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WP5
Elaboration and Validation
of CARE-W Prototype

D13 - The Architecture of
the CARE-W Prototype
software

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CARE

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

CARE – W

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

WP5 – Elaboration and Validation of the CARE-W Prototype Software

Report D13

THE ARCHITECTURE OF THE CARE-W PROTOTYPE SOFTWARE

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1. INTRODUCTION

1.1 CARE-W Aims

The CARE-W project aims to develop methods and software that will enable engineers of the water undertakings to define and implement an effective management of their water supply networks, rehabilitating the right pipelines at the right time. The results will be disseminated as a manual of Best Management Practice (BMP) for water network rehabilitation.

The ultimate goal of the CARE-W project is to develop a suite of tools, which will provide the most cost efficient approach for the maintenance of water distribution networks. The major products of the project will be the CARE-W prototype software and a handbook.

This project is organised in the following Work Packages (WP):

- WP1: Construction of a control panel of performance indicators for rehabilitation;
- WP2: Description and validation of technical tools;
- WP3: Elaboration of a decision support system for annual rehabilitation programmes;
- WP4: Elaboration of long-term strategic planning and investment;
- WP5: Elaboration of the CARE-W prototype;
- WP6: Testing and validation of the CARE-W prototype;
- WP7: Dissemination;
- WP8: Project management.

WRc is the lead partner responsible for WP5.

1.2 WP5 Objectives

WP5 will produce the software application enabling a range of tools (identified and developed under work packages 1 to 4) to be applied methodically to the rehabilitation planning process. The specific objectives of WP5 are as follows:

- Specify the data input/output and storage requirements for the integrated CARE-W package;

- Produce a specification for software that will integrate the use of the tools defined in CARE-W in an optimal manner;

- Deliver working prototype software that will manage the information needed and results generated from the tools defined in CARE-W, enabling the integrated CARE-W package to identify optimum rehabilitation strategies.

WP5 is divided into three specific tasks, as follows:

Task 5.1: Develop the CARE-W procedure for optimising rehabilitation planning.
The individual CARE-W tools will be thoroughly evaluated in terms of their benefits, data requirements and inter-relationships. The applications benefits will be mapped and a procedure for optimum integration developed. Descriptions will be presented on how to utilise the tool box most efficiently in order to address a given problem or circumstance.

The CARE-W Procedure was presented in the report Deliverable 12 (D12), November 2002[1].

Task 5.2: Define the structure of database (data needs and outputs) between the individual tools of the CARE-W suite.
The key performance indicators and data flows must be developed and specified as a prerequisite to development of the software. It is essential, at this stage, to thoroughly specify the data outputs and reports that are required and output by the CARE-W tools.

Task 5.3: Create the CARE-W Prototype Software
A database will be developed that will support the integration and data flows between the CARE-W component tools. This will support automatic and manual data input. The database will store information (results of analysis) that can, for example, enable write back to electronic corporate data storage systems. A manual will be produced to support the use of the prototype software.

This report (D13) is the output for Task 5.2.

1.3 Overview of CARE-W Prototype Software

1.3.1 Scope

The prototype software will be a versatile and powerful application, incorporating a variety of rehabilitation planning tools. It will have the flexibility to allow the rehabilitation of networks to be planned at both strategic and tactical levels, or in other words, at various levels of complexity: network, sector or pipe. This flexibility is possible because of the nature of the tools that form the prototype software. It should be noted that the CARE-W prototype software is a tool to *help* an engineer devise annual and strategic rehabilitation plans; it does **not**, and is **not intended to** produce the plan itself.

1.3.2 Architecture

The prototype software will consist of a central MS Access 2000 database Visual Basic 6.0 application which has the following attributes:

- Provides a central storage area and reference point for essential CARE-W data;

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[1] Conroy, P.; Kowalski M.; Hulance, J.; *The CARE-W Procedure*, Report D12 for Task 5.1, CARE-W WP5 – Elaboration and Validation of CARE-W Prototype. Swindon, UK; November 2002.

- Accepts **user-validated** input data in a pre-defined format. Data source fields will be mapped to fields within the CARE-W database according to the specification of the declared input data source;

- Provides automatic conversion of data item units to standard CARE-W convention;

- Performs rudimentary data validation including duplication, data type and range checking;

- Allows user interaction with a pre-determined range of tools under the CARE-W umbrella;

- Interacts with a pre-determined range of tools at the user's request by

   (a) creating the necessary input file(s) from the data stored in the CARE-W database to enable the tool to be run, and

   (b) accepting and storing necessary output data on completion of tool use.

The general architecture of the CARE-W prototype software is shown in Figure 1.1.
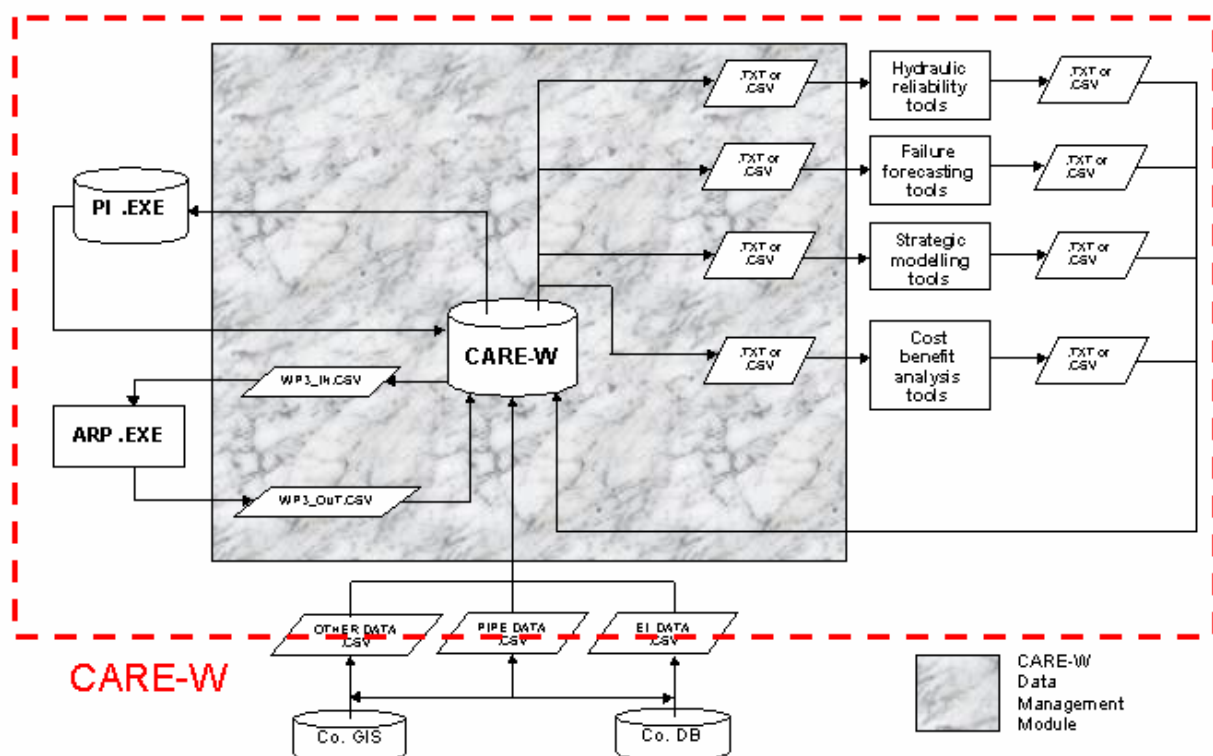
Figure 1.1   CARE-W architectural design

1.3.3   The central CARE-W database

The heart of the software is a database containing a series of tables which are used to store information from a number of different input sources. The CARE-W software will manage the import of data to these tables through the user interface. Only information required for further analysis by CARE-W tools is stored in the central database. Information is stored once only. Geospatial elements, pipe-based information and zonal information is recorded in individual tables with suitable cross-referencing. Other tables record utility, operating environment and performance data and, of course, also hold relevant results for use by the tools and reporting to the user.

1.3.4   Data flow and tools interaction

All external tools are referenced by the CARE-W database according to a series of input and output protocols written by WRc in close consultation with the tool developer. On user request, the central software package produces the necessary input and output files which may be read and interpreted correctly by each of the tools in order that information may be passed back and forth between the CARE-W database and the external tool in current use.

CARE-W is not intended to bind together the external tools produced as part of WP1, WP2, WP3 and WP4 in a fixed and constraining way, but rather to allow the user to use them individually or in a sequence appropriate to the data available for analysis.

1.3.5   User interface

The user interface is constructed using Visual Basic 6.0. A standard Windows-style menu structure provides access to the necessary functions and forms.

1.4   <u>Scope of this report</u>

Report D12 for Task 5.1 provided an overview of the structure of the CARE-W prototype software. This report (D13) will present a technical discussion on the use of the various CARE-W tools, their data requirements and how they function together.

The structure of the report is as follows:

Section 2 describes the structure of the CARE-W central database, including how the various tables that form the database relate to each other and to the CARE-W tools.

Section 3 describes the flow of data within the CARE-W prototype software. It discusses the procedure for importing data into the prototype software, exporting data to the various tools and also storing and reporting the analysis results from the tools.

Finally, Section 4 discusses the CARE-W prototype software's user interface.

2. CENTRAL DATABASE

2.1 General description

The heart of the CARE-W prototype software is its central database. This database consists of a series of tables which are used to store information from a number of different input sources. Each table contains specific types of information, such as pipe-based data, zonal, geospatial or hydraulic information. Other tables will hold information specific to a *project* or a *dataset*, including analysis results. The necessary link between input and results data will be maintained to allow proper reporting of analysis history and results to the user.

Each database table contains a range of fields which relate to the various parameters or data fields used by each tool. Many of these fields, such as pipe diameter, length, and material, are used by a number of different tools. Others will be unique to a specific tool. It has been necessary to adopt a standardised set of parameter properties in order that CARE-W can communicate with all analysis tools. The design of the most important tables is discussed in more detail in section 2.5 and expounded in Appendix A.

At the request of the user, the CARE-W prototype software will create the necessary input file(s) for an analysis tool according to a pre-defined specification held internally. These files may then be used to run the analysis tool within (or outside) the CARE-W framework. Similarly, the prototype will enable the results of the analysis to be exported back to CARE-W and stored as necessary on completion of the analysis task.

2.2 Definition of key terms

2.2.1 Project

The CARE-W project is a collection of data items, analyses and results pertaining to an area or areas of interest to the CARE-W user. The area of interest may be geographic (such as a city network) or thematic (e.g. water quality issues). The notion of a project provides a means to work with, and maintain, multiple CARE-W model simulations.

In practical terms, creating a new project will create a new CARE-W database based on a pre-defined template database. The user should then save his new project database with a memorable and recognisable name. It is envisaged the user may wish to make modifications to the standard template and provision for editing and saving templates will be provided through the interface in a later version. In all cases, if the user wishes to use a number of CARE-W tools he must first import his data into an open CARE-W project database. More information on importing data to a project is given in sections 3.4 and 4.2.3.

2.2.2 Dataset

At its most fundamental level, the dataset is a user-specified collection of pipes. All analysis within CARE-W will be carried out on an *input* dataset and, for each simulation, a *results* dataset will be created. Clearly, the link between pipe attribute information and the results from analysis carried out on these pipes must be maintained. An electronic analysis history

will be kept, and results datasets named such that they reference the analysis tool and input dataset used.

Input datasets may be of three types: *network*, *sector*, or *cluster*. Datasets may only belong to one project and are created by selecting pipes. Pipes may be selected for inclusion in a dataset in a variety of ways depending on whether geospatial information is available or not. More information on creating datasets and selecting pipes is given in sections 4.3.2 and 4.6 respectively.

A sector is understood as a collection of pipes which have been grouped under a reference name, typically an operational or management unit, e.g. water supply zone, hydraulic zone, district meter area.

A cluster is understood, in practice, to mean a geographic clustering or grouping of pipes with one or more common attributes which may or may not lie within one sector.

A network is understood to be the largest grouping of pipes, typically a collection of sectors of a company or municipality.

The creation of a dataset allows the user to filter out unwanted information and focus on the areas of interest. The dataset is therefore a convenient mechanism to reference and manage pipe selections and results.

2.3   Summary of database contents

2.3.1   Main CARE-W database

The central database of the prototype will consist of over 30 tables, which may be categorised according to their function. Tables 2.1 to 2.5 below describe the five general categories into which the database tables are grouped.

Table 2.1 lists the database tables which relate to CARE-W *projects*.

Table 2.1   General project information tables

Table name	Function
Carew	Used for version control and to identify the database as a CareW database
CareWAnalysis	Used to store global constants (e.g. analysis year, planning horizon)
Project	Stores the project properties (e.g. project name, objectives)
PIBands	Used for thematic mapping of results (colour coding)

Table 2.2 summarises the database tables which contain information relevant to the *dataset*. The definition of a dataset can be modified by the user, therefore it is important that general dataset information is cross-referenced to pipes information associated with each dataset. Dataset information tables allow datasets to be identified and described, to provide a cross

reference to the *elements* that form the dataset and to keep a record of the analysis that has been carried out.

Table 2.2   Dataset information tables

Table name	Function
DataSet	Contains the property information of the dataset. Also used by PI tool.
DataSetLog	Contains a record of events for the dataset
DataSetPipes	Identifies which pipes belong to a dataset

The database tables which describe the physical attributes of the *elements* of a dataset are listed in Table 2.3. The physical *elements* of a dataset are the pipes or segments or hydraulic nodes. Each pipe or node will have information associated with it which would be required for analysis by the various CARE-W tools. Results from analysis will also naturally reference the dataset elements.

The attribute information tables are discussed in more detail in Appendix A.

Table 2.3   Attribute information tables

Table name	Function
Node	Contains information for hydraulic model nodes (for tools that require nodal data)
NodeOutputs	Contains results from hydraulic models. Used to derive pipe pressures.
NonPipeOutputs	Contains result information that is applicable to the data set (but not to individual pipes)
Pipe	Contains basic pipe attribute information (e.g. length, diameter, material)
PipeFailure	Contains pipe event data (e.g. bursts, complaints)
PipeOutputs	Contains results relating to individual pipes (e.g. predicted failure rate)
EI_UI_PI	Performance indicators inputs and outputs table. Also used by PI tool.

