CARE-W ARP tool

Care-W_ARP tool

Tool version Number: 1.03
Help file version number: 1.02
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Date: March 2003

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SCIENTIFIC BACKGROUND - PRINCIPLES

POINTS OF VIEW

Regarding the decision problems that we are considering in Care-W_ARP, points of view can be divided into two types:

- "Internal" points of view (points of view of the operator) corresponding to technical concerns and technical costs such as:
  - Repair Costs
  - Rehabilitation costs
  - Water Losses *(Water losses and corresponding costs)*

- "External" points of view (of customers, road users, etc.):
  - Water Interruptions *(impacts of water interruptions)*
  - Damages and disruptions *(damages and disruptions caused by bursts or repairs)*
  - Water quality *(water quality deficiencies)*
  - Hydraulic reliability *(hydraulic deficiencies)*
  - Disturbances induced by rehab. measure *(disruptions associated with a particular rehab. method)*

Criteria and sub-criteria have been defined in order to evaluate and compare candidates (rehabilitation projects) according to these various points of view.

Another important aspect has been taken into account in order to assess candidates:

- Co-Ordination *(co-ordination with other utilities and roadway rehabilitation programmes, co-ordination with service connection replacement programmes)*

Additional criteria (calculated by external tools) may be used (values are loaded as "Info1", "Info2", etc. Input file

CRITERIA

POINTS OF VIEW	CRITERIA
Co-Ordination	- Co-ordination Score (COS)
Repair Costs	- Annual Repair Cost (ARC)
Water Losses	- Water Losses Index (WLI)
Water Interruptions	- Predicted Water Interruption (PWI) - Predicted Critical Water Interruption (PCWI) - Predicted Frequency of Water Interruption (PFWI)
Damages and disruptions	- Damages due to Flooding in Housing area (DFH) - Damages due to Flooding in Industrial or commercial areas (DFI) - Damages due to Soil Movement (DSM) - Traffic Disruption (DT) - Damages and/or Disruption on other Infrastructure (DDI)
Water quality	- Water Quality Deficiencies (WQD)
Hydraulic reliability	- Hydraulic Criticality Index (HCI)

CO-ORDINATION SCORE (COS)

This aspect can be studied in considering the impact of co-ordination on rehab costs, or in using a scoring system taking into account “external” reasons for including (or not) a pipe length in the annual rehab programme, allowing to represent the utility’s concerns.

1) CO-ORDINATION & REHAB COSTS

Economies may be achieved by co-ordinating rehabilitation of distribution mains with service connection replacement and roadway rehabilitation. The former may be done by defining unit costs of rehabilitation to be used for work on the main only. Costs would then need to be added for replacing or remaking each service connection (or part of). This approach is used in the Waterfowl™ whole life costing approach.
In some countries the savings (to the water utility) achievable through co-ordinating mains rehabilitation with roadway rehabilitation can be significant.
Factors need to be produced for type of rehabilitation method (e.g. perhaps one factor for open-cut and a second for trenchless methods).
This will need to take account of the increase in costs to co-ordinate the activities. For this to be of use in the software, knowledge of planned roadway rehabilitation will also need to be input.

2) SCORING SYSTEM

Co-ordination of water mains rehabilitation with other utilities or roadway rehabilitation and service connection rehabilitation can be seen as a major criterion or non relevant criterion, depending on the water utility.

This leads us to propose a criterion “co-ordination score” associated with a scoring table that will have to be defined or calibrated by each water utility.

See Co-Ordination Score User Guide

CO-ORDINATION SCORE (COS) / KB1

EXAMPLE 1

1) Information coming from CARE_W Central database

Pipe ID	C_Cos
1235	7
2549	5
2497	5
2469	1
…	

2) Knowledge Base to be defined by the end-user

KB1	COS - Co-ordination score	
C_COS	Score ε [-1,-1]	description
1	1	Service connections have to be rehabilitated
2	1	Work of other utilities in the same location
3	1	Roadway rehabilitation: rebuilding
4	0.5	Roadway rehabilitation: resurfacing
5	-0.5	Work of other utilities in the same location in the last 5 years
6	-1	Service connections have been rehabilitated in the last 3 years
7	-1	Roadway has been rehabilitated in the last 5 years
8	-0.5	Roadway is planned to be rehabilitated later
9	0	Other case

3) COS

Pipe ID	Cos
1235	- 1
2549	-0.5
2497	-0.5
2469	1
…	

Comment:

A positive score indicates a motivation for rehabilitating the considered pipe. A negative score quantifies reasons against rehabilitation

EXAMPLE 2

1) Information coming from CARE_W Central database

2) Knowledge Base to be defined by the end-user

Pipe ID	C_Cos
1235	2
2549	2
2497	1
2469	1
…	

3) COS

Pipe ID	Cos
1235	- 1
2549	- 1
2497	1
2469	1
…	

KB1	COS - Co-ordination score	
C_COS	Score ε [-1,-1]	description
1	1	Other works in the same location
2	-1	Future works in the same location

See Co-Ordination Score
PRINCIPLES
Seecriterion ARC

ANNUAL REPAIR COST (ARC) / KB2

CRITERION

$$ARC(i) = PFR(i) \times UCRp(i)$$

Units: (No./100m/year) x (€)

With :

PFR(i) Predicted Failure Rate for pipe *i* (No./100m/year)

UCRp(i) is the Unit Cost of Repair (€) **KB2**

KNOWLEDGE BASE FOR CRITERION ARC (examples)

Example 1

KB2	UCRp - Unit Cost of Repair UCRp	
C_UCRp	€	description
1	3000	unknown
2	1900	diam < 300mm & easy context
3	3100	diam < 300mm & normal context or diam >= 300mm & easy context
4	4700	diam >= 300mm & easy context or diam < 300mm & difficult context
5	6200	diam >= 300mm & difficult context

1) Information coming from CARE_W Central database

Pipe ID	C_UCRp
14	5
19	2
26	1
33	3
…	

2) Knowledge Base to be defined by the end-user in CARE_W_ARP tool

Cf. Example 1

3) UCRp used to calculate ARC(i)

Pipe ID	UCRp
14	6200 €
19	1900 €
26	3000 €
33	3100 €
…	

Example 2

KB2	UCRp - Unit Cost of Repair UCRp	
C_UCRp	€	description
1	3000	unknown
2	1600	diam < 200mm & easy context
3	2800	diam < 200mm & normal context or diam >= 200mm & easy context
4	3400	diam]200-600] mm & easy context or diam < 200mm & difficult context
5	5900	diam]200-600] mm & difficult context
6	5100	diam >= 600mm & easy context or diam <]200-600]mm & difficult context
7	6500	diam >= 600mm & difficult context

1) Information coming from CARE_W Central database

Pipe ID	**C_UCRp**
112	1
952	7
126	2
365	6
…	

2) Knowledge Base to be defined by the end-user in CARE_W_ARP tool

Cf. Example 2

3) UCRp used to calculate ARC(i)

Pipe ID	**UCRp**
112	3000 €
952	6500 €
126	1600 €
365	5100 €
…	

Seecriterion WLI

KB3 : REHABILITATION COSTS / KB16 : REHABILITATION RULES / RELEVANT TECHNIQUE

Blue cells to be filled by the end user
The orange cells correspond to results of calculation

KB3 REHABILITATION TECHNIQUES

rehab technique	1	2	3	4	5	6
rehab code						
rehabilitation technique						
SL service life (years)						
r interest rate						
1/k						
k factor						

k: factor allowing to calculate the investment cost over a period corresponding to the service life of the technique;

- pour r > 0

$$k = \frac{r}{1-(1+r)^{-SL(RT)}}$$

- pour r =0
  k = 1 / SL

KB3 REHABILITATION COSTS

	UCR: Unit Costs of Rehab (€ / m) for each rehab.				
cc					
1					
2					
3					
4					
…					

EXAMPLES

Example 1

1)

rehab technique	1	2	3	4	5	6
rehab code	OC - PP	OC - DI	SL	PB	ER or CM	
rehabilitation technique	open cut replacement, with plastic pipe	open cut replacement, with DI pipe	sliplining	pipe bursting	cement mortar or epoxy resin lining	
SL service life (years)	40	60	50	50	25	
r interest rate	0.01					
1/k	32.8	45.0	39.2	39.2	22.0	
k factor	0.0305	0.0222	0.0255	0.0255	0.0454	

2)

cc		UCR: Unit Costs of Rehab (€ / m) for each rehab. Technique				
		1- OC PP	2- OC DI	3- SL	4- PB	5- ER or CM
1	diam [.. ; 80] & footpath	73	146	73	81	56
2	diam [.. ; 80] & minor road	89	178	73	81	56
3	diam [.. ; 80] & major road	105	210	73	81	56
4	diam] 80 ; 105] & footpath	89	178	81	89	56
5	diam] 80 ; 105] & minor road	105	210	81	89	56
6	diam] 80 ; 105] & major road	121	242	81	89	56
7	diam] 105 ; 155] & footpath	97	194	89	105	65
8	diam] 105 ; 155] & minor road	121	242	89	105	65
9	diam] 105 ; 155] & major road	137	274	89	105	65
10	diam] 155 ; 205] & footpath	113	226	105	129	73
11	diam] 155 ; 205] & minor road	137	274	105	129	73
12	diam] 155 ; 205] & major road	161	322	105	129	73
13	diam] 205 ; 255] & footpath	137	274	129	161	81
14	diam] 205 ; 255] & minor road	169	338	129	161	81
15	diam] 205 ; 255] & major road	194	388	129	161	81

3)

cc	AUCR: Annual Unit Costs of Rehab (€ / 100 m) for each Rehab. Technique				
	1- OC PP	2- OC DI	3- SL	4- PB	5- ER or CM
1	222	325	186	207	254
2	271	396	186	207	254
3	320	467	186	207	254
4	271	396	207	227	254
5	320	467	207	227	254
6	369	538	207	227	254
7	295	432	227	268	295
8	369	538	227	268	295
9	417	609	227	268	295
10	344	503	268	329	331
11	417	609	268	329	331
12	490	716	268	329	331
13	417	609	329	411	368
14	515	752	329	411	368
15	591	863	329	411	368

Example 2

1)

rehab technique	1	2	3	4	5	6
rehab code	OC	SL - PB	ER or CM			
rehabilitation technique	open cut replacement	sliplining - pipe bursting	cement mortar or epoxy resin lining			
SL service life (years)	50	50	25			
r interest rate	0.01					
1/k	39.2	39.2	22.0			
k factor	0.025513	0.025513	0.045407			

2) **UCR: Unit Costs of Rehab (€ / m) for each rehab. Technique**

cc		1- OC	2- SL - PB	3 - ER or CM	…	…
1	diam [.. ; 80] & footpath	109.5	77	56		
2	diam [.. ; 80] & minor road	133.5	77	56		
3	diam [.. ; 80] & major road	157.5	77	56		
4	diam] 80 ; 105] & footpath	133.5	85	56		
5	diam] 80 ; 105] & minor road	157.5	85	56		
6	diam] 80 ; 105] & major road	181.5	85	56		
7	diam] 105 ; 155] & footpath	145.5	97	65		
8	diam] 105 ; 155] & minor road	181.5	97	65		
9	diam] 105 ; 155] & major road	205.5	97	65		
10	diam] 155 ; 205] & footpath	169.5	117	73		
11	diam] 155 ; 205] & minor road	205.5	117	73		
12	diam] 155 ; 205] & major road	241.5	117	73		
13	diam] 205 ; 255] & footpath	205.5	145	81		
14	diam] 205 ; 255] & minor road	253.5	145	81		
15	diam] 205 ; 255] & major road	291	145	81		

3) **AUCR: Annual Unit Costs of Rehab (€ / 100 m) for each Rehab. Technique**

cc	1- OC	2- SL - PB	3- ER or CM	…	…
1	279	196	254		
2	341	196	254		
3	402	196	254		
4	341	217	254		
5	402	217	254		
6	463	217	254		
7	371	247	295		
8	463	247	295		
9	524	247	295		
10	432	298	331		
11	524	298	331		
12	616	298	331		
13	524	370	368		
14	647	370	368		
15	742	370	368		

KB16 REHABILITATION RULES / RELEVANT TECHNIQUE

- Rules chosen by the end user to define the elimination conditions of a technique
- These same techniques are used in the KB3 - Rehabilitation costs
- A pipe can belong to several categories: cc_16 is a list of codes ex. [1,3]

	Relevant techniques					
cc_16	1 - OC PP	2 - OC DI	3 - SL	4 - PB	5 - ER or CM	…
1	0	1	1	0	1	
2	0	0	1	1	1	
3	1	1	1	1	0	
4						
5						
6						
7						
8						

In this example, three defined rules are the following ones:

	pipe categories
1	ductile iron pipes
2	open cut is not relevant / this pipe
3	burst rate > 0,05

For this example, pipe cc_16=[1,3], the result will be the following one :

0	1	1	0	0	
No	Yes	Yes	No	No	

That means that for this pipe, techniques 2-OC DI (Open cut replacement with ductile iron pipe) and 3 – SL (Sliplining) are relevant.

WATER LOSSES INDEX (WLI)

1) RANKING OF ZONAL PROBLEMS

For a level at which data are available (such as District Meter Area [UK], or Water Supply Zone, calculate the leakage cost, testing against a threshold, , i.e.

Leakage (l/connection/day) / 10^3 (litre/m^3) * MCW (€/m^3) > λ (€/connection/day) ?

MCW is the marginal cost of water (see 3.1.2.2. Energy costs)
At the same level, calculate an average repair rate (number/km/year) and test against a suitable threshold, μ, e.g. 0.4 repairs/km/yr.
This will give you the following table:

	Leakage Cost (€/connection/day)	Exceeds threshold?	Repairs Rate (no./km/yr)	Exceeds threshold?
Zone 1	1.4	Yes	0.9 μ	No
Zone 2		No	1.2 μ	Yes
Zone 3	0.8	No	0.7 μ	No
…				

Zones could be placed, using their threshold exceedance, into RED (Yes x 2), AMBER (Yes x 1), and GREEN (No x 2) categories:

	FR(z) failure rate > μ	**FR(z) failure rate < μ**
LC(z) Leakage cost > λ	**RED category**	**AMBER category**
LC(z) Leakage cost < λ	**AMBER category**	**GREEN category**

2) RANKING OF PIPE CONTRIBUTIONS TO WATER LOSSES

Each pipe can be evaluated in using the priority class of the corresponding zone, and the performance indicators Op26_link, Op27_link and Op5_link.

WATER LOSSES INDEX (WLI) / KB5

CRITERION

WLI(i)

Index: [0, 1] coming from KB5

KNOWLEDGE BASE FOR CRITERION WLI (examples)

The code of categories could be assigned to pipes in using the CARE_W central database.
For pipes / FR > *x* & Real Losses (Zone) > *y* code C_WLI = 3

Advises for the definition of scores:

Example 1

KB5	WLI - Contribution to leakage	
C_WLI	Index ε [0,1]	description
1	0	unknown
2	0.5	The pipe contributes to water losses
3	1	The pipe certainly contributes to serious water losses

Index = WLI(i)

Example 2

KB5	WLI - Contribution to leakage	
C_WLI	Index ε [0,1]	description
1	0	unknown
2	0	none
3	0.1	The pipe certainly contributes to low water losses
4	0.5	The pipe certainly contributes to medium water losses
5	1	The pipe certainly contributes to high water losses

PREDICTED WATER INTERRUPTION (PWI) / KB7

CRITERION

$$PWI(i) = PBR(i) \times EDI(i) \times NPS(i)$$

Units: (No./100m/year) x (hours) x (persons)

With :

PBR(i) Predicted Burst Rate for pipe *i* (No./100m/year)

EDI(i) Expected Duration of Interruption … (hours) **KB7**

NPS(i) Number of Customers Supplied by the pipe, within a length of pipes between two valves (persons)

KNOWLEDGE BASE FOR CRITERION PWI (examples)

Example 1

1) Information coming from CARE_W Central database

Pipe ID	C_EDI
110	1
23	4
5	2
72	2
…	

2) Knowledge Base to be defined by the end-user in CARE_W_ARP tool

KB7	EDI - Expected duration of interruption	
C_EDI	hours	description
1	3	unknown
2	2	low
3	5	medium
4	10	high

3) EDI used to calculate PWI(i)

Pipe ID	EDI
110	3 hours
23	10 hours
5	2 hours
72	2 hours
…	

Example 2

KB7	EDI - Expected duration of interruption	
C_EDI	hours	description
1	3	Mean duration of interruption

SeePCcriterion PCWI

PREDICTED CRITICAL WATER INTERRUPTION (PCWI) / KB7

CRITERION

$$PCWI(i) = PBR(i) \times EDI(i) \times SC(i)$$

Units: (No./100m/year) x (hours)

With :

PBR(i) Predicted Burst Rate for pipe *i* (No./100m/year)

EDI(i) Expected Duration of Interruption, depending of the diameter, the type of failure… (hours) **KB7**

SC(i) Degree of Sensitivity of Customers supplied by the pipe, [0,1]

KNOWLEDGE BASE FOR CRITERION PCWI (examples)

Example 1

1) Information coming from CARE_W Central database

Pipe ID	C_EDI
110	1
23	4
5	2
72	2
…	

2) Knowledge Base to be defined by the end-user in CARE_W_ARP tool

KB7	EDI - Expected duration of interruption	
C_EDI	hours	description
1	3	unknown
2	2	low
3	5	medium
4	10	high

3) EDI used to calculate PCWI(i)

Pipe ID	EDI
110	3 hours
23	10 hours
5	2 hours
72	2 hours
…	

Example 2

KB7	EDI - Expected duration of interruption	
C_EDI	hours	description
1	3	Mean duration of interruption

See PF criterion PFWI

PREDICTED FREQUENCY OF WATER INTERRUPTION (PFWI) / KB7

CRITERION

$$PFWI(i) = Li(i)/100 \times PBR(i) \times EDI(i)$$

Units: (Hours) / (Year)

With :

L(i) is the Length of pipe *i* (m)

PBR(i) Predicted Burst Rate for pipe *i* (No./100m/year)

EDI(i) is the Expected Duration of Interruption, depending of the diameter, the type of failure… (hours) **KB7**

KNOWLEDGE BASE FOR CRITERION PFWI (examples)

Example 1

1) Information coming from CARE_W Central database

Pipe ID	C_EDI
110	1
23	4
5	2
72	2
…	

2) Knowledge Base to be defined by the end-user in CARE_W_ARP tool

KB7	EDI - Expected duration of interruption	
C_EDI	hours	description
1	3	unknown
2	2	low
3	5	medium
4	10	high

3) EDI used to calculate PFWI(i)

Pipe ID	EDI
110	3 hours
23	10 hours
5	2 hours
72	2 hours
…	

Example 2

KB7	EDI - Expected duration of interruption	
C_EDI	hours	description
1	3	Mean duration of interruption

See DFH criterion DFH

DAMAGES DUE TO FLOODING IN HOUSING AREAS (DFH) / KB8

CRITERION

$$DFH(i) = PBR(i) \times D(i)^2 \times P(i) \times SFH(i)$$

Units: (No./100m/year) x (mm^2 . MPa)

With :

PBR(i) Predicted Burst Rate for pipe i (No./100m/year)

$D(i)^2P(i)$ = $[Diameter(i)]^2$ Pressure(i) (Aggravating factors associated with bursts)

SFH(i) $\in$ [0,1] a value representing the Sensitivity to Flooding of Housing areas **KB8**

KNOWLEDGE BASE FOR CRITERION DFH (examples)

Example 1

1) Information coming from CARE_W Central database

Pipe ID	C_SFH
10	1
3	2
21	3
…	

2) Knowledge Base to be defined by the end-user in CARE_W_ARP tool

KB8	SFH - Sensitivity of housing areas to flooding or KB13 & KB14	
C_SFH	Index ε [0,1]	description
1	0	low
2	0.4	medium
3	1	high

3) SFH used to calculate DFH(i)

Pipe ID	SFH
10	0
3	0.4
21	1
…	

Example 2

1) Information coming from CARE_W Central database

2) Knowledge Base to be defined by the end-user in CARE_W_ARP tool

3) SFH used to calculate DFH(i)

Pipe ID	C_SFH
10	1
3	1
21	2
…	

KB8	SFH - Sensitivity of housing areas to flooding or KB13 & KB14	
C_SFH	Index ε [0,1]	description
1	0	low
2	1	high

Pipe ID	SFH
10	0
3	0
21	1
…	

SeeDFH_Vul *an other calculation method for criterion DFH*

DAMAGES DUE TO FLOODING IN HOUSING AREAS (DFH) / KB13 – KB14

CRITERION

$$DFH(i) = PBR(i) \times D(i)^2 \times P(i) \times IFH(i) \times VFH(i)$$

Units: (No./100m/year) x (mm^2 . MPa)

With :

PBR(i) Predicted Burst Rate for pipe i (No./100m/year)

$D(i)^2P(i)$ = [Diameter(i)]^2 Pressure(i) (Aggravating factors associated with bursts)

IFH(i) $\in$ [0,1] a value representing the Intensity of Flooding of Housing areas **KB13**

VFH(i) $\in$ [0,1] a value representing the Vulnerable values in Housing areas **KB14**

KNOWLEDGE BASE FOR CRITERION DFH (example)

1) Information coming from CARE_W Central database

Pipe ID	C_IFH
10	1
3	3
21	2
…	

Pipe ID	C_VFH
10	7
3	3
21	6
…	

2) Knowledge Base to be defined by the end-user in CARE_W_ARP tool

KB13	IFH - Intensity factor Flooding in housing areas	
C_IFH	Index $\in$ [0,1]	description
1	0	low: no basement, grown floor above soil
2	0.4	medium: no basement, grown floor below soil
3	1	high: basement

KB14	VFH - Vulnerable values in housing areas	
C_VFH	Index $\in$ [0,1]	description
1	0.69	individual housing with retail shop
2	0.65	individual housing with retail shop, allotments
3	0.65	rural housing
4	0.56	collective buildings with numerous flats
5	1	attached houses of small height
6	1	attached collective buildings of small height
7	0	no housing

3) IFH & VFH used to calculate DFH(i)

Pipe ID	IFH
10	0
3	1
21	0.4
…	

Pipe ID	VFH
10	0
3	0.65
21	1
…	

DAMAGES DUE TO FLOODING IN INDUSTRIAL OR COMMERCIAL AREAS (DFI) / KB9

CRITERION

$$DFI(i) = PBR(i) \times D(i)^2 \times P(i) \times SFI(i)$$

Units: (No./100m/year) x (mm^2 . MPa)

With :

PBR(i) Predicted Burst Rate for pipe i (No./100m/year)

$D(i)^2P(i)$ = [Diameter(i)]^2 Pressure(i) (Aggravating factors associated with bursts)

SFI(i) $\in$ [0,1] a value representing the Sensitivity to Flooding of Industrial or commercial areas) **KB9**

KNOWLEDGE BASE FOR CRITERION DFI (examples)

Example 1

1) Information coming from CARE_W Central database

Pipe ID	C_SFI
10	1
2	1
3	1
21	2
…	

2) Knowledge Base to be defined by the end-user in CARE_W_ARP tool

KB9	SFI - Sensitivity of industrial areas to flooding or KB13 & KB15	
C_SFI	Index ε [0,1]	description
1	0.1	low
2	1	high

3) SDI used to calculate DFI(i)

Pipe ID	SFI
10	0.1
2	0.1
3	0.1
21	1
…	

Example 2

1) Information coming from CARE_W Central database

2) Knowledge Base to be defined by the end-user in CARE_W_ARP tool

3) SDI used to calculate DFI(i)

Pipe ID	C_SFI
10	1
2	2
3	2
21	3
…	

KB9	SFI - Sensitivity of industrial areas to flooding or KB13 & KB15	
C_SFI	Index ε [0,1]	description
1	0	low
2	0.4	medium
3	1	high

Pipe ID	SFI
10	0
2	0.4
3	0.4
21	1
…	

See DFI_Vul *an other calculation method for criterion DFI*

DAMAGES DUE TO FLOODING IN INDUSTRIAL OR COMMERCIAL AREAS (DFI) / KB13B – KB15

CRITERION

$$DFI(i) = PBR(i) \times D(i)^2 \times P(i) \times IFI(i) \times VFI(i)$$

Units: (No./100m/year) x (mm^2 . MPa)

With :

PBR(i) Predicted Burst Rate for pipe i (No./100m/year)

$D(i)^2P(i)$ = [Diameter(i)]^2 Pressure(i) (Aggravating factors associated with bursts)

IFI(i) $\in$ [0,1] a value representing the Intensity of Flooding in Industrial or commercial areas **KB13-b**

VFI(i) $\in$ [0,1] a value representing the Intensity of Flooding in Industrial or commercial areas **KB15**

KNOWLEDGE BASE FOR CRITERION DFI (example)

1) Information coming from CARE_W Central database

Pipe ID	C_IFI
10	1
2	1
3	1
21	2
…	

2) Knowledge Base to be defined by the end-user in CARE_W_ARP tool

KB13-b	IFI - Intensity factor Flooding in industrial or commercial areas	
C_IFI	Index ε [0,1]	description
1	0.7	no significant soil slope
2	1	significant soil slope

3) IFI & VFI used to calculate DFI(i)

Pipe ID	IFI
10	0.7
2	0.7
3	0.7
21	1
…	

Pipe ID	C_VFI
10	1
2	2
3	7
21	5
…	

KB15	Vulnerable values in industrial/commercial areas	
C_VFI	Index $_{\varepsilon}$ [0,1]	description
1	0.03	open air storage
2	0.15	education buildings
3	0.15	industries allotment
4	0.2	sports halls
5	0.22	wide industrial site
6	0.23	big stores
7	0.4	industrial plant
8	1	offices

Pipe ID	VFI
10	0.03
2	0.15
3	0.40
21	0.22
…	

SeeDSMcriterion DSM

DAMAGES DUE TO SOIL MOVEMENT (DSM) / KB 10

CRITERION

$$DSM(i) = PFR(i) \times D(i)^2 \times P(i) \times LS(i)$$

Units: (No./100m/year) x (mm^2 . MPa)

With :

PFR(i) Predicted Failure Rate for pipe i (No./100m/year)

$D(i)^2P(i)$ = [Diameter(i)]^2 Pressure(i) (Aggravating factors associated with failures)

LS(i) $\in$ [0,1] a factor quantifying the possibility of Landslide due to water movement **KB10**

KNOWLEDGE BASE FOR CRITERION DSM (examples)

Example 1

1) Information coming from CARE_W Central database

Pipe ID	C_LS
11	1
12	2
13	1
23	2
…	

2) Knowledge Base to be defined by the end-user in CARE_W_ARP tool

KB10	LS - Risk of Landslides	
C_LS	Index ε [0,1]	description
1	0.1	low
2	1	high

3) LS used to calculate DSM(i)

Pipe ID	LS
11	0.1
12	1
13	0.1
23	1
…	

Example 2

1) Information coming from CARE_W Central database

2) Knowledge Base to be defined by the end-user in CARE_W_ARP tool

3) LS used to calculate DSM(i)

Pipe ID	C_LS
11	1
12	2
13	1
23	3
…	

KB10	LS - Risk of Landslides	
C_LS	Index ε [0,1]	description
1	0	low
2	0.4	medium
3	1	high

Pipe ID	LS
11	0
12	0.4
13	0
23	1
…	

SeeDTcriterion DT

TRAFFIC DISRUPTION (TD) / KB11

CRITERION

$$DT(i) = PFR(i) \times SR(i)$$

Units: (No./100m/year)

With :

PFR(i) Predicted Failure Rate for pipe i (No./100m/year)

SR(i) [0,1] a factor quantifying the importance of the road **KB11**

KNOWLEDGE BASE FOR CRITERION DSM (examples)

Example 1

1) Information coming from CARE_W Central database

Pipe ID	C_SR
11	1
12	2
13	1
23	2
…	

2) Knowledge Base to be defined by the end-user in CARE_W_ARP tool

KB11	SR - Street category factor	
C_SR	Index ε [0,1]	description
1	0.1	low traffic density
2	1	high traffic density

3) SR used to calculate DT(i)

Pipe ID	SR
11	0.1
12	1
13	0.1
23	1
…	

Example 2

1) Information coming from CARE_W Central database

2) Knowledge Base to be defined by the end-user in CARE_W_ARP tool

3) SR used to calculate DT(i)

Pipe ID	C_SR
11	1
12	2
13	1
23	3
…	

KB11	SR - Street category factor	
C_SR	Index ε [0,1]	description
1	0	no traffic
2	0.4	low traffic density
3	0.7	medium traffic density
4	1	high traffic density

Pipe ID	SR
11	0
12	0.4
13	0
23	0.7
…	

See DDI criterion DDI

DAMAGES AND/OR DISRUPTION ON OTHER INFRASTRUCTURES (DDI) / KB12

CRITERION

$$DDI(i) = PBR(i) \times D(i)^2 \times P(i) \times SI(i)$$

Units: (No./100m/year) x (mm^2 . MPa)

With :

PBR(i) Predicted Burst Rate for pipe i (No./100m/year)

$D(i)^2P(i)$ = [Diameter(i)]^2 Pressure(i) (Aggravating factors associated with bursts)

IF(i) $\in$ [0,1] a factor quantifying the sensitivity of urban infrastructure close to the pipe **KB12**

KNOWLEDGE BASE FOR CRITERION DDI (examples)

Example 1

1) Information coming from CARE_W Central database

Pipe ID	C_SI
11	1
12	2
13	1
23	2
…	

2) Knowledge Base to be defined by the end-user in CARE_W_ARP tool

KB12	SI - Parallel infrastructure factor	
C_SI	Index ε [0,1]	description
1	0.1	low
2	1	high

3) SI used to calculate DDI(i)

Pipe ID	SI
11	0.1
12	1
13	0.1
23	1
…	

Example 2

1) Information coming from CARE_W Central database

2) Knowledge Base to be defined by the end-user in CARE_W_ARP tool

3) SI used to calculate DDI(i)

Pipe ID	C_SI
11	1
12	2
13	1
23	3
…	

KB12	SI - Parallel infrastructure factor	
C_SI	Index ε [0,1]	description
1	0	low
2	0.4	medium
3	1	high

Pipe ID	SI
11	0
12	0.4
13	0
23	1
…	

See WQD criterion WQD

WATER QUALITY DEFICIENCY (WQD)

Criteria:
The **fulfilment of EC-water quality norms** and the **number of complaints** should be used as two independent criteria for water network rehabilitation. They should be judged against conditions relevant for the network, i.e.

- hydraulic functionality (detention time, pipe velocity, max velocity pr day),
- infiltration of pollution,
- Interaction water/pipe material.

Since the effect of hydraulic detention time and the interaction between water quality and pipe material strongly depends on the raw water quality, it is not advisable to create general rules for the interaction between water quality and pipe materials. The rehab planning should consequently be based on water quality monitoring.

The general rules for applying water quality criteria for rehabilitation could thus be:

- If the EC-norms for water quality are not fulfilled, and the reason is detention time, then a rehab plan to improve the hydraulic performance should be initiated.
- If the EC-norms for water quality are not fulfilled, and the reason is interaction water/pipe material, then the sites of interaction should be defined and concrete measures evaluated.
- If the EC-norms for water quality are not fulfilled, and the reason is infiltrated pollution, then the sites of infiltration should be defined and concrete measures evaluated.
- If level of water quality complaints are unacceptable, and the reason is detention time, than a rehab plan to improve the hydraulic performance should be initiated.
- If level of water quality complaints are unacceptable, and the reason is interaction water/pipe material, then the sites of interaction should be defined and concrete measures evaluated.
- If the level of water complaints is unacceptable, and the reason is infiltrated pollution, then the sites of infiltration should be defined and concrete measures evaluated.

The annual rehab planning should be assisted by a program of water quality monitoring and a computer network model. The water quality monitoring programme should include pH, Calcium, alkalinity, iron, lead, bacteria etc. depending on the local conditions. The computer model should be used for analysis of detention time and max daily velocity of each pipe.
The water quality monitoring programme will, as well as PI on quality complaints, give information on a **zone level**. In the next turn, this information has to be transferred to the **pipe level**, to define candidates for rehabilitation. The hydraulic model with the data on water velocity and detention time will be an important tool in this process, together

with information on pipe material, construction year, previous leakage and structures (valves, pipes) vulnerable with regard to infiltration of pollution.

WATER QUALITY DEFICIENCY (WQD) / KB6

CRITERION

WQD (i)

Index [0, 1] coming from **KB6**

KNOWLEDGE BASE FOR CRITERION WQD (EXAMPLES)

The code of categories could be assigned to pipes in using the CARE_W central database. For pies / FR > … and Real Losses (Zone) > … the code C_WLI= 3

Advises for the definition of scores:

Example 1

KB6	WQD - Contribution to Water quality deficiencies	
C_WQD	Index ε [0,1]	description
1	0	unknown
2	0	none
3	0.1	low
4	0.5	medium
5	0.9	high

Example 2

KB6	WQD - Contribution to Water quality deficiencies	
C_WQD	Index ε [0,1]	description
1	0	low or unknown
2	0.9	high

See HCI criterion HCI

HYDRAULIC CRITICALITY INDEX (HCI)

CRITERION

HCI (i)

Index [0, 1]

HCI(i) a value [0, 1] given by reliability modules (an index can be calculated for each pipe representing its criticality).

ELECTRE TRI : OUTRANKING METHOD

The outranking ELECTRE TRI method prioritises pipes by comparing each possible action with reference profiles (*Fig.1*).

In Care-W_ARP, three categories are defined in a hierarchical order by two reference profiles (b1 & b2) from category C3, for the best option, to category C1, the category for options which are "not so good" (*Fig* .1).

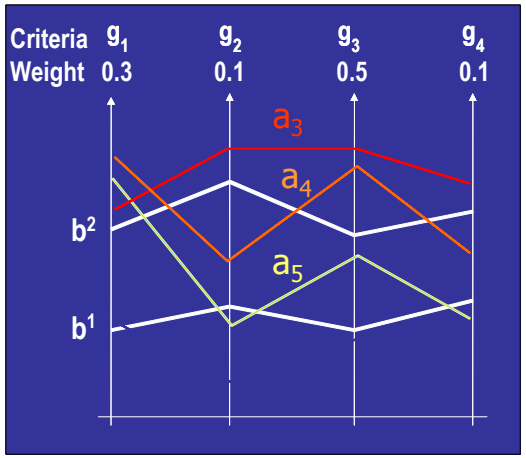


Fig.1: Reference Profiles / Action Profiles

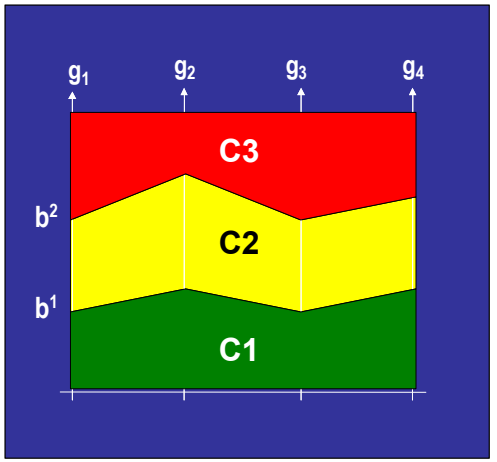


Fig.2: 2 Reference Profiles / 3 hierarchical categories

For the assignment of an action *a* to a category Cak, *a* is compared successively to the two reference profiles.

The comparison is used in two complementary procedures: an "optimistic procedure" (OP) and a "pessimistic procedure" (PP).

