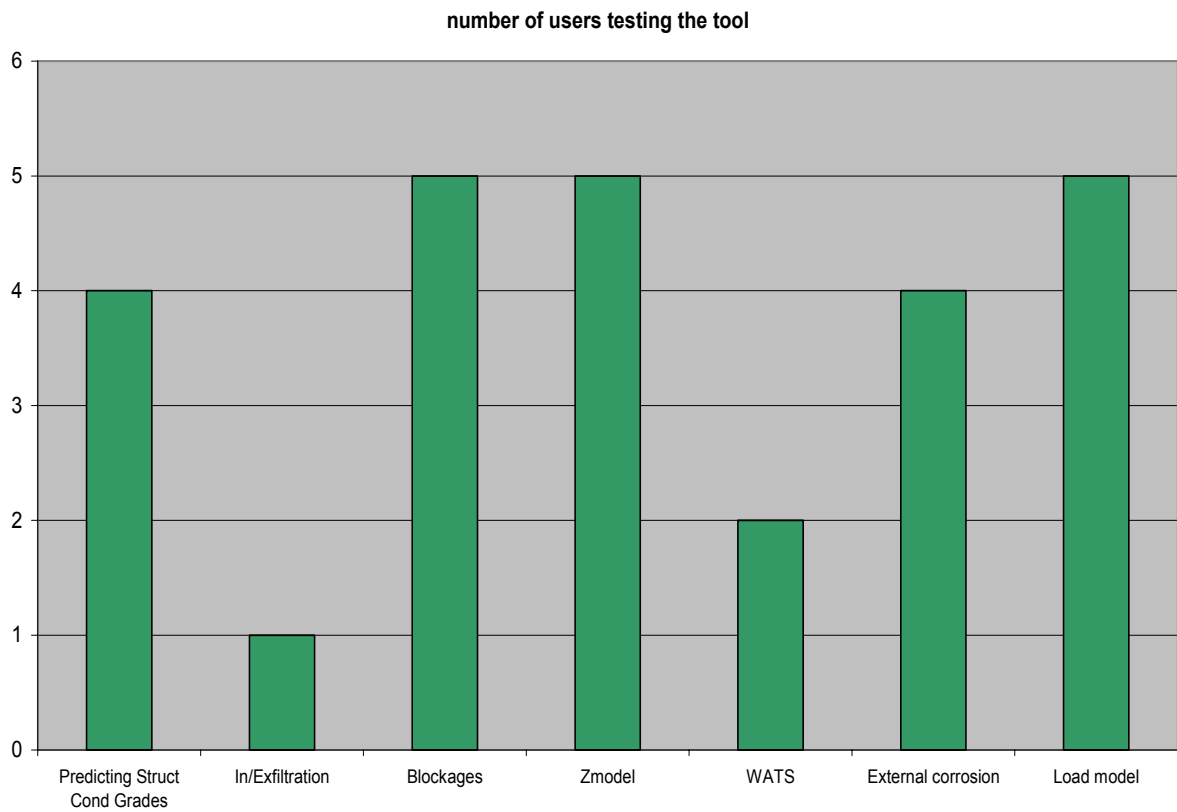


Figure 3: Structural tools: number of testing applications

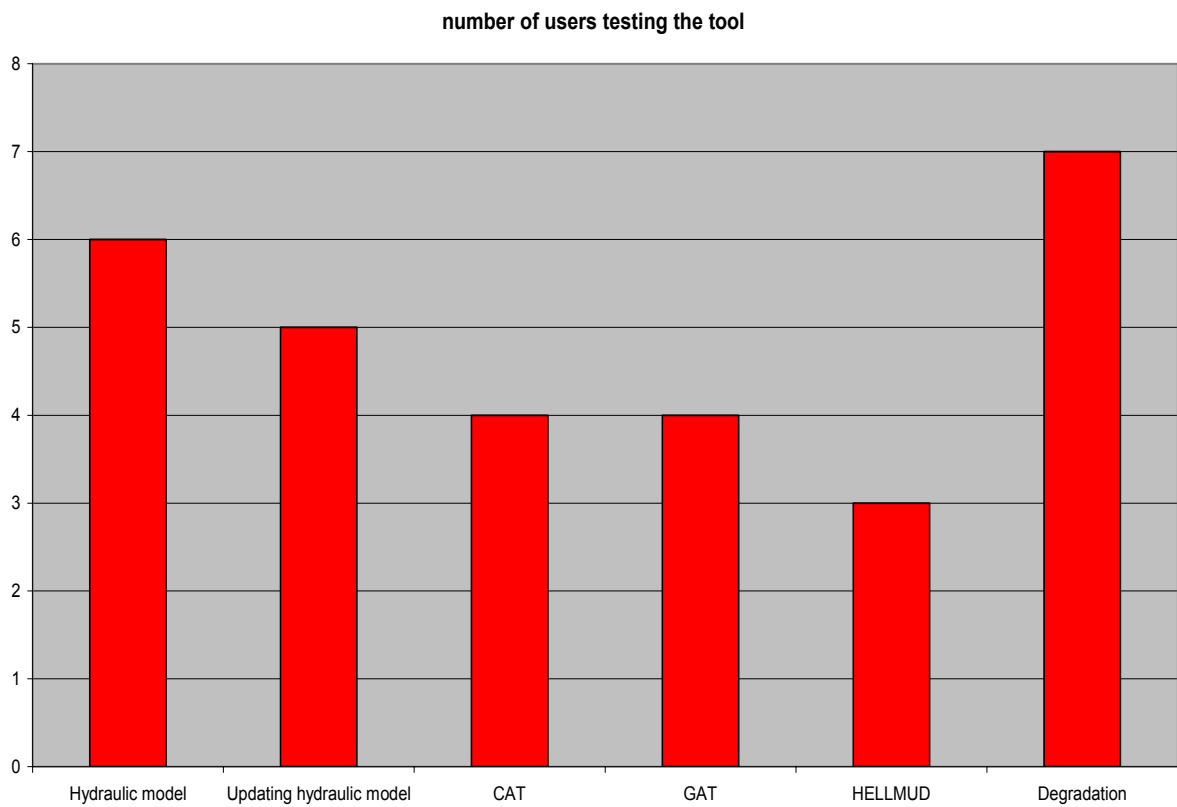


Figure 4: Hydraulic Models and tools: number of testing applications

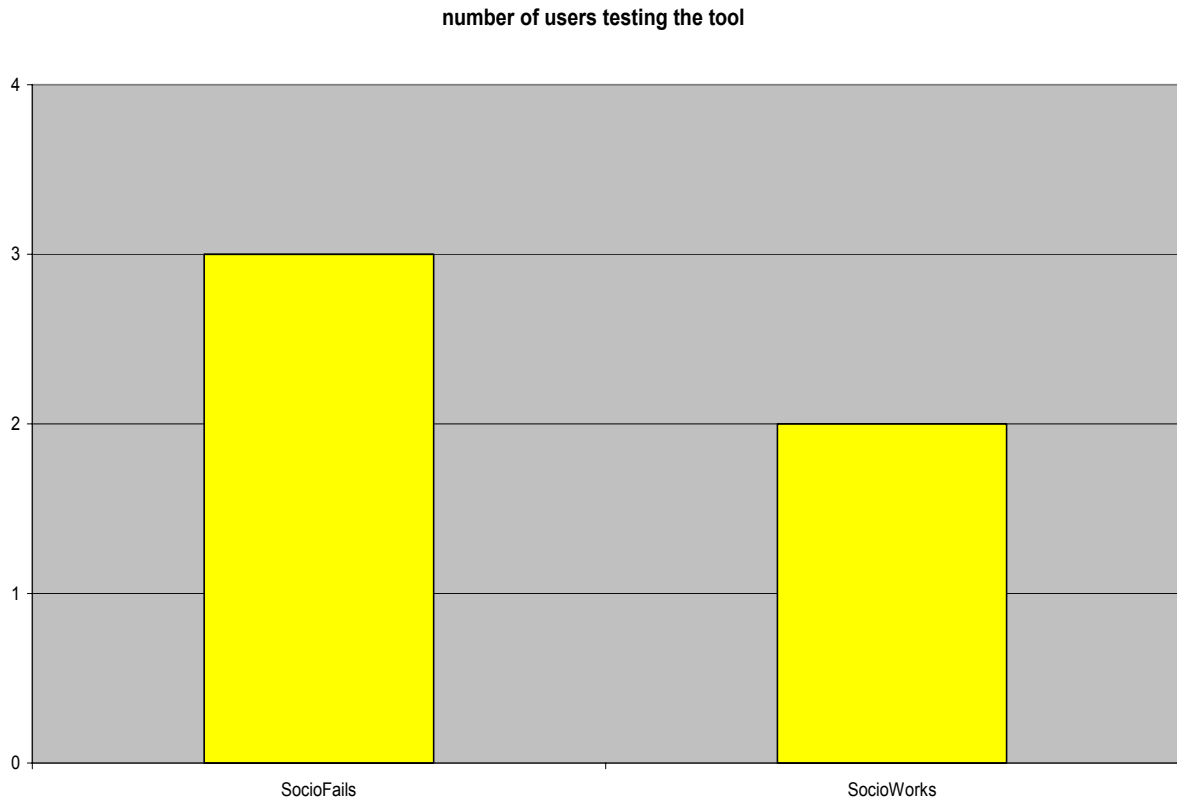


Figure 5: Socio – economic tools: number of testing applications

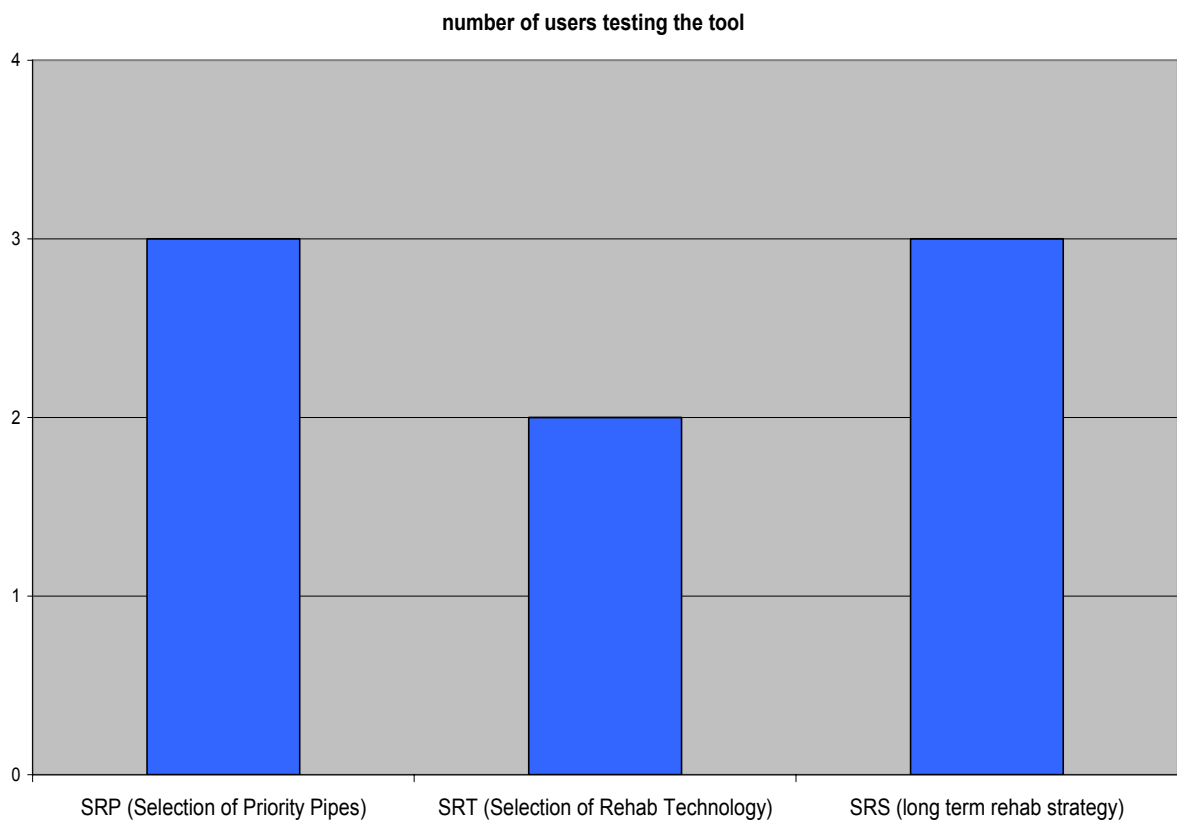


Figure 6: Decision support tools: number of testing applications

2.1 Testing approach

The testing was carried out by using error/issue log reports. As long as program errors were identified during the testing, partners and end-users were able to report about them. For this purpose, a server was set up with Basic Support for Cooperative Work (BSCW) software in order to provide an internal shared workspace for the project for CARE-s partners. A standard web form was designed and uploaded to the BSCW server intended for that purpose. The users could fill it with all details concerning each error found.

The information required to report any error is:

- Date
- Brief description of issue/error
- Tool where the error first located
- Tool where issue found
- Operating language and system
- Error type
- Contact details

S
CARE Managing errors on the CARE-S prototype and other tools:

Please fill in the form each time you run into problems with the prototype or other tools
(* mandatory information, ** mandatory if you choose "Other (specify)" in the above field)

Friday 21 October 2005

Date (dd/mm/yy):

Brief description of issue / error:

Tool where error FIRST located:

if other please specify**:

Tool version where issue found:

Operating Language & system:

Error type:

Other (specify)**:

Issue Identified By*:

Identifying organisation*:

Email (contact details)*:

Figure 7 The CARE-S issues reporting webform

All errors reported were stored in a workbook for further investigation (Figure 7). Once verified and tested the existence of each error, this was reported to the corresponding tool owner with as much details as possible to make possible to reproduce the error and fix it.

2.2 Updating tools

The testing process within the wastewater utilities has been performed by the end-user in close collaboration with partners of the CARE-S consortium. End-users could take advantage of the expertise and know-how of technical staff directly involved in the development of the different working packages of CARE-S. This made it possible for the users to validate the usefulness of the software within their utilities. Some utilities were concerned about the feasibility of their own data record-keeping systems to work with CARE-S. This issue also raised awareness of the lack of data (i.e. short periods of records for failure data) that may be needed to start gathering.

On the other hand, partners got feedback from end-users on the usage of the tools and existing bugs which showed up during the testing. In the mean time, the tools were updated accordingly and uploaded to the BSCW server.

3 End-user test results

3.1 Data availability and preparation

One of the objectives of *CARE-S* is for the software to be applicable to both data-rich and data-lean networks. Data availability influences the way the *CARE-S Rehab Manager* can be used. Some of the *CARE-S* modules are more data-consuming than others. The advanced user with updated GIS, digital maintenance records, calibrated hydraulic network simulation models, etc. can use all the functionality *CARE-S* provides. However, users with fewer data can also benefit, but will more than likely adopt a different path through the software (Figure 8). Exactly which tools to use should be decided case-by-case, based on an evaluation of availability and quality of data.

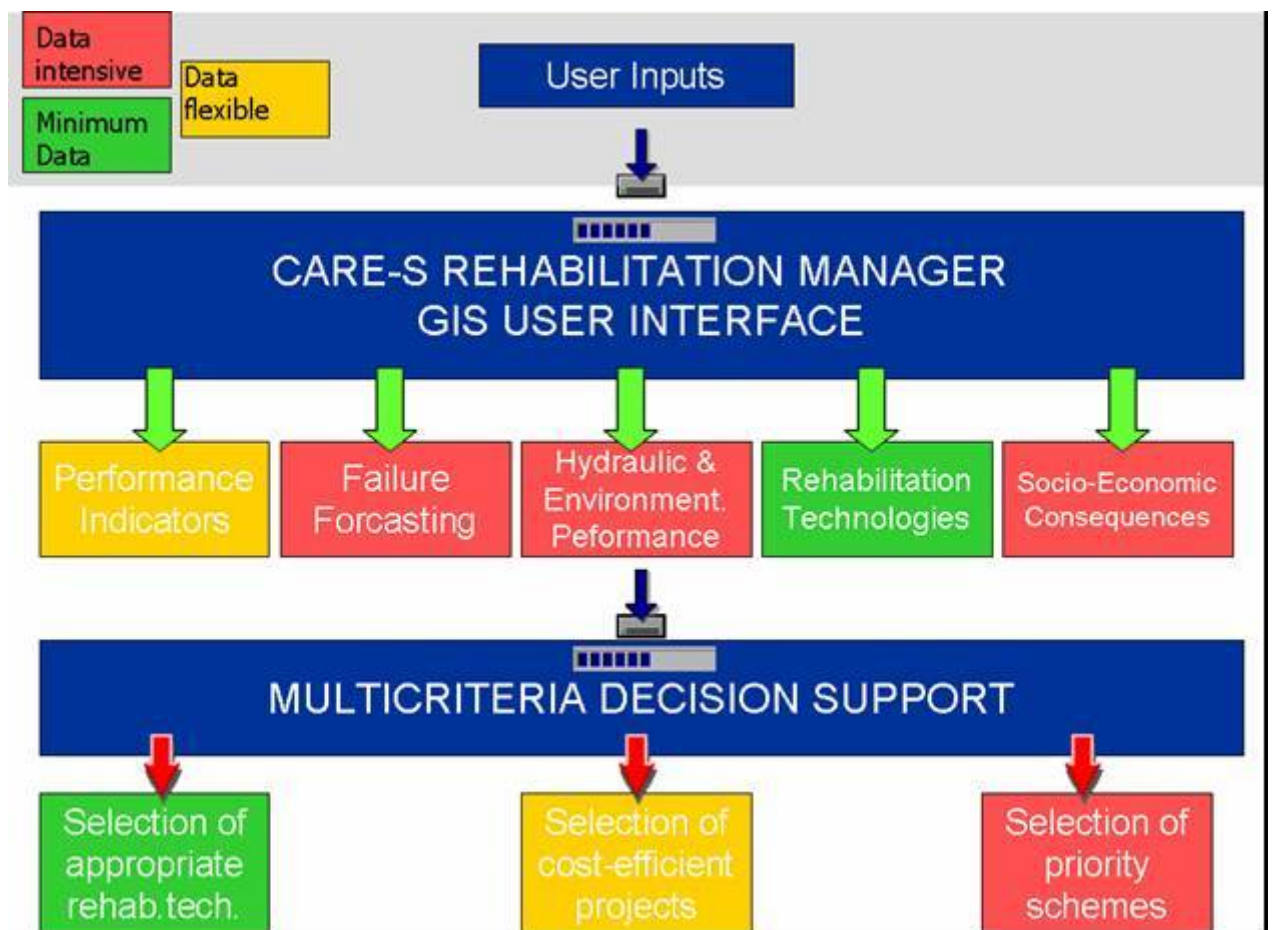


Figure 8: CARE-S flow chart and tools data demanding.

CARE-S can also have the role as a catalyst to start or improve the process of recording data and act as an incentive to store as much data as possible of the highest quality. Tools such as failure forecasting models require CCTV inspection records and the variation in record lengths (number of years of data) amongst the test sites, helps determine a minimum recommended value.

Testing has been done by end-users with various versions of the tools during the last year in the project. The results might therefore not always be consistent regarding documentation of

problems. Testing has proved to be very valuable in terms of tool improvement and reported problems and bugs have been solved by the respective tool developer in the course of the testing period. Additionally, application of *CARE-S* to real cases unmasked obstacles existing on corporate databases to implement the software: lack of data, quality, etc. At the end of the CARE-S project most tools obtained a satisfying functionality as outlined in Table 3.

Table 3: State of the art of the CARE-S tools

Tool	Still Bugs	Ok as stand alone	Ok inside prototype
PI	-	Yes	Yes
CCTV Converter	-	Yes	Yes
Predicting Struc Cond grades	Yes	Yes	-
Blockages	-	Yes	Yes
Zmodel	-	Yes	Yes
WATZ	-	Yes	Yes
External corrosion	-	Yes	Yes
In - exfiltration	-	Yes	Yes
Load Model	-	Yes	Yes
Degradation	-	Yes	Yes
CAT	Yes	Yes	-
GAT	-	Yes	Yes
HELLMUD	-	Yes	Yes
Rehabilitation Tech Database	-	Yes	Yes
SocioFails	-	Yes	Yes
SocioWorks	-	Yes	Yes
SRP	-	Yes	Yes
SRT	-	Yes	Yes
SRS	-	Yes	

Some of the listed tools as SocioFails, SocioWorks and SRP, SRT work as stand alone tools, but since their input data are directly prepared by the CARE-S prototype after selection of pipes candidate for rehabilitation plan, the use of that tools as stand alone is not really meaningful.

In general, the preparation of raw data to supply the software in order to be able to run is still an important aspect of the *CARE-S* and represents the major workload of *CARE-S* projects. On the other hand, this is maybe the most critical part of the project. In fact, results from *CARE-S* will depend on the quality of the input data: any analysis undertaken using the *CARE-S Rehab Manager* will only be as good as the data used. Therefore, in order to produce reliable results the input data has to be checked.

The *Rehab Manager* in its present version does not supply features for automatic quality control of ALL the input data. It is the user's responsibility to ensure that valid data are available for import into the *Rehab Manager*.

3.2 Main findings

In general, no problems were encountered during the installation of the individual tools. The installation procedure of the *CARE-S Rehab Manager* was not found however particularly straightforward. However, installing subsequent upgrades is much easier and there is no need to remove and reinstall the software longer.

There is a wide variety of database structures being currently used by utilities. Moreover, structural and maintenance data use to be stored in separate databases. In the *CARE-S Rehab Manager*, GIS asset and failure data are imported as shape files (*.shp) or comma separated value (.csv). Some end-users use GIS software which does not produce shape files, being therefore necessary to extract data with other external tools in order to produce shape files importable by the *CARE-S Rehab Manager*. Nonetheless, several features like selection of elements in the GIS interface, expression builder and help file have proved usefulness.

Since not every tool could be tested completely by all end-users, a procedure was performed in order to evaluate the applicability of each tool to their particular situation.

3.2.1 CARE-S_PI

Regarding the individual tools, the *CARE-S_PI Tool* allowed to retrieve a complete outline of the network performance and conditions, disclosing needs for rehabilitation activities.

PI availability on utilities highly depends on recording habits. End-user have their own data recording system which may allow for the calculation of some indicators in the *CARE-S_PI Tool*, It proved to be useful for finding network zones with potential for rehabilitation and to monitor its effects. The *CARE-S_PI Tool*, together with the built-in GIS system on the *CARE-S Rehab Manager* have provided end-user with suggestion on the methodology to collect data. ***Structural Analysis(CCTV Converter, Predicting Structural Condition grades (GompitZ), in-exfiltration, Blockages, Zmodel, WATZ, External corrosion, Load Model)***

Setup and run of *CARE-S_Structural tools* encountered no problems and was found to be easy and straightforward. The user-friendly interface made possible an intuitive usage of most of the listed tool. However the need of CCTV inspection data available for condition grade prediction limited the use and testing of the GompitZ tool and tools related with its results (SRS, SRP). The GompitZ tool is not completely implemented in the prototype, the need of running it as stand alone in a DOS window reduces the possibilities of application of the tool.

3.2.2 Hydraulic Analysis (Degradation, CAT, GAT, HELLMUD)

Setup and run of *CARE-S_Hydraulic tools* encountered no problems and was found to be easy and straightforward. The user-friendly interface made possible an intuitive usage of most of the listed tool.

Problems incurred with the use of the COSs Assessment Tool (CAT): the tool is not implemented yet in the prototype, but can run as stand alone.

3.2.3 Rehabilitation Tech Database

The Rehabilitation Technology database has been positively evaluated by users. The possibility of adding their specific technology names and select only the one really applied by the utility represents a useful feature. The tool is considered useful also as stand alone database.

3.2.4 Socio-economic Analysis (SocioFails, SocioWorks)

Socio and economic tools have been tested in few networks. The two tools developed are highly data hungry and their application doesn't appear easy to understand for users.

Informatic improvement should be add in order to make the tools

3.2.5 Decision Support (SRP, SRT, SRS)

Setup and run of *CARE-S_SRP and SRT tools* encountered no problems and was found to be easy and straightforward. The user-friendly interface made possible an intuitive usage of most of the listed tool. However, for SRP, special care had to be taken when planning rehabilitation policies: if socio-economical issues are taken into account as criteria for annual rehabilitation

plans, results might significantly differ from those obtained if only hard facts such hydraulic reliability or condition grades are considered.

SRS tool needs informatics development in order to completely implement it in the CARE-S prototype and to allow a more user friendly interaction with the GompitZ tool, only manually done so far.

CARE-S usage by the end-user might be a tough task to undertake if there is no additional consultation supports from the partners. This is an important finding highlighted several times on this testing: proper training is therefore essential.

3.3 Updated help files

Each of the individual tools, and also the *CARE-S Rehab Manager* has its own help system.

The testing proved the need of end-users for a suitable on-line help system that makes possible an easy usage of the software and a better understanding of the scientific fundamentals behind each individual tool.

The Help file has been made using “HTML HELP Control Version 5.2.3750.1280”.

The Help files created during the first stages of development of the tools have been kept updated according to the suggestions made by end-users and when new features have been added to the software.

The quality on the Help system varies between the different tools. Some are more clear or user-friendly than others.

A common Help file is available inside the CARE-S prototype.

The user can browse the different help topics in different ways: through navigation buttons or by means of index of contents, or searching facilities.

The CARE-S Help file guides the user through the topics:

- CARE-S overview
- Software basics
- Data issues
- Working with CARE-S tools
- Working with projects and datasets
- Getting results
- Using your results
- Brief help of the tools

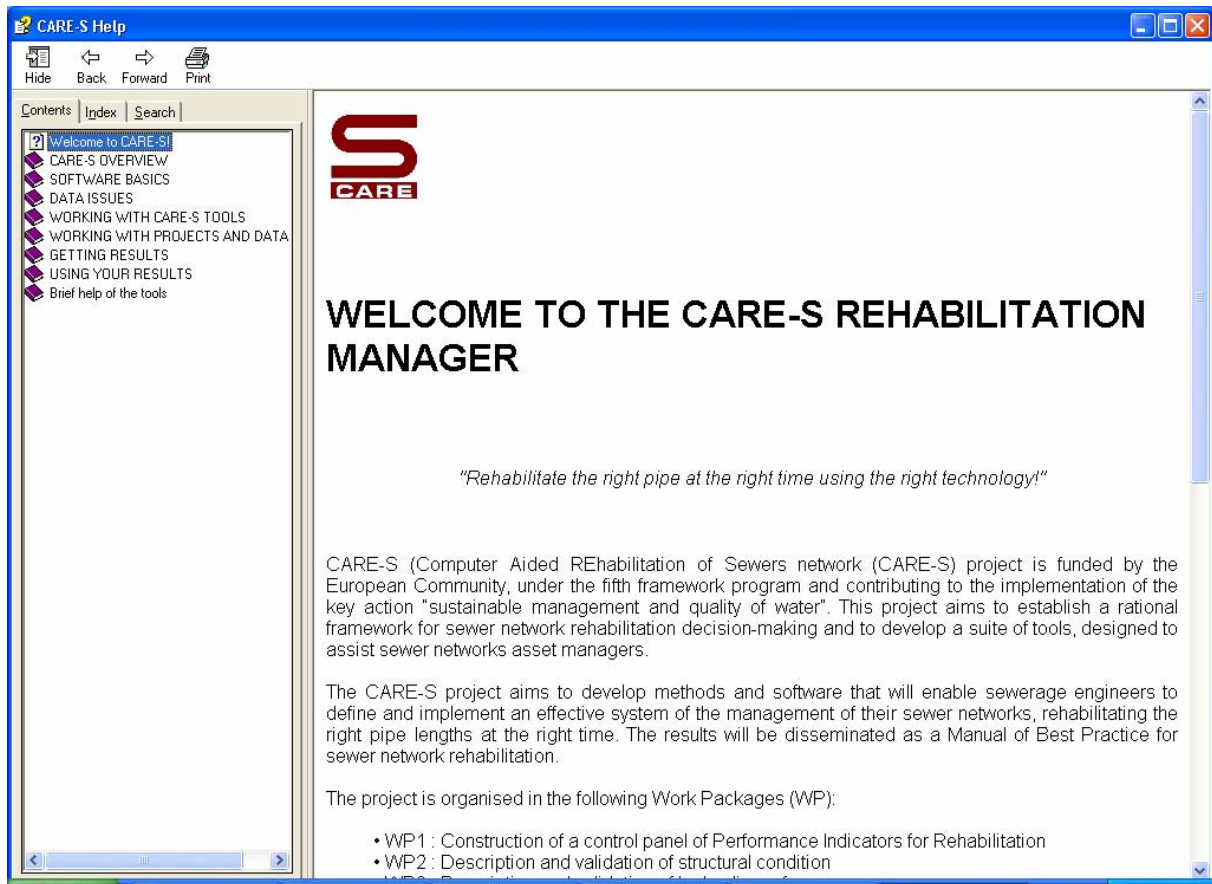


Figure 9: CARE-S Help File

3.4 Proposals for enhancement

The maintenance and upgrading of the *CARE-S* software and toolkit is an issue that needs to be addressed in the commercial phase of *CARE-S*.

Hydraulic results are provided by external software. As long as *CARE-S* results rely to certain extent on that software, compatibility should be maintained for future versions of this.

The *CARE-S* prototype needs to be improved in order to include hydraulic simulations run using the freeware model SWMM.

Some tools, e.g. *CAT*, *GompitZ*, *SocioFails/Works*, still require much computer resources to run in a user friendly way.

Limits have been highlighted by users in CCTV availability: users often suffer of lack of data on pipe inspected. In many cases the percentage on inspected pipes is around 1% and, when CCTV are available, they are not digitalised but recorder on written protocols.

Care-S, as Care-W, are data hungry and time demanding on data collection.

Another weakness is that a very small number of end-user performs hydraulic modelling; and, in turn, the lack of hydraulic data limits the use of Care-S.

As a consequence, an end user desiring to use Care-S must be prepared to invest a large amount of money and time in collecting data and performing hydraulic modeling.

CARE-S usage by the end-user might be a tough task to undertake if there is no additional consultation supports form the partners. This is an important finding highlighted several times on this testing: proper training is therefore essential.

Other minor improvements, although not critical, might be considered to be include within the software. Better integration with the Windows environment can be achieved by using controls from the Microsoft *Common Dialogs* dynamic link library in many of the forms within the tools. This is applicable to most of the tools so there is still some room for the improvement

of the interface, reducing the opportunity for user error, providing all the tools of *CARE-S* with a similar appearance.

Some users appreciated also the possibility to have *CARE-S* translated to the local language.

4 Concluding remarks

Overall, the tools included in *CARE-S* can work successfully with the *CARE-S* Rehab Manager. All bugs identified during the testing have been fixed and validated. Compatibility between input and output data from *CARE-S* Rehab Manager and the individual tools has been found to be an important issue, and proved to be acceptable at the current stage. Compatibility with existing information systems used by utilities is still an issue to be addressed.

The testing carried out by end-users made it possible to evaluate data availability on corporate databases as well as their structure, thus enabling the way for future implementation of rehab programmes based on *CARE-S*. New ideas for data recording have been identified by the end-users. On the other hand, extra functionality needed in the software was identified.

Feedback provided by the testing and validation of *CARE-S* extends and enhances the current possibilities to approach rehabilitation of Sewer networks. End-users participating in the testing of *CARE-S* generally validated the software as a useful tool which fits with those already being used in water/wastewater utilities for asset maintenance management. It is expected that the *CARE-S* toolkit as a whole will allow for the definition of a recommended best practices for future rehabilitation plans, based on data availability and management goals.

Appendices

Report on testing carried out in Brno, Czech Republic

Partner: Brno University

Catchment: Ivancice catchment, Brno, Czech Republic

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INTRODUCTION

This report concerns Rehabilitation Manager Prototype 2.5.0.0 (respective 2.6.0.0) testing by BUT during the period January - September 2005.

First part of the report describes Ivance catchment, available data and data preparation. Main part consists of tool testing within CARE-S (“integrated versions”) if no mention. Last version tested or date of tool version change is written. Ivance testing results and final resume can be found at the end of the third chapter. A brief conclusion is included and additional comments and explanations are listed in the Appendixes.

Ivancice case study

Catchment description

The Ivancice municipality is located in South Moravia, approximately 30 km south-west from Brno at the confluence of three rivers – Jihlava, Oslava, Rokytna. Ivancice catchment performs 162,77 ha, and it can be considered as a residential area. There are 7785 inhabitants.

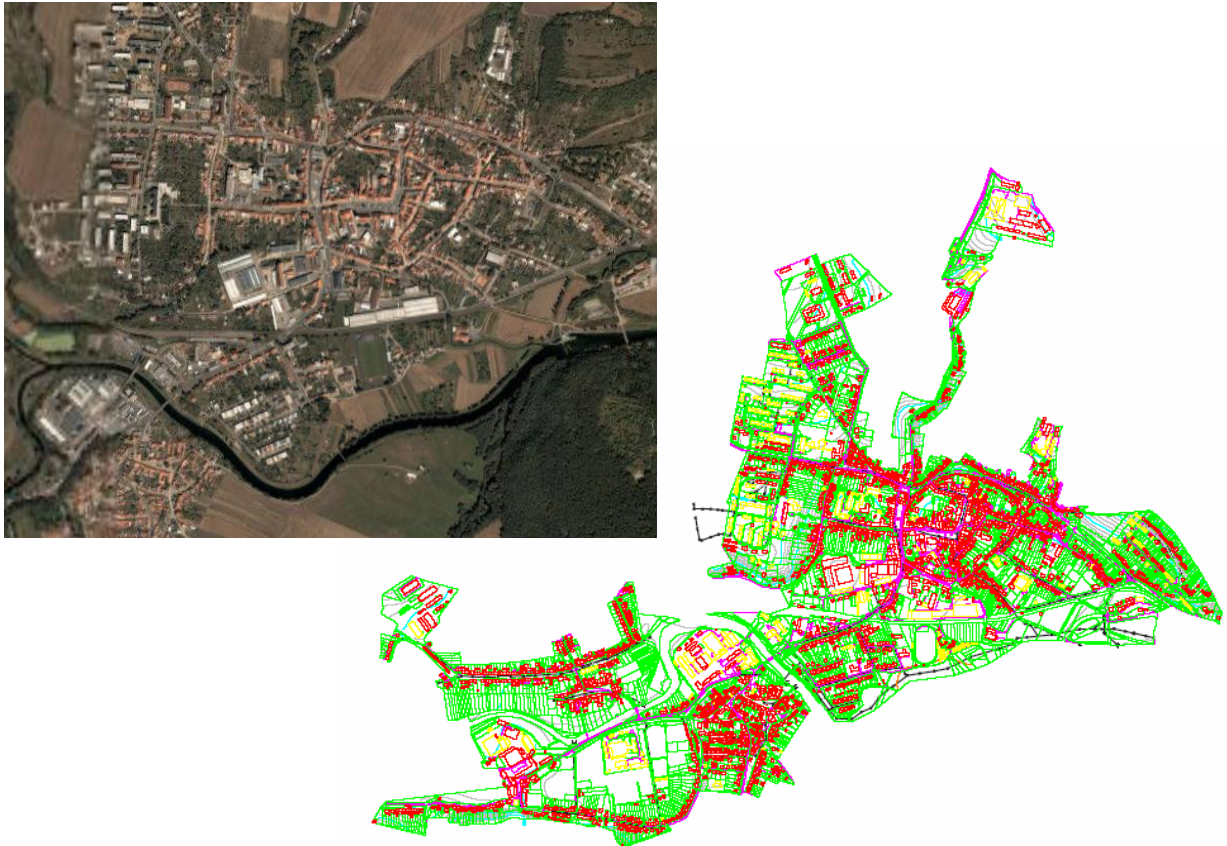


Figure 1 Ivancice municipality

There were very different socio-politic situation in time of preparing Ivancice sewer network project documentation. Different design parameters were used. Water consumption was over 250 l/ capita/day in about 1980 in Ivancice. An increasing trend was forecasted but it has decreasing direction as the time goes. The evolution of urbanism is changing impermeability coefficient which causes that more rain water has to be drained. The incidence of long time rain events, in the last decades, causes more flooding.

It is necessary to design optimal technical measures and sewer system rehabilitation for system adaptation to current environment conditions and where it is technically possible to improve current state.

The sewer system has a total length of 26 km and it contains three main sewers A, B, C. The drainage system includes 732 pipes and 739 manholes, 8 weirs and 5 pumping stations. It is mainly combined sewer system, average impermeability coefficient is of 0,34, average pipe depth is 3 m below the ground level. Pipes cross section is of 96% circular, the rest is egg-shaped.

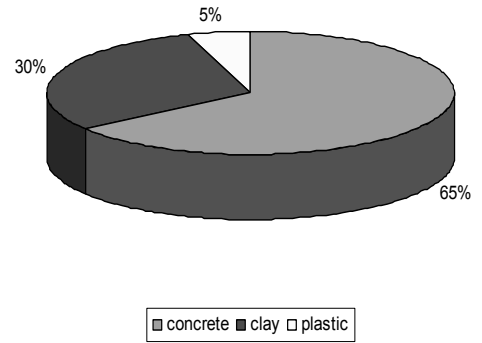


Figure 2 Material distribution

Profil [mm]	délka [m]
DN 150	118
DN 200	138
DN 300	6 914
DN 400	8 065
DN 500	3 623
DN 600	2 467
DN 700	542
DN 800	916
DN 900	540
DN 1000	1 180
Dn 1100	1 118
DN 1200	238
Celková délka	25 859

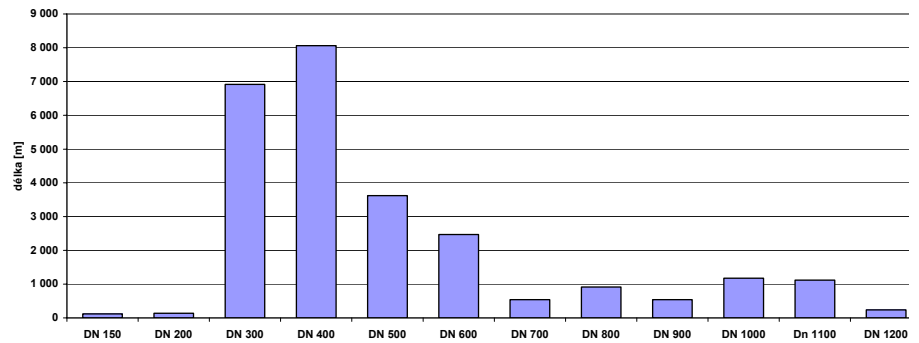


Figure 3 Pipe length information according dimension

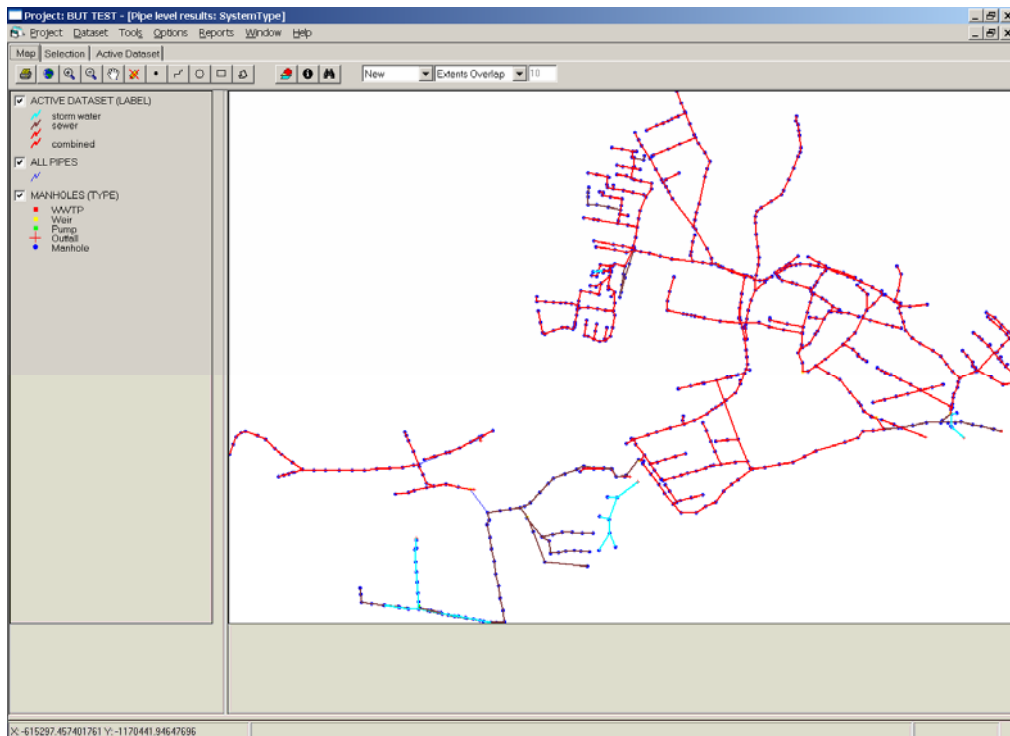


Figure 4 Distribution of system type

Data availability

Data for hydraulic simulation

Dry weather flow (DWF):

A dry weather flow determination has a substantial effect on calculation accuracy of combined sewer overflow and consequently on pollution impact to the river. Q/H measurement was done during 06-08/2003. Figure 5 shows flow curves inside the last manhole in front of WWTP during monitoring campaign.

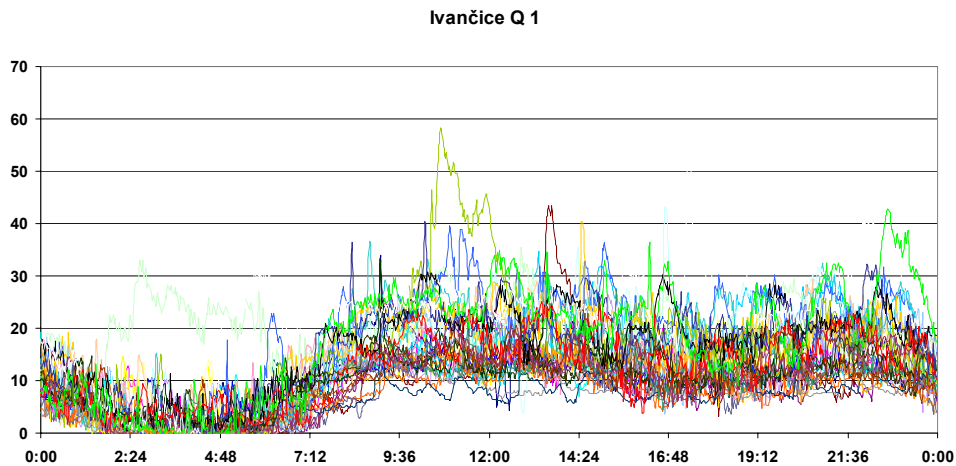


Figure 5 Monitoring campaign of DWF

These DWF values were found out by the sewer operator:

No EO		Inhabitants	7 785
		Industry	5 788
		Sum	13 573
Collected sewage	Inhabitants	water consumption	l/capita.day 120
			m3/day 936
	Industry	water consumption	l/capita.day 120
			m3/day 695
	Sum	water consumption	l/capita.day 120
			m3/day 1 631
	Balast		%
			m3/day 181
Total		l/capita.day	133
			m3/day 1 812

Figure 6 DWF values summary

The synthetic rains (SE):

We used three synthetic design storms (according Sifald) with frequency 1; 0,2; 0,05.

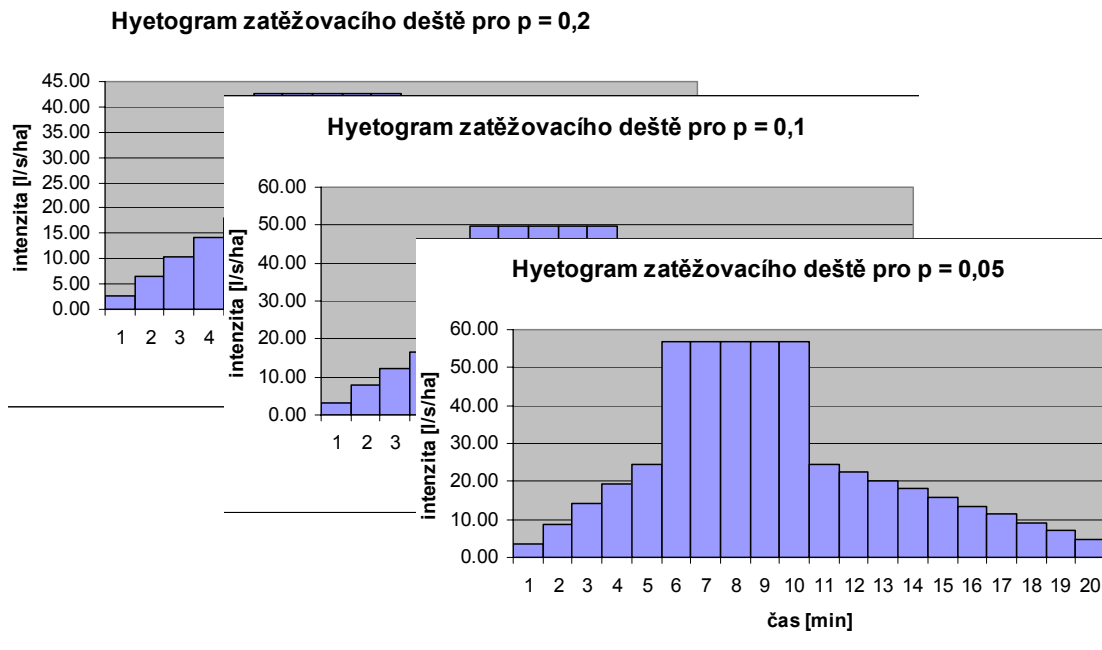


Figure 7 Hyetographs of synthetic rains (periodicity 0,2; 0,1; 0,05)

The historical rain data (HRD):

There is no measurement of rain events in this area. For testing purposes, a historical rain data from near catchment was used. HRD consists of 29 worst rains from a time period 1975-96.

The additional information

- *Installation year* partly based on resident verbal information.
- *CCTV data (protocols and camera inspection records)* were provided by Master plan maker.
- *Wall thickness* obtained from pipe producers and distributors
- *Current roughness* from MOUSE.
- *Ground water level and soil type* from a geological-engineering survey.
- *Entry information for performance indicators* were provided by Master plan maker and operator of sewer network.
- *BOD, COD, specific water consumption* was derived from Master plan.

Data preparation and data import

- Firstly a file with sewer topology (*.und) has to be imported for creating of a new project.
- The hydraulic simulation (DWF, HRD, SE) output files (*.htm) were directly imported to Care-S because some of the tool (E/I Tool, Hellmud) required them.
- There is not common measurement of overflows in conditions of Ivancice municipality (duration, volume, time). That is why an evaluating data of environmental impacts (CAT) were prepared from hydraulic simulation manually by means of MikeView.
- Camera inspection records had to be translated manually to electronic format (*.dat) according CEN coding system.
- The additional information was added to each pipe of sewer system mainly by Expression Builder. (installation year, wall thickness, ground water level, manhole type, current roughness, names of streets, system type, ...).
- For testing purposes the input data were adequately simplified.