Table 2.4 describes the database tables holding information relating to the geographical position of both pipes and zones.

Table 2.4   Geospatial information tables

Table name	Function
Vertex	Contains positional data to define any pipe vertex
ZoneVertex	Contains positional data to define any zone polygon

2.3.2   The CARE-W configuration database

The CARE-W configuration database contains information on properties not specific nor unique to a single project, plus tools necessary for the efficient operation of the CARE-W software. These include, for example, database start-up information, dynamic look up tables for common pipe attributes, and formatting information for the colour-coding of results. A full list of tables in the configuration database and their function is in Appendix B.

2.4   <u>Data relationships</u>

2.4.1   Philosophy

Data are stored in CARE-W such that the same data record is never stored more than once. Figure 2.1 below shows the principal tables that form the central database and the relationships between them. For example, these relationships allow nodes to be referenced to pipes, pipes referenced to datasets and datasets to projects.

For those unfamiliar to relational database structures, some explanation of the key to Figure 2.1 is required. **The seasoned database user should skip the text in section 2.4.2.**

2.4.2   Explanation of relationships diagram

Good database designers use *primary keys* in data tables where possible. These allow relationships between data tables to be established efficiently, and can be used to prevent entry of duplicate information. For example the Pipe table has one primary key; the *PipeID* field. In this instance each pipe will have a unique reference which cannot be duplicated in this table. As this is the only such table within the CARE-W database which can store pipe information, the primary key ensures the data for this pipe is not stored more than once.

A *one-to-one relationship* means that one record in one table will only have one related record in another table. The LevelCodeDescription and DataSet tables have a one to one relationship via the ID and SetType fields. Therefore a dataset can only have one SetType description.

One-to-one relationships are denoted in Figure 2.1 by a link between corresponding field names (no arrowhead).

A *one-to-many relationship* means that one record in a table can have many related records in another. An example of this is the relationship between pipes and datasets. A dataset can have many pipes associated with it, therefore the DataSetPipes and Pipe tables have a one to many relationship via the PipeID field. (Explicitly, each PipeID is unique in the Pipe table, but may be found more than once in the DataSetPipes table, appearing once for each dataset to which it is associated.)

In Figure 2.1, links with arrowheads denote a one-to-many relationship, the arrow pointing from 'one' to 'many'.

CareWAnalysis
StartYearOfAnalysis
Planning Horizon
YearStartMonth

PipeOutputs
SetID
PipeID
BR Poisson
BR5 Failnet Stat
BR5a Failnet Stat
BR5b Failnet Stat
BR10 Failnet Stat
BR10a Failnet Stat

[See Table A.4 for full list of Parameters

Vertex
VertexID
PipeID
VertexCount
X
Y

PipeFailure
PipeFailureID
UserReference
CreationDate
LastEditDate
EventID
FailureDate
MaintenanceType
X
Y
CauseOfFailure
Visit
ConfidenceFactor
TypeOfRepair
DateOfRepair

ZoneVertices
VertexID
SetID
VertexCount
X
Y

DataSet
ID
Name
BelongingSetID
Description
CreationDate
LastEditDate

DataSetPipes
SetID
PipeID

Pipe
PipeID
UserReference
HeadNodeName
TailNodeName
Length
Diameter
Material

[See Table A1 for full list of Parameters]

HydraulicDataSet
SetName
SetID
Hydraulic Reliability tool ID
Failure prediction Tool ID
Other tools 1 ID
DataState
Duration
TimeStep

EI_UI_PI
ID_DataSet
EI_UI_PI_Code
StartDate
EndDate
Value

PIBands
PICode
BandLower
BandHigher

Node
NodeID
CreationDate
LastEditDate
NodeType
NodeName
X
Y
Z
Demand
DesiredHead
Importance
WaterLevel
MinWaterLevel
MaxWaterLevel
TankVolume
TankDiameter
MinTankVoume
MaxFlowRate
MinPressure
MaxPressure

Key:
⎯⎯⎯▶ One-to-Many relationship

⎯⎯⎯ One-to-one relationship
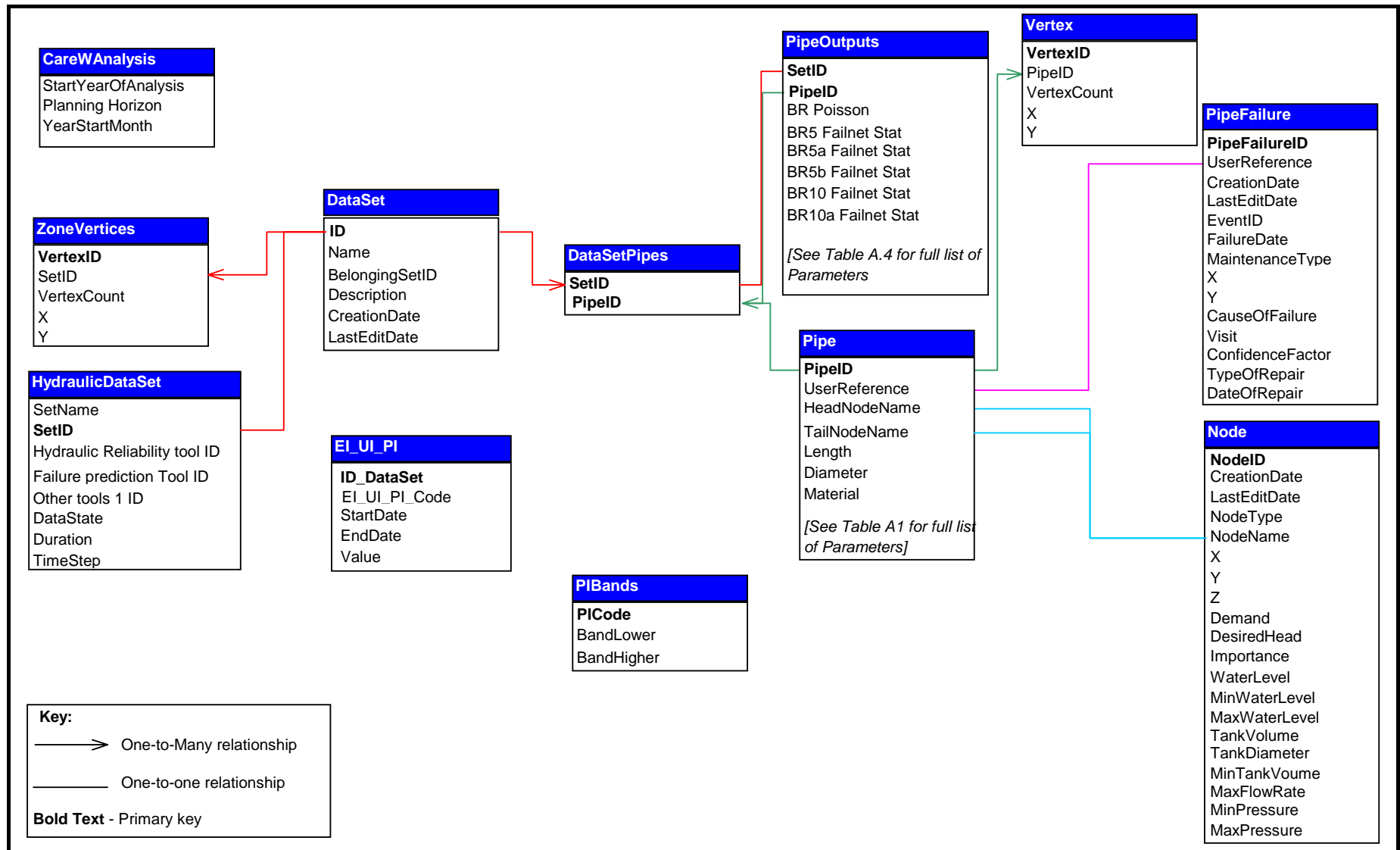
Bold Text - Primary key

Figure 2.1   Principal relationships in CARE-W database

2.5 Key tables

2.5.1 Introduction

Four of the main database tables are discussed in more detail here, namely the Pipe table, the PipeFailure table, the Node table and the PipeOutputs table. All of these tables contain information about the attributes of either nodes or pipes. In the case of the first three tables, data will be imported to them by the user through the user interface. More information on data import is given in section 3.4. The PipeOutput table holds relevant results from the analysis conducted by the user using the range of tools within the CARE-W prototype software.

In this section, we will restrict ourselves to discussing the format of these tables and general design principles. A full listing of their contents is given in Appendix A as follows:

Table 2.5   Attribute information table reference

Table name	Reference
Pipe	Table A.1
PipeFailure	Table A.2
Node	Table A.3
PipeOutput	Table A.4
Key to PipeOutput table	Table A.5

2.5.2   Table design

The attribute information tables have similar designs (Figure 2.2). Data parameter properties (name, data type and measurement unit) have been standardised to ensure consistency of reporting and data handling amongst all tools.

Prototype Parameter	Data type	Units	SDF.txt	HLF.txt	RELNET. txt/.xls	
Last Edit Date	Date					
UserReference	Text		I1	L1	Link_ID	
Pipe Equipment	Text			L7		
HeadNodeName	Text			L2	NB	
TailNodeName	Text			L3	NE	
Length	Single	M	C1	L4	Length	L
Diameter (nominal)	Single	Mm	C2	L5	DN	D
Material	Text		C3	L8	Pipe material	M

CARE-W Tool header spanning: AssetMap 1 / WINROC / FailNet Stat, FailNet Reliab, Relnet, ARP

Callouts: CARE-W standard name; CARE-W data type and units; CARE-W tool list (one tool per column); Corresponding name used by tool; Non-blank entries indicate which tools use which parameters

Figure 2.2   Format of Pipe database table lookup

Entries in the lookup tables (listed in Appendix A, an example of which is shown in Figure 2.2) denote which parameters are required for each tool. The standard names used by the CARE-W software are given in the first column. The other fundamental properties used in the CARE-W database, namely data type and measurement unit, are presented in the second and third columns. The software automatically converts all data to these formats when it is imported into the central database tables. Conversely, the data will be converted back into the original format when it is exported from the central database for tool use.

The remaining columns in Tables A.1 to A.4 list the equivalent parameter defined by each CARE-W tool. For instance, the CARE-W *Diameter* field in the Pipe table is equivalent to the *C2* input parameter for Poisson, Winroc and PHM, the *DN* parameter for Relnet, and so forth. Many of the parameters will be relevant to a number of the CARE-W tools, where as others will be unique to a specific tool.

The content of such tables is important as it contributes to the design specification of the routines for data transfer between the central database and the CARE-W tools. Further information on the Specification Manager is found in section 3.3.

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3. DATA FLOW AND TOOLS INTERACTION

3.1 Introduction

Chapter 2 discussed the structure of the CARE-W database, which forms the core of the CARE-W software. It is a cornerstone in the integration of a number of tools, which in turn provides users with alternative routes to prepare their rehabilitation strategies and plans for the years ahead. This is not possible, however, without a facility to move data between the central database and the tools and vice versa. The main benefit of the CARE-W prototype software to the rehabilitation planner is the power and flexibility of data handling and analysis. *The prototype software must allow the user the option of using different tools to ensure a complete analysis and preparation of their rehabilitation plan.* A rehabilitation planning procedure and how CARE-W can help in this process was described in an earlier CARE-W report for Task 5.1.[1]

This chapter describes the flow of data within the CARE-W prototype software. It will discuss the procedure for importing data into the central database, exporting data to the various tools and also storing and reporting the analysis results from the tools.

3.2 General data handling requirements

The prototype will have a powerful facility for storing and processing data, the details of which will be discussed in this chapter. However, any analysis undertaken using the CARE-W prototype will only be as good as the data used for that analysis. It should be emphasised that it is the user's responsibility to ensure that valid data are available for importing into the prototype, i.e. the data are arranged in a consistent and definable manner, data types are correct, and data values are meaningful.

Some rudimentary data validation is carried out at present. It is envisaged that later versions of the prototype will undertake further basic data validation checks on data as they are imported into the central database tables. For instance, the fields within the central database tables have set units (m, mm, MPa, etc.) and data types (text, integer, binary [yes/no], etc.). On import to the database tables, the data will be automatically converted to the units required by the prototype. Conversely, on export the data will be converted to the units required by the individual CARE-W tools (although it is noted that, in most cases, the units required by the prototype are consistent with those required by the tools). The prototype will also check the data type as it is imported and check that it matches that of the recipient field in the CARE-W database. The user will be notified of any data format violations during validation.

The data could also be checked to ensure that values fall within reasonable tolerances. For instance, pipe diameters might not exceed 1 m for distribution mains and therefore the user would be prompted to check the validity of the data presented.

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[1] Conroy, P.; Kowalski M.; Hulance, J.; *The CARE-W Procedure*, Report D12 for Task 5.1, CARE-W WP5 – Elaboration and Validation of CARE-W Prototype. Swindon, UK; November 2002.

3.3 The Specification Manager

Each tool must have input and output specifications in order for the CARE-W import and export routines to function, thereby permitting secure data transfer to and from CARE-W applications. These are handled by the Specification Manager (Figure 3.1).
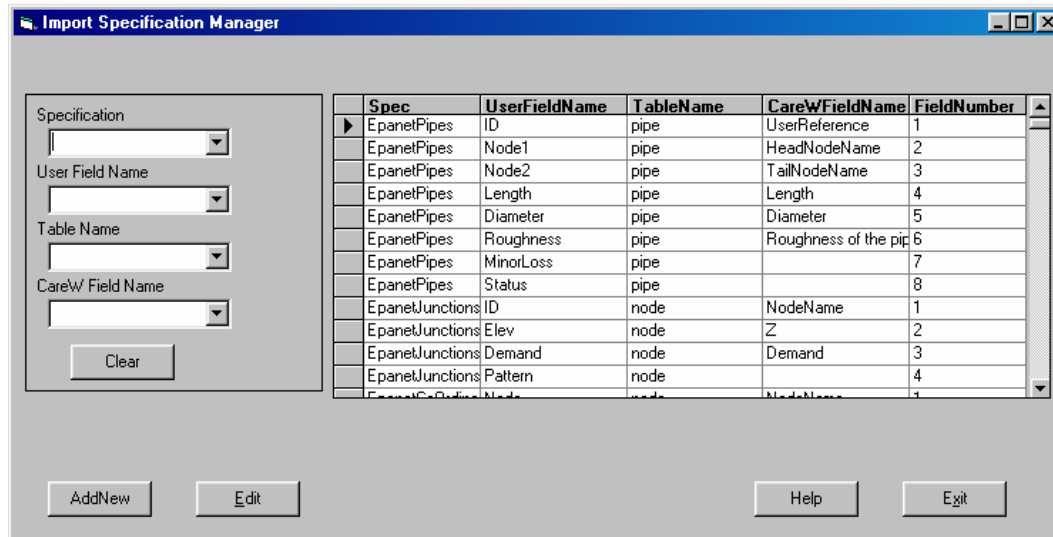

Figure 3.1   Import Specification Manager main screen

The Specification Manager allows the *experienced* user to interact with the central database and add or update input and output protocols which govern this data transfer process. The protocol data are held in the LookupImportFields table, whose fields are accessed and displayed through the interface shown in Figure 3.1.