The two procedures applied to a given set of candidates lead to a result illustrated with opposite figure (*Fig.3*)

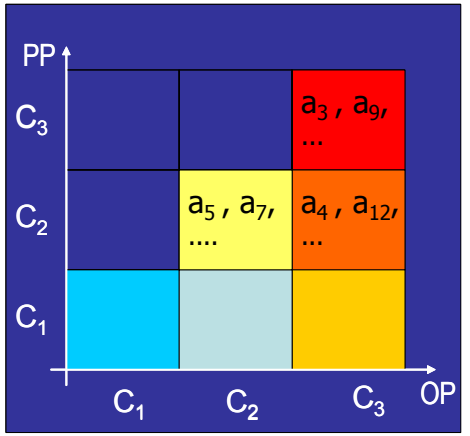


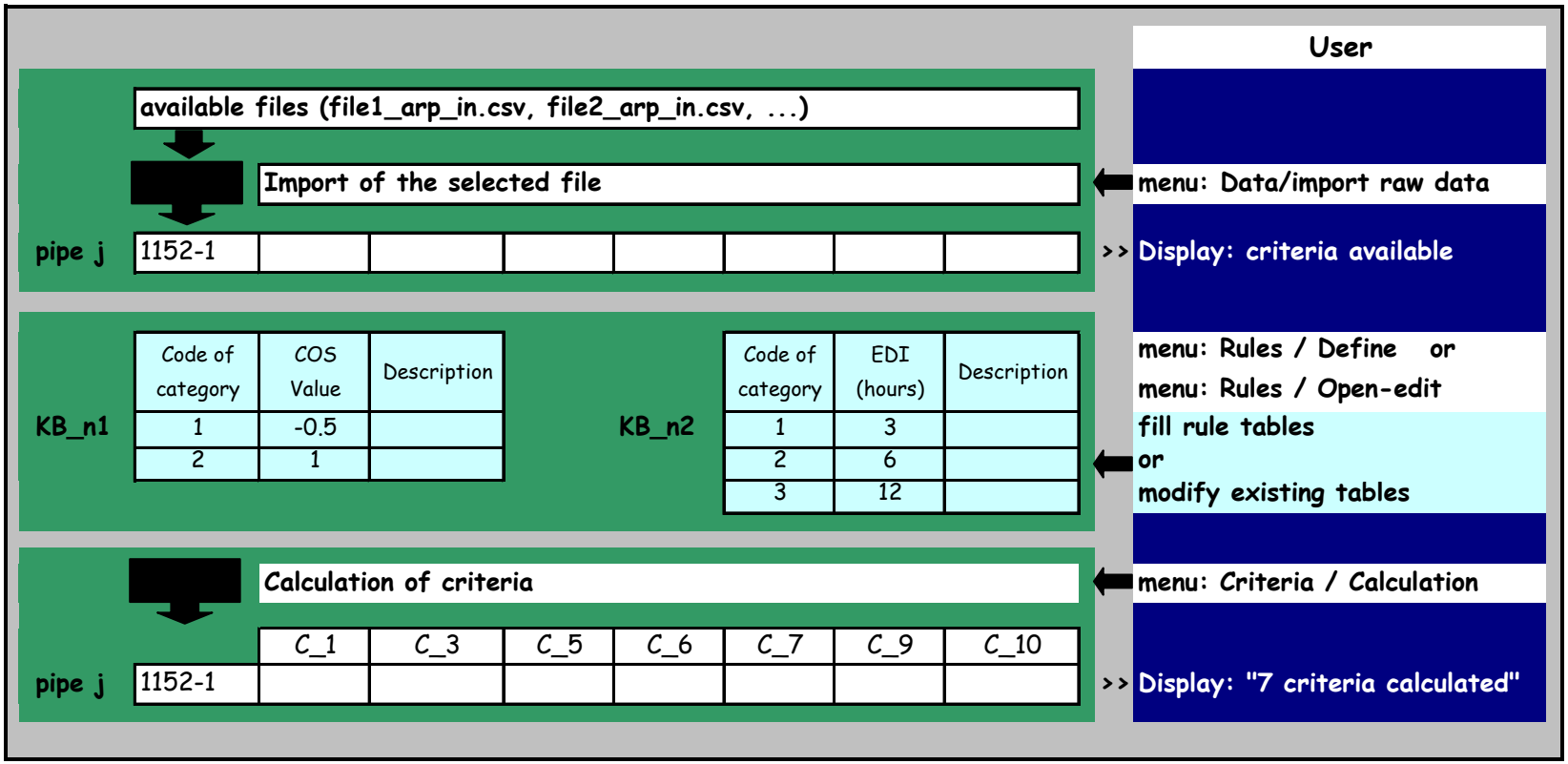
Fig.3: Pipes assignment

PRACTICAL ASPECTS – USER GUIDE

Overview

Data :	Load data & calculate criteria
Parameters :	Define PARAMETERS for ELECTRE_TRI
Ranking :	ELECTRE_TRI: Ranking in assigning each pipe in one of 6 categories
Hot-Spots :	Hot-spots (unacceptable deficiencies / deficiencies exceeding a threshold)
Compare rankings :	Visualisation of Sensitivity analysis with ELECTRE_TRI

DATA : LOAD DATA & CALCULATE MULTICRITERIA PROFILES



Data (Input file)
>> Care-W_ARP screen view

Knowledge Bases / Rules
>> Care-W_ARP screen view

Calculation of criteria
>> Care-W_ARP screen view

DATA

File : **file_arp_in.csv,** generated by the CARE_W central database

Input file description

ID; L; M; D; P; NPS; SC; C-COS; C-UCRp; C-UCRh; *C-CF*; C-WLI; C-WQD; C-EDI; C-SFH; C-SFI; C-LS; C-SR; C-SI; C-IF; C-VFH; C-VFI; Info1; Info2; Info3; Info4; Info5; PBR; PFR; HCI

Where :

ID	User Reference (Pipe Id)
L	Length (m)
M	Material
D	Diameter (nominal) (mm)
P	Average Working Pressure (MPa) used to calculated criteria : DFH(i), DFI(i), DSM(i)
NPS	Number of People Supplied (Number of people connected to adjacent pipes between 2 valves) used to calculate criterion : PWI(i)
SC	Sensitive Customer used to calculate criterion : PCWI(i)
C-COS	Code of category used in KB1 to calculate criterion : COS
C-UCRp	Code of category used in KB2 to calculate criterion : ARC(i)
C-UCRh	Code of category used in KB3
C-CF	*Not used in this version*
C-WLI	Code of category used in KB5 to calculate criterion : WLI(i)
C-WQD	Code of category used in KB6 to calculate criterion : WQD(i)
C-EDI	Code of category used in KB7 to calculate criteria : PWI(i), PCWI(i),PFWI(i)
C-SFH	Code of category used in KB8 to calculate criterion : DFH(i)
C-SFI	Code of category used in KB9 to calculate criterion : DFI(i)
C-LS	Code of category used in KB10 to calculate criterion : DSM(i)
C-SR	Code of category used in KB11 to calculate criterion : DT(i)
C-SI	Code of category used in KB12 to calculate criterion : DDI(i)
C-IF	Code of category used in KB13 to calculate criterion : DFH(i)
C-VFH	Code of category used in KB14 to calculate criterion : DFH(i)

C-VFI	Code of category used in KB15 to calculate criterion : DFI(i)
Info1	Criterion calculated by another tool (imported in CARE_W)
Info2	idem
Info3	Idem
Info4	Idem
Info5	Idem

are coming from the Pipe table (so far as they are available for each pipe)

Prototype parameter	**WP3_in.csv**
PBR	Predicted Burst Rate, used to calculate criteria : PWI(i), PCWI(i),PFWI(i), DFH(i), DFI(i), DDI(i)
PFR	Predicted Failure Rate, used to calculate criteria : ARC(i), DSM(i), DT(i)
HCI	Hydraulic Criticality Index

are coming from the Pipe_Output table (so far as they are available for each pipe)

Example for incomplete data

ID	L	M	D	P	NPS	SC	PBR	PFR	C-WLI	C-EDI	C-LS	C-SR	Info1
E1	109.45	GG	100	0.4	59	0	0.03	0.03	1	1	1	2	-1975
E2	133.04	GG	150	0.4	37	0	0.03	0.03	1	1	2	2	-1975
E126	420.52	GG	150	0.4	257	0	0.03	0.03	1	1	1	3	-1979
E127	31.6	GG	150	0.4	4	0	0.03	0.03	1	1	1	2	-1979
E128	151.62	GG	150	0.4	83	0	0.03	0.03	1	1	1	2	-1979
E129	27.33	PE	90	0.4	16	0	0.05	0.05	2	1	1	3	-1997
E130	314.57	GG	400	0.4	178	0	0.005	0.005	1	1	1	3	-1970
E137	522.45	GG	250	0.4	372	0	0.01	0.01	1	1	2	4	-1972
…													

For these data, the **example_arp_in.csv** file is :

```
ID;L ;M ;D ;P ;NPS;SC;PBR;PFR;C-WLI;C-EDI;C-LS;C-SR;Info1;;;;;;;;;;;;;;
E1;109.45;GG;100;0.4;59;0;0.03;0.03;1;1;1;2;-1975;;;;;;;;;;;;;;
E2;133.04;GG;150;0.4;37;0;0.03;0.03;1;1;2;2;-1975;;;;;;;;;;;;;;
E126;420.52;GG;150;0.4;257;0;0.03;0.03;1;1;1;3;-1979;;;;;;;;;;;;;;
E127;31.6;GG;150;0.4;4;0;0.03;0.03;1;1;1;2;-1979;;;;;;;;;;;;;;
E128;151.62;GG;150;0.4;83;0;0.03;0.03;1;1;1;2;-1979;;;;;;;;;;;;;;
```

```
E129;27.33;PE;90;0.4;16;0;0.05;0.05;2;1;1;3;-1997;;;;;;;;;;;;;
E130;314.57;GG;400;0.4;178;0;0.005;0.005;1;1;1;3;-1970;;;;;;;;;;;;;;
E137;522.45;GG;250;0.4;372;0;0.01;0.01;1;1;2;4;-1972;;;;;;;;;;;;;;
```

KNOWLEDGE BASES

KB1: Co-ordination Score (COS)

KB2: Unit Cost of Repair (UCRp)

KB3: Unit Cost of Rehabilitation (UCRh)

KB5: Contribution to leakage (WLI)

KB6: Contribution to Water Quality Deficiencies (WQD)

KB7: Expected Duration of Interruption (EDI)

KB8: Sensitivity of housing areas to flooding (or KB 13 & KB 14) (DFH)

KB9: Sensitivity of industrial and commercial areas to flooding (or KB 13 & KB 15) (DFI)

KB10: Risk of landslide (LS)

KB11: Sensitivity of the road (SR)

KB12: Sensitivity of parallel infrastructure (SI)

KB13: Intensity of flooding in housing/industrial/commercial areas (IFH)

KB14: Vulnerable values in housing areas (IFI)

KB15: Vulnerable values in industrial/commercial areas (VFI)

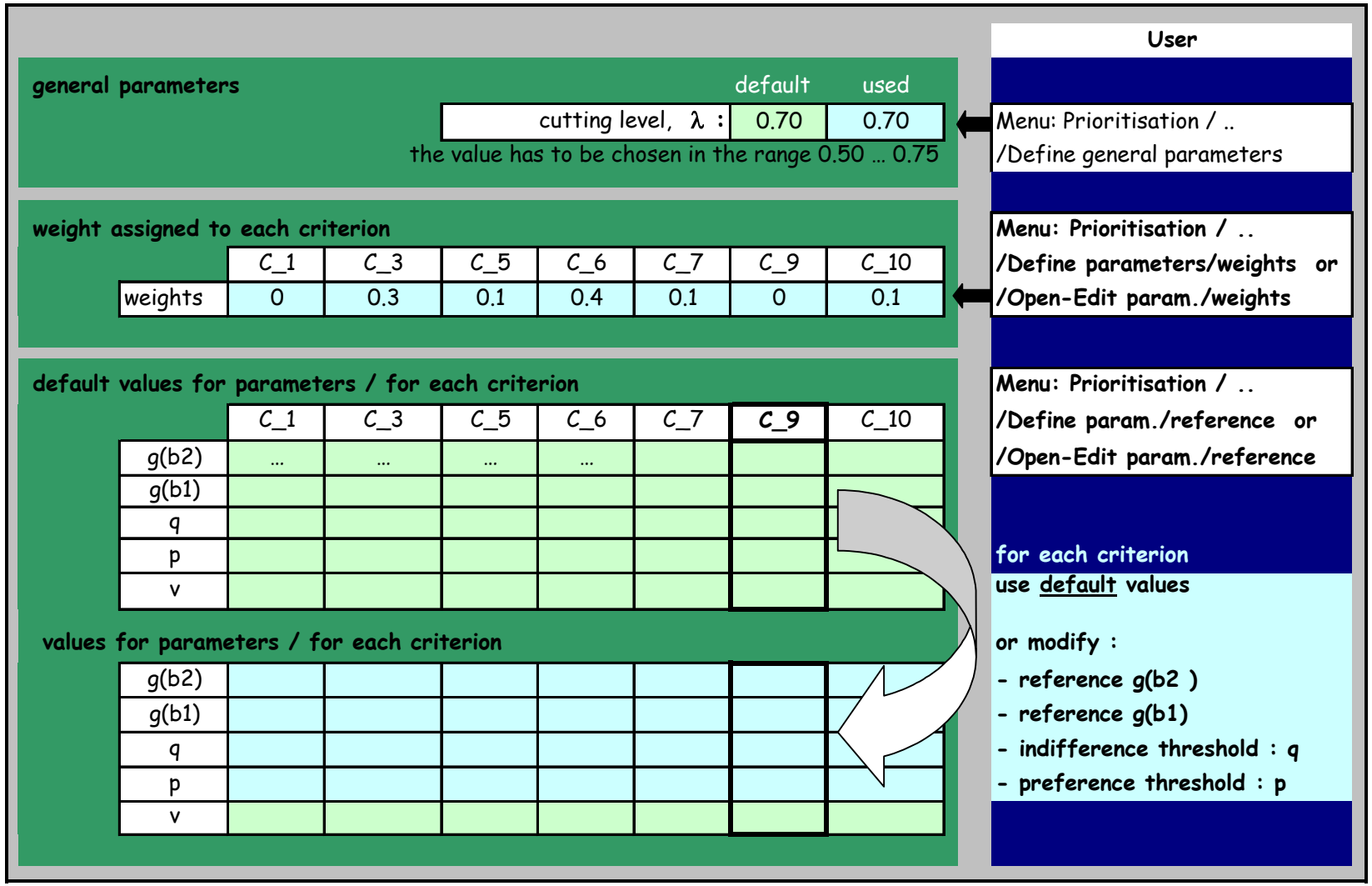
KB16: Rehabilitation Rules / Relevant Technique

CRITERIA CALCULATION

CRITERIA

Co-ordination Score	COS	Score [-1,1]
Annual Repair Cost	ARC	ARC(i) = PFR(i) x UCRp(i)
Water Losses Index	WLI	Index [0,1]
Predicted Water Interruptions	PWI	PWI(i) = PBR(i) x EDI(i) x NPS(i)
Predicted Critical Water Interruptions	PCWI	PCWI(i) = PBR(i) x EDI(i) x SC(i)
Predicted Frequency of Water Interruptions	PFWI	PFWI(i) = Li(i)/100 x PBR(i) x EDI(i)
Damages due to Flooding in Housing area	DFH	DFH(i) = PBR(i) x $D(i)^2$ x P(i) x SFH(i)
	DFH	DFH(i) = PBR(i) x $D(i)^2$ x P(i) x IFH(i) x VFH(i)
Damages due to Flooding in Industrial or commercial areas	DFI	DFI(i) = PBR(i) x $D(i)^2$ x P(i) x SFI(i)
	DFI	DFI(i) = PBR(i) x $D(i)^2$ x P(i) x IFI(i) x VFI(i)
Damages due to Soil Movement	DSM	DSM(i) = PFR(i) x $D(i)^2$ x P(i) x LS(i)
Traffic Disruption	DT	DT (i) = PFR(i) x SR(i)
Damages and/or Disruption on other Infrastructure	DDI	DDI(i) = PBR(i) x $D(i)^2$ x P(i) x SI(i)
Water Quality Deficiencies	WQD	Index [0,1]
Hydraulic Criticality Index	HCI	Index [0,1]

PARAMETERS: DEFINE PARAMETERS FOR RANKING WITH ELECTRE_TRI



>> Care-W_ARP screen view

Define weights

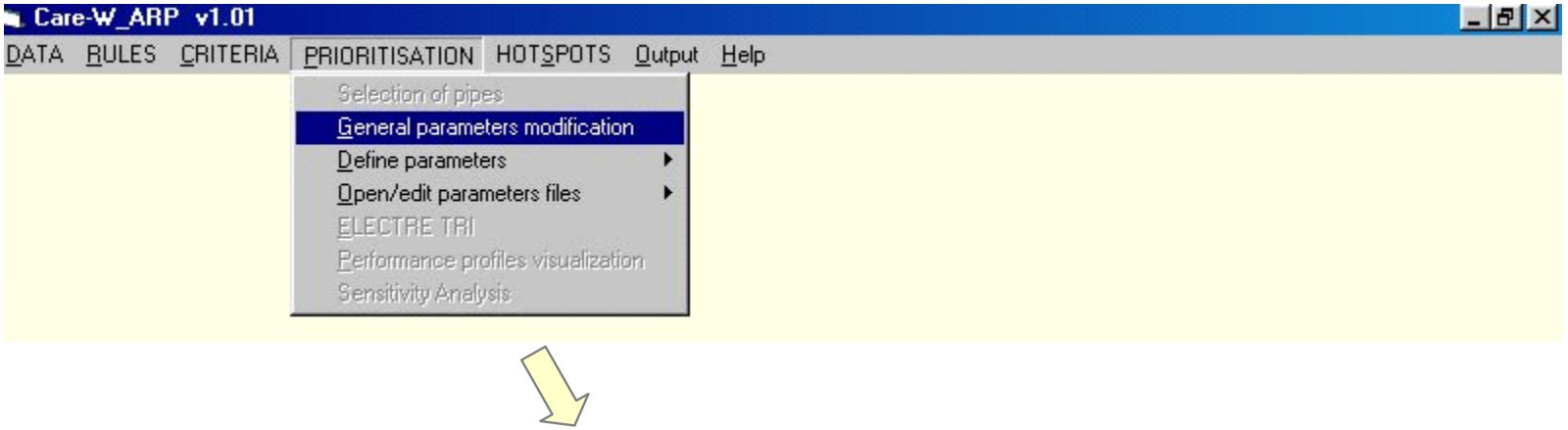
>> Care-W_ARP screen view

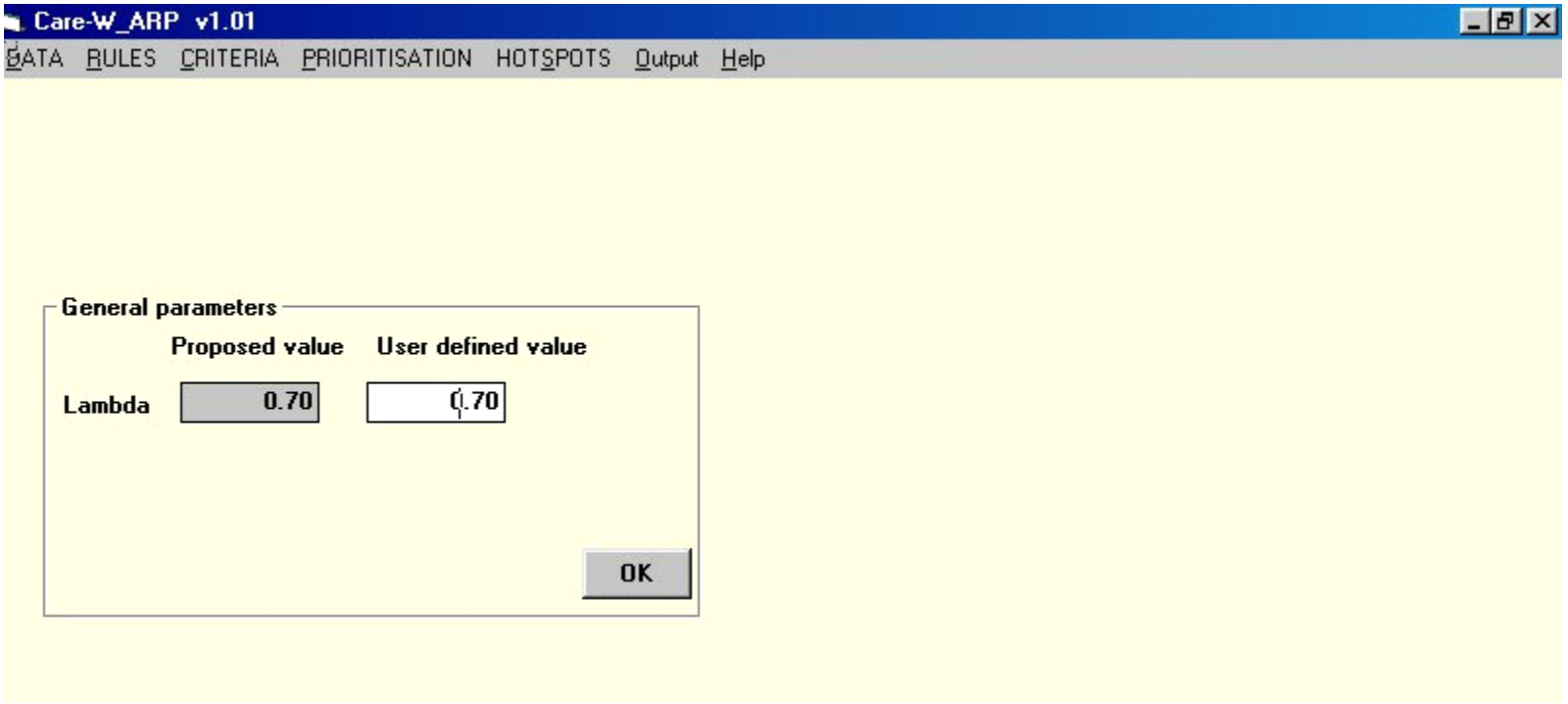
Define Reference profiles & other parameters for ELECTRE

>> Care-W_ARP screen view

EXAMPLE 1: NEW PROJECT

PRIORITISATION / DEFINE GENERAL PARAMETERS



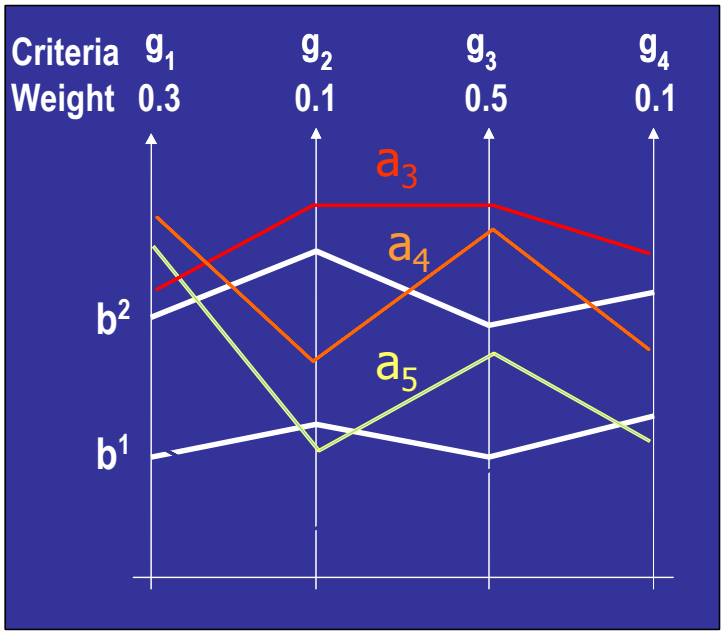

Care-W_ARP v1.01
DATA RULES CRITERIA PRIORITISATION HOTSPOTS Output Help
General parameters
Proposed value
User defined value
Lambda
0.70
0.70
OK

DEFINE WEIGTHS FOR ELECTRE TRI

copie d'écran

poids / point de vue
poids à l'intérieur d'un point de vue

variantes

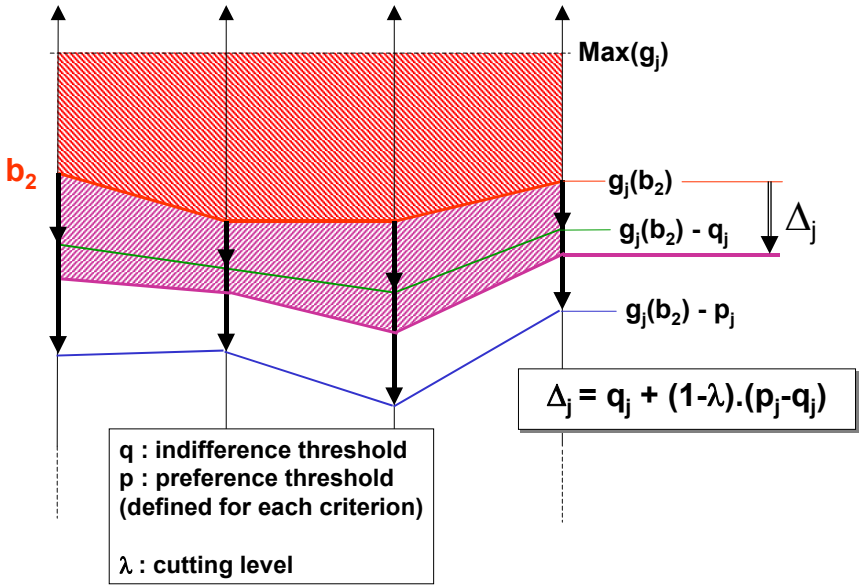


DEFINE REFERENCE PROFILES & INTERNAL PARAMETERS (q, p, v) FOR ELECTRE TRI

For each criterion, **q** & **p** thresholds have to be defined by users in order to represent **imprecision** associated with the calculation of the criterion and/or with the user's judgement. (see D7 report)

These parameters determine the width Δ of a band. Profiles in this band will be indifferent with ***b2***. (see examples presented below)

Δ is depending on λ (cutting level) which is a general parameter of ELECTRE TRI. Relevant values for λ are in the range [0.5, 0.75].

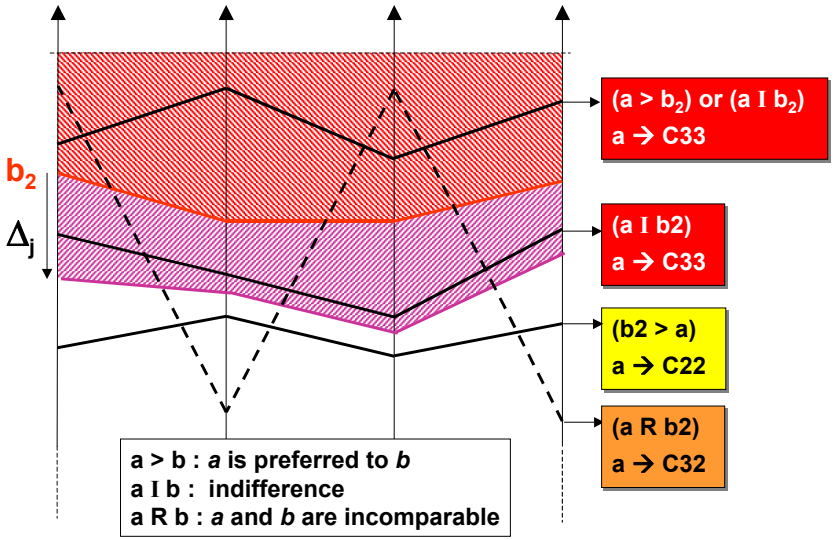


Example with 4 criteria

These thresholds are used by the ELECTRE TRI procedure when defining the relationship between an action ***a*** and a reference action ***b*** .

If profile ***a*** is under profile ***b2*** but close to it (band calculated with Δ) then the procedure will lead to the conclusion that **a is indifferent with b2**.

Action ***a*** will be assigned in C33.



Relationship between ***a*** and ***b2***: 4 possible cases
(hypothesis: ***a*** is preferred to ***b1***)

Default values for **q** and **p**

Default values for **q** and **p**
are proposed by the software together with default values for g(b1) and g(b2).
This is done according to the fig.

These values may be modified.
For instance, g(b2) may be raised in order to decrease the number of pipes assigned in C33.

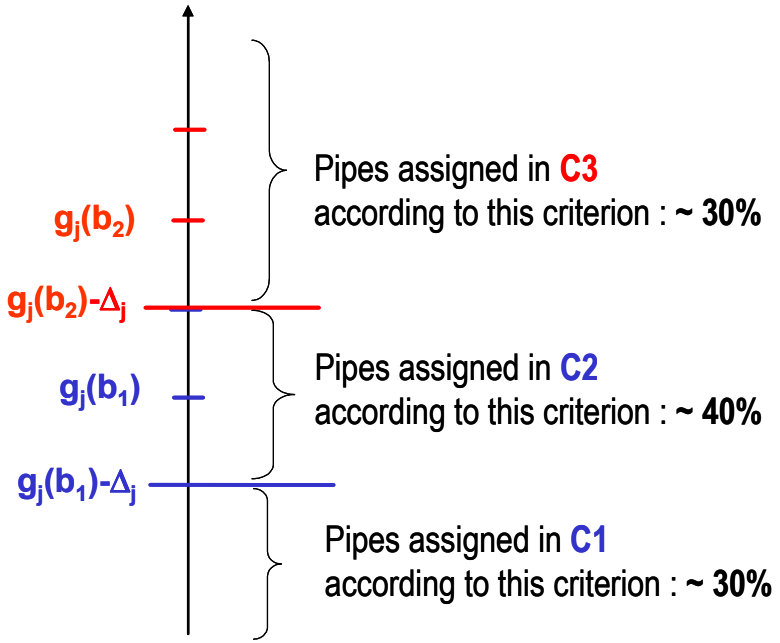
q and p may be reduced, if the imprecision is estimated to be less important.

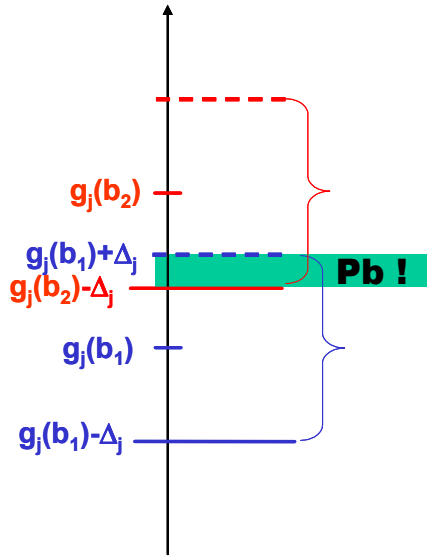
We suggest to use a fixed ratio:

$$p = 2.q$$

We also suggest to use a fixed ratio for v and p:

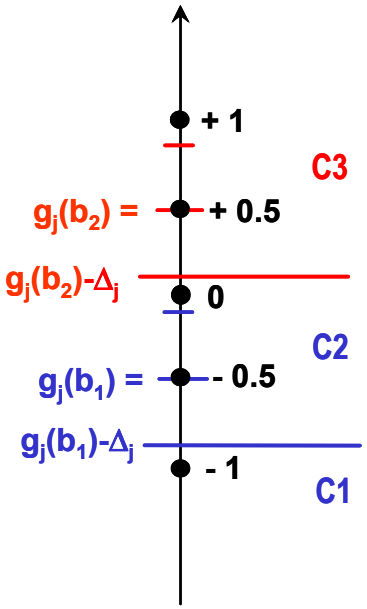
$$v = 3.p$$





Warning: when modifying
g(b2) and/or
g(b1) and/or
p and/or **q**
you have to verify that this combination of parameters is not inconsistent, like for this example.

The 2 indifference bands have to be separated.

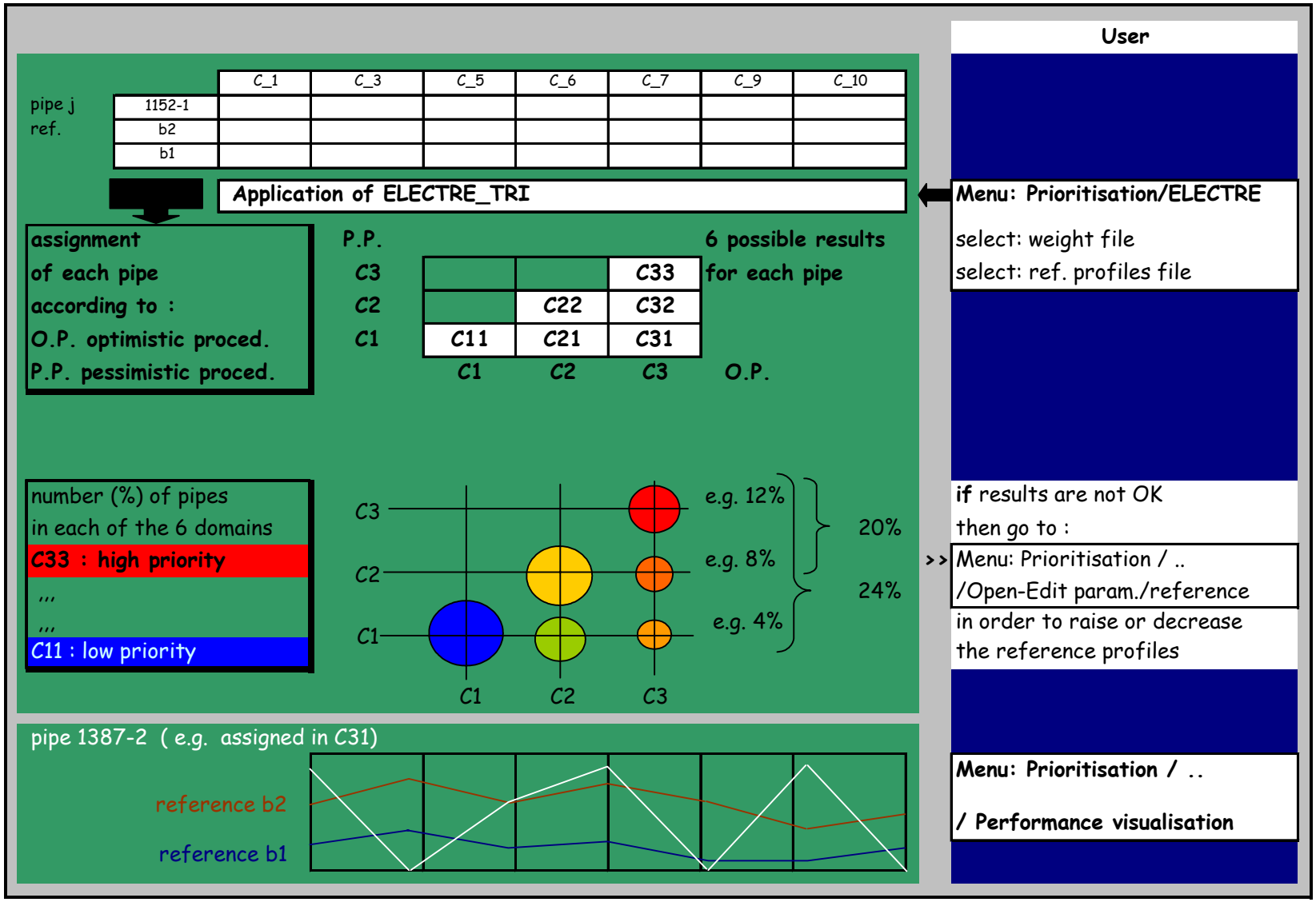


Warning:
For criterion COS (Co-ordination score) we suggest to use the following values:

g(b2) = + 0.5
g(b1) = - 0.5

v = 2
p = 1
q = 0.3

RANKING : ELECTRE_TRI: RANKING IN ASSIGNING EACH PIPE IN ONE OF 6 CATEGORIES

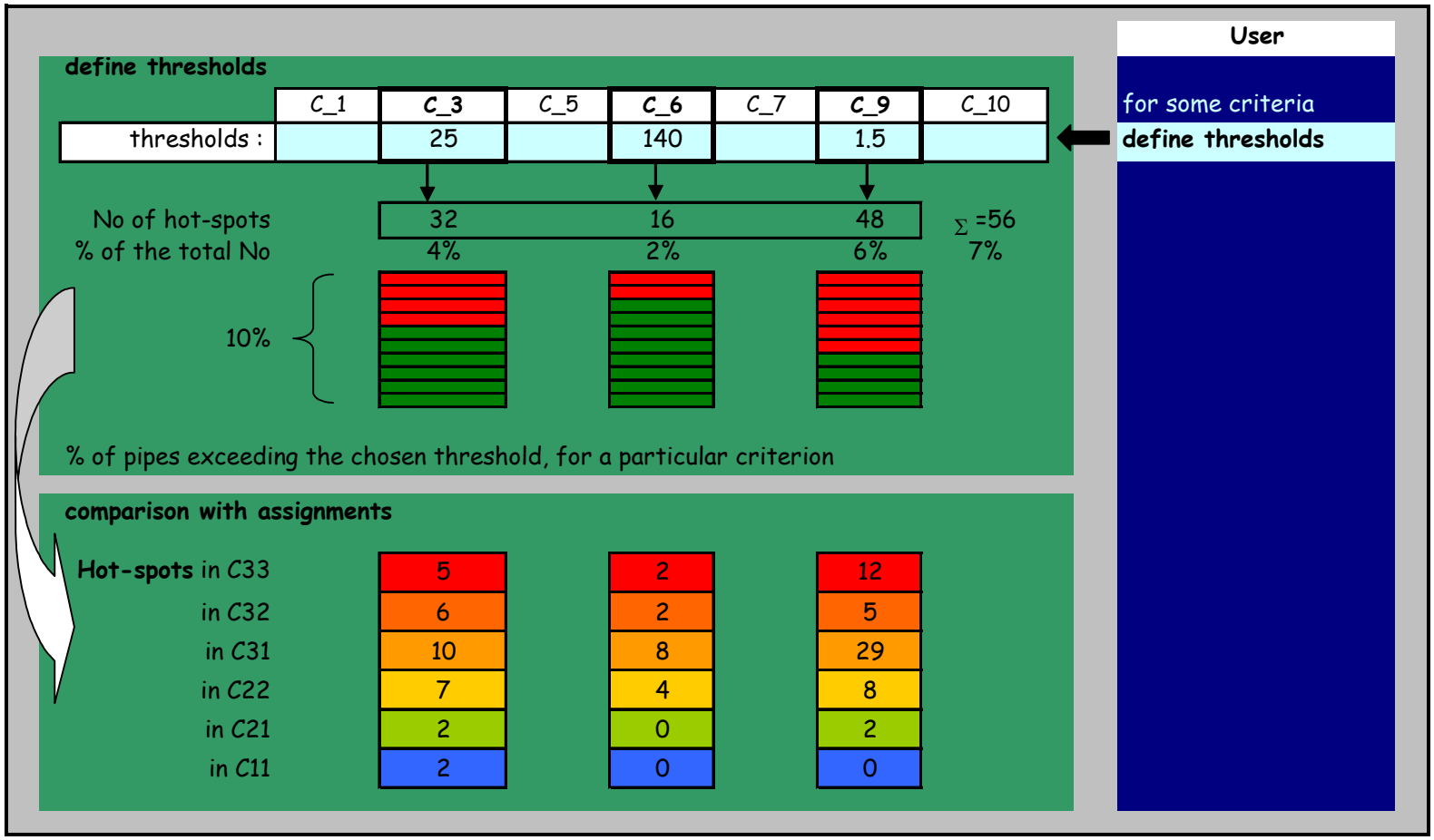


ELECTRE Tri

>> Care-W_ARP screen view

Parameters

HOT-SPOTS



Define Thresholds

>>Care-W_ARP screen view

If run ELECTRE TRI

>>Care-W_ARP screen view

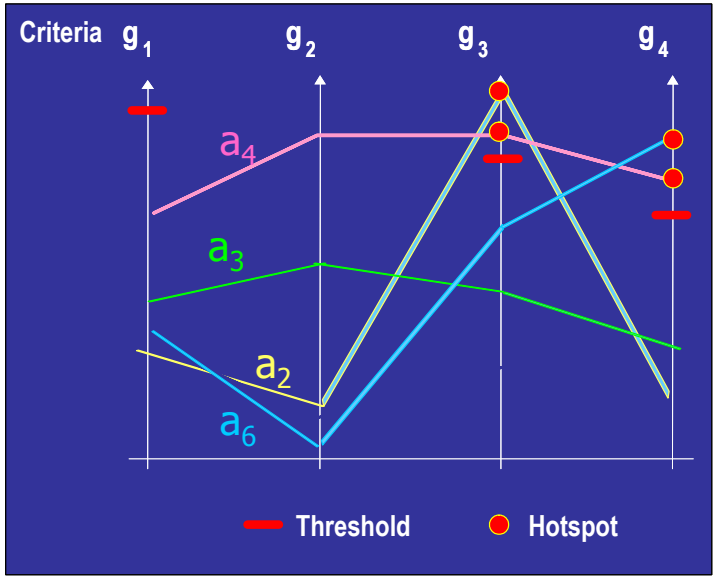
HOT-SPOTS

A hot-spot is a pipe for which a particular criterion value is exceeding a given threshold.

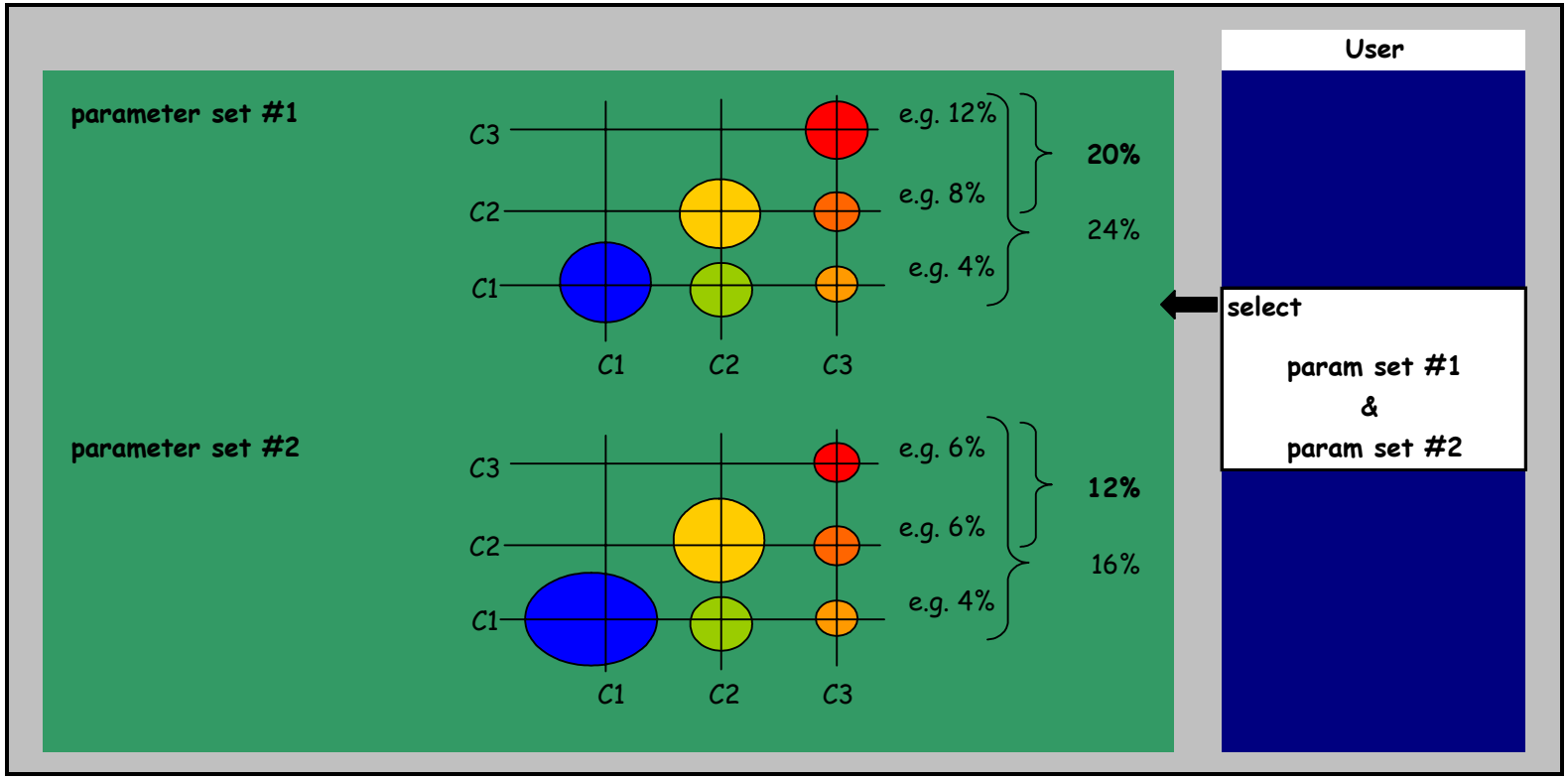
Thresholds have to be defined by the water utility in order to express **unacceptable performance deficiencies**.