CARE-S Rehab Manager Prototype testing

Overview

User can find the tools in following order in Menu Tools in CareS. We tested tools written in *Italic*.

Tools menu:

- *Performance indicators*
- *CCTV data*
- **Structural condition**
 - *Predicting structural condition grades*
 - *Infiltration/exfiltration*
 - *Chokes/blockages*
 - *Analysis of internal corrosion (simple model)*
 - *Analysis of internal corrosion (detailed model)*
 - *Analysis of external corrosion*
 - *Load carrying capacity (probability of collapse)*
- **Hydraulic and environmental performance**
 - *Hydraulic model*
 - *Updating hydraulic parameters*
 - *Environmental consequences*
 - *CSO assessment*
 - *Groundwater assessment*
 - *Calculation of probability of hydraulic and environmental failure*
 - *Alternative to capital cost*
- **Rehabilitation technology database**
- **Socio-economic consequences**
 - *Consequences of failure*
 - *Consequences of rehabilitation work*
- **Decision support**
 - *Selection of pipes requiring rehabilitation*
 - *Selection of rehabilitation technologies*
 - *Long term rehabilitation strategies*

Tools function testing

PI Tool/S (version 1.0.0.2)

Data preparation:

- Prepared form is clear and easy to fill.
- Import UI OK.
- Import EI KO. String values of EI (e.g. yes/no, codes, ...) cannot be imported neither manually inserted. Import of EI runs successfully only for first several numerical values (up to first string value), then aborts and following cells are empty. Consequent numerical values can be entered manually into PI Tool/S, consequent string values cannot be entered at all.

EI table					30102002-122002
	EI code	Internal Code	EI name	Unit	
Demography and economics	EA01		Population density	inhab./km2	
	EA02		Current population growth rate	% per year	-0.03
	EA03		Gross National Product per capita	€ per capita/year	7890.47
	EA04		Inflation rate	%/year	1.80
Environment	EB01		average yearly rainfall	mm/year	543.00
	EB02		maximum yearly rainfall	mm/year	863.40
	EB03		minimum yearly rainfall	mm/year	371.20
	EB04		availability of local statistical data	yes/no	no
	EB05		10 min, 10 year return period	mm/year	
	EB06		60 min, 10 year return period	mm/year	
	EB07		daily average air temperature	°C	8.30
	EB08		daily maximum air temperature	°C	18.10
	EB09		daily minimum air temperature	°C	-2.60
	EB10		maximum altitude	m	250.37
	EB11		minimum altitude	m	200.50
	EB12		Receiving bodies - ocean	yes/no	no
	EB13		waters	yes/no	no
	EB14		rivers	yes/no	yes
	EB15		Receiving bodies - streams	yes/no	yes
	EB16		bays	yes/no	no
EB17		Receiving bodies - wetlands	yes/no	no	
EB18		Receiving bodies - soil	yes/no	yes	
EB19		Special protected areas	yes/no	no	
EB20		special protected area	km2	0.00	
Sewer system aggressive factors	EC01		Sewer seat stability	yes/no	
	EC02		Maximum soil movement due to soil liquefaction	mm	
	EC03		Maximum angular deflection in joints	°	
	EC04		Maximum axial displacement in joints	mm	
	EC05		High volume traffic	code HV	
	EC06		Normal volume traffic	code NV	nv
	EC07		Low volume traffic	code LV	lv
	EC08		Risk to be affected by other infrastructures works	yes/no	yes
Special protected areas	sC36	ED01	Sewers located under flexible roadway	Code UFR	ufr
	sC37	ED02	Sewers located under rigid roadway	Code URF	urr
	sC38	ED03	Sewers located under sidewalk	Code USM	usm
	sC39	ED04	Sewers located under green areas	Code UGA	uga
	sC42	ED05	Bedding soil type (categories to be defined)		avel sand

Import of EI was stopped on the first non numeric value.

Figure 8 Data-entry form of EI table

Data processing:

- Calculation and export file CareSave.xls OK.
- Time series graph OK.
- Dataset comparison graph OK.
- PI comparison KO (Graph error).

Comments:

- None.

CCTVCEN Corvertor (version 1.0.0.1)

Data preparation:

- Manually.

Data processing:

- Data registering OK. (We did not need to use convertor, because codes were directly written in CEN code.)
- Result presentation in GIS KO. (Presented CCTV inspection was not the same with reality, see Appendix 5.2)

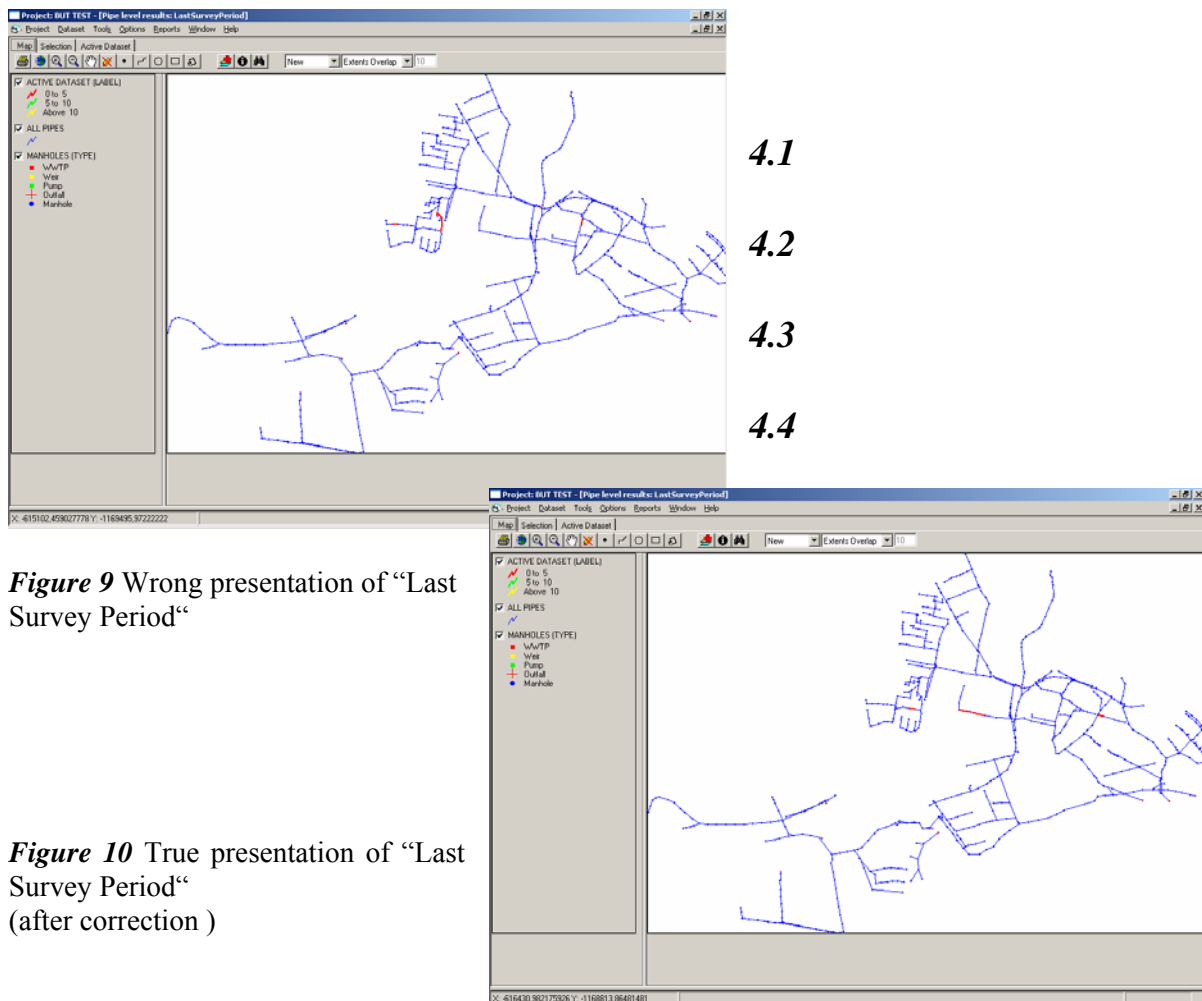


Figure 9 Wrong presentation of “Last Survey Period“

Figure 10 True presentation of “Last Survey Period“ (after correction)

Comments:

- If a user does not dispose with exported files from program for CCTV, a manual preparation of codes to electronic format is very difficult.
- Uncomfortable user interface of simple text file (notepad).

GompitZ (9/9/2005)Data preparation:

- Automatic creation of input file Strata.txt OK (with wrong order condition grades and without item “Inspection Year” for pipes without CCTV inspection)

Data processing:

- Automatic creation of output file calibr.txt OK.
- Evaluating of future condition grades was aborted. Unfortunately we are not able to accomplish a minimum CCTV sample size requirement (number of pipe with CCTV is less then nbcond*25=75).

Figure 11 Strata.txt, calibr.txt

```

Strata.txt - Poznámkový blok
Soubor Úpravy Formát Zobrazení Nápořádá
3,2,1
combined, sewer
LENGTH
combined,1
sewer,1
combined,302,1955,,3,1,27.56
combined,255,1970,,2,1,28.5
combined,428,1955,,3,1,28.44
combined,155,1970,,3,1,28.37
combined,590,1955,,3,1,28.03
combined,393,1980,,2,1,28.01
combined,729,1995,,1,1,27.94
combined,684,1980,,2,1,27.85
combined,414,1955,,2,1,27.71
combined,243,1995,,1,1,26.63
combined,642,1960,,2,1,27.63
combined,288,1980,,2,1,28.54
combined,229,1995,,1,1,27.27
combined,3,1995,,1,1,27.26
combined,732,1995,,1,1,27.25
combined,469,1980,,2,1,27.2
combined,191,1995,,1,1,27
combined,560,1975,,2,1,26.93
combined,703,1995,,1,1,26.87
combined,604,1980,,2,1,26.82
combined,498,1955,,3,1,30.77
combined,227,1995,,1,1,27.64
combined,444,1955,,3,1,29.39

calibr.txt - Poznámkový blok
Soubor Úpravy Formát Zobrazení Nápořádá
Gompitz v1.05 - Calibration results

*** Stratum combined ***
597 (total weight = 597.00) pipelines described in this stratum

6 (total weight = 6.00) inspections reported:
1 (total weight = 1.00) of which in condition state 3
4 (total weight = 4.00) of which in condition state 2
1 (total weight = 1.00) of which in condition state 1

Convergence achieved in 21 iterations
Log-Likelihood = -5.204971

Parameter estimates and wald chi2 tests
-----
Label                                Estimate      Std. Error   DF   Chi2        Pr>Chi2
-----
Alpha(3) (vs 0)                      +5.5262e-001 1.1845e+000  1    2.1765e-001 0.640836
Alpha(2) (vs Alpha(3))               -1.7329e+000 1.4770e+000  1    4.9340e+000 0.026333
LENGTH (vs 0)                        +9.0326e-004 3.1565e-002  1    8.1886e-004 0.971717
T (vs 0)                              -2.5933e+001 1.0000e+005  1    6.7252e-008 0.999793
-----

*** Stratum sewer ***
92 (total weight = 92.00) pipelines described in this stratum

0 (total weight = 0.00) inspections reported:
Warning: Stratum void of inspection data - Calibration aborted

```

Comments:

- We would appreciate possibility to run this tool without CCTV inspection. An operator is often able to assess current condition grade in base of his long time experience with sewer system. Now “Inspection Year” is not editable within CARE-S. Our problem could be solved if we will be allowed to change data in Strata.txt file.
- Finally, we run the tool as a stand-alone version in DOS window, which is not very user-friendly. Theoretical condition state labels in Strata.txt should be ordered from the best to the worst one, but it is created automatically conversely. We changed this and added “Inspection Year” into the file. The tool gives results but we are not able to import the results into CARE-S Rehab Manger.

E/I Tool (version 1.1.0.0)Data preparation:

- Data preparation KO. Non of imported Mouse results in the list cannot be used for calculation.

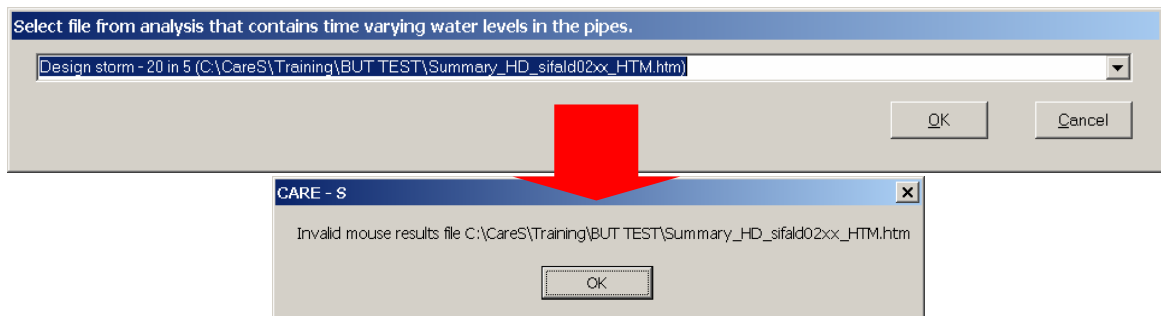


Figure 12 Invalid Mouse results file

Data processing:

- Calculation KO.

Comments

- All these Mouse result files were used successfully for running of other tools.

Blockage Tool (2/8/2005)

Data preparation:

- Creation of input file CS_Segments(*)In.csv OK.
- Creation of input file CS_Blockages(*)In.csv OK.

Data processing:

- Creation of output file blocakges_out.txt OK.
- Saving tool results in Rehab Manager database OK.
- Result presentation in GIS OK.

Comments:

- None.

Zmodel (version 1.4.0.0)

Data preparation:

- Creation of input file FileIn.txt OK.

Data processing:

- Creation of output file FileOut.txt OK.
- Saving tool results in Rehab Manager database KO (in spite of a report message „ZModel result imported“ and after project saving).
- Result presentation in GIS KO.

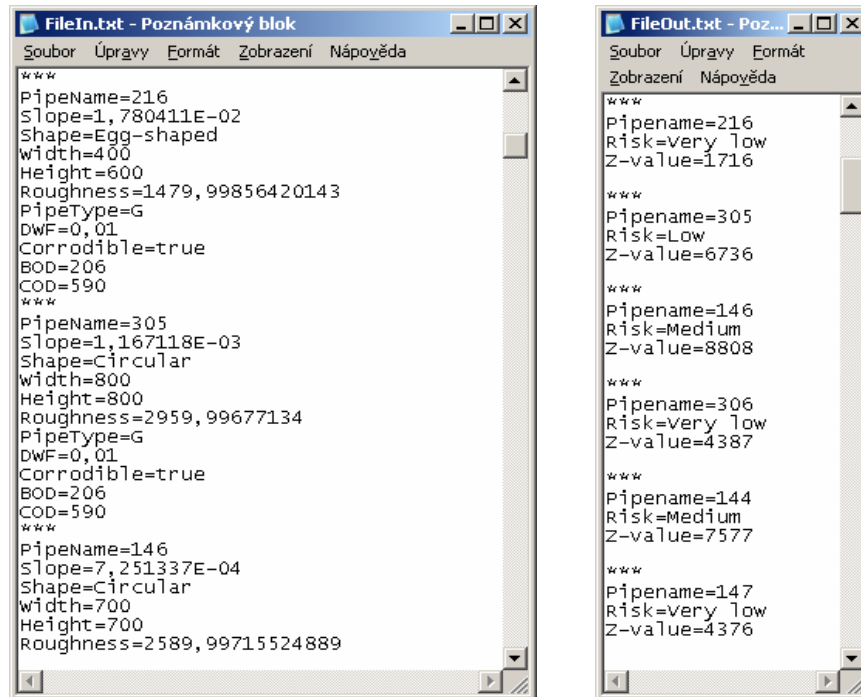


Figure 13 Input/Output files ZModel

Comments:

- The roughness has a strange value, units are neither known not displayed.

WATS (31/3/2005)

Data preparation:

- Creation of input file FileIn.txt OK.

Data processing:

- Creation of output file FileOut.txt OK.
- Saving tool results in Rehab Manager database KO (in spite of a report message „Internal corrosion result imported“ and after project saving).
- Result presentation in GIS KO.

Comments:

- None.

External corrosion (version 1.0.0.2)

Data preparation:

- Creation of input file i-fil.txt OK.

Data processing:

- Creation of output file expcorr.txt OK.
- Saving tool results in Rehab Manager database OK.
- Result presentation in GIS OK.

Comments:

- None.

Load model (version 1.0.0.2)

Data preparation:

- Creation of input file i-fil.txt OK.

Data processing:

- Creation of output file expload.txt OK.
- Saving tool results in Rehab Manager database OK.
- Result presentation in GIS OK.

Comments:

- None.

Create hydraulic model file

Data processing:

- Creating of a new file (*.und) OK.

Degradation Tool (version 1.2.13)

Data preparation:

- Creation of file CS(*).xls OK.

Data processing:

- Computation OK.
- Saving tool results in Rehab Manager database OK.
- Result presentation in GIS OK.

Comments:

- It is a very user friendly program.

CAT (version 1.0.0.14)

Data preparation:

- Required input data for CAT are start/end time of CSO and volume of overflow.
- Overflow progress during one rain event can have various shapes. (one rain event is not equal one overflow event; see Figure 14).

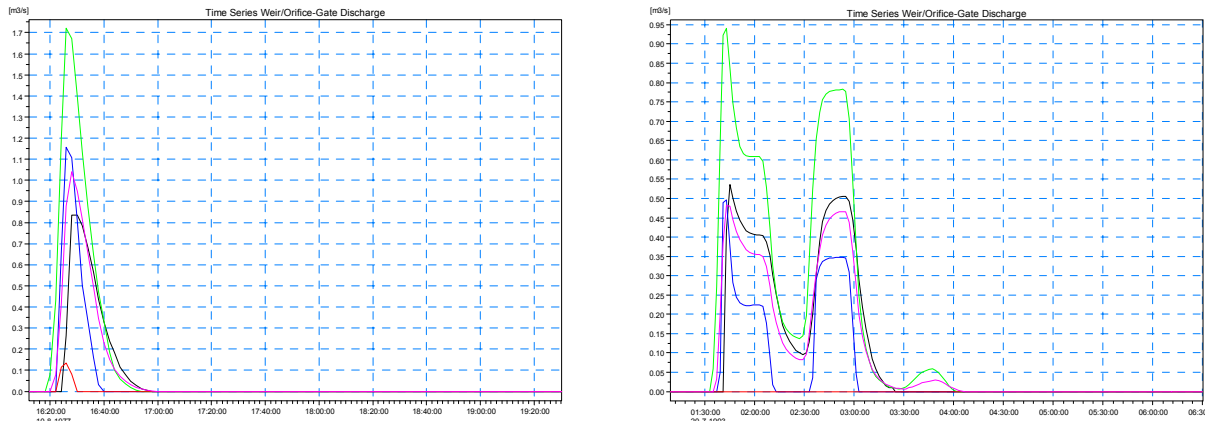


Figure 14 Mouse result file (*.prf) - Time Series Weir/Orifice-Gate Discharge

- Hydraulic result files MOUSE (*.htm) contain information about CSO shown in Figure 15 (Note, that accumulated value means TOTAL overflow volume of each weir, regardless number of overflow events, and there is not start/end time of overflows but only time of MIN/MAX thresholds of overflow in the table)
- Input data were manually prepared in file *.csv by means of MikeView software (working with files *.prf).
- Keep right time data format (rrrr-mm-dd hh:mm:ss).

	Minimum	Maximum	Flow - Accumulated	Time - Minimum	Time - Maximum
	[m ³ /s]	[m ³ /s]	[m ³]		
OK707w1	0,000	0,537	1788,4	1993-07-20 01:09:00	1993-07-20 01:45:00
OK706w1	0,000	0,495	963,9	1993-07-20 01:09:00	1993-07-20 01:43:00
OK704w1	0,000	0,940	2930,5	1993-07-20 01:09:00	1993-07-20 01:43:00

Figure 15 Mouse result file (*.htm) - Table Weir/Orifice-Gate Discharge

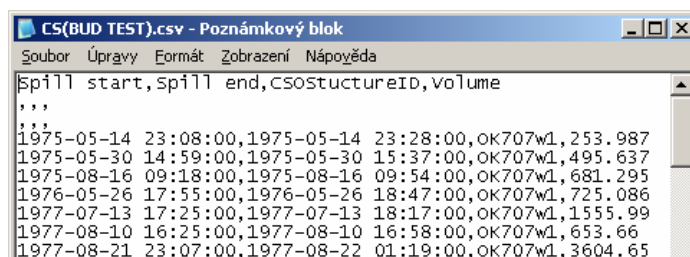


Figure 16 CAT input file (*.csv)

Data processing:

- Creation of file CS(*) .xls OK.
- Graph shows only 10 years with rain event, why no more? (we have 18 years with rain events, 10 years were displayed, the rest is not shown)

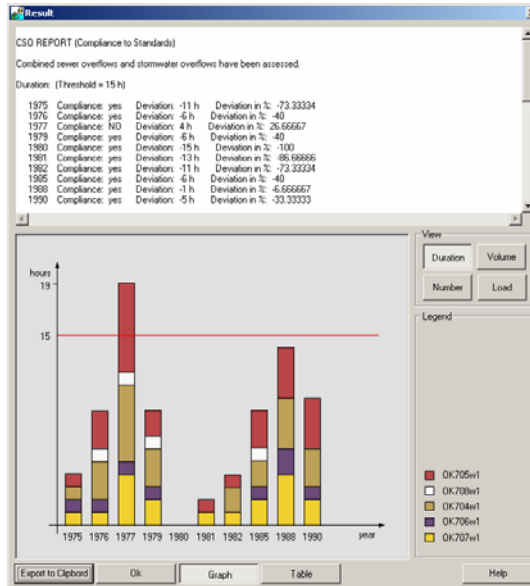


Figure 17 CAT result graph

Comments:

- It is not possible to run CAT within CARE-S therefore it was tested as stand alone version. Hydraulic simulation of 10 years long rain data series is very time consuming, and no every operator has continual rain measurement.

GAT (version 1.0.0.7)

Data preparation:

- Creation of input file CS(*) .csv OK. (with wrong LinkID = User reference, see comments for Hellmud, chapter 3.2.14)

Data processing:

- Creation of output file CS(*)out.csv OK.

Comments:

- Error displaying in GIS („Ground water level class“) signalizes something wrong. But there is “only” ground water level above the pipe - and it is not error!

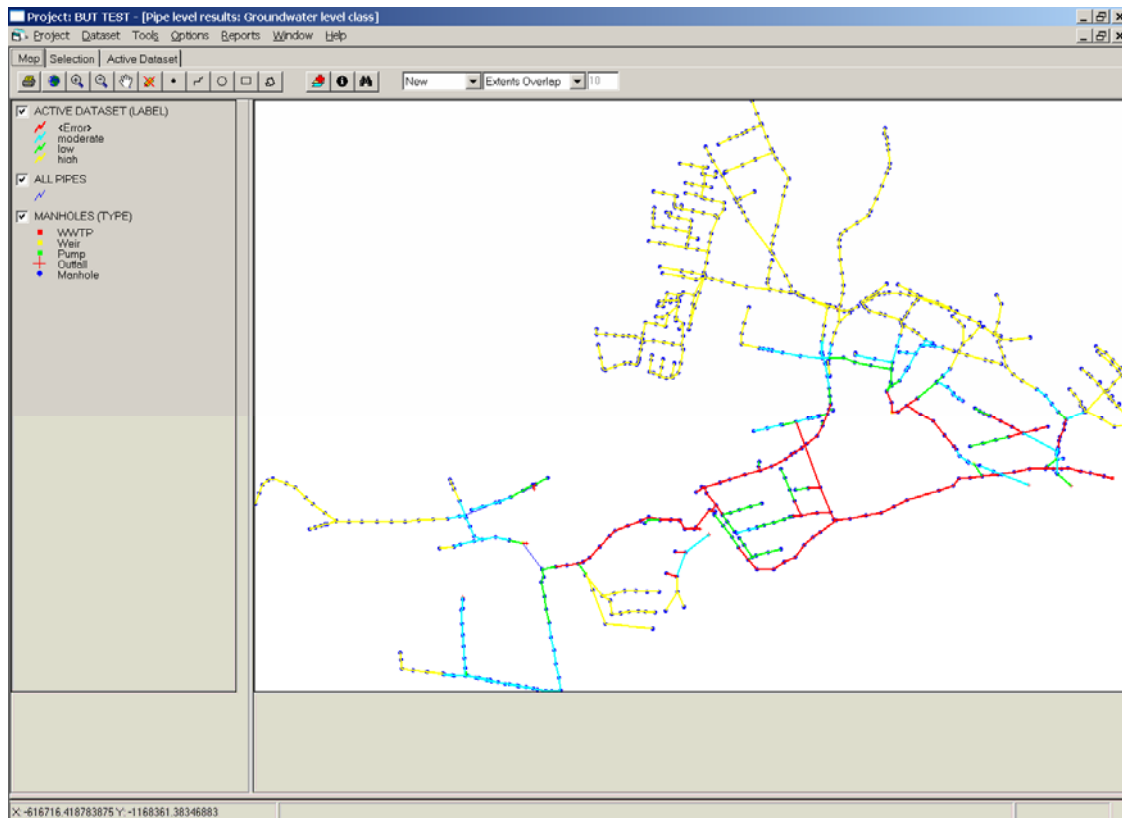


Figure 18 Ground water level class

Hellmud (version 3.4.0.7)

Data preparation:

- Automatic creation of input file CS(*)layout.csv OK.
- Automatic creation of input file CS(*)simulation.csv OK.
- Import CS(*)Gat.csv KO.
- Import CS(*)Cat.csv OK. (Firstly CAT has to be run as a stand alone version, its output file has to be named as CS(*)out.csv. and put into CareS/CAT folder).

Data processing:

- Calculation of SE simulation run OK, („Warnings“ are just informative).
- Calculation of HRD simulation OK (for approximately 8 rain events).
- Calculation of HRD simulation KO (tested for 22 rain events, we interrupted processing after approximately 6 hours).

- Graphs OK.
- Result presentation in GIS OK.

Comments:

- Do not forget to change a value “critical level” according your needs.
- GAT LinkIDs are different from Hellmud IDs. You can go around this mistake simply by copying and pasting values from Hellmud layout file to GAT output file.

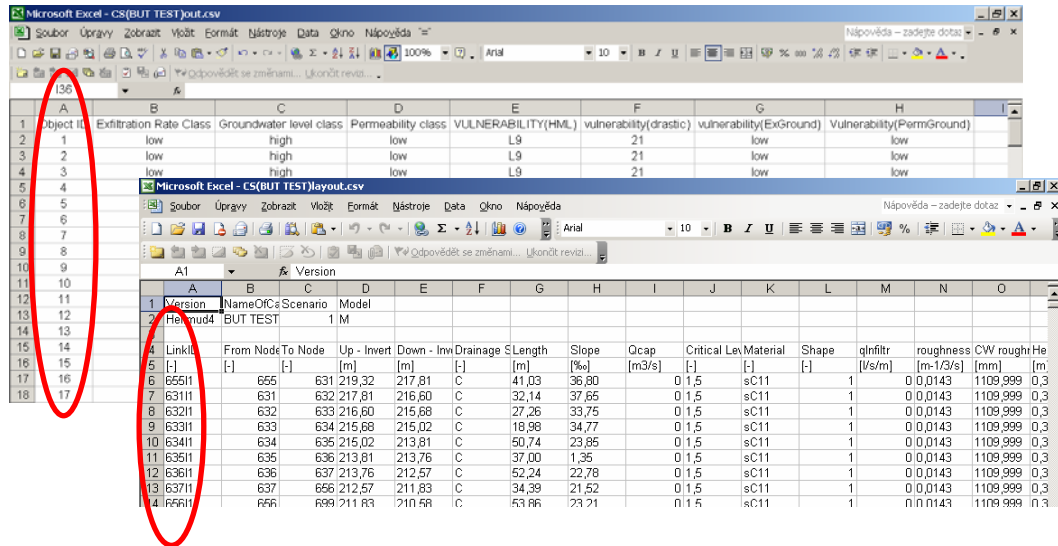


Figure 19 Different ID
(GAT output file x Hellmud input file)

SRS (13/9/2005)

Data preparation:

- Import of input file OK.

Data processing:

- Calculation OK
- Displaying of results OK
- Creation of output file KO (export of results not possible)

Comments:

- How to save data into CARE-S?

SRP (V2005.5.10. BETA)

Data preparation:

- Import of input file OK (but without results from some tools)

Data processing:

- Elimination OK

- Displaying of results OK
- Creation of output file OK/KO (in some cases export of results not possible)

Comments:

- Why not possible to export data into file time-to-time?

SRT (29/9/2005)

Data preparation:

- Creation of input file OK.

Data processing:

- Creation of output file OK.

Comments:

- None.

Report on testing results analysis on Ivancice network

Performance indicators

Performance indicators for years 2002/2003/2004 were evaluated. As the sewer system is of rather small size, operator does not have UI available / PI calculated for each parts of sewer network, but only for whole system.

UI:

- Environmental data 1/5
- Physical assets data 44/65
- Operational data 11/19
- Demografy (and customer) data 5/6
- Duality of service data 5/8
- Economic and financial data 0/7
- Time data 1/1

PI:

- Environmental 1/5
- Physical 1/3
- Operational 9/19
- Quality of service 5/8
- Financial 0/6

CCTV data

This municipality has approximately 160 m pipes inspected (less then 1 %). An operator does not use a program for CCTV data registering with export data to (*.dat format (only written protocols). In spite of that the end user has a long time experience of current state of sewer system.

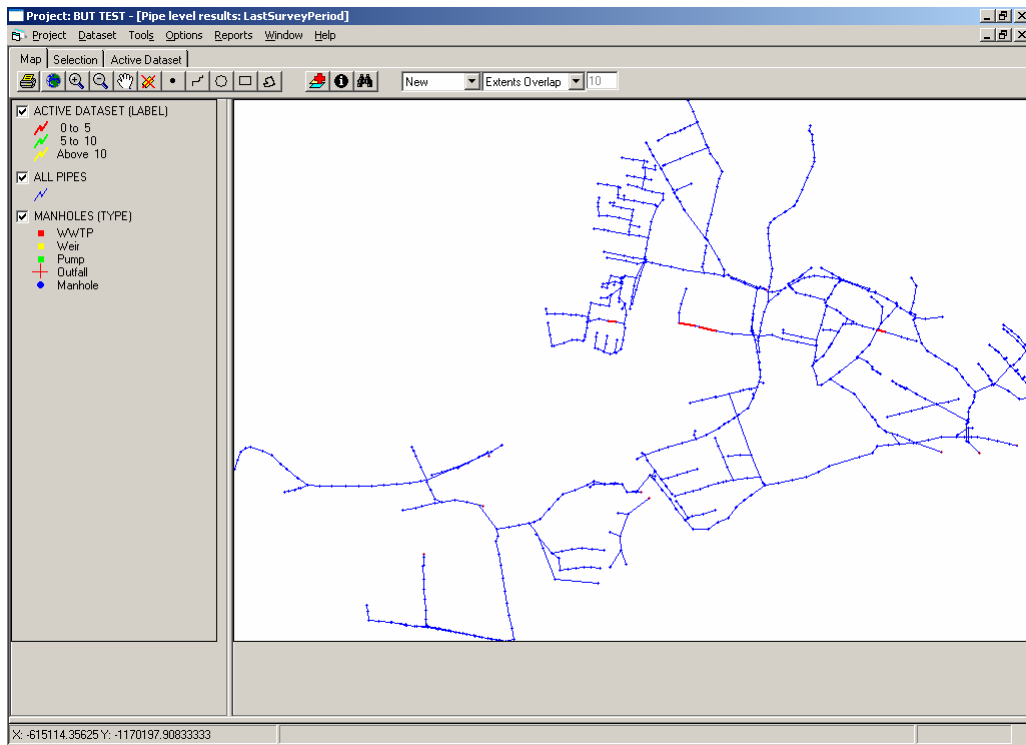


Figure 20 Last survey period

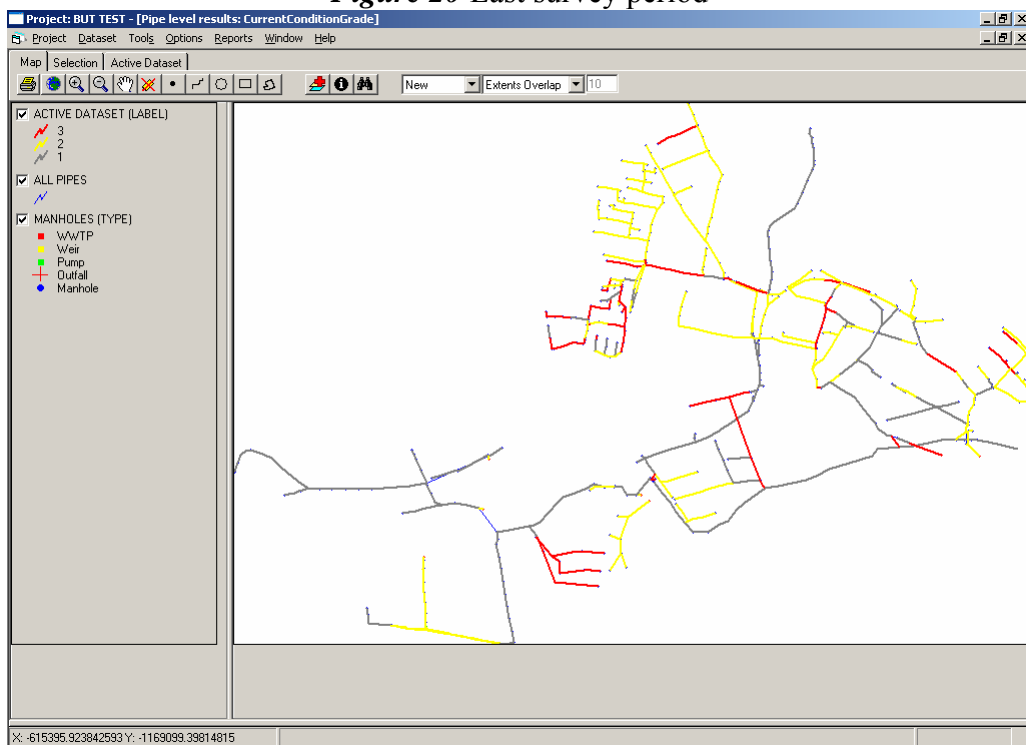


Figure 21 Current condition grade

Predicting structural condition grades

We are interesting in using this tool but evaluating of future condition grades was aborted. Unfortunately we are not able to accomplish a minimum sample size requirement and when using manual preparation (see 3.2.3., we are not able to find future condition grade in output files).

Analysis of internal corrosion (simple model)

Input values (BOD=206 mg/l, COD=590 mg/l, pH=7,66) are consider as average for all pipes. They are coming from measurement in front of WWTP.

Internal corrosion risk:

- Very low 48
- Low 6
- Medium 0
- High 1
- Very high 0

Analysis of external corrosion

There are 449 corrodible pipes in the network. External corrosion rate is of 0 to 4,6 mm/year. The maximum value seems to be a rather great.

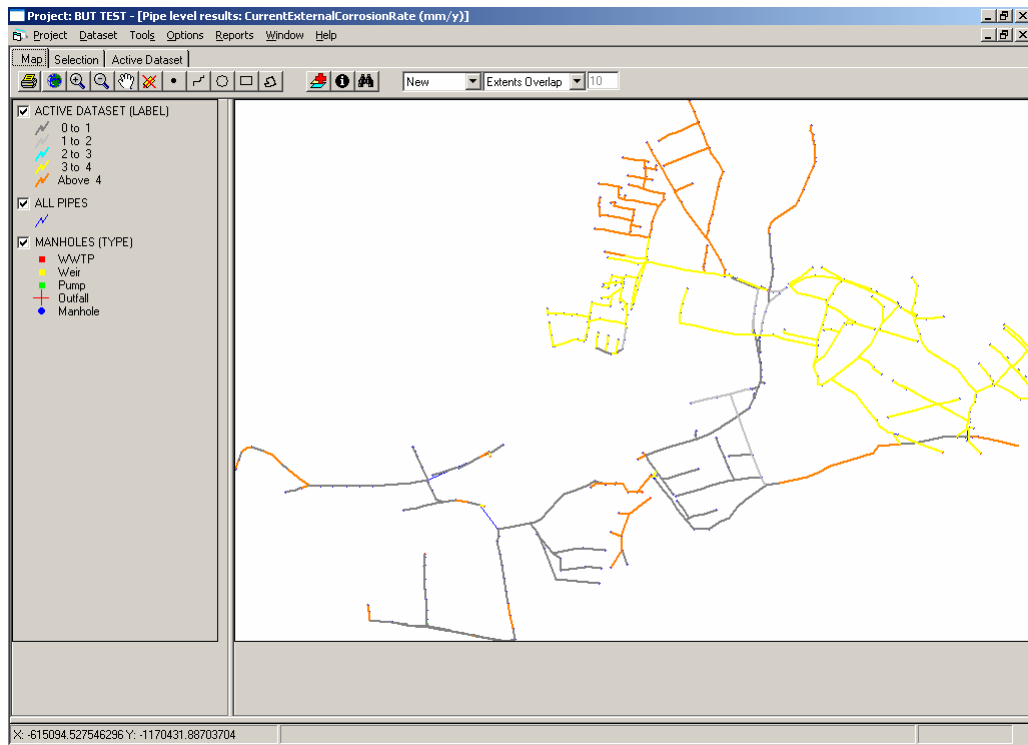


Figure 22 Current external corrosion

Load carrying capacity (probability of collapse)

Load model analyzed 408 pipes with required data for year 2010.

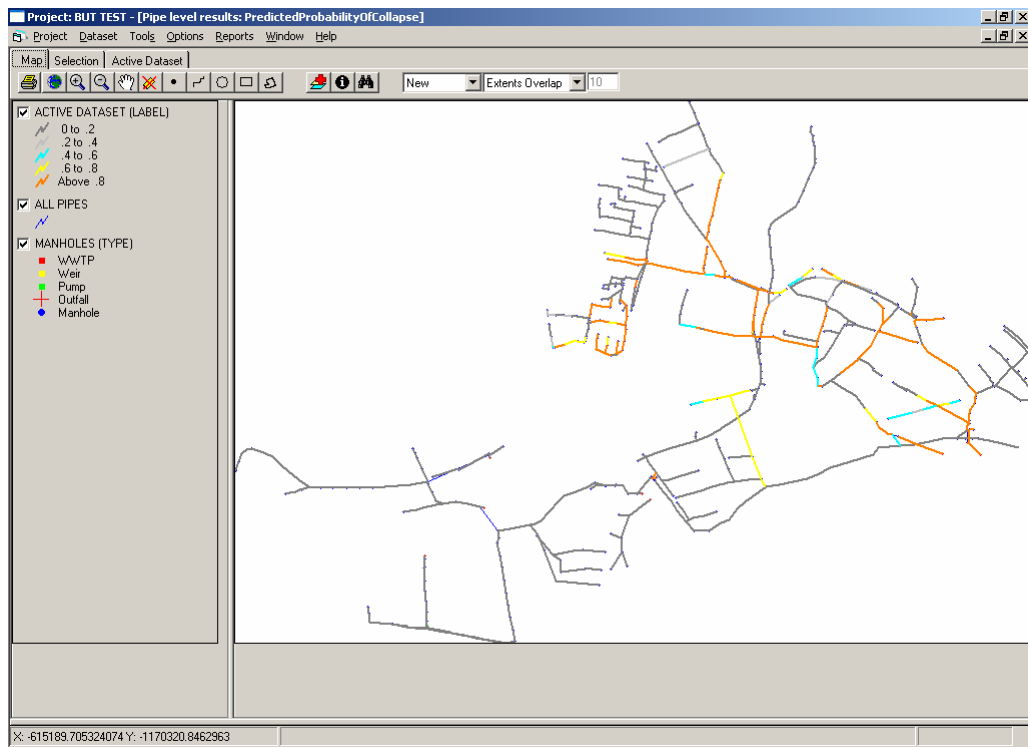


Figure 23 Predicted probability of collapse

Updating hydraulic parameters

Degradation Tool produces a change of roughness only in inspected pipes (CCTV); thus a new network can be simulated again with MOUSE and results imported back in the Rehab Manager central Database. There were 6 pipes inspected. The initial value of roughness range from 0,0118 to 0,0143. After Tool use, a new value has been found for pipes inspected; this value is of 0,01062 for all 6 pipes. Our user does not understand why new value is less then the initial value.

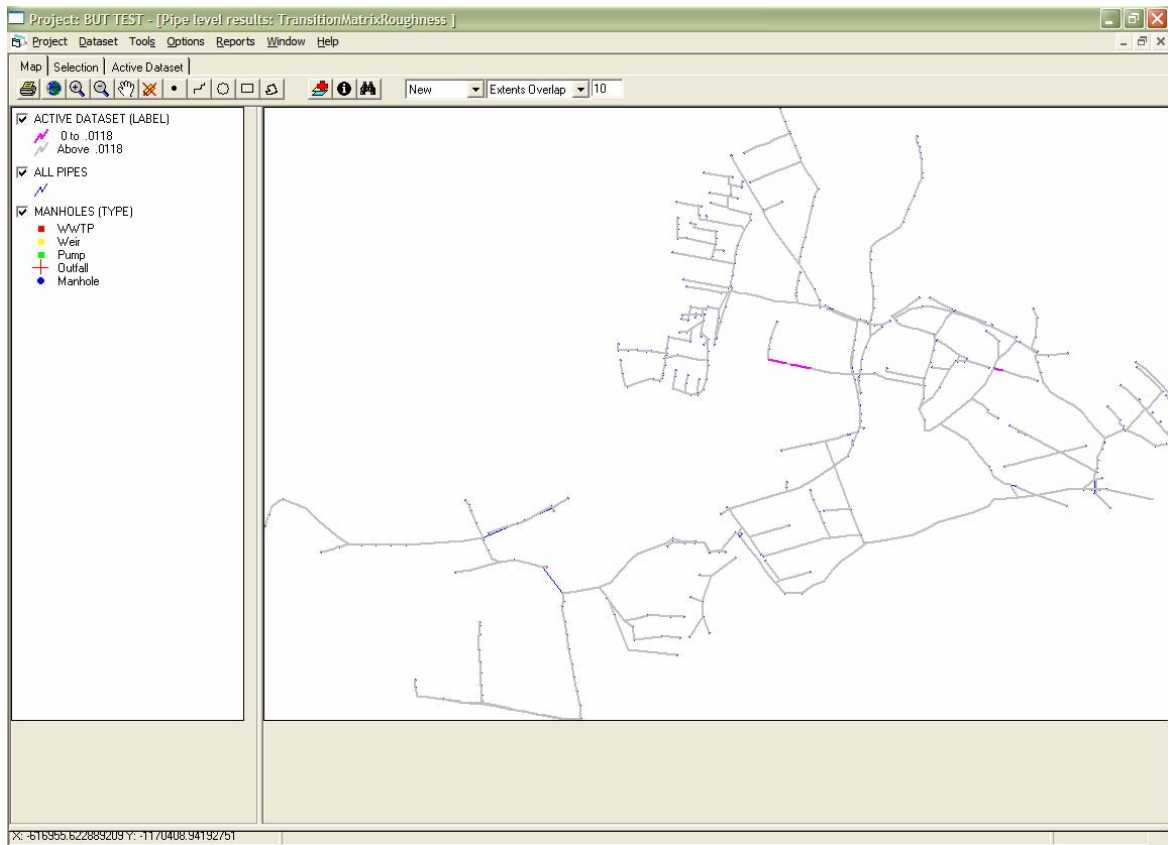


Figure 24 Transition matrix roughness

CSO assessment

Because time reasons (input preparation, uncertainty of results) we evaluated only 5 CSO structures by Method 1.

Input values: BOD (78,441 g/capita/day), COD (27,395 g/capita/day), NH-4-N (5,085 g/capita/day), specific water consumption (133 l/capita/day)

A-value: the river is probably not influenced by urban drainage.

B-value: the river biocoenosis is probably adversely affected by the hydraulic impact of CSO.

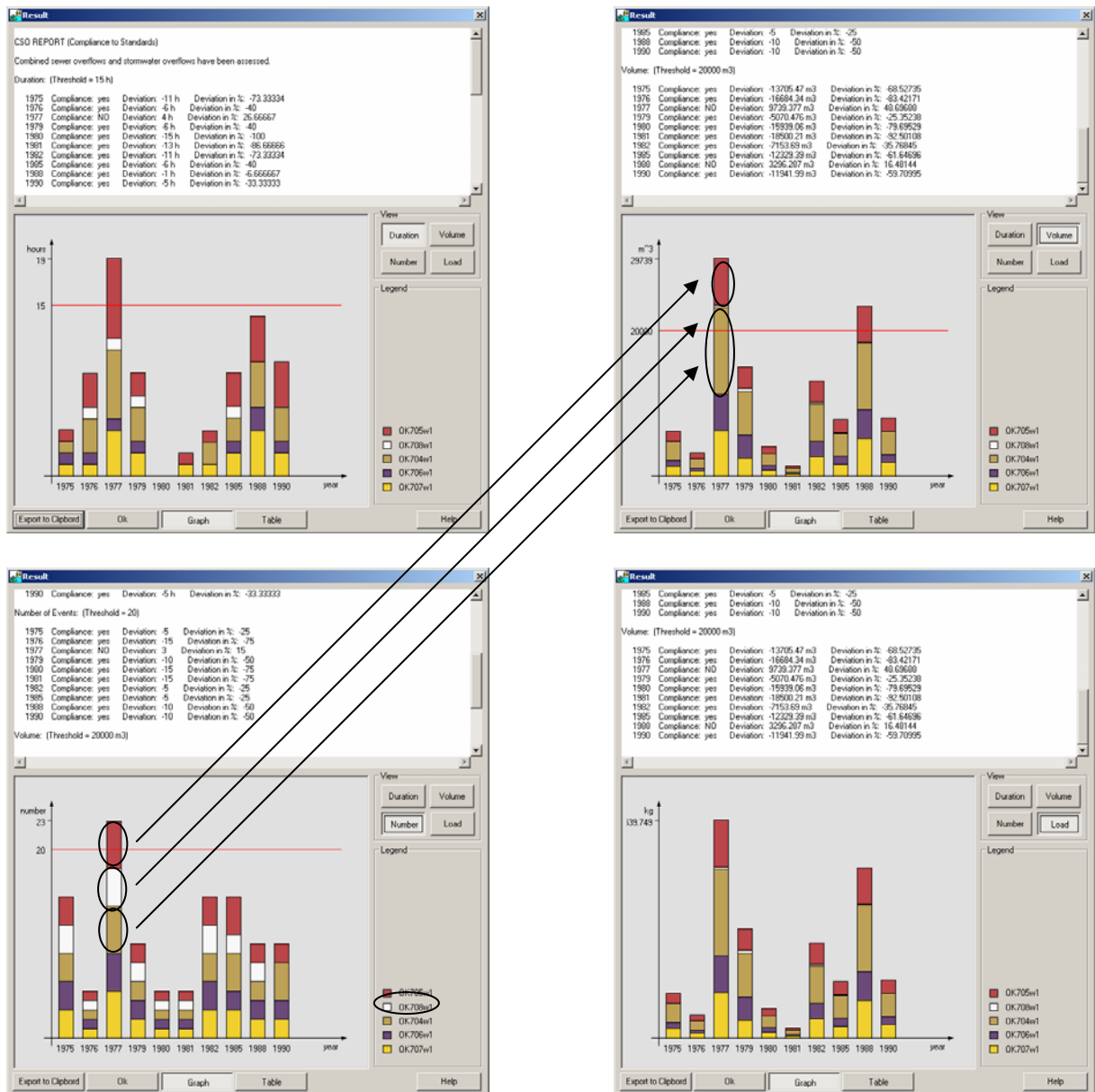


Figure 25 CAT graphs (Duration, Volume, Number, Load)

All four parameters should be evaluated together. From the Figure 25 is obvious, that any of the overflow parameters itself is not authoritative criterion for evaluation of CSO. E.g. white colored CSO Structure OK708: according to Number of overflow is seems so have a similar significance like OK704 and OK705. Nevertheless, according to Volume, OK708 has only very little significance in comparison with OK704 and OK705.