3.3.1 Searching the specification list

In the left-hand portion of the main screen there are four drop-down text boxes which allow one or more of the following search criteria to be specified: Specification, User field name, Table name, CARE-W field name.

The example in Figure 3.2 shows the complete list of specifications which will be restricted to 'Epanet coordinates' by selecting this item from the open drop-down menu.
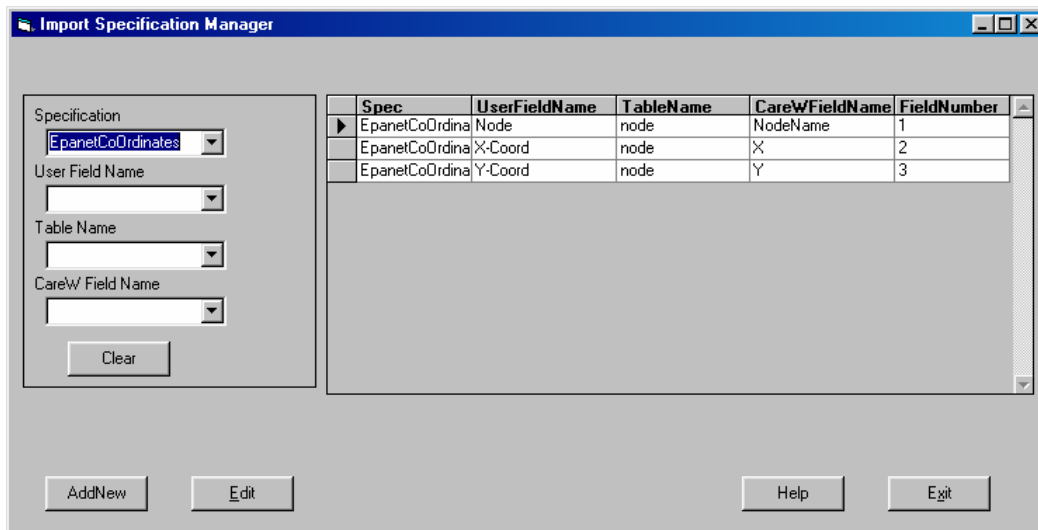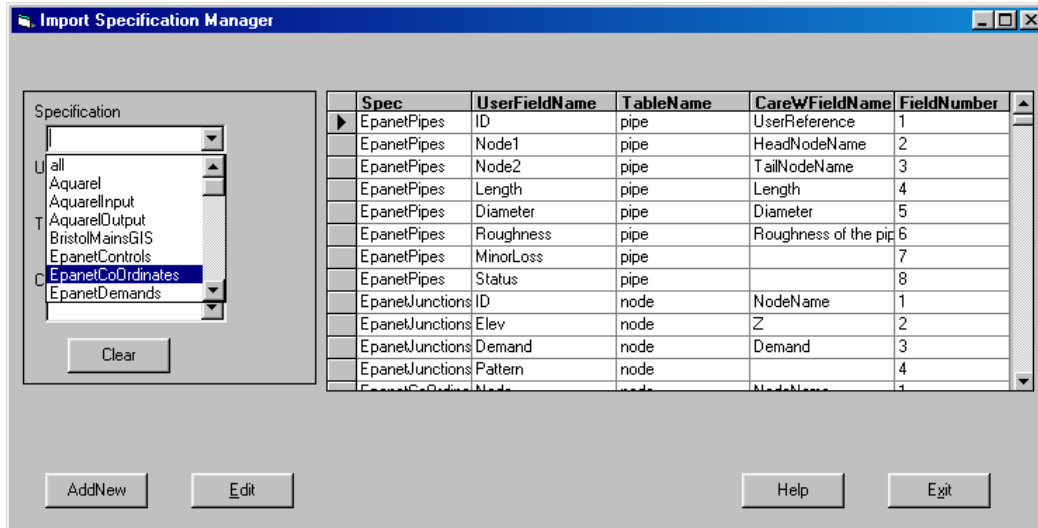
Figure 3.2   Example of specification selection

Note that the *Clear* button clears all selections displayed in the combo boxes.

The right hand portion of the screen identifies the specifications that already exist within the prototype. For each specification the name of the users data parameter is listed together with the equivalent field name within the central database where this data will be stored.

3.3.2   Adding new specification data

After clicking on the *Add New* button the Add New Specification dialog is displayed.
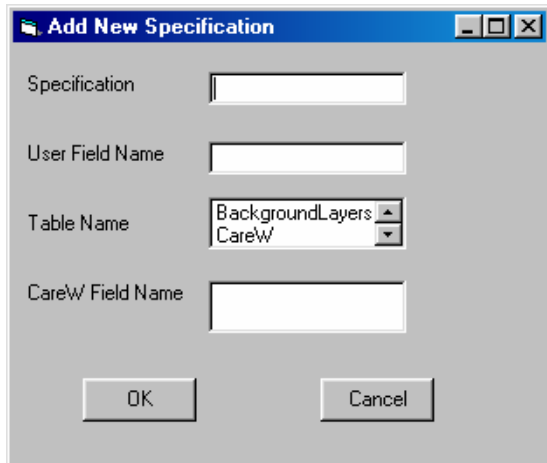
3.3(a) User must type a new specification name (in *Specification* box) and field name he wants to add (in *User Field Name* box)
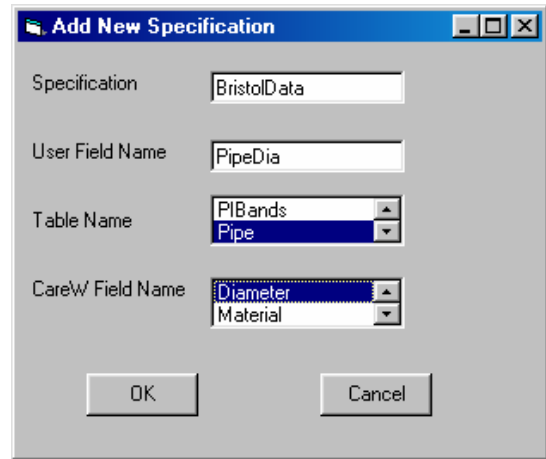
3.3(b) User must then choose the appropriate CARE-W table name and CARE-W field name which corresponds to his field name.

Figure 3.3   Adding a new specification

The user must decide upon a new name for his specification and type it in the Specification text box (Figure 3.3a). The user's name for the data field must also be specified (for instance "BristolData" as the specification and "PipeDia" as the User Field Name).

On selecting a CARE-W Table Name from the third list box, the corresponding CareW Field Names will automatically appear in the fourth text box (Figure 3.3b). In the example shown the user has selected the "Pipe" table and "Diameter" from the CareW Field Names list.

Clicking OK will add the new specification to the table automatically and therefore be displayed in the data grid (Figure 3.4).
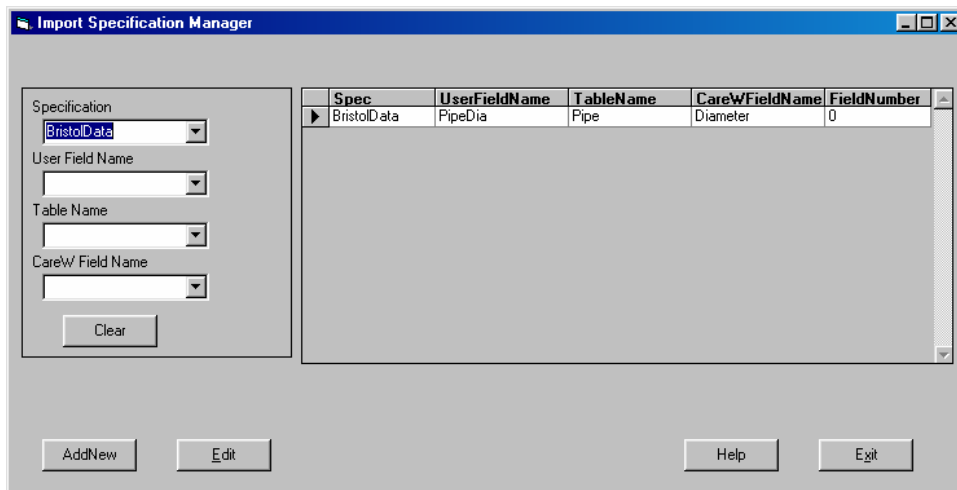

Figure 3.4   New specification data successfully added

3.3.3 Editing specification data

It is not possible to edit the data grid directly; the Edit button is provided for this function. The user may edit any field in Edit mode (Figure 3.5). After clicking one of the fields in the first column (*Spec*), a combo box will appear. The list of existing specifications is displayed in the usual way by clicking the down-arrow .

As before, the CARE-W field name options are displayed on completion of the Table name selection.
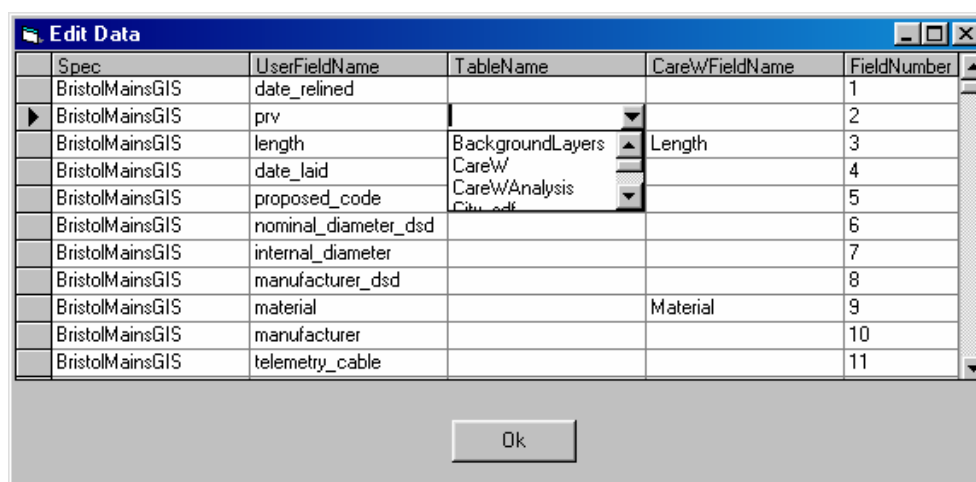

Figure 3.5   Edit specification data dialog

The user will not be able to save a specification which violates uniqueness rules in the database, i.e. two records with identical *Spec*, and *CARE-WFieldName* or *FieldNumber* entries cannot co-exist.

All changes are effected immediately. The OK button returns the user to the main form.

3.4   Adding information to the project database

Data may be imported to CARE-W from three sources, namely:

1. CSV data file, e.g. mains database or maintenance records;

2. Pre-existing analysis tool data file (e.g. SDF/MDF file for Poisson, and so on);

3. GIS data file, e.g. Bristol GIS.

Data may be imported into a project database in any number of steps and at any time. A mixture of data sources is also possible, and indeed likely, particularly where data have not been digitised or do not relate to a geospatial reference frame.

3.4.1 Importing CSV data

There are four principal steps in the import procedure of CSV data files, also shown schematically in Figure 3.6.

1. User selects *Import/CSV data…* from the Project menu and application prompts for file to import;

2. User browses for desired data to import;

3. CARE-W application selects appropriate specification from the specification table from user prompt *.

4. Application look-up associates data file with CARE-W input location and enters data to project database accordingly.

* If the user CSV format is not recognised, the user will be prompted to map the data items in the CSV file to the CARE-W database fields. For custom text file formats, it is advisable to create a new specification using the Specification Manager 'off-line' before any importing is attempted. In this way, when the user comes to import his data at a later date, he need only enter the name of his custom specification when prompted.
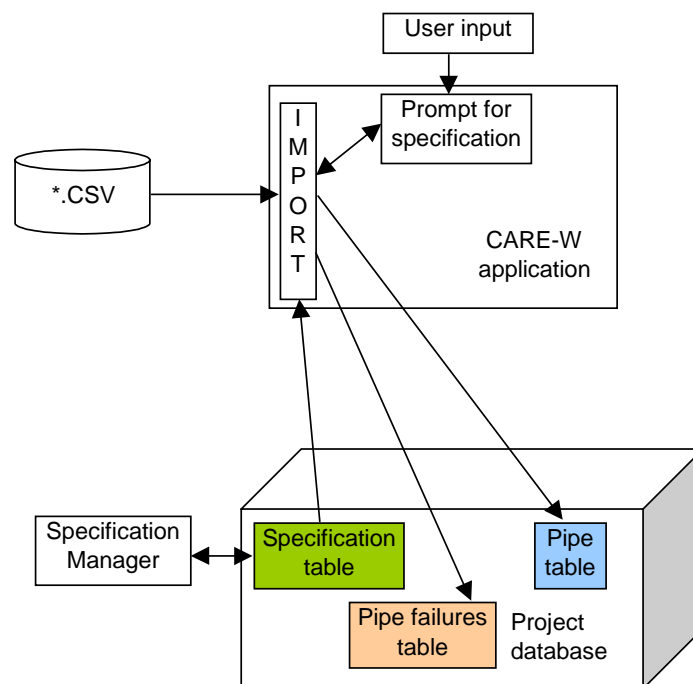
Figure 3.6   Import procedure schematic for CSV data

3.4.2 Importing existing tool input data

Importing existing tool input data follows a similar procedure to that of importing CSV data (Steps 1 to 4 above). Step 4 is straightforward as the data mapping between data file and CARE-W database input location is known and pre-defined using the Specification Manager.