We suggest to use this approach as a complementary tool to ELECTRE TRI:

- "Hot-spots" may be used for some critical criteria (e.g. PCWI, HCI);
- ELECTRE TRI may be used for other criteria.



COMPARE RANKINGS: VISUALISATION OF SENSITIVITY ANALYSIS WITH ELECTRE_TRI



>>Care-W_ARP screen view

EXAMPLE

Example 1 — New project

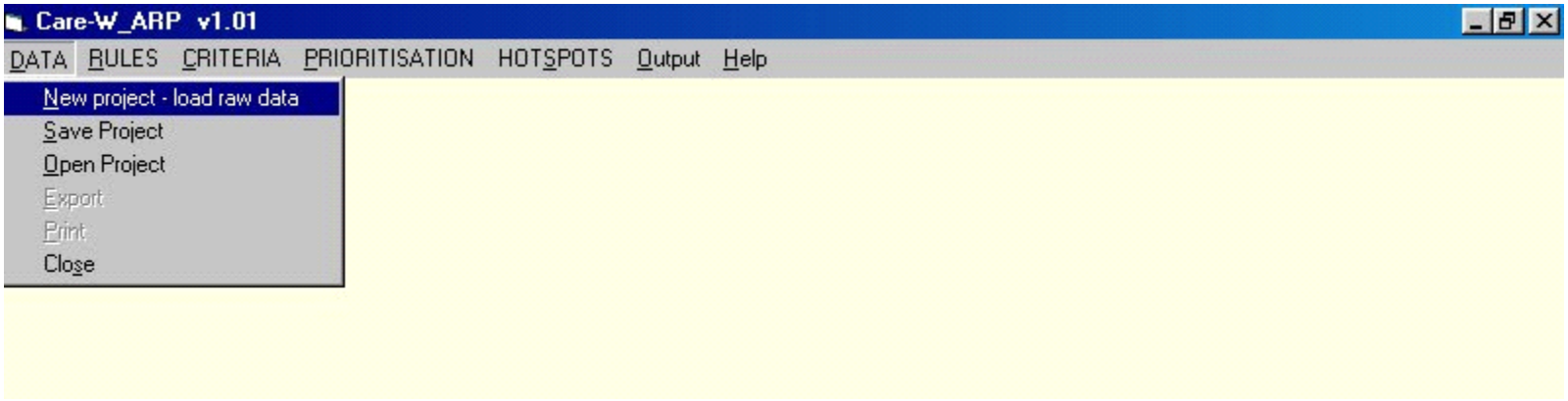
Data	Load data Knowledge bases Calculate criteria Criteria distribution
Parameters	Define PARAMETERS Weights Reference profiles
Ranking	ELECTRE_TRI: Ranking in assigning each pipe in one of 6 categories
Hot-spots	Hot-spots (unacceptable deficiencies – deficiencies exceeding a threshold)
About project	Save project & select result file

Example 2 — Work on an existing project and add simulations

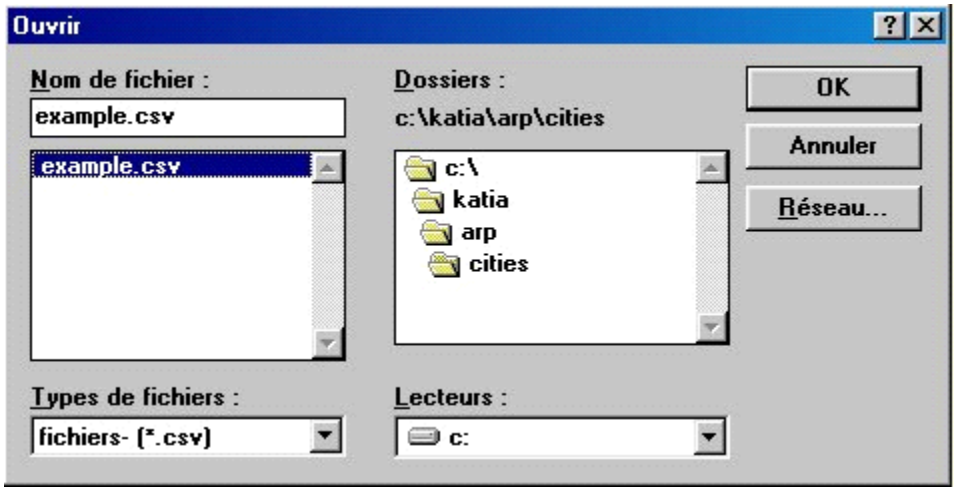
Open project	Open an existing project
Parameters	Define new reference profiles >> Open / Edit parameters
Ranking with new parameters	ELECTRE_TRI
Performance profiles	Visualisation of performance profiles by category
Compare rankings	Visualisation of Sensitivity analysis with ELECTRE_TRI
Export results	Create an output file

EXAMPLE 1: NEW PROJECT

IMPORT RAW DATA >> CREATE A NEW PROJECT

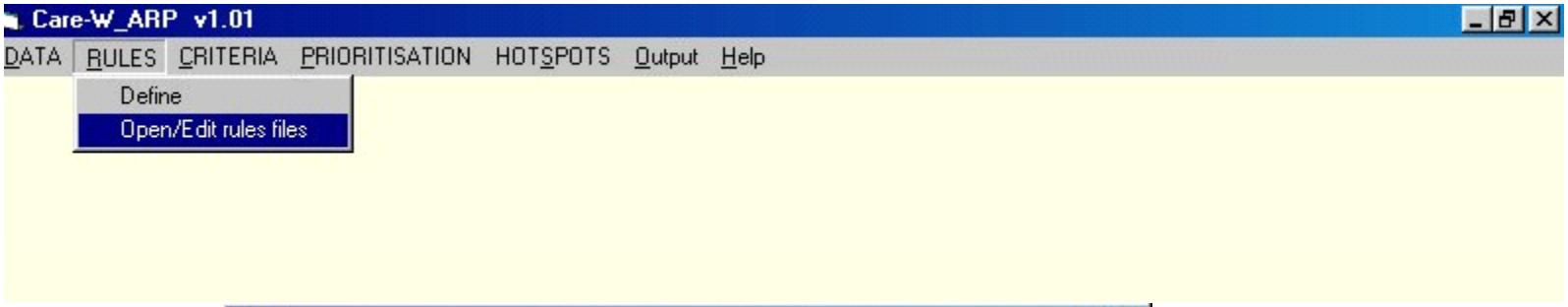


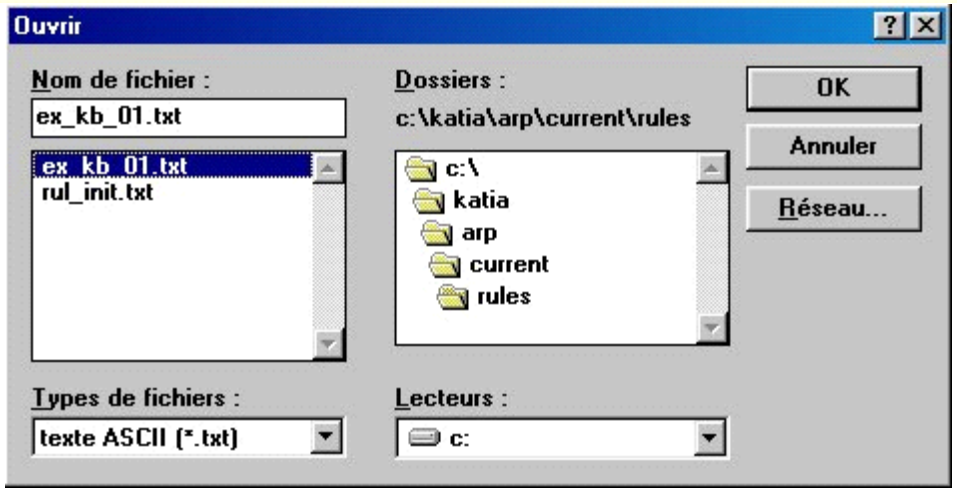
IMPORT RAW DATA >> CHOOSE THE FILE



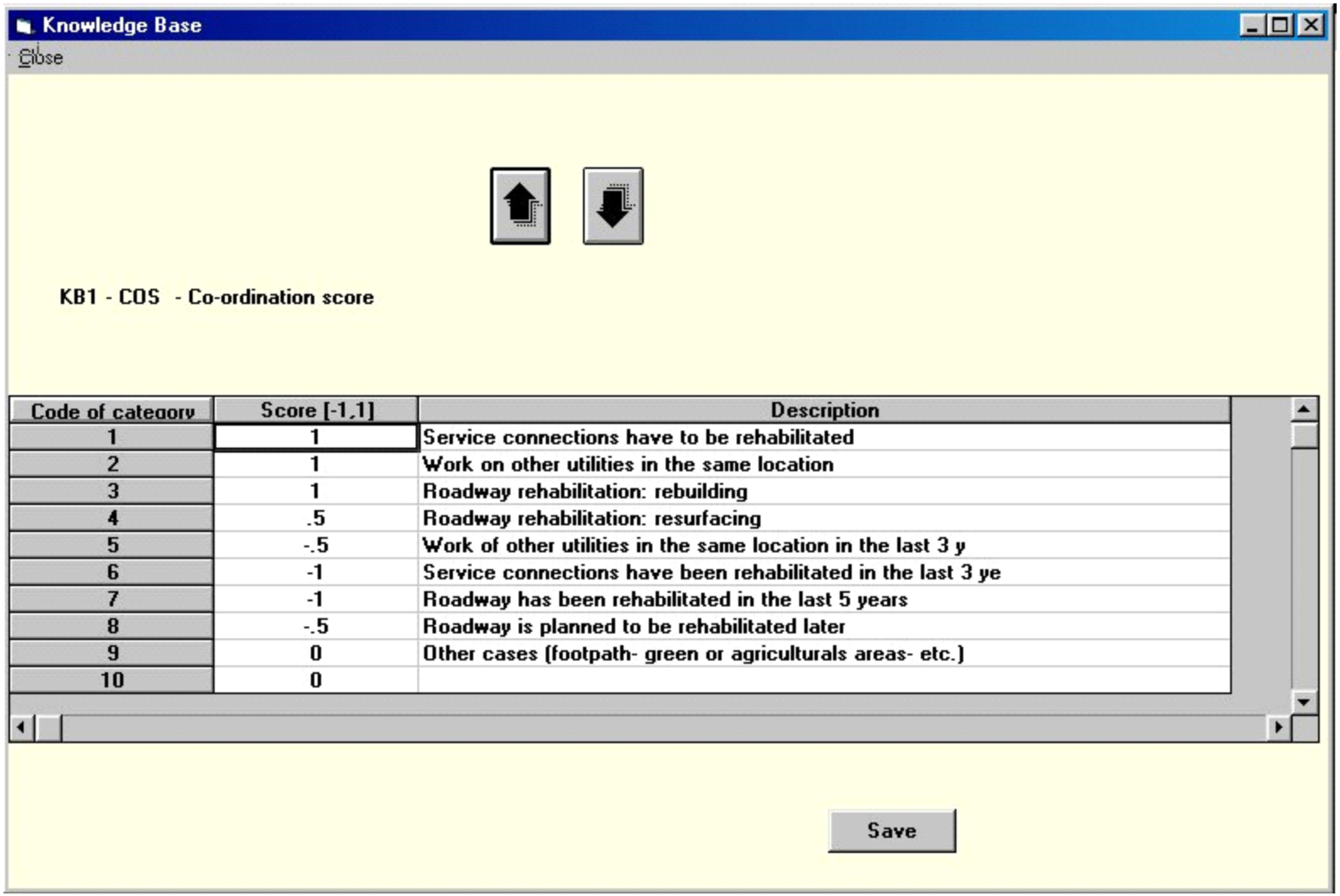
EXAMPLE 1: NEW PROJECT

DEFINE RULES





DEFINE RULES >> EXAMPLE :KNOWLEDGE BASE 1: COS (CO-ORDINATION SCORE)



All knowledge bases

EXAMPLE 1: NEW PROJECT

DEFINE RULES >> ALL KNOWLEDGE BASES

KB1: **COS** (Co-Ordination Score)
KB 2: **UCRp** (Unit Cost of Repair)
KB 5: **WLI** (Water Losses Index)
KB 6: **WQD** (Water Quality Deficiencies)
KB 7: **EDI** (Expected Duration of Interruption)
KB 8: **SFH** (Sensitivity of housing areas to flooding)
KB 9: **SFI** (Sensitivity of industrial & commercial areas to flooding)
KB 10: **LS** (risk of Landslide)
KB 11: **SR** (Sensitivity of the road)
KB 12: **SI** (Sensitivity of parallel infrastructure)
KB 13: **IFH** (Intensity of flooding in housing/industrial/commercial areas)
KB 14: **VFH** (Vulnerable values in housing areas)
KB 15: **VFI** (Vulnerable values in industrial/commercial areas)

EXAMPLE 1: NEW PROJECT

KB1: cos (Co-Ordination Score)

Knowledge Base

Close

KB1 - COS - Co-ordination score

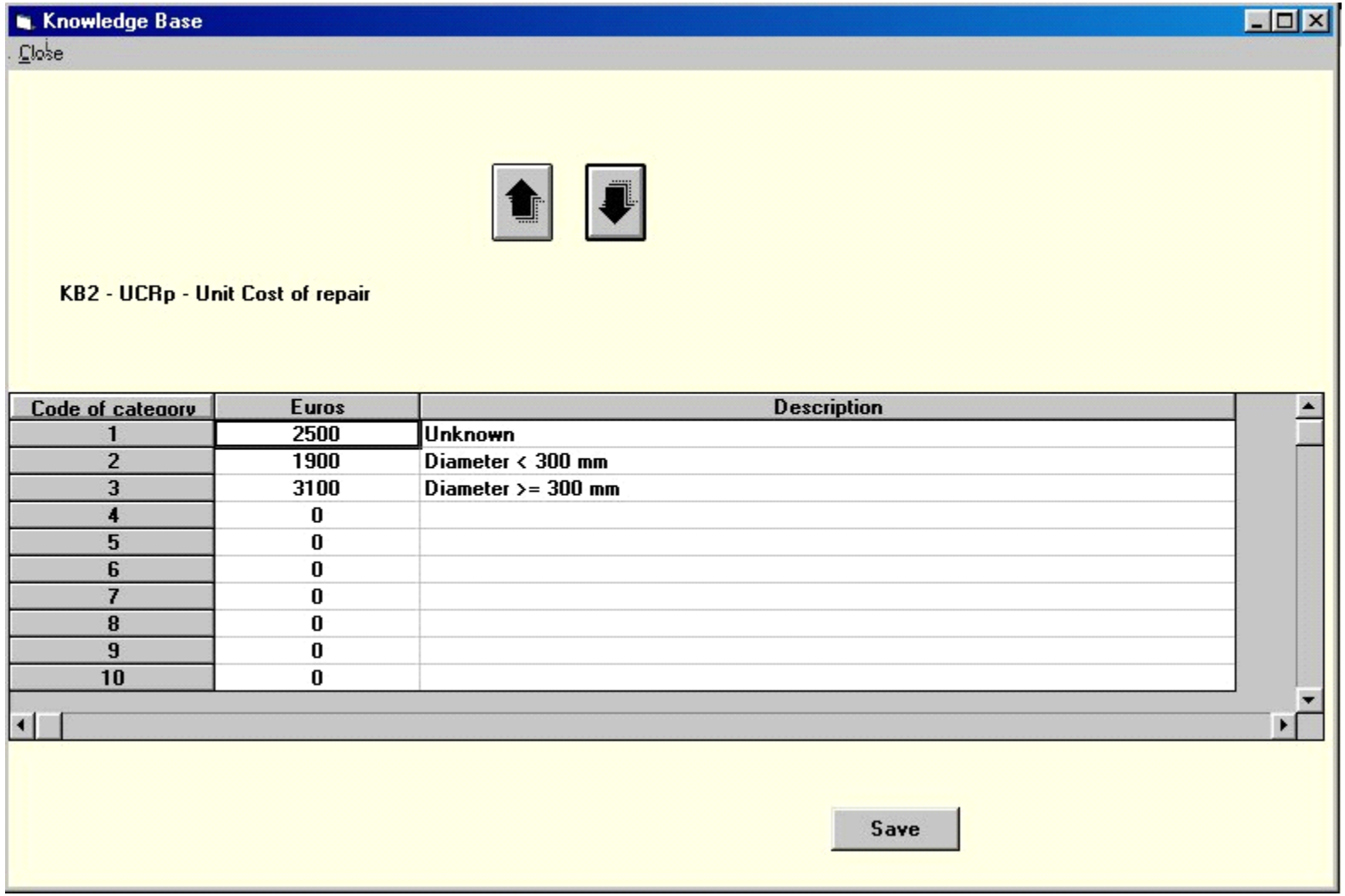
Code of category	Score [-1,1]	Description
1	1	Service connections have to be rehabilitated
2	1	Work on other utilities in the same location
3	1	Roadway rehabilitation: rebuilding
4	.5	Roadway rehabilitation: resurfacing
5	-.5	Work of other utilities in the same location in the last 3 y
6	-1	Service connections have been rehabilitated in the last 3 ye
7	-1	Roadway has been rehabilitated in the last 5 years
8	-.5	Roadway is planned to be rehabilitated later
9	0	Other cases (footpath- green or agriculturals areas- etc.)
10	0	

Save

See Next KB

EXAMPLE 1: NEW PROJECT

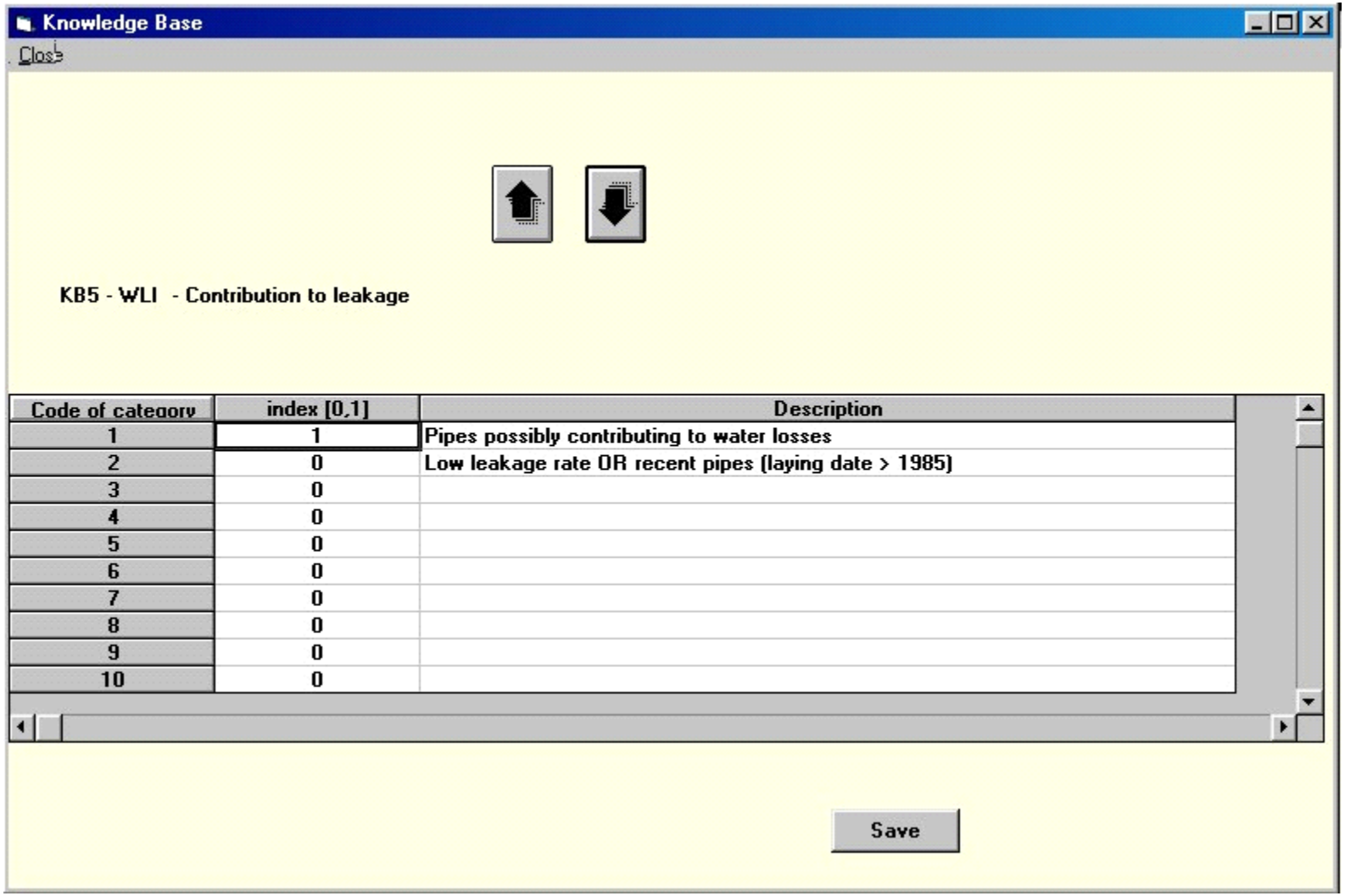
KB 2: UCRP (Unit Cost of Repair)



See Previous KB See Next KB

EXAMPLE 1: NEW PROJECT

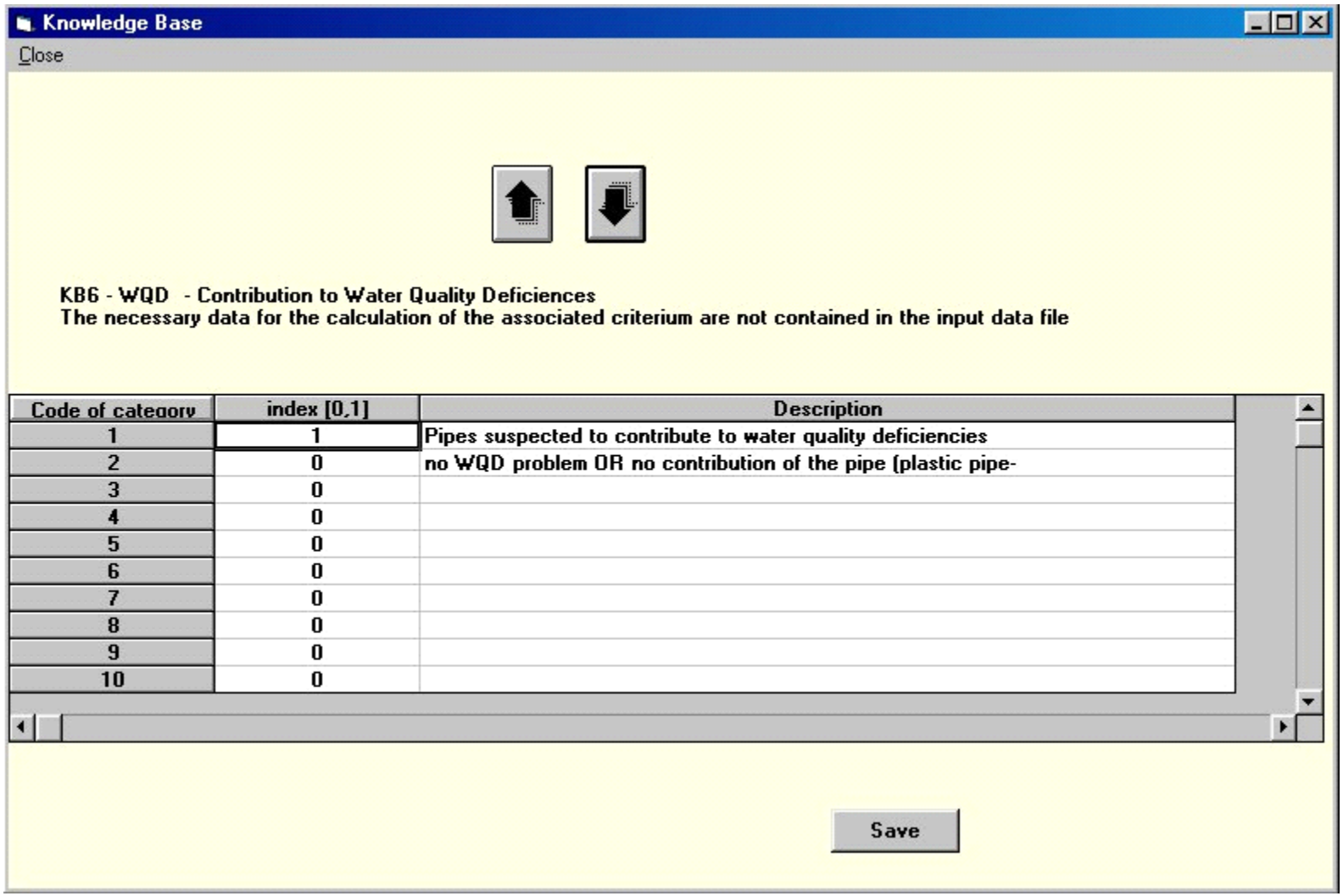
KB 5: WLI (Water Losses Index)



See Previous KB See Next KB

EXAMPLE 1: NEW PROJECT

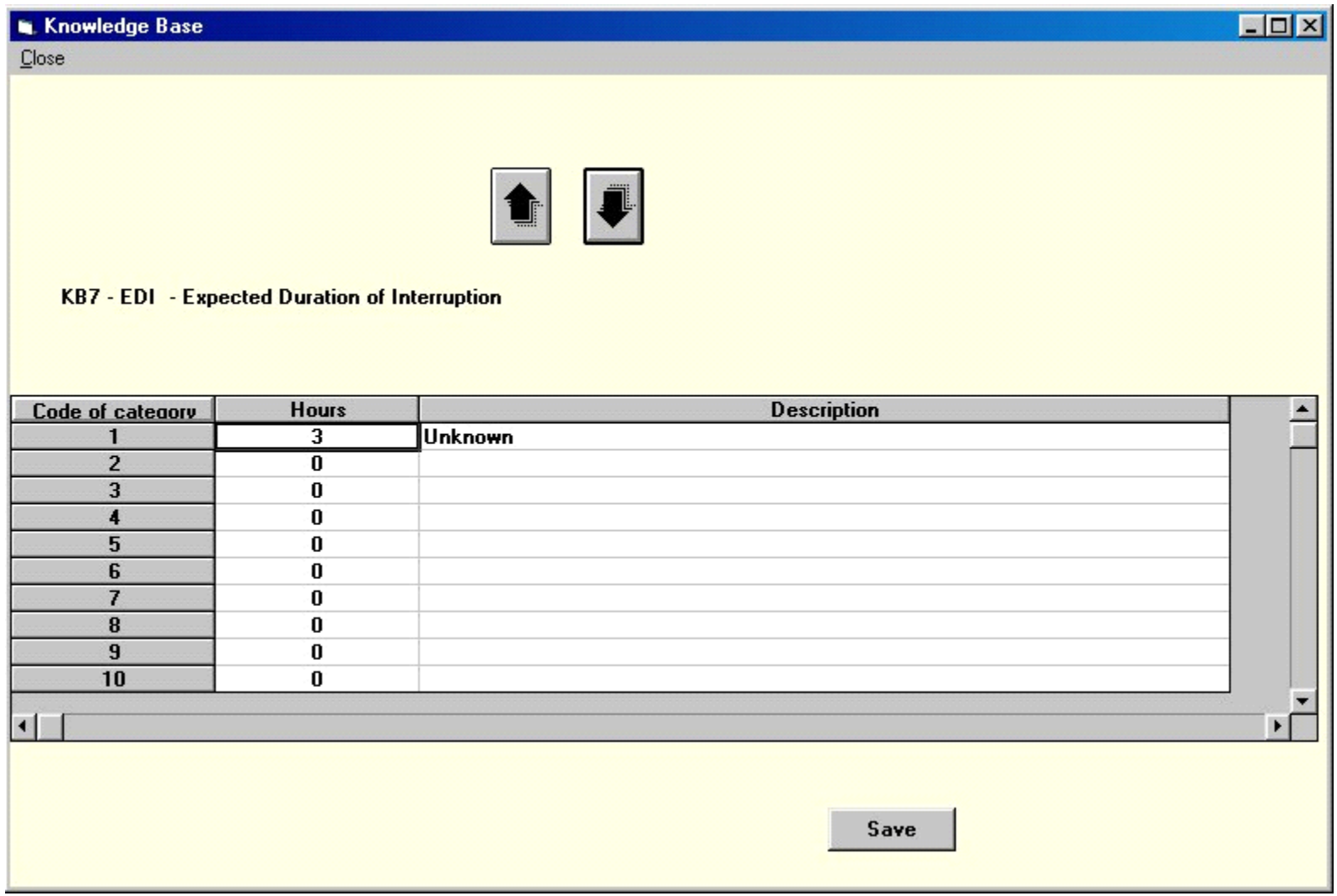
KB 6: WQD (Water Quality Deficiencies)



See Previous KB See Next KB

EXAMPLE 1: NEW PROJECT

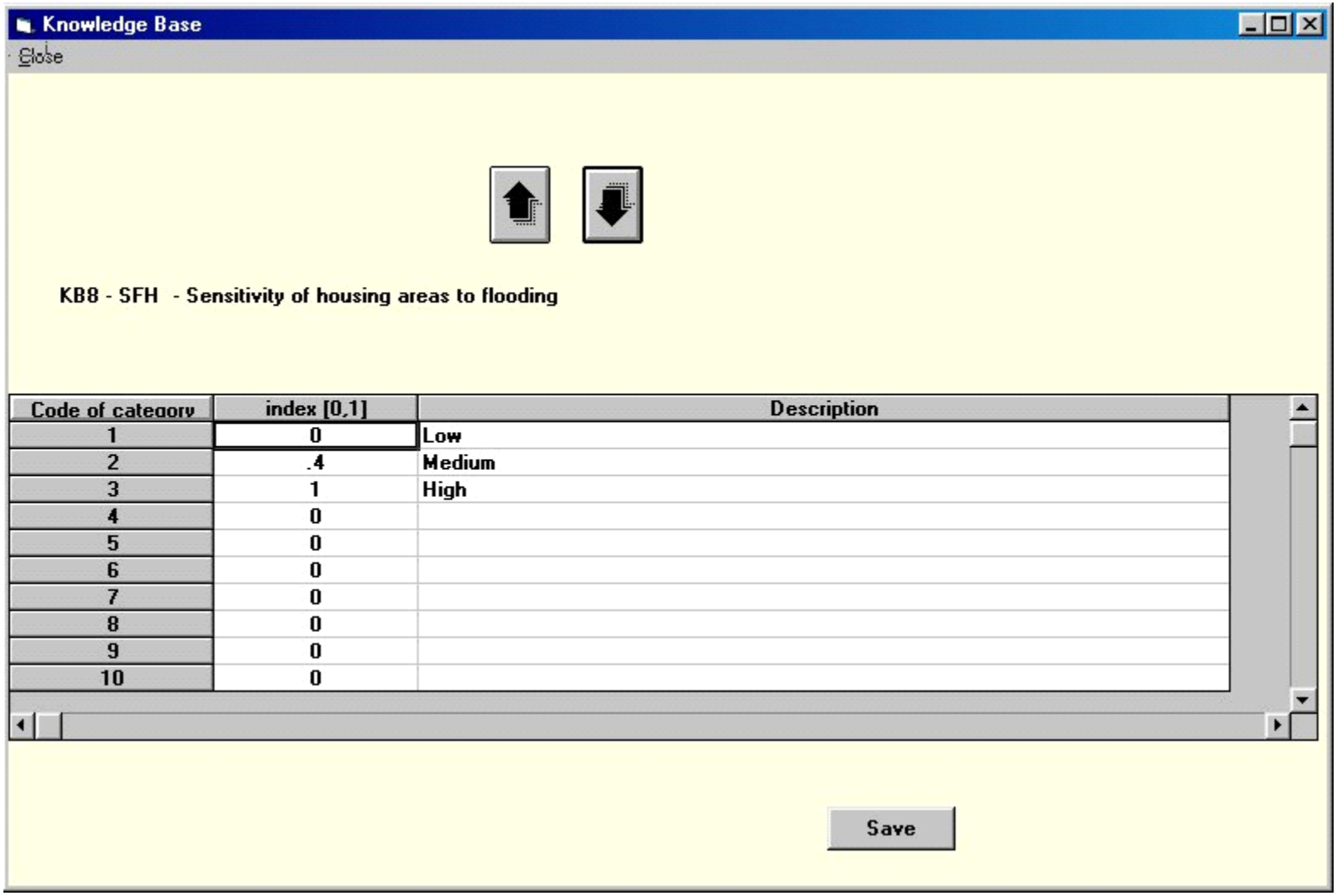
KB 7: EDI (Expected Duration of Interruption)



See Previous KB See Next KB

EXAMPLE 1: NEW PROJECT

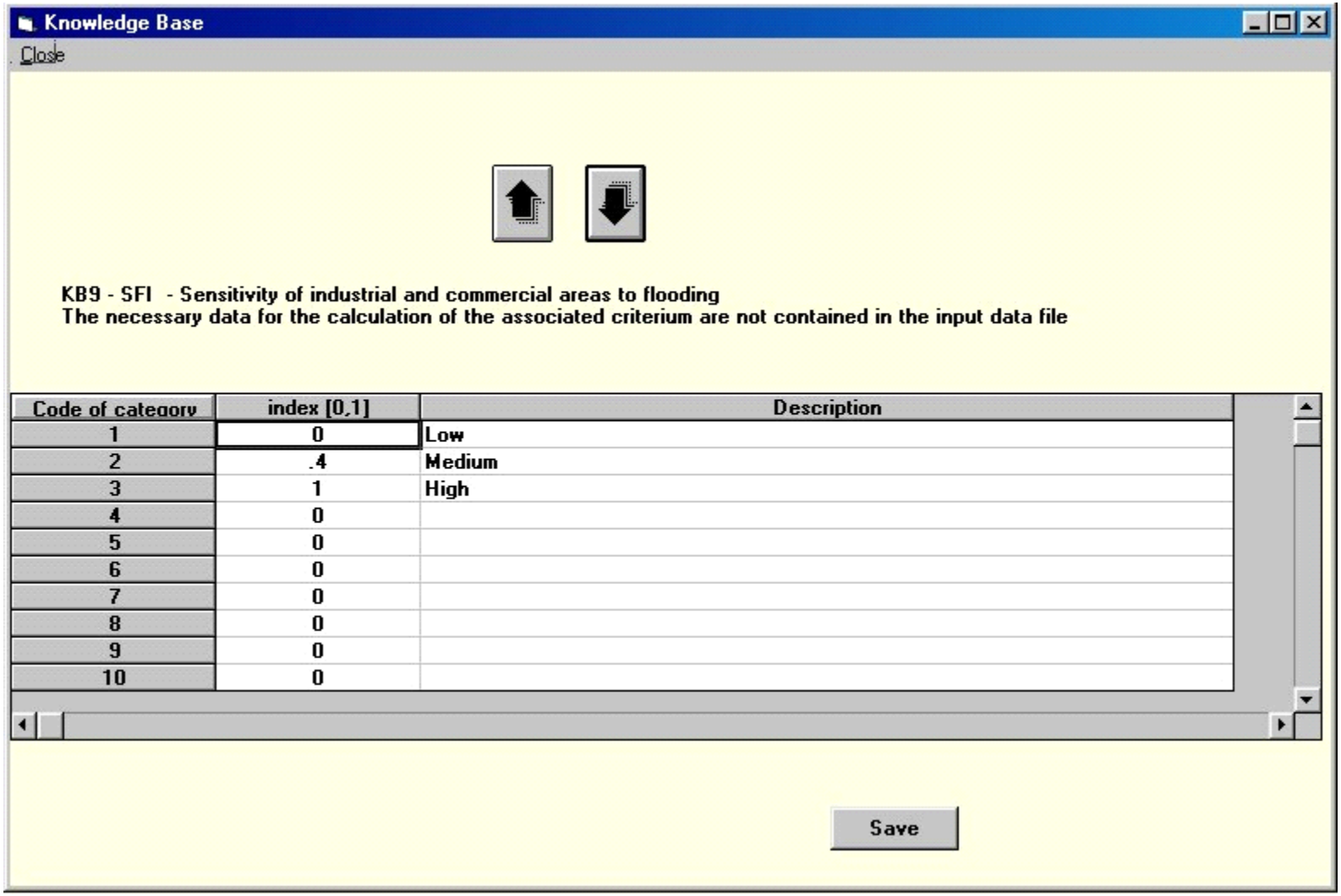
KB 8: SFH (Sensitivity of housing areas to flooding)



See Previous KB See Next KB

EXAMPLE 1: NEW PROJECT

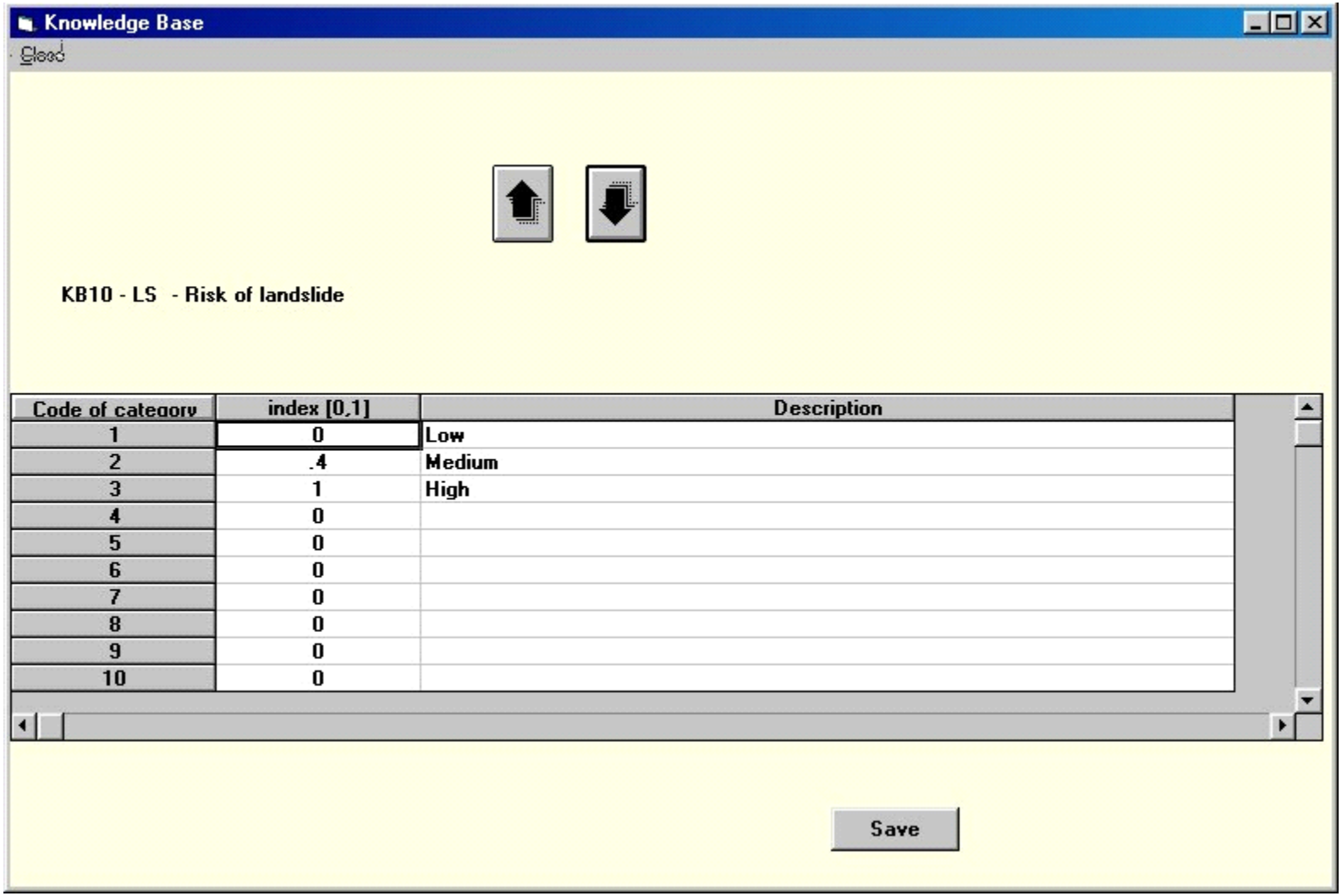
KB 9: SFI (Sensitivity of industrial & commercial areas to flooding)