Calculation of probability of hydraulic and environmental failure

Default critical level was changed to value 1,5. Computation runs also with GAT and CAT outputs. Velocity criteria were not changed (default). User gets knowledge of the potential problem pipes. We compared Hellmud results with an evaluation within Master plan. The results were very similar, Hellmud results were more detailed.

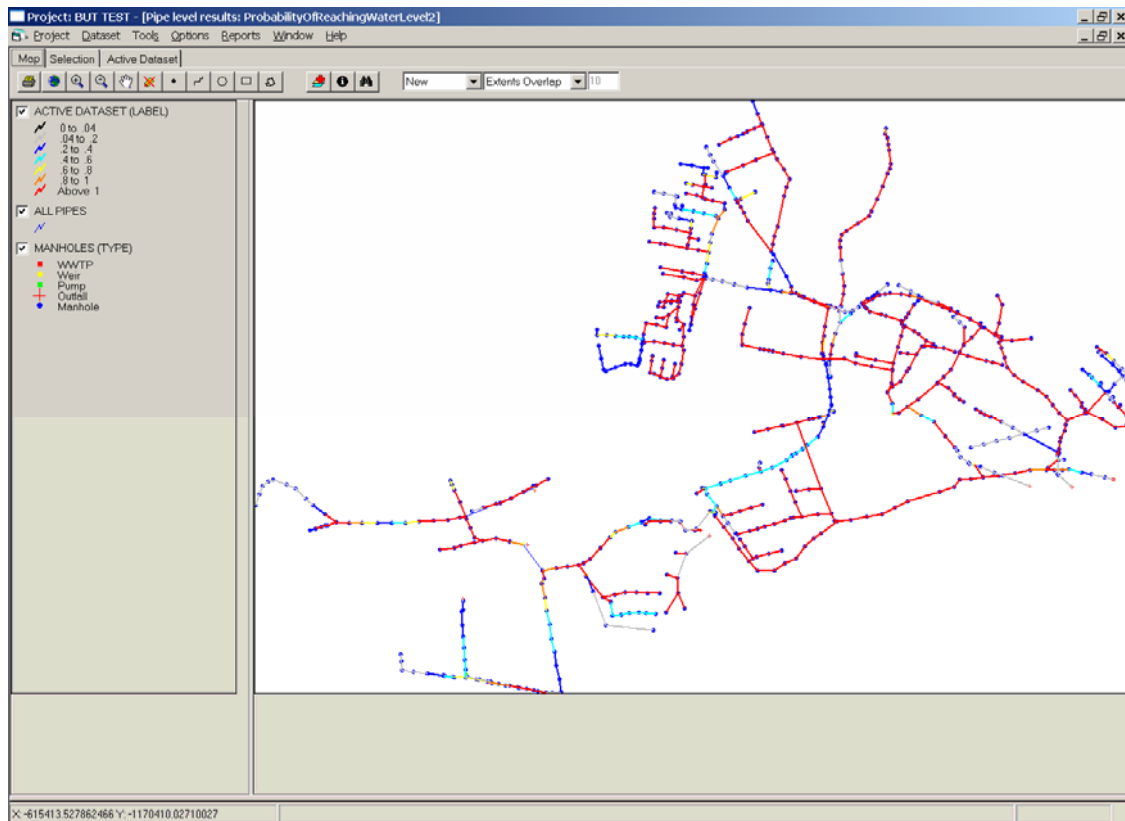


Figure 26 Probability of reaching level 2 (top of the pipe)

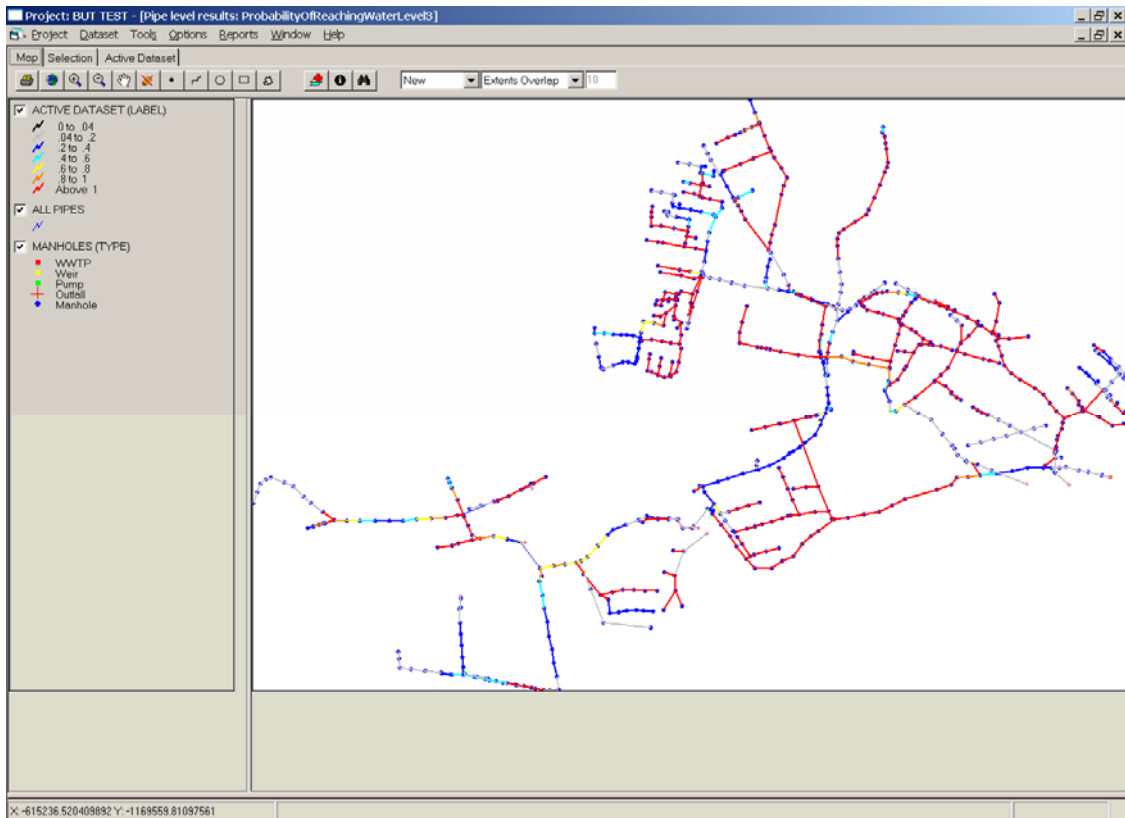


Figure 27 Probability of reaching level 3 (“critical level”)

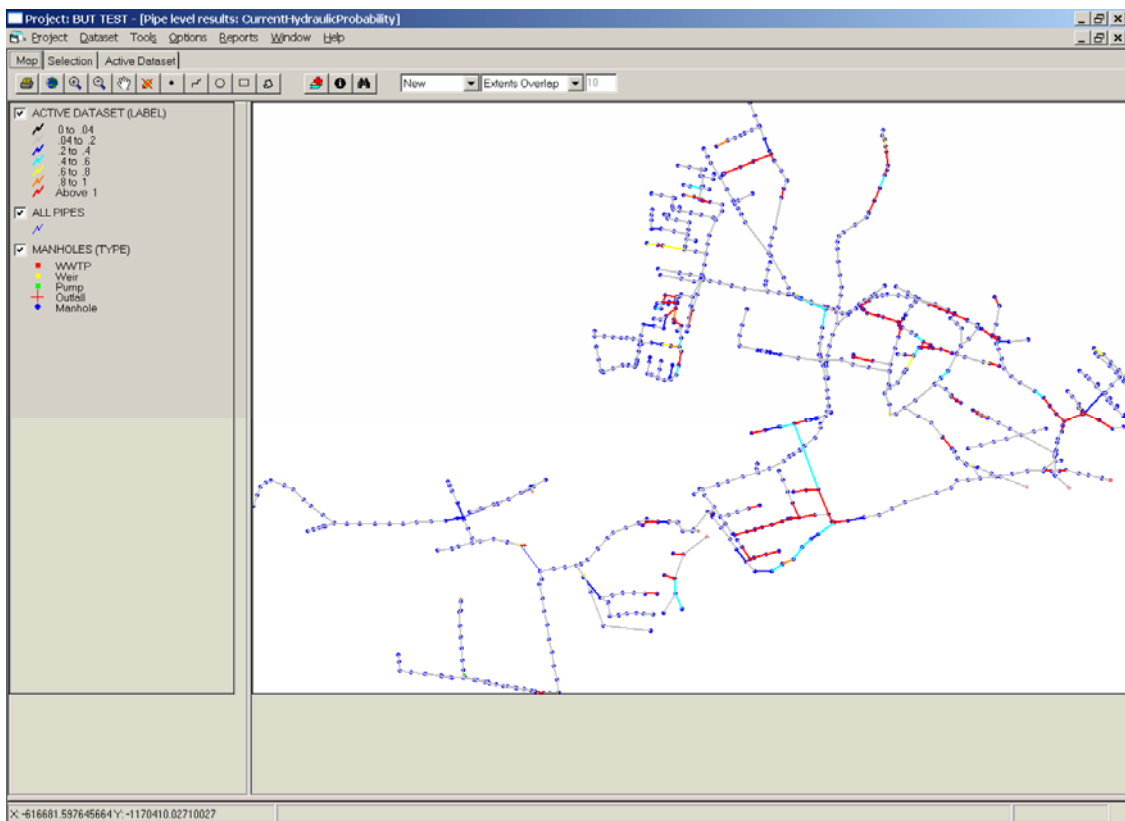


Figure 28 Current hydraulic probability (ground level)

Long term rehabilitation strategies

For the testing network, into three last tools (SRS, SRP, SRT) were entered only raw values (costs, inflation rate etc). The main aim was to try running the tool, not obtaining exact results. There are 4 condition classes (“1”, “2”, “3” according to user experience and “5” from CCTV inspection).

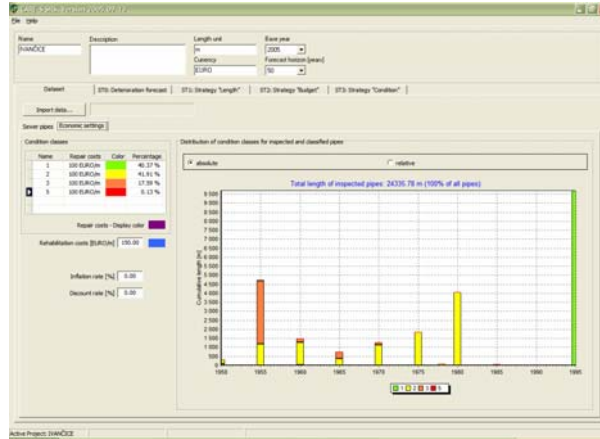


Figure 29 Distribution of condition classes for inspected and classified pipes

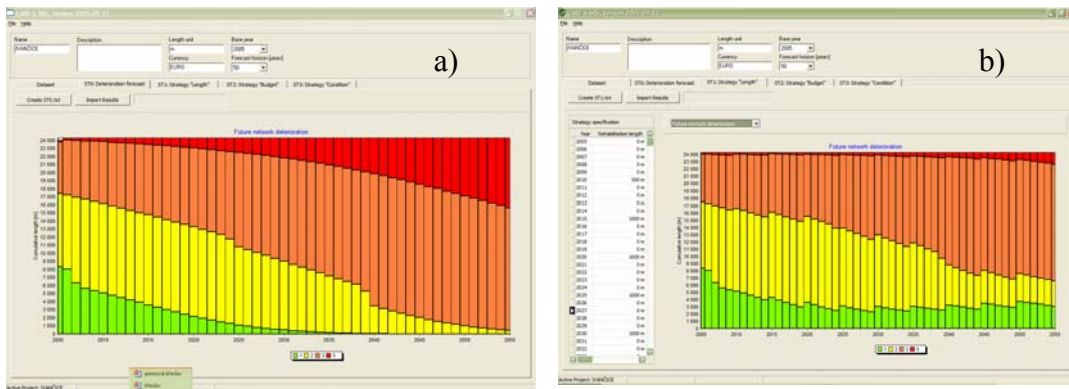


Figure 30 Future network deterioration:
 a) without any rehabilitation b) rehabilitation of 1000m every 5 years

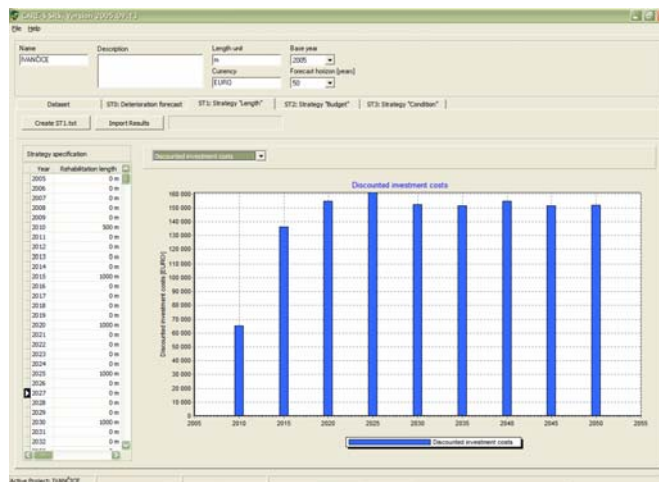


Figure 31 Discounted investment costs

Selection of pipes requiring rehabilitation

During creation of input file results from Hellmud tool were not imported as if the tool was not run. The cells “Filling level”, “Flow velocity” were empty although the data were saved in the Database. Socio-economic criteria were not imported as we have no data for running socio-economic tools.

Selection run successfully, problem with export of result occurs in some cases.

Figure 32 Imported data

Figure 32 Selection of pipes

Selection of rehabilitation technologies

SRT Tool was used for selection of suitable technology for several Candidates selected by SRP Tool, running as stand alone version.

As input data was entered only for testing purposes, no results were controlled and interpreted.

CONCLUSIONS

Working with CARE-S Rehab Manger was focused especially on following aims:

- Familiarization with CARE-S software
- Testing of functionality and reliability performance of the software
- Introduction of the CARE-S to our end-user
- Application on real sewer network
- Consultation of calculations, user interface and result with end user

Our end user is fairly satisfied with CARE-S Rehab Manger. He is persuaded that the software, describing performance of sewer network from various points of view, can bring a great benefit for sewer rehabilitation. Tested municipality already owns elaborated Masterplan of Urban Drainage including Rehabilitation plan, which enabled comparison of particular results from various CARE-S tools. A possibility to use results obtained on the base of this sophisticated Decision Support System for calling for funds from different sources is highly appreciated. Another advantage is registration and collection of important information on the network in the only database, within one integrated tool, and their presentation / visual display by means of GIS. For comparison of particular results would be excellent to enable opening of more then two GIS windows.

With respect to rather great requirements for input data, the end user will have to change his approach to data recording (new measurements, collection and registration of data etc.). For this case study represented by small district is not supposed an extensive CCTV inspection (because of costs), but in the frame of the whole competence of end user operation is expected a broad CCTV survey.

User would welcome easy reading, clear and understandable help and instruction for work with the software.

For distribution and usage in the Czech Republic, following factors will be crucial:

- Costs and return of investments
- Introduction of the product with presentation of advantages and demonstration of its functionality
- Further development of the product, customer service and consulting
- Language (can be limiting factor for using)

On the base of end user feed back, after launching of final CARE-S product we await further positive responses and interest in application of CARE-S in the Czech Republic.

Tips and suggestions for working with CARE-S

- Save, save, save project! Otherwise, in case the program failed, the results are lost.
- Be oriented in Rehab Manager database! (check out paths and addresses)
- Before you get a practice it is better simplified data at the beginning.
- Have a CareS really installed on disk C:\CareS, otherwise the unpredictable problems occur.
- Program is running even it seems to be dead.

Report on testing carried out in Dresden, Germany

Partner: TU Dresden

End User: Stadtentwässerung Dresden (SEDD)

Author: Stefan Hoefft

INTRODUCTION

The test case area is Pieschen, a sub-network of Dresden, operated by Stadtentwässerung Dresden (SEDD). The sub-network represents 139 km, or approximately 9% of the total network length of the sewer system of Dresden. Construction periods are well known for the network. However, data for the decades after World War II is rather assumptive, especially the significant peak in 1960 (Figure 1) is most probably due to the assignment of pipes for which the exact installation year is unknown.

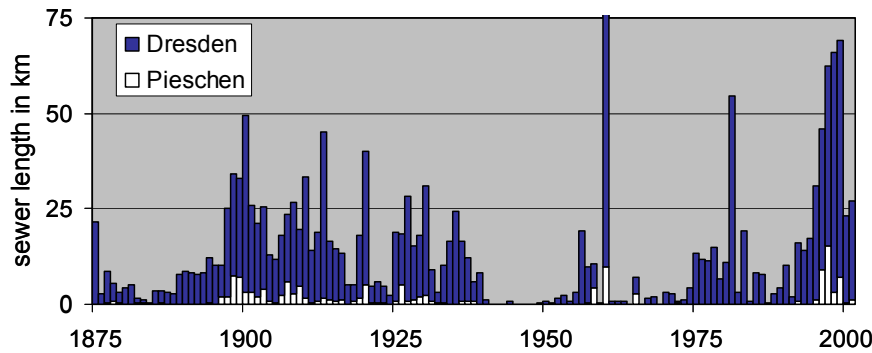


Figure 1: Sewer length in km by construction year for Dresden and Dresden-Pieschen

The sub-network is located in the North-West of Dresden on the right hand side of river Elbe (Figure 2). The area includes high density urban areas, industrial and commercial areas, a more rural area in the Northern part and the Wastewater treatment plant (WWTP, the blue point on the map, Figure 3).

With respect to the tools that require hydraulic simulation data it was decided to import the surrounding sub-network of Dresden-Neustadt additionally because this whole area drains into the network of Pieschen, especially into the main collector drain located along the river Elbe. That decision allows a hydraulic dissociation with a minimum number of system boundaries with unknown conditions (only two cut-offs) and it is assumed that the cut offs do not influence the hydraulic situation of the network.

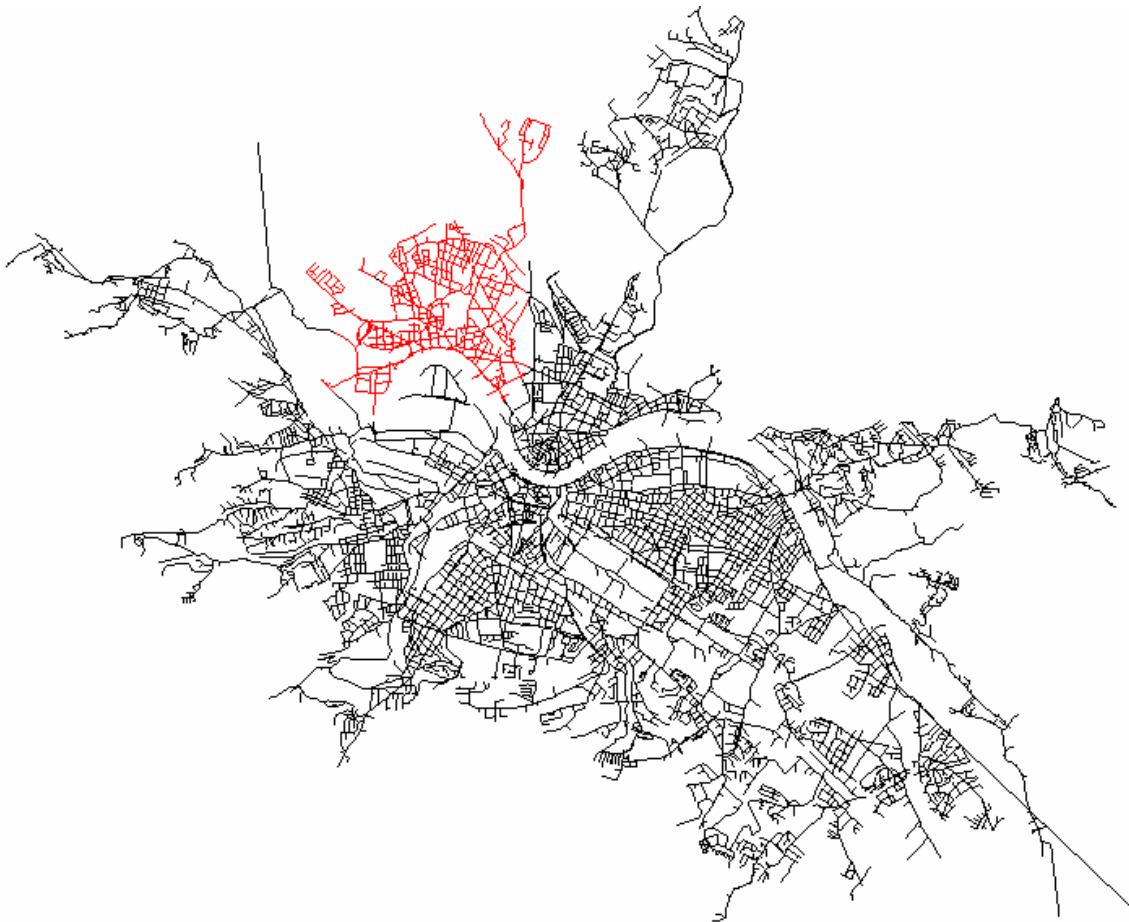


Figure 2: Scheme of the Dresden Sewer system indicated the Pieschen sub-network

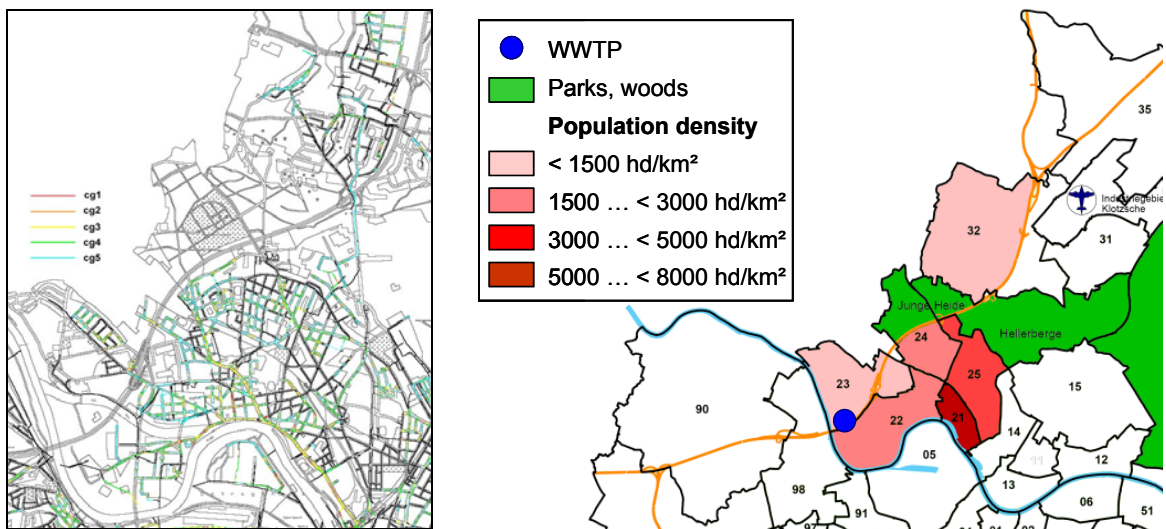


Figure 3: Condition grades of inspected sewer pipes, and area covered by the sub-network, indicated are green spaces, population densities of the area of interest and the location of the WWTP

DATA AVAILABILITY

During the tests we detected data format inconsistencies. Hydraulic data of SEDD is only available in Hystem Extran or GIS format, while Care-S requires the data according to Infoworks, Mouse and SWMM formats. Thus we wrote a routine to convert the Hystem Extran data into the SWMM5 format. After the implementation of the import function for hydraulic data in SWMM5-format it was announced that CARE-S can import SWMM4.4 data only. A new conversation of data to the supported format was necessary.

Another issue concerning data is related to the database of the operator of the sewer network. SEDD uses two different databases, one database contains data for all assets enclosing the complete network. For hydraulic simulations SEDD uses a simplified model to reduce the simulation time, therefore the associated database contains data of a reduced sewer network. These databases contain different IDs for the same conduits. Within CARE-S it is necessary to associate the hydraulic results for single pipes to data coming from other models. Due to the missing synchronisation of the databases it was not possible to test all CARE-S tools. Some tools were tested outside the Rehabilitation manager. Further comments are given in the chapter Recommendations and Requirements.

GUI

The Graphical User Interface provides a lot of useful tools and functions for selection and update of pipe and manhole properties. In particular the expression builder with its several options has shown to be very useful.

GAT tool

We tested the Groundwater Assessment Tool as stand alone version. The reason therefore is described under the chapter recommendations and requirements. Vulnerability values reach from 25 to 108 in the example (Figure 4).

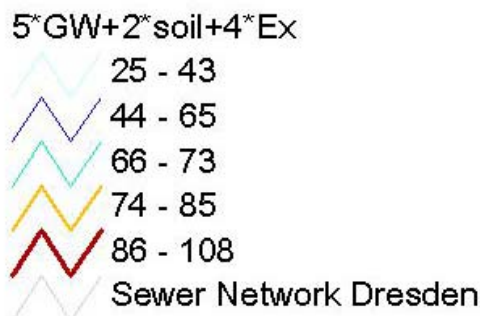
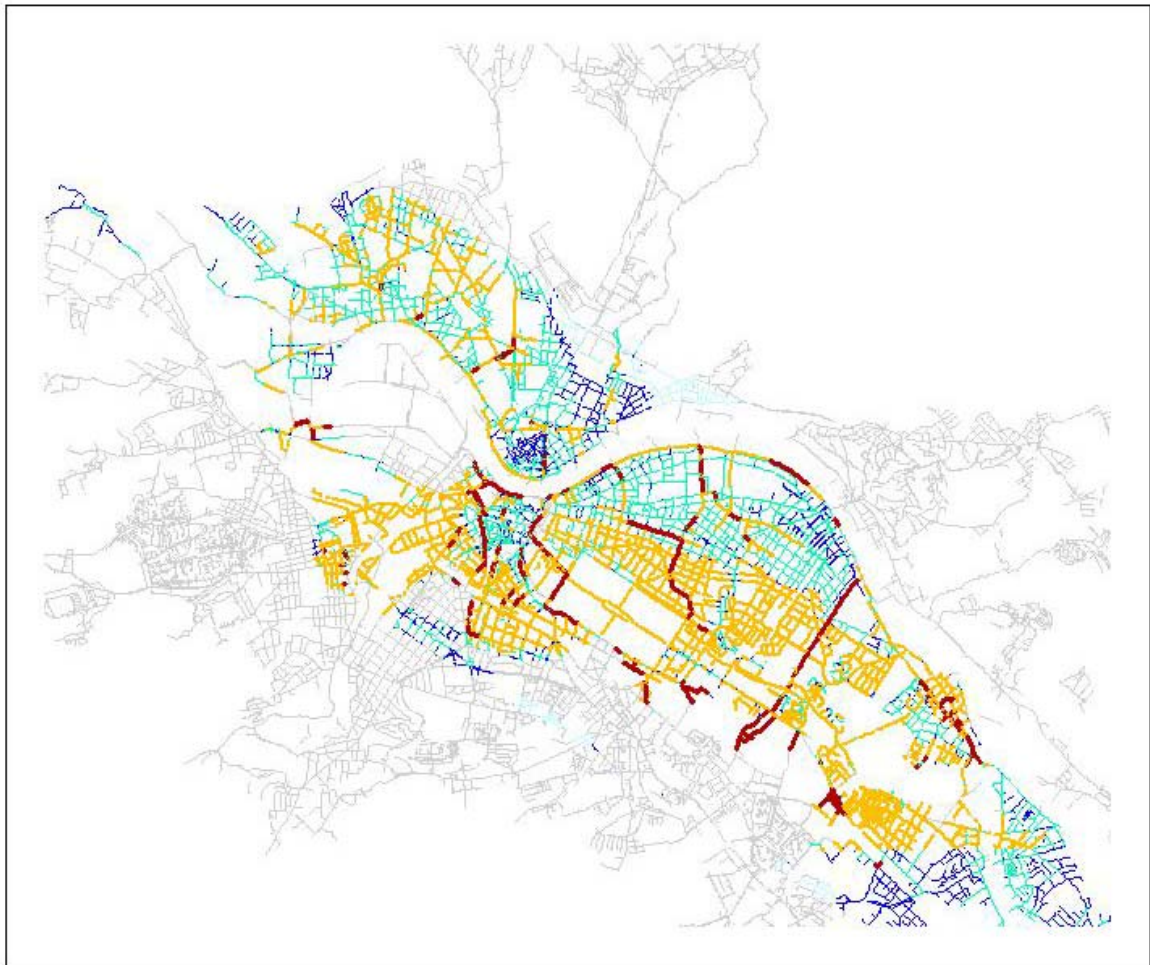


Figure 4: Result of the groundwater vulnerability evaluation for Dresden

Recommendations and Requirements

Hydraulic simulations in sewer networks with thousands of conduits are very time-consuming. Thus in most case studies the networks are simplified to reduce the simulation time. On that account there are two different network databases for the same network. Data like installation year, material, condition grade etc. are stored in the detailed database. Only the data set that is needed for hydraulic simulation is stored in the simplified model database. In case of SEDD only the simplified model can be imported to Care-S and there is no easy way to insert the missing data of the detailed model. For example the transfer of attributes of conduits of the detailed model that can be different for each of these conduits to only one lumped conduit in the simplified model is still impossible yet. A solution for this problem is required because other larger towns are also predestined for that problem.

CONCLUSIONS

In respect to the different data formats for the hydraulic model and the fact that two databases with different Pipe IDs exist makes the data import into Care-S very difficult. Before an effective use of Care-S for the interests of SEDD is possible it is necessary to import more information about the conduits from the detailed model easily.

Report on testing carried out in Oslo, Norway

Partner: SINTEF

End User: Oslo Municipality

Author: Ingrid Selseth

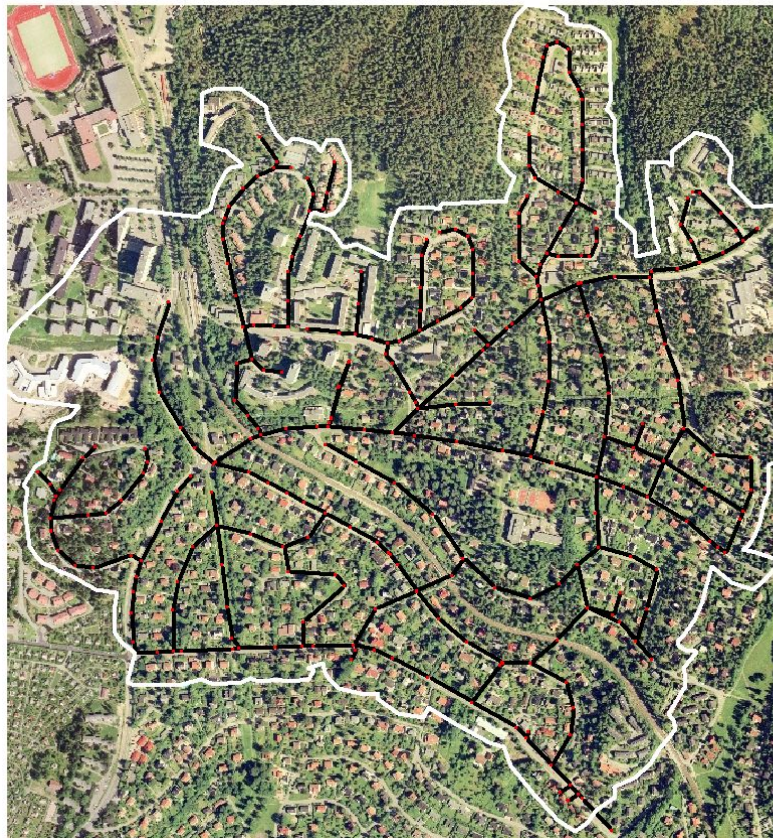
INTRODUCTION

The Nordberg catchment is situated in the northern part of Oslo.



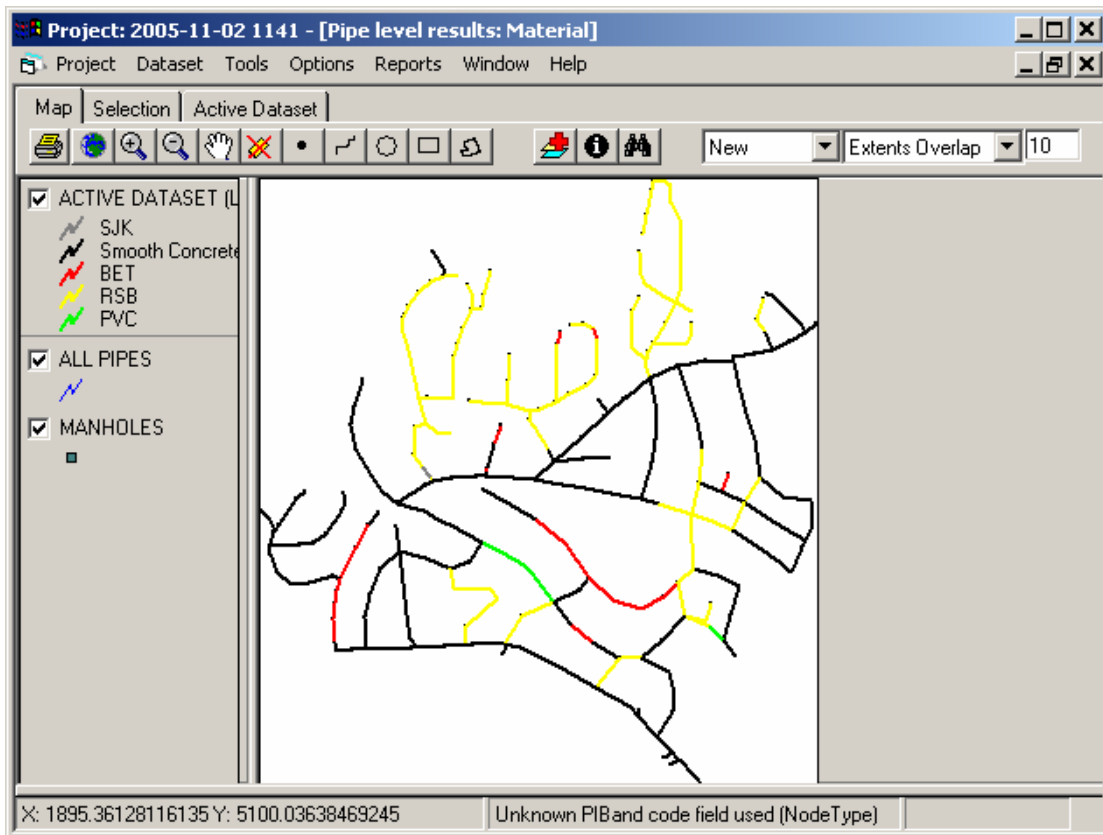
Location of the Nordberg catchment

For the testing of CareS, it was important to choose a subcatchment which contains pipes where operational failures were recorded (blockages) and where it is possible to get information about the pipes and their structural state. It was decided to consider only the subcatchment of Nordberg (called A1), and which has an area of around 125 hectares. The subcatchment can be considered as a residential area, with houses and inhabitants, 4813 inhabitants.



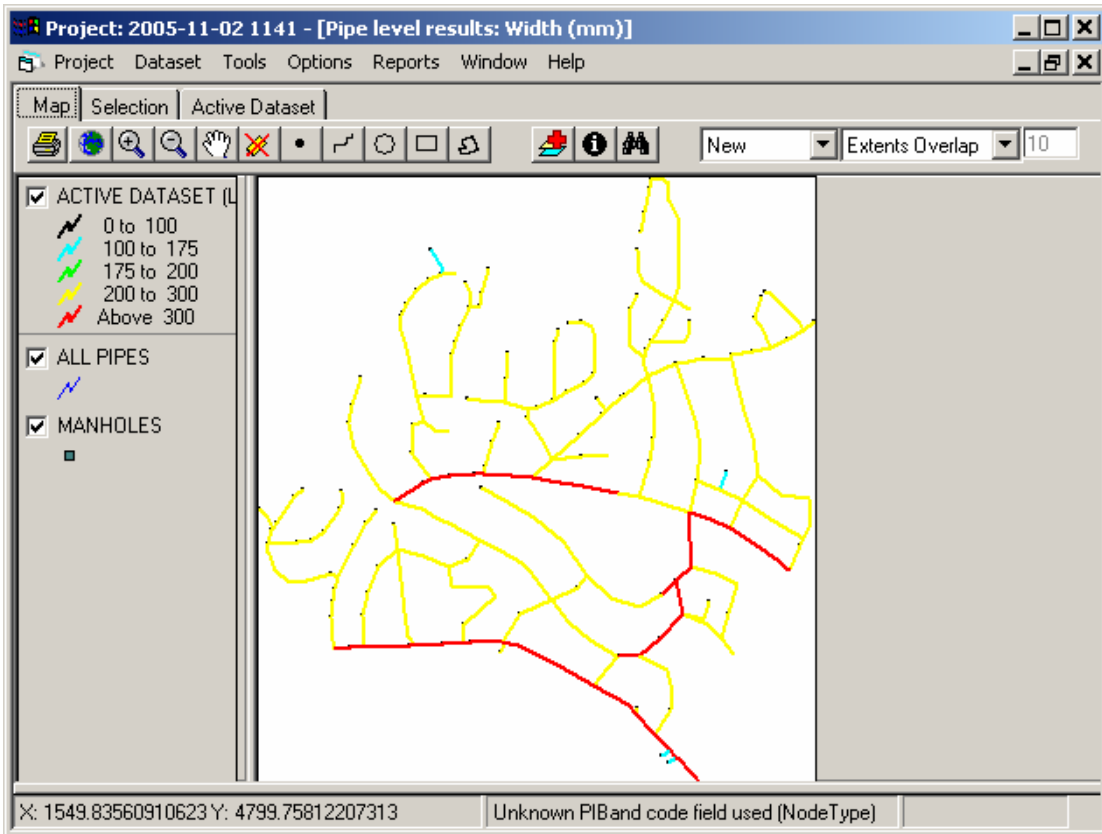
The Nordberg catchment (white line) and the network (black lines)

The combined area covers 73 ha, the separate one 50,5 ha. There is also a small storm water area of 1,5 ha. According to the classification made by Oslo municipality, there are some combined pipes (AF), some storm water pipes (OV), sewer pipes (SP) and sewer pumps (PS). Most of the pipes are combined or sewer pipes. The outlet is located in the lower right pipe.

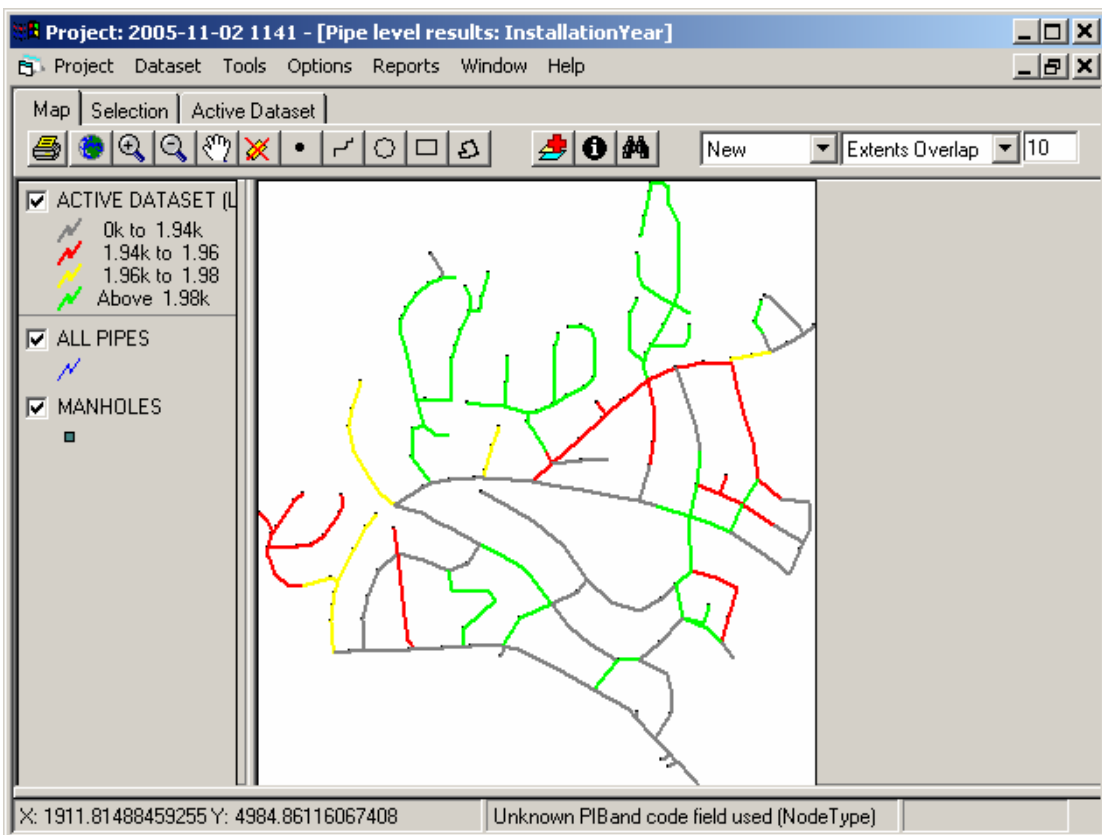


Pipe material

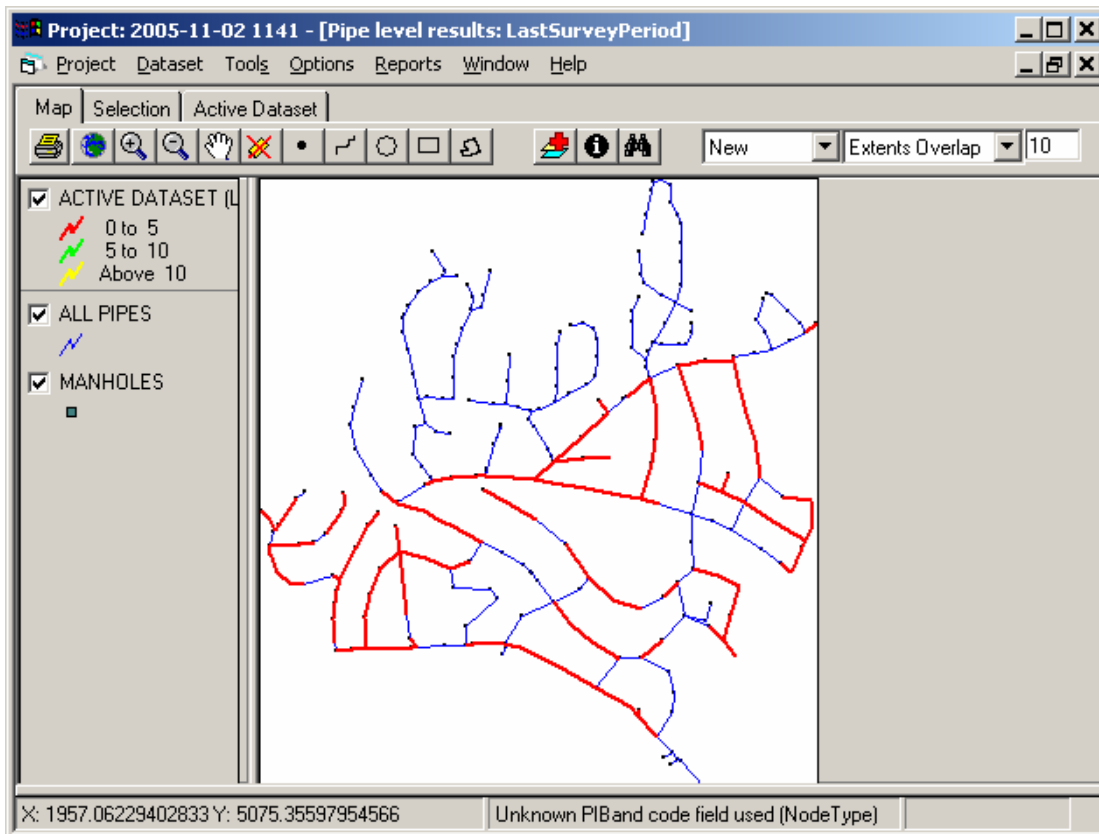
Most of the pipes in the south part of the catchment were built between 1926 and 1935, whereas most of the pipes in the northern part are more recent, from the sixties.



Pipe Diameter



Installation year



Inspected pipes

DATA AVAILABILITY

Network data

The Norwegian water and waste water database Gemini VA is used by almost every Norwegian municipality. This database includes pipe/manhole/valve/pump data and operating data (e.g. Blockage data). Oslo also has a GIS which includes roads, buildings, population as well as orthophotos. These data were imported using a csv file.

CCTV data

Oslo uses a WinCan system for their latest CCTV inspections. This system facilitates an export of data that can be imported almost directly to CareS.

Hydraulic model

The MOUSE hydraulic model of sewer system is used.