The user will not be required to interact with the Specification Manager when importing files that have been pre-formatted for use with the CARE-W tools. These import specifications will form part of the prototype software.

3.4.3 Importing GIS data

There are eight principal steps in importing GIS data to a CARE-W project (Figure 3.7).

1. Import procedure prompts for file to import;

2. User browses for desired data to import;

3. Application prompts for import specification;

4. Application populates Pipe table with pipe user references (pipe IDs);

5. Application populates Vertex table;

6. Application creates a shape file automatically from data imported to project database;

7. Application imports all other attributes to Pipe table;

8. Application displays GIS data in GIS viewer using newly created shape file.
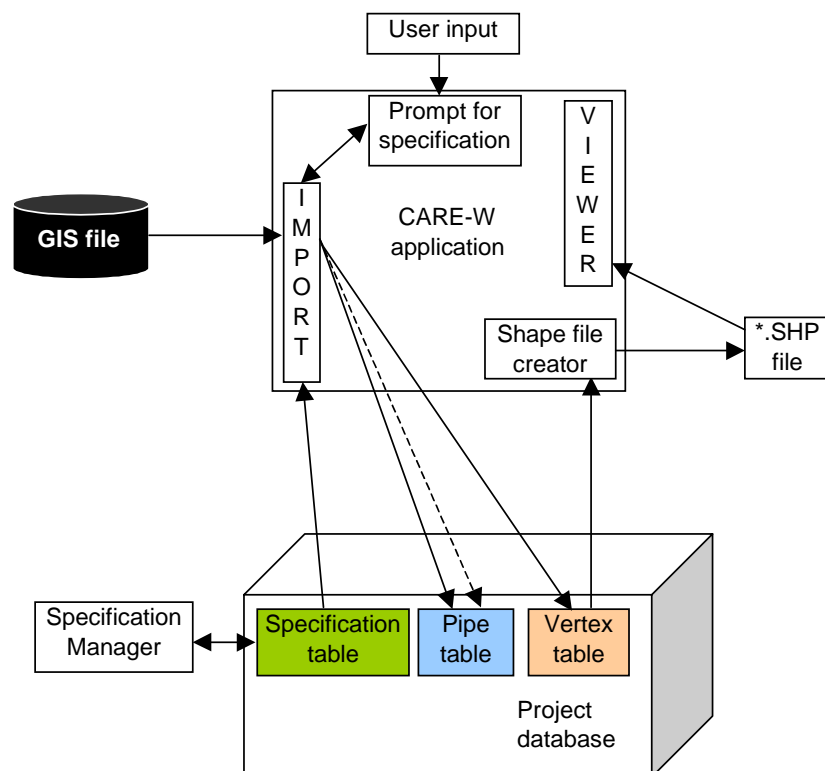

Figure 3.7   Import procedure schematic for GIS data

3.5   Interaction with CARE-W Tools

Another main feature of the prototype software is the facility to interact with a pre-determined range of tools. This interaction is initiated by the user and the process for doing this is described in more detail in section 4.7.

The principal actions are shown in bold and schematically in Figure 3.8 overleaf.

Once the user has selected a tool to use for his analysis, data files need to be created which will allow the necessary data to be used by the tool. The prototype has a facility to create the import files for each of the CARE-W tools, including the Annual Rehabilitation Planning (ARP) module. As part of an ongoing process to improve integration, the software already calculates a number of values required by the PI tool directly and automatically from information held in the project database.

Analysis tool input files are created from data previously imported to the relevant CARE-W project database. The specification for these files is pre-determined and forms part of the prototype software (see section 3.3). This specification will include the automatic conversion of units to those required by the individual tools, if different to those in the central database.

An additional feature of the prototype is the facility to allow the user to view and edit the import files created by the prototype before they are used by the tools. This allows the user to check the integrity of their contents and to ensure successful file creation. CARE-W will use a standard editing application such as Notepad or Excel to facilitate data editing.

N.B. If the input data files are edited interactively by a WP2 application, the edits should be returned to the CARE-W database in addition to the results (output) data. Only then will the input and output datasets be consistent. This is indicated by the dotted/dashed lines in Figure 3.8.

The prototype is designed to accept and store results from analysis using CARE-W tools, wherever possible. CARE-W will return results data to a number of output tables in the project database, as appropriate, when prompted by the user. The results returned are values required for use by other CARE-W tools and/or values which must be reported to the user directly, for example:

- *predicted failure and burst rates* calculated by the failure prediction tools (into PipeOutputs table)

- *hydraulic criticality indices* from the hydraulic reliability tools (into PipeOutputs table).

- PI results (into PI table)

- Pipe *status* calculated by the ARP MCD tool

- Medium to long term *budgets* from strategic rehabilitation planning

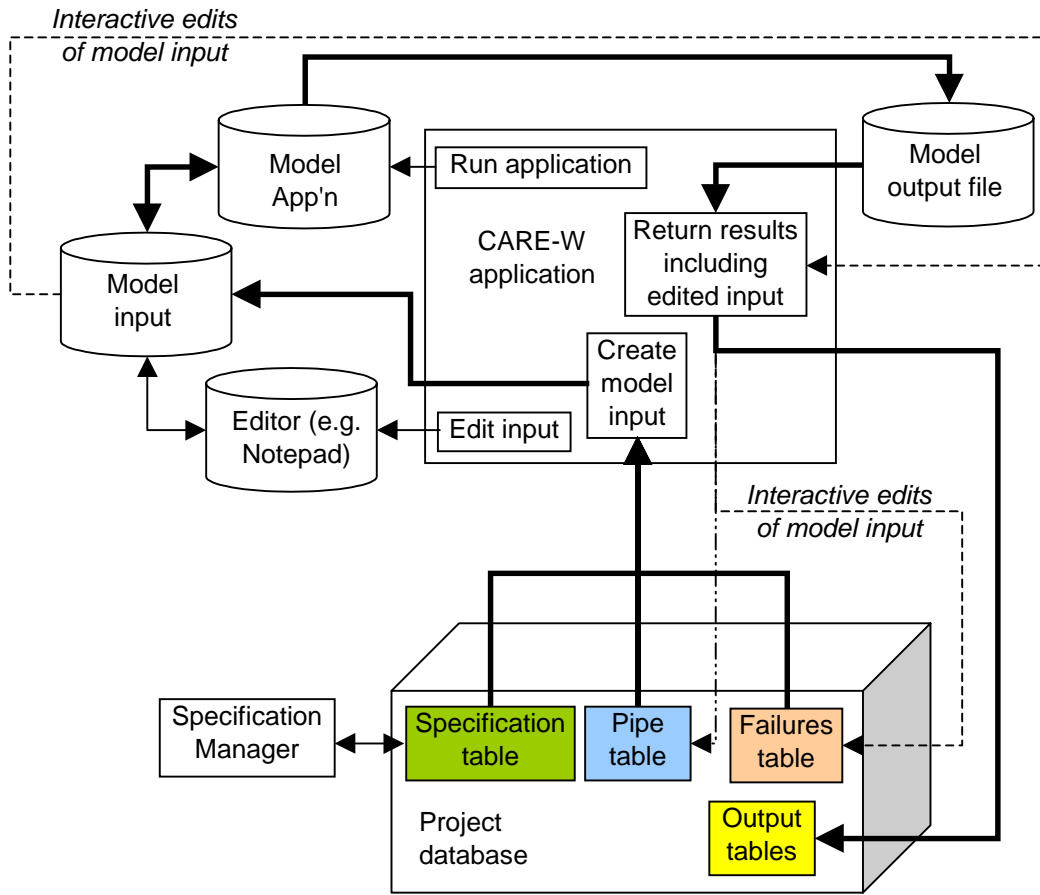For more information on reporting results, see section 4.8.

Figure 3.8 Tools data interaction

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4. USER INTERFACE

4.1 Introduction

The aim of the CARE-W prototype is to provide a software package which will enable engineers to plan rehabilitation schemes to assist in the effective management of water supply networks. The prototype will provide the most cost-efficient approach for the maintenance of water distribution networks. This report has so far discussed how the prototype will be constructed in order to meet the objectives of the CARE-W project, i.e. the use of a central database and the procedures for moving data within the prototype. The final, and vital, part of the prototype is the interface with the rehabilitation planner or user.

The CARE-W prototype will be a tool for use by the rehabilitation engineer. To be a successful product the user interface must have a logical format and be easy to use and understand. The presentation of this interface is also important. For this reason a Windows style has been adopted. This is a familiar format for most users.

The format of the user interface reflects the principals behind the architecture of the prototype itself. More specifically, the interface is designed to allow the user to work with projects and datasets within projects. The interface gives direct access to the CARE-W tools and provides the facility for importing data to and from these tools. It also provides a medium for reporting analysis results.

Figure 4.1 shows the menu options and toolbar of the prototype. The title bar details the name of the project that is currently open (in this example, 'WRc Test 1'), the project database filename (the template database called 'Copy of 2242.mdb'), the active dataset name ('All') and the active dataset description (in this case, 'All Pipes').
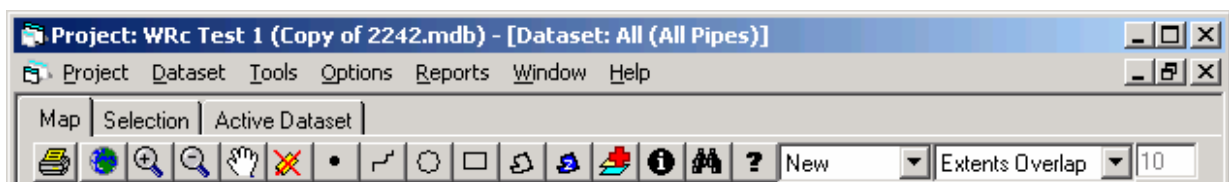

Figure 4.1   CARE-W menu options and toolbar

In summary, therefore, this chapter will discuss the format of the user interface, including the menus that drive the software and the principals behind how information is displayed.

4.2 Working with Projects

4.2.1 Introduction

The definition of the CARE-W project is as described in Section 2.2. In practical terms, a project is a version of the CARE-W database containing all the information relating to a

particular model of interest to the user. In order for the prototype to operate, an existing project must either be opened or a new project created.

The Project Menu, shown in Table 4.1 below, contains all the functions that relate to a Project. This menu allows the user to create new projects, open existing projects, save projects and so on. As in the Windows standard File menu, the option to exit from the prototype appears in the Project menu.

Table 4.1   Project Menu (to be updated)

Level 1	Level 2	Description
New		Creates a new Project.
Open		Opens an existing database using standard Windows Open dialog. Note: if the autoload option is set to 'on' by default, the prototype software will open up the last project used. See Project Properties dialog
Save		Saves the properties of the open project.
Save As		Saves a new open project or renames an existing one.
Objectives		Accesses the Project Objectives dialog.
Properties		Accesses the Project Properties dialog.
Import		Import data into the central database tables.
	Aquarel	Opens the relevant file using the standard Windows Open dialog. These menu items allow the User to import data in the form of files that have been pre-formatted for use by the relevant tools.
	Poisson	
	Failnet-Reliab	
	PHM	
	Kanew	
	Relnet	
	Waterfowl (v3)	
	Winroc	
	GIS	Imports GIS data
	CSV	Imports data in the form of CSV files.
Exit		Accesses the Exit dialog. User prompted to save on exiting the prototype.

When the New Project item is selected the Open dialog will be accessed and a blank copy of a template database will be selected by default. This project database will contain all of the tables required by the prototype software, but they will remain blank until data is imported into the project.

4.2.2   Setting objectives and properties

Once a new project has been created a Project Properties dialog will be shown. The user will be prompted for a project name and description (Figure 4.2). This form is accessed through the *Properties* menu item (see Table 4.1). This form will also provide other useful information about a project, such as which input datasets were used, and the names of the results datasets created following analysis.
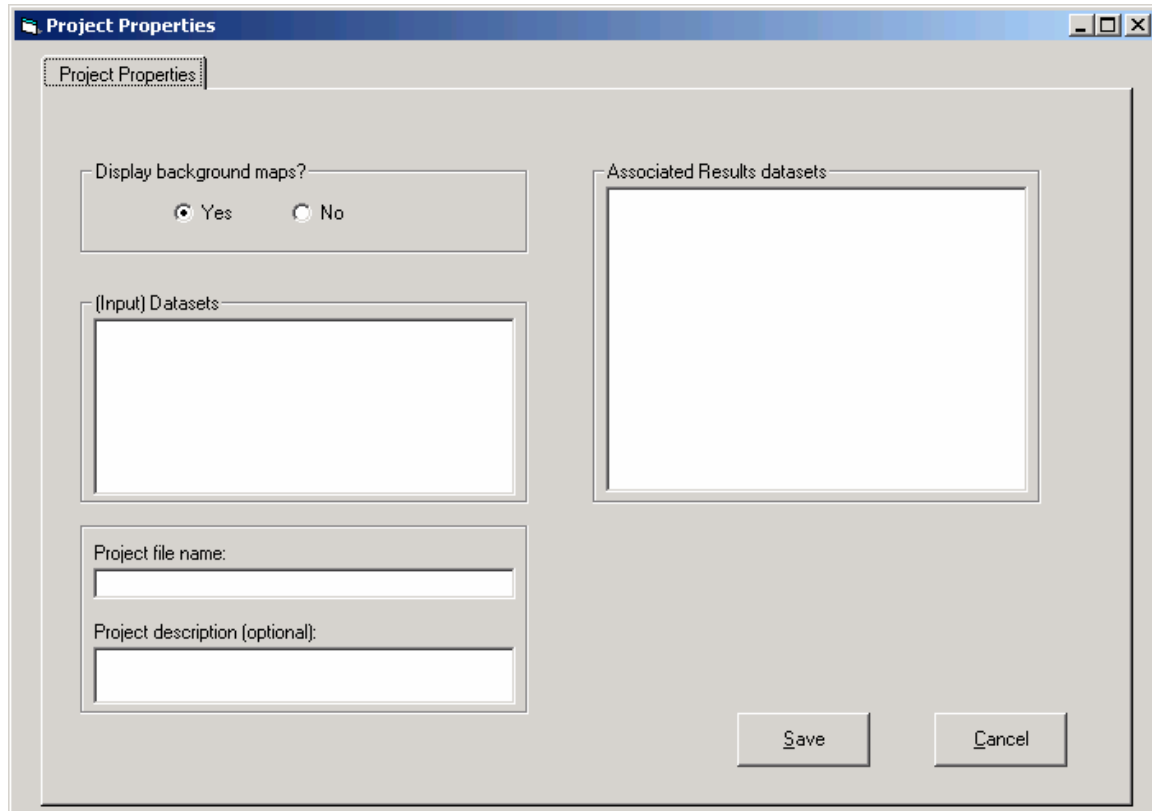
Figure 4.2   Project Properties form

4.2.3   Importing data to a project

Once a new [empty] project has been created, data must be imported into it, via the Import sub-menu. The prototype allows import via a number of known data formats including existing tool input files, GIS data (specifically, shape [*.shp] files) and comma separated value (CSV) format. Section 3.4.1 discusses the import procedure for CSV files.