See Previous KB See Next KB

EXAMPLE 1: NEW PROJECT

KB 10: LS (risk of Landslide)



See Previous KB See Next KB

EXAMPLE 1: NEW PROJECT

KB 11: SR (Sensitivity of the road)

Knowledge Base

Close

KB11 - SR - Sensitivity of the road

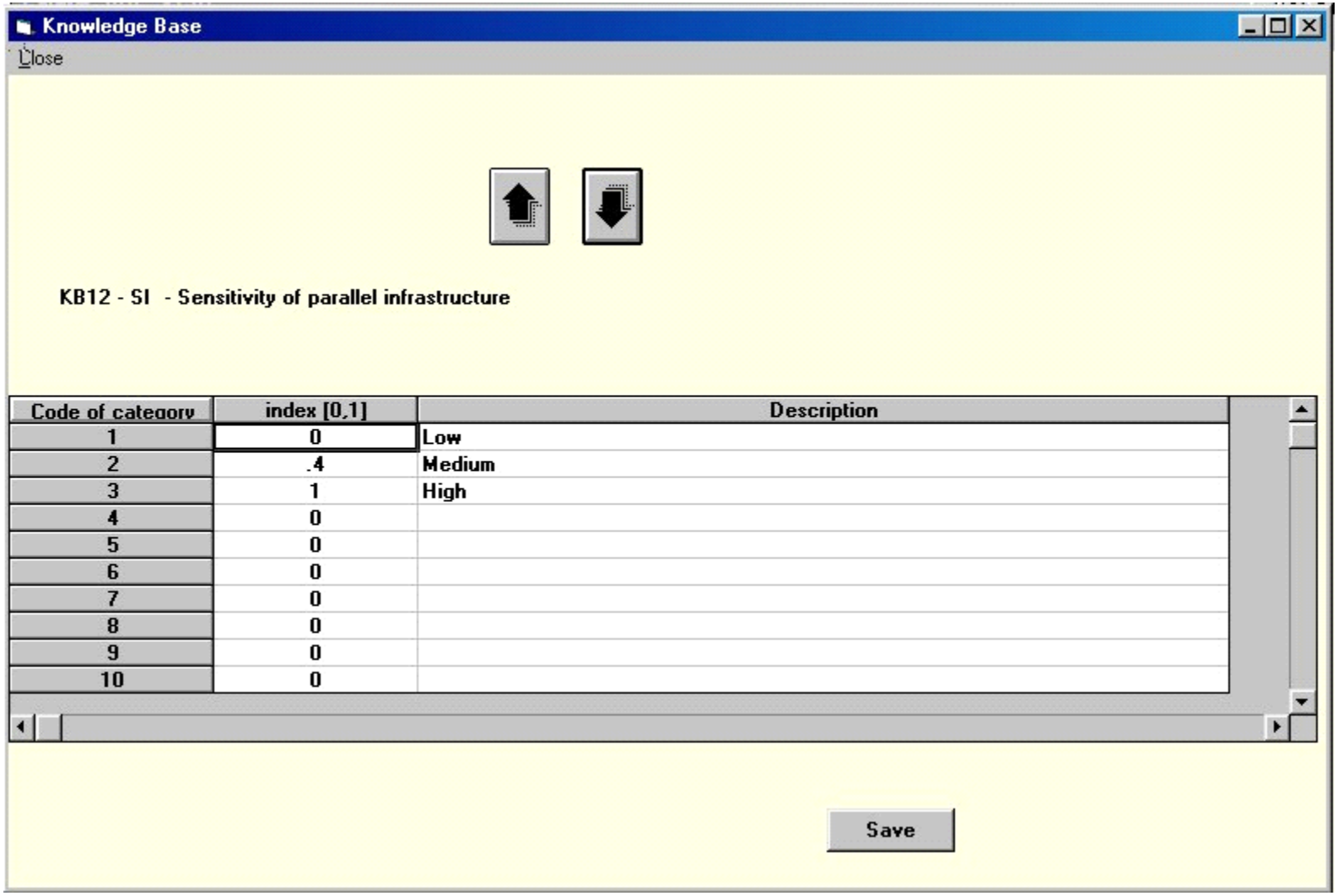
Code of category	index [0,1]	Description
1	0	No traffic
2	.4	Low traffic density
3	.7	Medium traffic density
4	1	High traffic density
5	0	
6	0	
7	0	
8	0	
9	0	
10	0	

Save

See Previous KB See Next KB

EXAMPLE 1: NEW PROJECT

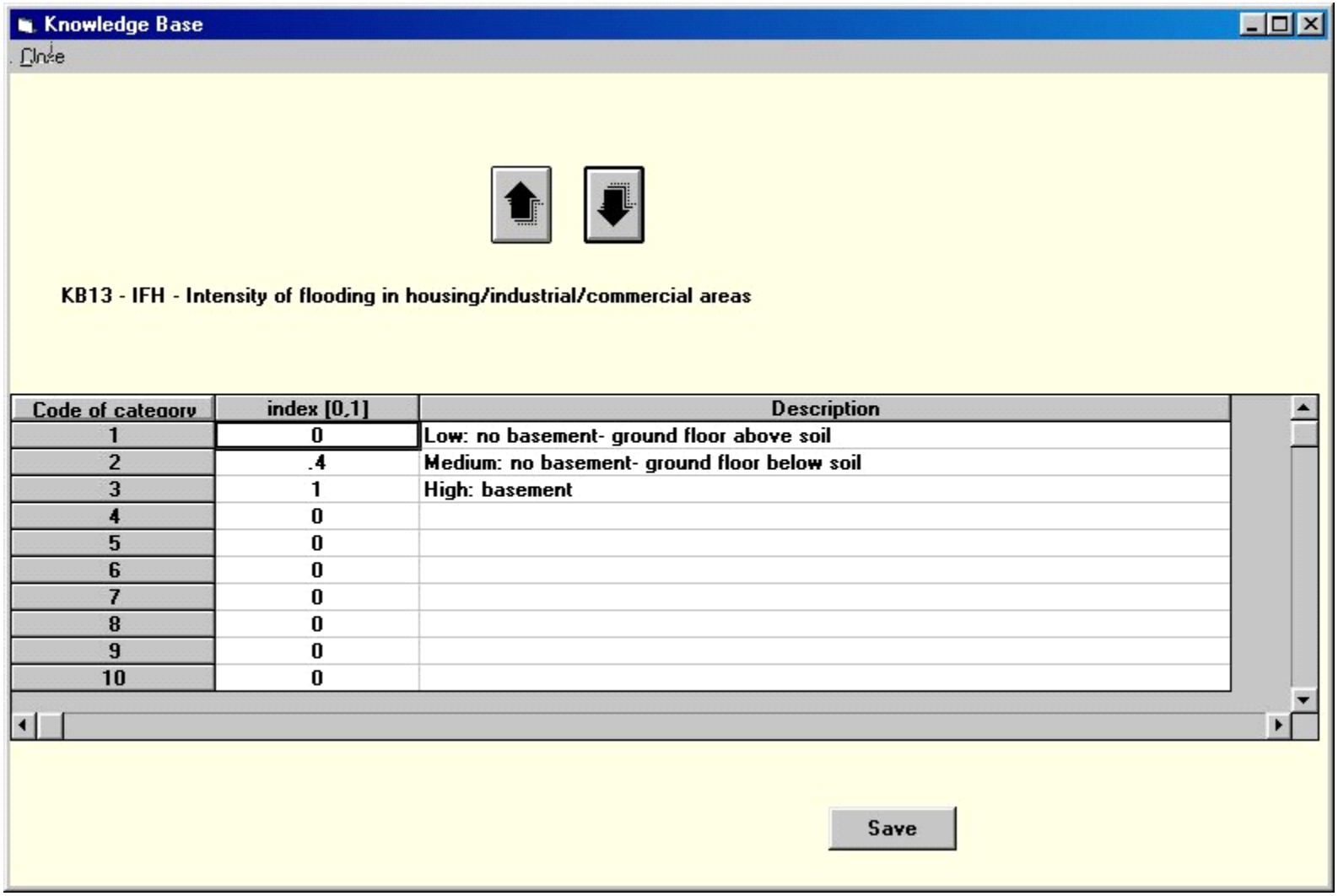
KB 12: SI (Sensitivity of parallel infrastructure)



See Previous KB See Next KB

EXAMPLE 1: NEW PROJECT

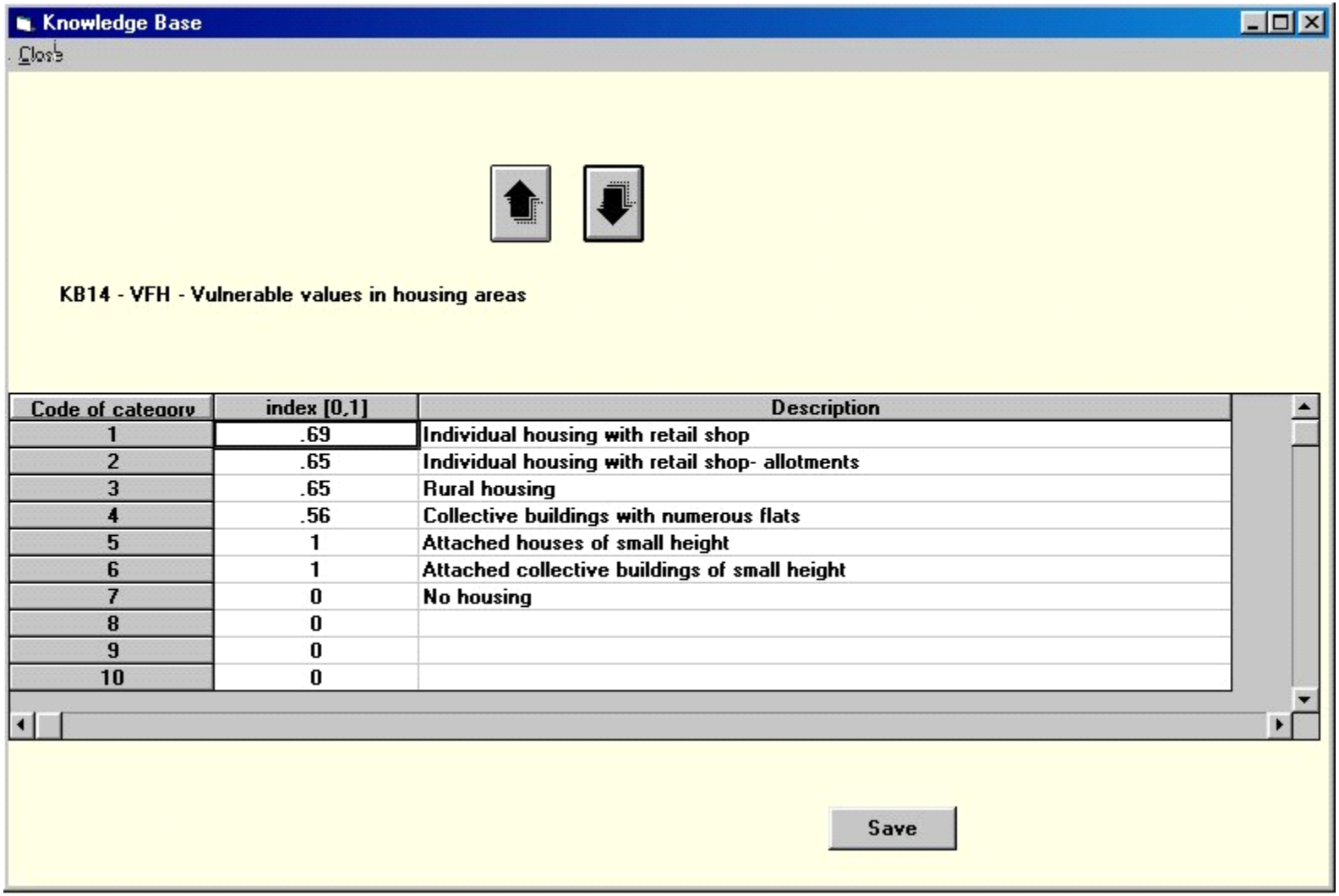
KB 13: IFH (Intensity of flooding in housing/industrial/commercial areas)



See Previous KB See Next KB

EXAMPLE 1: NEW PROJECT

KB 14: VFH (Vulnerable values in housing areas)

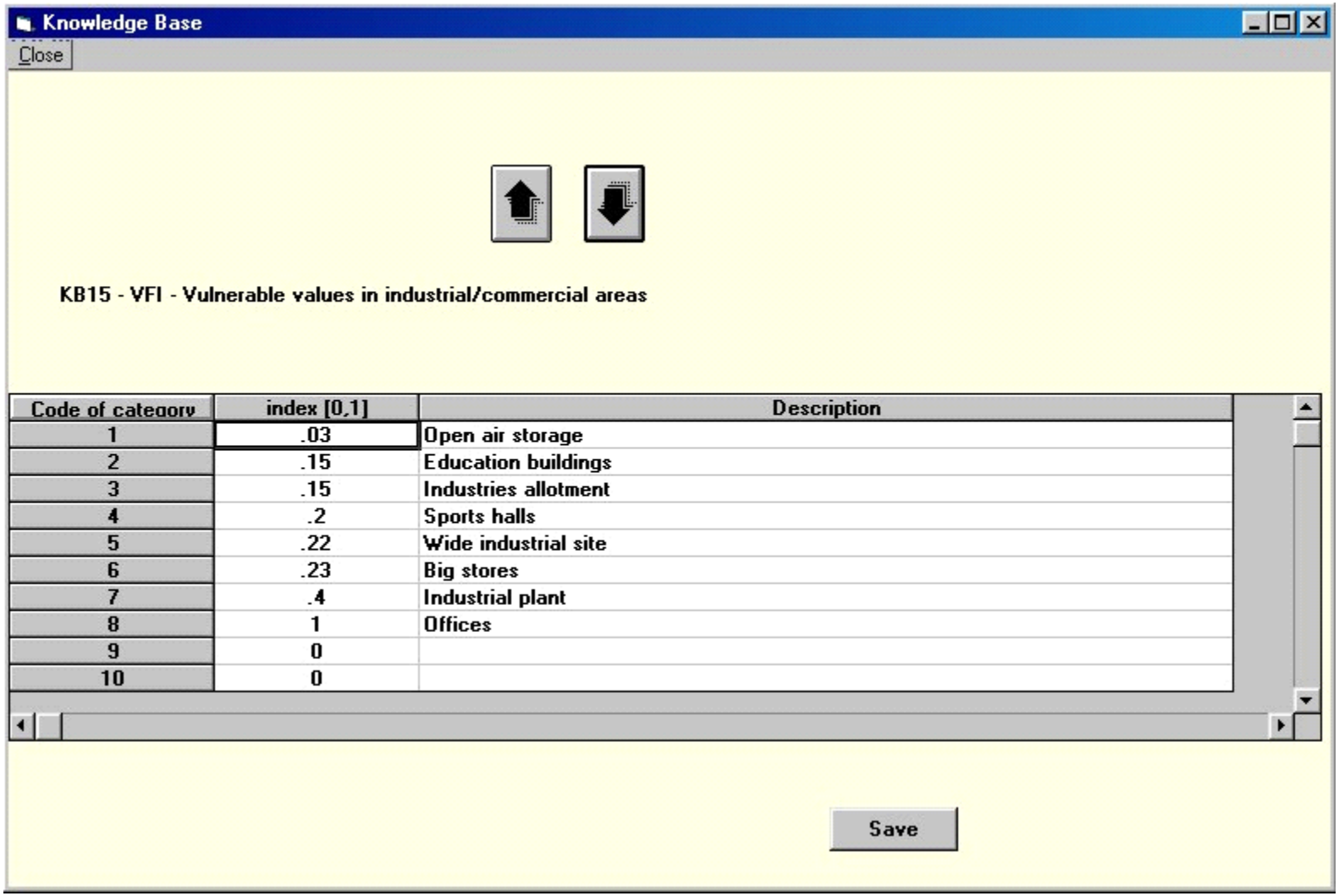


Code of category	index [0,1]	Description
1	.69	Individual housing with retail shop
2	.65	Individual housing with retail shop- allotments
3	.65	Rural housing
4	.56	Collective buildings with numerous flats
5	1	Attached houses of small height
6	1	Attached collective buildings of small height
7	0	No housing
8	0	
9	0	
10	0	

See Previous KB See Next KB

EXAMPLE 1: NEW PROJECT

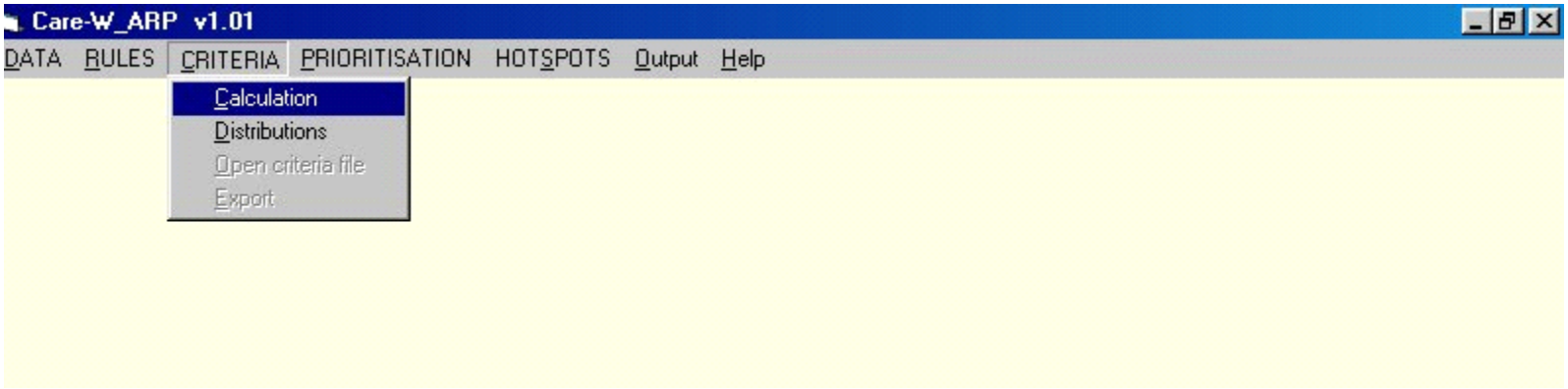
KB 15: VFI (Vulnerable values in industrial/commercial areas)



See Previous KB

EXAMPLE 1: NEW PROJECT

CRITERIA / CALCULATION

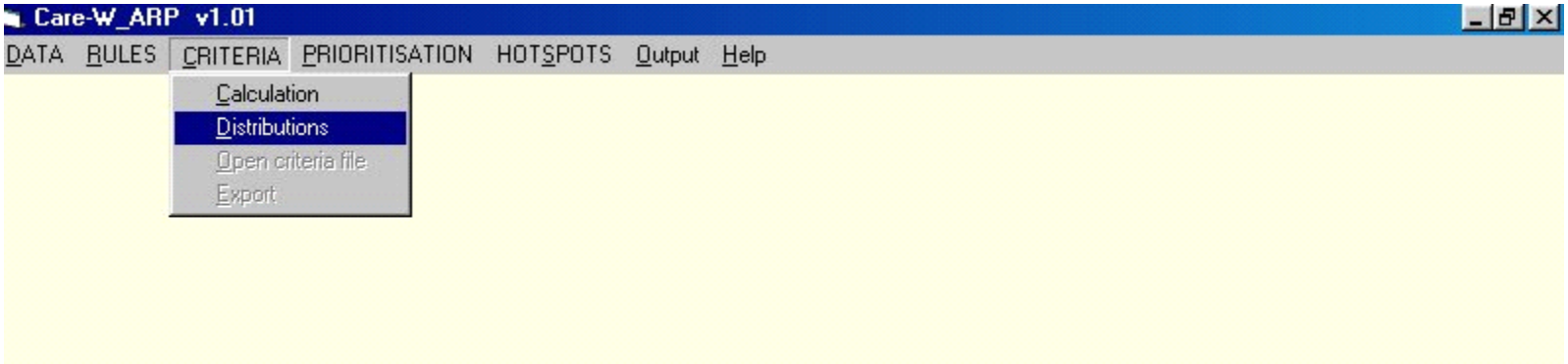


CRITERIA / CALCULATION >> DISPLAY CRITERIA AVAILABLE


WP3
Those criteria :
COS : Co-Ordination Score
ARC : Annual Repair Cost
WLI : Water Losses Index
PWI : Predicted Water Interruption
PCWI : Predicted Critical Water Interruption
PFWI : Predicted Frequency of Water Interruption
DFH : Damage due to Flooding in Housing areas
DFI : Damage due to Flooding in Industrial and Commercial areas
DSM : Damage due to Soil Movement
DT : Traffic Disruptions
DDI : Damage and/or Disruption on other Infrastructures
HCI : Hydraulic Critically Index
have been calculated for 128 actions
OK

EXAMPLE 1: NEW PROJECT

CRITERIA / DISTRIBUTION



COS: Co-Ordination Score

ARC: Annual Repair Cost

WLI: Water Losses Index

PWI: Predicted Water Interruption

PCWI: Predicted Critical Water Interruption

PFWI: Predicted Frequency of Water Interruption

DFH: Damage due to flooding in Housing areas

DFI: Damage due to flooding in Industrial or commercial areas

DSM: Damage due to Soil Movement

DT: Traffic Disruptions

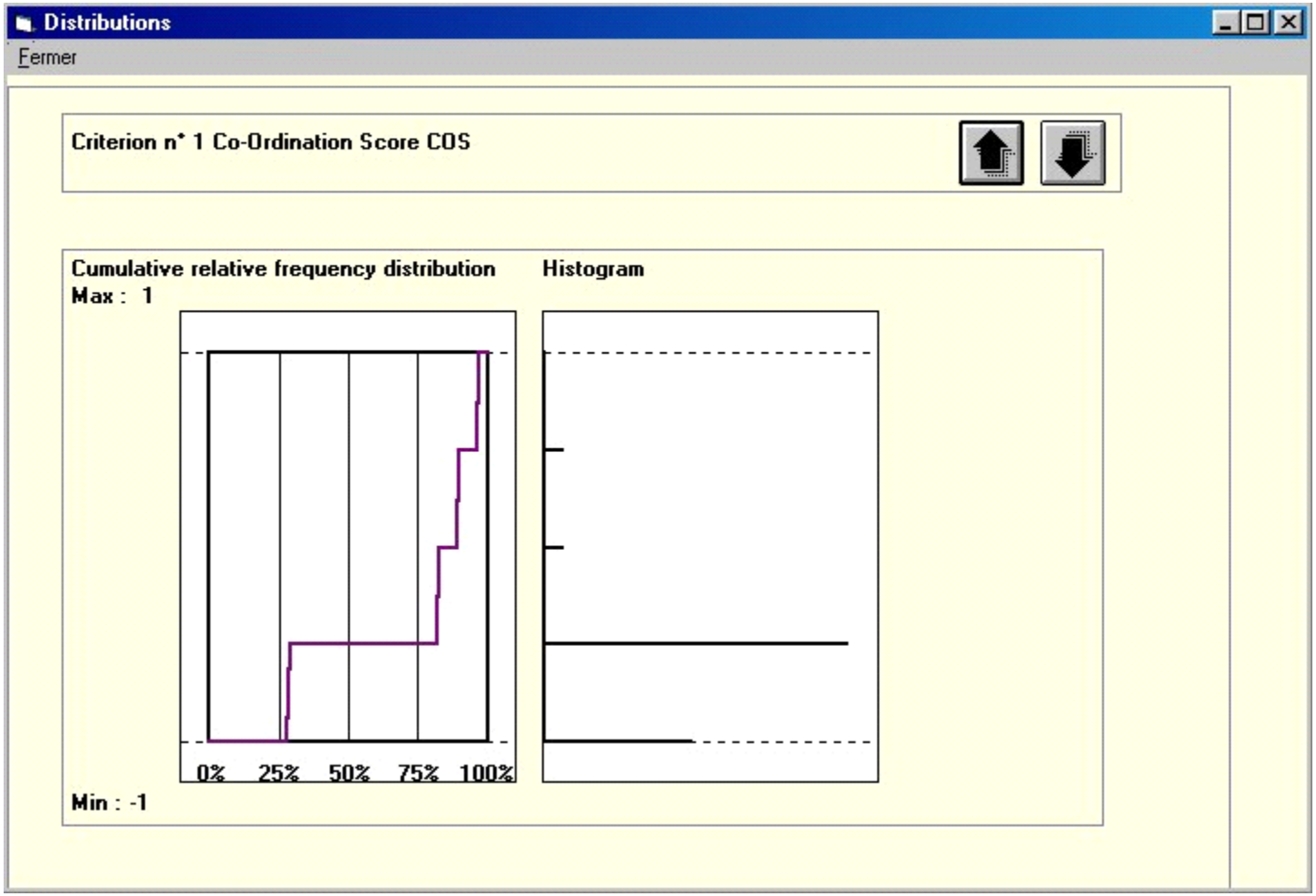
DDI: Damage and/or Disruption on other Infrastructures

HCI: Hydraulic Criticality Index

EXAMPLE 1: NEW PROJECT

CRITERIA / DISTRIBUTION: COS

Score [-1,1]

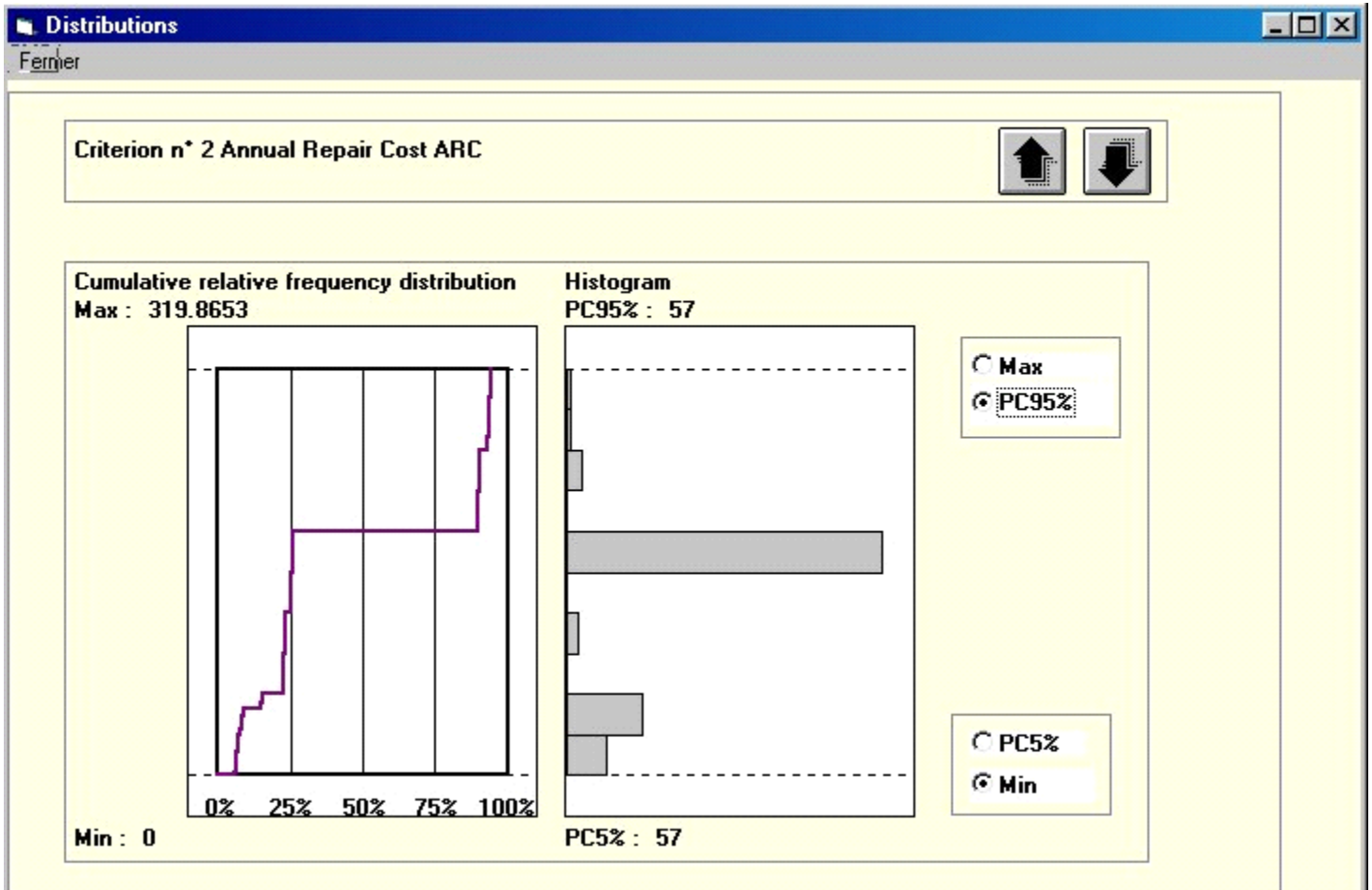


EXAMPLE 1: NEW PROJECT

CRITERIA / DISTRIBUTION: ARC: Annual Repair Cost

ARC(i) = PFR(i) x UCRp(i)

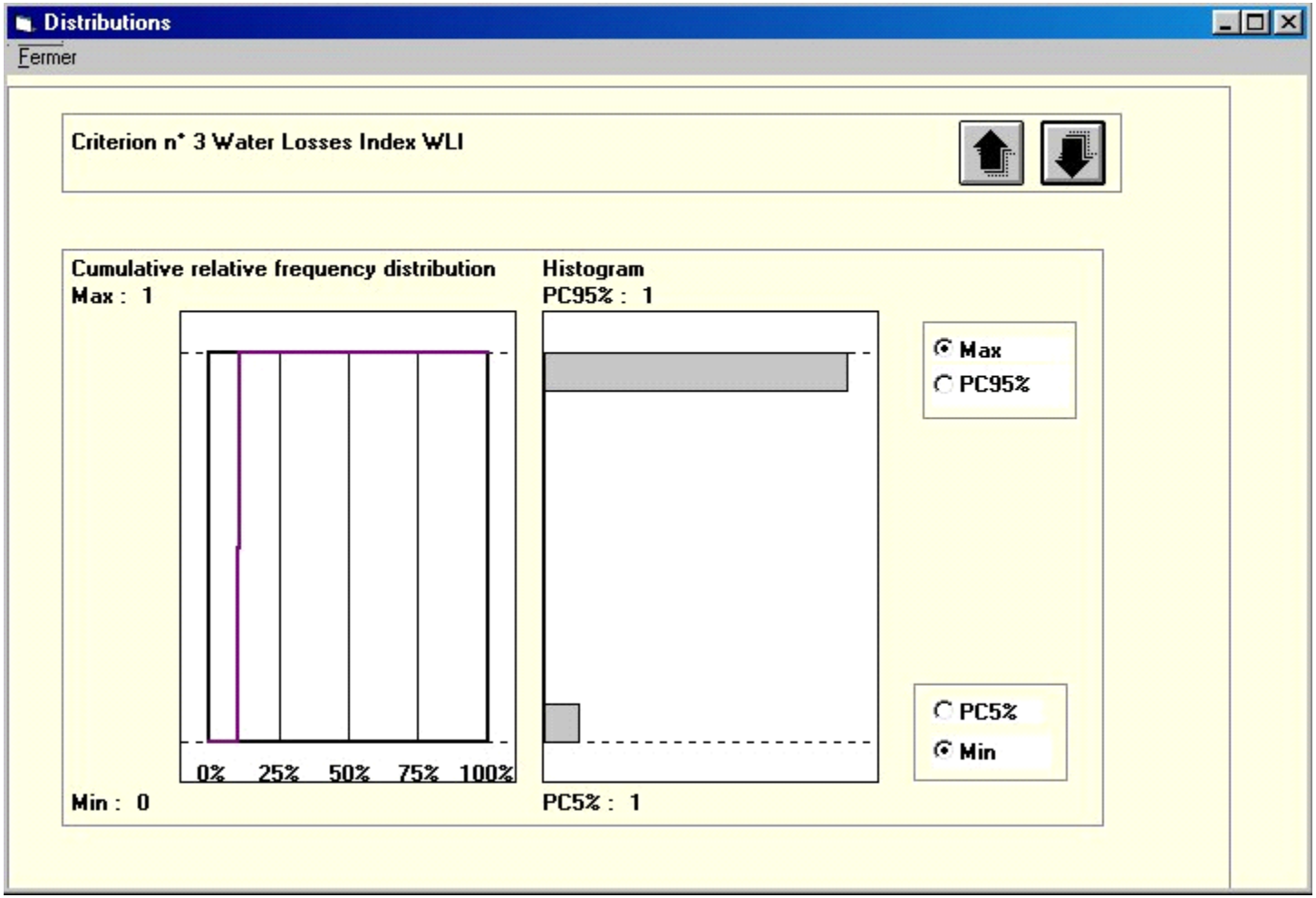
Units: (No./100m/year) x (€)



EXAMPLE 1: NEW PROJECT

CRITERIA / DISTRIBUTION: WLI

Index [0,1]

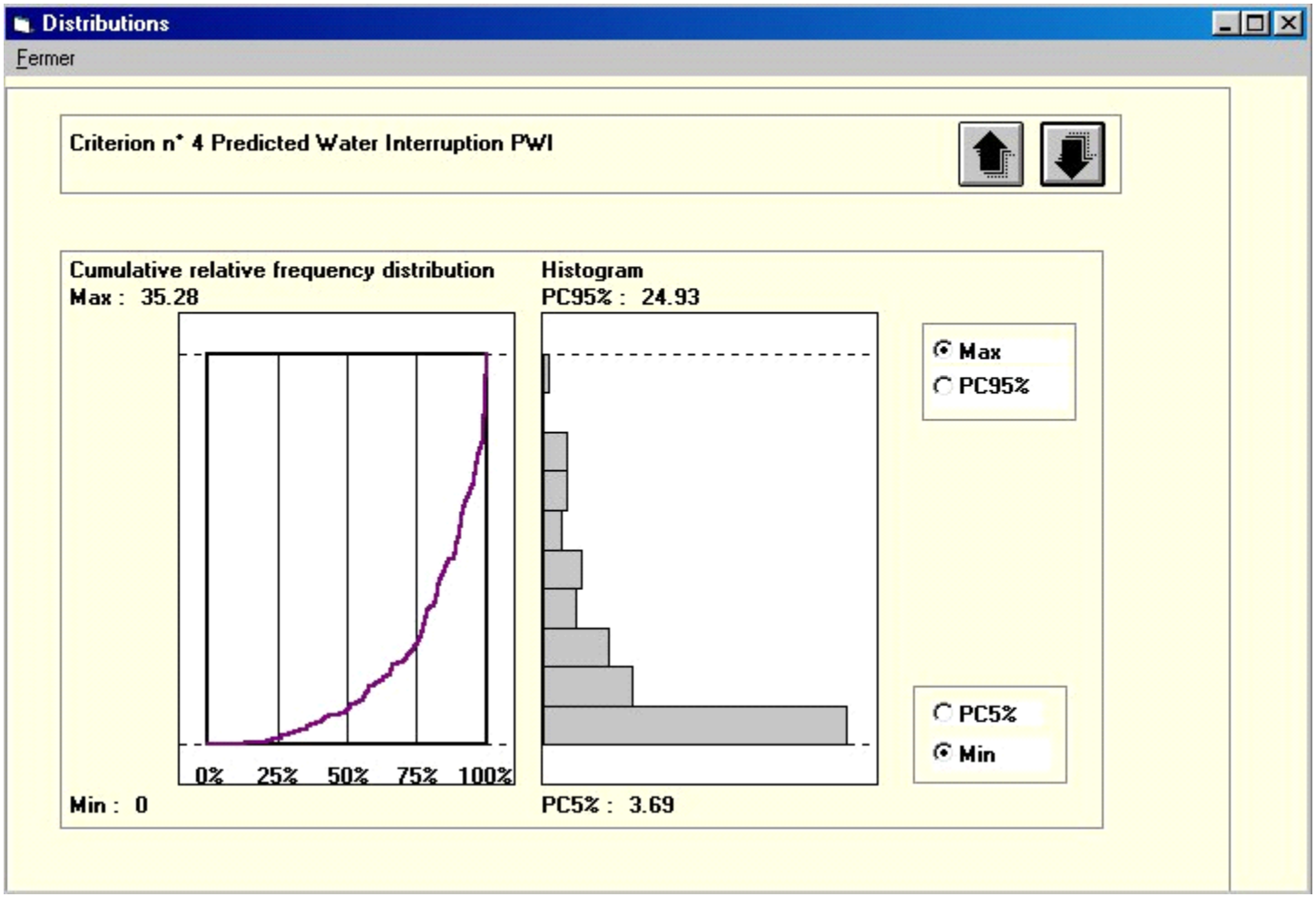


EXAMPLE 1: NEW PROJECT

CRITERIA / DISTRIBUTION: PWI

PWI(i) = PBR(i) x EDI(i) x NPS(i)

Units: (No./100m/year) x (hours) x (persons)

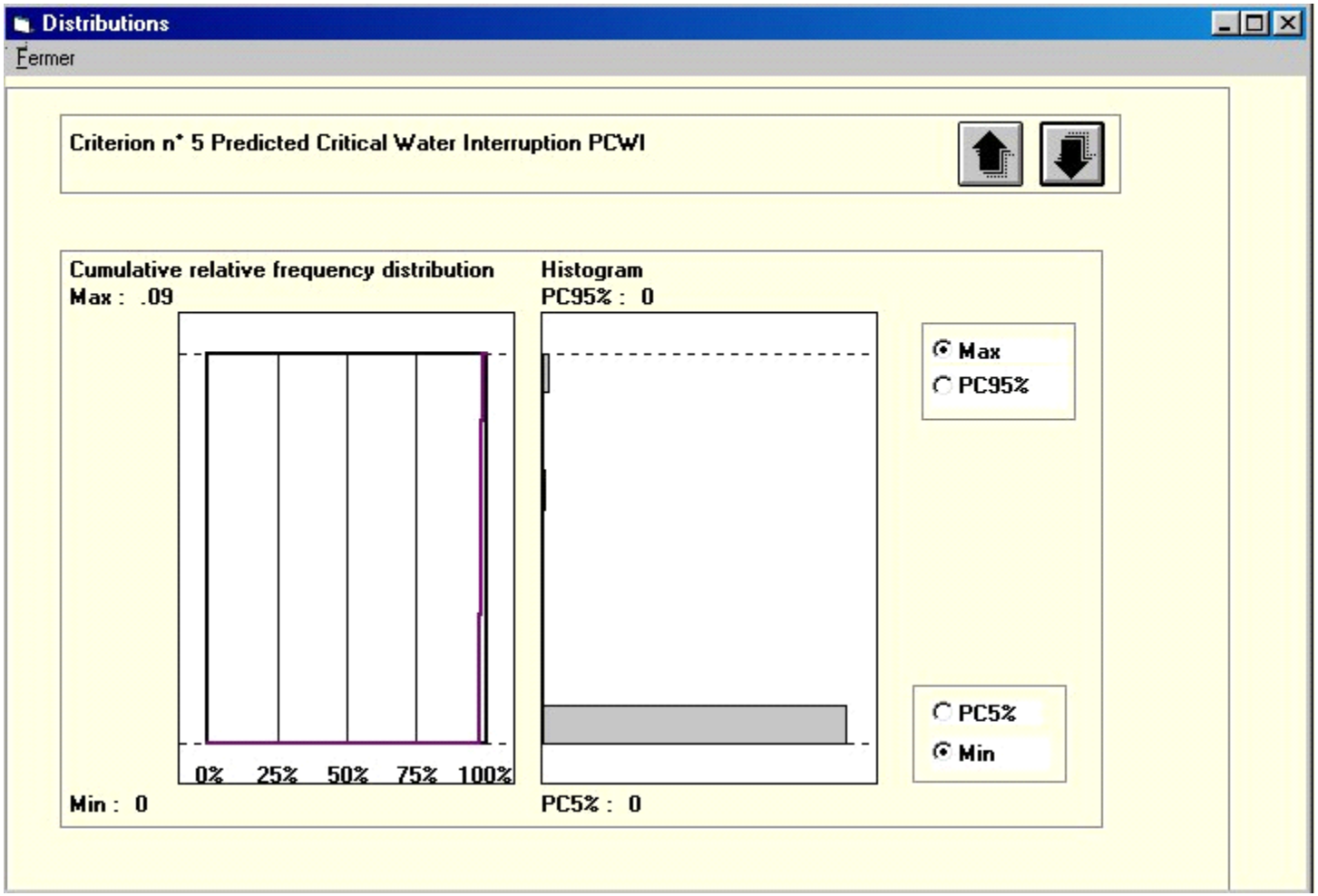


EXAMPLE 1: NEW PROJECT

CRITERIA / DISTRIBUTION: PCWI

PCWI(i) = PBR(i) x EDI(i) x SC(i)