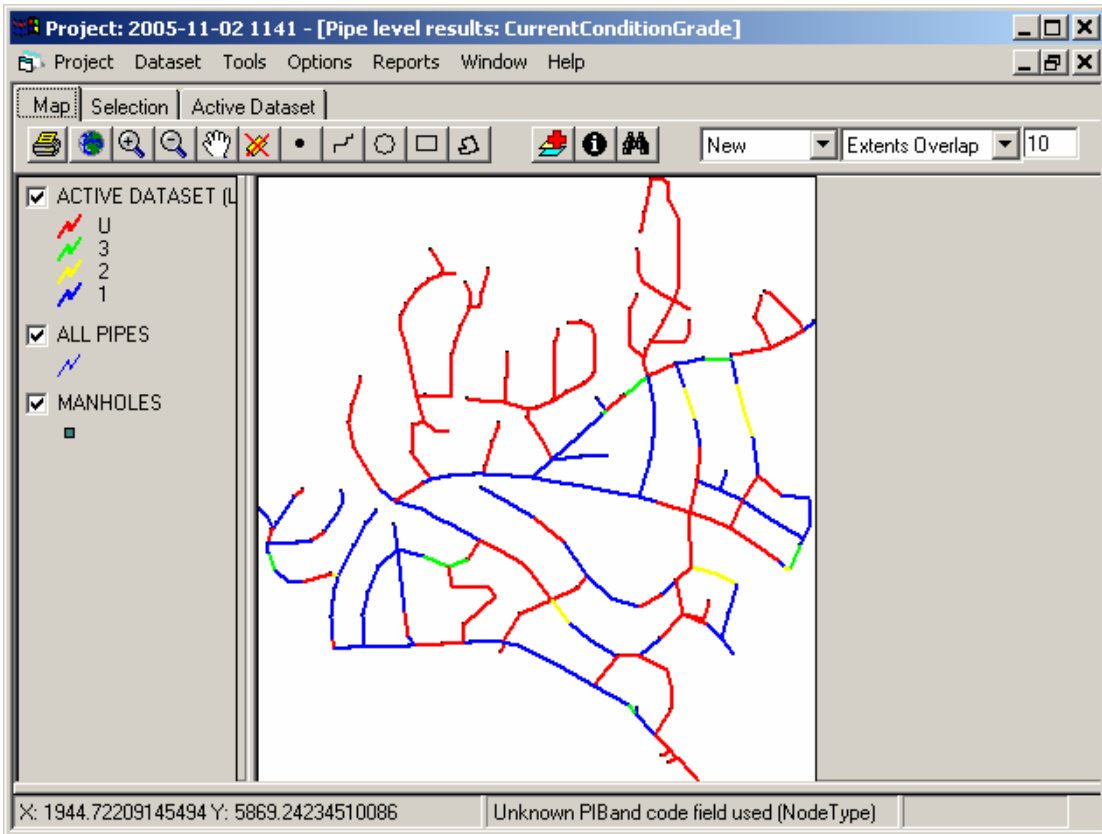
TESTING

PI Tool/S

Data for Nordberg was collected for 2004. 61 UIs were imported, but 33 of them were zeroes. 19 PIs were calculated, 16 of them were zeroes. The tool is working well.

CCTVconverter

119 pipe inspections from Aug until Dec 2001 were imported. We had a problem with longitudinal cracks, since these are not exported today (this might be included in the next version of WinCan primo 2006). Oslo Municipality has their own system for "calculating" the condition grades. These values were imported to CareS.



Current Condition Grade

GompitZ

Program runs OK

The selected strata and co-variates

StrataID	StrataStatus	StrataName	Material	PipesInStrata	ValidNumber	AgeInC	ValidAge	CurrentCondi	ValidCurrentC
2	Invalid	BET	BET	19	Invalid		Valid	Varies	Valid
3	Valid	Other	Other	136	Valid	0			
4	Invalid	PVC	PVC	7	Invalid		Valid	Varies	Valid
5	Invalid	RSB	RSB	109	Valid		Valid	U	Invalid
6	Invalid	SJK	SJK	1	Invalid	23	Invalid	U	Invalid
7	Valid	Smooth Concrete	Smooth Concrete	319	Valid		Valid	Varies	Valid

Summary of strata (only two valid strata)

```

GompitZ v2.01 - Calibration results

*** Stratum Other ***
0 (total weight = 0.00) pipelines described in this stratum

0 (total weight = 0.00) inspections reported:
Warning: Stratum void of inspection data - Calibration aborted

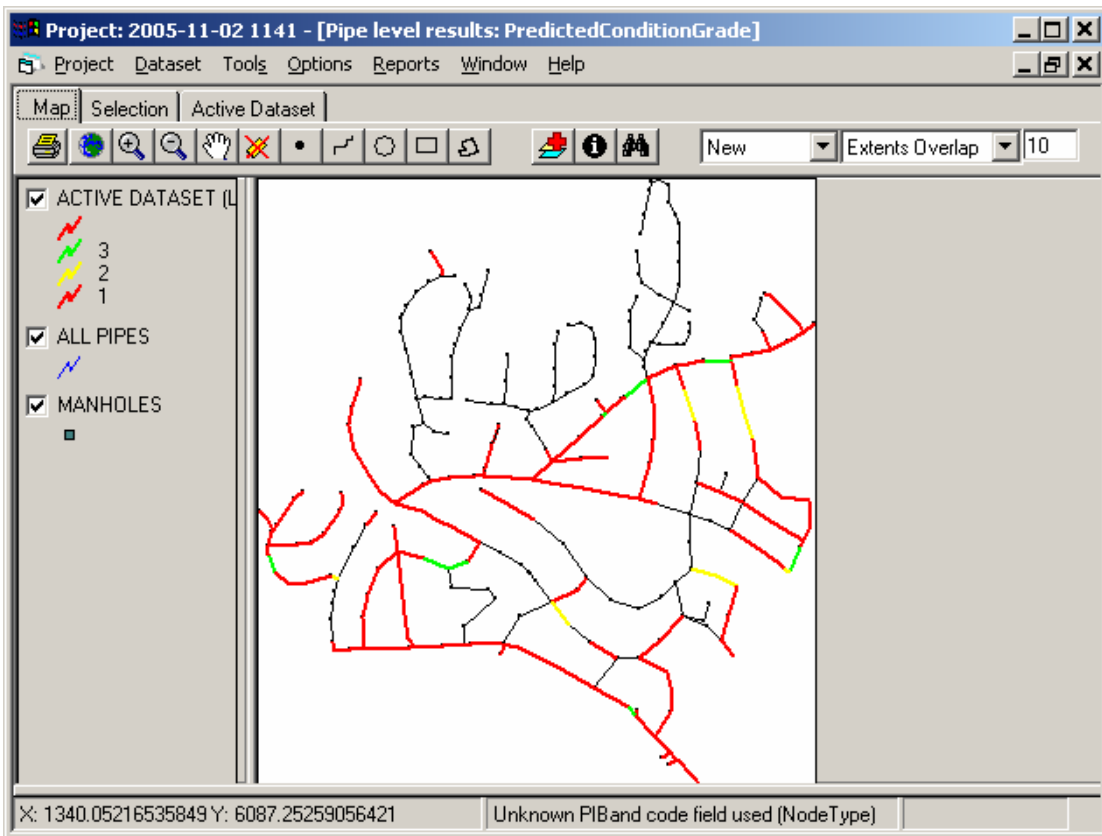
*** Stratum Smooth Concrete ***
159 (total weight = 159.00) pipelines described in this stratum

105 (total weight = 105.00) inspections reported:
89 (total weight = 89.00) of which in condition 1
8 (total weight = 8.00) of which in condition 2
8 (total weight = 8.00) of which in condition 3

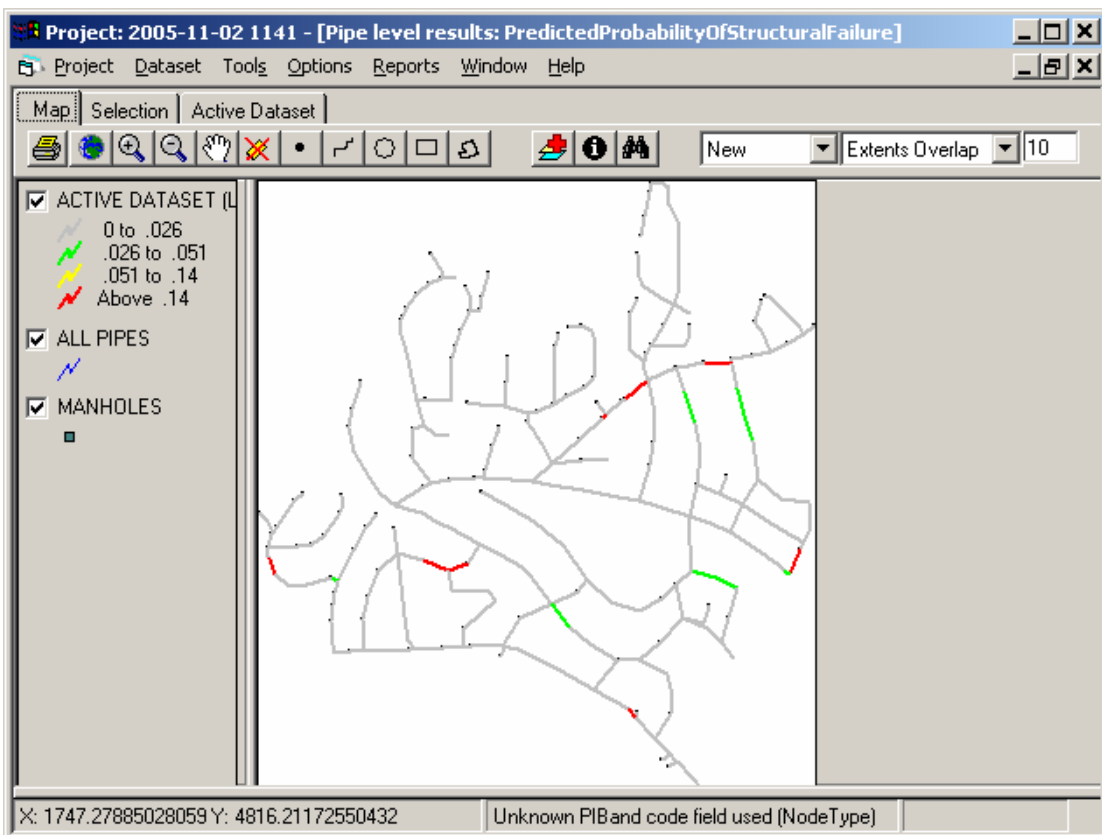
Convergence achieved in 95 iterations
Log-Likelihood = -61.193515

Parameter estimates and Wald Chi2 tests
-----
Label                Estimate      Std. Error  DF  Chi2      Pr>Chi2
-----
Alpha(1) (vs 0)      -4.6230e+000  9.9989e-003  1   2.1376e+005  0.000000
Alpha(2) (vs Alpha(1)) -1.1820e+002  1.0000e-002  1   6.4510e+007  0.000000
Height (mm) (vs 0)  +4.1601e-003  6.1969e-003  1   4.5067e-001  0.502016
T (vs 0)              -5.3801e+000  9.9355e-003  1   2.9322e+005  0.000000
Sigma (vs 0)         +5.7751e+000  9.9299e-003  1   3.3824e+005  0.000000
    
```

Calibration Log



Predicted Condition Grades



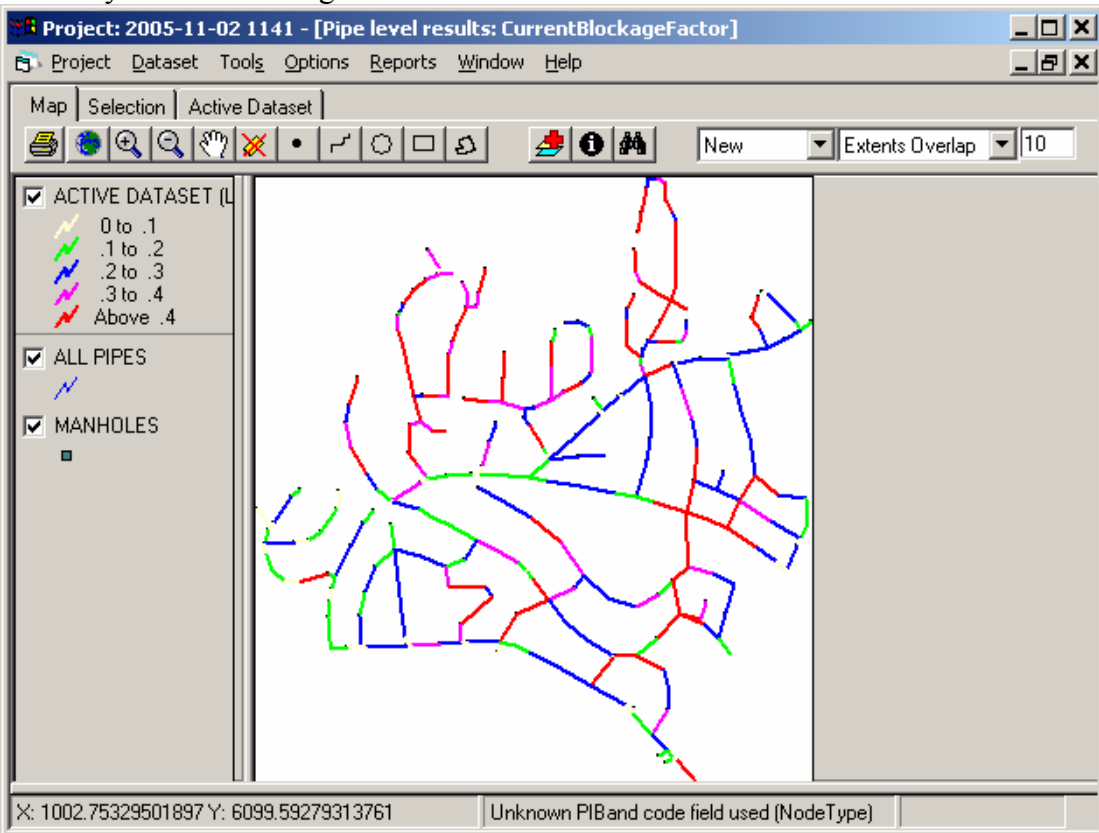
Predicted Probability of Structural Failure

In-/Exfiltration

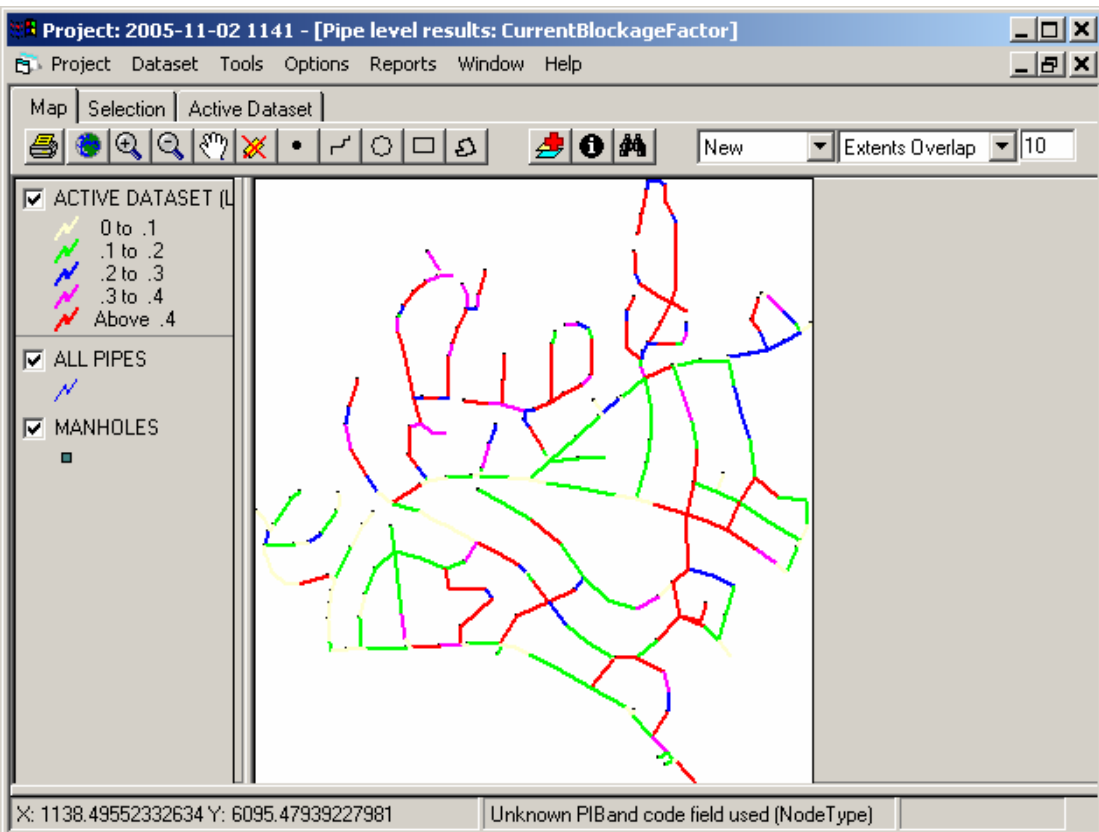
This was not tested due to difficulties with creating import files from Mouse.

Blockage Tool

A history with 41 blockages were used.

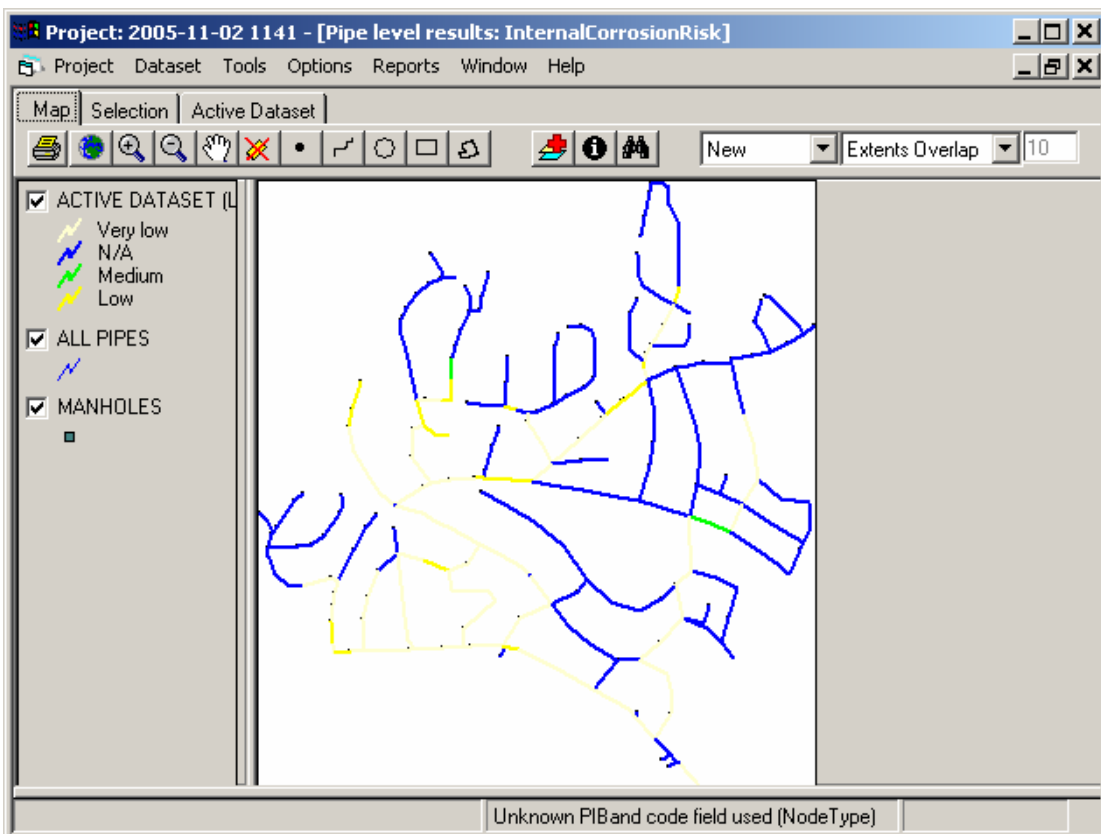
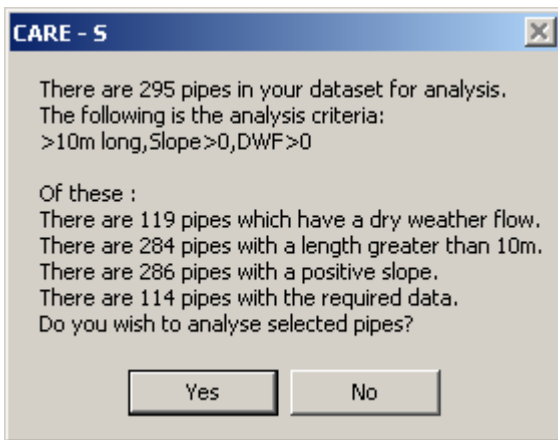


Blockage Factors based on Material, Diameter, InstallationYear and ConditionGrades

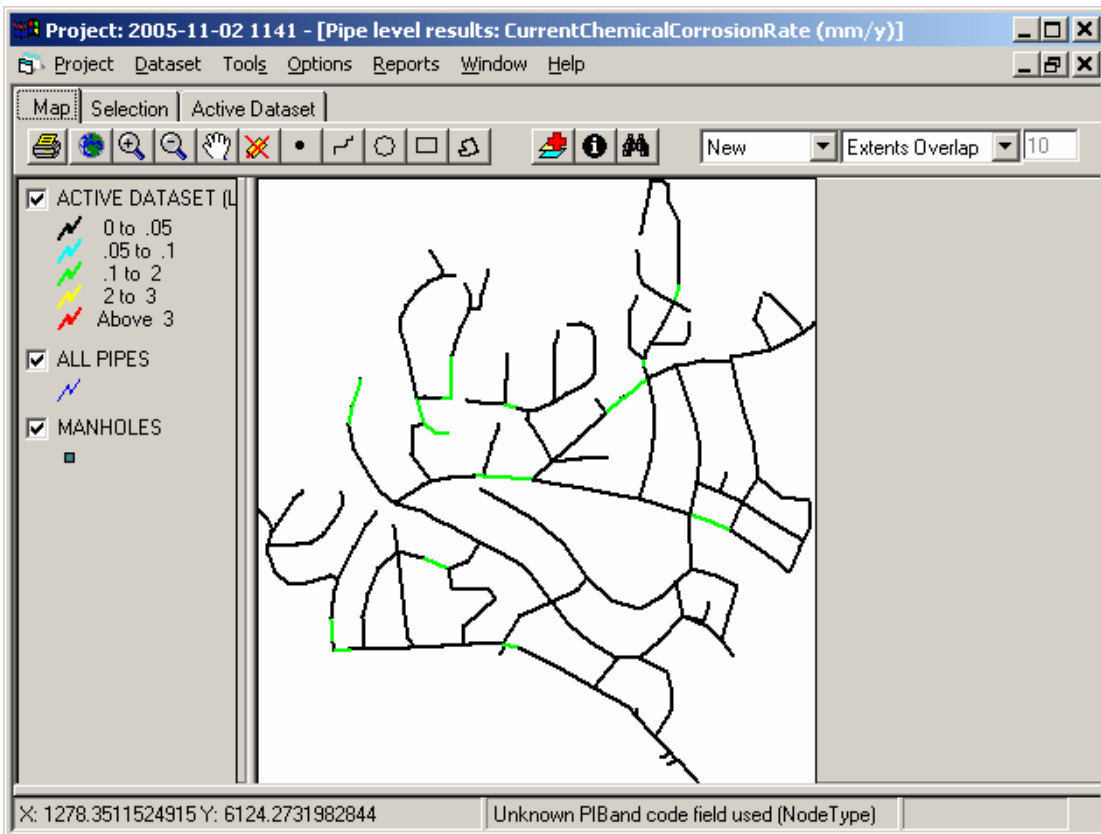


Blockage Factors based on Material and Condition Grades

Zmodel - not considered to be an interesting tool in Norway, since hydrogen sulphide is not a problem. Program runs OK.



InternalCorrosionRisk

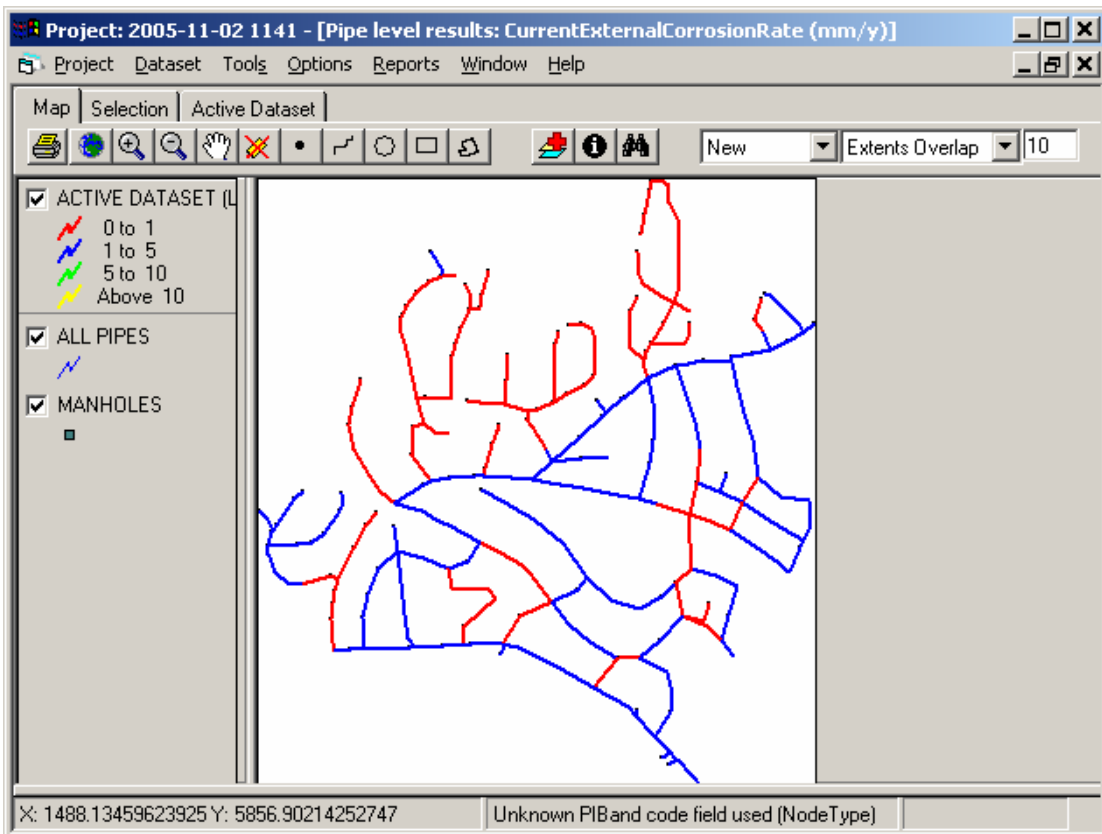


CurrentChemicalCorrosionRate (mm/y)

Wats - not considered to be an interesting tool in Norway, since hydrogen sulphide is not a problem

ExtCorr

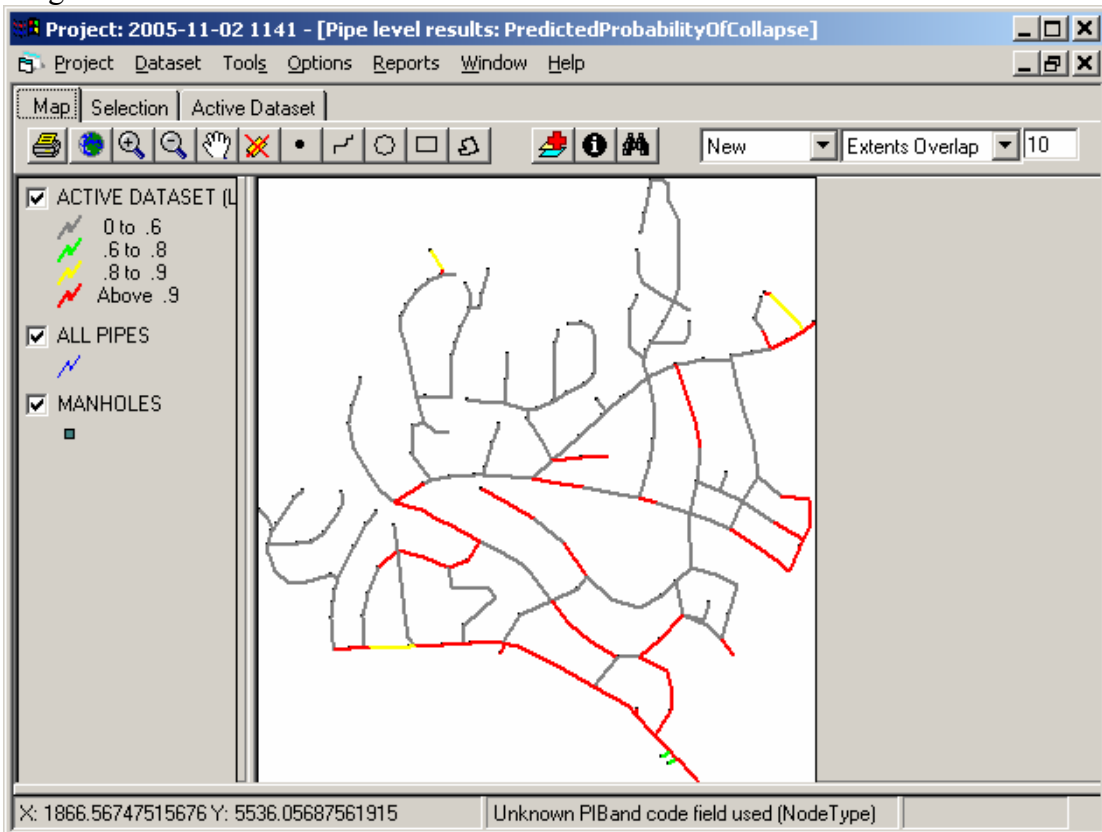
Program runs OK



Current External Corrosion Rate [mm/year]

Load

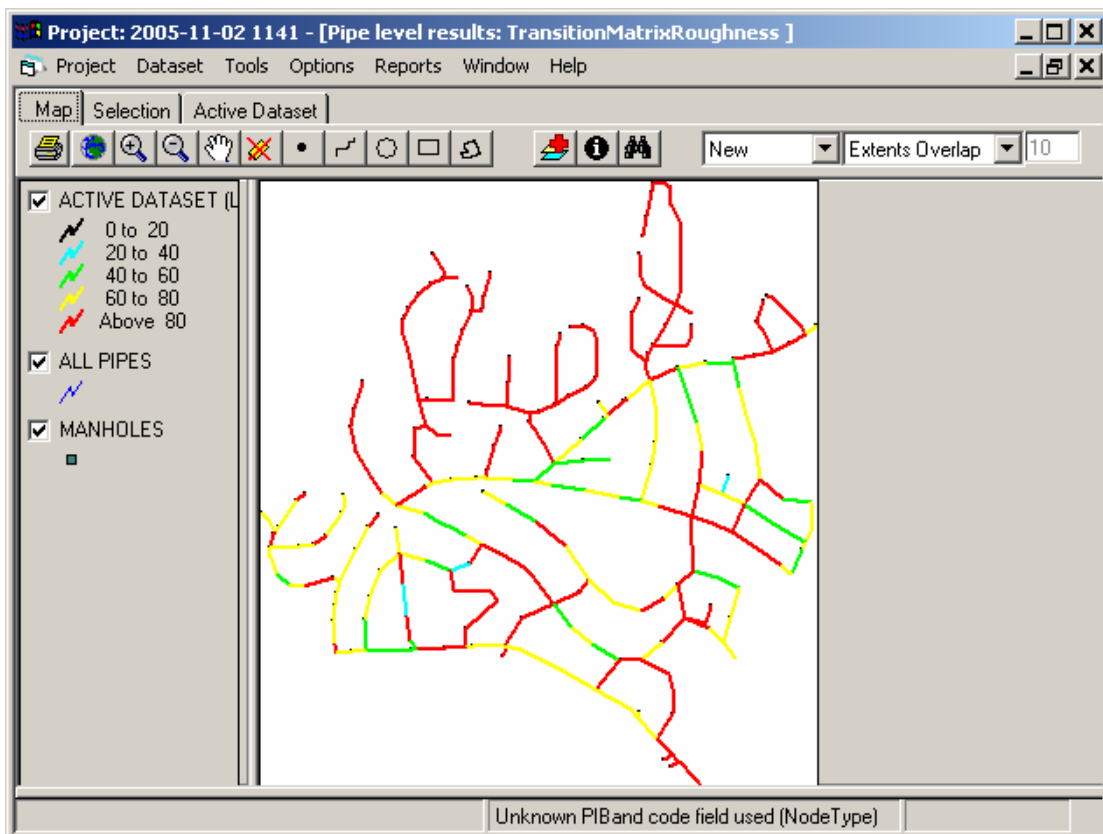
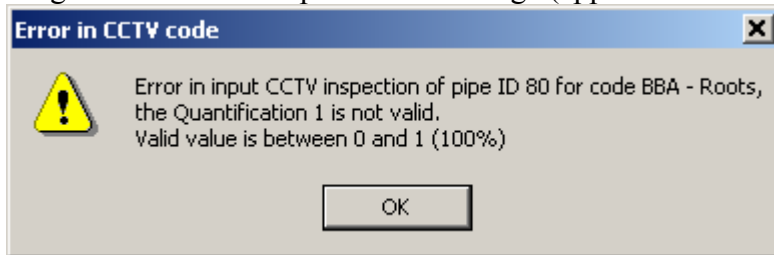
Program runs OK



Predicted Probability of Collapse

Degradation

Program runs OK except for this message (appears a few times)



Transition Matrix Roughness

Create Hydraulic Model

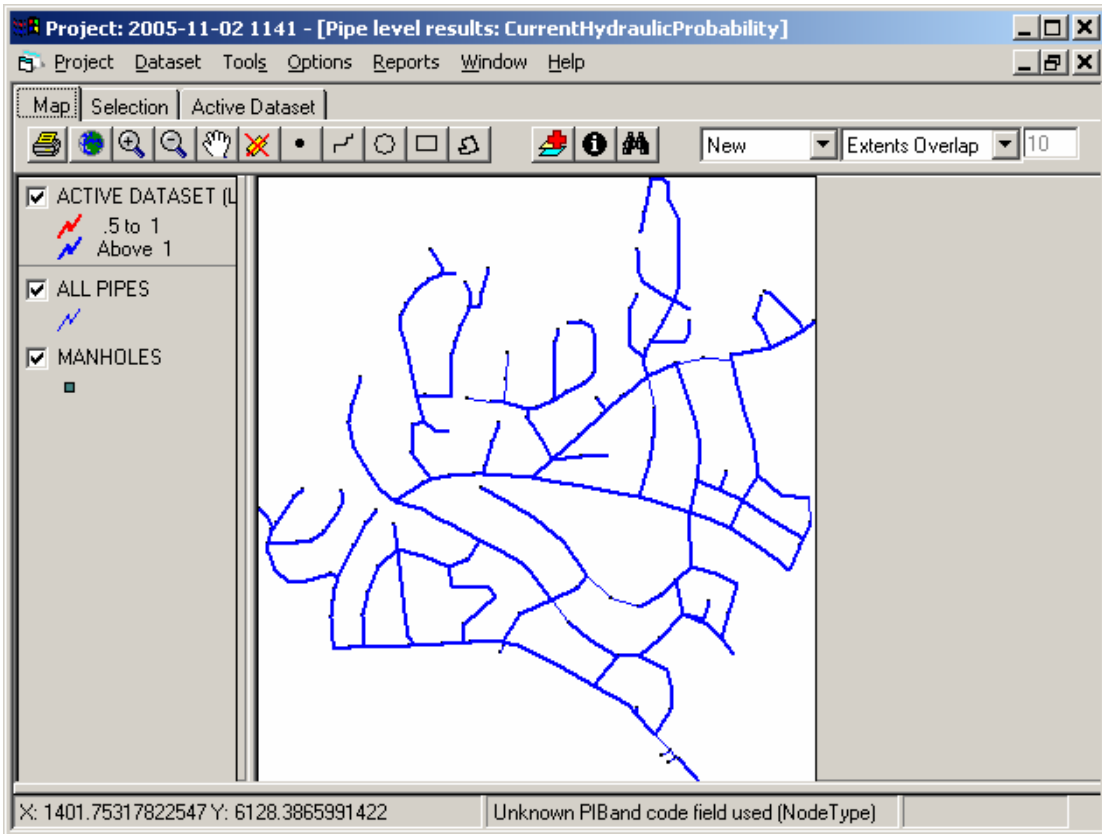
Program/function runs OK, except for after Mouse model is saved it continues to save as SWMM

CAT - not considered to be an interesting tool in Nordberg
Program runs OK

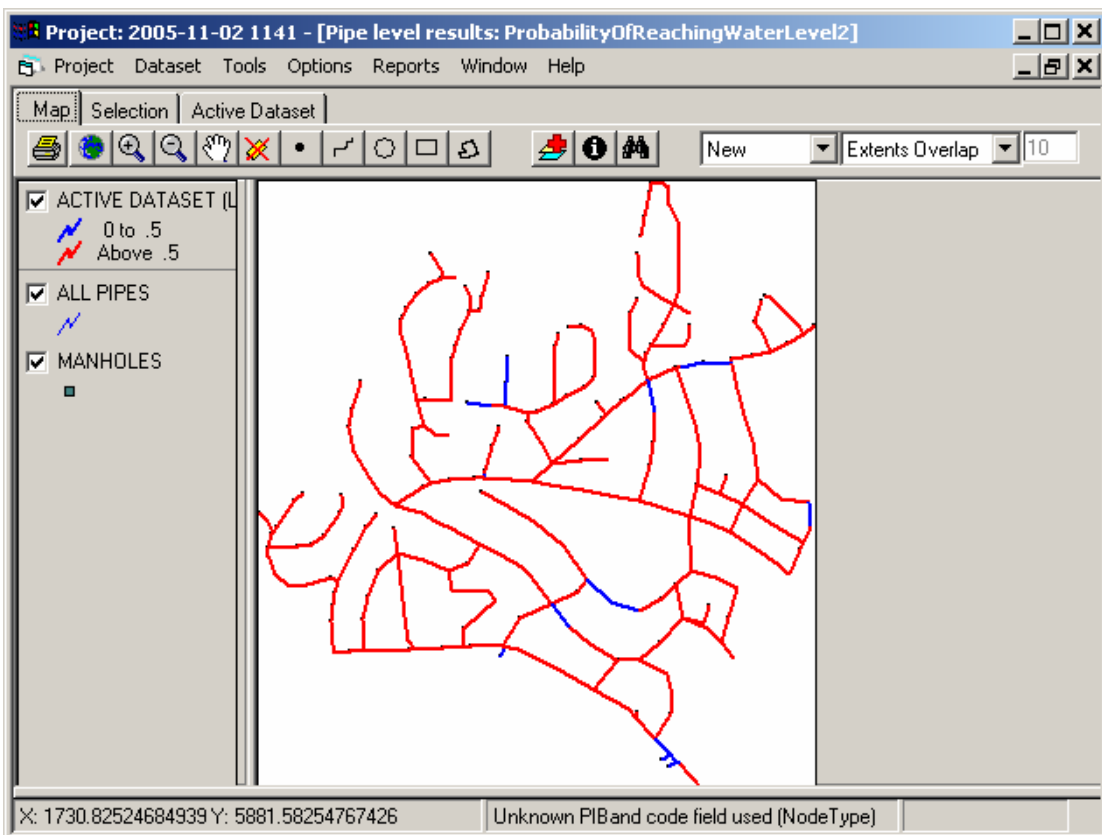
GAT – not considered to be an interesting tool in Nordberg
Program runs OK

Hellmud

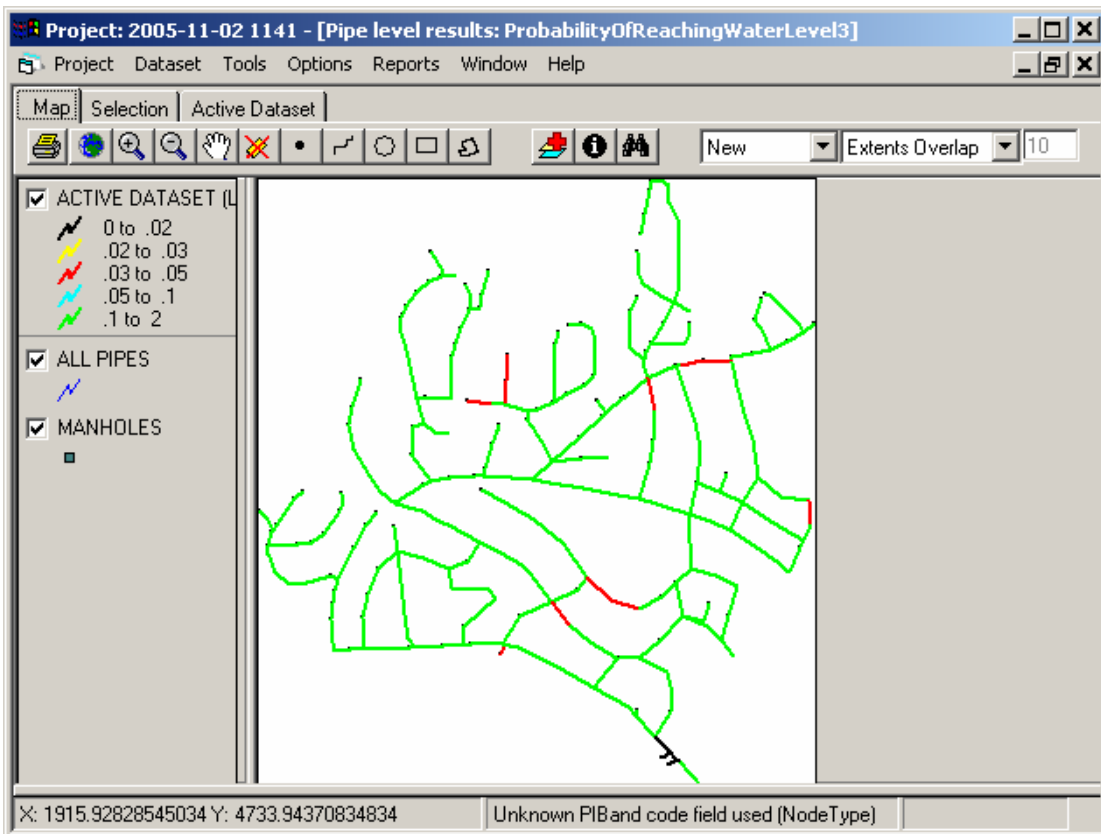
Program runs OK



Current Hydraulic Probability



Probability of reaching water level2 (critical level)



Probability of reaching water level3 (surface)

RehabDB– not considered to be an interesting tool in Norway (for the time being)
Program runs OK

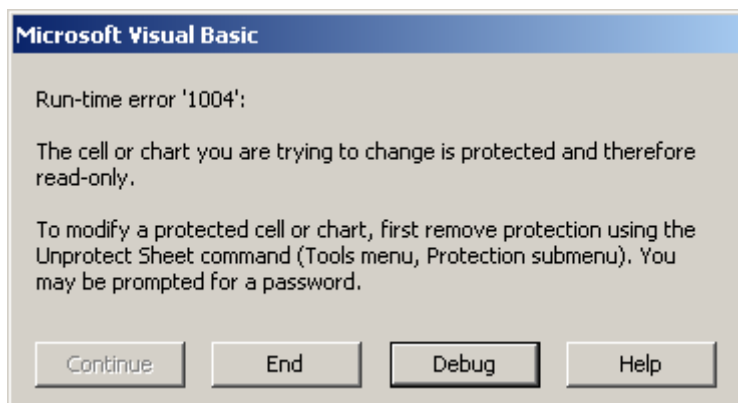
Cost - not considered to be an interesting tool in Norway (for the time being)
Error: Only pipes from example file are included in Pipe_characteristic

Socio-Fails

Error: Only pipes from example file are included in the Excel sheets?

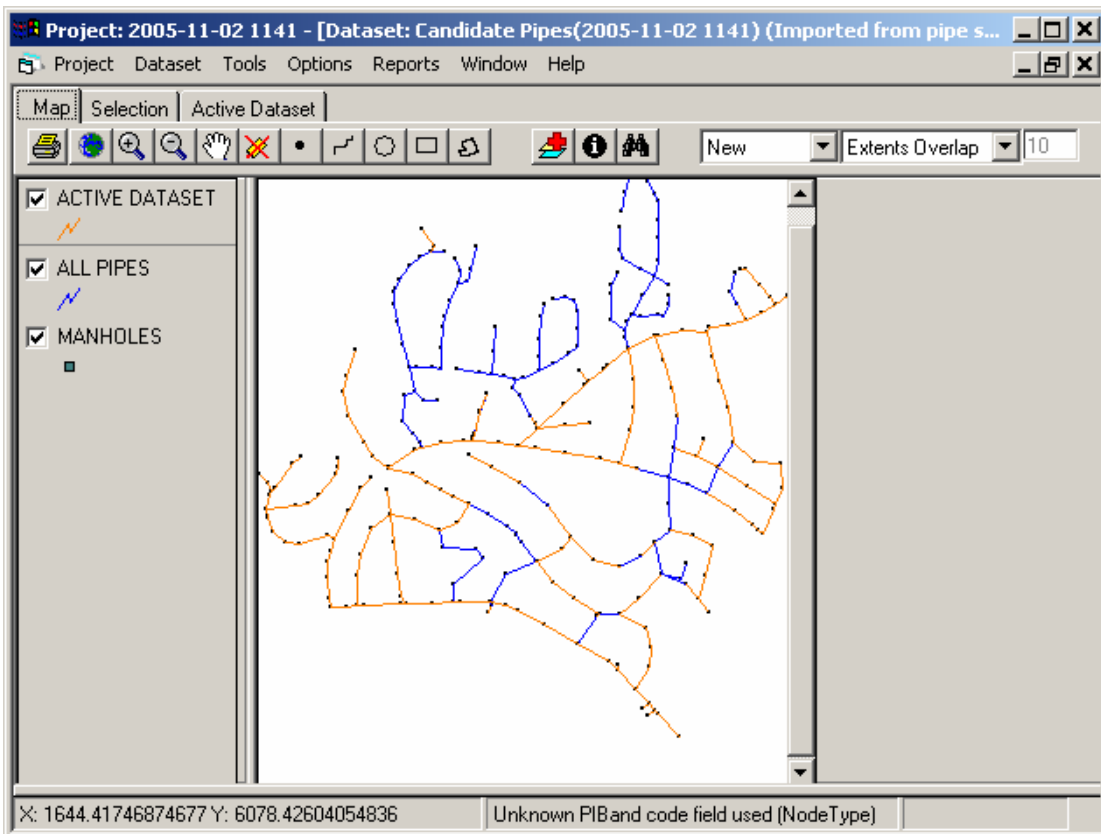
Socio-Works

Error: Only pipe from example file is included in the Excel sheets?