Clearly, no text file data can be imported without some knowledge of the structure of the file and what it contains. Only data of use to CARE-W should be extracted and mapped to the appropriate CARE-W data parameter in order that it can be used for further analysis. It is possible to map data fields manually by editing and/or appending information to the LookUpImportField table. However, a tool has been developed to facilitate this process. Use of the Specification Manager is recommended if import specifications need to be changed. See section 3.3.

The GIS import function imports positional data into the project and automatically activates the GIS viewer on completion (see also Section 4.4). Section 3.4.3 discusses the import of GIS data in more detail.

4.3 Working with Datasets

4.3.1 Introduction

A CARE-W project in use will contain one or more datasets. See Section 2.2 for a fuller definition of a dataset and its types. In brief, however, a dataset is fundamentally a user-specified collection of pipes. Analysis is carried out on input datasets, and for each simulation, a results dataset will be created. All analysis within the prototype is conducted on the *active* dataset, which, as the name suggests, is the current, selected dataset on which the user is working. The Dataset menu (Table 4.2) contains all the functions which allow the user to manipulate datasets, such as creating new datasets, opening existing datasets and deleting datasets from a project.

Table 4.2   Dataset Menu

Level 1	Description
New	Accesses the New Dataset dialog. Allows the user to create a blank dataset.
Open	Accesses the Open Dataset dialog. Open an existing dataset from a list of datasets associated with the Project. The selected dataset will become the *active dataset*.
Save As	Renames the active dataset.
Delete	Accesses the Delete Dataset dialog. The user will be presented with a list of all datasets in the Project that can be deleted.
Properties	Accesses the Dataset Properties dialog.
Add selection to dataset	Allows the user to add data to the active dataset using the GIS viewer.
Create new from selection	Accesses the New Dataset dialog. Allows the user to create a new Dataset from the assets selected in the GIS viewer.
Remove selection from dataset	Deletes selected data from the active dataset.

4.3.2 Creating a new dataset

New datasets are created at the request of the user. Datasets are a useful tool to manage the data used for analysis to an appropriate and meaningful level. It is envisaged that the rehabilitation planner would wish to investigate any problems in his network at a number of levels of complexity, not least in terms of geographic area covered.

There are several ways to create a new dataset, and these reflect the number of reasons why the user may wish to use a new dataset.

Table 4.3   Options in creating a new dataset

Scenario	Action
The user may have an existing dataset which he wants to amend but retain the original for comparison.	Use *Save As* and rename before making changes.

The user may wish to focus his analysis on a number of pipes in his current dataset.	Select the pipes of interest (see Section 4.4 on how to do this), then use *Create new from selection*
The user may wish to create an empty dataset to which he can add pipes.	Use *New* to create an empty dataset

The *New* and *Create New From Selection* functions will both access the New Dataset dialog, shown in Figure 4.3. This dialog allows the user to give the dataset a name, description and to set the dataset type. Dataset types are critical to proper use and reporting of CARE-W data, and are described in Sections 2.2.2-3 and 4.3.3.
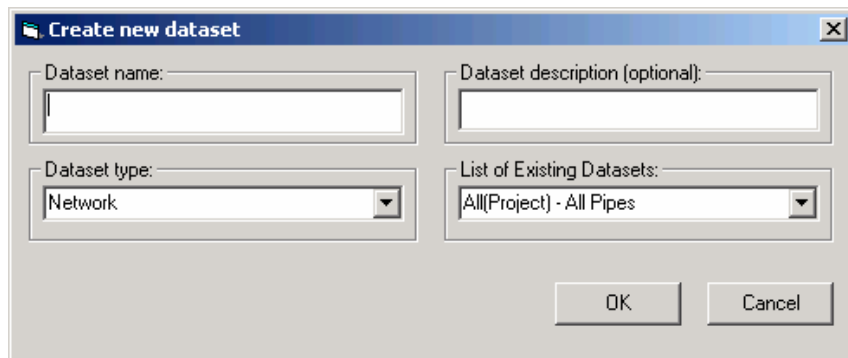

Figure 4.3   New Dataset dialog

New datasets can also be created using the GIS viewer. This menu item will automatically create a new dataset based on the assets that are currently selected in the GIS viewer.

4.3.3   Dataset properties

The Dataset properties form (Figure 4.4) summarises the details of the active dataset, including name and description. It also includes a history of the analysis that has been carried out using this dataset, i.e. which tools have been run using the active dataset.
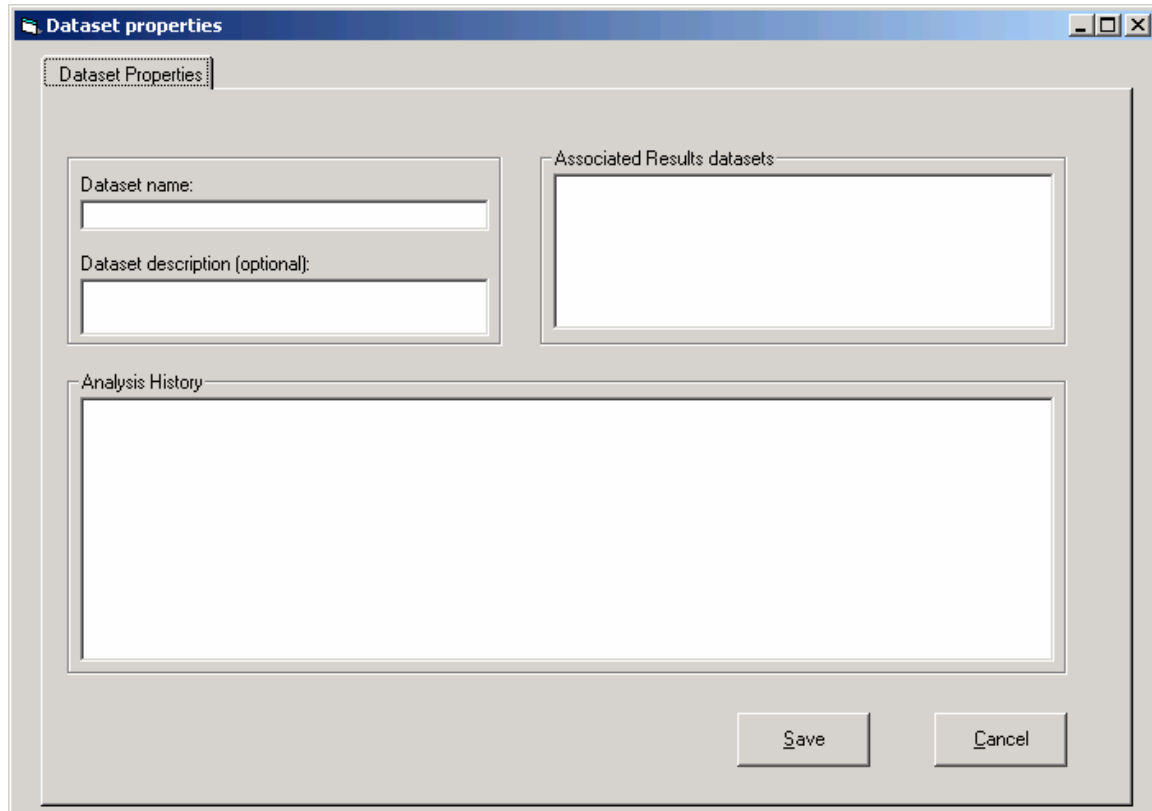
Figure 4.4   Dataset properties form

4.4   The GIS Viewer

The data contained within a project can be viewed in one of two ways; either using the GIS viewer or in tabular form. The GIS viewer will be the default view for a project and will become active once positional data has been imported to a project.

4.4.1   Properties

The GIS viewer provides a pictorial representation of the data contained within a project.

An example of the power of visualisation is demonstrated by the display in Figure 4.5. As in standard GIS applications, the display is constructed from a series of layers which may be toggled on and off by checking the appropriate check box. In CARE-W, the standard layers are *All Pipes* (all pipes in the project are shown), *Labels* (pipe labels toggle), *Failures* (failure data toggle), and *Active Dataset* (current dataset highlighted). All actions are carried out on the *active layer*. This is the layer which is highlighted in the left-hand pane of the GIS viewer. For example, in Figure 4.5, the 'All pipes' layer is the active layer.

There are also layers for results data and dataset boundaries, where applicable.
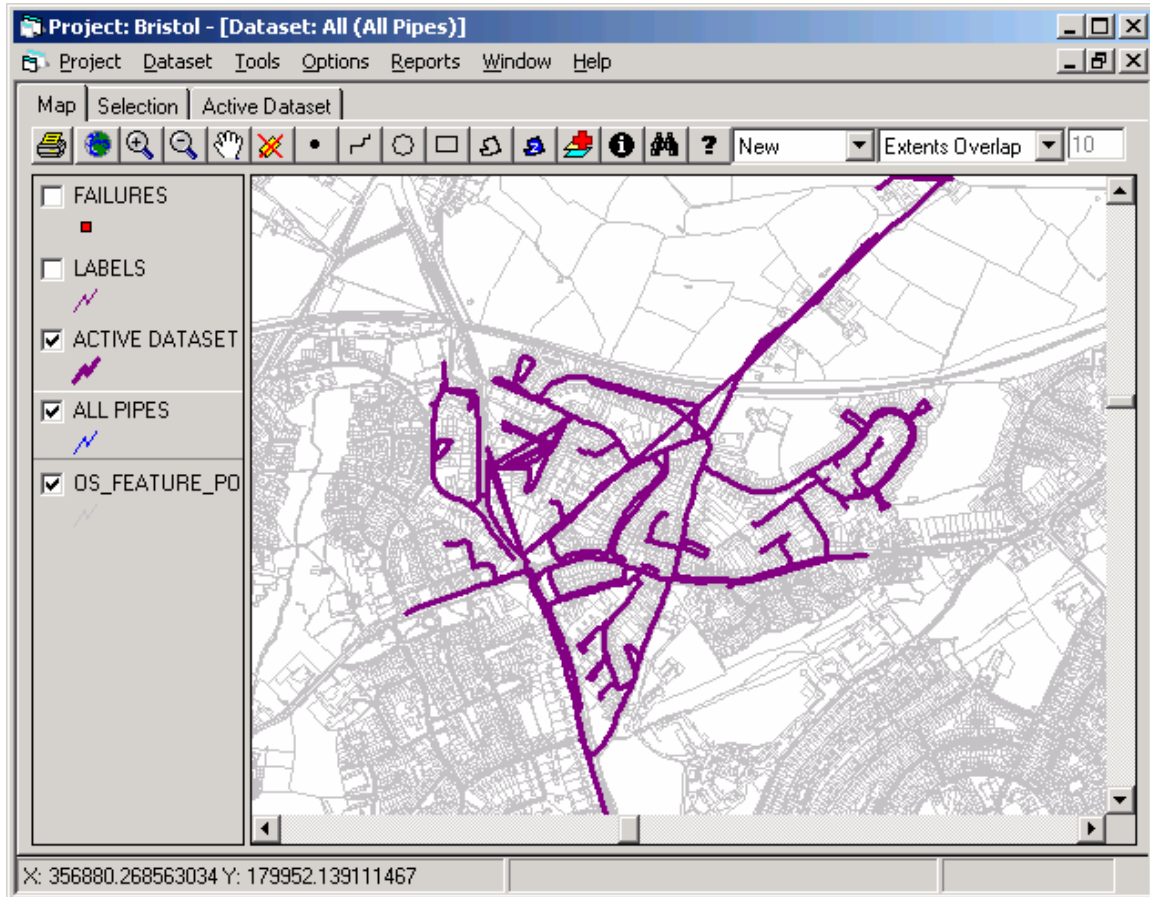
Figure 4.5   GIS viewer showing active dataset and background map

A standard colour scheme has been adopted. Pipes are shown in **mid-blue**, unless they are part of a user selection when they turn **yellow**. The constituent elements of the active dataset are shown in **purple**. Sector dataset boundaries are shown in **brown**.

The GIS viewer provides the user with the following functions:

- Zoom in and out of specific geographical areas;

- Move the view to various geographical areas (pan);

- Select individual assets or groups of assets;

- Add/remove labels for assets;

- Create/remove dataset boundaries;

- Add/remove background maps.