Units: (No./100m/year) x (hours)

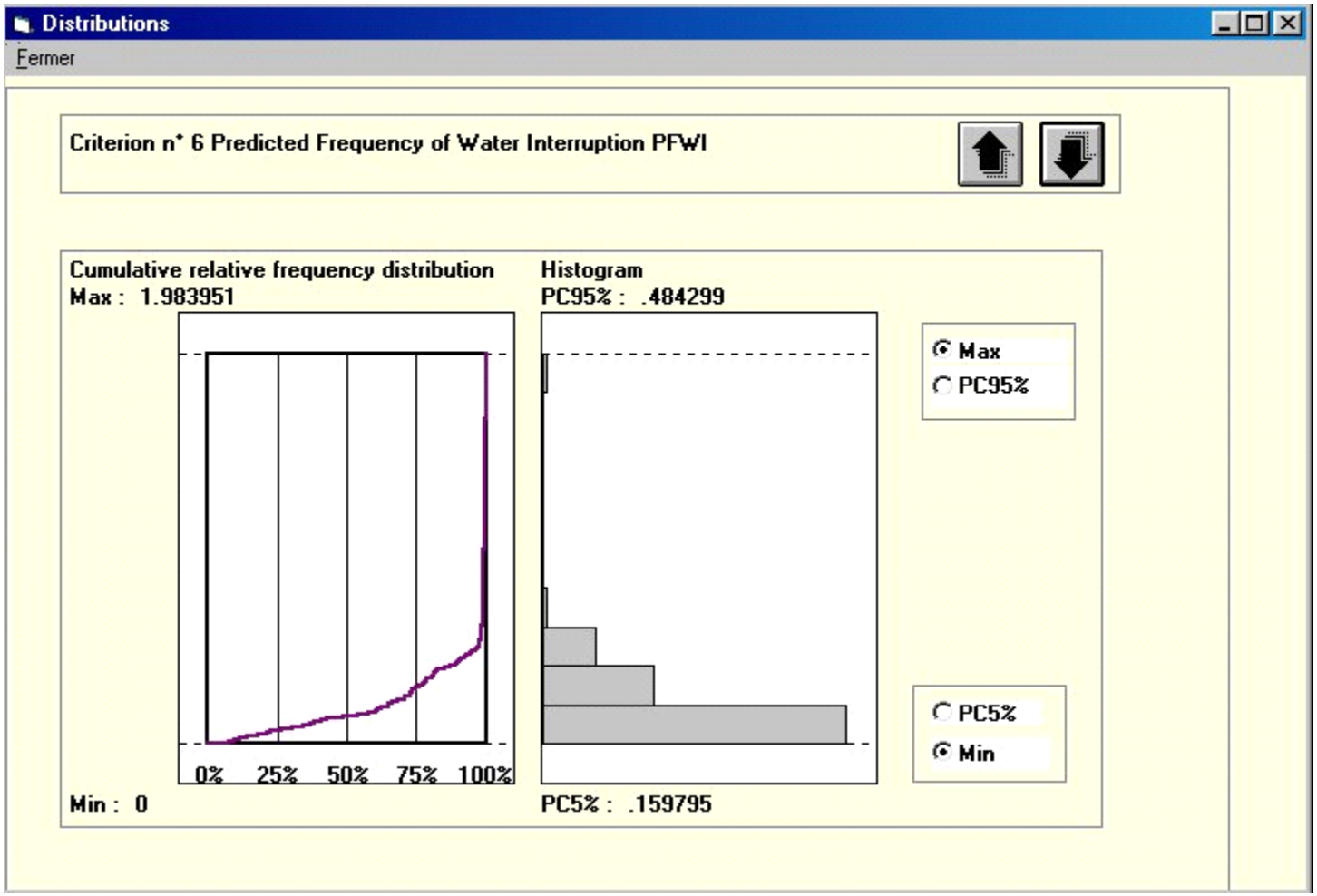


EXAMPLE 1: NEW PROJECT

CRITERIA / DISTRIBUTION: PFWI

$$PFWI(i) = Li(i)/100 \times PBR(i) \times EDI(i)$$

Units: (hours) x (Year)

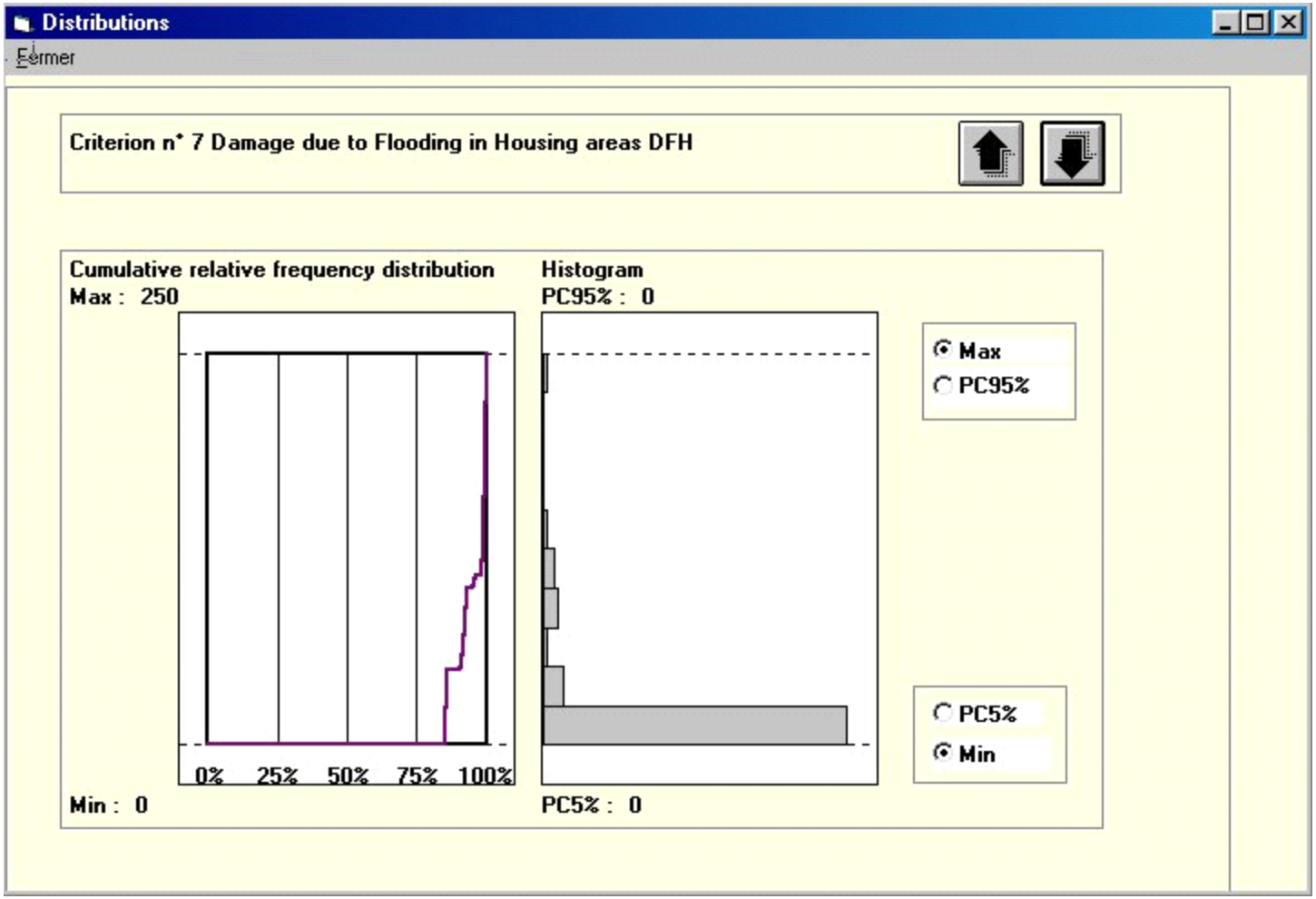


EXAMPLE 1: NEW PROJECT

CRITERIA / DISTRIBUTION: DFH

$$DFH(i) = PBR(i) \times D(i)^2 \times P(i) \times SFH(i)$$

Units: (No./100m/year) x (mm^2 . MPa)

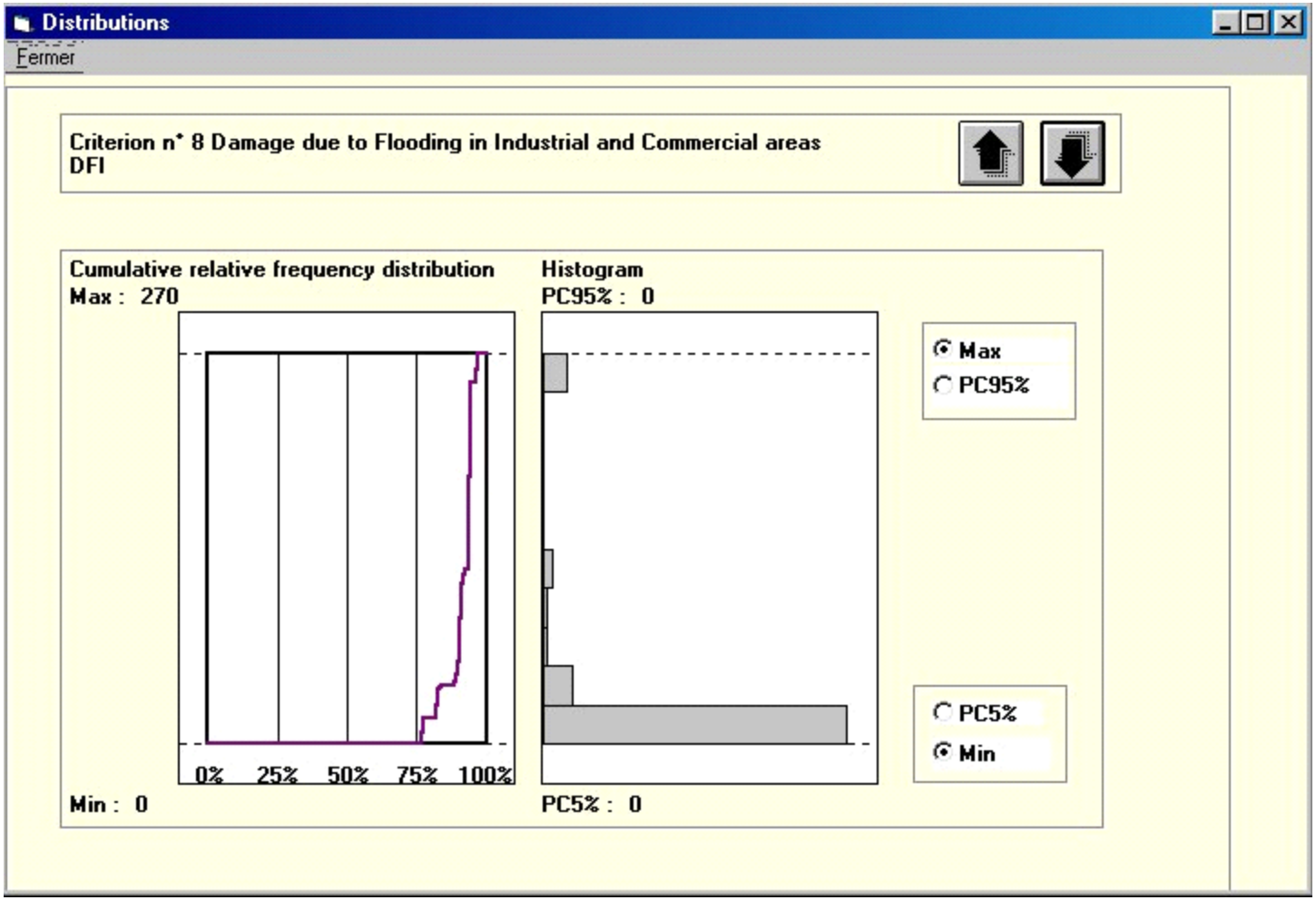


EXAMPLE 1: NEW PROJECT

CRITERIA / DISTRIBUTION: DFI

$$DFI(i) = PBR(i) \times D(i)^2 \times P(i) \times SFI(i)$$

Units: (No./100m/year) x (mm^2 . MPa)

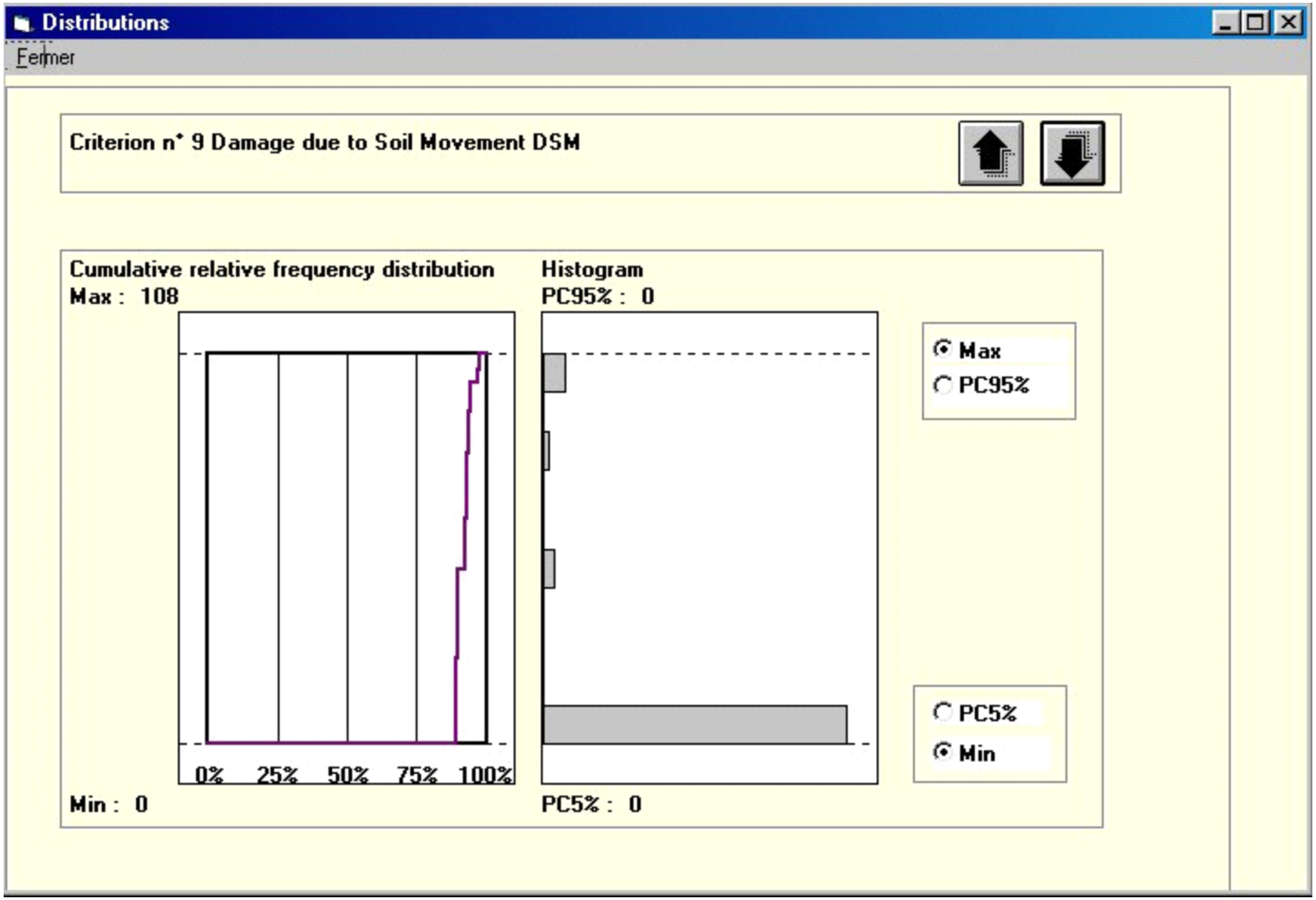


EXAMPLE 1: NEW PROJECT

CRITERIA / DISTRIBUTION: DSM

$$DSM(i) = PFR(i) \times D(i)^2 \times P(i) \times LS(i)$$

Units: (No./100m/year) x (mm^2 . MPa)

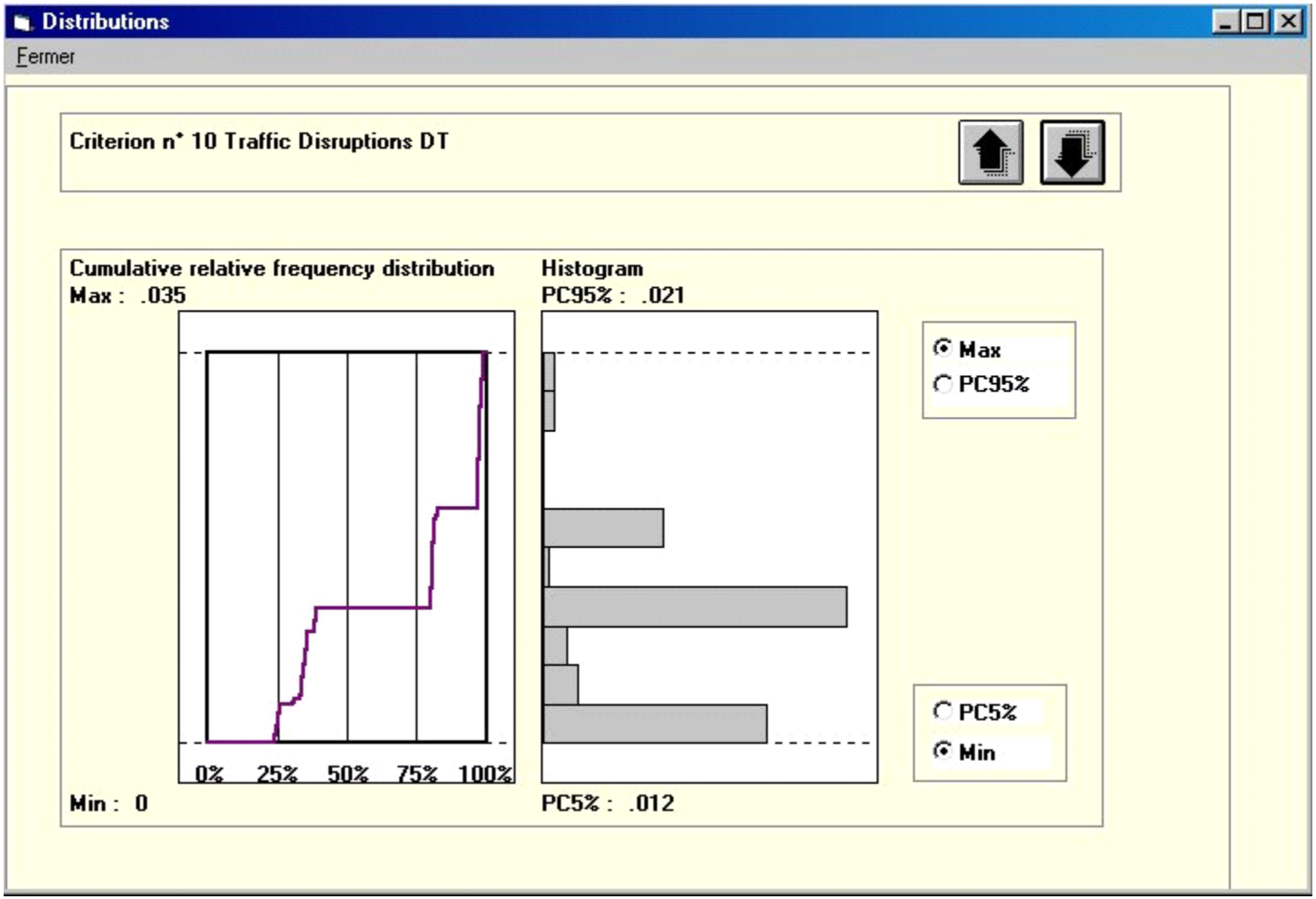


EXAMPLE 1: NEW PROJECT

CRITERIA / DISTRIBUTION: DT

$$DT(i) = PFR(i) \times SR(i)$$

Units: (No./100m/year)

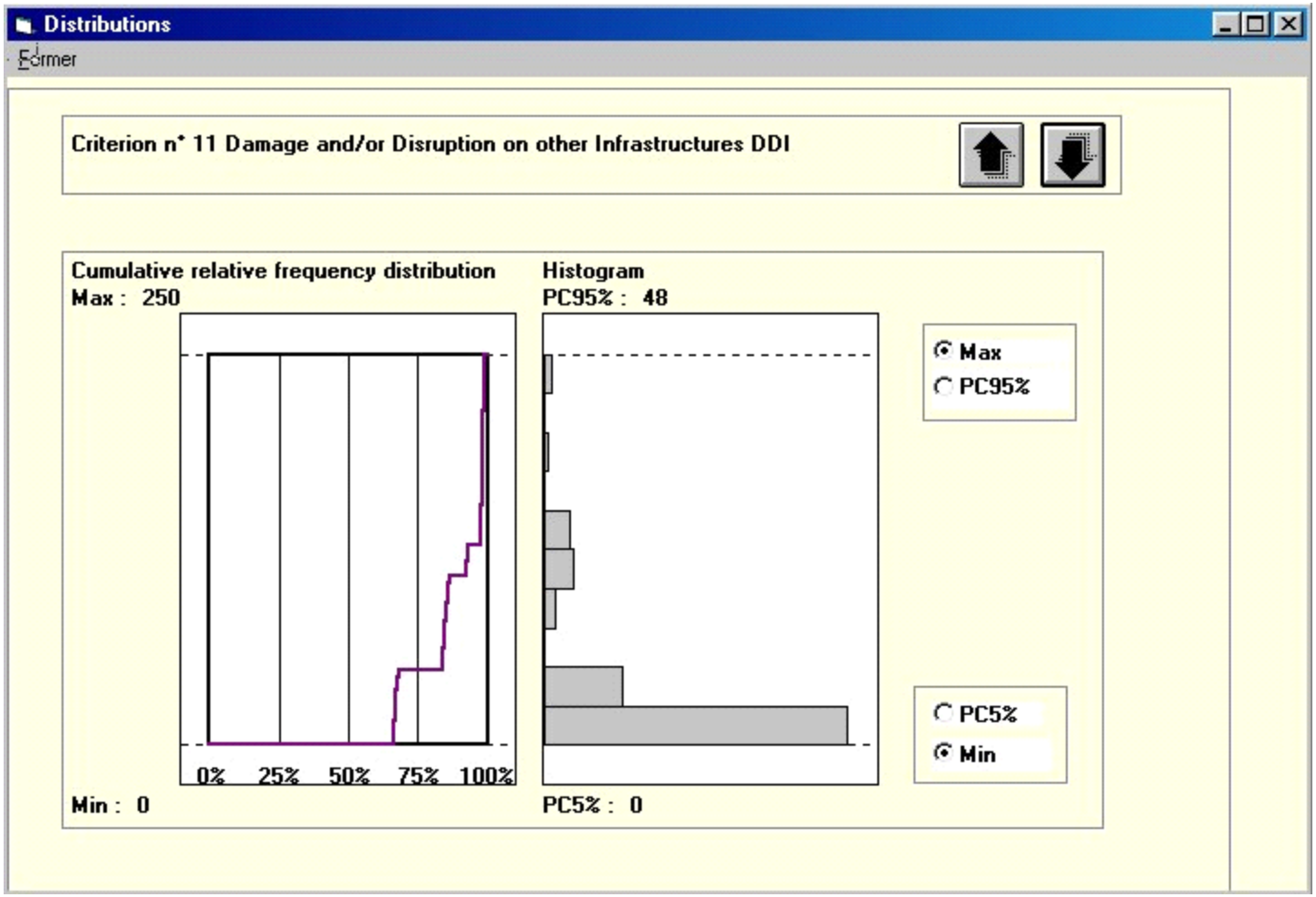


EXAMPLE 1: NEW PROJECT

CRITERIA / DISTRIBUTION: DDI

$$DDI(i) = PBR(i) \times D(i)^2 \times P(i) \times SI(i)$$

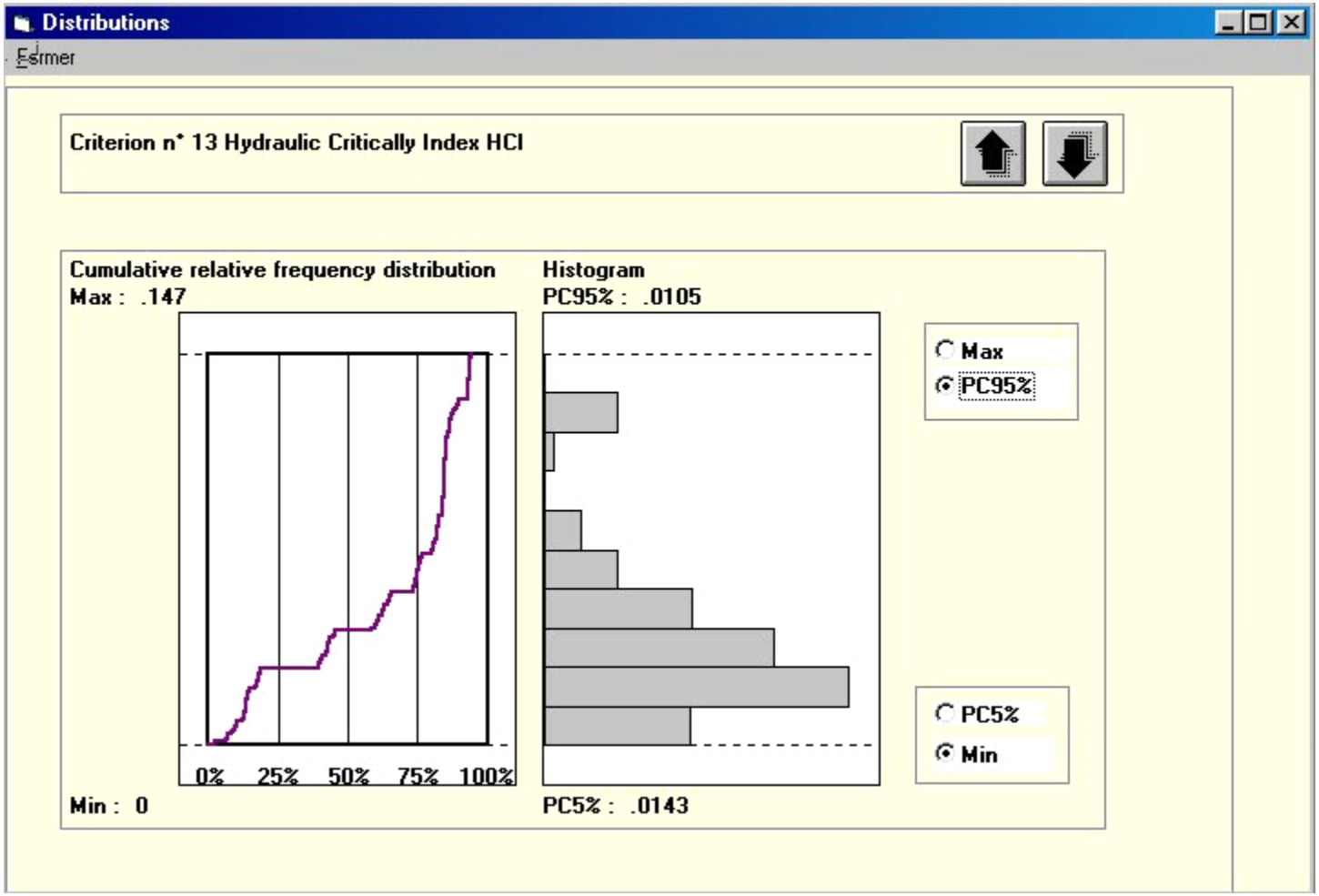
Units: (No./100m/year) x (mm^2 . MPa)



EXAMPLE 1: NEW PROJECT

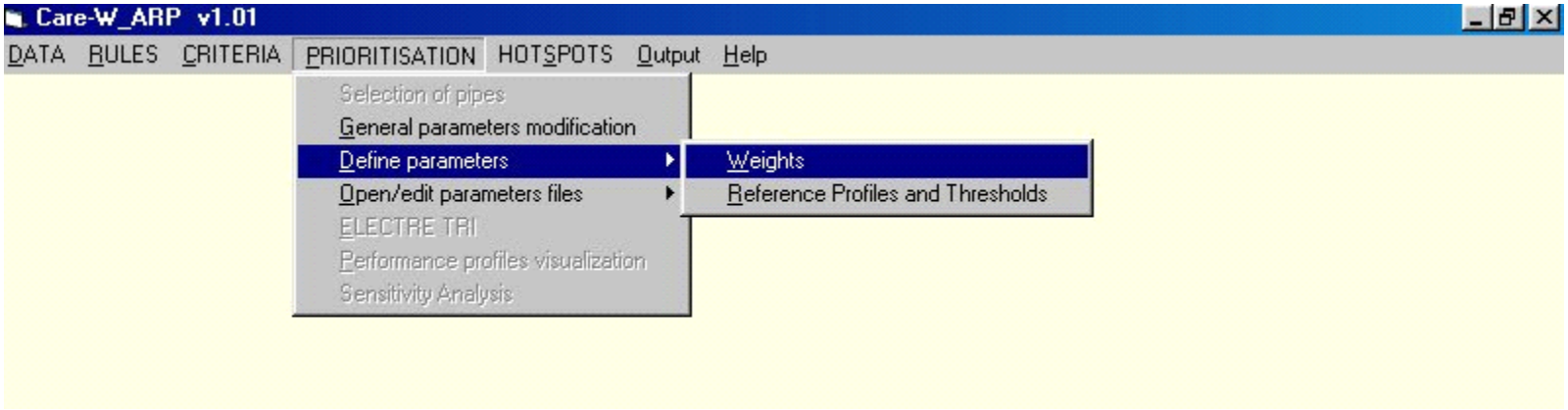
CRITERIA / DISTRIBUTION: HCI

Index [0,1]

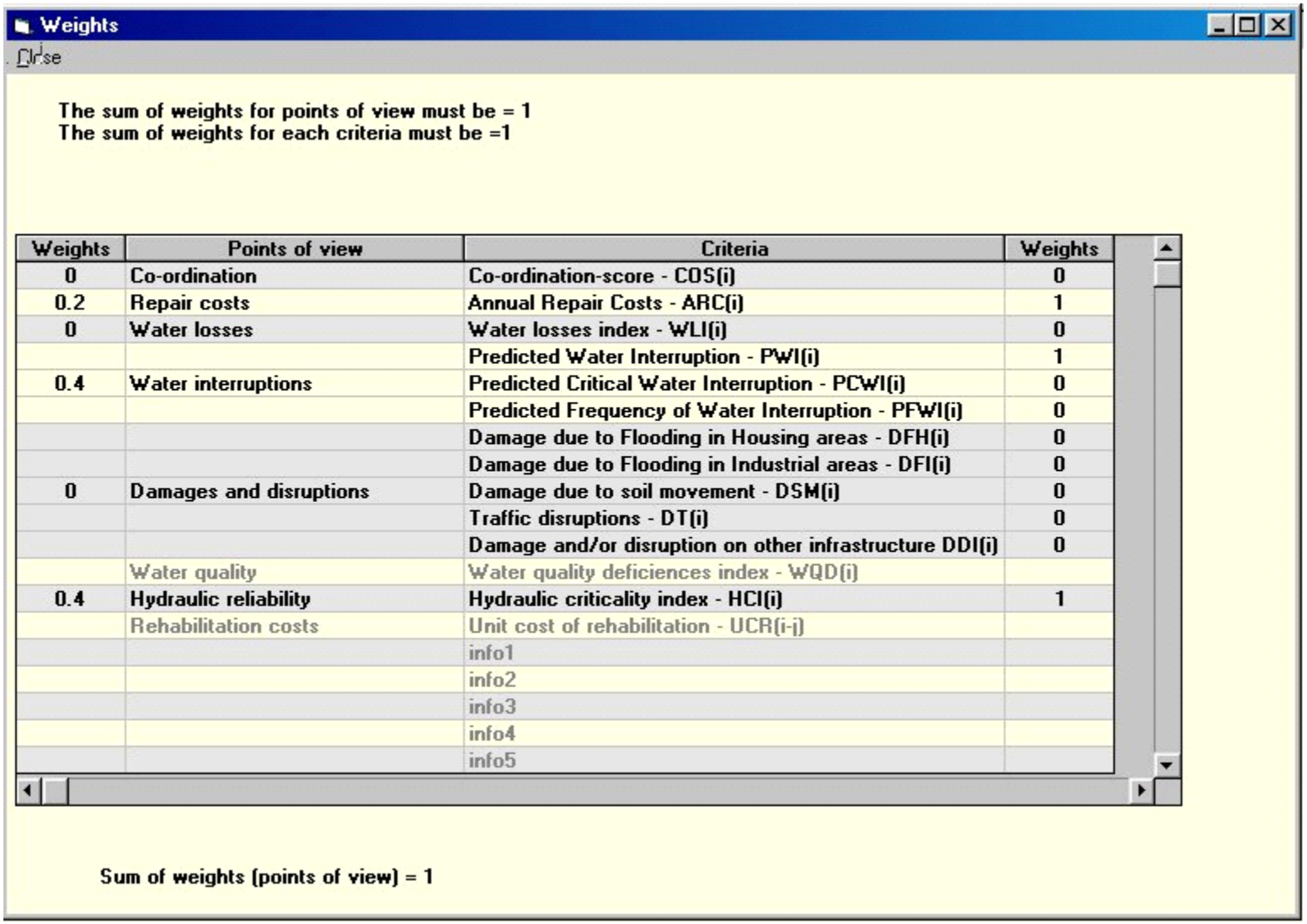


EXAMPLE 1: NEW PROJECT

PRIORITISATION / DEFINE PARAMETERS >> WEIGHTS

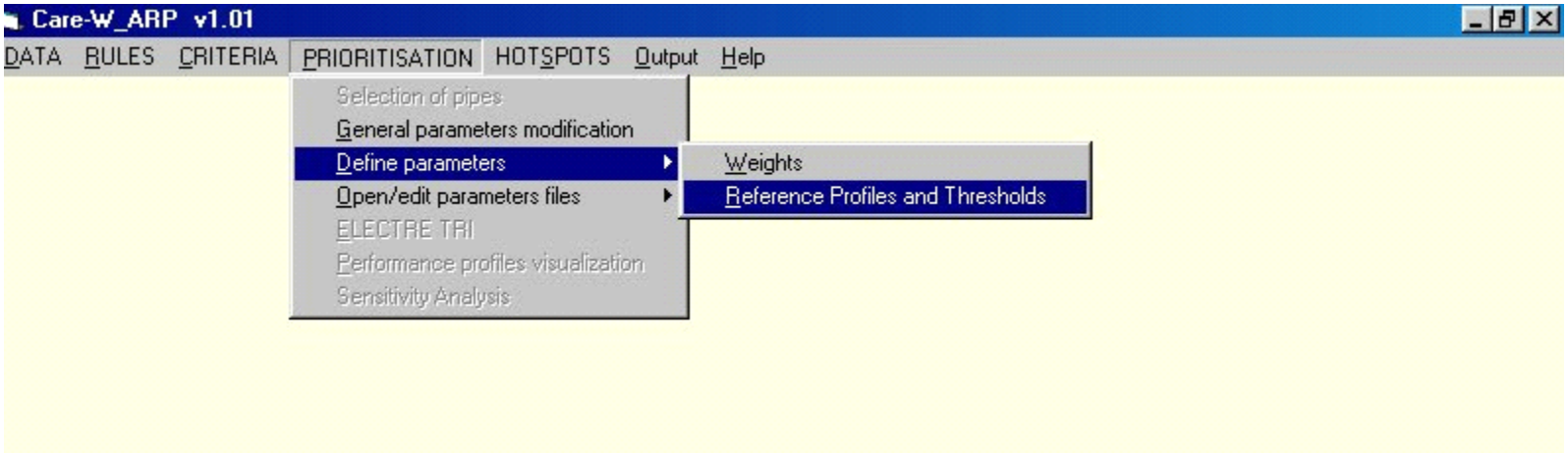


PRIORITISATION / DEFINE PARAMETERS >> WEIGHTS


Weights
Close
The sum of weights for points of view must be = 1
The sum of weights for each criteria must be =1
Weights
Points of view
Criteria
Weights
0
Co-ordination
Co-ordination-score - COS(i)
0
0.2
Repair costs
Annual Repair Costs - ARC(i)
1
0
Water losses
Water losses index - WLI(i)
0
Predicted Water Interruption - PWI(i)
1
0.4
Water interruptions
Predicted Critical Water Interruption - PCWI(i)
0
Predicted Frequency of Water Interruption - PFWI(i)
0
Damage due to Flooding in Housing areas - DFH(i)
0
Damage due to Flooding in Industrial areas - DFI(i)
0
0
Damages and disruptions
Damage due to soil movement - DSM(i)
0
Traffic disruptions - DT(i)
0
Damage and/or disruption on other infrastructure DDI(i)
0
Water quality
Water quality deficiences index - WQD(i)
0.4
Hydraulic reliability
Hydraulic criticality index - HCI(i)
1
Rehabilitation costs
Unit cost of rehabilitation - UCR(i-j)
info1
info2
info3
info4
info5
Sum of weights (points of view) = 1