SRP Selection of pipes requiring rehabilitation

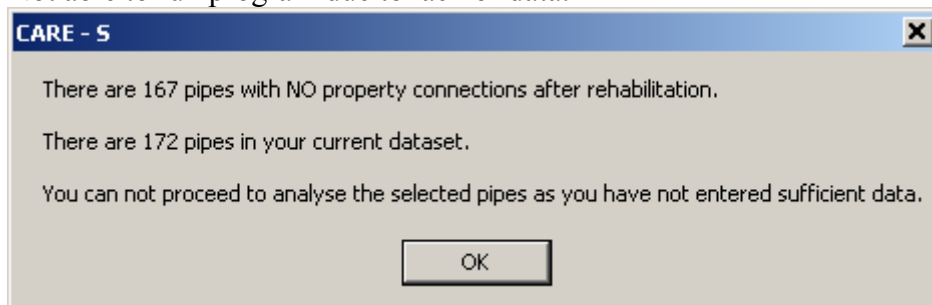
Program runs OK. Deleted pipes with Condition Grade = U



Exported rehab plan

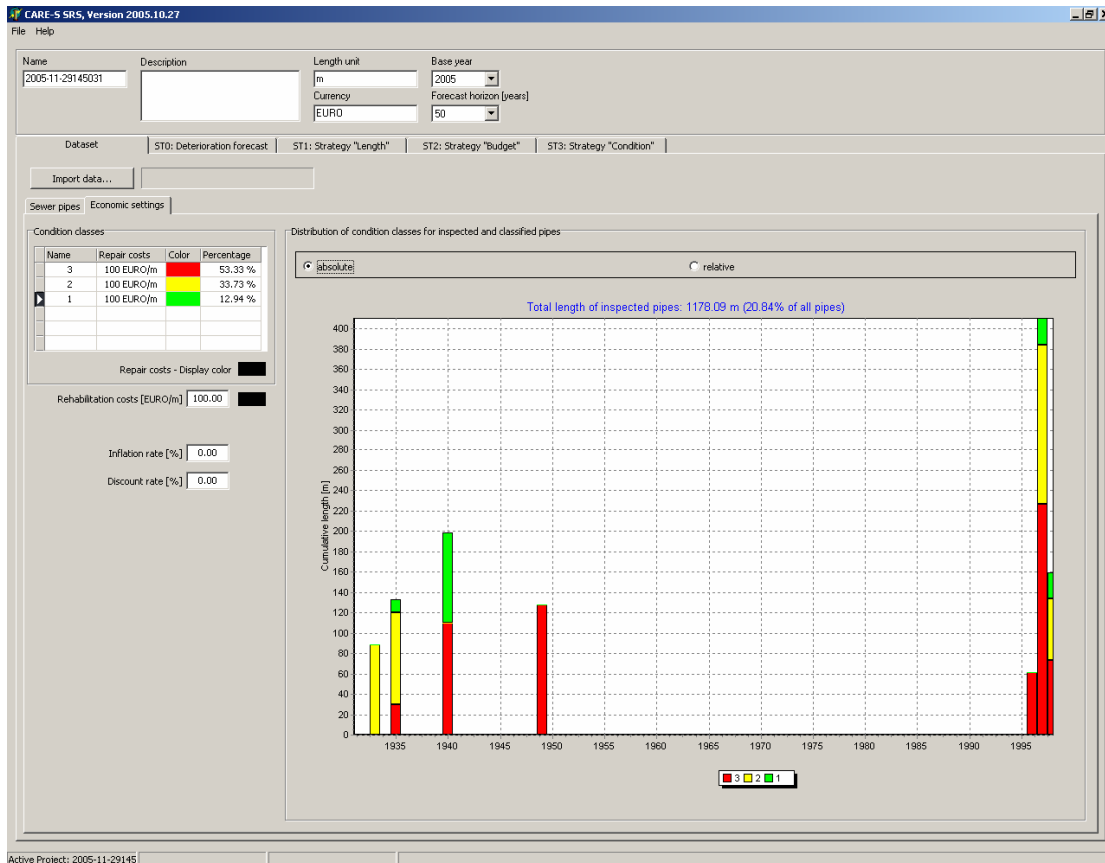
SRT Selection of Rehabilitation Technologies

Not able to run program due to lack of data:



SRS Long Term Rehabilitation Strategies

In order to import data I had to copy strata.txt file from PredicitingConditionGrade folder to LongTermRehabStrategy folder AND change the delimiter from “,” to “;”



All the calculations have to be runned manually in DOS and the files have to be copied manually from PredictingConditionGrade folder to LongTermRehabStrategy folder.

CONCLUSIONS

- Decision support (WP6) tools not well integrated yet.
- Plots takes about 35 seconds to produce, why?
- Errors in Cost tool, SocioFails and SocioWorks need to be sorted out.
- Comments from Oslo municipality (from their testing before summer 2005):
 - PI Tool:** is an interesting tool. Oslo is already involved in some projects that collect similar data and therefore they are not sure if they use this system also.
 - Blockage Tool:** It is not easy to understand how to organize input data regarding blockages.
 - CAT:** Oslo do not have design rains (yet)
 - CCTVconverter:** OK, problem with the longitudinal cracks, since these are not exported today (this might be included in the next version of WinCan primo 2006)
 - Degradation:** OK. Problem with returning new roughness coefficients to MOUSE
 - RehabDB:** Only a quick glance, hard to know what to do, no help file.
- In general:** in stead of trying the software by ourselves, we could prefer a work-shop and an introduction to the software. Some of the messages that appear are not easy to understand. Finally a hour glass to visualize that the software is running is much wanted.

Report on testing carried out in Reggio Emilia, Italy:

Partner: Bologna University (Ferrara University, for WP2 tools)

End User: AGAC (ENIA) – Reggio Emilia, Italy

Author: Mauro Pacchioli

Co-authors: Vittorio Di Federico, Rita Ugarelli, Sara De Angelis, Marco Maglionico

Co - Authors Ferrara University: Sante Mazzacane, Denise Adzvedo, Massimo Gaddoni.

INTRODUCTION

This report gives a description and introduction to all WPs tools tested by Bologna University and Ferrara University during the period March – June 2005 (WP 1-2-3) and from Bologna University during the period July – October 2005 (WP4-5-6). The tools theoretical background, informatics requirements, and data needs, were thoroughly reviewed in order to plan testing strategies.

Care-S Tools were tested both as stand alone software and part of the CARE-S Rehabilitation Manager prototype: each tool has been analysed in detail, its reaction to data changes verified inside the specific tool and with respect of its interactions with other tools in the whole CARE-S system.

The importance given to this level of testing is justified by the need of avoiding software crashes due to an incorrect use by users not fully conversant with the tools.

This report doesn't lists all the bugs collected for each tool because all bugs have been meticulously referred to SINTEF and WRc.

DESCRIPTION OF DATASETS

The Correggio catchment case study (Reggio Emilia – Italy)

The Correggio municipality is located at 12 km North – East from Reggio Emilia in Emilia Romagna region in Northern Italy (Figure 1).

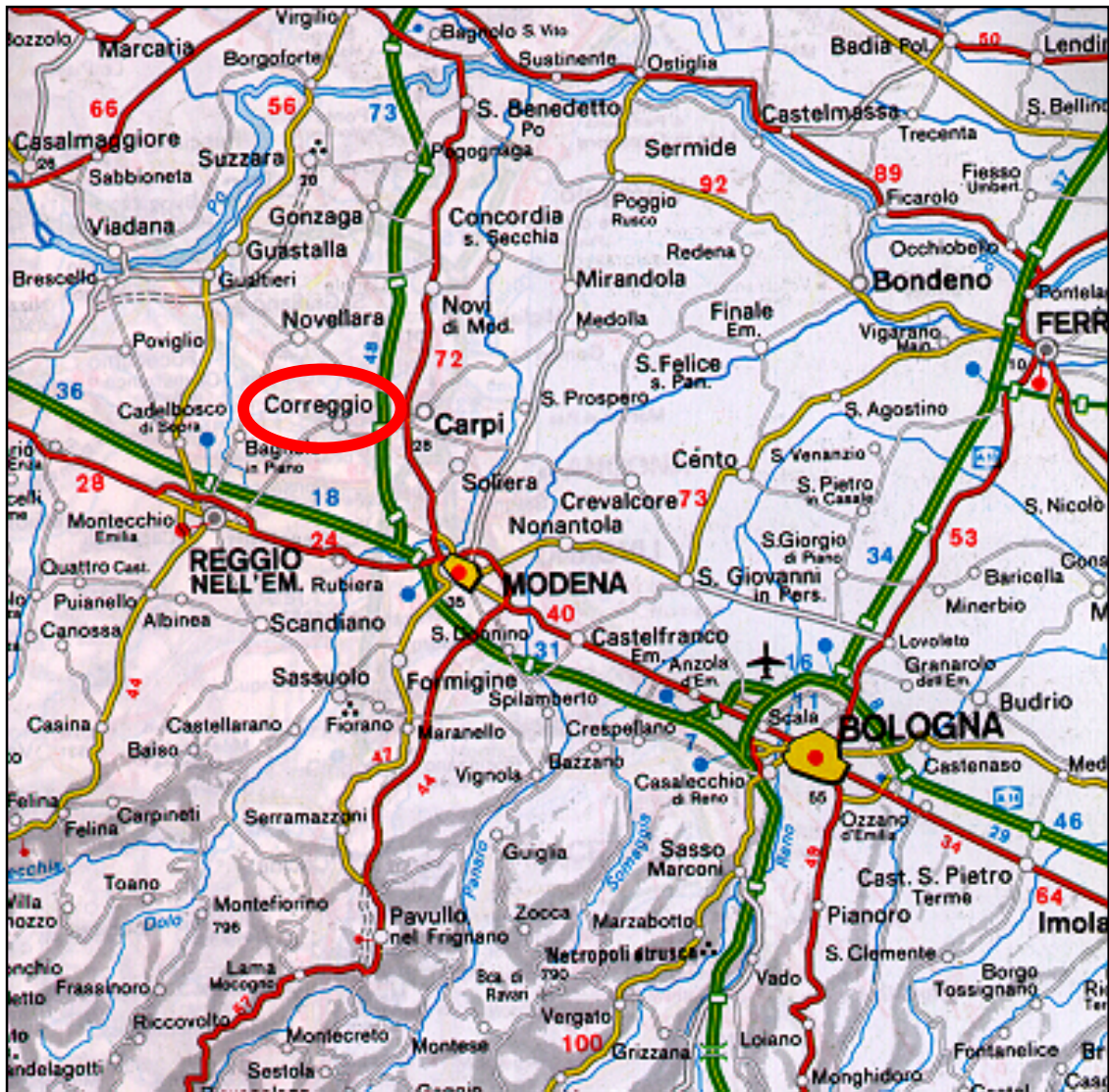


Figure 1. Correggio position

The catchment can be considered as a residential area. The 487 ha of surface are occupied by 20769 inhabitants (31.12.2000).

The evolution of economic activities, in the last decades, has increased the extension of impervious surfaces, with a consequent increase in the amount of water to be drained. The municipality did not improve the system performance according with the system evolution; as a consequence, even relatively low-return time rainfall events (2-5 years return period) may easily cause flooding events, with serious consequences for customers.

The drainage network is oriented north to east, following the natural catchment slope; thus the main outlet of the system is located in the final node of the network in the east side of the area. The network is a gravity system with an impermeability coefficient of 27%. Pipes depth is from 1 to 3 m below the road.

The sewer system has a total length of 92,7 km: the 63% is combined sewer system, 32% is separate system, 2% represents open channels and the remaining 3% is unknown, being located in Correggio downtown (Figure 2).

The 78% of the pipes are concrete, while the rest are mainly PVC.

Pipes cross-section are subdivided as follows:

circular section: 91% of the total length;

rectangular section: 7,4% of the total length;

other section: 1,6% of the total length.

Pipes diameters are subdivided as follows:

$D \leq 300$ mm: 43% of the total length;

$350 < D < 600$ mm: 35% of the total length;

$700 < D < 800$ mm: 12% of the total length;

$D > 800$ mm: 10% of the total length.

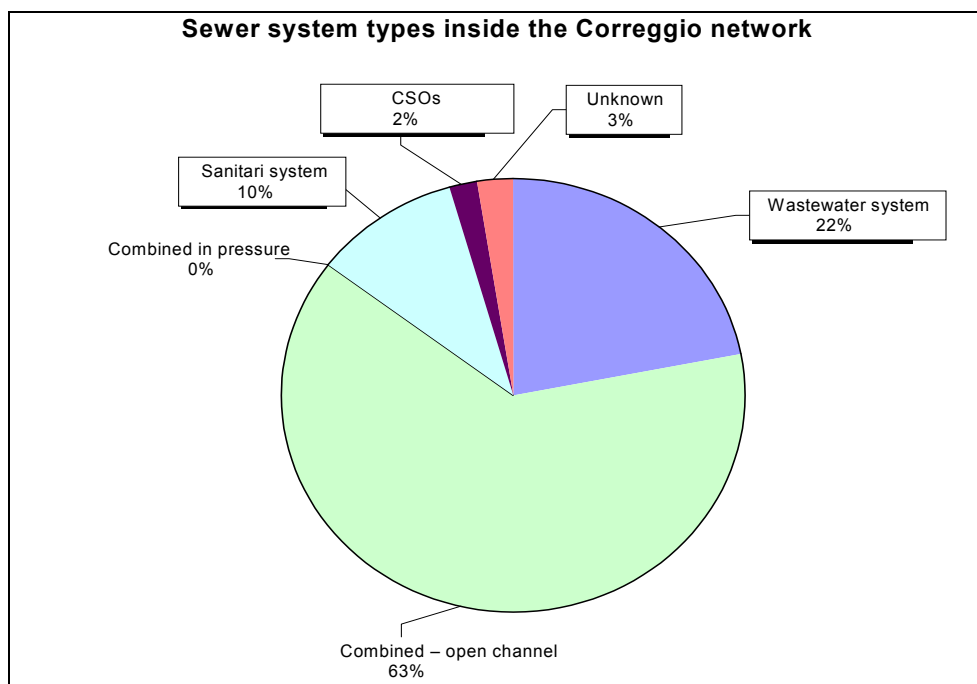


Figure 2. Sewer types on the Correggio system

The studied area can be divided in 7 zones (Figure 3):

Zone A: it is the old side of the town located in the centre of Correggio;

Zone B: located in the South part of the system;

Zone C: located in the centre – East side of the system;

Zone D: located in the West side of the network;

Zone E: it is the portion of the system on the North of the old town centre;

Zone F: the South – East side;

Zone G: it is the industrial area.

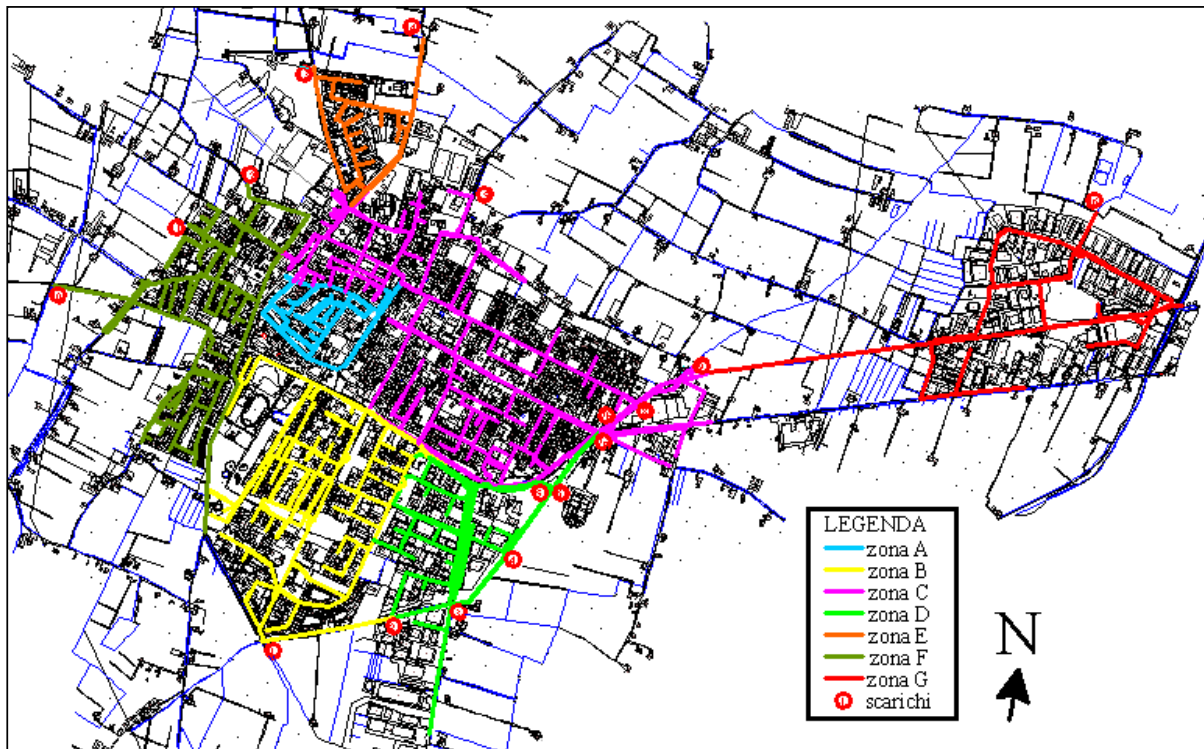


Figure 3. Distribution of the seven areas on the Correggio system

The system includes 5 receiving water bodies:

Cavo Argine: the most important of the water bodies, which influences the drainage system performance. Its water level affects zone B, C and F.

Cavo Rio;

Fossetta Seconda;

Scolo Mandrio;

Fossetta delle Monache.

Using data provided by the Correggio municipality, it has been possible to define the areas subject to frequent flooding events, and draw a map where those areas are highlighted (Figure 4). The map is a useful tool to compare real flooding information with the model results.

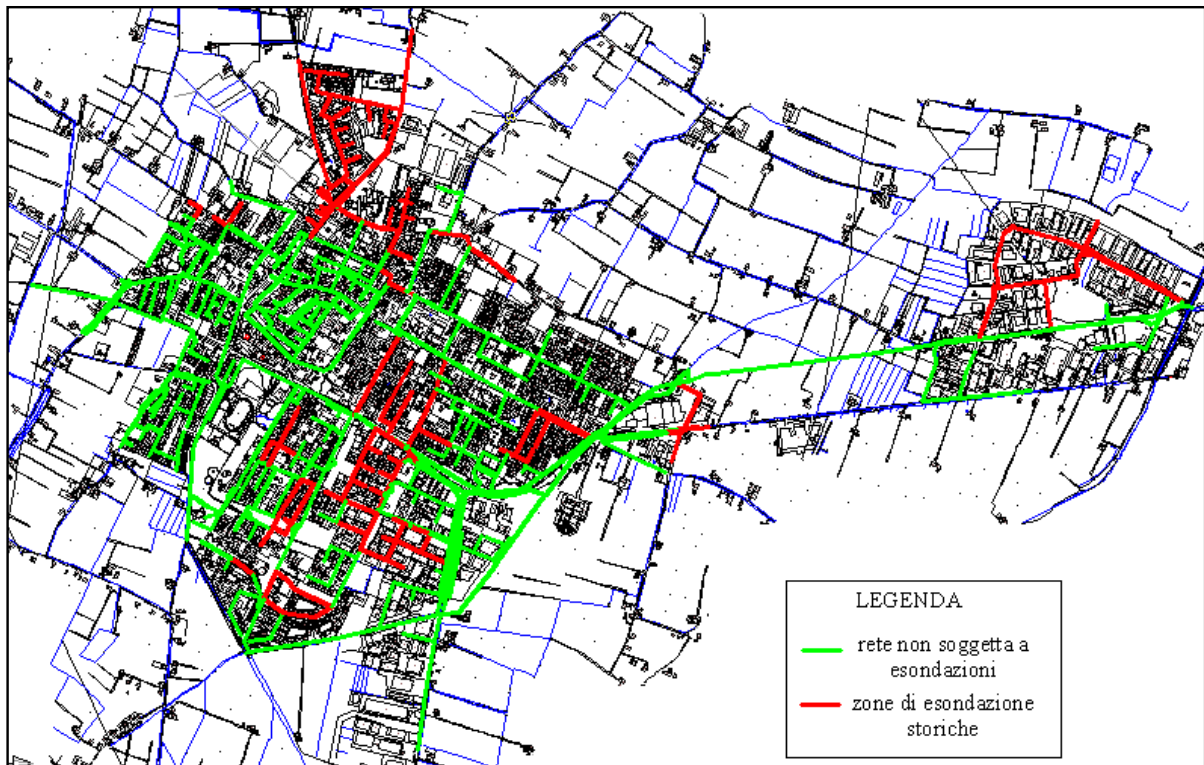


Figure 4. Flooding Map

DATA AVAILABILITY

Data from hydraulic simulations

Correggio has a catchment of 470 ha; which was modelled dividing it in 540 sub - catchments. Sub – catchments boundaries were defined considering the contribution area for each manhole.

The drainage system includes 888 pipes and 816 nodes, further subdivided into 769 manholes, 6 ponds and 14 outfalls. There are 2 manholes with pumps stations.

From the simulation performed using the Infoworks code, the modelled network was obtained as a “csv” file, which was imported and visualized in GIS format inside the Rehab Manager. The “csv” includes information regarding pipes (length, material, shape, diameter or height and width if necessary, roughness, slope, initial and final node, upstream and downstream invert level) and nodes (coordinates, type of node, ground level, subcatchment to which it belongs and related inhabitants). The simulations performed using Infoworks are the following:

Dry weather flow simulations;

Single event simulations with a return period of 2,5,10 years;

Continuous storm simulation using 1 year of rainfall data;

24h continuous storm simulation.

The previous simulations were imported inside the Rehab Manager, and include data needed to run some of the tools, such as Exfiltration, CAT and Hellmud.

Other data

To test all the tools of WP1, WP2 and WP3, also other types of data were needed; these were collected manually and stored inside the Rehab Manager either manually or by creating “csv” files; the following data were imported creating a “csv” file:

groundwater level: level of groundwater was determined for each pipe of Correggio network through available hydrogeologic maps;

wall thickness: was derived from technical literature, knowing material, shape and diameter for each pipe;

installation year: from paper sheet format data are being collected and the relative “csv” file has been created; installation year has been obtained only for 297 pipes;

blockages: were derived from paper repair logs and from CCTV codes reported therein; thus far 46 blockage events were localized in the period April 1998 - November 2004 (Figure 5);

soil type: the soil in the Correggio area is clay as derived from geological maps;

road name;

number of lanes for each road;

type of road;

traffic flow for each road: was calculated after to have made a traffic survey;

bus traffic.

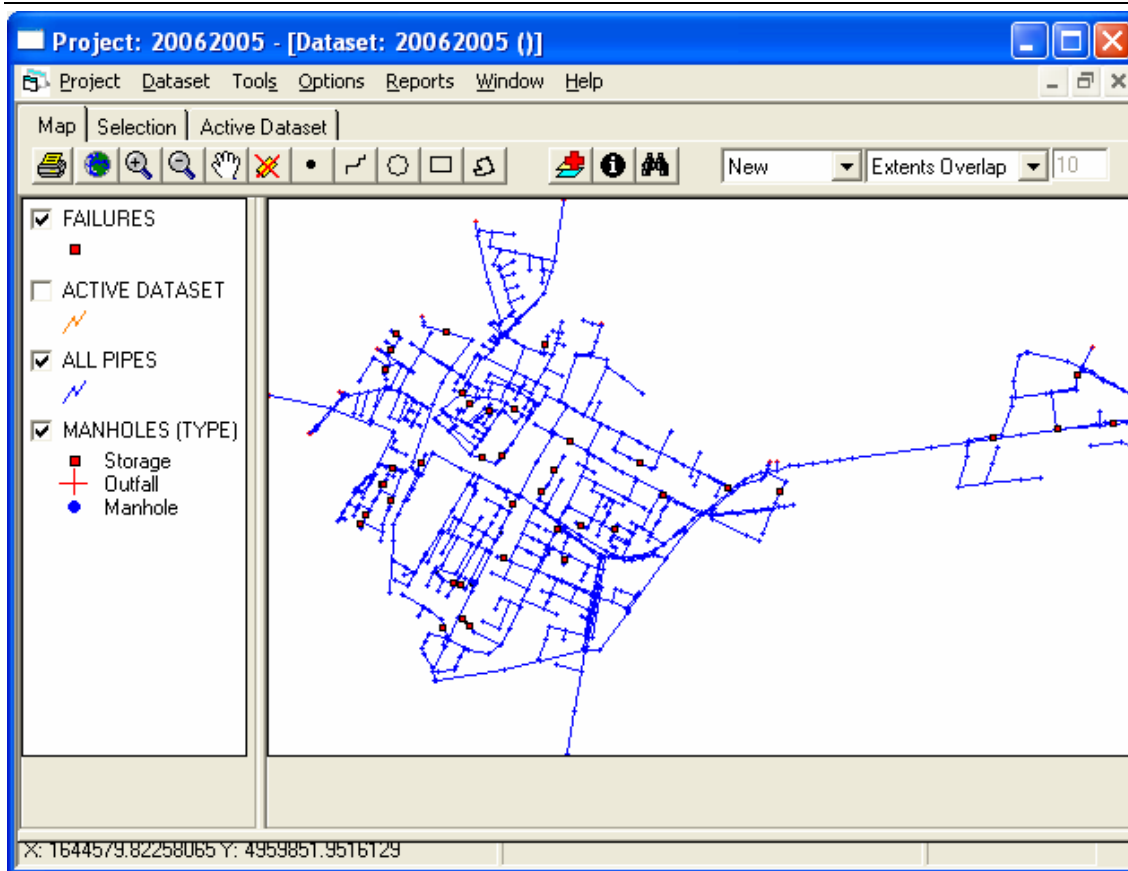


Figure 5. Blockages in Correggio network

The following data were manually collected and stored inside the Rehab Manager:
 CCTV codes: not having “dat” file to run the CENConvertor Tool, relevant CCTV codes (referring to EN13508-2) were established through careful inspection of 16 CCTV movies which were available; these data were filled in the CCTV Data Table inside the Rehab Manager (147 codes referred to 10 pipes); the resulting distribution of CCTV in the network is visualized in Figure 6.

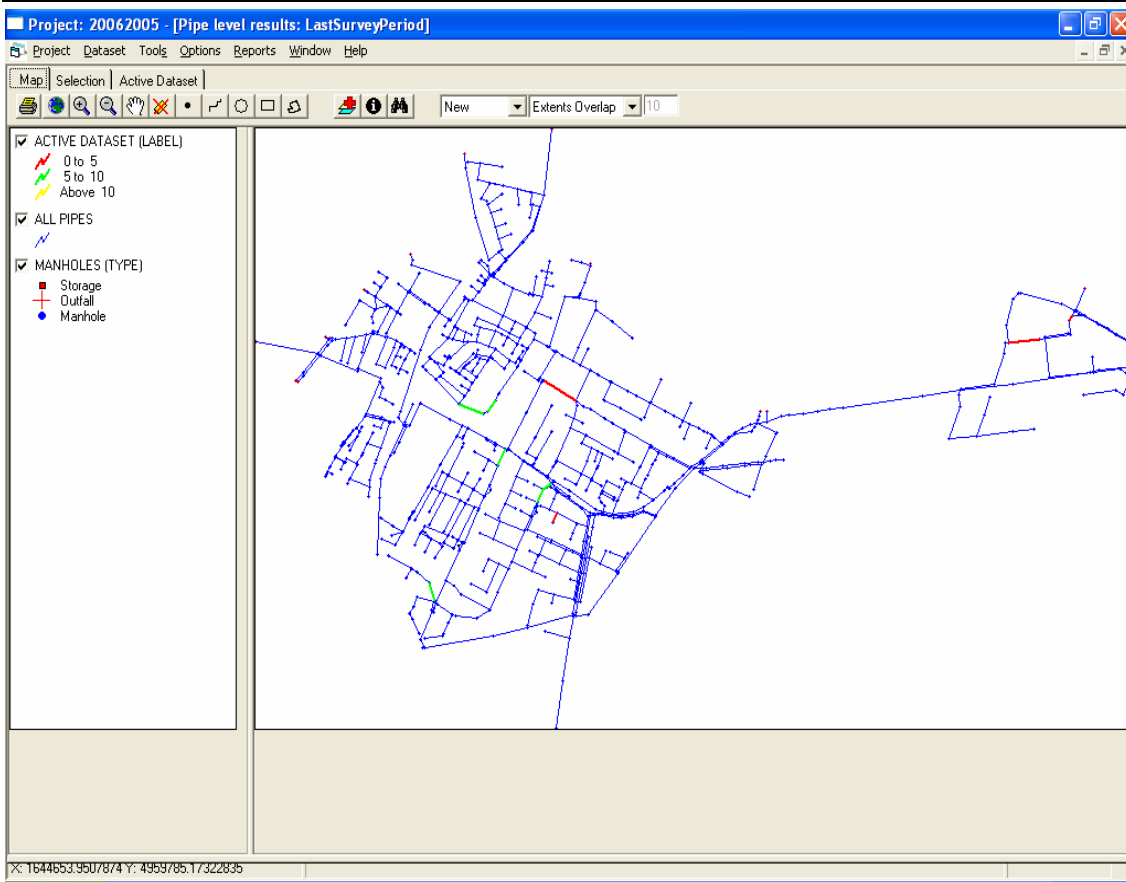


Figure 6. Current Status of inspection data

Report on testing results analysis on Correggio network

The following sub-chapters refer to those tools for which it was possible to have results using Rehab Manager v2.6.0.1. Due to some Rehab Manager minor bugs, it was not possible to have results for CAT Tool, Infiltration/Exfiltration Tool and SRS Tool. Due to some problems related to network topology, it was not possible to have results for WATZ model.

PI Tool

For PI Tool, 53 Utility Information (UI) were collected, and 17 PI were calculated, subdivided as follows:

Environmental Indicators: 0/5;

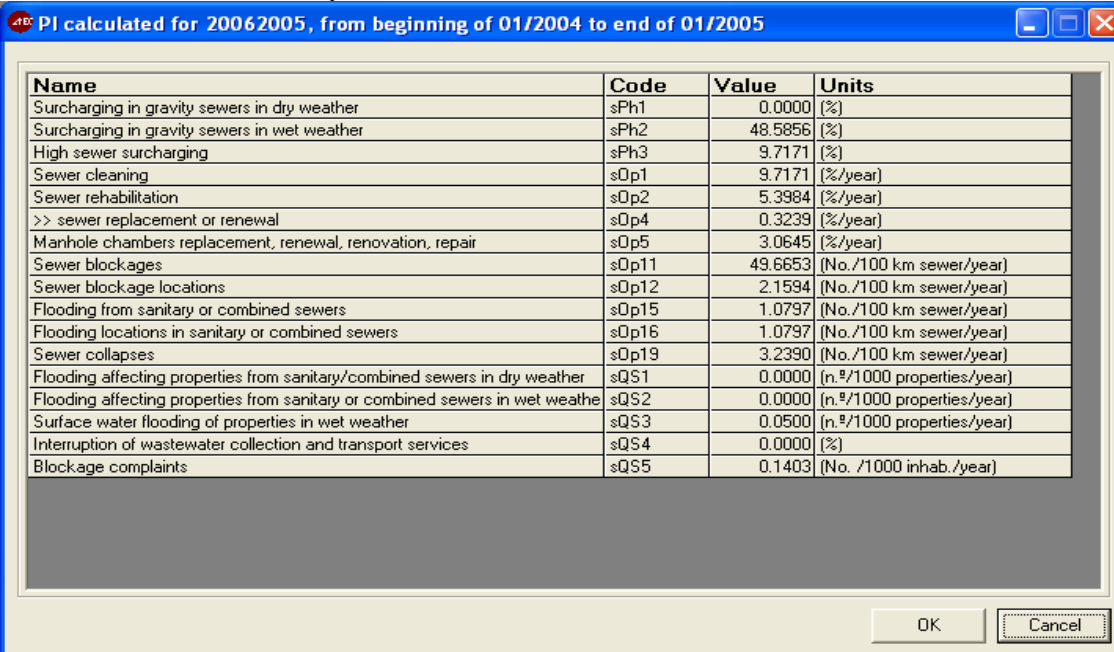
Physical Indicators: 3/3;

Operational Indicators: 9/19;

Quality of service Indicators: 5/8;

Financial Indicators: 0/6.

Some examples of PI calculated (Figure 7) are sPh3 (High sewer surcharging) expressed as percentual and with a value of 9.72%, sOP15 (Flooding from sanitary or combined sewers) expressed as number/100 km sewer/year and with a value of 1.08, sQS5 (Blockage complaints) expressed as number/1000 inhabitants/year and with a value of 0.14.



Name	Code	Value	Units
Surcharging in gravity sewers in dry weather	sPh1	0.0000	(%)
Surcharging in gravity sewers in wet weather	sPh2	48.5856	(%)
High sewer surcharging	sPh3	9.7171	(%)
Sewer cleaning	sOp1	9.7171	(%/year)
Sewer rehabilitation	sOp2	5.3984	(%/year)
>> sewer replacement or renewal	sOp4	0.3239	(%/year)
Manhole chambers replacement, renewal, renovation, repair	sOp5	3.0645	(%/year)
Sewer blockages	sOp11	49.6653	(No./100 km sewer/year)
Sewer blockage locations	sOp12	2.1594	(No./100 km sewer/year)
Flooding from sanitary or combined sewers	sOp15	1.0797	(No./100 km sewer/year)
Flooding locations in sanitary or combined sewers	sOp16	1.0797	(No./100 km sewer/year)
Sewer collapses	sOp19	3.2390	(No./100 km sewer/year)
Flooding affecting properties from sanitary/combined sewers in dry weather	sQS1	0.0000	(n./1000 properties/year)
Flooding affecting properties from sanitary or combined sewers in wet weather	sQS2	0.0000	(n./1000 properties/year)
Surface water flooding of properties in wet weather	sQS3	0.0500	(n./1000 properties/year)
Interruption of wastewater collection and transport services	sQS4	0.0000	(%)
Blockage complaints	sQS5	0.1403	(No./1000 inhab./year)

Figure 7. PI calculated

External Corrosion Tool

An input file called “infile.txt” (Figure 8) has been created from Rehab Manager, containing information regarding only the characteristics of corrodible pipes. In Correggio network there are 813 /

885 corrodible pipes but only 287 with the installation year. The analysis was performed for all the 287 pipes. The prediction year adopted was 2010.

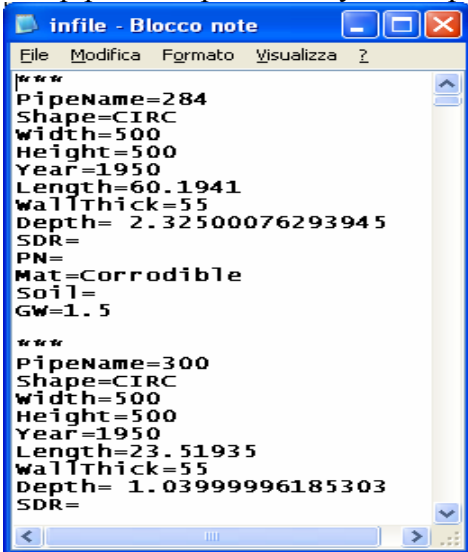


Figure 8. “Infile.txt”

For Correggio network, the External corrosion rate [mm/year] for each pipe ranges from a minimum of 0 (zero) to a maximum of 2.84. Figure 9 shows a GIS View in which five classes were created and in which the most part of the network belongs to the green class (from 0.01 to 1 [mm/year]). The first class (grey class) has been created to contain all the pipes in which the analysis has not been performed and in which the value of External Corrosion is equal to zero. The most corrodible pipes (external corrosion rate = 2.84 mm/year) are quite diffused and involve some km of network.

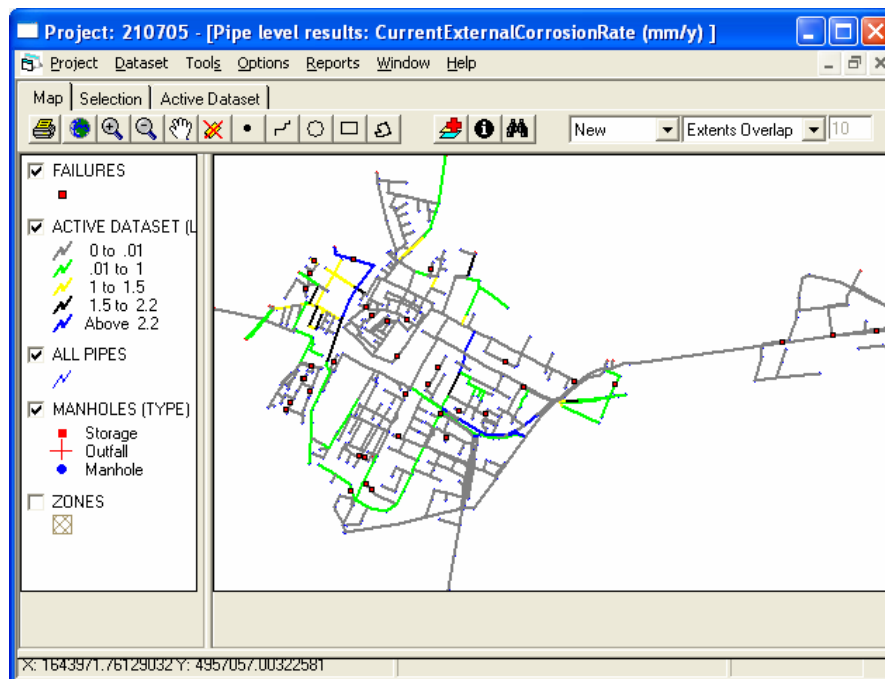


Figure 9. Correggio External Corrosion Rate

Load Model

For Load Tool, as for External Corrosion Tool, the analysis was performed only on pipes (260/885) having some required data available, as for example wall thickness and installation year; 2010 was considered the prediction year and for safety factor (W) and Probability (P) the default values were assumed. The input file is a text file called “i-fil.txt” (Figure 10) and as Output of the tool the values can be exported in Excel format and in text format (Figure 11).

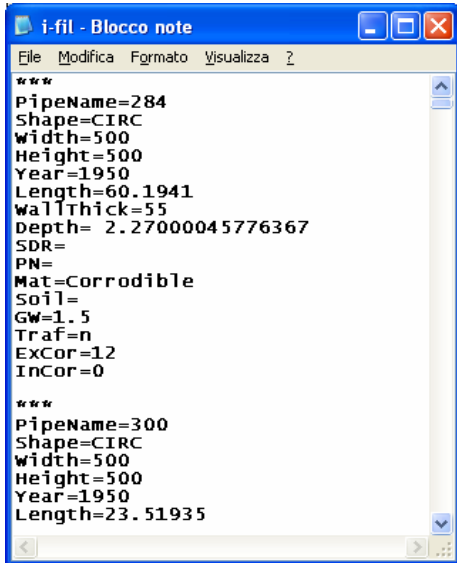


Figure 10. “i-fil.txt”

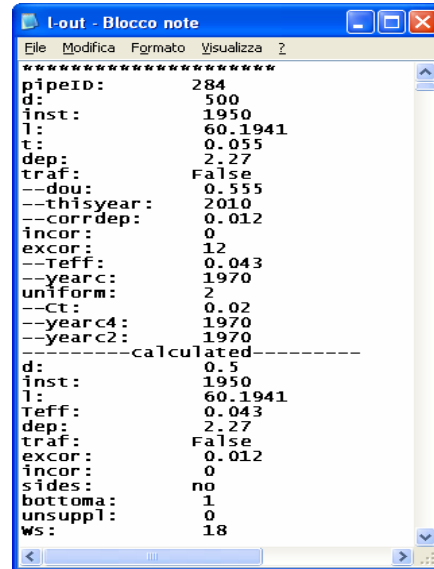


Figure 11. “i-out.txt”

The Predicted Probability of Collapse is a value ranging from 0 (zero) to 1; Figure 12 shows the GIS view from Rehab Manager with values for Correggio network. As for External corrosion, five classes were created and as for External Corrosion the first class (light-grey class) has been created to contain all the pipes in which the analysis has not been performed and in which the value of Predicted Probability of Collapse is equal to zero. Most of the network has a Predicted Probability of collapse between 10% and 20%. Comparing Figure 9 and Figure 12, it is possible to notice that the portion of the network with the highest values of Probability of collapse (from 70% to 100%) is the same having the highest external corrosion rate.

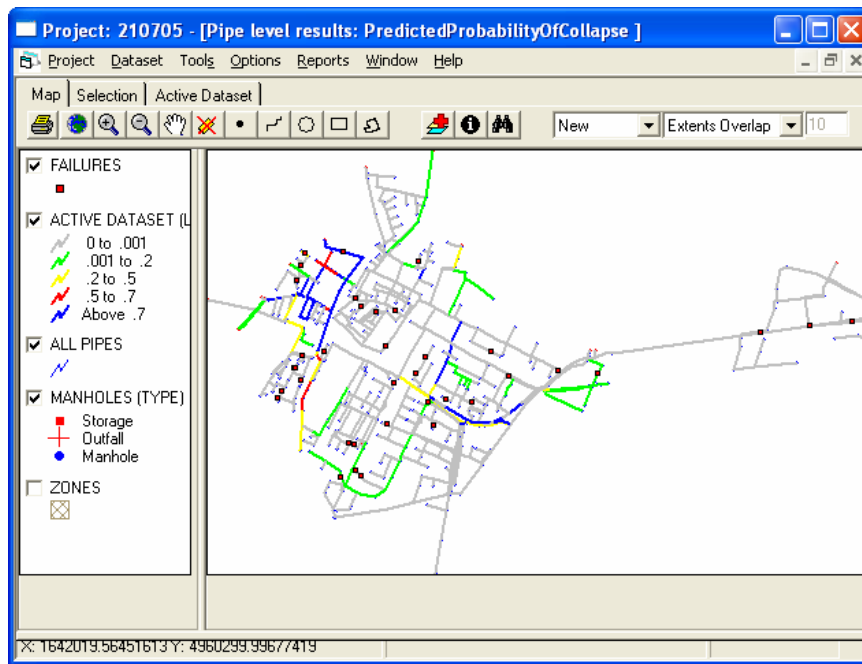


Figure 12. Predicted Probability of Collapse

Blockage Tool

For Blockage tool, all the pipes have been considered in the analysis; having imported into Rehab Manager a “csv” file containing blockage events, the program was able to create input files containing characteristics of all pipes, such as length, diameter, sewer type, slope (Figure 13) and characteristics related to Blockage event, such as the event date and the pipe involved (Figure 14). The results obtained were stored in an Excel file (GIS view not performed); the average blockage rate of the network is 0,085752 [blockages/km/year]; the values of the predicted blockage rate range from a minimum value of 0,047350 [b/km/y] to a maximum value of 0,097083 [b/km/y].

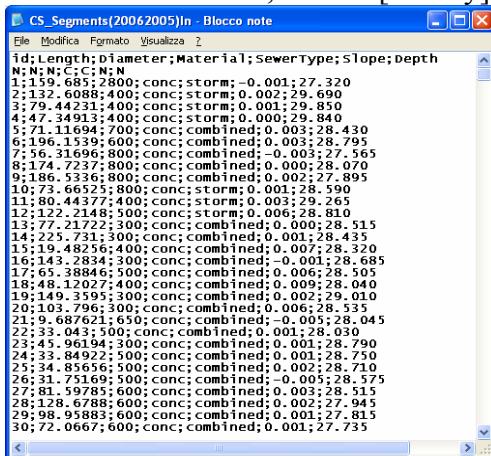


Figure 13. Segments input file

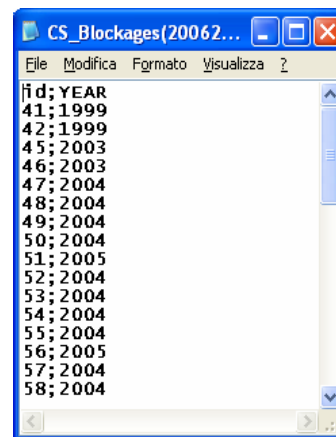


Figure 14. Blockage event input file

Figure 15 shows the GIS view for the Predicted Probability of Blockage: 4 classes were created.

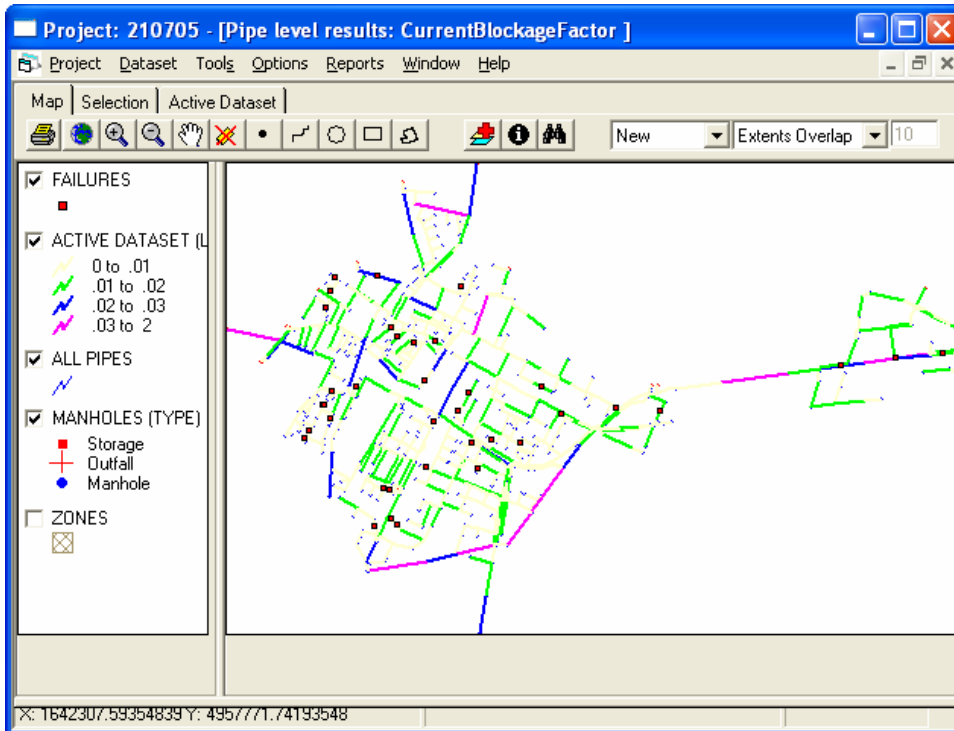


Figure 15. Predicted Probability of Blockage

GompitZ Tool

For GompitZ Tool the analysis was performed on 287 pipes; these have the installation year available, and some of them also the inspection state and the inspection year.

The prediction was calculated grouping the pipes by material, called strata in GompitZ and using Length as covariate.

In the calculation the prediction year was fixed to 2015.

GompitZ tool considered of poor quality the prediction because the number of inspection data was not sufficient and aborted the calibration. Only a substantial ad-hoc modification of the data allowed a good computation. The modification regarded the number of inspected pipes and the relative condition class; after a meeting with our End user, 20 pipes with a relative condition class were added to the 10 pipes really inspected.

GompitZ makes a validation on the chosen strata, and the analysis begins only if they are consistent.