GIS functions are accessed via the GIS toolbar (Figure 4.6). Most of these functions are generic to geographical information systems and will not be explained in detail here, except where the authors wish to draw attention to important and/or useful features.
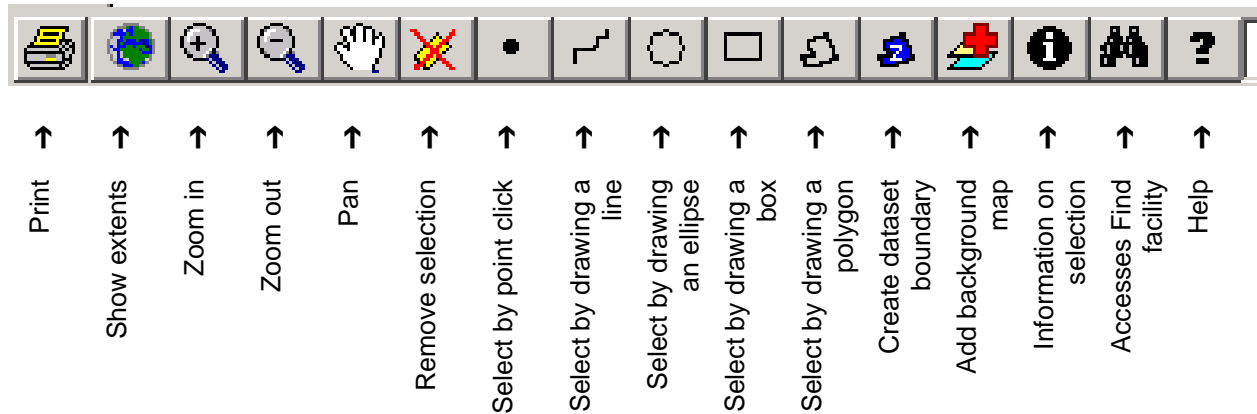
Figure 4.6   CARE-W toolbar with GIS functions

The GIS viewer will be an effective way of displaying results from the analysis carried out in the prototype. Results datasets at individual pipe and dataset (network, sector or cluster) levels of detail will be displayed in separate windows for comparison. See Section 4.8 for more details of reporting CARE-W results.

4.4.2   Creating dataset boundaries

Why do we need them?

Dataset boundaries will enrich the geospatial reporting of results which are not specific to a particular pipe. An example of data to be displayed in this way include performance indicator data applicable across all pipes in a network, sector or cluster dataset. Dataset boundaries may be created for **network** and **sector** datasets (see also sections 2.2.2 and 4.3.3).

What are their properties?

Creating a dataset boundary creates a polygon with a particular boundary linestyle and fill pattern. Network and sector datasets will have identical boundary but different fill characteristics (except where fill colours are required to illustrate dataset results) and will be labelled with the appropriate dataset name.

How do I create them?

At the moment, automatic generation of dataset boundary polygons as part of the CARE-W software is not planned. This is a significant amount of additional work for marginal benefit. As such, the user is invited to create dataset boundaries using the Create Dataset Boundary icon on the GIS toolbar.

 This button will prompt the user for a selection from a list of available datasets (Figure 4.7).
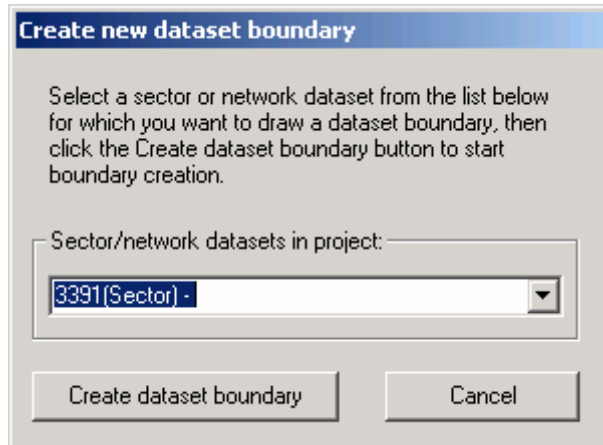
Figure 4.7   Create new dataset boundary dialog

The user may then draw a polygon around the zone in the usual way (single mouse click fixes vertex position; double click completes polygon).

4.5   Working with tabular views

The other way in which data can be displayed in the prototype is in a tabular form, i.e. displaying data directly from the tables in the central database. This allows the prototype the flexibility to process both positional and non-positional data. The user does not need to have GIS data in order to use the facilities of the prototype. The CARE-W screen has three tab options; *Map*, *Selection* and *Active dataset* (Figure 4.5). The Map tab displays the GIS viewer, discussed in section 4.4 above. The other two tabs allow the user to view and manipulate data in tabular form. The aim of these two tabs will be to view selected assets and associated attribute data, in much the same way as the results of an MS Access query would be viewed. The Active dataset tab will display all the assets associated with the active dataset, where as the Selection tab will display assets specifically selected by the user. Methods for finding and selecting assets is discussed in Section 4.6 below.

When the Selection and Active Dataset tabs are selected only two command buttons will be available on the CARE-W toolbar, the Print and Find buttons (see Figure 4.6). The function of the Find button is discussed in section 4.6. However, note that the Find command can be used to add data to a dataset directly from the project database. This facility allows the user to directly query the data in the database, select the relevant data and save it to the active dataset.

It is envisaged that in later versions of the software, customised tabular reports will be available based on user preferences. For the moment, it is proposed that a fixed number of key fields be reported for each pipe or sector or cluster in standard report templates, available from the Reports menu (see Section 4.8).

4.6   Finding and selecting assets

The find and selection mechanisms are generally different for GIS and non-GIS users, with common components where possible to avoid user confusion.

4.6.1 Selection using the GIS viewer

CARE-W selects objects residing in the active layer. The active layer is the layer highlighted in the left-hand pane of the GIS viewer. The 'All pipes' layer is the default active layer (as in Figure 4.5). To change the active layer, click the left-hand pane on the name of the desired layer (but not the check box as this will remove the layer details from view).

The GIS functions on the toolbar provide a number of ways by which users can select objects (i.e. pipes or sectors) in the GIS viewer. Figure 4.9 shows that objects may be selected by point-clicking, or by drawing a variety of shapes around the desired object(s) to select them. Additional drop-down lists (e.g. Figure 4.8) allow the user to select the mechanism by which the drawn shape or line is to select the underlying map objects.
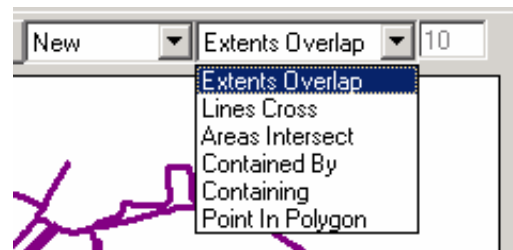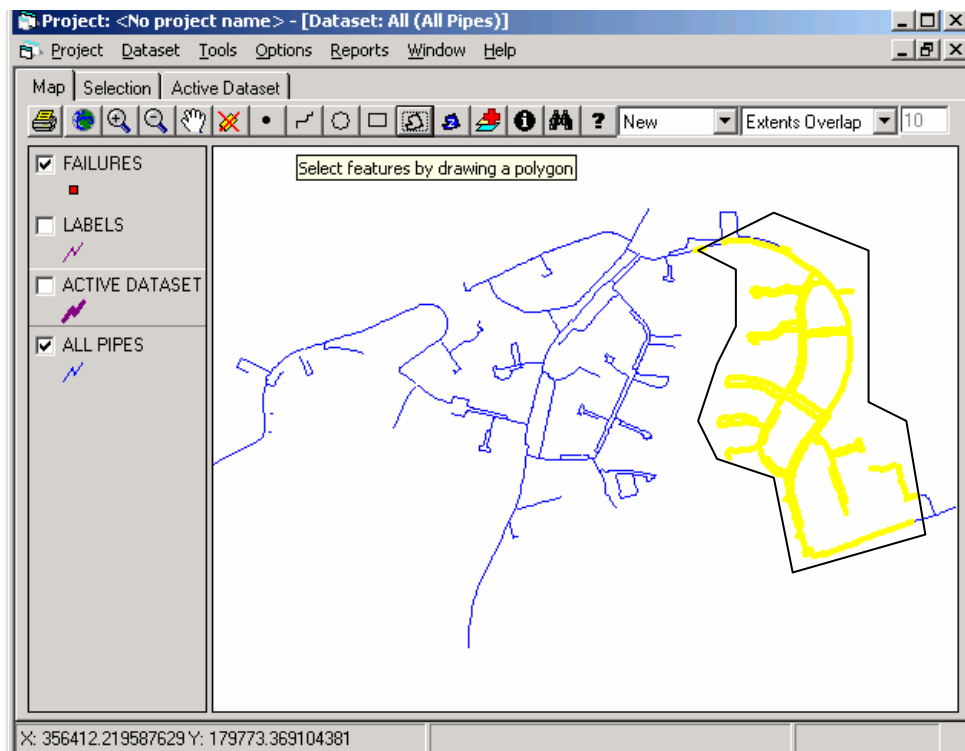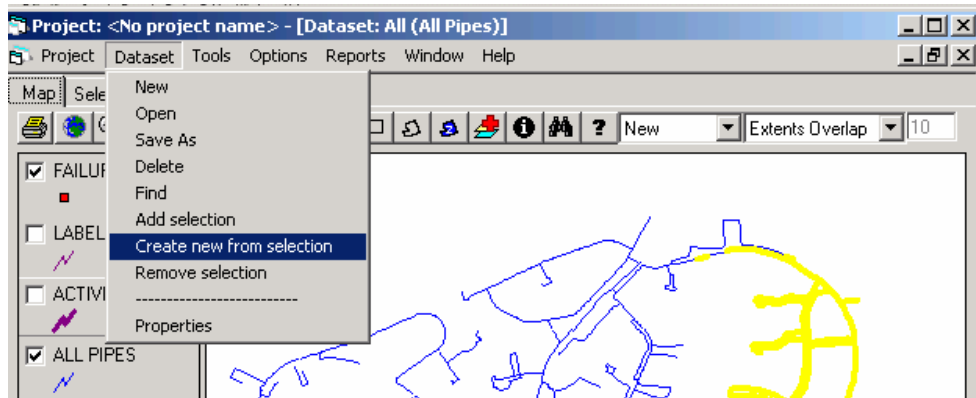

Figure 4.8   GIS selection options

4.9(a) Selection made (yellow pipes) by drawing a polygon around desired pipes

4.9(b) New dataset created using Create new from selection on Dataset menu

Figure 4.9   Selecting pipes in an existing dataset to create a new dataset

4.6.2   Find facility

CARE-W finds objects residing in the active layer (GIS users) or simply the current [open] project (non-GIS users). (Note that a search on the All Pipes layer is equivalent to searching through the current [open] project.) Clicking the *Find* button on the GIS toolbar will display the standard dialog as shown in Figure 4.10. This allows a range and combination of criteria to be applied to restrict the user's search for objects.
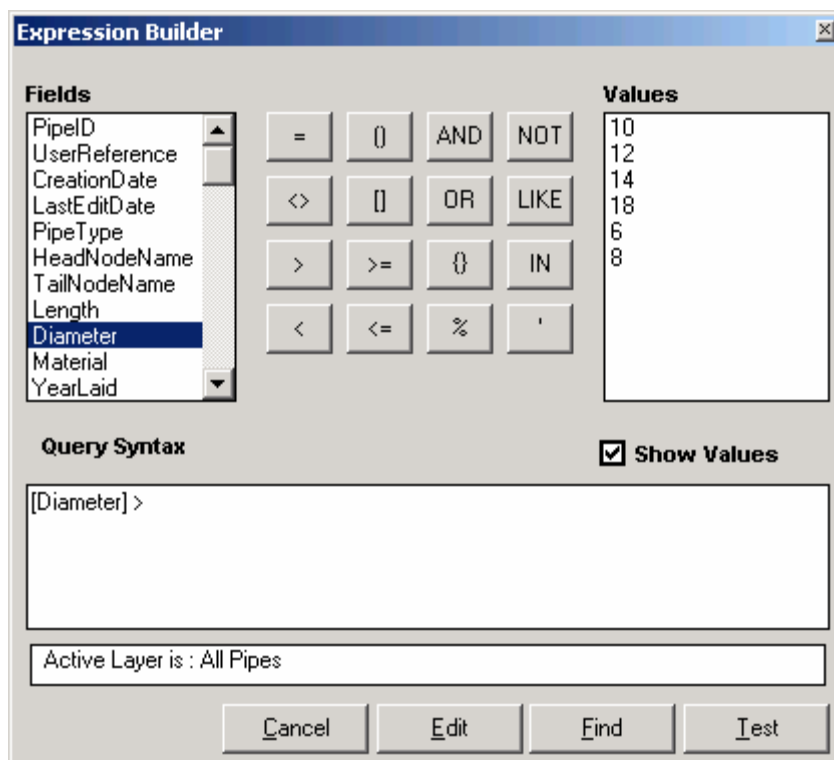

Figure 4.10   Find dialog example

The buttons on the Find dialog have the following associated functions (Table 4.4):

Table 4.4   Command button functions on Find dialog

Button	Function
Test	Tests the criteria you entered in the Query syntax text box without selecting the pipes. Returns the number of records which match the criterion/criteria you entered.
Find	Searches the project database and selects those elements which match your search criteria. Highlights selection in GIS window in yellow.
Edit	Allows editing of a specified data field using the Query syntax text box as an optional filter. If one or more criteria are specified in the Query syntax text box, the data which may be edited is restricted to those which match the specified criteria.

For GIS users, the pipes in the Find result are coloured yellow to indicate their selection (Figure 4.11). Where geospatial information is not available, the pipe selection will be displayed in a table instead.
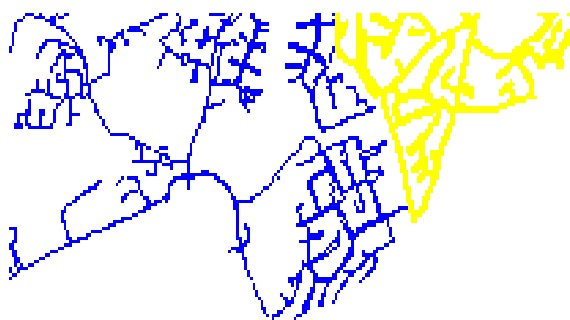

Figure 4.11   Selection from Find dialog criteria (yellow)

4.7   Using the CARE-W Tools

4.7.1   Introduction

Most interaction with the range of tools included in the CARE-W prototype is managed via the Tools menu. At the request of the user, the CARE-W prototype software will create the necessary input file(s) for an analysis tool from data held in the project database according to a pre-defined specification (managed by the Specification Manager – see section 3.3). These files may then be used to run the analysis tool within (or outside) the CARE-W framework. Similarly, the prototype will enable the results of the analysis to be exported back to CARE-W and stored as necessary on completion of the analysis task.