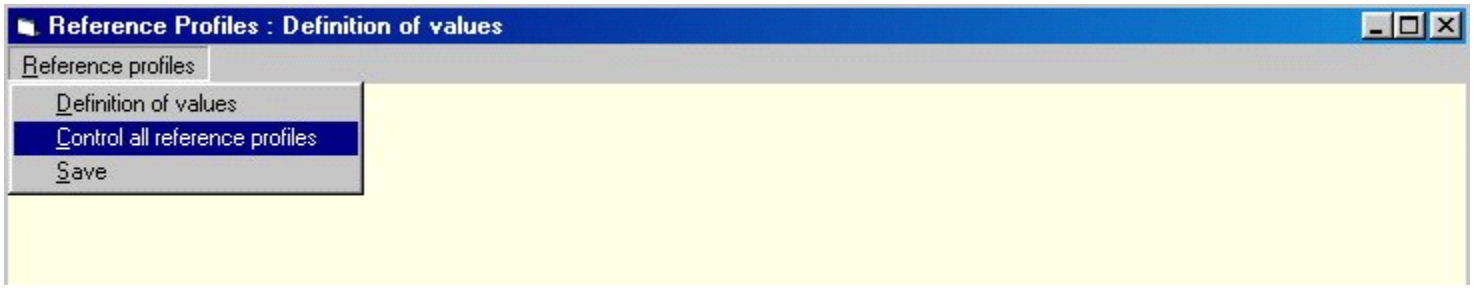
EXAMPLE 1: NEW PROJECT

PRIORITISATION / DEFINE PARAMETERS >> REFERENCE PROFILES

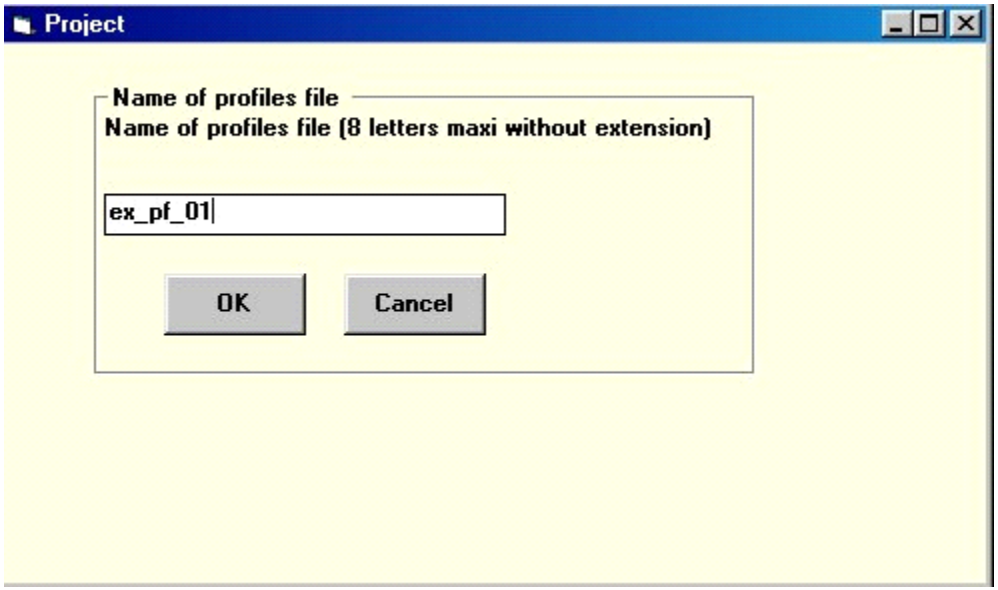


PRIORITISATION / DEFINE PARAMETERS >> REFERENCE PROFILES

All Reference Profiles



Control all Reference Profiles


Project
Name of profiles file
Name of profiles file (8 letters maxi without extension)
ex_pf_01
OK
Cancel

EXAMPLE 1: NEW PROJECT

REFERENCE PROFILES: Proposed values (example 1) **and modified values** (example 2)