After the validation, an input file, called “Strata.txt” (Figure 16), containing the pipes data, was created, and a “ST0.txt” file, containing the prediction years, was requested. The “ST0.txt” file means a prediction without using any rehabilitation strategy; the Rehab manager does not allow the possibility to use GompitZ to analyze any strategy, and only outside the Rehab Manager there is the possibility to use this feature.

GompitZ made a calibration of the data creating two intermediate file called “param.txt” and “calibr.txt” (shown respectively in Figure 17 and in Figure 18) used in the prediction computation.

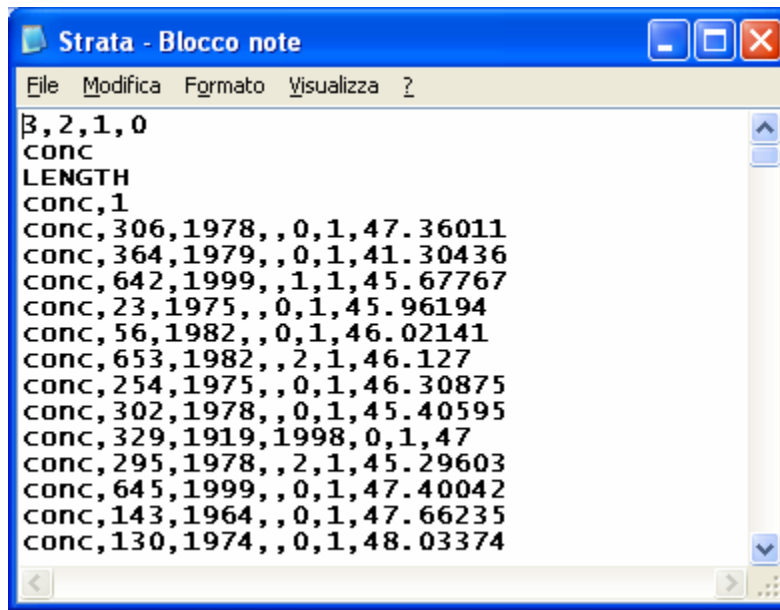


Figure 16. “Strata.txt” input file

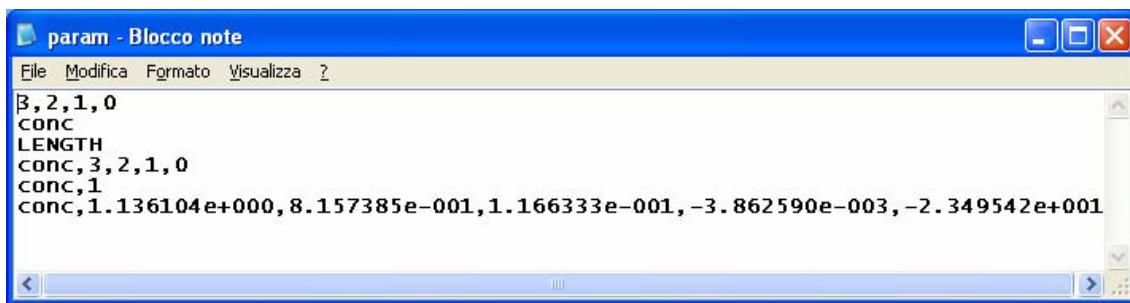


Figure 17. “param.txt” intermediate file

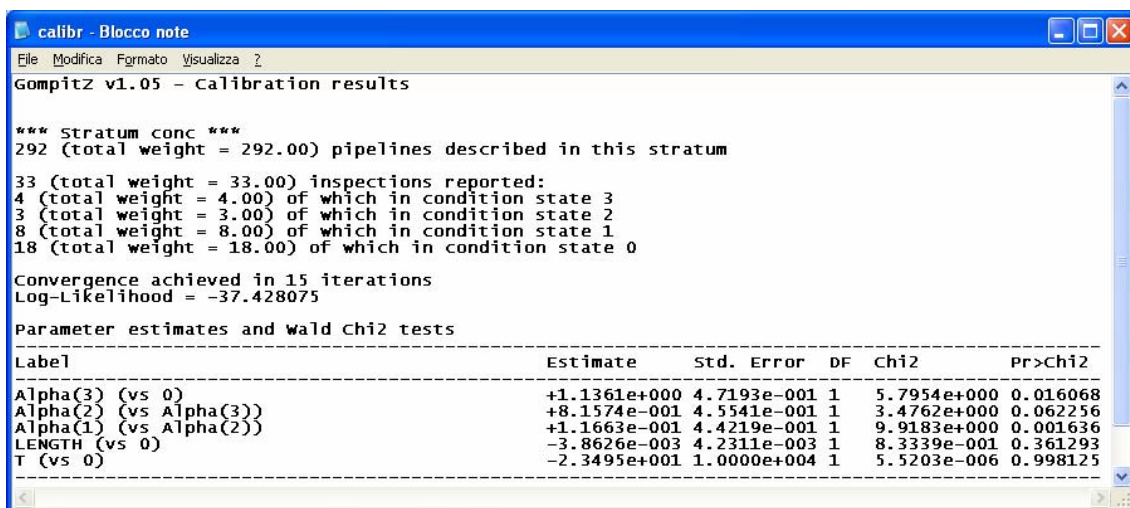


Figure 18. “calibr.txt” intermediate file

Finally an output file named "predict0.txt" (figure 19) was created; for each pipe and for each year, it includes a line representing a vector of condition probability. Because of a coding error the rehab manager fails to import correctly the result data.

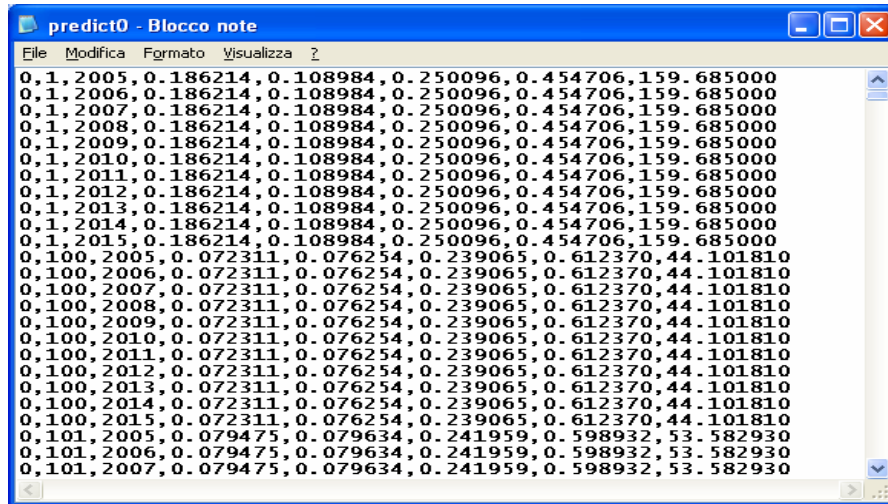


Figure 19. the Output file "predict0.txt"

Z-model

For the Z-model Tool, the analysis was performed only on pipes (409/885) having some required data available, as for example a positive slope and a dry weather flow different from zero. A FileIn.txt was created (Figure 20), containing some pipe characteristic such as roughness (in mm), shape, etc...A calculation error of Rehab Manager in roughness value did not permit to consider reliable the obtained results showed in Figure 21.

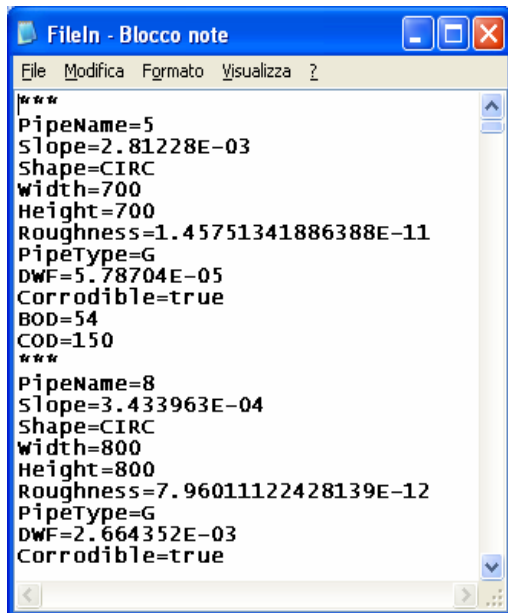


Figure 20. the input file "FileIn.txt"

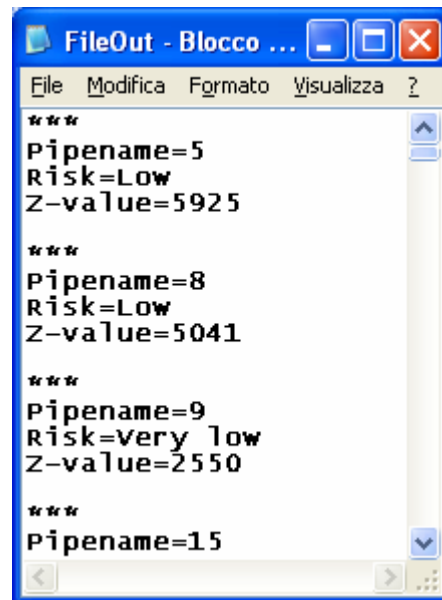


Figure 21. the output file "FileOut.txt"

Degradation Tool

For Degradation Tool, all pipes have been considered in the analysis; CCTV data imported in the Rehab Manager were also used. For Degradation Tool, an Excel file was created by Rehab Manager, containing pipe characteristics and EN13508-2 CCTV codes.

Degradation Tool produces a change of roughness only in inspected pipes; thus a new network can be simulated with Infoworks, MOUSE or SWMM code, and results imported again in the Rehab Manager central Database. The pipes inspected were ten, but a new roughness was calculated only for nine pipes, because the codes related to pipe number 416 did not imply a roughness change. The initial value of roughness for all the pipe is assumed to be 65 [m1/3/sec]; after Tool use, a new value has been found for pipes inspected; this value ranges from a minimum of 50,90 [m1/3/sec] for pipe 795 to a maximum value of 61,75 [m1/3/sec] for pipes 285 and 321. Five classes of roughness value were created to illustrate the results (Figure 22).

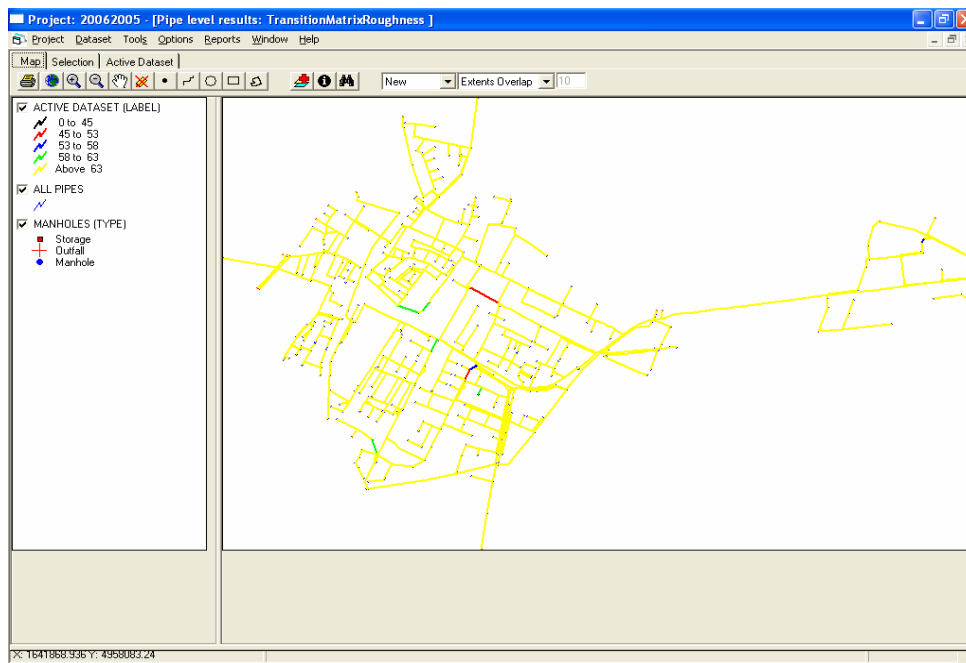


Figure 22. Transition Matrix Roughness

GAT Tool

In GAT Tool, four possible methods to calculate pipe vulnerability are available, depending on data availability. In Correggio case, having “csv” files containing soiltype and groundwater level available for each pipe, the fourth method called Permeability-Groundwater level was chosen. In Correggio the soil type is clay for each pipe, while the groundwater level is comprised between a minimum value of 1 m to a maximum value of 3 m.

The results regarding the vulnerability of pipe using Permeability-Groundwater level method are not meaningful, in that the vulnerability is “low” for all the pipes.

HELLMUD Tool

The HELLMUD (Hydraulic and Environmental reLiabiLiTy Model of Urban Drainage) mathematical model is focused on service reliability, which reflects the probability of hydraulic efficiency and environmental impacts of a sewer system for one predetermined scenario. The model aims at a definition of several criteria that can be used for the assessment of reliability aspects on the existing sewer system or for the examination of proposed scenarios of the urban drainage system rehabilitation. HELLMUD needs 4 input files: the 2 output files provided by the CAT and GAT tools, plus 2 additional files describing network assessment and hydraulic performance.

Having not run CAT Tool due to problems in Rehab Manager, related to the reading of continuous storm simulation of 1 year, the analysis was performed using hydraulic simulations and GAT results only.

The Output file is a file containing the values of all Criteria calculated, as shown in Figure 23.

LinkID	FillingLeve	FrequencyFillingLevelA	FrequencyFillingLevelB	FrequencyFillingLevelC	ProbabilityB	ProbabilityC	ProbabilityD	Weighting	Insufficient	Velocity
1 A		0.02	0.02	0.02	0.04	0.04	0.04	1	1	yes
2 D		5	5	2.21	1	1	1	0	1	yes
3 D		5	5	3.17	1	1	1	0	1	yes
4 D		5	5	3.23	1	1	1	0	1	yes
5 D		3.25	0.98	0.1	1	1	0.19	0	1	yes
6 D		0.97	0.42	0.09	1	0.67	0.18	0	1	yes
7 D		5	5	0.1	1	1	0.19	1	1	yes
8 D		5	3.68	0.24	1	1	0.42	0	1	yes
9 D		5	1.29	0.08	1	1	0.15	0	1	yes
10 C		2.28	0.42	0.05	1	0.66	0.09	0	1	yes
11 C		0.32	0.16	0.04	0.54	0.3	0.09	0	0.63	yes
12 D		0.32	0.17	0.06	0.53	0.31	0.11	0	0.63	yes
13 D		0.9	0.41	0.07	0.99	0.66	0.14	0	1	yes
14 D		0.91	0.42	0.07	0.99	0.66	0.13	0	1	yes
15 C		0.74	0.32	0.04	0.93	0.53	0.08	0	1	yes
16 D		5	5	0.47	1	1	0.72	1	1	yes
17 D		2.32	0.89	0.25	1	0.99	0.44	0	1	yes
18 C		1.59	0.52	0.02	1	0.77	0.04	0	1	yes
19 D		1.86	0.89	0.23	1	0.99	0.4	0	1	yes
20 D		4.65	1.92	0.28	1	1	0.49	0	1	yes
21 D		5	1.84	0.2	1	1	0.37	1	1	yes
22 D		5	5	0.36	1	1	0.6	0	1	yes
23 D		3.98	1.67	1.14	1	1	1	0	1	yes
24 D		1.52	0.62	0.33	1	0.85	0.55	0	1	yes
25 D		1.61	0.64	0.29	1	0.87	0.49	0	1	yes
26 D		4.11	1.36	0.28	1	1	0.49	1	1	yes
27 D		1.31	0.5	0.21	1	0.75	0.37	0	1	yes
28 D		5	2.38	0.26	1	1	0.45	0	1	yes
29 D		5	1.72	0.1	1	1	0.18	0	1	yes
30 C		1.04	0.28	0.02	1	0.48	0.04	0	1	yes
31 C		5	0.72	0.02	1	0.92	0.04	1	1	yes
32 B		0.33	0.02	0.02	0.55	0.05	0.04	1	1	yes

Figure 23. Criteria Output file

In Figure 24 and in Figure 25 there is a GIS view of propability, for each pipe, to reaching water Level 2 and water level 3 respectively.

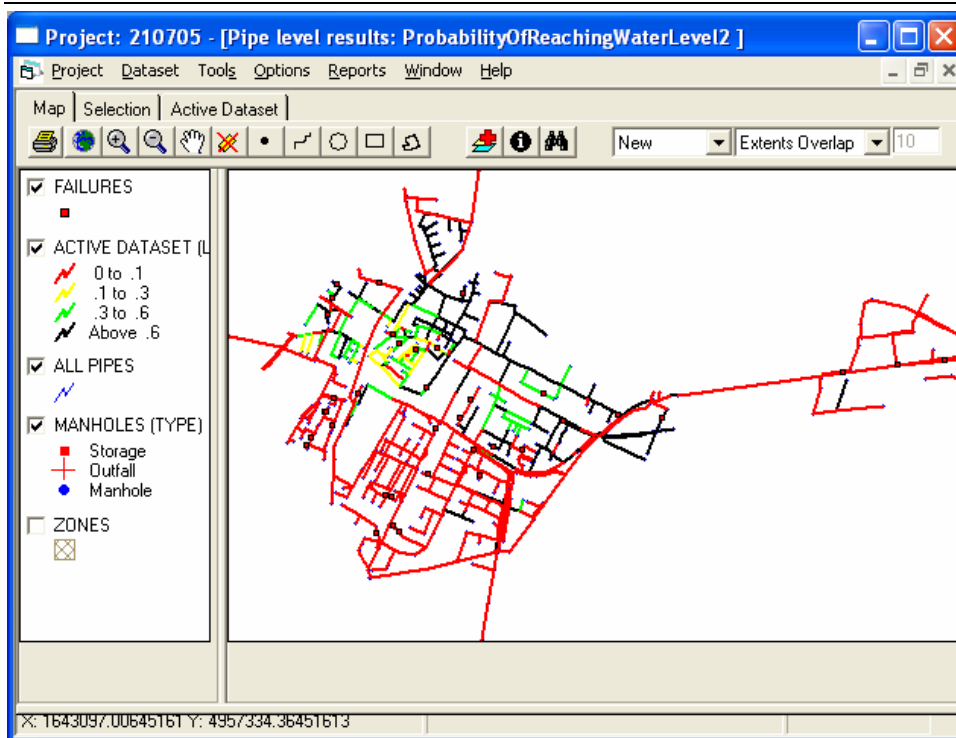


Figure 24. Probability of reaching Level2

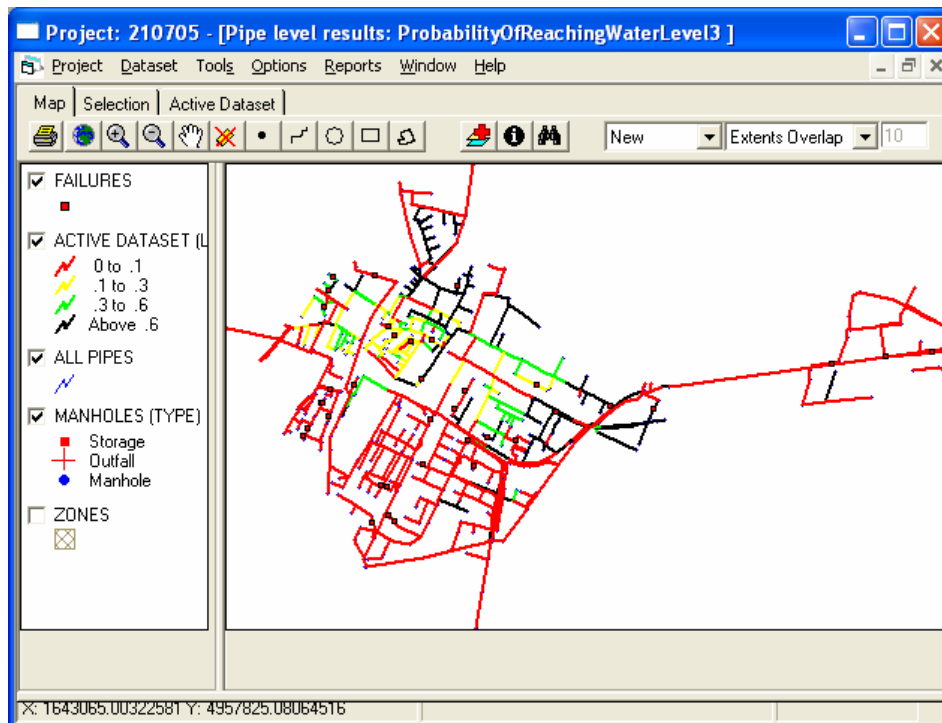


Figure 25. Probability of reaching Level3

As shown in the previous figures, most of the pipes of the network have a probability of reaching water level 2 or 3 from 4% to 10%, but a consistent part of the network belongs to the last class, with a probability to reach water level 2 or 3 from 60% to 100%.

SRP Tool and Socio Failure

Sewer Rehabilitation Planning Tool enables to make a first list of pipes to rehabilitate, depending from pipe characteristics. The list of pipes is then exported into Socio Failure and 10 criteria are calculated for each pipe of the list.

A second use of SRP is made after to have run Socio-Failure and a final list of pipes to rehabilitate is obtained, depending from the values of criteria.

In our analysis in the first list are grouped all the pipes with condition class equal to 2 and 3 (worst cases). From an initial number of 885 pipes, the analysis of Socio-Failure was performed only on 194 pipes.

In the figure 26 is shown the final step of the first selection in SRP in which in grey colour there are the excluded pipes and in red colour the pipes to be considered in the analysis with Socio Failure.

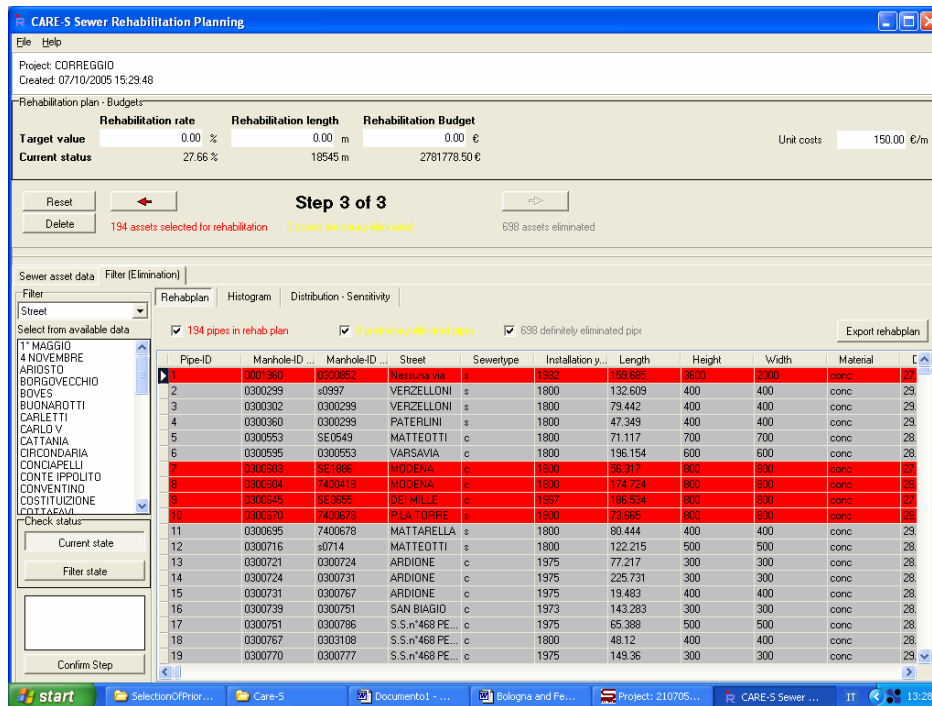


Figure 26. SRP: first list of pipes

Socio Failure calculates the value of the 10 criteria, depending from data availability, for each pipe in the first selection (Figure 27). The criteria are:

- flooding damage to buildings and their contents, and business losses;
- flooding intangible damage;
- traffic disruption and trouble due to flooding;
- degradation of surface water quality and consequences on present or future water uses;
- degradation of groundwater quality and consequences on present or future water uses;
- wastewater service interruption;
- traffic disruption and trouble, annoyances to life quality, due to soil depression;
- annoyances and damage from dry weather flooding in basements;
- annoyances and damage from dry weather flooding on the street;
- annoyances due to odours, insects, rodents.

DatasetID	PipeID	ICF Flooding (material damage + loss of trade)	ICF Flooding (intangible damage to population)	ICF Flooding (road traffic disturbance)	ICF pollution of receiving waters by overflows	ICF pollution of groundwater	ICF service interruption	ICF soil depression	ICF wastewater dry weather flooding in basement	was dry floods
20	1	1.2	0	#N/D	10	5	#DIV/0!	#N/D	#DIV/0!	#
20	7	30	0	#N/D	0	5	#DIV/0!	#N/D	#DIV/0!	#
20	8	30	0	#N/D		5	0.04560485	#N/D	0.00348015	0
20	9	60	0	#N/D		5	#DIV/0!	#N/D	#DIV/0!	#
20	10	19.8	0	#N/D		5	0	#N/D	0	#
20	31	27.6	0	#N/D		5	#DIV/0!	#N/D	#DIV/0!	#
20	32	1.5	0	#N/D		5	#DIV/0!	#N/D	#DIV/0!	#
20	36	1.2	0	#N/D		5	#DIV/0!	#N/D	#DIV/0!	#
20	37	104	0	#N/D		5	#DIV/0!	#N/D	#DIV/0!	#
20	38	30	0	#N/D		5	#DIV/0!	#N/D	#DIV/0!	#
20	39	30	0	#N/D		5	#DIV/0!	#N/D	#DIV/0!	#
20	40	28.5	0	#N/D		5	#DIV/0!	#N/D	#DIV/0!	#
20	41	36	0	#N/D	#RIFI	5	#DIV/0!	#N/D	#DIV/0!	#
20	42	36	0	#N/D	#RIFI	5	#DIV/0!	#N/D	#DIV/0!	#
20	45	33.12	0	#N/D	#RIFI	5	#DIV/0!	#N/D	#DIV/0!	#
20	46	36	0	#N/D	#RIFI	5	0.00848897	#N/D	0.00194236	0
20	47	1.44	0	#N/D	#RIFI	5	#DIV/0!	#N/D	#DIV/0!	#
20	51	36	0	#N/D	#RIFI	5	#DIV/0!	#N/D	#DIV/0!	#
20	53	36	0	#N/D	#RIFI	5	0.01293208	#N/D	0.002028431	0.0
20	57	36	0	#N/D	#RIFI	5	#DIV/0!	#N/D	#DIV/0!	#
20	77	20.88	0	#N/D	#RIFI	5	0.02338539	#N/D	0.003224805	0.0
20	83	18.72	0	#N/D	#RIFI	5	0.01695575	#N/D	0.002739799	0.0
20	84	19.08	0	#N/D	#RIFI	5	#DIV/0!	#N/D	#DIV/0!	#
20	86	18.72	0	#N/D	#RIFI	5	0.01956472	#N/D	0.002941539	0.0
20	90	12.96	0	#N/D	#RIFI	5	0.03580856	#N/D	0.003376063	0.0
20	111	9.72	0	#N/D	#RIFI	5	#DIV/0!	#N/D	#DIV/0!	#
20	114	7.92	0	#N/D	#RIFI	5	0.00778707	#N/D	0.001858425	0.0

Figure 27. Socio Failure: criteria calculated

At this point all results have been registered in Rehab Manager and can be visualized in SRP, in order to make a final selection of pipes to rehabilitate. As shown in Figure 28, 11 pipes have been prioritized for rehabilitation and criteria used to make the selection have been:

- flooding damage to buildings and their contents, and business losses;
- traffic disruption and trouble due to flooding;

The motive of this choice has been that only for those 2 criteria there were values different to zero for all the 194 pipes of the first selection.

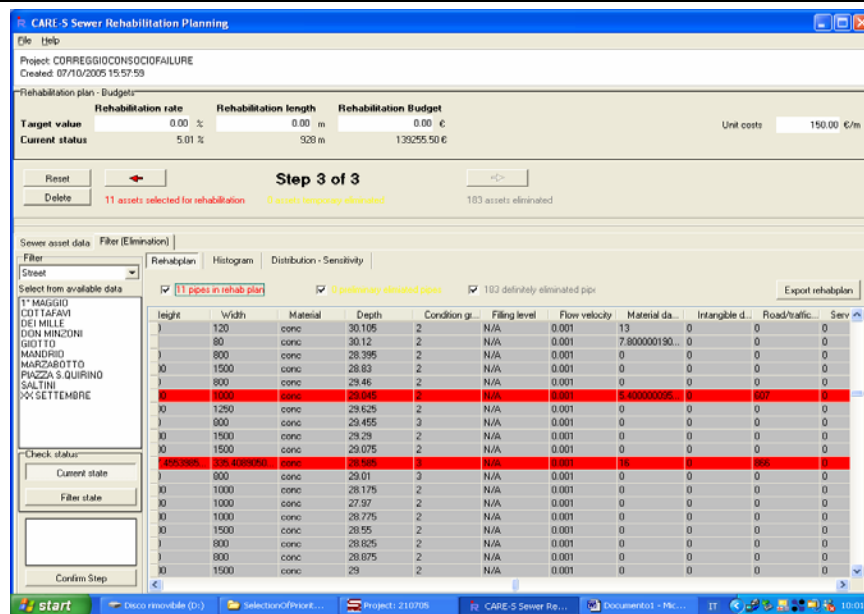


Figure 28. SRP: pipes to rehabilitate

In Figure 29 is shown a GIS view in Rehab Manager of the pipes to rehabilitate.

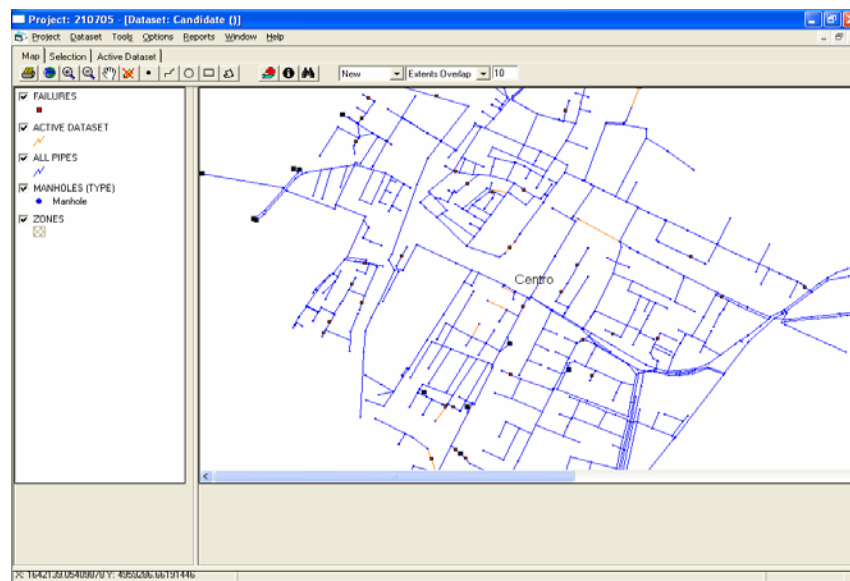


Figure 29. GIS view of pipes to rehabilitate

Cost Tool and Socio Works

Socio Work is a tool that has to be run for each pipe of the selection; selecting each of the 11 pipes viewed in Figure 29, 6 criteria were calculated. Criteria are:

- noise impact;
- dust impact;
- groundwater pollution ;
- service interruption ;

- traffic and road ;
- loss of trade.

From Rehabilitation Technology Database, our end-user has chosen 3 technology to be compared each other, that are:

- in situ repair;
- CIPP hot water cure;
- conventional trench.

Depending from network characteristics and from technology characteristic 6 criteria were calculated. In Figure 30 is shown some criteria calculated for pipe 751.

Technology ID	Rehabilitation Technique	Day or night work	Duration value (days)	ICW noise	ICW dust	ICW pollution of ground water	ICW service interruption	ICW re dte
16	in situ repair	d	1.50	0.00	0.00	0	0.00	
42	conventional trench	n	5.00	0.08	0.00	0	0.00	1.5
0	0	0	0					
0	0	0	0					
0	0	0	0					
0	0	0	0					
0	0	0	0					
0	0	0	0					
0	0	0	0					
0	0	0	0					
0	0	0	0					
0	0	0	0					
0	0	0	0					
0	0	0	0					
0	0	0	0					
0	0	0	0					
0	0	0	0					
0	0	0	0					
0	0	0	0					

Figure 30. Example of criteria calculated

Cost Tool was applied to pipes that were selected; depending from technologies cost for each pipe rehabilitation costs were calculated, as shown in Figure 31.

PIPE ID	Rehab ID	Rehab Technology	Rehab cost 1 (€)	Rehab cost 2 (€)
297,100	1.1.1	conventional trench	72000	108000
297,100	1.1.2.1	shoring and trench box	136000	202500
297,100	1.1.2.2a	concrete sheet pile (single)	153860	230790
297,100	1.1.2.2	milling robot	600000	900000
297,100	1.2.1.3	root cutting robot	6000	9000
297,100	1.2.3.1	masonry	26274	42411
297,100	1.2.3.4	injection	277200	415800
297,100	1.2.3.6	pre-cast repair	54000	81000
297,100	1.2.4.2	mortar stabilization	277200	415800
321,335	1.1.1.1	conventional trench	72000	108000
321,335	1.1.2.1	shoring and trench box	136000	202500
321,335	1.1.2.2a	concrete sheet pile (single)	153860	230790
321,335	1.2.1.2	milling robot	600000	900000
321,335	1.2.1.3	root cutting robot	6000	9000
321,335	1.2.3.1	masonry	26274	42411
321,335	1.2.3.4	injection	277200	415800
321,335	1.2.3.6	pre-cast repair	54000	81000
321,335	1.2.4.2	mortar stabilization	277200	415800
432,200	1.1.1.1	conventional trench	72000	108000
432,200	1.1.2.1	shoring and trench box	136000	202500
432,200	1.1.2.2a	concrete sheet pile (single)	153860	230790
432,200	1.2.1.2	milling robot	600000	900000
432,200	1.2.1.3	root cutting robot	6000	9000
432,200	1.2.3.1	masonry	26274	42411
432,200	1.2.3.4	injection	277200	415800
432,200	1.2.3.6	pre-cast repair	54000	81000

Figure 31. Rehab Costs for each pipe

All the results of Cost Tool and Socio Works should have been used in SRT Tool but there has not been much time to test; SRT Tool should provide the best technology for each pipe and a report of rehabilitation plan.

SRS Tool

SRS Tool enables to make, in junction with Gompitz Tool, a long term rehabilitation planning. Importing “Strata.txt” file and “ST0.txt”, coming from Gompitz Tool, the state of the art of the network is provided, as shown in Figure 32. The Time horizon was 10 years and time prediction 2015. For each condition class a value of repair cost of 100 euro/m has been fixed, a rehabilitation cost of 150 euro/m, an inflation rate of 2,70% and a discount rate of 3 %.

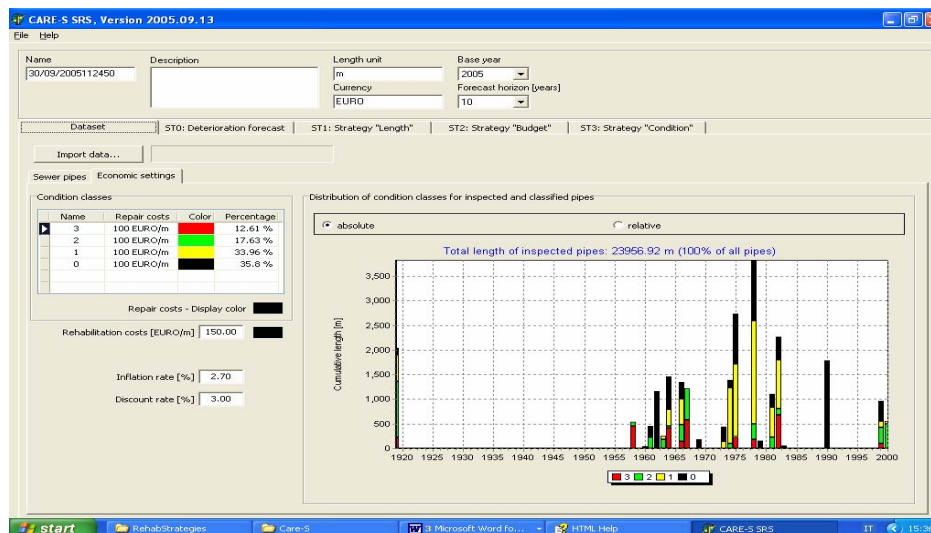


Figure 32. Rehab Costs for each pipe

To run SRS Tool, 3 different kind of strategies have been performed, depending from “Length”, “Budget” and “Condition”. Depending from the strategy chosen, Gompitz predicted the condition grade of each pipe and SRS, depending from discount rate, inflation rate, repair costs and rehabilitation costs, calculated the future economic investment in the network.

Gompitz results were imported and results visualized.

1) Strategy “Length”

A “St1.txt” (figure 33) file was created to run Gompitz Tool. The Strategy “Length” consists to fix for each year the length of network to rehabilitate and, depending from Gompitz, for each year of prediction and for each pipe in the analysis the condition grade was calculated and visualized in “Predict1.txt” file (Figure 34) and the investment costs were calculated and visualized in “Rehab1.txt” file (Figure 35); after that “Predict1.txt” and “Rehab1.txt” files were imported into SRS.

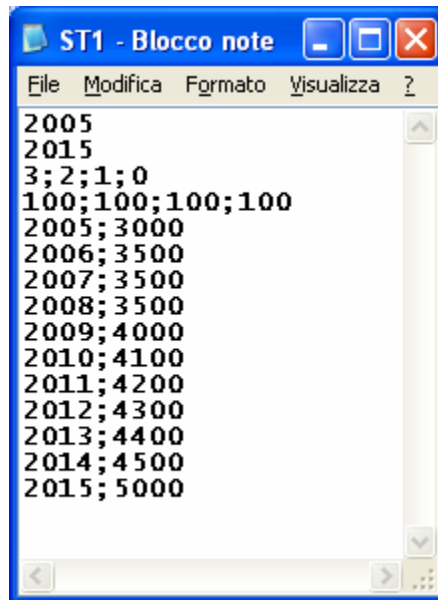


Figure 33. “St1.txt” file

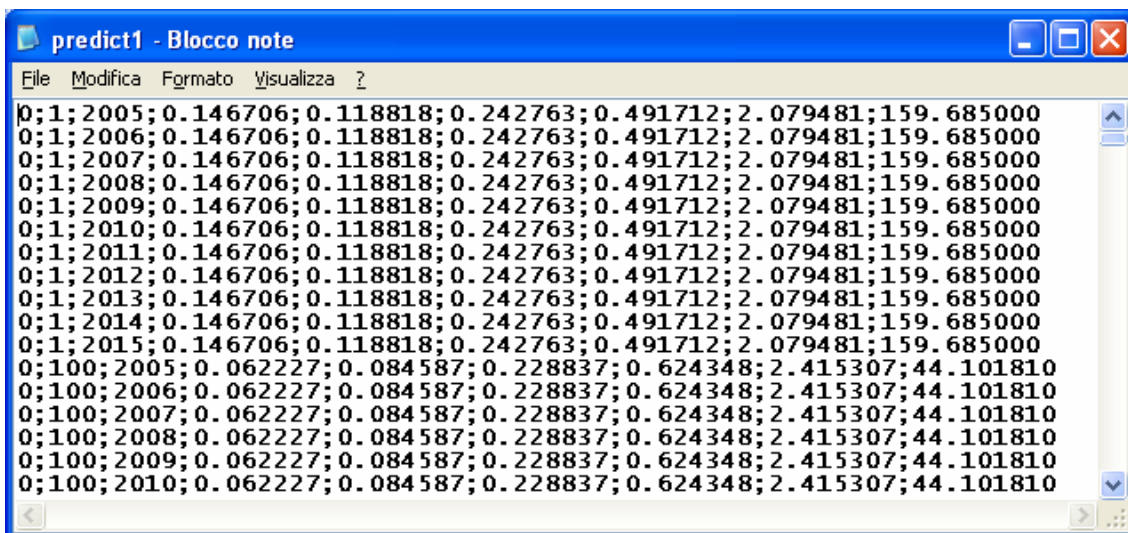


Figure 34. “Predict1.txt” file

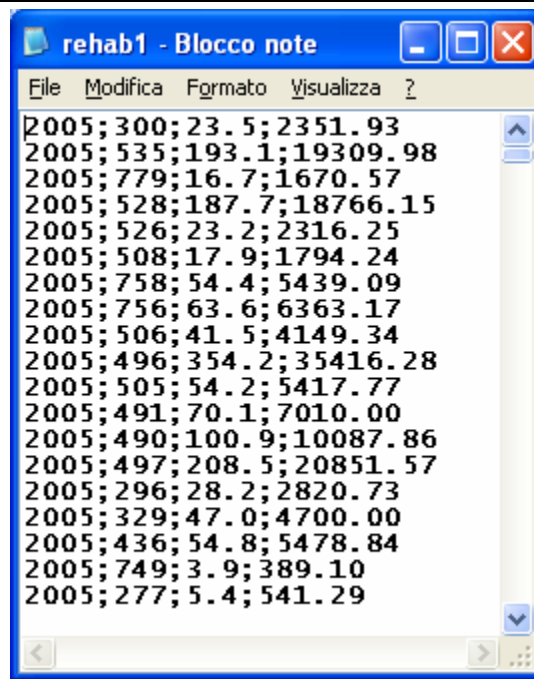


Figure 35. “Rehab1.txt” file

As shown in Figure 36, for each strategy 3 possible graphics are available:

- future network deterioration;
- discounted investment costs;
- discounted running costs.

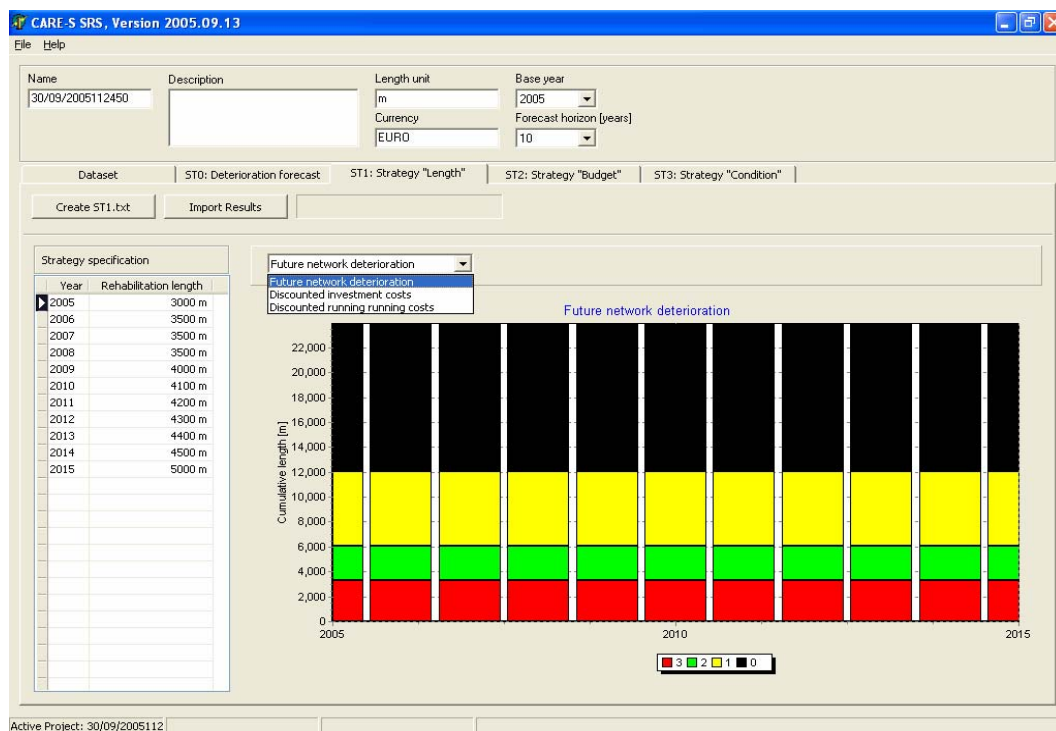


Figure 36. Strategy “Length”: future network deterioration

2) Strategy “Budget”

A “St2.txt” (figure 37) file was created to run Gompitz Tool. The Strategy “Budget” consists in fixing for each year the economic budget for rehabilitation; depending from Gompitz, for each year of prediction and for each pipe in the analysis, the condition grade was calculated and visualized in “Predict2.txt” file; the investment costs were calculated and visualized in “Rehab2.txt” file; after that “Predict2.txt” and “Rehab2.txt” files were imported into SRS.

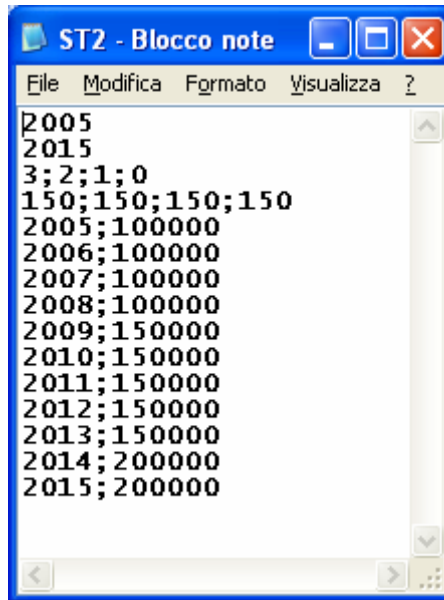


Figure 37. “St2.txt” file

Figure 38 shows the discounted running costs for “Budget” strategy.

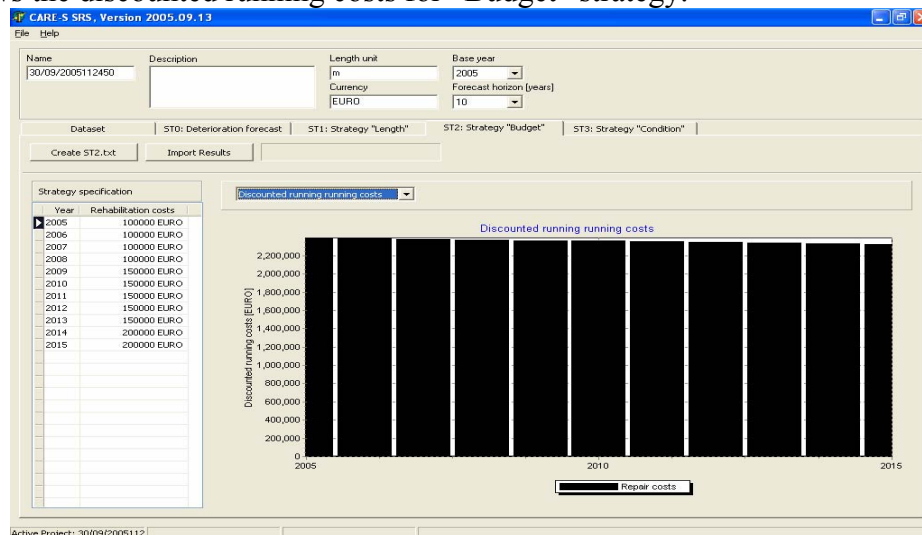


Figure 38. Strategy “Budget”: discounted running costs

3) Strategy “Condition”

A “St3.txt” (figure 39) file was created to run Gompitz Tool. The Strategy “Condition” consists to fix, for all the pipes, a condition grade to be reached in a certain year. Depending from Gompitz, for each year of prediction and for each pipe in the analysis, the condition grade was calculated and

visualized in “Predict3.txt” file and the investment costs were calculated and visualized in “Rehab3.txt” file; after that “Preditc3.txt” and “Rehab3.txt” files were imported into SRS.