4.7.2   The Tools menu

Table 4.5 details the items contained within the Tools menu. The tools are grouped according to their analysis function, namely: failure prediction, hydraulic reliability, multi-criterion decision support, cost benefit analysis and strategic planning. The specific tools are listed under these generic items. The options for each of the tool sub-menus are consistent throughout. Generic functions include;

- accessing tool-specific help;

- generating of input files from data in the project database (in order that the tool may be used to analyse the active dataset);

- running the tool;

- importing the analysis results back into the central database.

The user may also view the input files that have been created by the prototype before the tool is run. The Edit Input Files menu item will open the specified input file, typically, as an Excel worksheet. The user can then view, edit and save the input file as they would a standard Excel workbook.

4.7.3   Tool Manager

It is envisaged that the Tool Manager form will have tabs relating to tool-specific CARE-W user preferences where required. Its primary function, however, is to control the accessibility of tools by setting data types and locations of the input data and application files required to run the tool under the CARE-W umbrella. This information is found on the *Tools (location)* tab shown in Figure 4.12.

Figure 4.12   Tool Manager form

Table 4.5   Tools Menu

Level 1	Level 2	Level 3	Level 4	Description
Tool Manager				Accesses the Tool Manager dialog
Performance Indicator	Load active dataset info			Runs the routine to automatically load relevant data from the active dataset.
	Evaluator			Runs the PI tool
Failure Prediction	Poisson	Help About Poisson		Accesses Help information specific to each tool
		Generate All Input Files		Runs routine to generate all the input files required by the specific tool.
		Edit Input Files	Segment Description File (SDF)	Opens the relevant input files.
			Maintenance Data File (MDF)	
		Run		Runs the tool using the input files previously generated by the prototype
		Return Results to CARE-W		The results from the tool analysis are imported back into the central database.
	PHM (Failnet-Stat)			Level 3 menu items as per Poisson
	Winroc			(not active in first version)
Hydraulic Reliability	Aquarel			Level 3 menu items as per Poisson
	Failnet-Reliab			Level 3 menu items as per Poisson
	Relnet			Level 3 menu items as per Poisson
Annual Rehabilitation Planning *(incorporating Multi-criterion Decision Support)*	Help about ARP			Accesses Help information
	Generate input file			Runs routine to generate wp3_in.csv or equivalent
	Edit CSV input file			Opens the relevant input file.
	Run ARP Tool			Runs the tool using the input file previously generated by the prototype
	Return results to CARE-W			The results from the tool analysis are imported back into the central database.
Cost Benefit Analysis	Waterfowl			Level 3 items as per ARP

Level 1	Level 2	Level 3	Level 4	Description
Strategic Planning	Scenario Writer	Help about Scenario Writer		Accesses Help information
		Generate input files		Runs routine to generate all the input files
		Edit input files		Opens the relevant input files.
		Run Scenario Writer		Runs the tool using the input files previously generated by the prototype
		Return results to CARE-W		The results from the tool analysis are imported back into the central database.
	Rehab Strategy Manager			Menu items as per Scenario Writer
	Rehab Strategy Evaluator			Menu items as per Scenario Writer **except** Return Results to CARE-W
Other	Epanet			Runs Epanet hydraulic modelling application
	Markov 3	Help about Markov 3		Accesses Help information
		Generate input files		Runs routine to generate all the input files
		Edit input files		Opens the relevant input files.
		Run Markov 3		Runs the tool using the input files previously generated by the prototype
		Return modified input file(s) to CARE-W		The modified input data from the tool analysis are imported back into the central database

4.8   Reporting

The Reports Menu, detailed in Table 4.6, allows the user to access all the functions which relate to reporting analysis results undertaken for the active dataset. The first two items will display analysis results using the GIS viewer. The GIS pipe view item will display the analysis results for each pipe and will correspond to results obtained from the asset-based analysis tools (failure forecasting, hydraulic modelling and the ARP tool developed as part of CARE-W Work Package 3).

The *Sector results (GIS display)* view option will display results which are not specific to individual pipes. This would be results obtained from the Performance Indicator and Strategic Planning tools. The reporting of results in this way relies upon the user manually assigning boundaries to a dataset as discussed in Section 4.4.2.

The final menu item will allow the user to access non-GIS reports, detailing both project summary information and analysis results from individual CARE-W tools. The reports will be created by querying data directly from the central database and exporting it to a spreadsheet. A series of templates have been created to accept data from the PipeOutput, Dataset and Pipe tables. It should be noted that these tabular reports are a supplementary feature to the GIS results display. The advantage of using these tabular reports is that a permanent record can be kept of the analysis undertaken and the results obtained by simply saving the spreadsheet with an appropriate name. All the tabular reports can be printed and saved by the user. The data within the reports can also be manipulated by the user and further analysis undertaken, if required.

When the Tabular reports menu item is selected a dialog box will appear listing the reports that can be generated by the prototype. This list is shown in Table 4.6 below. These reports are discussed in turn in the following sections.

Table 4.6   Reports Menu

Level 1	Description
Pipe (GIS display)	View results per pipe in GIS Viewer
Sector Results (GIS display)	View results at less than pipe-level detail in GIS Viewer

Tabular reports…..	Accesses the Tabular reports dialog listing the available reports, as follows:
	      Strategic Planning– global budget
	      Project summary – current performance.
	      Dataset summary
	      Dataset failure forecasting results
	      Dataset hydraulic reliability results
	      Dataset PI report
	      Dataset pipe rehabilitation plan

4.8.1   Strategic Planning – global budget

This report will summarise results from the WP4 Rehabilitation Strategy Manager. The aim of this report is to present the strategic budget value (in Euro) and the rehabilitation strategy that

has been specified to develop this budget. The following information could therefore be displayed in this report:

- Ageing parameters specified for each type of asset (pipe, valve, etc.) within the dataset;

- The rehabilitation scenario selected by the user;

- The rate of rehabilitation and forecast failure rate as a result of the rehabilitation work, and;

- The global budgets developed by the rehabilitation strategy manager over the specified planning horizon.

A rehabilitation scenario would show the asset type(s) and length(s) to be rehabilitated in a given period and the replacement material. For example *'100km of cast iron main should be entirely replaced by polyethylene pipe between 2002 and 2003'*.

The global rehabilitation budget would be displayed as a total spend for the period of rehabilitation, as an annual spend or as a spend over a given period, e.g. annually for the first 5 years then the total for each subsequent 5 year period.

The rehabilitation strategy manager tool can display a wide range of analysis results, such as the expected service life for each asset type, based on the specified rehabilitation scenario. These results can be printed as charts or exported as text files. It is therefore not proposed that the prototype reproduce such reports, but will instead produce a summary of the information required by the user as specified in the CARE-W procedure.

4.8.2   Project Summary Report

This report would summarise the calculated performance indicators for a given CARE-W project. The PIs would be listed for each dataset within the project, where these values have been calculated by the PI tool. This report would have the same function as the Sector results (GIS display) menu item discussed at the start of this section 4.8, but the PIs would be listed against each dataset rather than displayed as coloured GIS polygons, and can be permanently recorded by saving the report file.

The spreadsheet format report will also allow the user to plot the PI values and directly compare the performance of the datasets within a given project. Threshold values for each PI can be manually input by the user into the project summary report and plotted against the calculated PI values. These threshold values would typically be determined by the rehabilitation planner when setting the goals for the rehabilitation plan, i.e. the minimum performance level required by specific areas of a network.

4.8.3   Dataset summary report

This is a straightforward report which summarises the current status of the active dataset, i.e. before any rehabilitation plan is implemented. This report would contain the following information:

- Category of asset, grouped by material, diameter and age;

- Details of any previous rehabilitation undertaken, i.e. cement mortar lined cast iron pipe, and;

- The length of each category of asset.

4.8.4 Dataset failure forecasting and hydraulic reliability reports

As with the project summary report discussed earlier, these dataset reports will serve a similar function as the pipe (GIS display) menu item. They will summarise asset-based results from the failure forecasting and hydraulic reliability modelling tools. Again, these reports will allow the user to have a permanent record of the analysis results that have been obtained.

These reports will list the analysis results for each pipe within the active dataset, displaying the pipe ID, material, diameter and length.

4.8.5 Dataset PI report

This report will summarise the calculated PI values for the active dataset. This report will list the performance indicators that have been selected within the PI tool, together with the code and units that apply to each. The PIs values will be displayed for the period over which they were calculated. Where a number of analysis periods have been taken for the same dataset, a chart can be produced displaying the change in the PI over time.

4.8.6 Dataset pipe rehabilitation plan

This report presents the analysis results from the ARP tool. The calculated values for each criteria from the desired *points of view* selected by the user will be listed for each pipe in the active dataset. The report will also indicate whether an individual pipe has been classed as a *hotspot* for a particular criterion. The pipe status table (MCD *Status* versus pipe ID) will be at the top of the report, followed by values for the selected points of view criteria in turn, underneath.

4.9 <u>Other Menus</u>

There are three remaining menus available to the user, namely:

- Options;

- Window;

- Help.

4.9.1 Options

The Options menu contains the User Preferences item which accesses the User Preference dialog. This has currently only the option to switch the project autoload function on or off. Further user preferences may be added at a later stage.

4.9.2 Window

Table 4.7 below details the functions available on the Window menu. These items are mainly standard MS Windows® functions so will not be described further. The one exception is the *Show GIS window* item which opens the GIS viewer should it not already be open.

Table 4.7   Window Menu

Level 1	Description
Cascade	Standard MS Windows® menu item
Tile Vertically	Standard MS Windows® menu item
Tile Horizontally	Standard MS Windows® menu item
Arrange Icons	Standard MS Windows® menu item
Show GIS window	Opens GIS window if not already open

4.9.3 Help

The current Help menu items are listed in Table 4.8.

Table 4.8   Help Menu

Level 1	Description
Help	Accesses the general CARE-W Help file [to be done]
About CARE-W	Accesses the About CARE-W dialog

Help will access a general CARE-W help file. It is envisaged that this will be context-specific in later versions of the CARE-W software. *About CARE-W* will provide the user with the software version number, copyright and licensing information.

APPENDIX A   ATTRIBUTE INFORMATION TABLES

Table A.1   Parameters in Pipe Table in Central Database

			CARE-W Tool									
			Poisson / Markov 3 / Failnet-Stat	Failnet-Reliab	Relnet	ARP	Aquarel	Waterfowl	Scenario Writer	Rehab Strategy Manager	Rehab Strategy Evaluator	Utilnets
Prototype Parameter	**Data type**	**units**	**SDF.txt**	**HLF.txt**	**RELNET. txt/.xls**	**WP3_in .csv**	***.mdb**	***.wdf**	***.odbc**	***.odbc**		***.dbf/*.txt**
Last Edit Date	Date											
Creation Date	Date											
UserReference	Text		I1	L1	Link_ID	ID	pipe_ID	MAIN id				Link_ID
Pipe Equipment	Text			L7								
HeadNodeName	Text			L2	NB							A_End
TailNodeName	Text			L3	NE							B_End
Length	Single	m	C1	L4	Length	L		Length		Length		Length
Diameter (nominal)	Single	mm	C2	L5	DN	D		Diameter				Nominal_ Diameter
Material	Text		C3	L8	Pipe material	M		Pipe material		pipe type		Is_Made_Of
YearLaid	Date		C4					Year laid		construction year or period		Year_Laid
DMA Name	Text											DMA
Supply Zone	Text				PZ							Supply_Zone
Compliance Zone	Text											Compliance_ Zone
Internal lining	Text		C7									Internal_Lining
Internal protection (date)	Date											Internal_ Protection_date
External lining	Text		C8									External_Lining
External protection (date)	date											External_ Protection_Date
Joint type	Text		C9									Joint_Type

Prototype Parameter	Data type	units	CARE-W Tool									
			Poisson / Markov 3 / Failnet-Stat	Failnet-Reliab	Relnet	ARP	Aquarel	Waterfowl	Scenario Writer	Rehab Strategy Manager	Rehab Strategy Evaluator	Utilnets
			SDF.txt	HLF.txt	RELNET. txt/.xls	WP3_in .csv	*.mdb	*.wdf	*.odbc	*.odbc		*.dbf/*.txt
Number Of People Supplied	Integer				c1	NPS						people
Number Of Service Connections	Integer		E6									
DateAbandoned, replaced	Date		C5									
Depth of installation	Single	m	C10									Depth_At_ Crown
Confidence Factor	0 to 100 (integer)							Confidence factor				
Supply Importance	Text											Supply
Danger Importance	Text											Danger
Damage importance	Text											Damage
Original Internal Diameter	Single	mm										Org_Int_ Diameter
Original External Diameter	Single	mm										Org_Ext_ Diameter
Original Wall Thickness	Single	mm										Org_Wall_ Thickness
Trench width	Single	m										Trench_Width
Roughness of the pipe (Colebrook formula)	Single	mm		L6	k							
Roughness of the pipe (Hazen-Williams formula)	Single	mm										
Cathodic protection	yes/no											Cathodic_ Protection
Average Working Pressure	Single	mPa	E5			P						Working_ Pressure

			CARE-W Tool									
			Poisson / Markov 3 / Failnet-Stat	**Failnet-Reliab**	**Relnet**	**ARP**	**Aquarel**	**Waterfowl**	**Scenario Writer**	**Rehab Strategy Manager**	**Rehab Strategy Evaluator**	**Utilnets**
Prototype Parameter	**Data type**	**units**	**SDF.txt**	**HLF.txt**	**RELNET. txt/.xls**	**WP3_in .csv**	***.mdb**	***.wdf**	***.odbc**	***.odbc**		***.dbf/*.txt**
Max flow capacity	Single	l/s										Max_Flow_ Capacity
Date of rehabilitation	Date		C6									
Date of epoxy lining	Date							Year ER lined				
Date of cement mortar lining	Date							Year CM lined				
Date of sliplining	Date							Year sliplined				
Street,road,locality (optional)	Text		I2									
Type Of soil	Text		E1					Ground type				Soil_Class_ Zone
Traffic In street	Text		E2									Truck_Load
Pavement (surface type)	Text		E3					Surface type				Pavement_ Condition
Bedding	Text		E4									Bedding_ description
Other networks	yes/no											Other_Utilities
Corrosivity	Integer							Soil corrosivity				
Backfill	Text											Backfill_ Description
Has subsidence	yes/no											Has_Subsidence
Probability in service	Single	%			APS							
Surge Pressure	Single	N/m2										Surge_Pressure
Surge Pressure Occ Rate	Single	No per year										Surge_Pressure_ Occur_Rate