COS: Co-Ordination Score

ARC: Annual Repair Cost ---------- ARC modified

WLI: Water Losses Index

PWI: Predicted Water Interruption ---------- PWI modified

PCWI: Predicted Critical Water Interruption

PFWI: Predicted Frequency of Water Interruption

DFH: Damage due to flooding in Housing areas

DFI: Damage due to flooding in Industrial or commercial areas

DSM: Damage due to Soil Movement

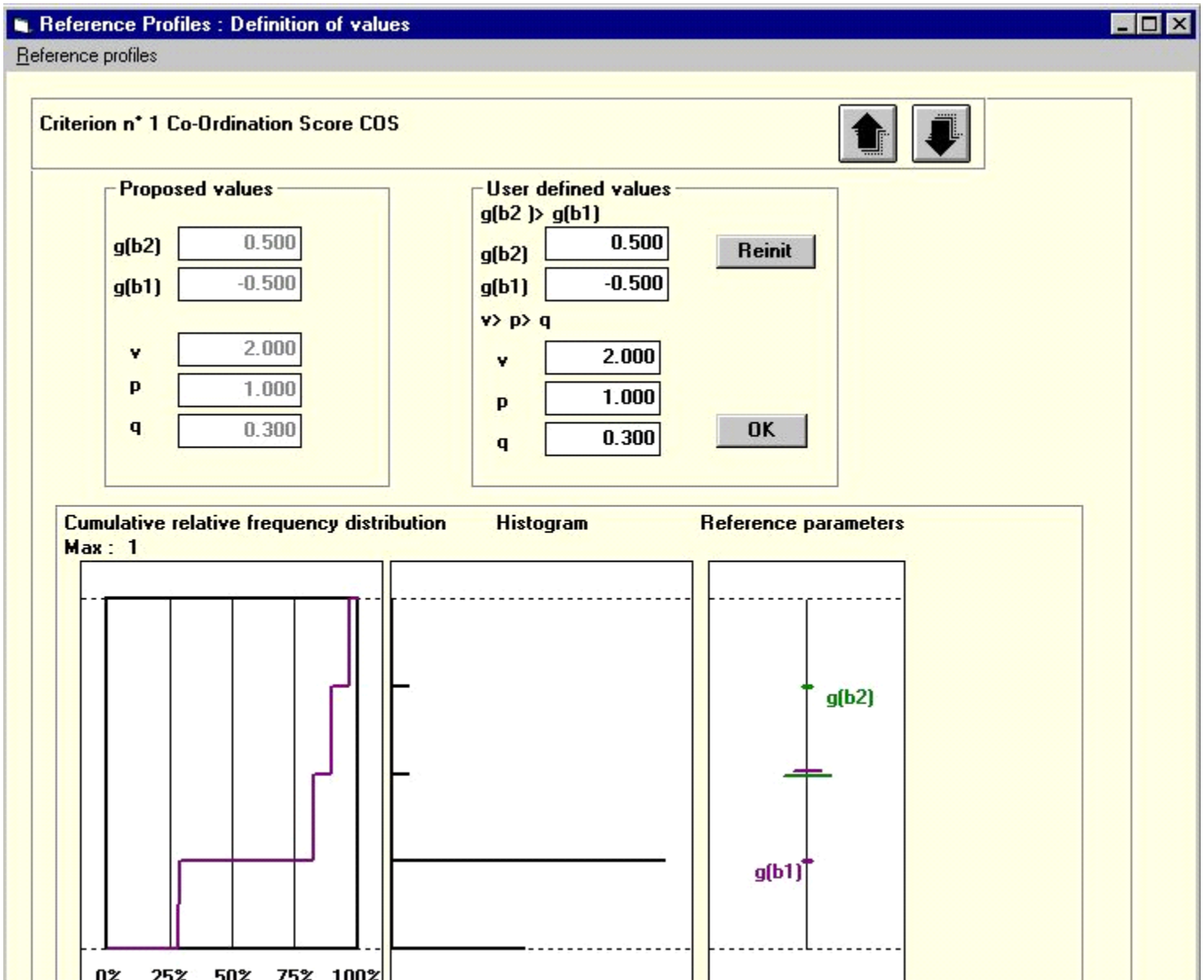
DT: Traffic Disruptions

DDI: Damage and/or Disruption on other Infrastructures

HCI: Hydraulic Criticality Index

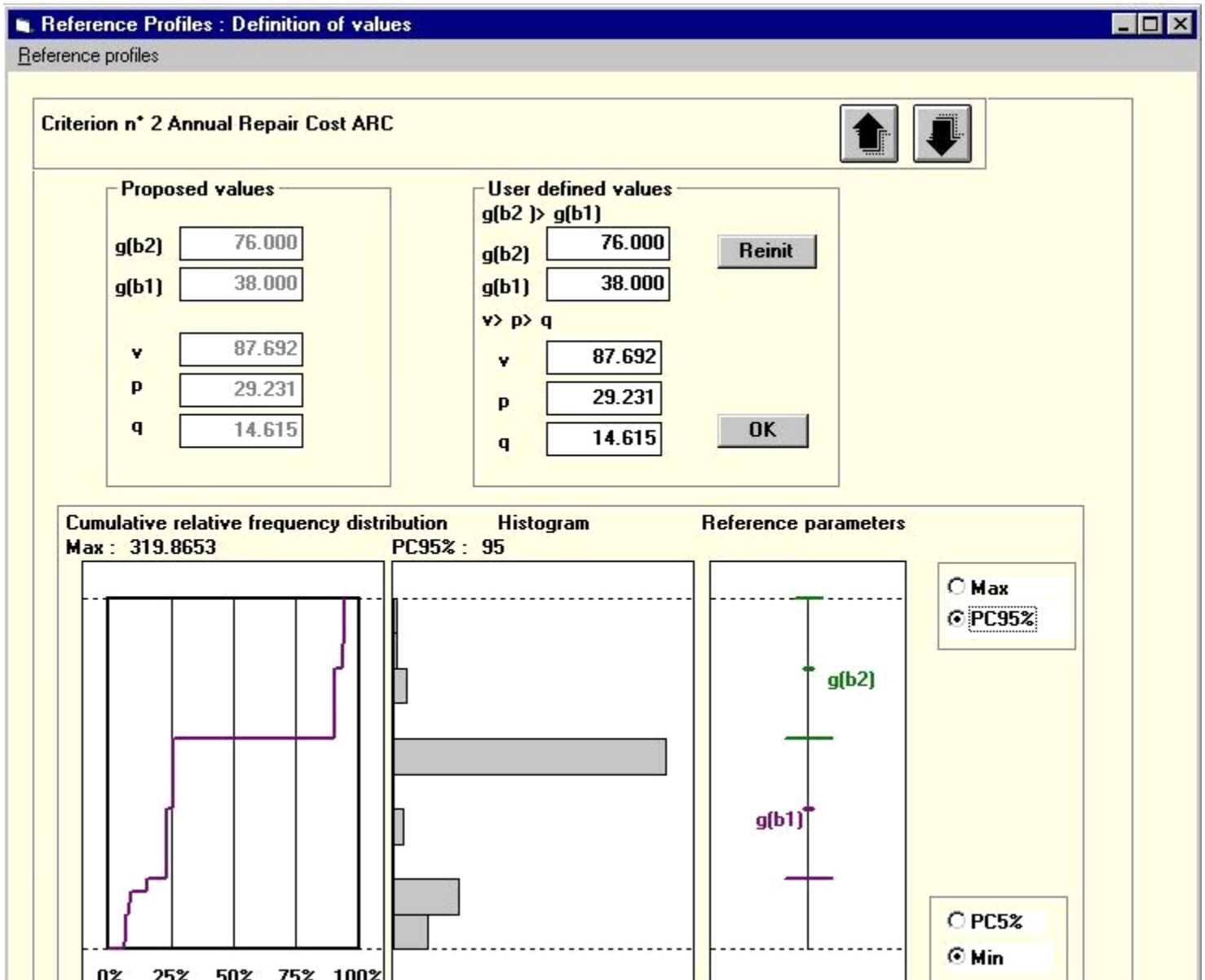
EXAMPLE 1: NEW PROJECT

PRIORITISATION / DEFINE PARAMETERS REFERENCE PROFILES >> COS



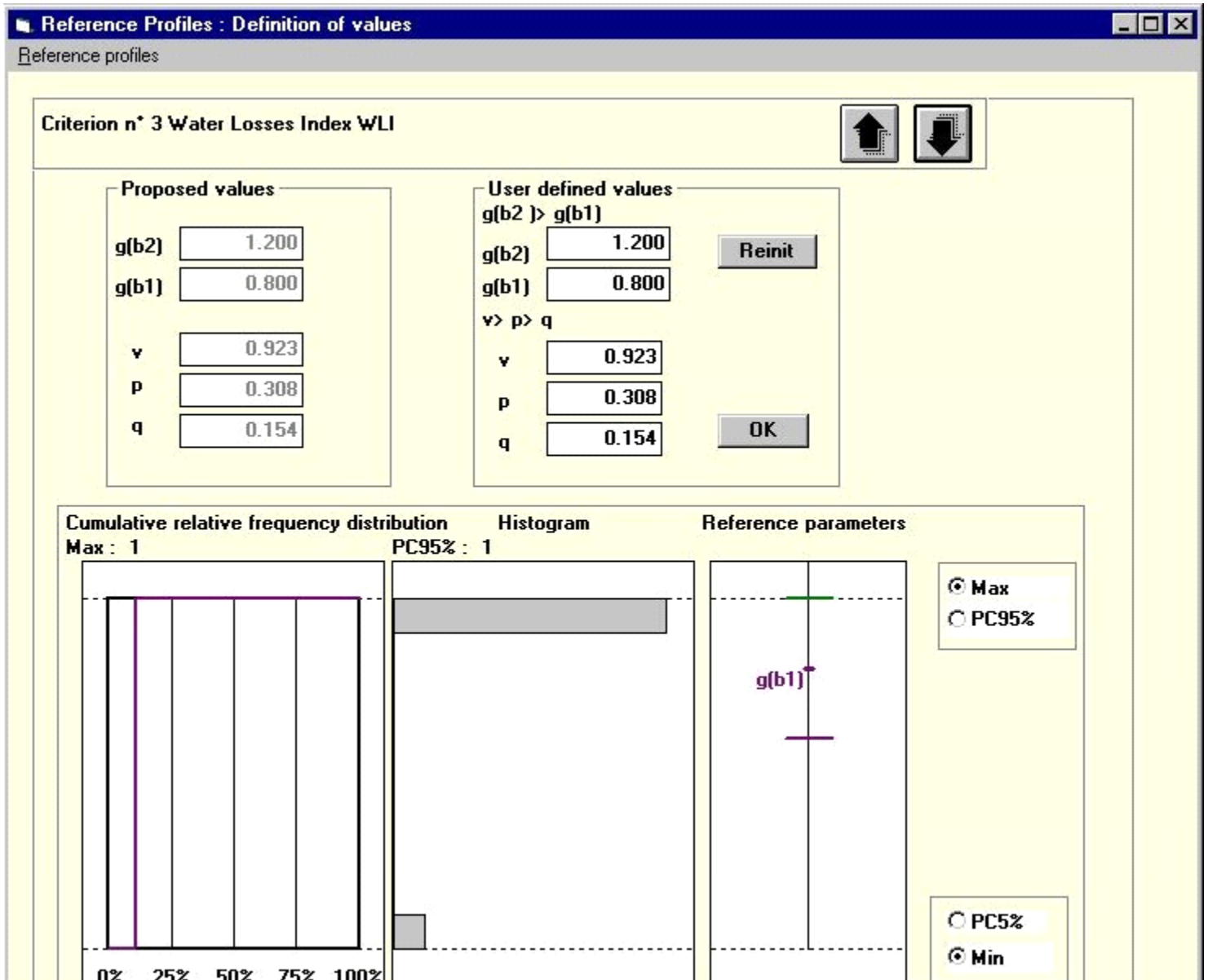
EXAMPLE 1: NEW PROJECT

PRIORITISATION / DEFINE PARAMETERS REFERENCE PROFILES >> ARC



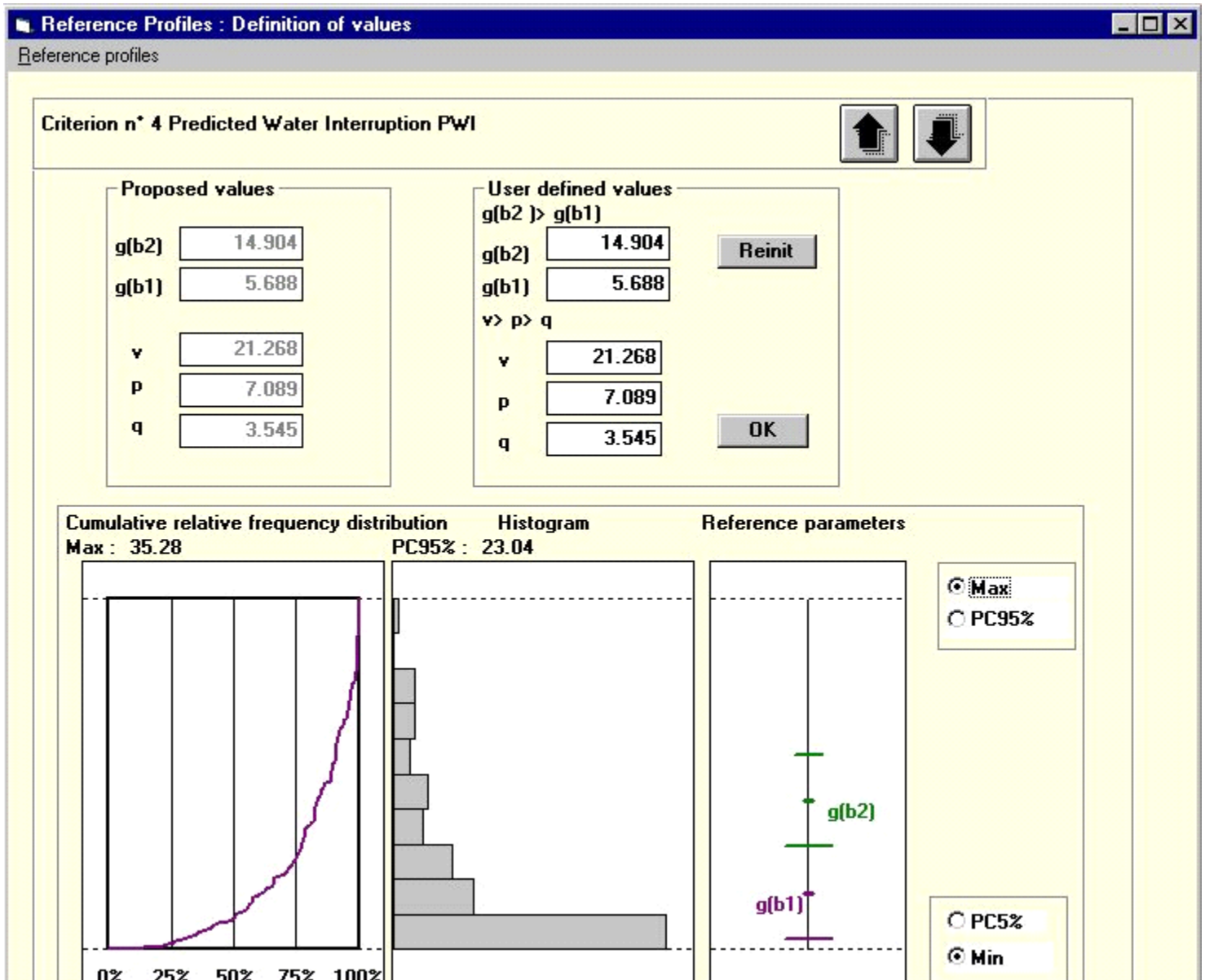
EXAMPLE 1: NEW PROJECT

PRIORITISATION / DEFINE PARAMETERS REFERENCE PROFILES >> WLI



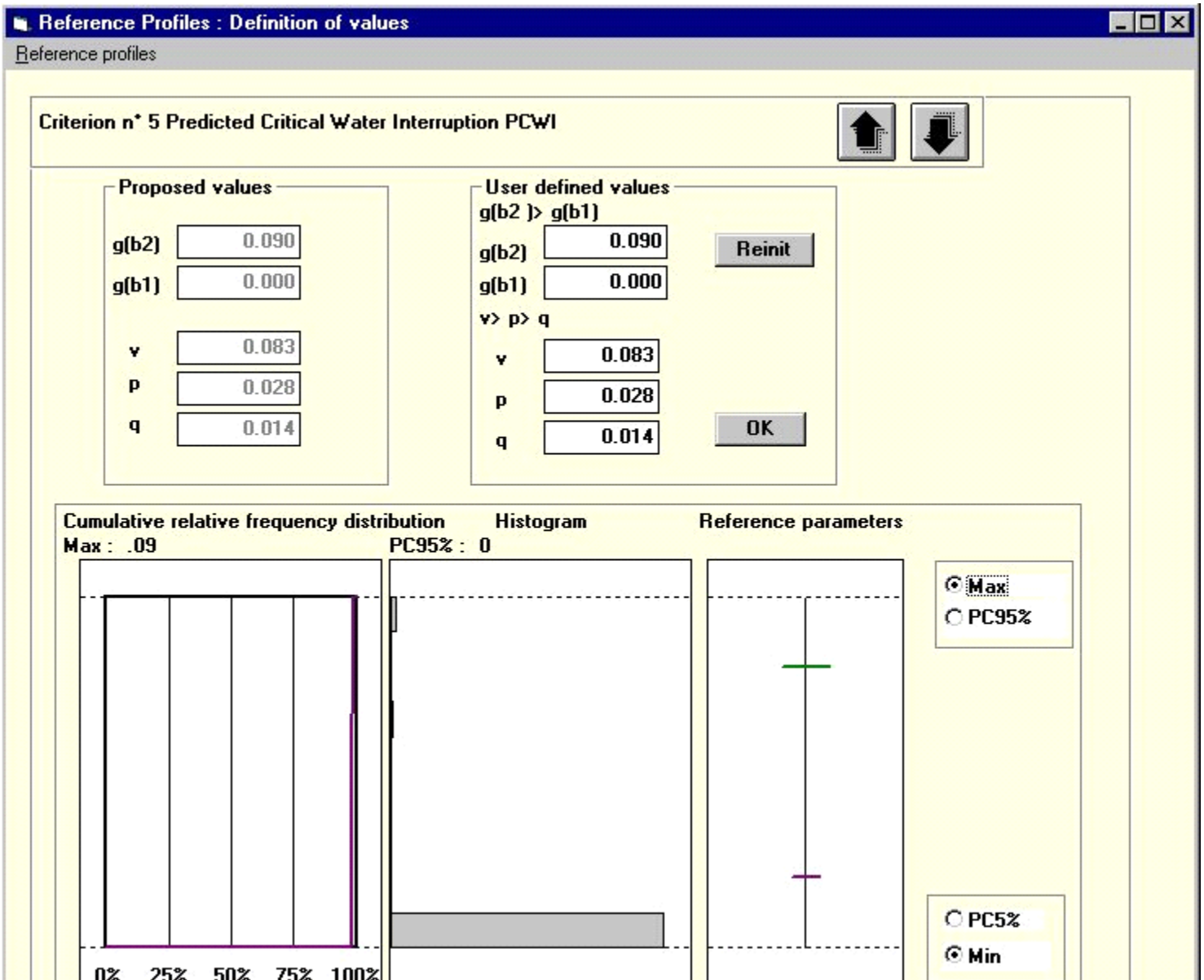
EXAMPLE 1: NEW PROJECT

PRIORITISATION / DEFINE PARAMETERS REFERENCE PROFILES >> PWI



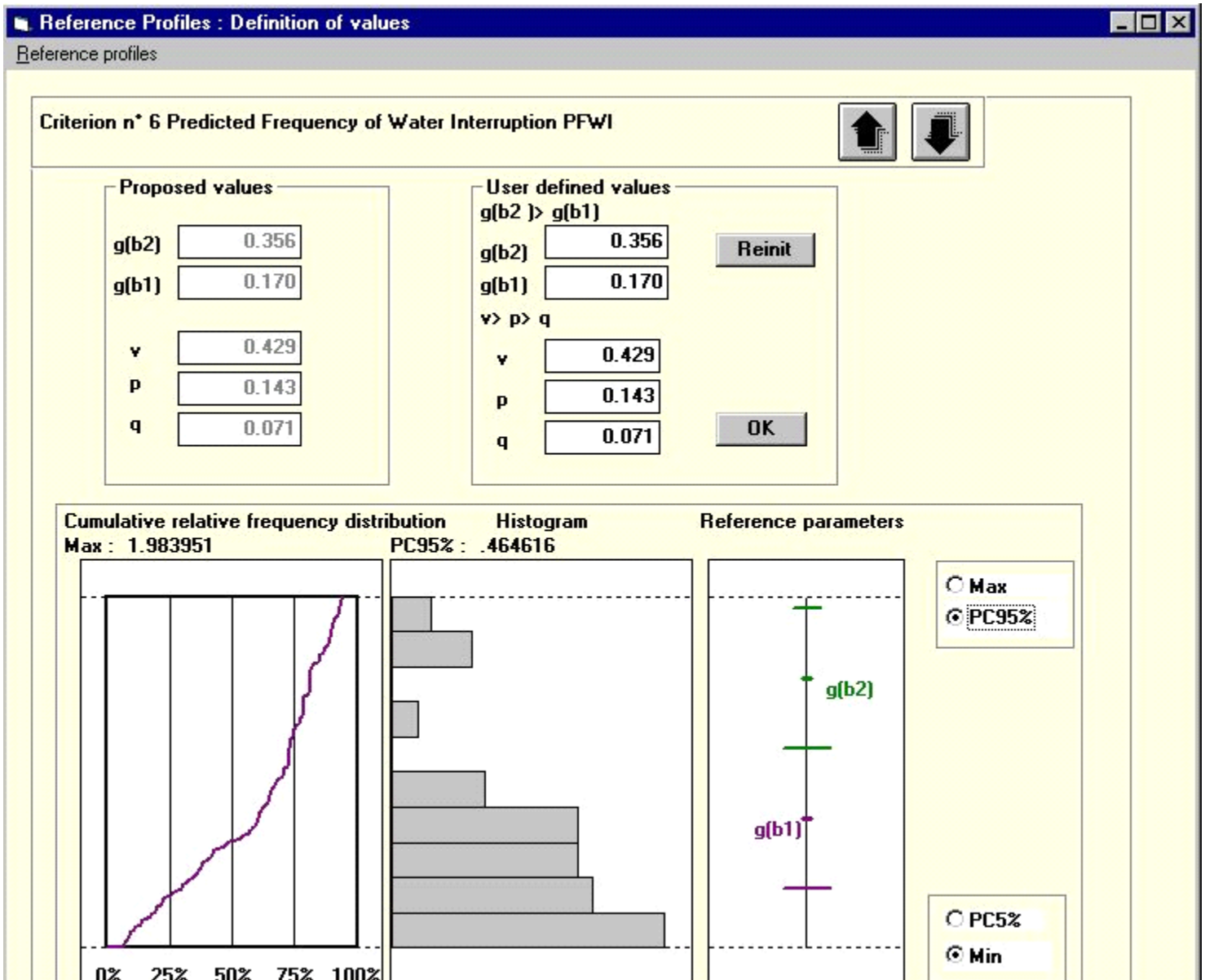
EXAMPLE 1: NEW PROJECT

PRIORITISATION / DEFINE PARAMETERS REFERENCE PROFILES >> PCWI



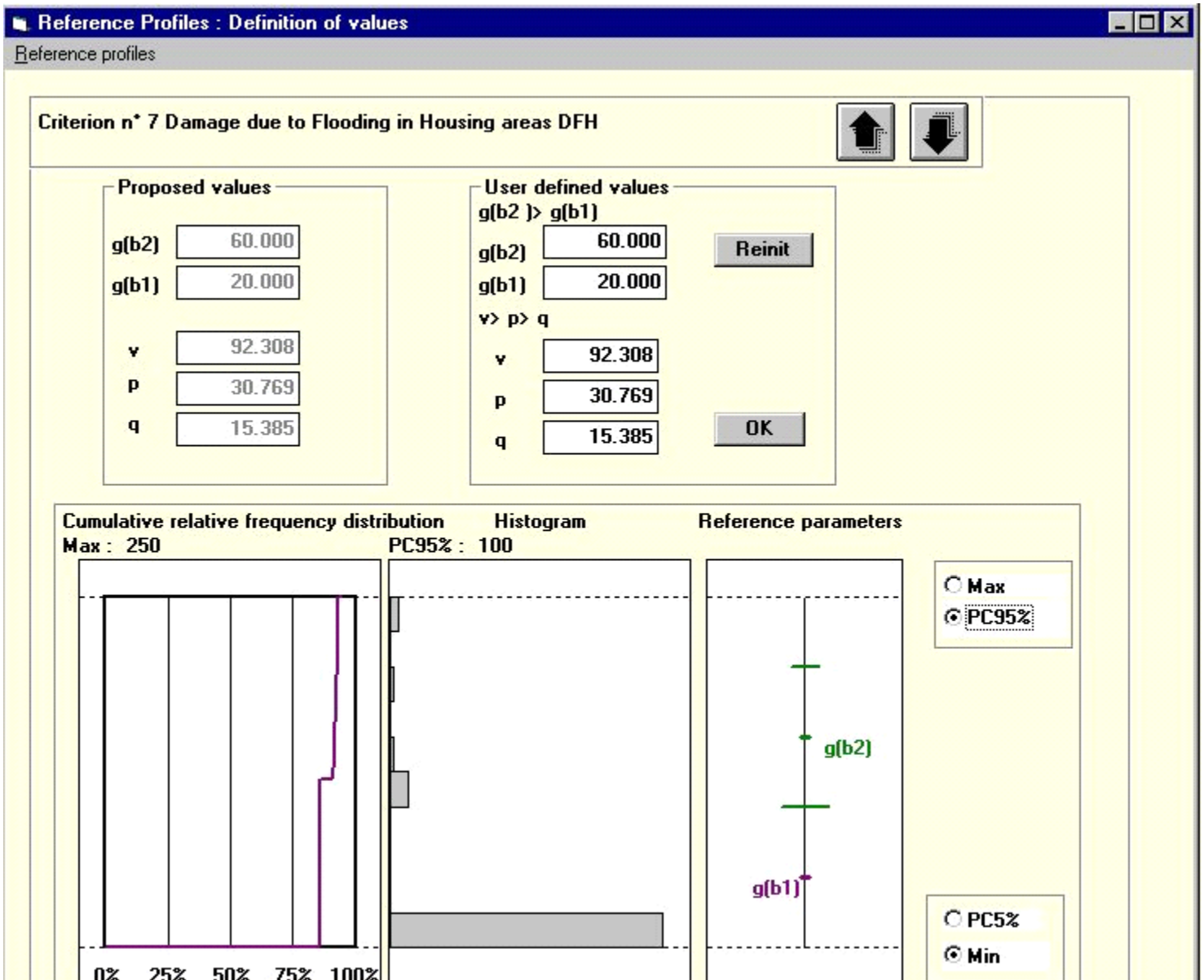
EXAMPLE 1: NEW PROJECT

PRIORITISATION / DEFINE PARAMETERS REFERENCE PROFILES >> PFWI



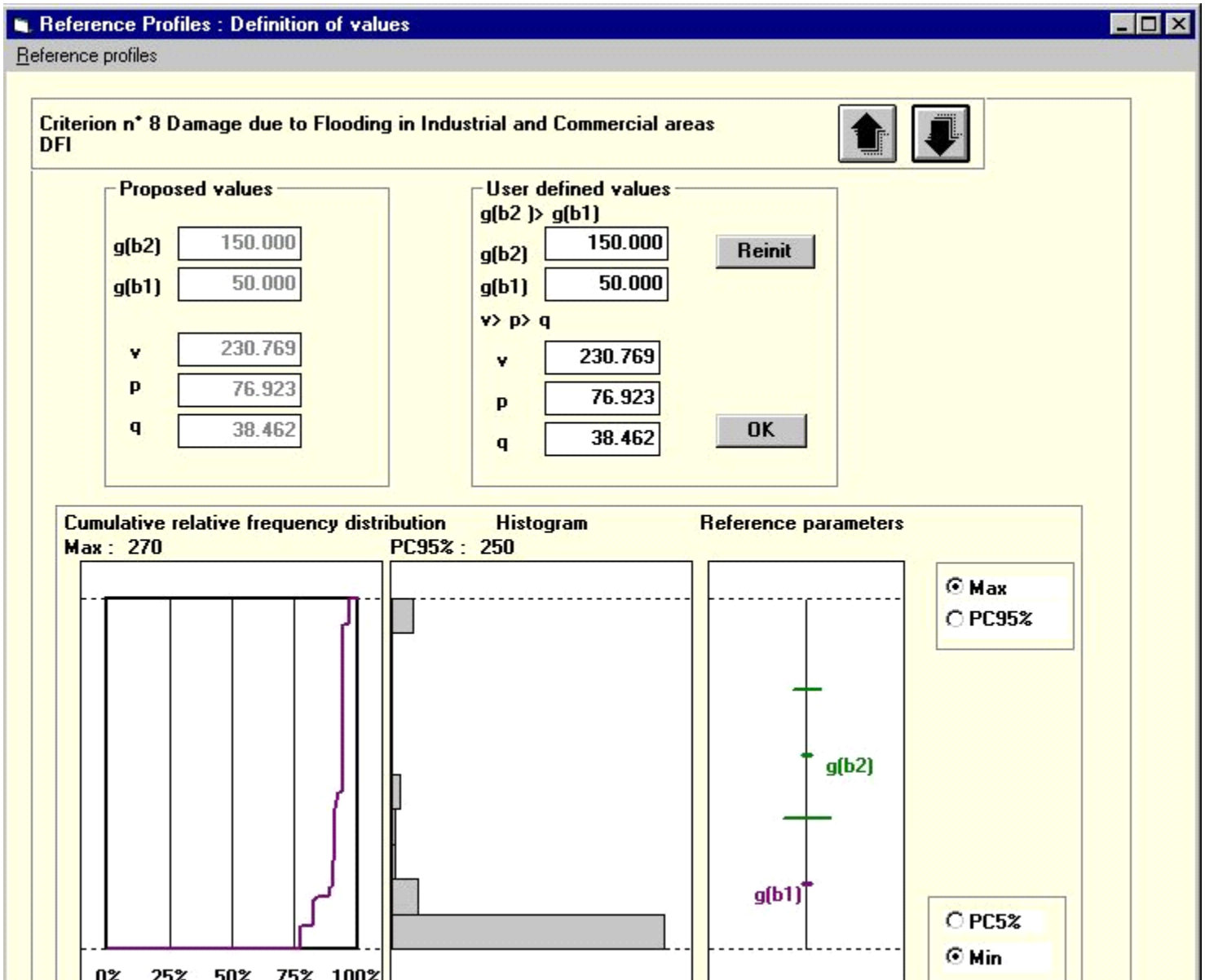
EXAMPLE 1: NEW PROJECT

PRIORITISATION / DEFINE PARAMETERS REFERENCE PROFILES >> DFH



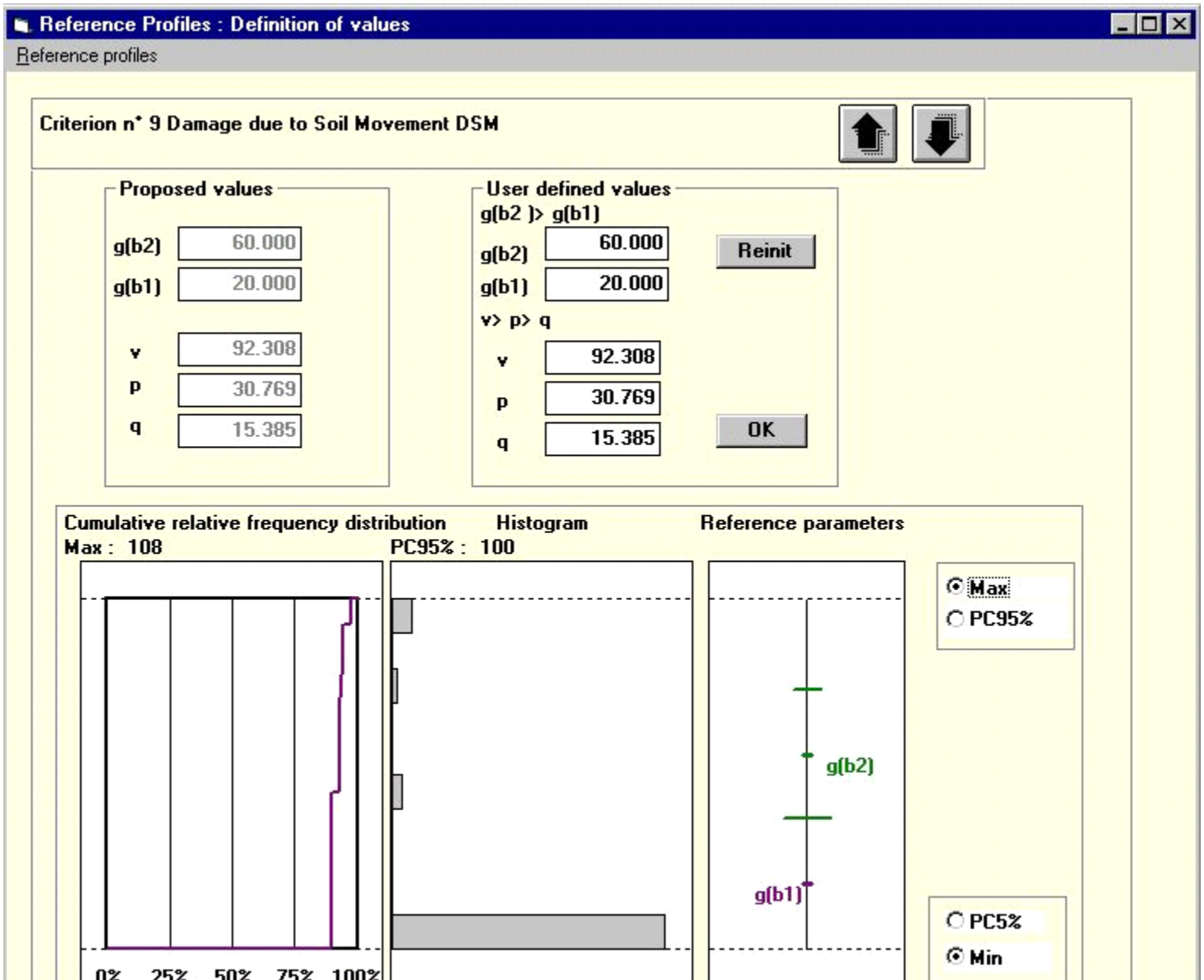
EXAMPLE 1: NEW PROJECT

PRIORITISATION / DEFINE PARAMETERS REFERENCE PROFILES >> DFI



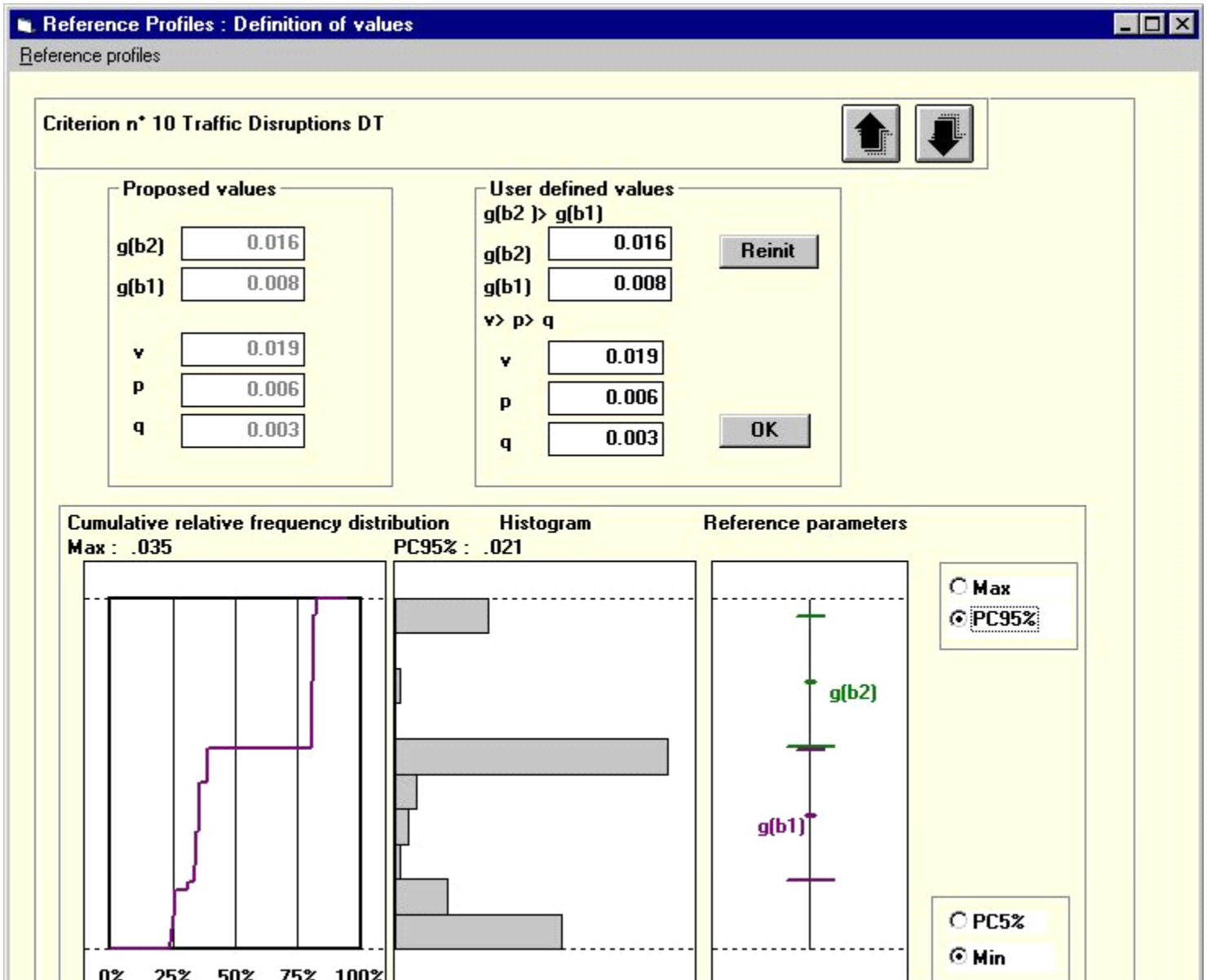
EXAMPLE 1: NEW PROJECT

PRIORITISATION / DEFINE PARAMETERS REFERENCE PROFILES >> DSM



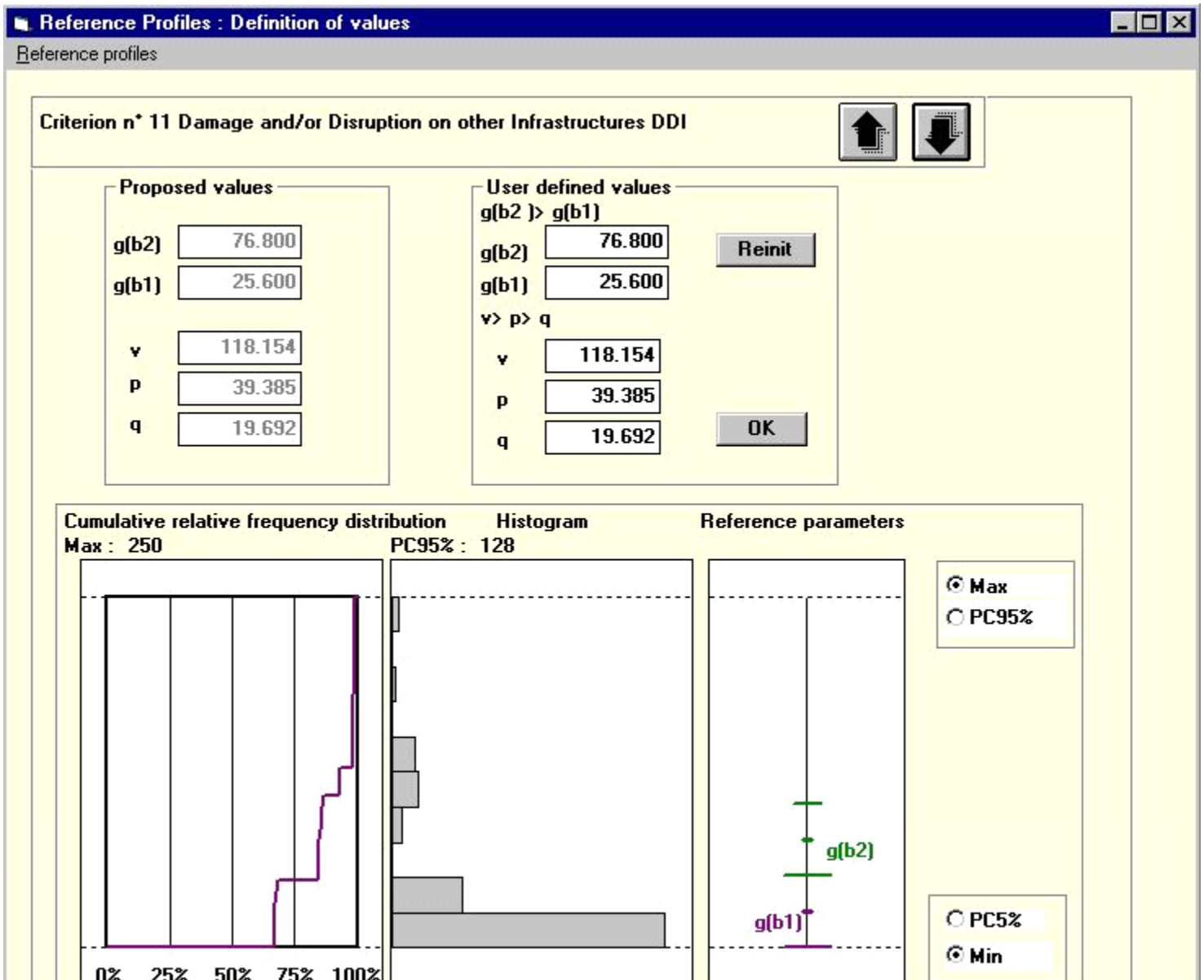
EXAMPLE 1: NEW PROJECT

PRIORITISATION / DEFINE PARAMETERS REFERENCE PROFILES >> DT



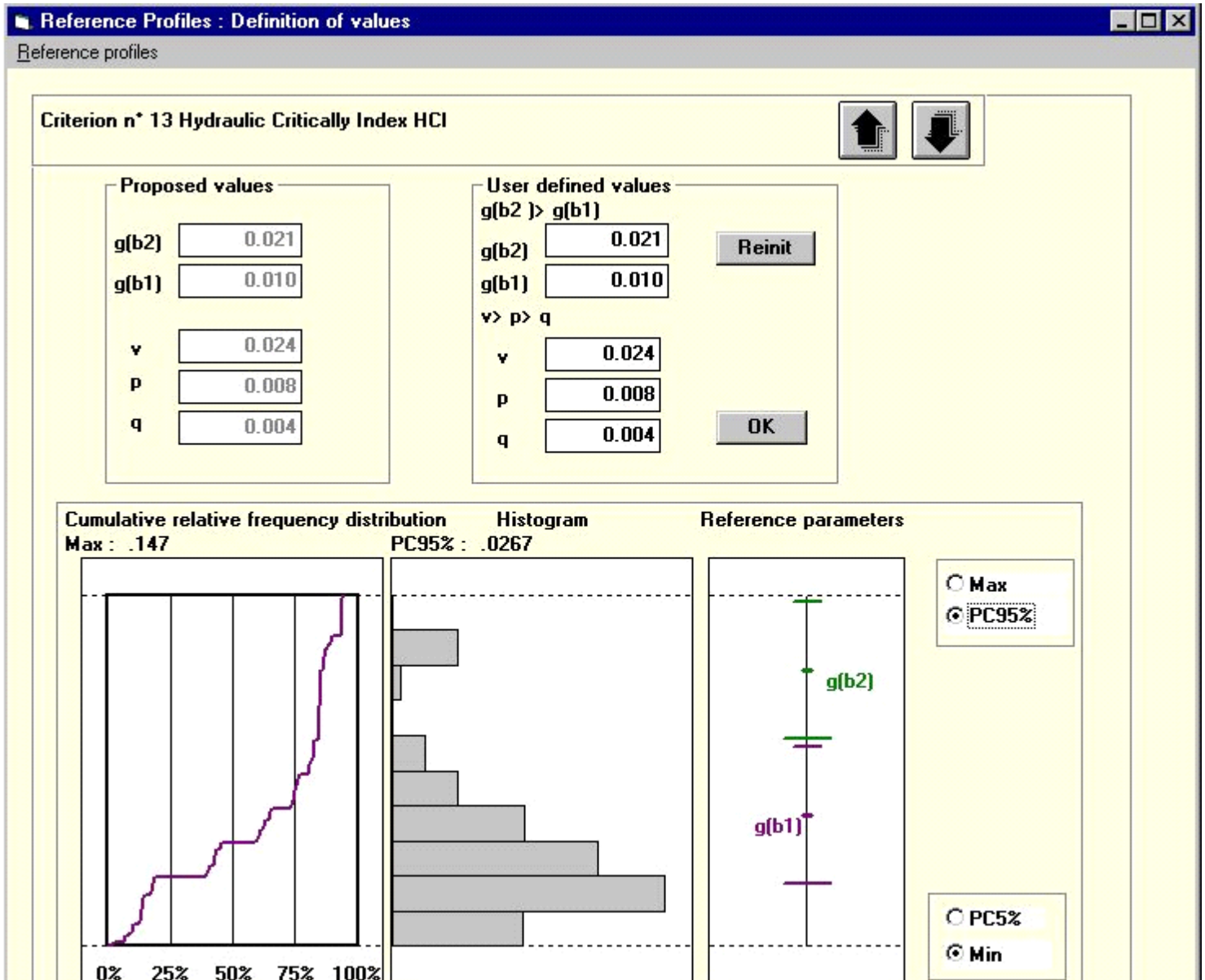
EXAMPLE 1: NEW PROJECT

PRIORITISATION / DEFINE PARAMETERS REFERENCE PROFILES >> DDI



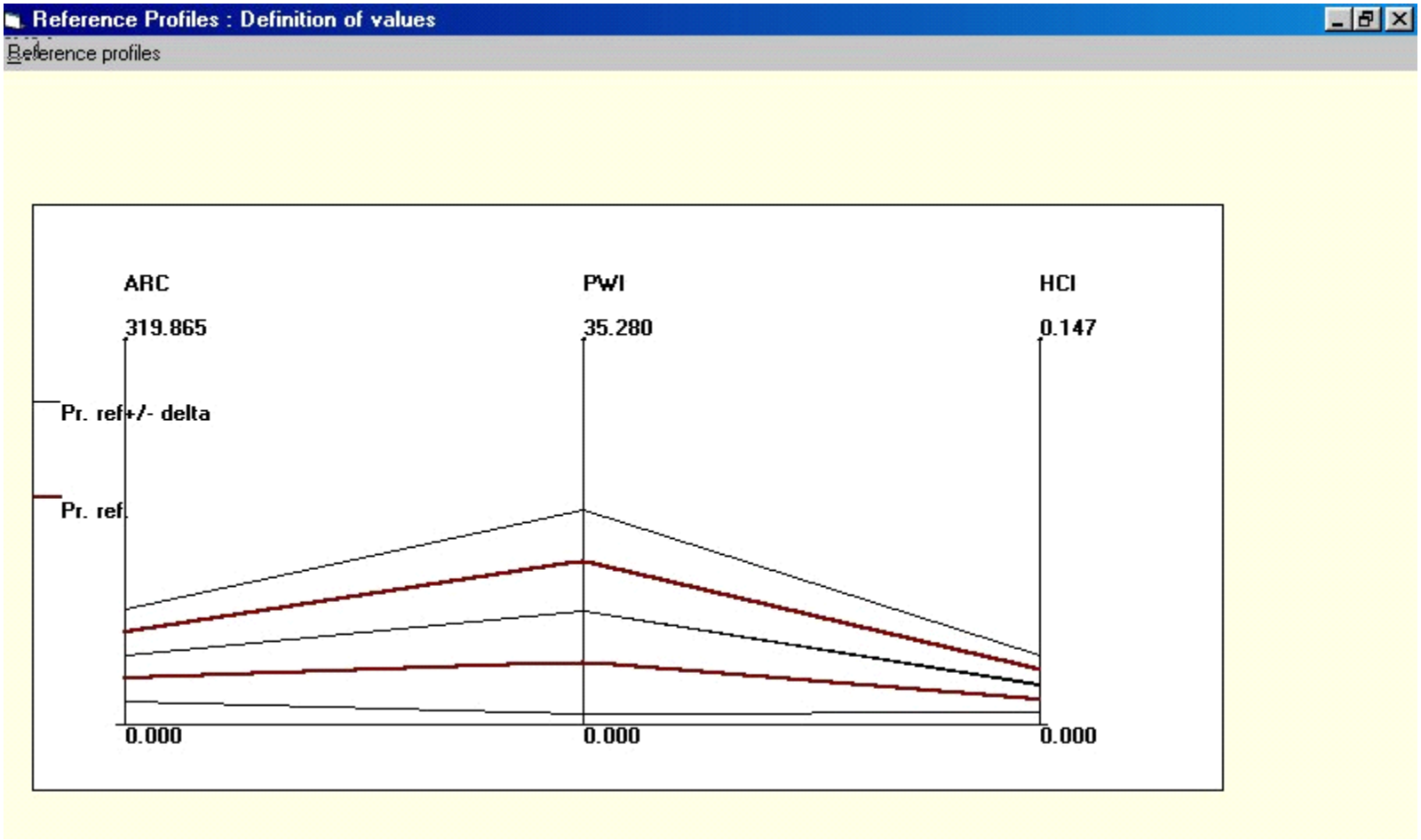
EXAMPLE 1: NEW PROJECT

PRIORITISATION / DEFINE PARAMETERS REFERENCE PROFILES >> HCI



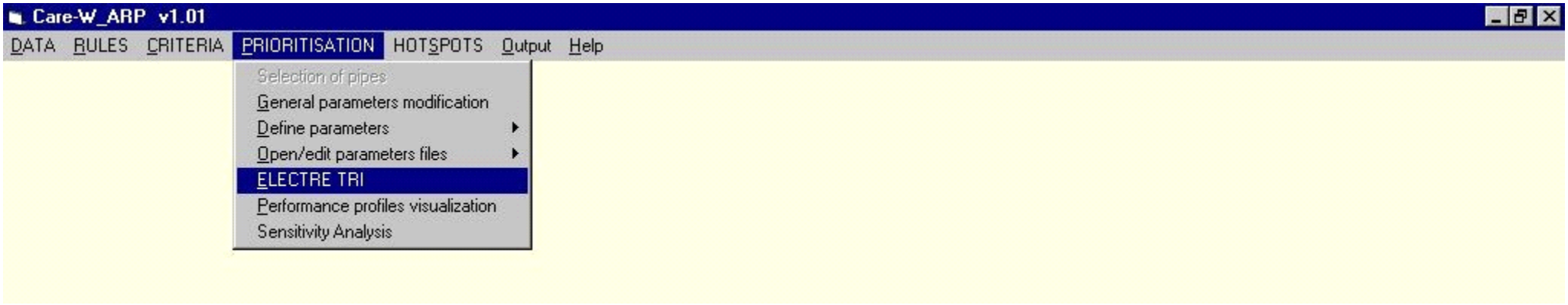
EXAMPLE 1: NEW PROJECT

PRIORITISATION / DEFINE PARAMETERS >> REFERENCE PROFILES >> CONTROL ALL REFERENCE PROFILES



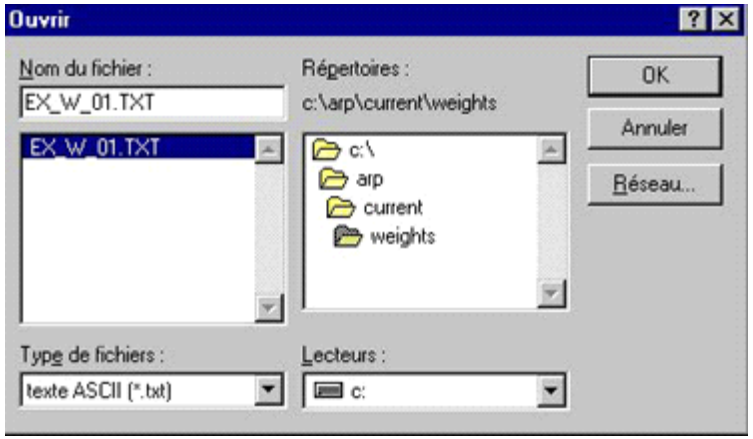
EXAMPLE 1: NEW PROJECT

PRIORITISATION / ELECTRE TRI

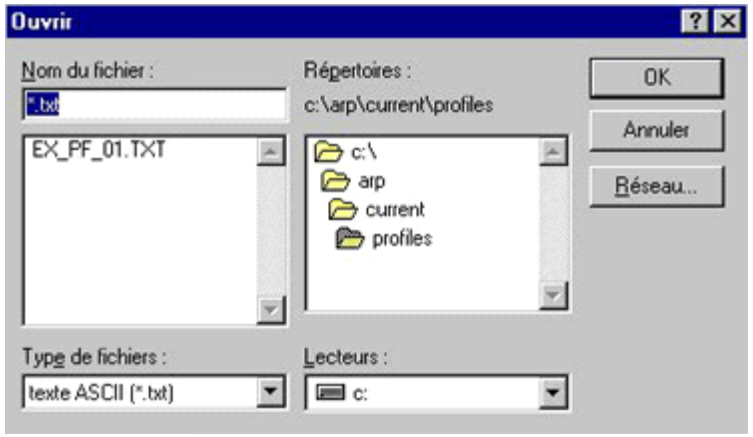


PRIORITISATION / ELECTRE TRI

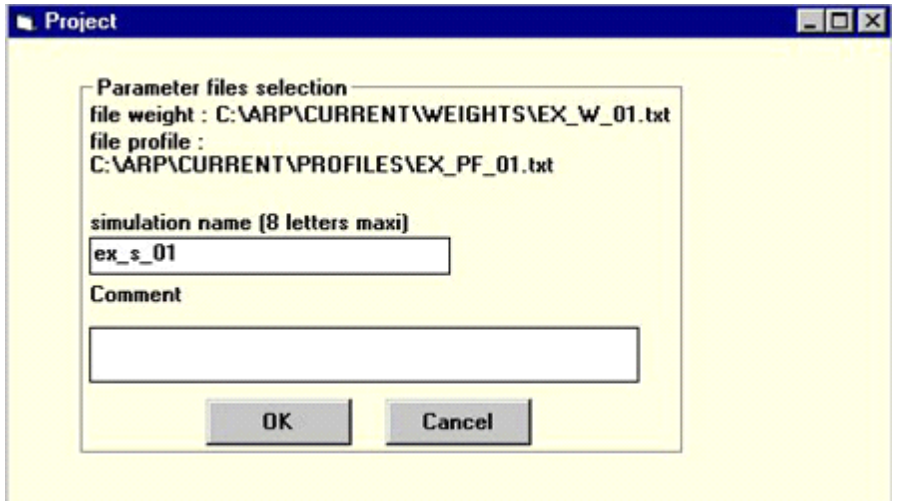
Choose Weight file



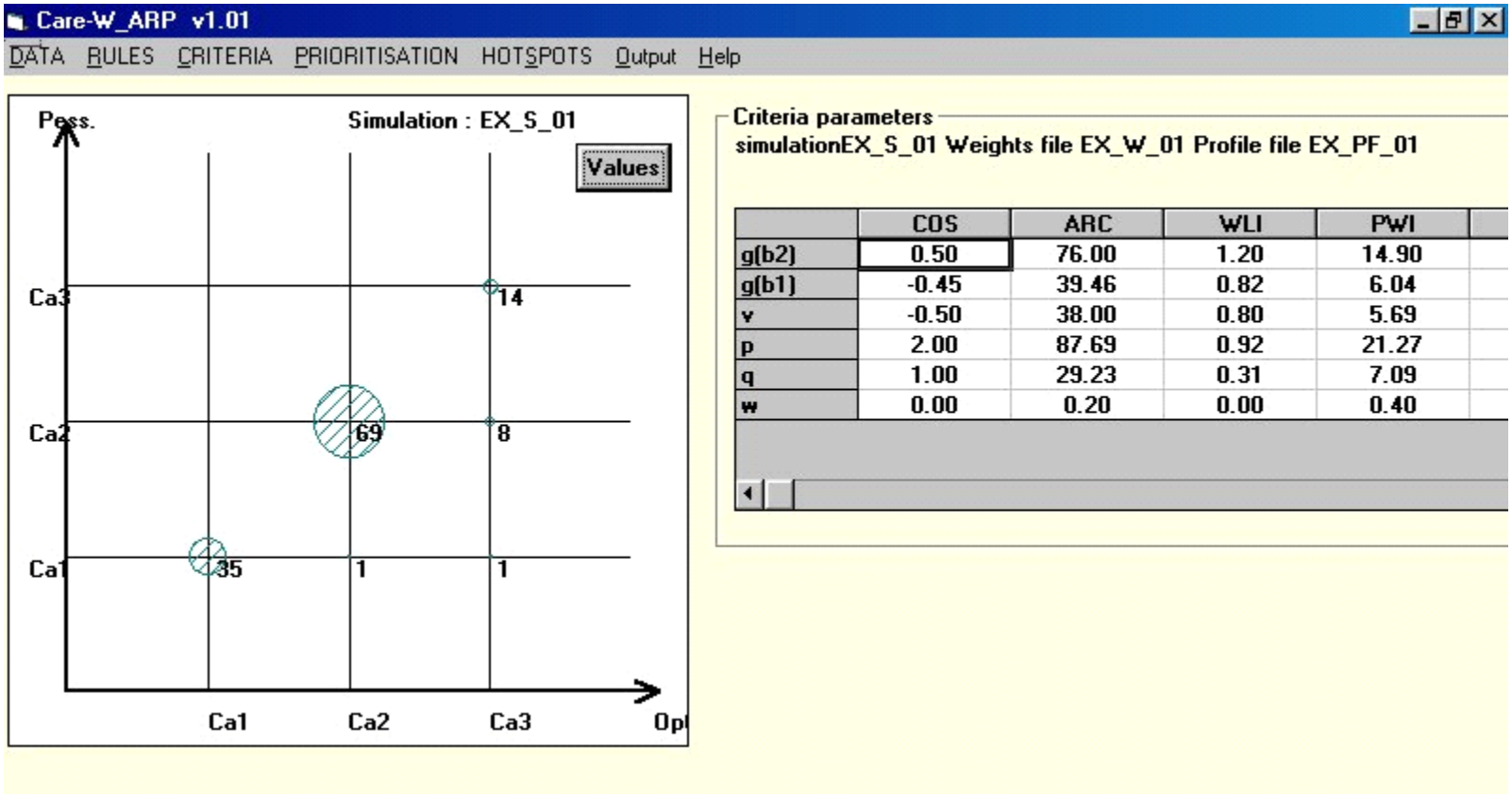
Choose Reference profiles file



Name your simulation

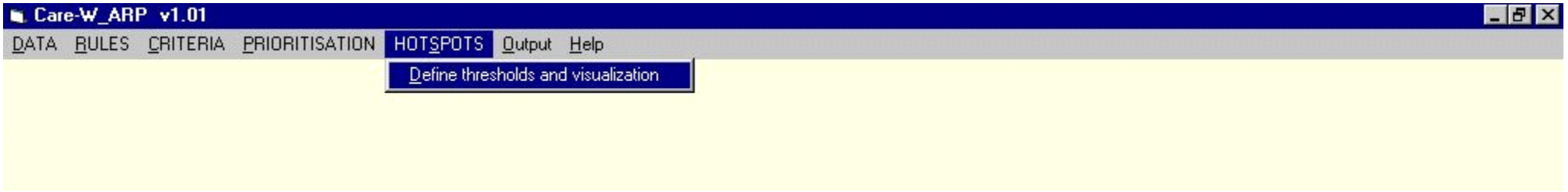


PRIORITISATION / ELECTRE TRI >> DISPLAY RESULT

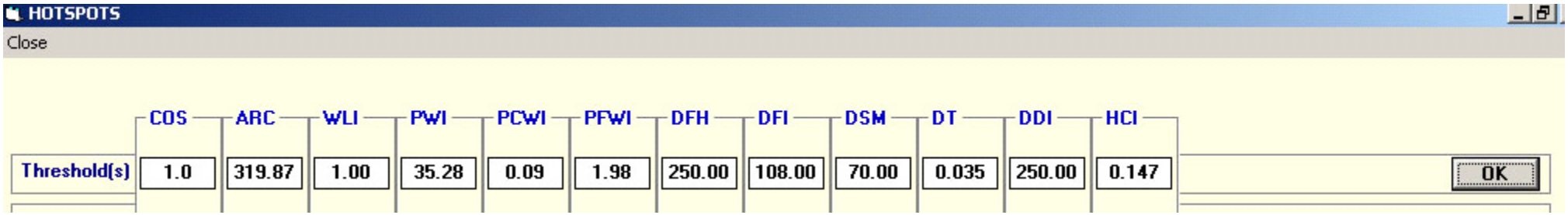

Care-W_ARP v1.01
DATA RULES CRITERIA PRIORITISATION HOTSPOTS Output Help
Pess.
Simulation : EX_S_01
Values
Ca3
Ca2
Ca1
14
69
8
35
1
1
Ca1
Ca2
Ca3
Criteria parameters
simulationEX_S_01 Weights file EX_W_01 Profile file EX_PF_01
COS ARC WLI PWI
g(b2) 0.50 76.00 1.20 14.90
g(b1) -0.45 39.46 0.82 6.04
v -0.50 38.00 0.80 5.69
p 2.00 87.69 0.92 21.27
q 1.00 29.23 0.31 7.09
w 0.00 0.20 0.00 0.40

EXAMPLE 1: NEW PROJECT

HOT-SPOTS



HOT-SPOTS >> CHOOSE THRESHOLD(S)

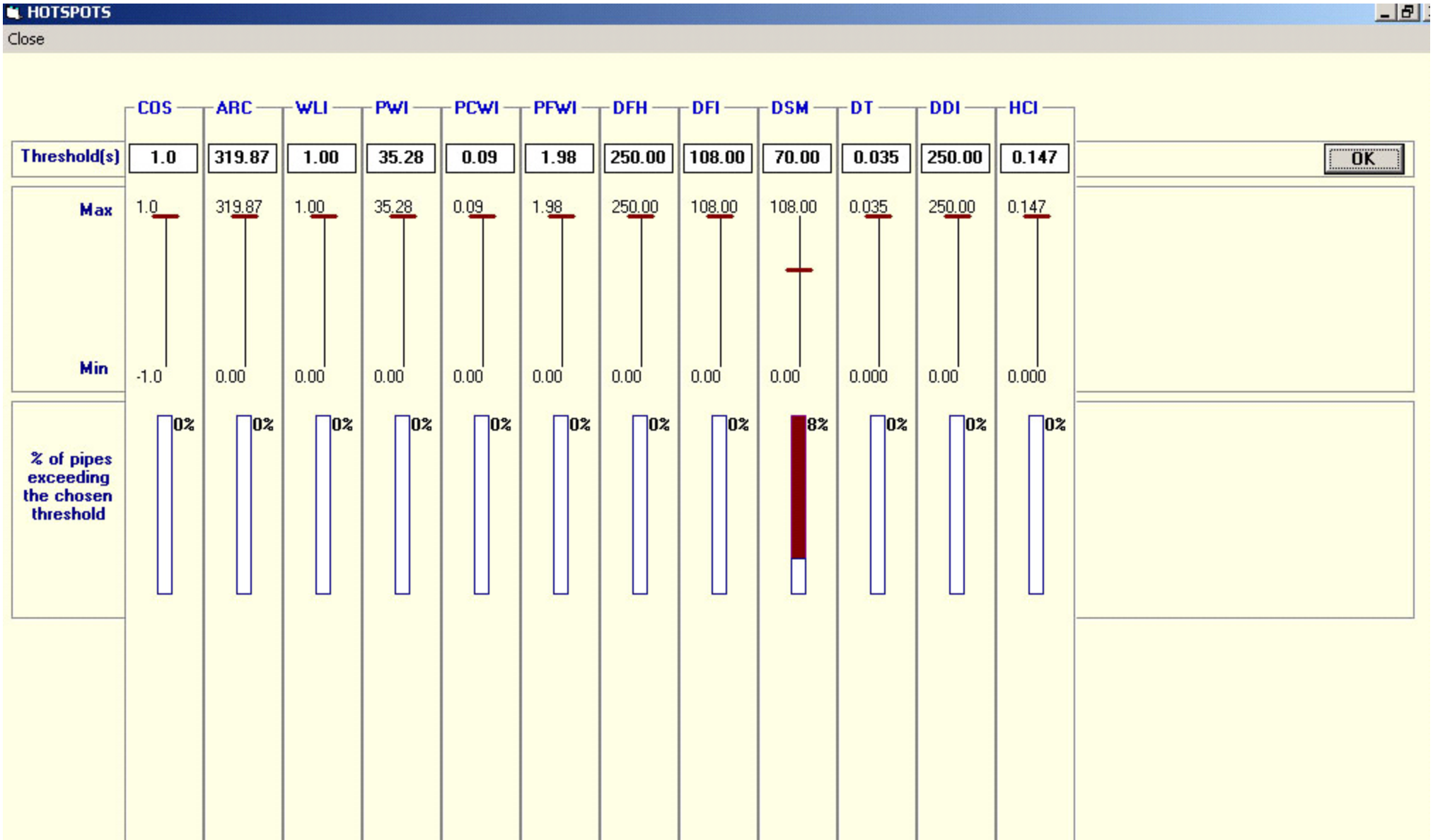


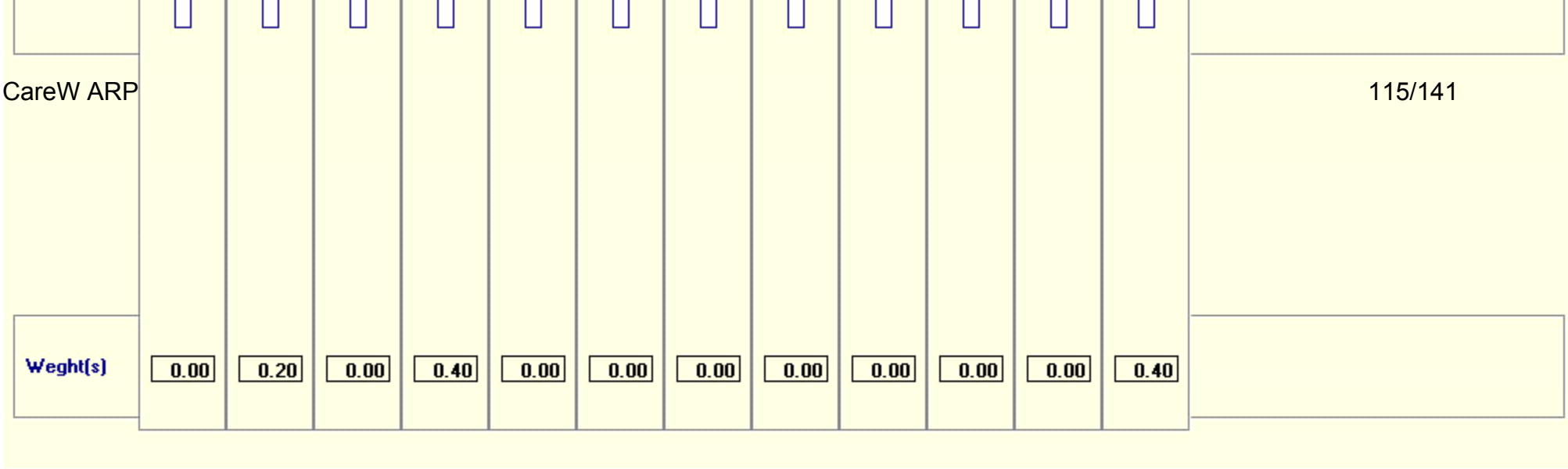
Hot-Spots >> Display results, if no run Electre Tri

Hot-Spots >> Display results, if run Electre Tri

EXAMPLE 1: NEW PROJECT

HOT-SPOTS >> DISPLAY RESULTS (*if no run Electre Tri*)

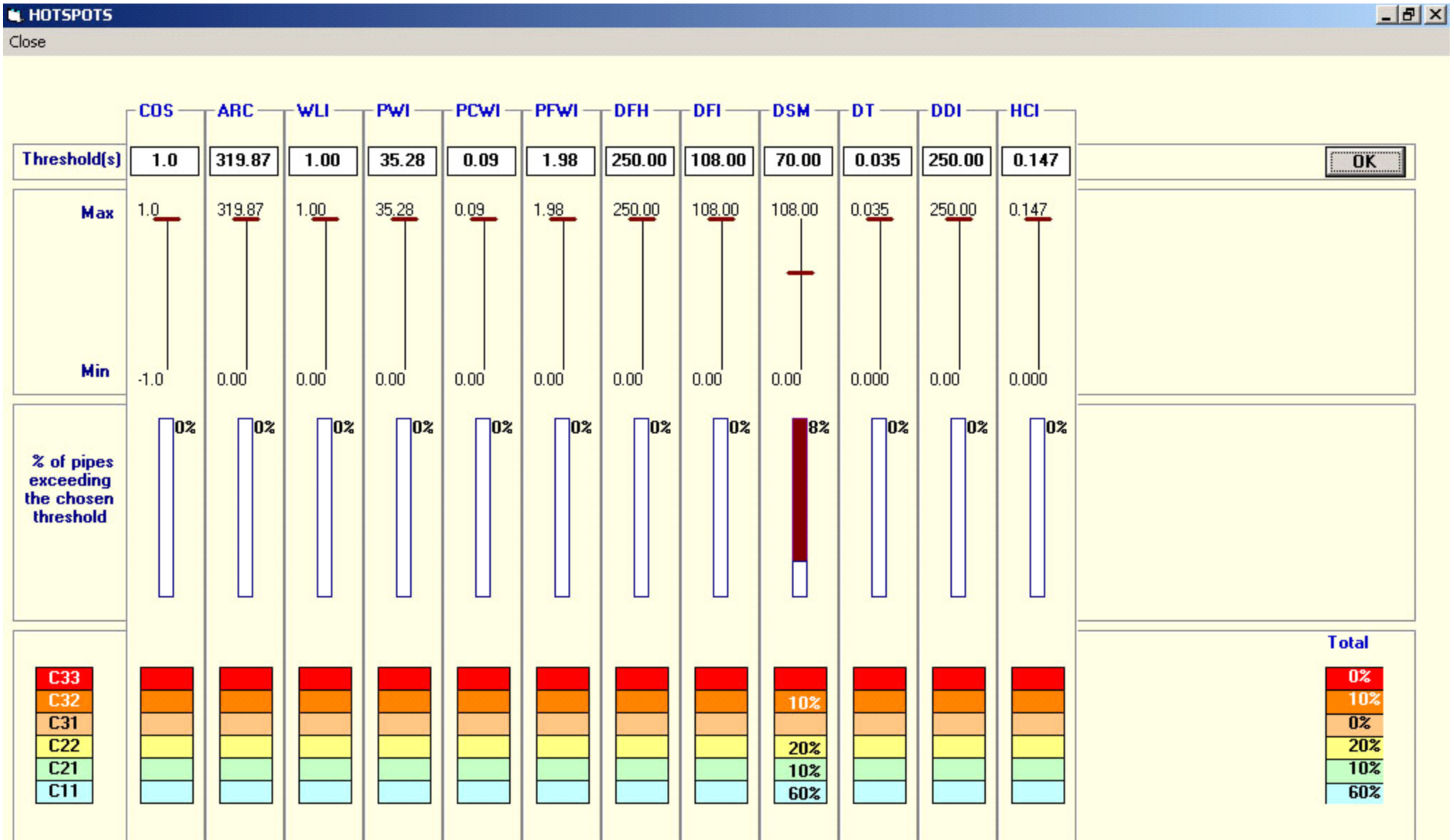




Weght(s)	0.00	0.20	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40

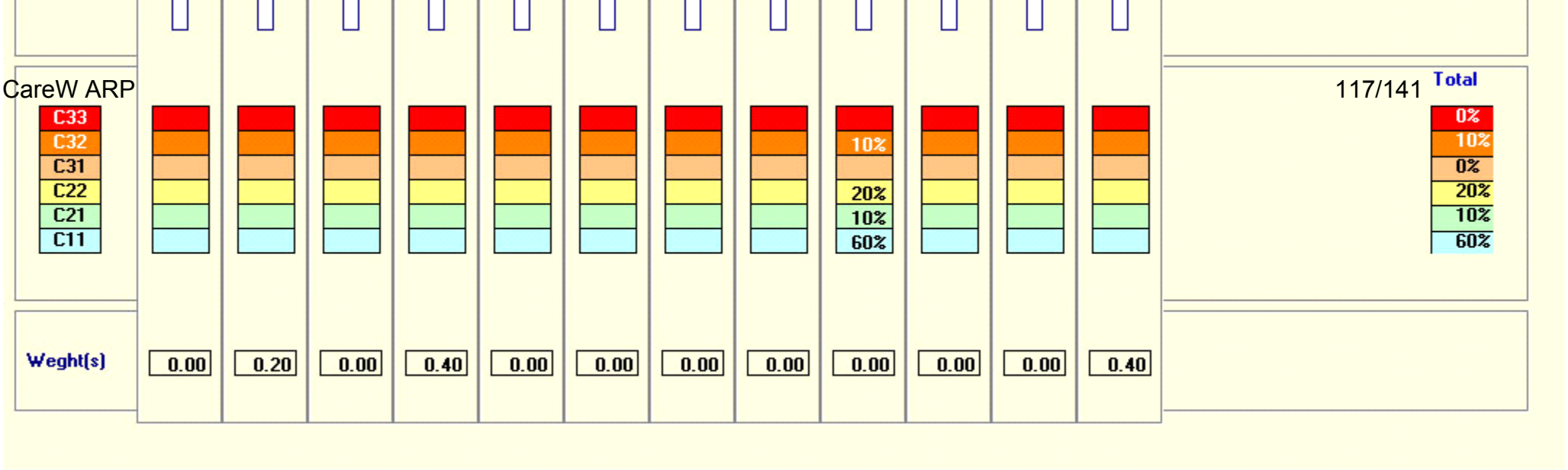
EXAMPLE 1: NEW PROJECT

HOT-SPOTS >> DISPLAY RESULTS (*if run Electre Tri*)