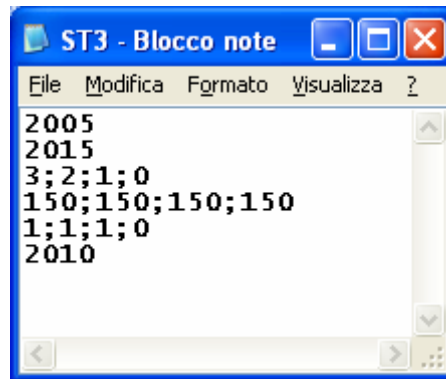


Figure 39. “St2.txt” file

Figure 40 show the discounted investment costs for “Budget” strategy.

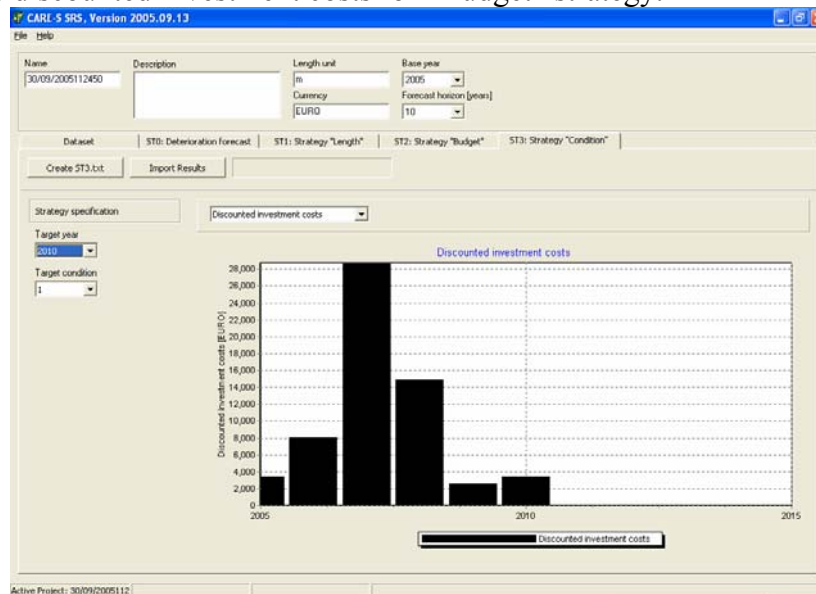


Figure 40. Strategy “Condition”: discounted investment costs

CONCLUSIONS

The testing activities performed and a thorough analysis of results demonstrate that Care-S is a valid instrument to plan rehabilitation in sewer networks. In fact, even if we have not been able to run in full Cost Tool and MCD, we have been able to individuate 11 pipes prioritised for rehabilitation.

Care-S, as Care-W, needs a lot of data and time spent in data collection; in Italian water industry, this represents a weak point, because in many utilities data are not in electronic format. Another weakness is that a very small number of end-user actually performs any hydraulic modelling; and, in turn, the lack of hydraulic data limits the use of Care-S.

As a consequence, an Italian end user desiring to use Care-S must be prepared to invest a large amount of money and time in collecting data and performing hydraulic modeling.

Report on testing carried out in Barcelona, Spain

Partner: CLABSA

End User: CLABSA

Authors: Carlos Montero, Delphine Boullay

Testing in Barcelona

Objectives

The objectives of the testing of the CARE-S software in Barcelona, done by CLABSA have been defined as:

- Understand how does CARE-S work: Use of the Rehab Manager, dataflow, how to import files, data and tools management (edit, copy, etc.)
- Check what data requires each tool, and in what format file must if be provided for data reading.
- Prepare CLABSA's GIS data for exporting data in the required format and prioritize collection of new data, when detected important missing information.

These have been pointed as the steps to follow in the way for an extensive application of CARE-S software in Barcelona, planned for the next months.

General testing procedure

According to the objectives, a testing methodology has been established. The main tasks pointed have been:

- Select priority tools: no each one of the tools have been tested. A priority list has been developed, according to the interest of the results provided by the tool for Barcelona case, considering also those tools which produce input for other tools (the main interest is not in the direct results of the tool, but these results are required to run other tool). Obviously, data availability has been another variable considered in order to test a tool.

Tools selected under these conditions have been:

- PI Tool
- CCTVcon
- Blockage model
- Degradation model
- Z-model
- GAT
- CAT
- Hellmud
- **Phase 1: Training with example files provided by tool developers.** The first step in the testing was learning how does the software function. Once used to the Rehab Manager function, tools were tested with the original example files for learning function procedure and checking consistency (version problems, local settings, etc.). So, the objective of this phase was understanding the procedure.
- **Phase 2: Application to sample case.** Those tools tested in phase 1 were checked with a semi-synthetic catchment. This dataset corresponds to real sewer system of a Tarragona catchment. Selected dataset was of reduced dimensions, in order to be able to change or add any required data manually. Sewer topology is real, but other data, as material and defects were edited to present a variety of cases (different material, different defects and years of inspection etc.). This semi-synthetic dataset has a sewer length of 3.410 m, 14 pipe length and a catchment area of 114,83 hectares. The main objective of this second phase was the checking of compatibility problems.
- **Phase 3: Transference to Barcelona pilot catchment.** Once verified the correct function of the tools in previous steps, a pilot catchment of Barcelona was selected to test the tools. The objective in this case was to prepare the GIS for massive data export. Some of the tools have already tested in this level, but this task is still under development. Selected pilot catchment has been Bac de Roda, with a sewer length of 3.006m, over 150 pipe length and a basin area of 178,3 hectares.

- **Phase 4: Massive application for Barcelona.** The final aim of the testing procedure is arrive to this phase: being able to apply CARE-S in Barcelona in order to develop a Rehabilitation Master Plan. This task is planned to begin in December 2005 and finish in July 2006.

As a previous consideration it's important to remark that this testing has been done up to August 2005, consequently, newer versions of tools have not been tested, and probably some defects found have been already mended.

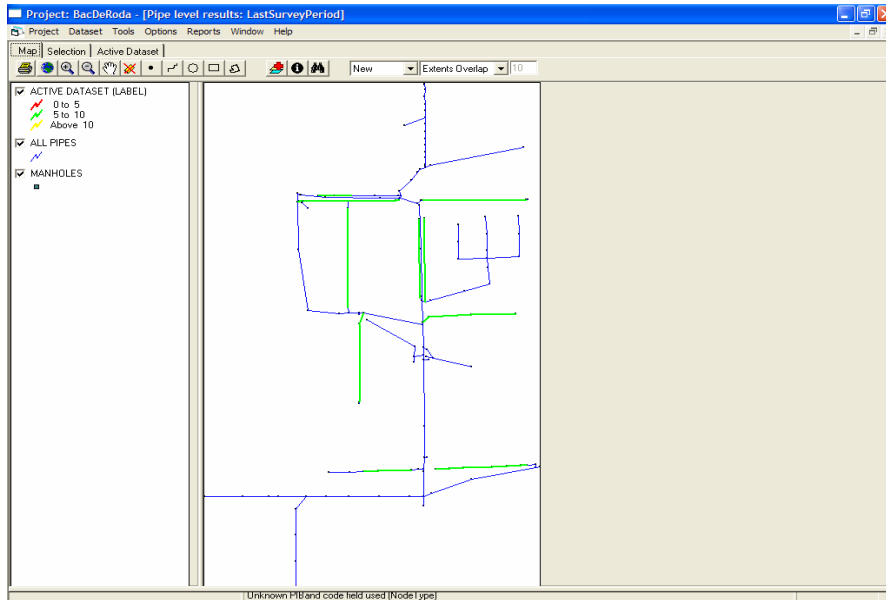


Figure 1. View of the Barcelona pilot catchment: Bac de Roda.

Testing of the PI tool

Short description of the tool

PI tool calculates performance indicators at catchment level.

Description of the testing procedure

Due to the characteristic of this tool, it has been tested with data of all the city of Barcelona, because the effort of calculating this for a catchment is similar than for the whole city.

Model verification, results and discussion

It's a very simple to use tool, that runs pretty well and provide good results. The most difficult part is the data collecting, because some of the performance indicators require information hard to find or to collect.

Higher interest of the tool is comparing results of different years or districts/catchments of the city.

Conclusion

Tool runs very smoothly. Very interesting tool for benchmarking (internal, in different catchments, or external, among different cities).

Testing of the CCTVcon

Short description of the tool

CCTVcon tool converts the national standard CCTV inspection coding system to European coding system EN 13508-2. National standards have been introduced for five countries: Australia, Norway, Germany, United Kingdom and Denmark.

Description of the testing procedure

Spain has not a specific national standard for CCTV inspection data collecting before adopting EN 13508-2. Consequently, many different coding systems can be found, depending on cities and even inspection companies. In the case of Barcelona, sewerage managers are working in the translation from their specific coding system to the European Norm.

CLABSA has tested this tool at phase 1, using the testing files provided by tool developers. (Nordberg)

Model verification, results and discussion

Tool seems to run well and provide good results in the tested case.

Conclusion

Tool works fine. No proper dataset in Barcelona to use it.

Testing of the Blockage tool

Short description of the tool

Blockage tool calculates the blocking probability for each pipe length of the sewer network.

Description of the testing procedure

Blockage has found to be a critical aspect of the sewerage system for pipes smaller than 300mm diameter. In the case of Barcelona, which has a combined sewer system, diameters are, as Municipal regulation state, of at least 400mm of diameter for the public network. The fact is that blockages in Barcelona are, until today, extremely rare. For this reason, this tool has not tested in subsequent phases.

CLABSA has tested this tool at phase 1, using the testing files provided by tool developers.

Model verification, results and discussion

Tool seems to run fine and provide coherent results in the tested case. A warning in German was found during the testing. No other incidence.

Conclusion

Tool works fine. No interest for Barcelona to use it, because blockage is not a problem.

Testing of the Degradation tool

Short description of the tool

Degradation tool has been designed to recalculate hydraulic parameters according to defects present in the sewer. Tool changes the Manning coefficient or inserts local head loss in the hydraulic model (SWMM, MOUSE or Infoworks) depending on the defect assigned in each pipe length by the CCTV inspection.

Description of the testing procedure

CLABSA has tested this tool at phase 1, 2 and 3. This means that tool has been tested with Nordberg files (example), semi-synthetic catchment and Barcelona pilot catchment.

Model verification, results and discussion

No problem found during testing phases 1 and 2. Testing in the pilot catchment some warnings were advised, and found caused by a lack of data (quantification and characterization of CCTV data).

Tool runs fine and provides logical results in all the tested cases.

Conclusion

Tool works very fine. Very interesting tool for Barcelona.

Testing of the Z-Model

Short description of the tool

Z-model tool has been developed for the rough assessment of problems related to H₂S in sewers.

Description of the testing procedure

CLABSA has tested this tool at phase 1 and 2. In this case, testing files were Nordberg, Cherston and Tarragona semi-synthetic catchment.

Model verification, results and discussion

No problem found during testing phase 1. Only the definition of pipe material was required, and it was done with the help of the Rehab Manager. In Tarragona case, an error was found: Z-model advised that there were no pipes with a positive slope, and consequently was unable to run. This problem was advised. Developers were aware of it, and mending it. No further testing was done after that.

Tool runs quick and fine in example files, but problems were found with semi-synthetic catchment.

Conclusion

Tool seems to work fine, but further testing is required by CLABSA to check the repair of the error. Quite interesting tool for Barcelona, because provides valuable information with easy to input data.

Testing of GompitZ

Short description of the tool

Degradation model for sewer pipes. Requires CCTV inspection data of several years and basic pipe data.

Description of the testing procedure

This tool has been tested at phase 1 and 2. Unfortunately, Tarragona semi-synthetic catchment did not have enough CCTV inspection data to run the calibration block, and so it was not possible to run the prediction block.

Model verification, results and discussion

No problem found during testing phase 1. The required amount of information (CCTV inspection in different years) for calibrating the deterioration curves was large, and so it has not been possible to obtain results for semi-synthetic catchment.

Tool seems to run fine.

Conclusion

Tool works fine, but further testing with more CCTV inspection data is required. Extremely interesting tool for Barcelona, provides very valuable and innovative information, nevertheless it requires costly data for its calibration.

Testing of GAT

Short description of the tool

Groundwater Assessment Tool is used for assessment of sewer waste water exfiltration problems that may cause pollution in groundwater.

Description of the testing procedure

This tool has been tested at phase 1. No further testing has been done, as groundwater pollution is not a major issue in Barcelona.

Model verification, results and discussion

Some problems found during testing phase 1 inside the Rehab Manager (probably some import failed). These problems were not found when running the tool as a stand alone.

Conclusion

Tool seems to work fine, but further testing with real dataset should be convenient. Low interest for its application in Barcelona, because groundwater pollution is not a major problem.

Testing of CAT

Short description of the tool

Combined Sewers Overflows Assessment Tool is used for assessment of CSO risk in receiving waters.

Description of the testing procedure

This tool has been tested at phase 1, with Nordberg test file.

Model verification, results and discussion

Minor problems found running the tool as a stand alone. Some problems found during testing inside the Rehab Manager (format mismatch).

Conclusion

Tool seems to work fine, but further testing with real dataset should be convenient. Very interest for its application in Barcelona, because CSO are closely watched by authorities and citizens in receiving waters (beach zone).

Testing of Hellmud

Short description of the tool

Hydraulic and Environmental reliability Model of Urban Drainage) uses as input hydraulic model, GAT and CAT to produce hydraulic and environmental risk maps.

Description of the testing procedure

This tool has been tested at phase 1, with Nordberg test file.

Model verification, results and discussion

Minor problems found running version 3.3.0. No problems found during testing of version 2.2.0.

Conclusion

Tool seems to work fine, but further testing with real dataset should be convenient. Very interest for its application in Barcelona, because it point the high priority pipes according to the hydraulic and environmental risk they produce.

General conclusions and recommendations

CARE-S project has developed a large number of programs and tools, able to cover diverse requirements. In the case of Barcelona, some of the tools have not been tested, mainly due to lack of data.

The Rehab Manager organizes all the tools, avoiding the repeated import of the same data, which is a major advantage. Some facilities have been included in this Manager, like numeric or GIS reports. Even that, the general procedure to implement the CARE-S in a city is not simple, and consultancy and or training is highly recommended.

An issue of importance is the number of data required by many of the tools. In some cases, data are basic asset information, available in almost any GIS, but in other cases (e.g. infiltration/exfiltration) the required data are complex to measure and/or costly to acquire.

As a consequence of these facts, investment in data collecting and office staff is necessary.

Regarding the tools, tested software ran very fine in general, and provided logical results. More testing effort will be done during the next months in order to implement CARE-S system in Barcelona.

CLABSA considers that a software rehabilitation like CARE-S is essential for medium or large cities, and in any case for cities with sewer degradation problems.

Report on testing carried out by Severn Trent Water and United Utilities

Partner: WRc plc

End User: Severn Trent Water, United Utilities

Authors: Roger Hurley, Kevin Taylor, Jeanette Cooke

Introduction

The aim of this phase of the CARE-S project was to test the various tools in the CARE-S toolkit within the main framework of the rehabilitation manager software.

This document describes the scope of the testing work undertaken by WRc in conjunction with Severn Trent Water and United Utilities, the UK end users of the CARE-S project.

This is the final report of the end user testing and, as such, presents the testing that has been carried out up to the beginning of October 2005. The first training and testing session took place in February 2005, when version 2.2.0.0 of the CARE-S software was issued. The final testing session was carried out on the August 2005 release, version 2.5.0.0.

The testing addressed both the ease of use of the rehabilitation manager and tools as well as the relevance of the analysis that has been undertaken. In particular, the following points were discussed:

- Data collection
- Running the software
 - Importing data
 - Using the rehabilitation manager
 - Using the individual tools
- Discussion of results
- The relevance of the CARE-S software to the needs of the end-user

Scope of the testing work

The testing work consisted of one day of training and two days of testing, spread out over several months. The end users chose which tools to test, based on their companies' needs and data availability.

The following tools were tested:

- The CCTV conversion tool;
- The degradation tool,
- The structural condition prediction tool (GompitZ);
- The blockages tool;
- The CSO Assessment tool (CAT);
- The hydraulic reliability tool;
- The socio-economic consequences of pipe failures tool

Description of test site

Most of the testing was undertaken using data from the "Darlaston" catchment. Darlaston is a sub district of Walsall Metropolitan Borough Council, which lies some 8 miles north-west of Birmingham, England.

The catchment covers some 488 hectares and, with a population of approximately 15,000, is almost entirely urbanised. It is roughly 70 % residential and 30 % industrial with the industry concentrated on the southern edge and in an area in the north, north of the Walsall Canal and the Black Country Route highway.

The topography of the area shows a gradual fall from the town centre (slightly to the east of the centre of the catchment) which forms the high point of the catchment. The land falls in all directions from the town centre, but more steeply towards the south-east into Sandwell.

The area lies in the South Staffordshire Coalfield and was mined extensively during the nineteenth and early twentieth century. The ground consists mainly of heavy clay, which underlies considerable amounts of fill.

There is ongoing redevelopment within the area and many new industries have replaced the traditional heavy industries. The town centre has undergone major redevelopment in recent years.

There are just over 80km of public sewers, with three CSOs and no pumping stations. Approximately 35% of the drainage is fully separate, with 45% partially separate and the remainder combined. The separate areas are mainly in the newer industrial areas in the north, south and south-eastern parts of the catchment. The combined areas are mainly in the older residential areas scattered around the catchment.

The main watercourse is the Darlaston Brook which drains to the River Tame on the northern edge of the catchment. The foul/combined sewer system drains, via the Black country Trunk Sewer, to Minworth wastewater treatment works.

Data

The data files used for the testing consisted of:

- Hydraulic model of the catchment
- Hydraulic results files
- CCTV survey data
- Failure data, relating to pipe blockages, flooding and collapses
- A list of rehabilitation technologies available in the company.

Data preparation

Hydraulic models

Models from the Severn Trent Water, Cherston and Darlaston catchments were used. The Darlaston model was used for most of the testing.

Pipe age (installation year)

United Utilities hold information on the installation year of the pipe in their corporate “MapInfo” GIS database but, since we were testing CARE-S using Severn Trent catchments, we were unable to use this information. The equivalent information is not readily available in Severn Trent, but it can be estimated using property age data. Severn Trent provided WRc with property age data in MapInfo format and the files were converted to shape files for importing into the rehabilitation manager. We then assigned property ages to the pipes adjacent to each of the properties by a semi-automatic method. This was a time-consuming process.

Pipe wall thickness

Wall thickness is not formally measured but manufacturers’ datasheets provide wall thicknesses for given pipe materials and diameters. Users can be fairly confident in using this material and diameter information to identify wall thicknesses. Pipe depth should also be considered: The deeper the pipe, the thicker the wall. WRc therefore estimated wall thicknesses based on pipe material and diameter, and used expert knowledge regarding depth. Severn Trent Water were satisfied with this approach, see table in Appendix A.

Soil type

Soils map were provided in MapInfo format. These were loaded into the rehabilitation manager and soil types assigned to the pipes using the “update attribute” function of CARE-S.

Groundwater levels

This a “nice to have” data item. UK companies do not collect it routinely and, as it is not considered important, they are not prepared to commit resources to collecting it. Groundwater levels could be identified on a scenario basis. For example, estimates could be made for groundwater levels during wet and dry periods or according to soil type. It should be understood, however, that such data would be based on very broad estimates. Levels could also be estimated by reference to infiltration observed during CCTV inspections. For the purposes of testing, a predefined query was written in the rehabilitation manager’s ‘Expression Builder’, to define groundwater levels for selected pipes at a fixed depth below ground level.

CCTV inspection survey data

Two surveys were available, one from 2002, the other from 1990 to 2002.

Rehab technologies

See Appendix B for a list of the technologies available to Severn Trent Water.

Hydraulic results

Hydraulic results requirements were as follows.

- Dry weather flows: In “.prn” format for use in the simple internal corrosion tool (the “Z” model).
- Design storms: Flow depths at each link at hourly intervals over a 24-hour period, in “.csv” format for use in the infiltration/exfiltration tool. Flood volumes at each node over a 24-hour period (preferably for at least one year), in “.csv” format for use in the CAT tool. Other design storms in “.prn” format.

Overall, the preparation of hydraulic results is not a data intensive exercise. Nearly all data requirements can be fulfilled and there are means by which missing data can be estimated.

Testing

First, we created a new CARE-S “Project” and provided CARE-S with the basic network by importing the Darlaston hydraulic model. We then added the CCTV survey data and ran CCTV conversion tool.

CCTV conversion tool

We imported the two different sets of survey data. It was noted that CARE-S overwrites old information with newer information. It is important that users are aware of this because, sometimes, the older data are more accurate than more recent data. The opportunity to retain the older data should be provided.

Similarly, if more than one CCTV inspection survey has been registered in CARE-S, the rehabilitation manager will automatically use the latest (most up-to-date) data. It was suggested that it would be useful if users could to compare different CCTV inspection results in order to study deterioration over time and the impact of rehabilitation work.

Our end users did not know what the CEN material-type codes meant and requested a table of information explaining the meaning of each code. This has been added to the later versions of CARE-S.

End-users believed that the CCTV tool was *very important*. Companies spend a lot of money on CCTV inspections, so it is beneficial if the CCTV tool provides a means by which they can exploit the data further and produce more meaningful results.

Degradation tool

The degradation tool’s “Help” was reviewed and found to be acceptable.

We then ran the tool to calculate revised pipe roughnesses, based on information from the CCTV inspections.

The following comments were made:

1. An error message appears each time there’s a blank in the CCTV file, this needs to be OK’d before processing will continue. This is not acceptable, since an “error” message suggests problems, which these are not. Also the text of the message is misleading; it should say the value in “quantification 1” is not valid
2. The message informing users that the recalculation has been completed is not good English; it needs re-writing.

3. The recalculation is carried out twice. The reason for this is unclear.

Next we checked the results produced by the tool, by double clicking on “sewer pipe data for recalculation” in the input screen. A set of results was generated, but the interpretation of the results was not intuitive.

The action generates the MS Excel spreadsheet and the “old” & “new” roughnesses are on the far right of the “results” worksheet. In order to identify pipes for which the degradation tool had identified a change in roughness we added fields to subtract one from the other. (This can be done using the standard report “update numeric 4...” in the expression builder, which generates a GIS report, demonstrating the use of the expression builder).

This additional functionality could be useful as, at present, roughnesses must be identified and changed by inspection. However, InfoWorks has the capacity for users to enter two roughness values, one for the bottom of the pipe and one for the top. The degradation tool only provides one roughness. We must assume, for the time being, that this is the same for the two InfoWorks values.

The following additional comments were made:

1. The column headings on the “CCTV” worksheet are incomplete – they stop at column “BC” whilst the spreadsheet goes to “IV”.
2. The tool is ignoring a significant number of defects – eg. all the “BB’s” which do occur in the CCTV input file. Is this because the “recalculation matrix” ignores surface defects such as sediment and only looks at structural defects? This is inconsistent with the information provided in the “help” file.
3. In the “Recalculation formulae” table, the field headings “A”, “B”, etc...are not clear, they need to be labelled the same as in the “Recalculation matrix” table: Characterisation 1 / 2 and Quantification 1 / 2.
4. Whilst the tool was running, the following error messages appeared for different pipes and different defect codes:
 1. “Characterisation 1 is not valid. Check Characterisation letter”
 2. “Quantification is not valid at 1. Valid value is between 0 and 1 (100%)”.

These errors appeared when there were blank cells in the CCTV data. The tool developer should allow for blank cells or improve the error messages.

5. *End-users found it useful to be able to view the base data in the results file.*
6. It is not clear when the tool has finished running. Although it reads “Done” in the processing box, the progress bar is still shaded-in and this normally means that the tool is still running.
7. Windows ‘Service Pack 2’ is required to run the degradation tool. This should be mentioned in the tool’s “Brief Help” file so the user has an idea of a possible reason, if the tool should fail to operate.
8. The roughness values in the “Results” sheet look different because of different cell formats e.g. some are presented to one decimal place and others to four. This can mislead the user into thinking

that roughnesses have changed slightly. It is preferable that all results are displayed to the same number of decimal places.

9. It was uncertain whether all the defects in the CCTV survey data were registering in the degradation tool. Only structural defects were listed for Darlaston data, but problems due to silt and other such issues were expected.

Predicting structural condition tool (GompitZ)

Both our end users were Interested but, before proceeding further, would need to gain confidence in the statistical techniques used and the validity of the results.

Blockage tool

Severn Trent hold past blockage data in MapInfo. The quality of the blockage data was often poor and it was a time-consuming task to prepare the data for import into CARE-S.

Most blockages are in “Section 24”¹ sewers but these sewers are not included in Severn Trent’s hydraulic models because of the limited information known about them. However Ofwat (the economic regulator) consider Section 24 sewers to be important because, in the future, they are likely to require increasingly large maintenance investments to maintain their serviceability. There is therefore a need to obtain more information on Section 24 sewers. Severn Trent are aware that the issue of data quality is a problem for them to resolve. The first step is to ensure that field operatives record blockages accurately against the pipes in which they occur.

WRc staff spent a significant amount of time during testing, explaining the data requirements to our end users, considering where (in their corporate systems) data are held, and how data can be retrieved and prepared for importing into CARE-S.

The following general comments were made:

1. The tool is very easy to understand and use.
2. The output “Probability of blockage” is preferable to “Blockage factor”.
3. The first page in the tool’s ‘Brief help’ suggests that ‘slope’ is a factor used to calculate the blockage factor for each pipe. However slope is not required in the tool’s input file.

The CAT tool

The first function of the tool was tested to assess the sensitivity of receiving water to drainage system (“A” & “B” values). Our end users considered the results to be reasonable and thought they could be used as a “rule of thumb” for assessing CSO impacts.

The comments generated by the tool were not particularly useful. Velocity and depth seemed to have little impact on results. The end users believed that a graphical output, depicting the effect of changes to the “A” values (e.g. PE) on the sensitivity of receiving water, would be useful. Users could then observe at what point in the model issues would occur.

We attempted to test the second function of the tool, to assess the performance of CSO’s with reference to national standards. This failed due to problems creating a suitable input file for the tool.

¹ “Section 24” is a term used to describe sewers which were originally the responsibility of a local housing authority. They are generally small sewers, are often poorly constructed and have low quality location and attribute records.

Socio-economic consequences of pipe failures

The following comments were made:

1. The end user currently has to *enable macros* when commencing work with the tool (either by simply clicking on “enable” or by changing the security level, from high to medium or low, and then reopening the tool and clicking on “enable”). This is unacceptable. Macros should be enabled automatically so that the user does not have to enable them.
2. Once working with the tool, the end users had difficulty understanding the column headings. Column headings must be clearer. The meaning of “Groundwater type – Y/N” was also unclear.
3. The pipe environment data in the sheet “Validation of environment data” did not contain any data for the user to check and validate.

United Utilities explained that this tool could be useful to UK water companies as, in theory, it provides important information. However, socio-economic consequences are already considered by the UK companies when deciding which assets are “critical”. For users to adopt this tool, it would have to offer something not already done or, indeed, a better way of collecting and analysing the data they already process. Current impressions are that the tool is too data intensive.

Other tools

Both end users explained that *internal and external corrosion* of sewer pipes were not real problems for UK companies. They were therefore not interested in testing these tools.

Likewise, the end users were not interested in the *load-carrying capacity* or *infiltration/exfiltration* tools. However United Utilities explained that the Environment Agency are now asking companies to collect information on exfiltration in areas close to groundwater boreholes. Infiltration/exfiltration is not a significant issue at present, but could well be in the future.

The *groundwater assessment tool (GAT)* was not tested because no groundwater level data were available. See “General data requirements” below.

Due to time constraints, *the following tools were not tested*: pipe selector; socio-economic consequences of rehabilitation work; rehabilitation technology database; rehabilitation technology costing tool; multi-criterion decision making tool. The *long-term strategy tool* was not available from the tool developers at the time of testing.

Rehabilitation Manager

The following comments were made:

General comments

1. “New project” form – there are two redundant data-entry boxes on the right-hand side of the screen which should be removed.
2. The name of the project and template folders in the CARE-S directory start with an “s”. Severn Trent questioned whether the “s” was necessary. The “s” stands for “sewers” to distinguish the files from those produced by CARE-W(which are prefixed “w”. The “s” could be removed.
3. It is advisable to save a project regularly to reduce the risk of losing data, should the program crash. In this case, automatic back-up at defined time intervals would be useful.

4. In the GIS viewer, the selected layer should be made more prominent, so that the user knows which layer is selected. For example, a lightly-shaded box around the layer would make it stand out.
5. United Utilities asked whether the flow direction in the pipes could be displayed and/or whether the user can add such arrows manually. At present, neither facility is possible.
6. Severn Trent requested that a note be added to the Help file explaining that the user can change pipe attributes but cannot add or delete pipes.

Comments on reports

1. “Reports – GIS – current status of inspection data”

“0 to 5”, “5 to 10”, etc., is difficult to understand if you don’t realise you have to read the file name at the top of the screen.

This should say “Pipe level results : Last-Survey_Period_ (years)”

2. Report on condition grades

The CCTV Condition Grades are colour-codes inappropriately, the best condition being shown in red. This should be changed to green. The colours are set at initial installation and, in the majority of cases, are correct, but some anomalies will require modifying.

The interaction between the degradation tool and the rehabilitation manager

The end user may not wish pipe attributes in the hydraulic model tool to be updated automatically by the degradation after processing of CCTV survey data.

In the UK, existing pipe measurements are more likely to be correct than those obtained from CCTV surveys. CCTV operatives often measure the pipe attributes, but this is not an important requirement of the CCTV work and companies often disregard the information recorded. Diameter and depth are often poorly recorded during CCTV work and the method of measuring length is not accurate. Utilities therefore consider the pipe measurements from the CCTV surveys to be unreliable and do not use them.

The end users considered what data should be transferred from the degradation tool to the rehabilitation manager. They thought that users should be given the option to accept or decline each change to a pipe attribute prompted by the degradation tool. For example, changes to pipe attributes and roughnesses (after the degradation tool has been run) could be highlighted so that, when the updated hydraulic model is exported from CARE-S and imported into the hydraulic modelling application (Infoworks, MOUSE OR SWMM), pipes that have changed can be identified. This would allow the user to compare the updated model to the original model and accept/reject the changes. If this facility cannot be provided, then the following message would be useful: “Of the pipes inspected, the following attributes may have changed:”. The user would then be aware of possible changes to the hydraulic model.

Four GIS reports would be useful to show the results from the Degradation tool

1. Initial roughness;
2. Derived roughness;
3. “+” or “-“ difference between the initial and derived roughness;
4. Different defect types.

A tabular report would also be useful, showing the initial and derived roughness values and the difference between the initial and derived roughness values.

End-users found the data label “Current roughness” too ambiguous and suggested “initial roughness” instead. Similarly, the data label “Transitionalmatrix roughness” is no longer valid and should be changed. Suggestions made included “Derived roughness” or “DegradationTool roughness”.

The interaction between the hydraulic model and the rehabilitation manager

During testing there was a problem with *the unit of pipe length*. To create a hydraulic model with the correct units, the end-user must select “Native” units in the hydraulic modelling package. This could be explained in the Help file, with the aid of screen dumps.

When importing a hydraulic model, the user is currently asked to define a name in a blank text box. Throughout the training and testing sessions, the name entered was always the same as the project name. The project name could therefore be the default hydraulic model name and the user can change it if necessary.

Miscellaneous comments

1. On opening the socio-economic tool for pipe failures, groundwater levels were present in the input sheet, but there were no groundwater levels in the hydraulic model linked to the Rehabilitation Manager. It is not clear where these values come from.
2. In the Socio-economic tool for pipe failures, data values for “backwater values” and “basement exists” should be “No” by default.
3. When importing “.csv” files it is easy for the user to select the wrong file for import. It would be useful if the rehabilitation manager were to check the field headings in the import file against the data specification in the Rehabilitation Manager and informed the user of any mismatch.
4. For the CAT tool, CARE-S does not identify CSO’s automatically (these are not identified in InfoWorks), so the user must know which nodes are CSO’s and enter this information into the CARE-S database. This is no problem if the network has (say) 20 CSO’s but what about 100?
5. An egg-timer is displayed but the cursor returns before processing has been completed. This can be confusing, as users will not know the program is still carrying out on operation.

APPENDIX A – Standard pipe wall thicknesses

Material	Diameter (mm)	Wall thickness (mm)
Brick	400	200
	500	200
Concrete	225	40
	450	50
	525	60
	600	60
	750	70
	925	90
	950	90
	1050	100
	1200	120
	1275	120
	1350	130
	1500	150
	1600	160
Vitreous clay	150	30
	225	30
	300	40
	375	40
	400	50
	450	50
Unknown (assume as clay) – <i>OK</i>	150	30
	225	30
	300	40
Unknown (assume as concrete) – <i>OK</i>	375	40
	400	50
	450	50
	500	50
	600	60
	1350	130
	1500	150
The following large pipe diameters were identified in the model as vitreous clay, but this is doubtful.	1350	
	1600	
	1650	
	2100	
	3000	

APPENDIX B – List of rehabilitation technologies available to Severn Trent Water

CARE-S code	Technology	Available Y/N ?
1.1.1.1	Conventional trench	Y
1.1.2.1	Shoring and trench box	Y
1.1.2.2	Concrete sheet pile	Y
1.1.2.3	Steel sheet pile	Y
1.2.1.1	Injection in joints or cracks	Y
1.2.1.2	Milling robot	N
1.2.1.3	Root cutting robot	Y
1.2.1.4	Pointing	Y
1.2.1.5	Rerounding	Y
1.2.2.1	Short-liner fiberglass and polymer	Y
1.2.2.2	Short-liner metallic	Y
1.2.3.1	Masonry	N
1.2.3.2	Fill with mortar and plaster	N
1.2.3.3	Pointing	Y
1.2.3.4	Injection	Y
1.2.3.5	In situ repair	Y
1.2.3.6	Pre-cast repair	Y
1.2.4.1	Chemical stabilisation (fill and drain systems)	Y
1.2.4.2	Mortar stabilisation	Y
1.2.4.3	Joint sealing	Y
1.2.4.4	Resin injection	Y
1.2.4.5	Compacted filling	Y
1.2.4.6	Surrounding stabilization	Y
2.1.1.1	Conventional trench	Y
2.1.2.1	Shoring and trench box	Y
2.1.2.2	Concrete sheet pile	Y
2.1.2.3	Steel sheet pile	Y
2.2.1.1	Reinforced cementitious	Y
2.2.1.2	Steel reinforced cement mortar spray	Y
2.2.1.3	Fibres reinforced cement mortar spray	Y
2.2.1.4	Polymer lining	Y
2.2.2.1	Swaged liners (swagelining)	Y
2.2.2.2	Folded liners (fold & form lining)	Y
2.2.3.1	Continuous sliplining	Y
2.2.3.2	Discrete sliplining	Y
2.2.3.3	Segmental sliplining	Y
2.2.4.1	Spiral lining	Y
2.2.5.1	CIPP hot water cure	Y
2.2.5.2	CIPP steam cure	Y
2.2.5.3	CIPP UV cure	Y

CARE-S code	Technology	Available Y/N ?
2.2.5.4	CIPP ambient cure	Y
3.1.1.1	Conventional trench	Y
3.1.2.1	Trench box	Y
3.1.2.2	Concrete sheet pile	Y
3.1.2.3	Steel sheet pile	Y
3.1.2.4	Mole ploughing	Y
3.2.1.1	Pipebursting percussive (pneumatic)	Y
3.2.1.10	Pipe extraction (modified static pull)	N
3.2.1.11	Pipe pulling	N
3.2.1.2	Pipebursting hydraulic	Y
3.2.1.3	Pipebursting static	Y
3.2.1.4	Controlled Line and Grade system (CLG)	Y
3.2.1.5	Pipe splitting	N
3.2.1.6	Pipe eating	N
3.2.1.7	Pipe reaming	Y
3.2.1.8	Pipe crushing (implosion)	N
3.2.1.9	Pipe ejection (modified pipe jacking)	Y
3.2.2.1	Rod pushing	N
3.2.2.2	Pneumatic hammer	N
3.2.2.3	Hydraulic hammer	Y
3.2.2.4	Steerable moling	Y
3.2.2.5	Pipe ramming (impact ramming)	Y
3.2.2.6	Auger boring	Y
3.2.3.1	Guided auger boring (guided boring)	Y
3.2.3.10	Shield	Y
3.2.3.2	Horizontal directional drilling (HDD)	Y
3.2.3.3	Guided drilling (mini-HDD)	Y
3.2.3.4	Conventional pipe jacking	Y
3.2.3.5	Low load pipe jacking	Y
3.2.3.6	Thrust jacking	Y
3.2.3.7	Microtunneling	Y
3.2.3.8	Minitunneling	Y
3.2.3.9	Tunneling	Y

Report on testing carried out in Oeiras - Madeira, Portugal

Partner: LNEC

End User: SMAS

Author: Adriana Cardoso

Co-authors: Julieta Marques, Maria Helena Silva, Sofia Coelho, André Pina

Description of test case

Catchment description

The catchment of Borel for the CARES testing is located in the Municipality of Amadora, near Lisbon, in Portugal. Borel has a separate sewer system built in 1981/1982, with a total catchment area of 13 ha, about 80% considered as impervious. Domestic sewers are circular with diameters from 200 mm to 300 mm, the pipe material is vitrified clay, concrete and polyvinyl chlorine and the total domestic sewer length is 1460.1 m. Storm sewers are also circular with diameters in the range 200 to 700 mm, the pipe material is reinforced concrete and polyvinyl chlorine and the total storm sewer length is 2208.7 m. The main problems detected are wrong connections, surcharging of sewers in wet weather, odours, structural defects and sediments in upstream reaches.



DATA AVAILABILITY

Data from SMAS Oeiras e Amadora

A survey on data availability was done in order to assess which CARES Tools could be applied using the Borel sewer system. SMAS Oeiras e Amadora have available data to run most of the tools.

Data from hydraulic simulations

The hydraulic simulations were performed considering dry weather flow and three rain events with different characteristics: low, medium and high rain intensity.

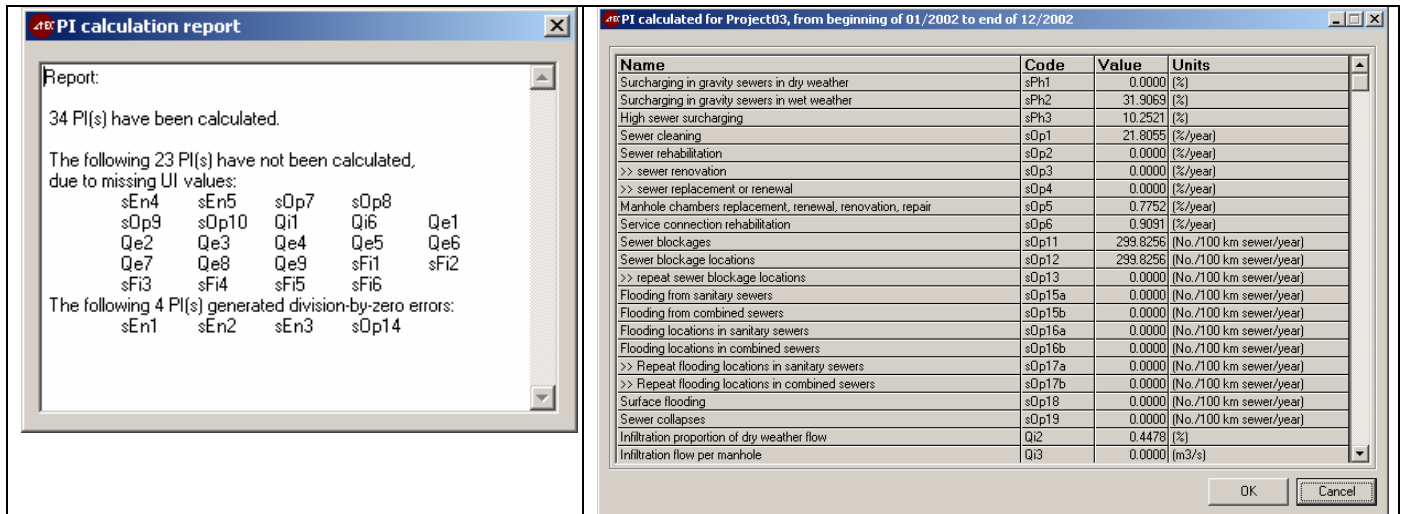
Event intensity	Date	Duration	H_{tot} (mm)	I_{average} (mm/h)	I_{max} (mm/h)	T_{antecedent dry} *
Low	2004-03-27 (12h15–22h00)	8h46m	18.10	2.06	12	15d 00h 17m
Medium	2004-02-21 (15h30) to 2004-02-22 (18h00)	22h05m	24.50	1.11	42	18d 09h 11m
High	2004-03-31 (20h45) to 2004-04-02 (06h00)	1d 08h 47m	27.50	0.84	84	0d 18h 20m

***Events with antecedent dry weather flow period longer than 4 h were considered independent.**

TESTING RESULTS ANALYSIS ON BOREL NETWORK

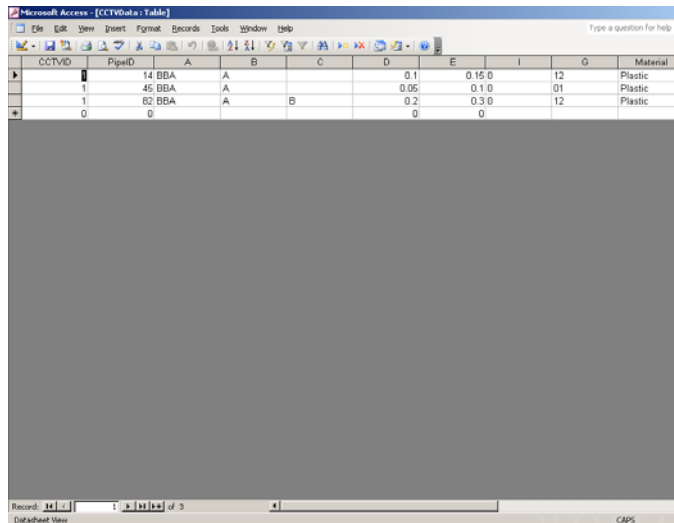
PI TOOL/S

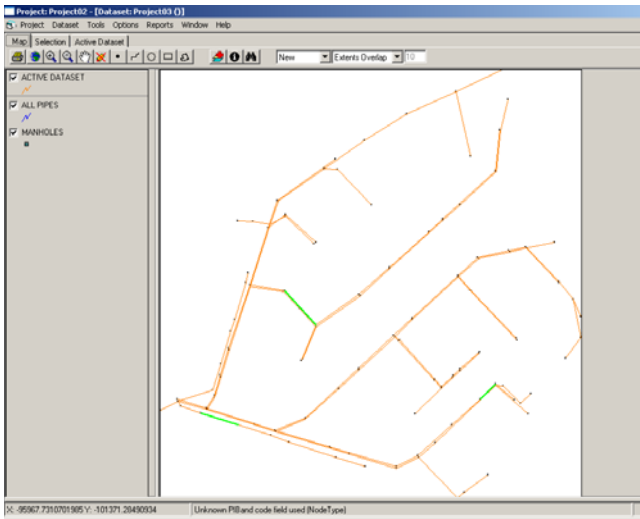
The data was prepared in an excel file (using the sample excel file format) that was imported without problems to the PITool/S. The tool run to calculate PI and allowed the graphical representation as well as exported the results to an excel file. There was no problems with PITool/S.



CCTV DATA

There were some difficulties with the use of CCTV data converter. It was not possible to test the option “Convert Data to CEN standards and/or register” as there was not a file “.dat”. CCTV data was introduced in the database table CCTVDATA after fulfilling the table CCTVSURVEY. There were some doubts on the meaning of columns I and SCORE however, it was possible to visualize in the GIS window and when using DEGRADATION Tool there was no problems with CCTV data.





PREDICTING STRUCTURAL CONDITION GRADES

The GompitZ did not work because an error always occurred indicating Invalid Strata. We intend to continue to solve this problem and try to use this tool.

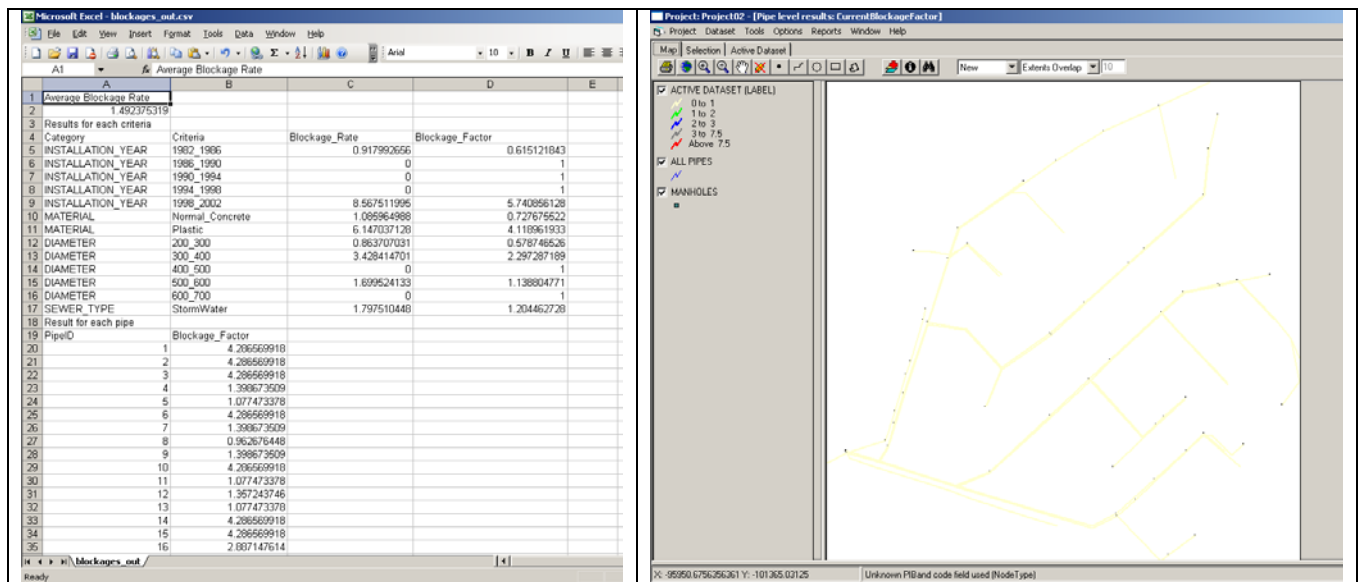
StrataID	StrataStatus	StrataName	Material	PipesInStrata	ValidNumber	AgeInConst	ValidAge	CurrentCondit
1	Invalid	Concrete	Concrete	76	Valid	2005	Invalid	
2	Invalid	Plastic	Plastic	20	Invalid	2005	Invalid	
3	Invalid	ceramic	ceramic	31	Valid	2005	Invalid	

INFILTRATION/EXFILTRATION

It was not possible to use the Infiltration/Exfiltration Tool because we could not input the information file from MOUSE that contains time varying water levels in the pipes on time varying water levels into the Manager. We only could import from MOUSE the summary data files.