			CARE-W Tool									
			Poisson / Markov 3 / Failnet-Stat	**Failnet-Reliab**	**Relnet**	**ARP**	**Aquarel**	**Waterfowl**	**Scenario Writer**	**Rehab Strategy Manager**	**Rehab Strategy Evaluator**	**Utilnets**
Prototype Parameter	**Data type**	**units**	**SDF.txt**	**HLF.txt**	**RELNET. txt/.xls**	**WP3_in .csv**	***.mdb**	***.wdf**	***.odbc**	***.odbc**		***.dbf/*.txt**
Water Source Type	Text											Water_Source_ Type
Leakage rate	yes/no											Hydraulic_Failure
Temperature zone	Single											Temperature_ Zone
Sensitive Customer						SC						
MTTR	Single						MTTR					
TTR95	Single						TTR95					
Operational probability of all pipes	Single			pe_o								
Unavailability probability	Single			pe_i								
#cat_KB1	Integer	-				C-COS						
#cat_KB2	Integer	-				C-UCRp						
#cat_KB3	Integer	-				C_UCRh						
#cat_KB4	Integer	-				C_CF						
#cat_KB5	Integer	-				C-WLI						
#cat_KB6	Integer	-				C-WQD						
#cat_KB7	Integer	-				C-EDI						
#cat_KB8	Integer	-				C-SFH						
#cat_KB9	Integer	-				C-SFI						
#cat_KB10	Integer	-				C-LS						

			CARE-W Tool									
Prototype Parameter	**Data type**	**units**	**Poisson / Markov 3 / Failnet-Stat** SDF.txt	**Failnet-Reliab** HLF.txt	**Relnet** RELNET.txt/.xls	**ARP** WP3_in.csv	**Aquarel** *.mdb	**Waterfowl** *.wdf	**Scenario Writer** *.odbc	**Rehab Strategy Manager** *.odbc	**Rehab Strategy Evaluator**	**Utilnets** *.dbf/*.txt
#cat_KB11	Integer	-				C-SR						
#cat_KB12	Integer	-				C-SI						
#cat_KB13	Integer	-				C-IF						
#cat_KB14	Integer	-				C-VFH						
#cat_KB15	Integer	-				C-VFI						
*Criterion_1 **						*Info1*						
*Criterion_2 **						*Info2*						
*Criterion_3 **						*Info3*						
*Criterion_4 **						*Info4*						
*Criterion_5 **						*Info5*						
*UserIntegerData1 ***												
*UserIntegerData2 ***												
*UserSingleData1 ***												
*UserStringData20 ***												
*UserStringData30 ***												
*UserStringData50 ***												

*Criteria added outside CARE-W. ** User-defined fields for search facilities (e.g. zone name)

Table A.2   Parameters in Pipe Failure Table in Central Database

Prototype Parameter	Data Type	Units	CARE-W Tool	
			Poisson, Markov 3, PHM	**Waterfowl**
			MDF.txt	***.wdf**
UserReference			M1	
LastEdit & Creation Dates				
Event ID				Event ID
FailureDate	date		M2	date of event
Maintenance type	text		M3	complaint type
CauseOf Failure	text		M4	
Visit	Yes/No			visit
confidence factor	0 to 100 (integer)			Confidence factor
Type of Repair	text		M5	
DateOf repair	date			
X	single			
Y	single			

Table A.3   Parameters in Node Table in Central Database

Prototype parameter	data type	units	NDF.txt	RELNET .txt / .xls	*.dbf/ *.txt
			CARE-W Tools		
			FailNet Reliab	**Relnet**	**Utilnets**
NodeName			N1/T1/R1	NT	Node_ID
Last Edit Date	Date				
Creation Date	Date				
Node Type (Normal/Tank/ Resource)	Text		Type of node		
X	positional data - single		N2/T2/R2		
Y	positional data - single		N3/T3/R3		
Z	single	m	N4/T4/R4	NL	Depth
Demand	single	m3/s	N5		
DesiredHead	single	bar	N6		
Importance	text		N7		
WaterLevel	single	m	T5/R5	TNL	
MinWaterLevel	single	bar	T6		
MaxWaterLevel	single	bar	T7		
Tank volume	single	m3	T8		
Tank diameter	single	m			
MinTankVolume	single	m3			
MaxFlowRate	single	m3/s	R6		
Min pressure	single	bar		PN	
Max pressure	single	bar	Maximum pressure		
Weight			Wi		

Table A.4   Interaction with Pipe Output Table in Central Database

In addition to *PipeID*, *DataSetID* and *User Reference* fields (which are used to relate this information to that in the Pipe and Dataset tables), the data flow from the tools which generate data for use by CARE-W ("Tool 1") to the Pipe Outputs table in the project database, and then to the tools which use the data in the Pipe Outputs table ("Tool 2") is as shown. A tick (✓) indicates a corresponding item in the tool input/output file:

Tool 1 (generates data for entry to CARE-W database)						Pipe output table (CARE-W database)			Tool 2 (uses data entered into CARE-W database)				
Poisson model [1]	*Failnet-Stat*	*Failnet-Reliab*	*Relnet*	*Aquarel*	*ARP* [2]	*Attribute*	*Data type*	*Unit*	*Failnet-Reliab*	*Relnet*	*Aquarel*	*ARP*	*GIS viewer*
BR						PBR	Single	No/km/yr				No/100m/yr [3]	
	✓					PBR_5 [4]	Single	No/km/yr					
	✓					PBR_5_a	Single	No/km/yr					
	✓					PBR_5_b	Single	No/km/yr					
	✓					PBR_10 [5]	Single	No/km/yr					
	✓					PBR_10_a	Single	No/km/yr					
	✓					PBR_10_b	Single	No/km/yr					
FR						PFR	Single	No/km/yr				No/100m/yr [3]	
	✓					PFR_5 [6]	Single	No/km/yr					
	✓					PFR_5_a	Single	No/km/yr					
	✓					PFR_5_b	Single	No/km/yr					
	✓					PFR_10 [7]	Single	No/km/yr					

[1] two output files are generated: Poisson_Output_FR.txt and Poisson_Output_BR.txt.
[2] one output file is generated : wp3_out.csv
[3] when generating the input file for ARP (wp3_in.csv) the user will be asked to select one of the available rates
[4] PBR_5 is the average burst rate for the next 5 years;   PBR_5_a and PBR_5_b are the associated confidence intervals
[5] Average burst rate for the next 10 years
[6] Average failure rate for the next 5 years
[7] Average failure rate for the next 10 years

Tool 1 (generates data for entry to CARE-W database)						Pipe output table (CARE-W database)			Tool 2 (uses data entered into CARE-W database)				
Poisson model [1]	*Failnet-Stat*	*Failnet-Reliab*	*Relnet*	*Aquarel*	*ARP* [2]	*Attribute*	*Data type*	*Unit*	*Failnet-Reliab*	*Relnet*	*Aquarel*	*ARP*	*GIS viewer*
	✓					PFR_10_a	Single	No/km/yr					
	✓					PFR_10_b	Single	No/km/yr					
		✓				HCI_FR							
			✓			HCI_Rel						$HCI \in_3 [0\text{-}1]$	
				✓		HCI_Aq							
					Status	Status	Text [8]						✓
					AUCR	AUCR	Single	€/100m					✓
					COS	COS	Single						✓
					ARC	ARC	Single	€/100m					✓
					HS_ARC	HS_ARC	Binary (Y/N)						✓
					WLI	WLI	Single $\in[0\text{-}1]$						✓
					HS_ WLI	HS_ WLI	Binary (Y/N)						✓
					PWI	PWI	Single	(No/100m/yr) x (hours.persons)					✓
					HS_PWI	HS_PWI	Binary (Y/N)						✓
					PCWI	PCWI	Single	(No/100m/yr) x (hours)					✓
					HS_PCWI	HS_PCWI	Binary (Y/N)						✓
					PFWI	PFWI	Single	Hours/yr					✓
					HS_PFWI	HS_PFWI	Binary (Y/N)						✓
					DFH	DFH	Single	(No/100m/yr) x (mm^2.MPa)					✓
					HS_DFH	HS_DFH	Binary (Y/N)						✓

---

[8] Six possible values : C33 / C32 / C31 / C22 / C21 / C11. See Report D7

Tool 1 (generates data for entry to CARE-W database)						Pipe output table (CARE-W database)			Tool 2 (uses data entered into CARE-W database)				
Poisson model [1]	*Failnet-Stat*	*Failnet-Reliab*	*Relnet*	*Aquarel*	*ARP* [2]	*Attribute*	*Data type*	*Unit*	*Failnet-Reliab*	*Relnet*	*Aquarel*	*ARP*	*GIS viewer*
					DFI	DFI	Single	(No/100m/yr) x (mm^2.MPa)					✓
					HS_DFI	HS_DFI	Binary (Y/N)						✓
					DSM	DSM	Single	(No/100m/yr) x (mm^2.MPa)					✓
					HS_DSM	HS_DSM	Binary (Y/N)						✓
					DT	DT	Single	(No/100m/yr)					✓
					HS_DT	HS_DT	Binary (Y/N)						✓
					DDI	DDI	Single	(No/100m/yr) x (mm^2.MPa)					✓
					HS_DDI	HS_DDI	Binary (Y/N)						✓
					WQD	WQD	Single $\in[0\text{-}1]$						✓
					HS_WQD	HS_WQD	Binary (Y/N)						✓
					HCI	HCI	Single $\in[0\text{-}1]$						✓
					HS_HCI	HS_HCI	Binary (Y/N)						✓
					C1	C1	Single						✓
					HS_C1	HS_C1	Binary (Y/N)						✓
					C2	C2	Single						✓
					HS_C2	HS_C2	Binary (Y/N)						✓
					C3	C3	Single						✓
					HS_C3	HS_C3	Binary (Y/N)						✓
					C4	C4	Single						✓
					HS_C4	HS_C4	Binary (Y/N)						✓

Tool 1 (generates data for entry to CARE-W database)						Pipe output table (CARE-W database)			Tool 2 (uses data entered into CARE-W database)				
Poisson model [1]	*Failnet-Stat*	*Failnet-Reliab*	*Relnet*	*Aquarel*	*ARP [2]*	*Attribute*	*Data type*	*Unit*	*Failnet-Reliab*	*Relnet*	*Aquarel*	*ARP*	*GIS viewer*
					C5	C5	Single						✓
					HS_C5	HS_C5	Binary (Y/N)						✓

Table A.5   Key to abbreviations in Table A.4

Abbreviation	Meaning
AUCR	Annual Unit Cost of Rehabilitation
COS	Co-Ordination Score
ARC	Annual Repair Costs
WLI	Water Losses Index
PWI	Predicted Water Interruption
PCWI	Predicted Critical Water Interruption
PFWI	Predicted Frequency of Water Interruption
DFH	Damage owing to Flooding in Housing areas
DFI	Damage owing to Flooding in Industrial/commercial areas
DSM	Damage owing to Soil Movement
DT	Disruption caused by Traffic
DDI	Damage and/or Disruption of other Infrastructure
WQD	Water Quality Deficiency Index
HCI	Hydraulic Criticality Index
HS_*	Hotspot criterion – hotspot threshold defined by user via ARP tool for each index above

APPENDIX B   CONFIGURATION DATABASE

Table B.1   Auxiliary data in configuration database

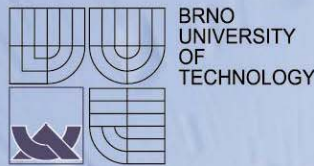| Table name	Function
CareWOptions	Contains program settings (e.g. autoload)
DefaultPIBands	Contains default thresholds for colour coding bands
LevelCodeDescription	LookUp for Data set types (network, sector, cluster)
LookUpImportFields	Specification for data transfer to/from all tools
LookUps	Generic lookup for any pipe attribute
Project Objectives	Contains project start-up properties
Projects	List of ALL projects on system
ProjectStage	Lookup for project events record
ToolTypes	Lists tools installed on PC and their locations (pathnames)
WP1_EI	Lookup table for WP1 (part of PI application)
WP1_PI	Lookup table for WP1 (part of PI application)
WP1_PI-UI	Lookup table for WP1 (part of PI application)
WP1_UI	Lookup table for WP1 (part of PI application)

APPENDIX C   COMMON TOOL PARAMETERS REQUIRING EXPLANATION

Table C.1   Tools parameters used by Poisson and PHM

Parameter	Data type	Units	Definition
I1	Text	Dimensionless	Variable or set of n variables that identify univocally the segment (unique to every segment)
I2	Text	Dimensionless	Street, road or locality
I3	Text	Dimensionless	Area (municipality or region or zone)
I4	Text	Dimensionless	Geodetic co-ordinates
C1	Single	Metres	Segment length
C2	Single	Millimetres	Segment diameter
C3	Text	Dimensionless	Segment material
C4	Date	Day, month or year	Date of installation
C5	Date	Year	Date of replacement of segment
C6	Date	Year	Date of rehabilitation of segment
C7	Text	Dimensionless	Internal Protection
…	…	…	…
…	…	…	…

SINTEF The Foundation of Scientific and Industrial Research, Trondheim, Norway
Norwegian University of Science and Technology, Trondheim, Norway
Brno University of Technology, Brno, Czech Republic
Cemagref, Bordeaux, France
Dresden University of Technology, Dresden, Germany
INSA, Lyon, France
LNEC, Lisbon, Portugal
WRc, Swindon, UK
University of Bologna, Bologna, Italy
University of Ferrara, Ferrara, Italy
AGAC, Reggio Emilia, Italy

Institute name: WRc plc
Contact person: Paul Conray
E-mail: carew@wrcplc.co.uk
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Phone: +44 1793 865038
Fax: +44 1793 865001
Work Package: 5   Task no.: 5.2