BLOCKAGE

The Blockage Tool was run using CARES 5.0 version and obtained the Blockage Rate and the Blockage Factor for the defined classes. The Blockage Factor is also obtained for each PipeID. GIS presentation of results does not correspond to the values obtained in the file produced by the Tool. This Tool does not in the last version of CARES 6.0.



Z-Model

All sewers within the criteria were analysed and results were obtained. The result file includes the risk level and the Z-value for each pipe. There was not any problem with this Tool.

CARE - S

There are 127 pipes in your dataset for analysis.
The following is the analysis criteria:
Corrodible, >10m long, Slope>0, DWF>0

Of these :
There are 17 pipes which have a dry weather flow.
There are 117 pipes with a length greater than 10m.
There are 127 pipes with a positive slope.
There are 76 corrodible pipes.
There are 5 pipes with the required data.
Do you wish to analyse selected pipes?

Z model v. 1.5

Average wastewater temperature: 25
Average wastewater pH: 8.2

	Z
Sulfide problems rarely present when Z is below 5000	0
Low concentrations of sulfide may be produced, resulting in marginal problems when Z is between 0 and 5000	5000
Sulfide may develop sufficient to cause odor and corrosion problems when Z is between 7500 and 10000	7500
Frequent problems with odor and significant corrosion problems when Z is between 10000 and 15000	10000
Very frequent problems with odor and very significant corrosion problems when Z is above 15000	15000

Additionally there are 0 pumping mains with high risk of causing problems

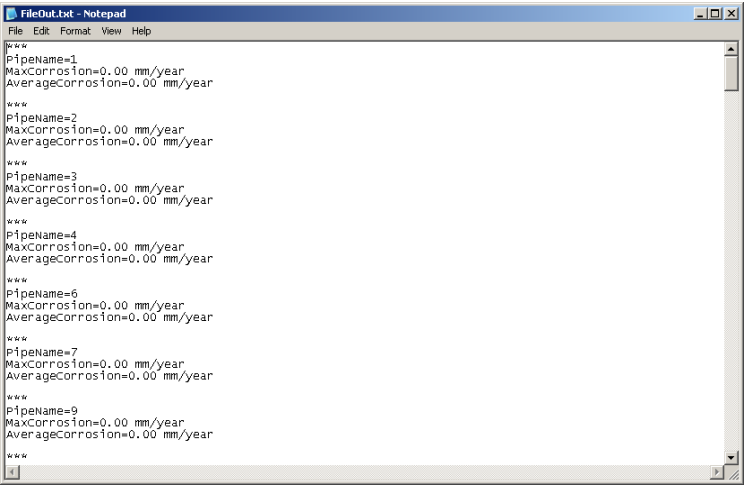
FileOut.txt - Notepad

```
File Edit Format View Help
***
PipeName=5
Risk=very low
Z-value=1979
***
PipeName=11
Risk=very low
Z-value=2010
```

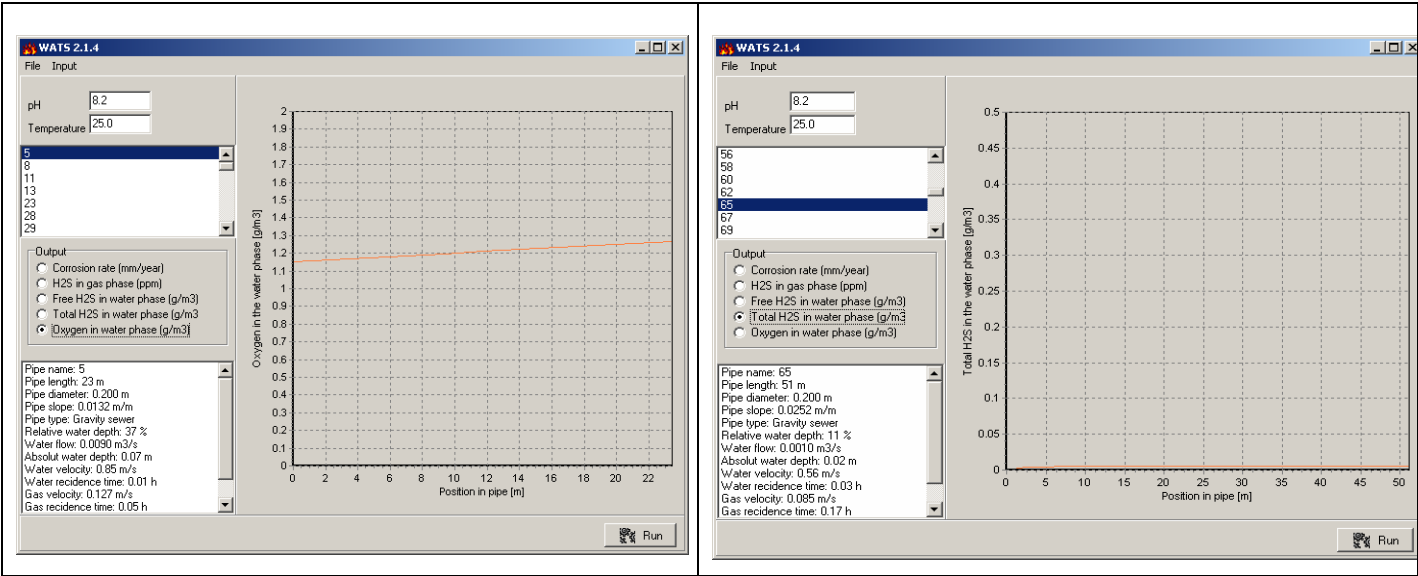
Project: Project102 - [Pipe level results: InternalCorrosionRisk]

WATS

This Tool was run for the domestic sewer and for the stormwater sewer. For stormwater sewer all the pipes presented a zero discharge and no value of O2 or H2S concentrations were presented.

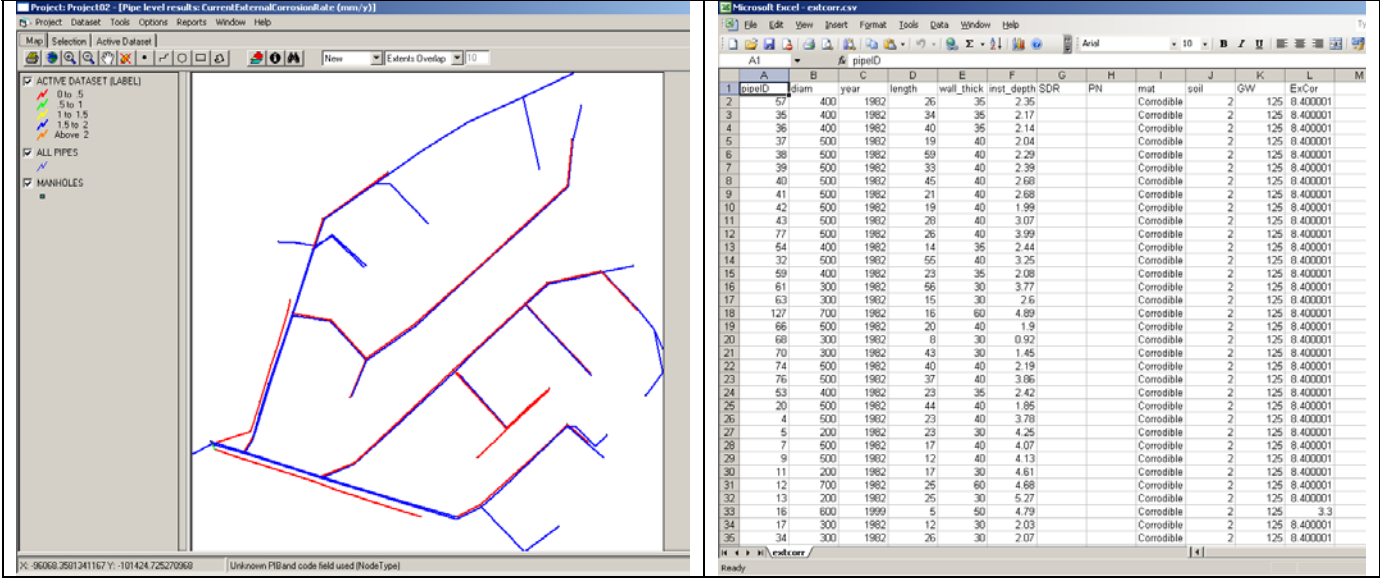


For the domestic sewer O2 and H2S concentrations graphics were calculated for pipes with discharge different from zero.



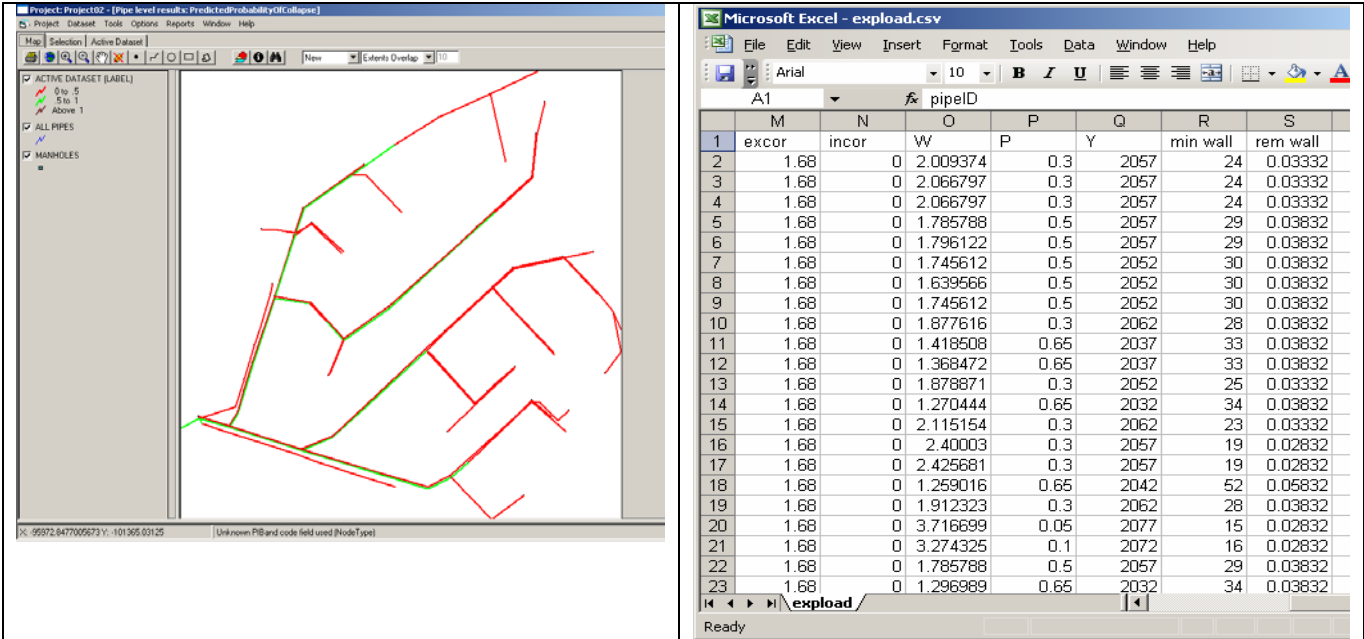
EXTERNAL CORROSION

This Tool run without problems and the file result contains the total external corrosion (ExCor). In the GIS is presented the Current External Corrosion Rate in mm/y.



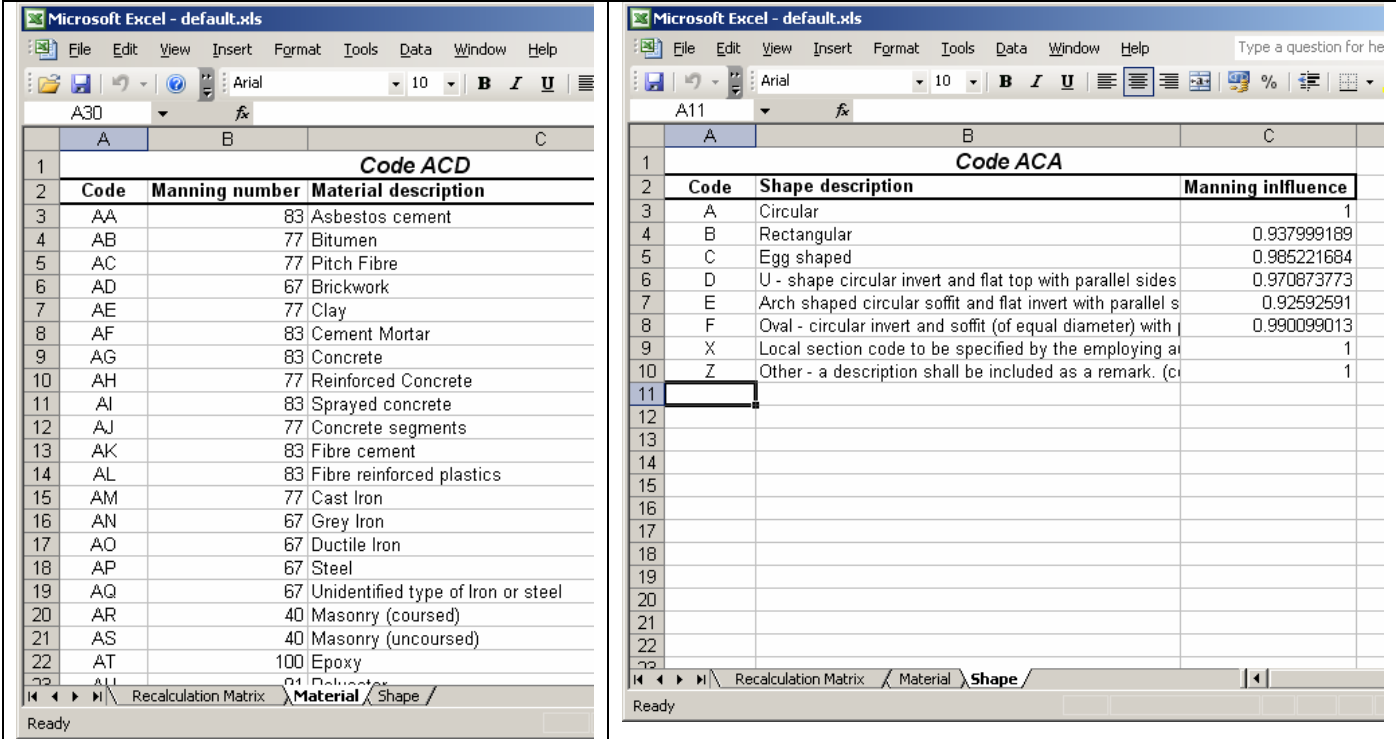
LOAD

This Tool run without problems and the file result contains the safety factor (W), probability of failure (P) and year of failure (Y).



DEGRADATION

This Tool run without problems and the file result default.xls was exported to the respective folder. Manning number for each material was obtained.



HYDRAULIC MODEL

This Tool run without problems and created a file to MOUSE.

GAT

This Tool run without problems. All the four methods were used and results presented in GIS.



CAT

It was not possible to apply this Tool because the system does not have CSO.

CONCLUSIONS

There are tools that could be used and run without problems. Some other tools still have problems that we are trying to solve. There is only one tool CAT that could not be used because it was not applicable, once there are no CSO, and tools from WP6 were not also tested because they were not available.

It is important to have an example case where all tools can be run without problems in order to support the end-user applications and preparation of files. There are still several problems in the creation of input data files and in the help of some tools that is not self explanatory neither clear. For example, by reading the CCTV data converter help it was not possible to use it.

Future use of CARES Manager

We intend to continue the testing of the CARES manager as soon as we have our questions solved and new versions are delivered. A new application will be made in the scope of the work of a University Student Training.

The end-user intends to continue the testing of tools, to conclude if this methodology is the more appropriate to SMAS de Oeiras e Amadora.

We are open to future collaborations in CARES applications since we have financial and technical support.

Report on testing carried out in Palermo, Italy

Partner: Palermo University

End User: AMAP – SPA, Palermo, Italy

Author: Gabriele Freni, Vincenza Notaro.

INTRODUCTION

The testing has been performed by AMAP – SPA in strict cooperation with University of Palermo. The testing has been performed in two phases: in the beginning a small area in northern part of the city has been used in order to get acquainted with the Rehabilitation Manager and with the tools developed during the project; a second testing area has been used for having a more significant example of CARE-S potentialities. The first testing example was used from December 2004 to April 2005 for evaluating the Rehab Manager, PI tools and Structural Condition Tools (WP2). The second testing area has been introduced when final version of the Rehabilitation Manager has been released (June – July 2005) in order to test the whole procedure.



Figure 1 – Testing areas: Area 1 – Sferracavallo catchment; Area 2 – Palermo city centre

The application of CARE-S project in Palermo produced an interesting secondary result convincing the City Administration to prepare standard criteria for acquiring and collecting data on sewer system condition. This aspect will be discussed in the following paragraphs comparing the old management procedures and the procedures that have been developed during CARE-S application.

DATA AVAILABILITY

Sferracavallo catchment

Sferracavallo is a small fisherman village that after the second world war was progressively adsorbed by the city of Palermo during the urban expansion of Sixties and Seventies. The catchment area is about 57 ha with a population of 12000 inhabitants. The network is combined and relatively new (being reconstructed in 1957 and progressively upgraded in recent times). The network length is around 80 km considering also private properties connections. Material used are concrete and polyethylene. Figure 1 represent principal sewers and connected areas: dark blue lines represent concrete egg-shaped pipes that have been installed before 1992; light blue lines represent polyethylene circular pipes that have been installed in recent times (since 1995).

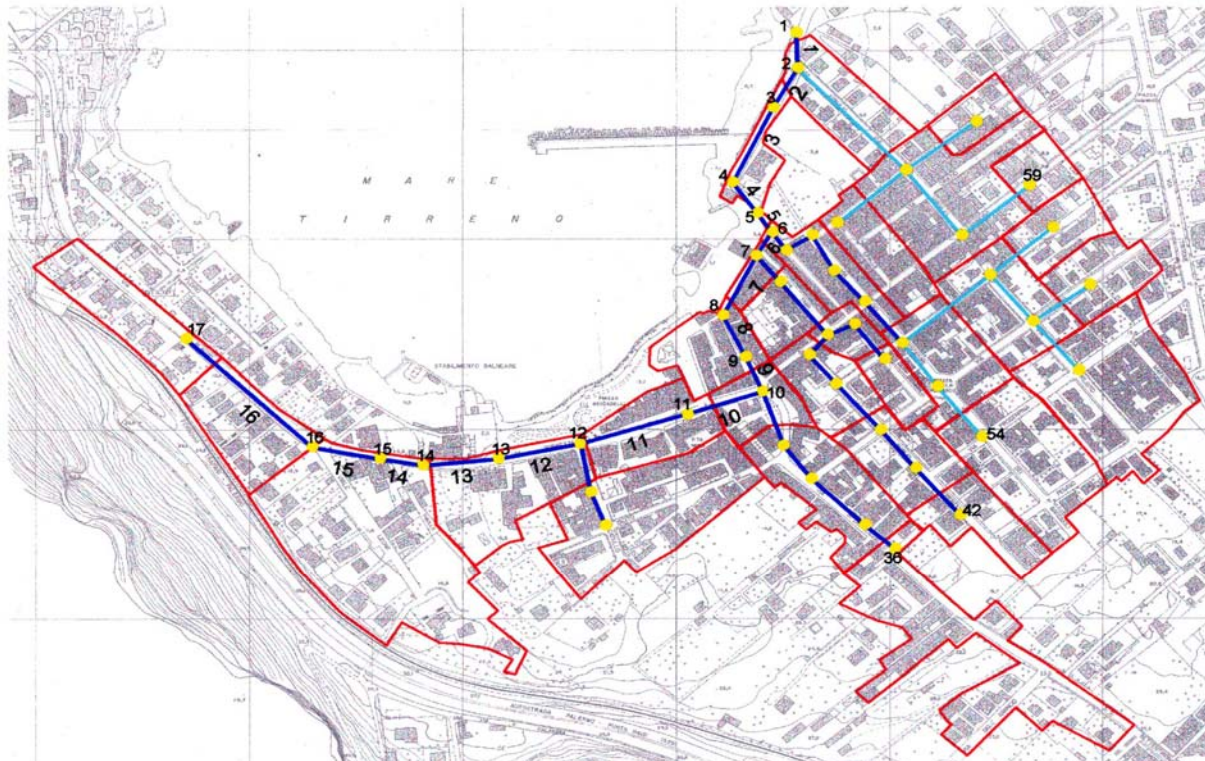


Figure 2 – Sferracavallo catchment and network

The area has been characterised by large expansion in the Seventies and sewer network has not been upgraded consequently. Moreover tourist activities have increased the pressure on the network and the damages consequent to sewer failure.

The seaside part of the catchment is interested by flooding, sewer blockages and collapses. Figure 2 shows part of the failures that have been registered in the last few years. These failures are creating a lot of damage especially considering the tourist vocation of the are that is now interested by restaurants, pubs and night clubs.

The sewer has been well monitored in the period 1980 – 2000. Inspections have been performed visually (without the use of CCTV) and results have been reported on paper inspection forms. During the CARE-S application those inspection forms have been converted to EN 13508 standard code in order to apply tools. During CARE-S project, the network has been partially re-inspected and new data cover the 20% of the network.

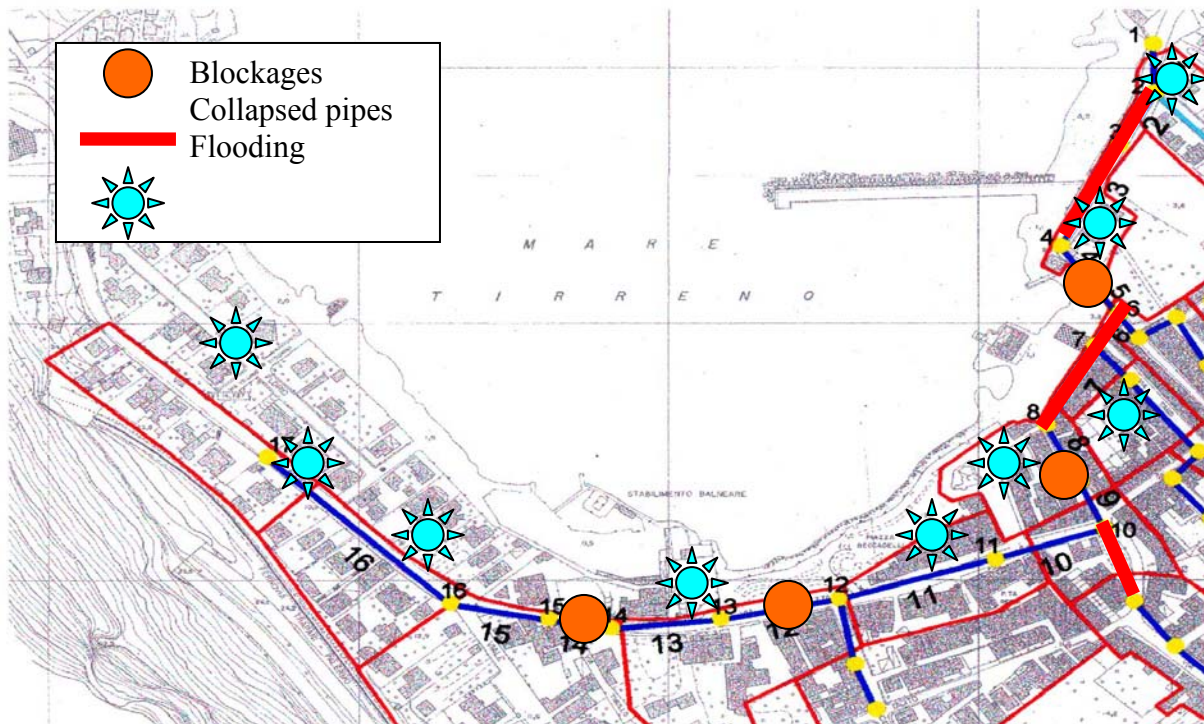


Figure 3 – Failures registered since 2000 in the seaside area

Palermo city centre

The “Centro Storico” of Palermo (Italy) is the oldest part of the city, strongly urbanised and with a very old drainage system, which receives both storm and waste water also from upstream less urbanized watersheds; local surface flooding due to the system insufficiency often occurs even for high-frequency rainfalls. The analysed area is shown in figure 4.

The “Centro Storico” catchment is about 2.5 km², with about 88% of impervious areas, mainly roofs and roads. The network is long more than 150 km including secondary network and property connections. The older part of the network has been installed in 1890 and it is currently in place. The other parts of the system have been built in different periods from 1910 to the current time. The 85% of the network is built in concrete and the 15% is constituted of old brick pipes and newer vitreous clay pipes. The 45% of the network has been visually inspected in the period between 1985 and 2005. The principal problems of the network are connected with flooding and collapses that especially interest concrete pipes built after the second World War.

As an example, figure 5 and 6 show the geographical distribution of the two Service Performance Indicators: SQS3 regarding flooding on properties during wet weather and SQS5 about blockages complains. In the figures the level of “no service” has been fixed, accordingly with the City Authorities, to 10 flooding per year every 1000 properties for SQS3 and 5 blockages complains per year every 1000 inhabitants.

By the example figures, it is possible to identify some priority areas (confirmed by several others PIs where measures have to be taken for increasing the overall performance of the network). The system performance is particularly critical in the most upstream and in the most downstream zones of the network. In the following paragraphs, discussing some results of the whole CARE-S procedures, those areas will be highlighted as critical sewers and they will be subjected to rehabilitation.

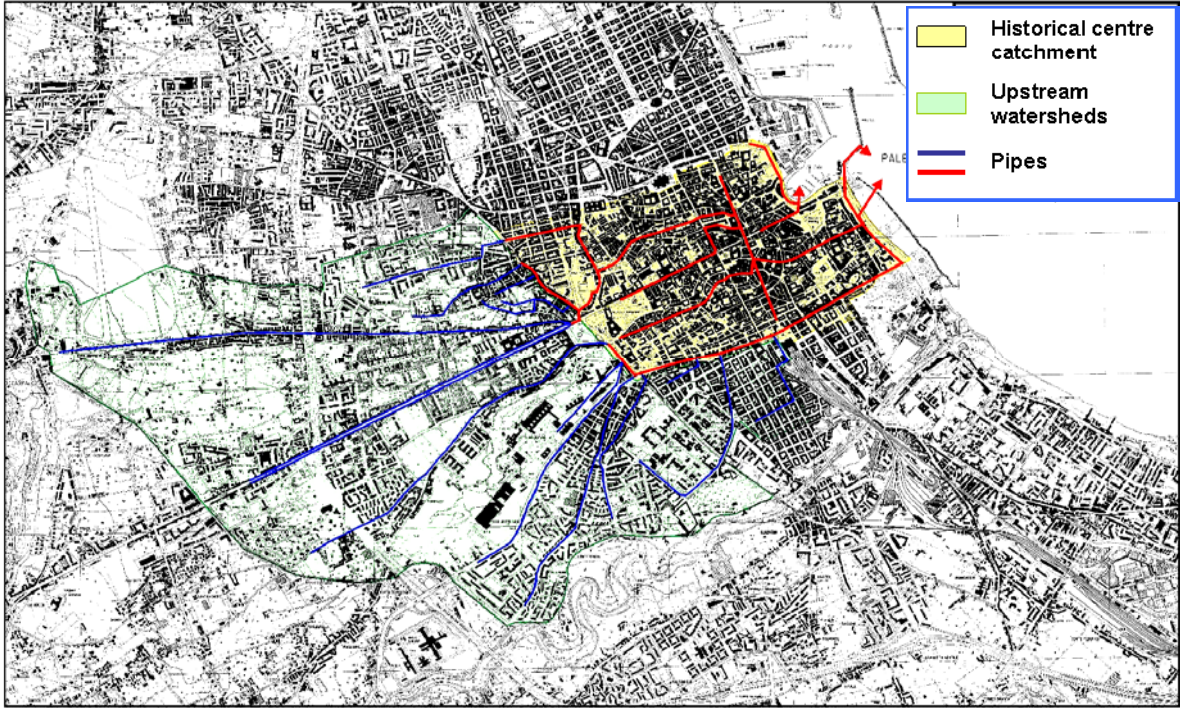


Figure 4:
Palermo
city
centre

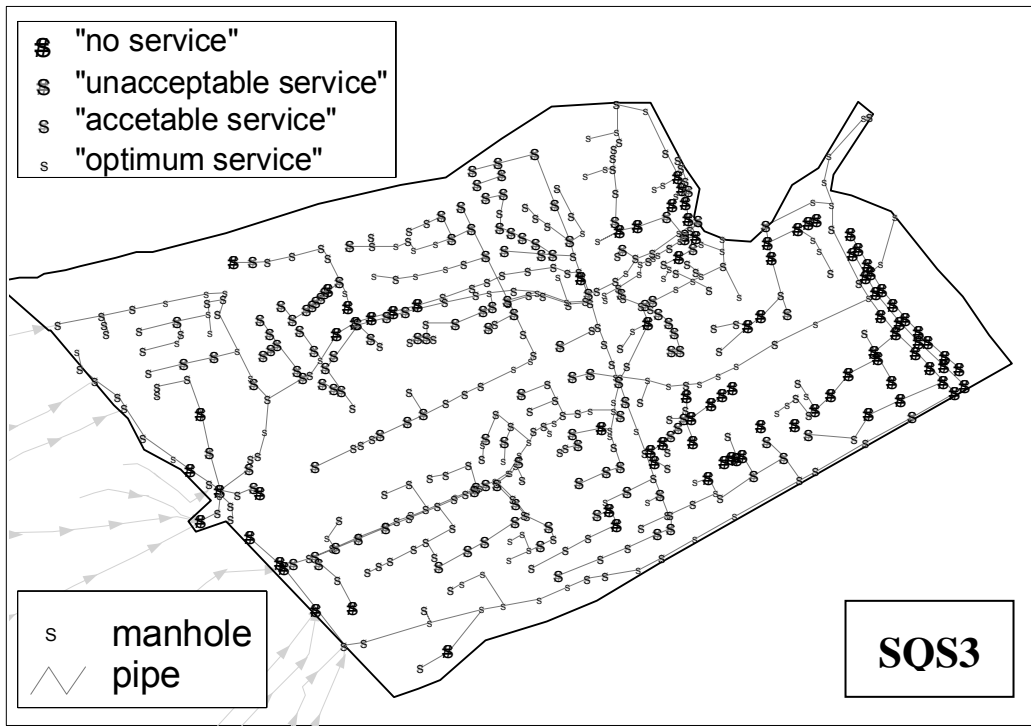


Figure 5: Distribution of Performance Indicator SQS3 about flooding on properties

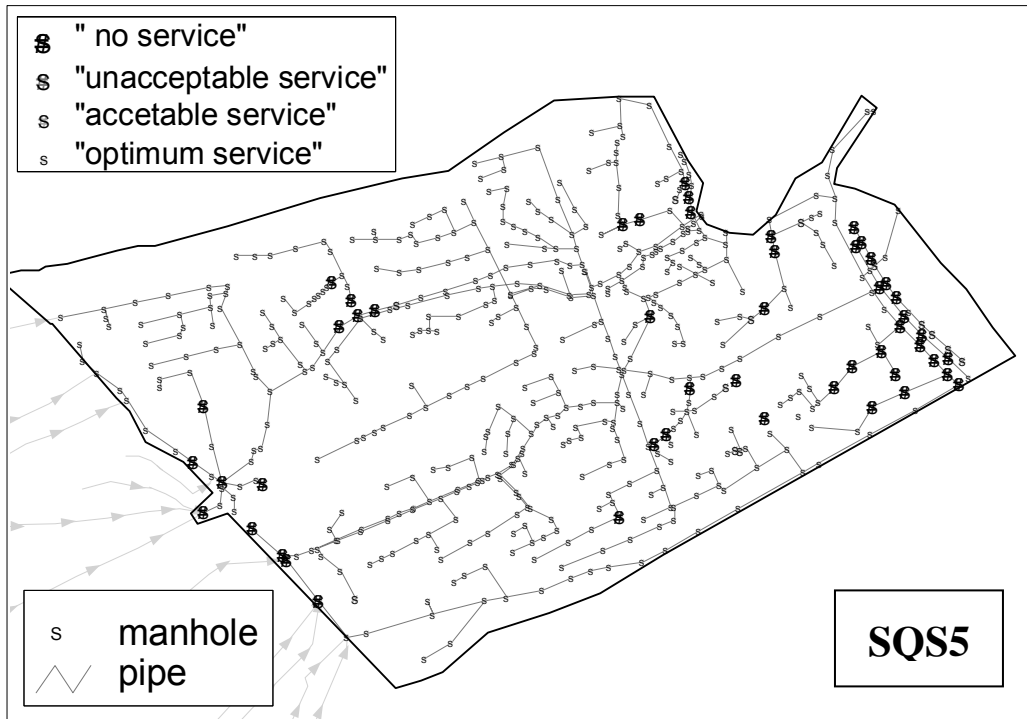


Figure 6: Distribution of Performance Indicator SQS5 about blockages complains

TESTING RESULTS ANALYSIS ON PALERMO CASE STUDY

As stated before, testing has been carried out in two subsequent periods. The first part of the testing has been carried out on the small and well documented catchment of Sferracavallo. The aim of this first testing period was the training of the end user in the use of CARE-S tools and the definition of specific data requirements for Palermo case study. This first testing period had also the advantage of highlighting the most common bugs of the tools allowing for their early solution. The second part of the testing was more detailed; the release of CARE-S version 2.5 allowed for testing more in details the hydraulic modelling tools because of the release of SWMM interface.

In the following lines, briefly, the feedback from the end-user will be discussed regarding all the applied tools. Some results will be also displayed for enforcing the discussion on the applicability and on the novelty of the CARE-S approach if compared with the previously adopted management procedures.

PI tool (WPI)

The PI tool was the first tool that has been tested also because it was the first being released for testing. The results from AMAP was outstanding for two main reasons:

1. the tool demonstrated the need for a comprehensive and easily accessible database of data concerning not only the network but also the users, social and economic information, traffic data, geologic maps, etc. Those data were only partially available in the beginning

and most of them were not included in a database but simply stored in paper archives. In the past, this aspect did not allow to integrate information about the network, the level of service and the potential impact on urban activities. The first application of PI tool allowed for calculating only 12 PIs. After the first application of PI Tool, an integration process has been started allowing for assessing 38 PIs

2. Transferring the information about PIs on a geographic database, it was possible to identify the most critical areas in terms of level of service and potential need for rehabilitation. Those areas were highlighted in PI tool application and then specifically addressed during the application of the whole procedure.

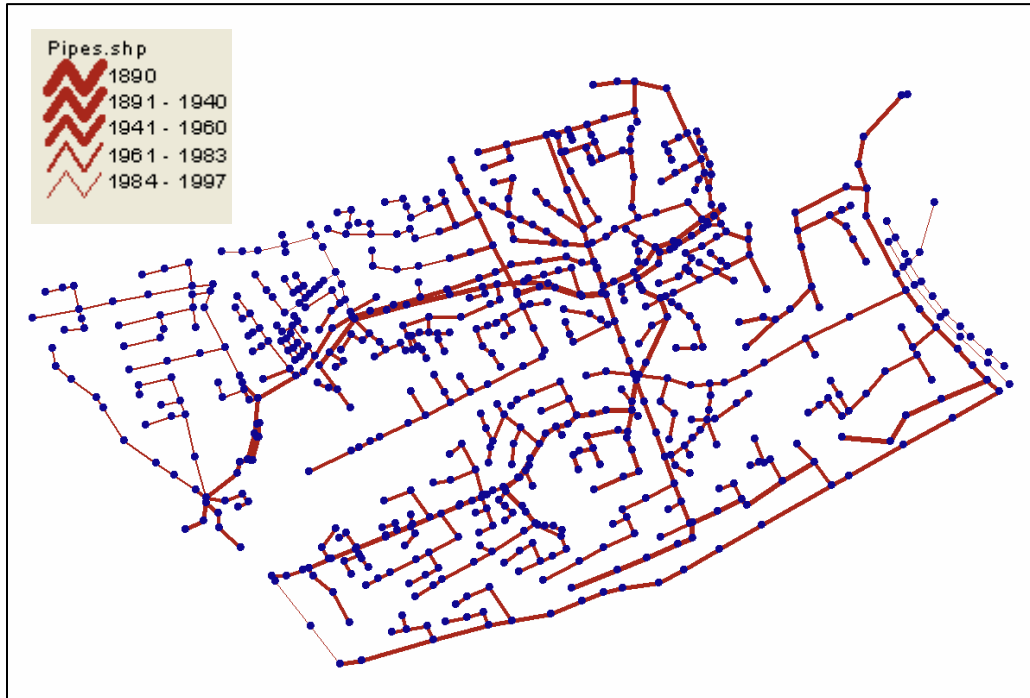


Figure 7: Age of pipes in Palermo city centre

Structural condition tools (WP2)

Several tools characterise the structural condition part of the rehabilitation manager. As the main input to these tools is characterised by the CCTV inspections, the first part of the testing was connected with the conversion of paper reports available in Palermo case studies to the EN 13508 codes on pipe defects. About 20 years of data were available for testing and around 1250 inspection reports were analysed for obtaining current condition classes. Figure 7 shows the age of pipes in Palermo network. Figure 8 shows condition classes in a scale between 1 (corresponding to new pipe) to 4 (corresponding to failing pipe). This scale has been changed from the default CARE-S approach in order to comply with Local Manager needs. The possibility of creating a new condition scale has been guaranteed by the user upgradeability of the whole approach. Figure 9 shows the probable condition class at 2050 if no rehabilitation measures are put in practice. The progressive aging of the pipes will extend the critical area that should be prone to failure in the immediate future.

All the tools in WP2 have demonstrated to be extremely useful in order to evaluate different aspects of structural failures:

- Infiltration – exfiltration tool has not been applied because of lack of data but an investigation protocol has been produced for starting analysing the problem and beginning a monitoring process that will be helpful to fulfil Italian regulation on service level that is being implemented and that will require infiltration – exfiltration measurements by 2010.
- Blockage tool was applied and “calibrated” by using data available in Palermo. In twenty years, around 270 blockage reports have been found and used in the testing process. The tool demonstrated to have very easy use and a good approximation with historical data.
- Simplified internal corrosion model has been applied to the whole network and no evidence of hydrogen sulphide problem has been reported during years in Palermo sewer. The tool confirmed the low risk for internal corrosion in the testing area. Palermo network manager plans to apply the detailed corrosion model to another part of the sewer system where a long pressurised pipe (around 5 km) has corrosion problems and needs specific attention
- External corrosion tool was not applied because of lack of data even if it was tested by the mean of example data.
- Pipe load tool has been tested and worked perfectly on the network even if no calibration was possible because traffic data were only available for a part of the network.

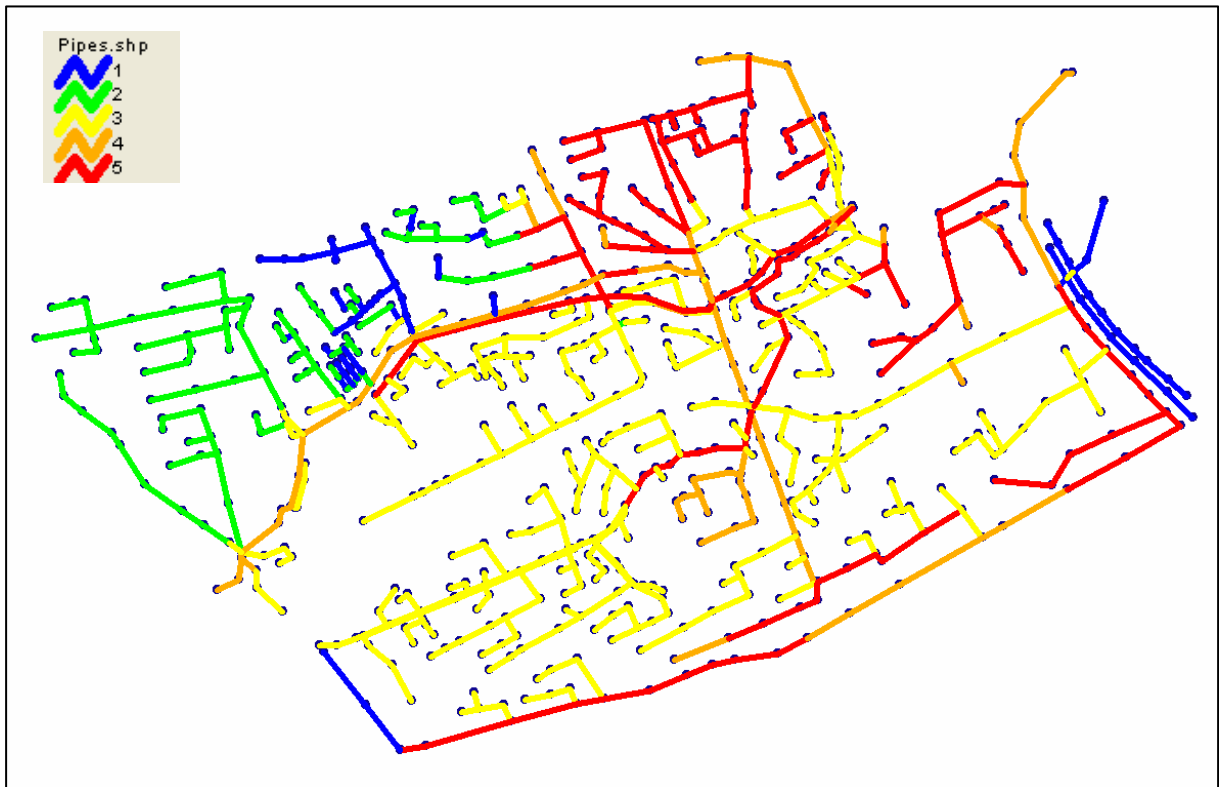


Figure 8: Pipe condition classes at the present time (CC1 corresponds to excellent condition; CC5 to failing pipes)

Hydraulic and environmental condition tools (WP3)

All the tools have been tested even if some problems arose because of the SWMM interface. Initially all the tools have been analysed by the use of example databases. In a later

stage, real data have been used but data input has to be done manually reducing the effectiveness of the tool and the interest of the end-user in its application.

The main outcome of these tools was once again end-user education to the research and storage of specific data and information. The application of WP3 resulted in the development of an hydraulic model for the entire city network. This task was accomplished through a cooperation agreement between Palermo University and the Municipality that also focused its attention on some relevant flooding problems in the urban area. The agreement will be now extended to water quality problems and to CSO impacts on receiving sea waters. The application of Obstacle tool for taking into account defects in hydraulic simulations was successful but model results were not relevantly different from the “new pipe” model. This was probably due to the general hydraulic insufficiency of the network and to the substantial absence of dislocated joints in the network that constitute the most important cause of pipe roughness changes.

GAT and CAT tools have been applied successfully but, as the open sea is exclusively used as receiving water body, CSO impact on the environment is not relevant and, even if Waste Water Treatment Plant is not properly working, the effect is diluted on large water volumes.

HELLMUD tool has been applied to the city centre network but was not possible to import maps in the rehabilitation manager. Its results were anyway used for the following prioritization of pipes to be rehabilitated.



Figure 9: Pipe condition classes at 2050 (CC1 corresponds to excellent condition; CC5 to failing pipes)

Rehabilitation technology database and rehabilitation cost tool (WP4)

The application of rehabilitation technology database was very simple and straight forward, as well as the application of rehabilitation cost tool. The most interesting outcome of the testing was the beginning of a personalization process by Palermo municipality: on the basis given by several projects finalised in the past years, Palermo end-user started to develop its own formulas for computing the costs of rehabilitation technologies that are currently used. In a list containing 78 rehab technologies and almost 40 operational approaches, 36 rehabilitation and operational methods have been selected and updated by the available local data.

Socio – Fail and Socio - Works (WP5)

The application of WP5 tools was particularly useful because allowed the end-user to start collecting data about the impact of sewer failures and rehabilitation works on the population. The application of the tools was only possible in Sferracavallo catchment because it is smaller and it was easier to collect information in the short range of time given for final testing. Once again the most interesting outcome of CARE-S application was the empowerment of the end-user in analysing specific problems with standard approaches allowing for building a large information database that will help future decisions on the same network.

Prioritization and selection tools (WP6)

The selection / elimination tool provided by WP6 is extremely powerful even if the impossibility of importing results from hydraulic models required to modify and import data manually. Testing and end-user training for this tool was quite long but, at the end, the tool was perfectly working and effective. Future applications of CARE-S will also consider the implementation of user defined criteria for the selection of most appropriate rehabilitation strategy to be applied to an area.

CONCLUSIONS

As stated several time before, Palermo feedback on CARE-S application can be summarised in two points:

1. The approach is perfect for standardising collection and storage of data and for simplifying decision criteria regarding the rehabilitation of sewer pipes
2. The approach has high potentialities for further development and for increasing the idea that urban drainage service can be provided with industrial standards, increasing technological level, reducing the cost of inappropriate actions and the cost of failures.

With this philosophy, Palermo Municipality has started some activities aimed at the introduction of standard practices and high technology in urban drainage management using CARE-S as a basis for future projects:

- A LIFE proposal has been presented in 2004 (without success) and it will be presented again in 2006 under the LIFE+ umbrella in order to develop a complete demonstration project of sewer rehabilitation based on CARE-S framework. The project will have the major financial contribution of the Municipality that is willing to invest on urban drainage management, especially for reducing damage connected with urban flooding.

- A technology introduction program is in its initial state and it will be hopefully extended in order to introduce Wireless Technology Networks in the monitoring and management process of urban sewer networks. The program consist of the introduction of a wireless network connecting sewer measurement and monitoring stations (flow meters, raingauges, water quality real time monitors, etc.), handheld devices provided to the management squads and an operative central that will collect data about the network and complains from the inhabitants and it will coordinate operations on the network exchanging continuously information with the operators distributed around the urban area. Each squad that will respond to a complain call will receive all the information about the part of the network where it will intervene (operation theatre) including the number and the type of complains and the data from real time monitoring; each squad will respond to a call by an operation form delivering to the central relevant information about the failure, the request of additional squads for specific tasks, updated information about the network.

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