CareW ARP

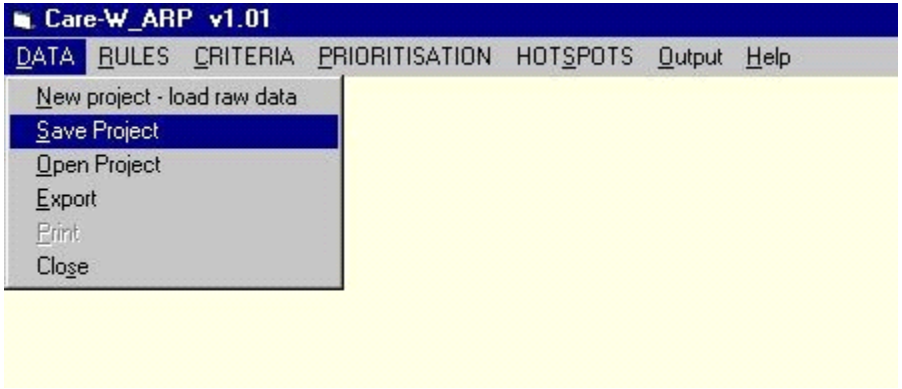
117/141



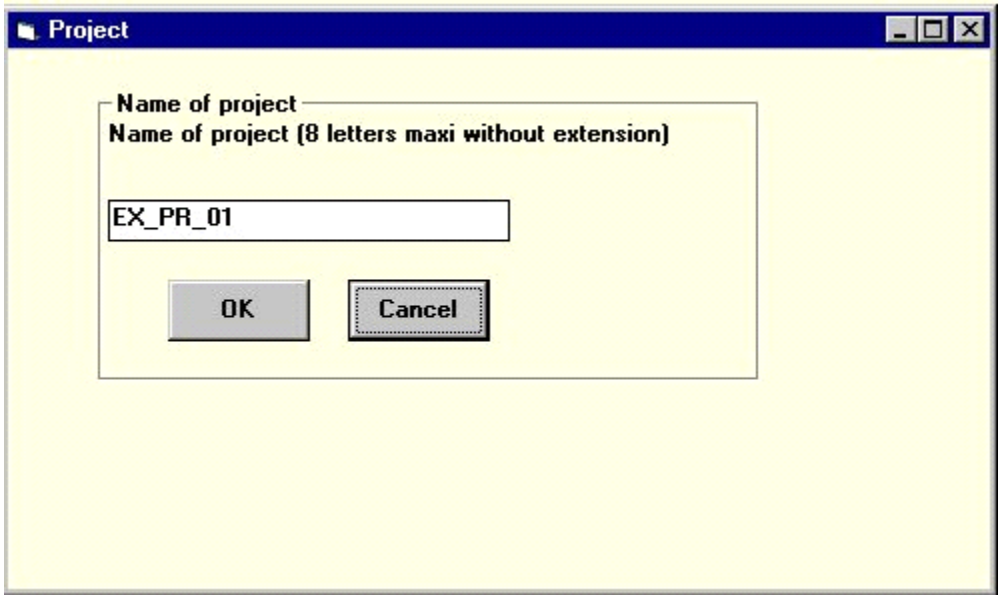
EXAMPLE 1: NEW PROJECT

DATA / SAVE PROJECT & EXPORT RESULT FILE

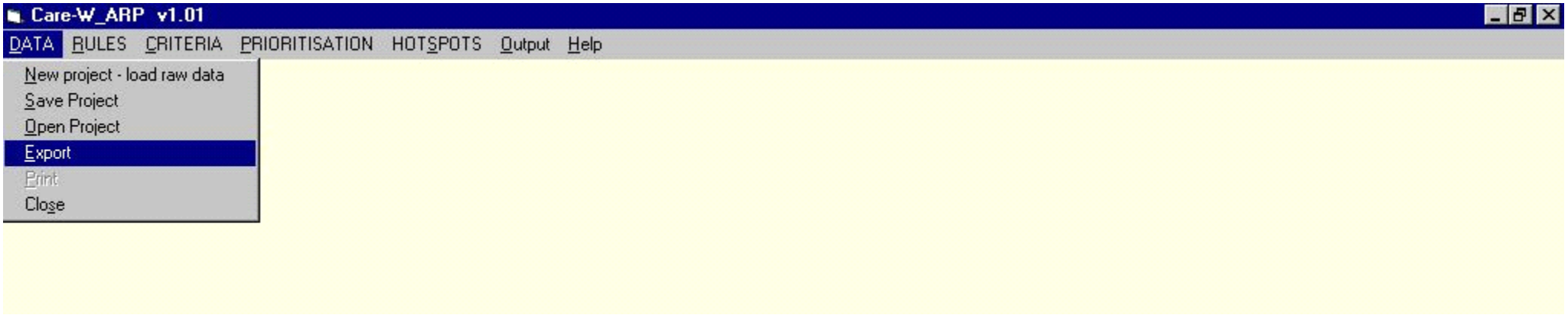
1)



2)

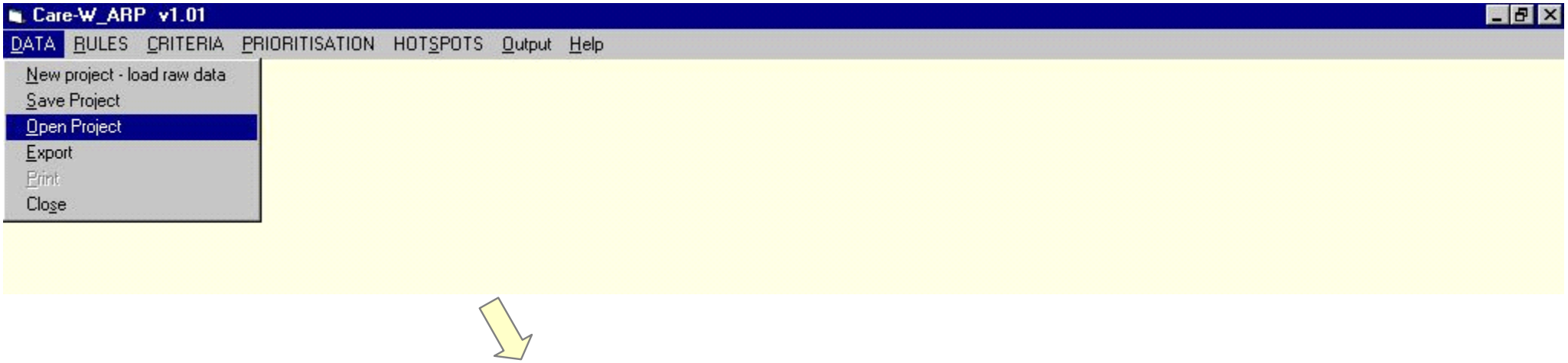


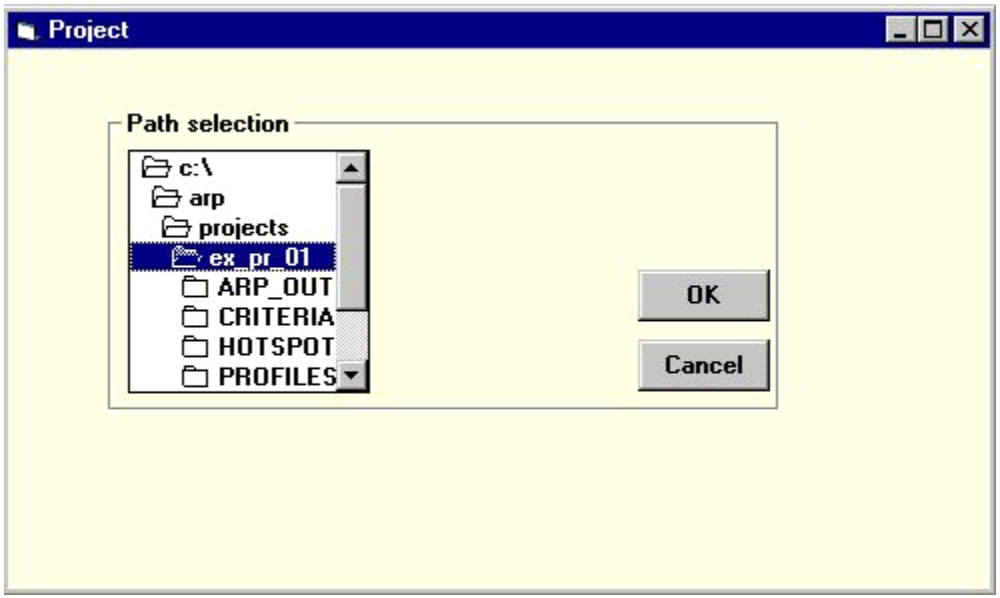
3)


Care-W_ARP v1.01
DATA
RULES
CRITERIA
PRIORITISATION
HOTSPOTS
Output
Help
New project - load raw data
Save Project
Open Project
Export
Print
Close

EXAMPLE 2: WORK ON AN EXISTING PROJECT AND ADD SIMULATIONS

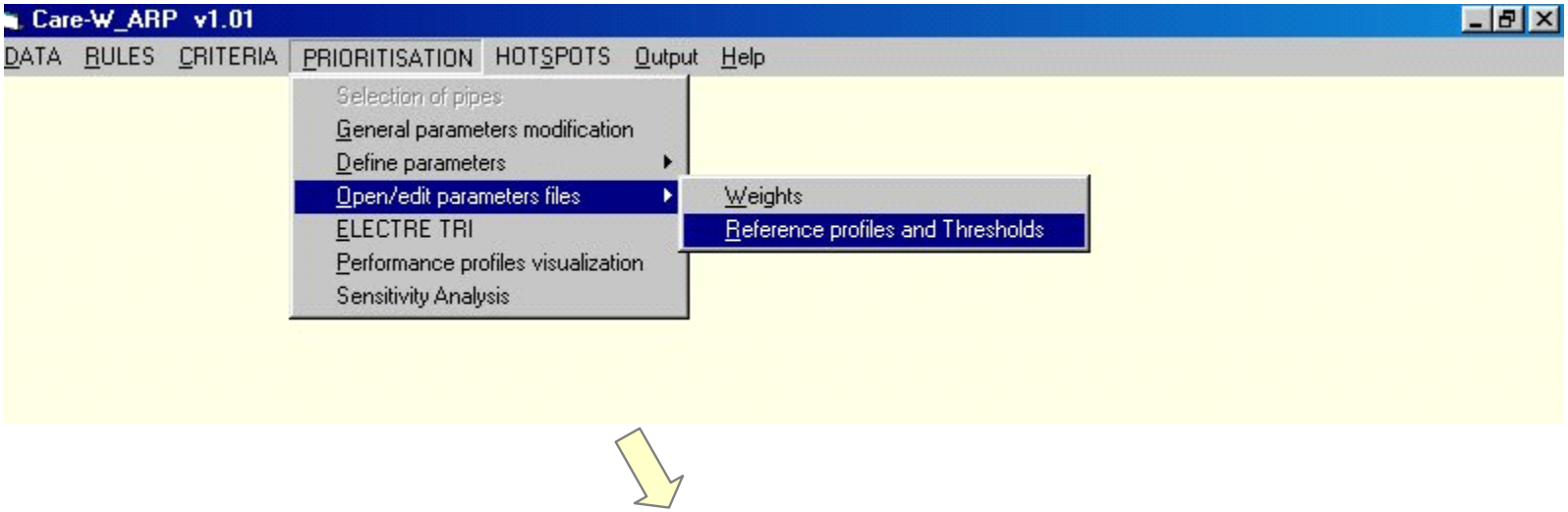
DATA / OPEN PROJECT

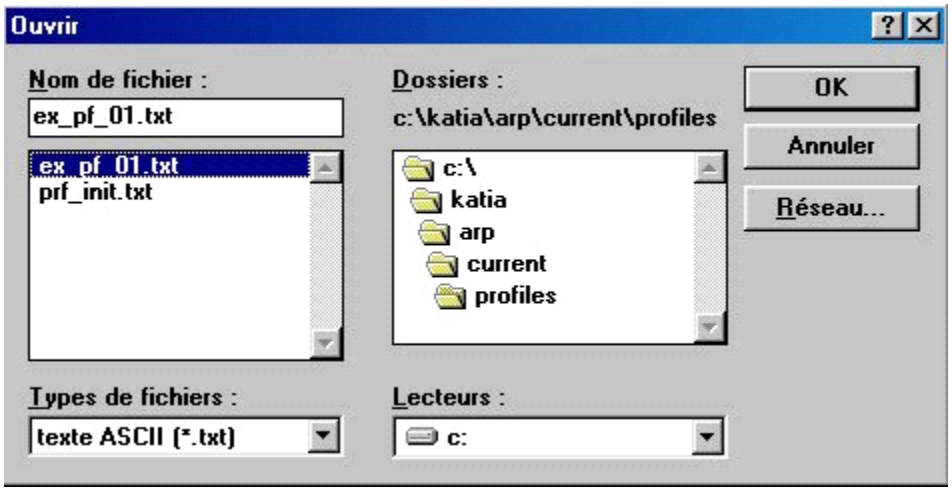



Project
Path selection
c:\
arp
projects
ex_pr_01
ARP_OUT
CRITERIA
HOTSPOT
PROFILES
OK
Cancel

EXAMPLE 2: WORK ON AN EXISTING PROJECT AND ADD SIMULATIONS

PRIORITISATION / OPEN-EDIT REFERENCE PROFILES

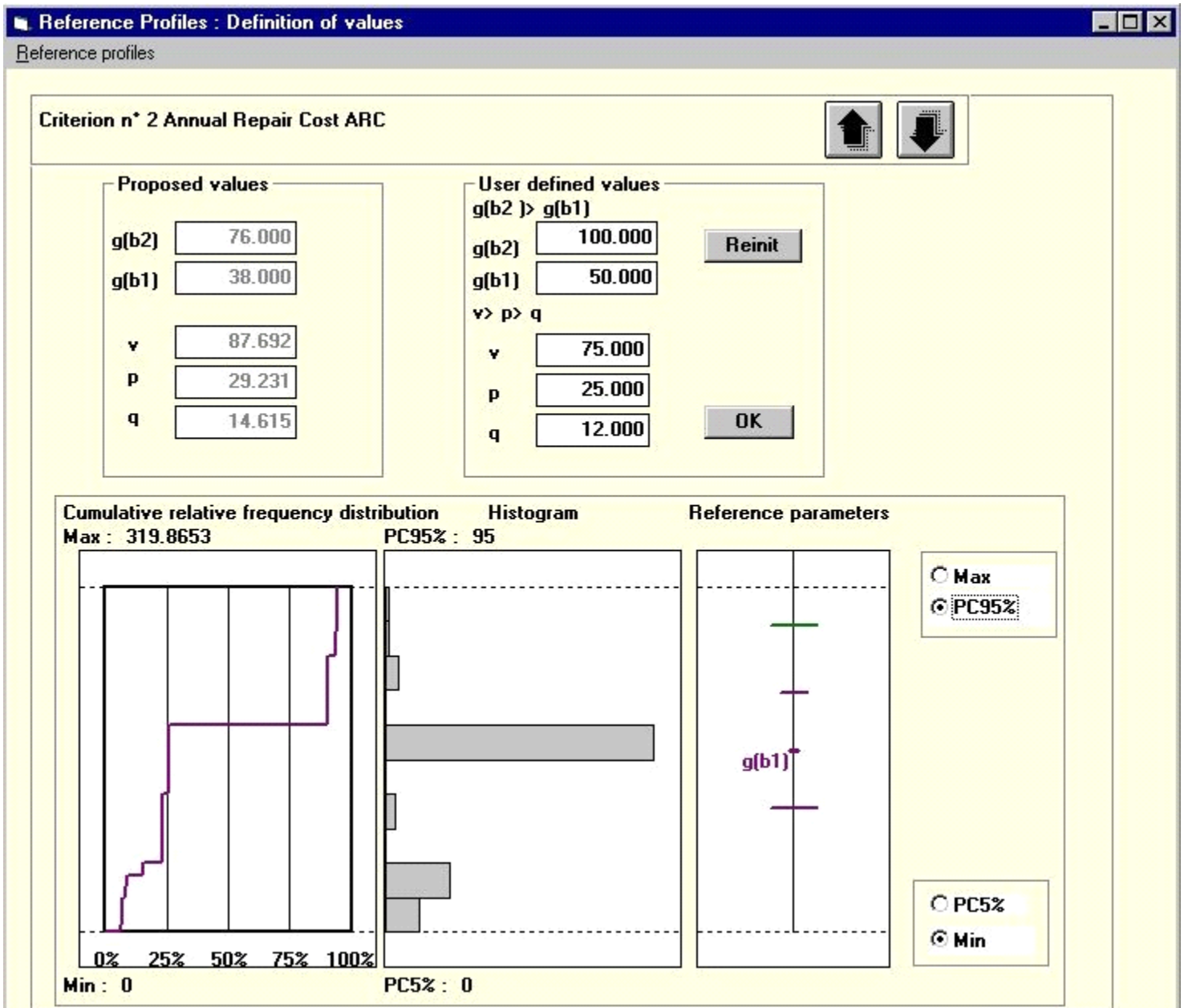




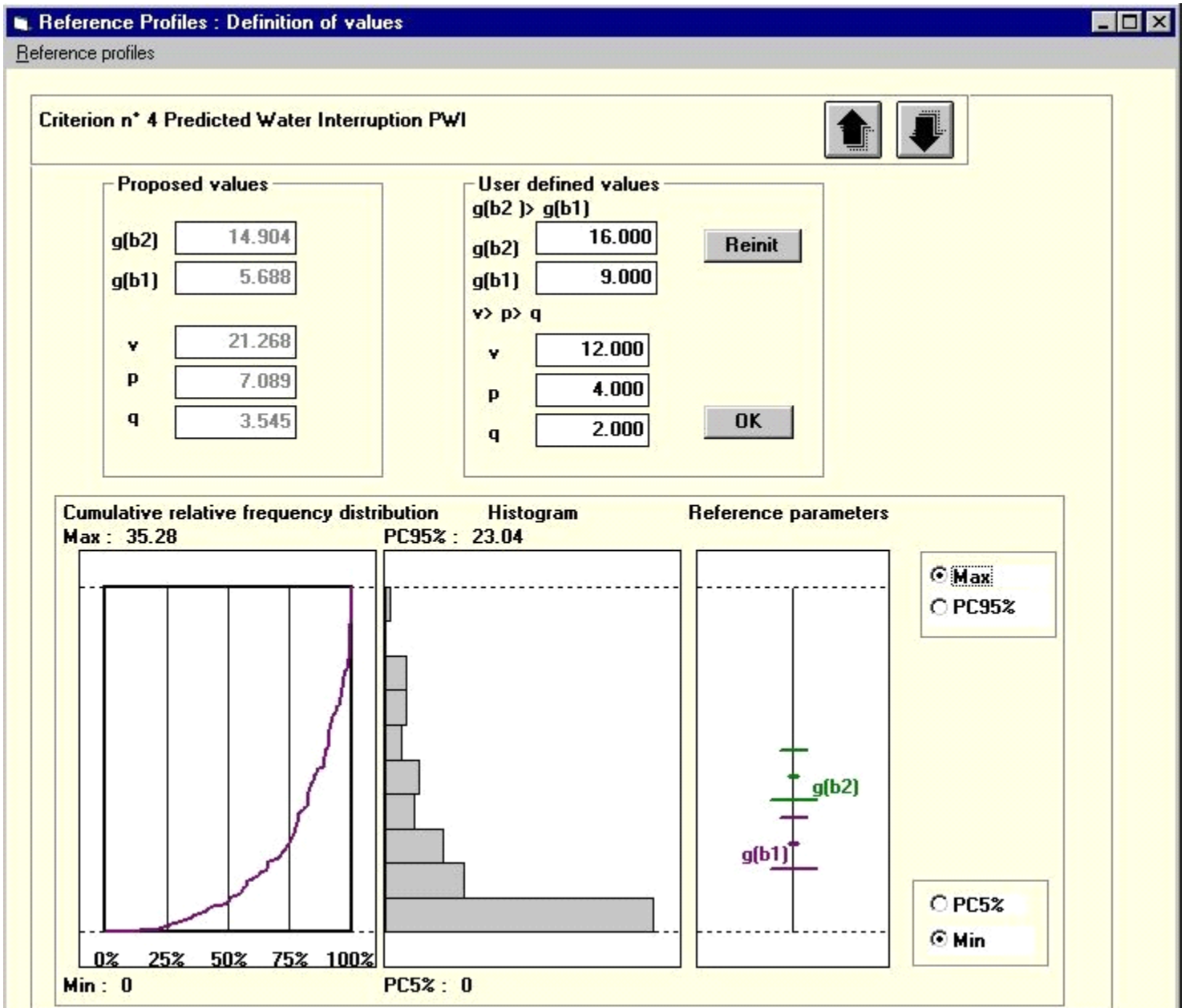
All Reference Profiles (example 1)

ARC new reference Profiles
PWI new reference Profiles

EXAMPLE 2: WORK ON AN EXISTING PROJECT AND ADD SIMULATIONS

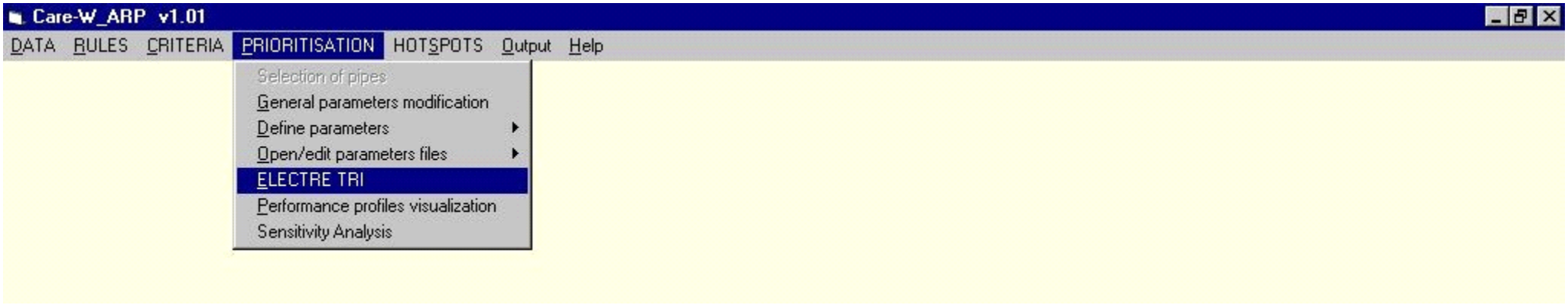


EXAMPLE 2: WORK ON AN EXISTING PROJECT AND ADD SIMULATIONS



EXAMPLE 2: WORK ON AN EXISTING PROJECT AND ADD SIMULATIONS

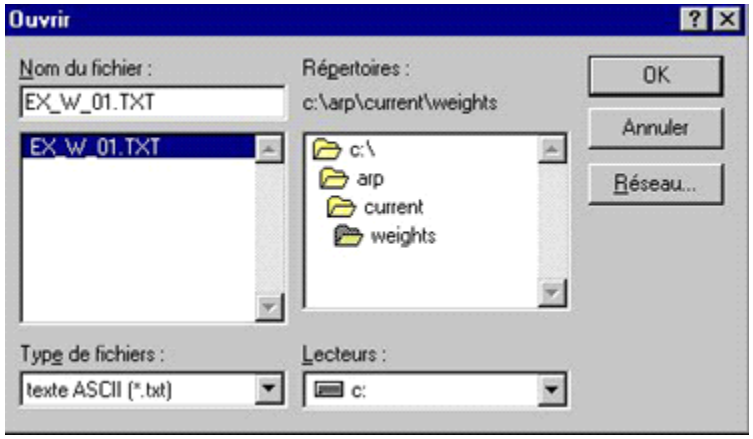
PRIORITISATION / ELECTRE TRI >> DISPLAY RESULT SIMULATION 2

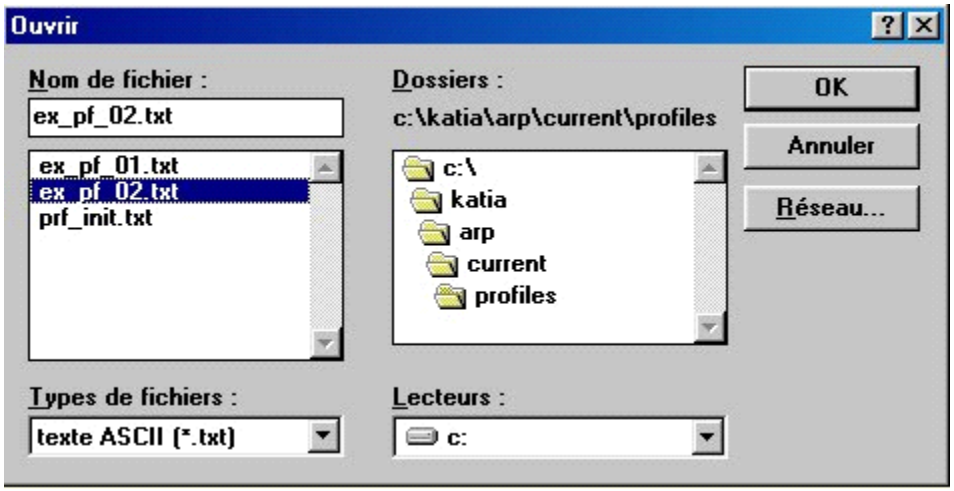


PRIORITISATION / ELECTRE TRI

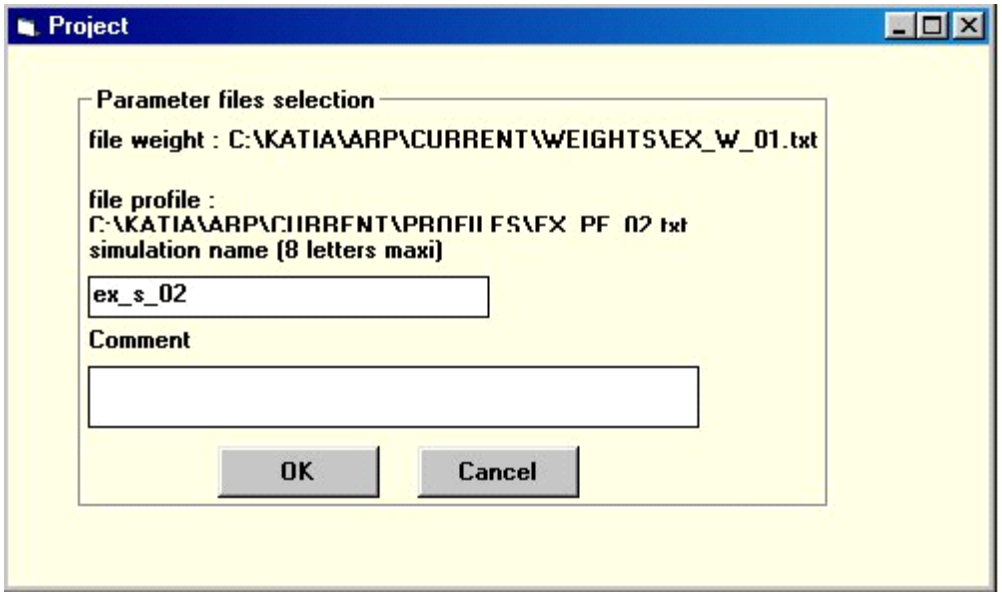
Choose Weight file

Choose Reference profiles file

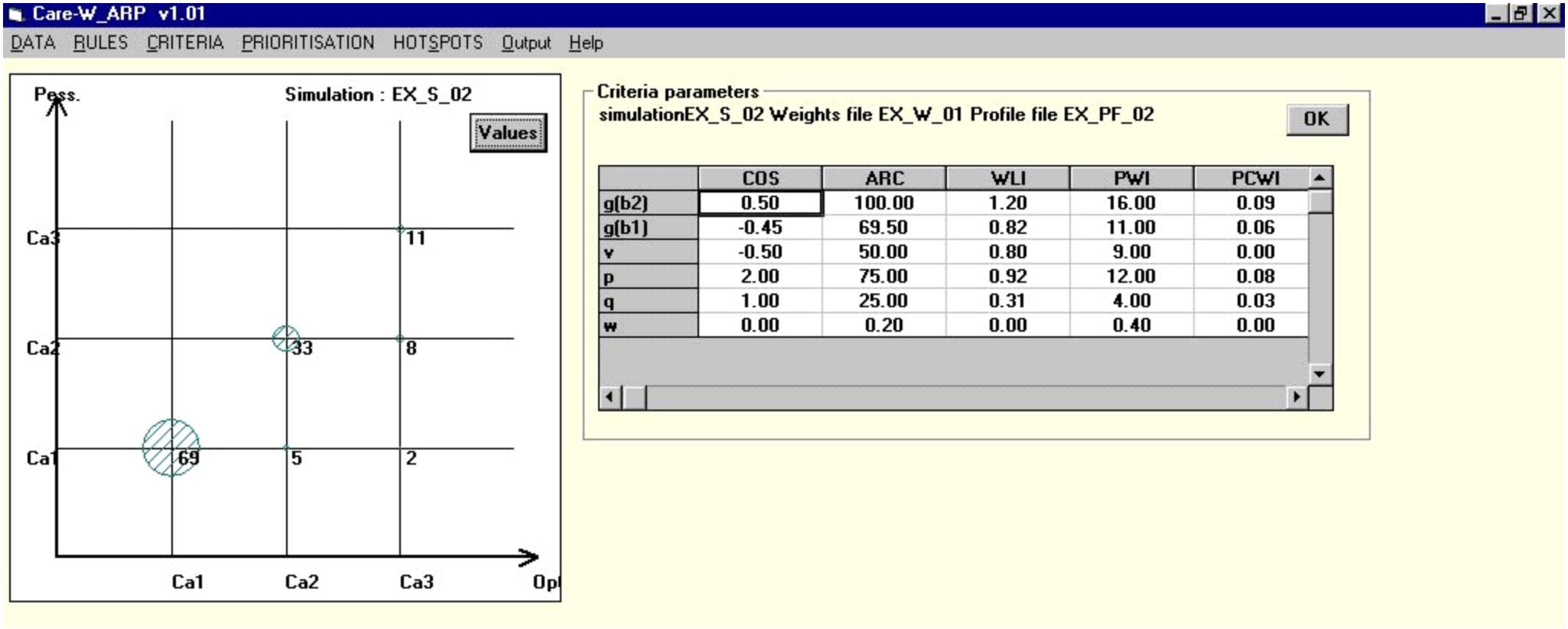




Name your simulation



PRIORITISATION / ELECTRE TRI >> DISPLAY RESULT

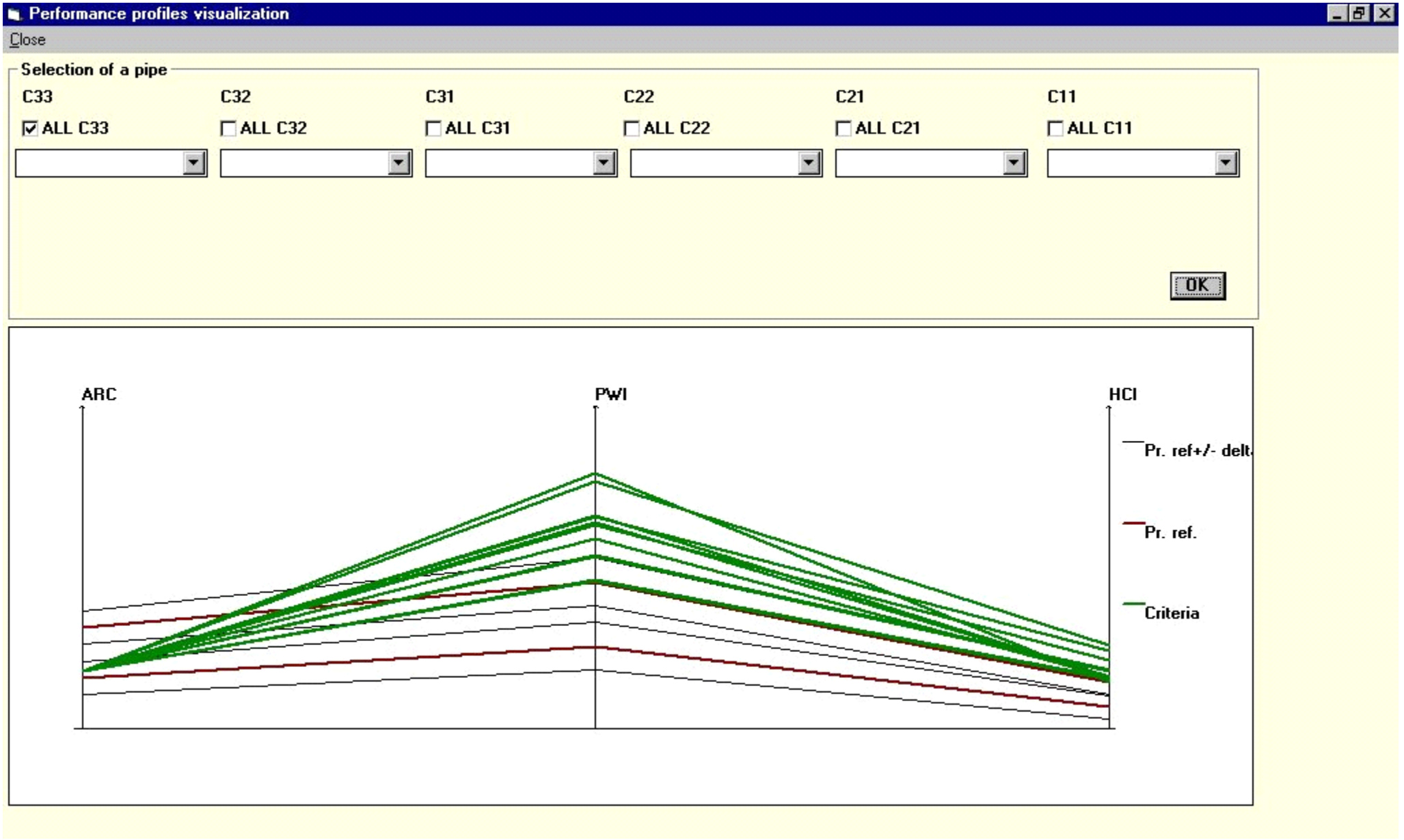


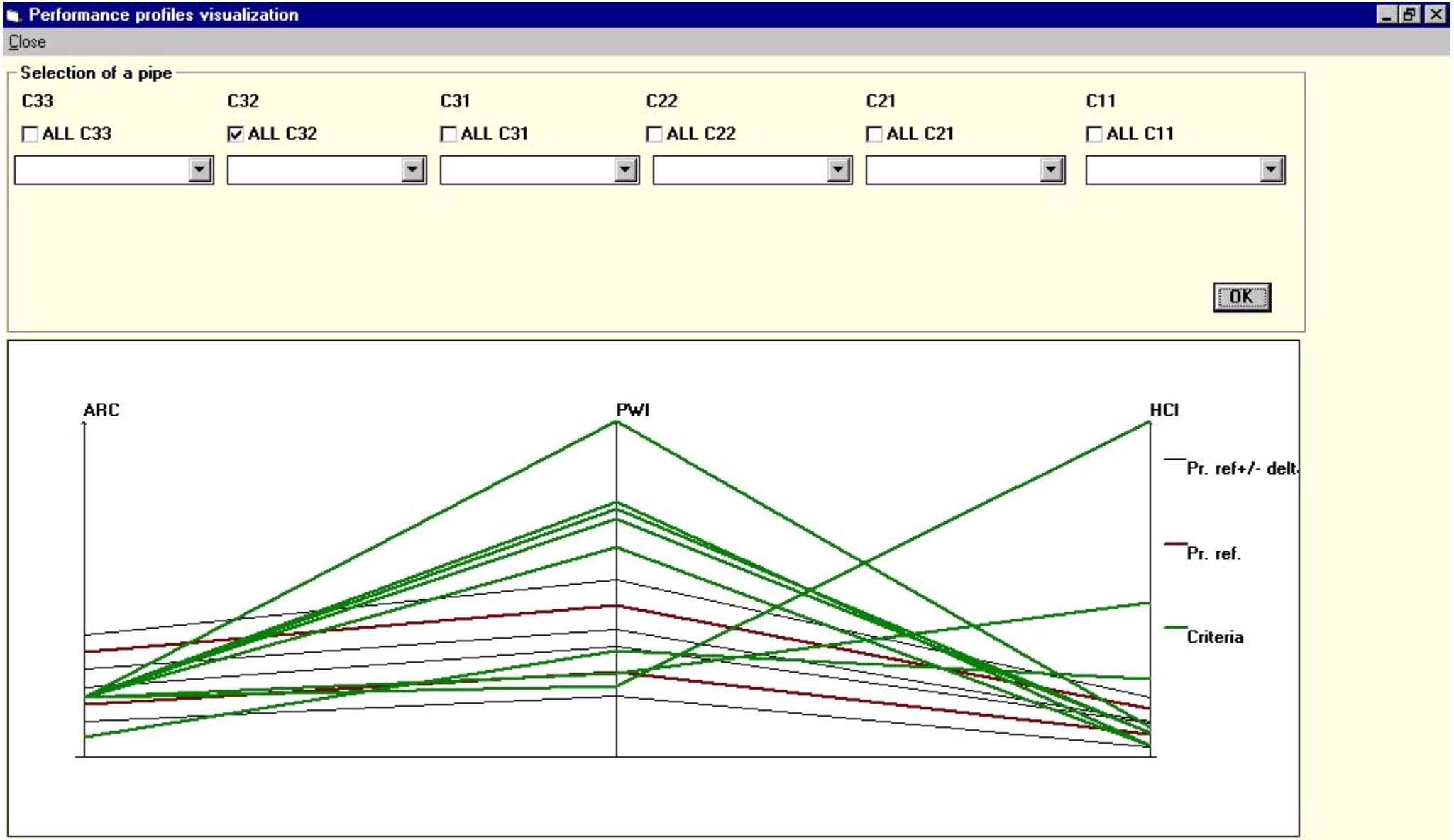
	COS	ARC	WLI	PWI	PCWI
g(b2)	0.50	100.00	1.20	16.00	0.09
g(b1)	-0.45	69.50	0.82	11.00	0.06
v	-0.50	50.00	0.80	9.00	0.00
p	2.00	75.00	0.92	12.00	0.08
q	1.00	25.00	0.31	4.00	0.03
w	0.00	0.20	0.00	0.40	0.00

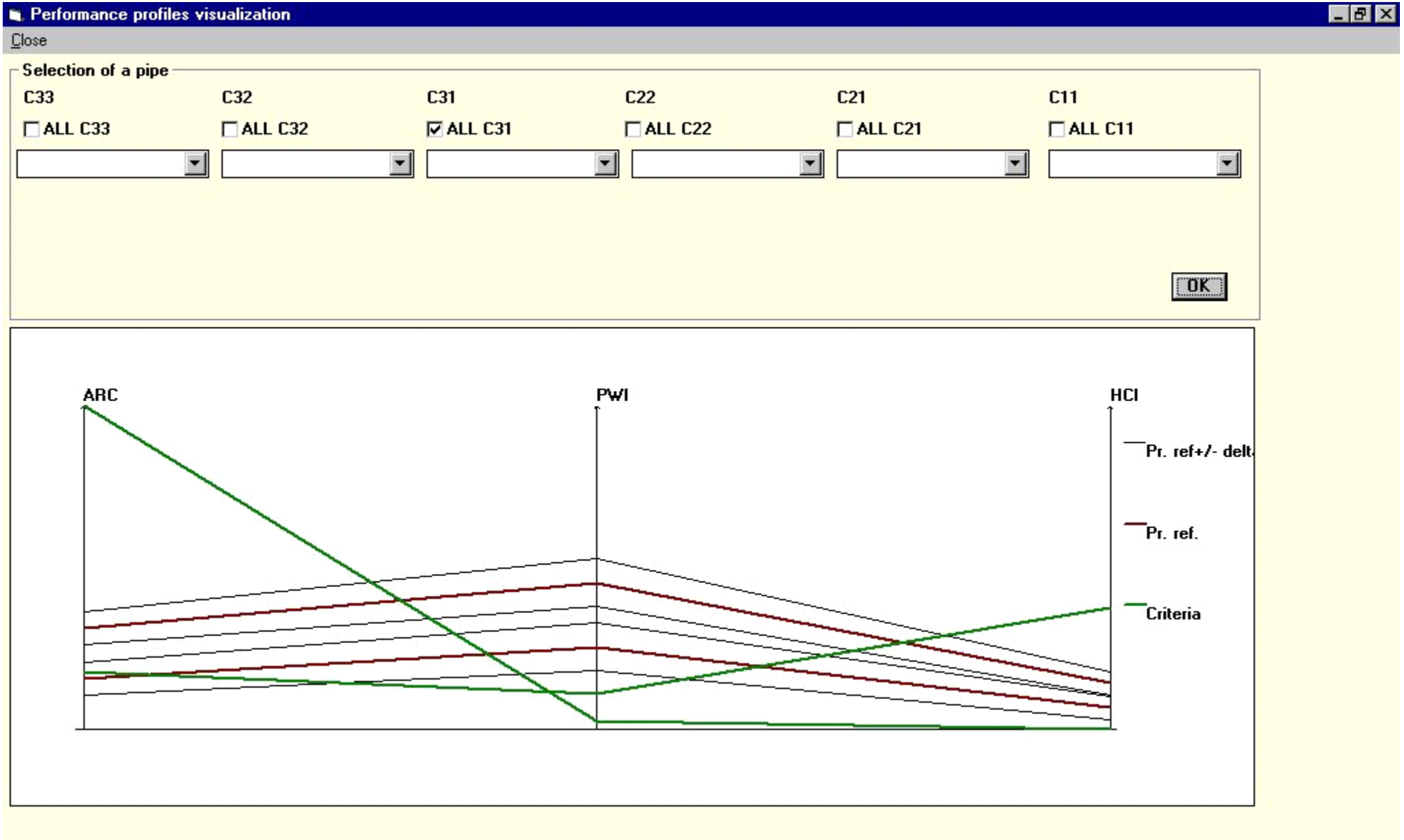
EXAMPLE 2: WORK ON AN EXISTING PROJECT AND ADD SIMULATIONS

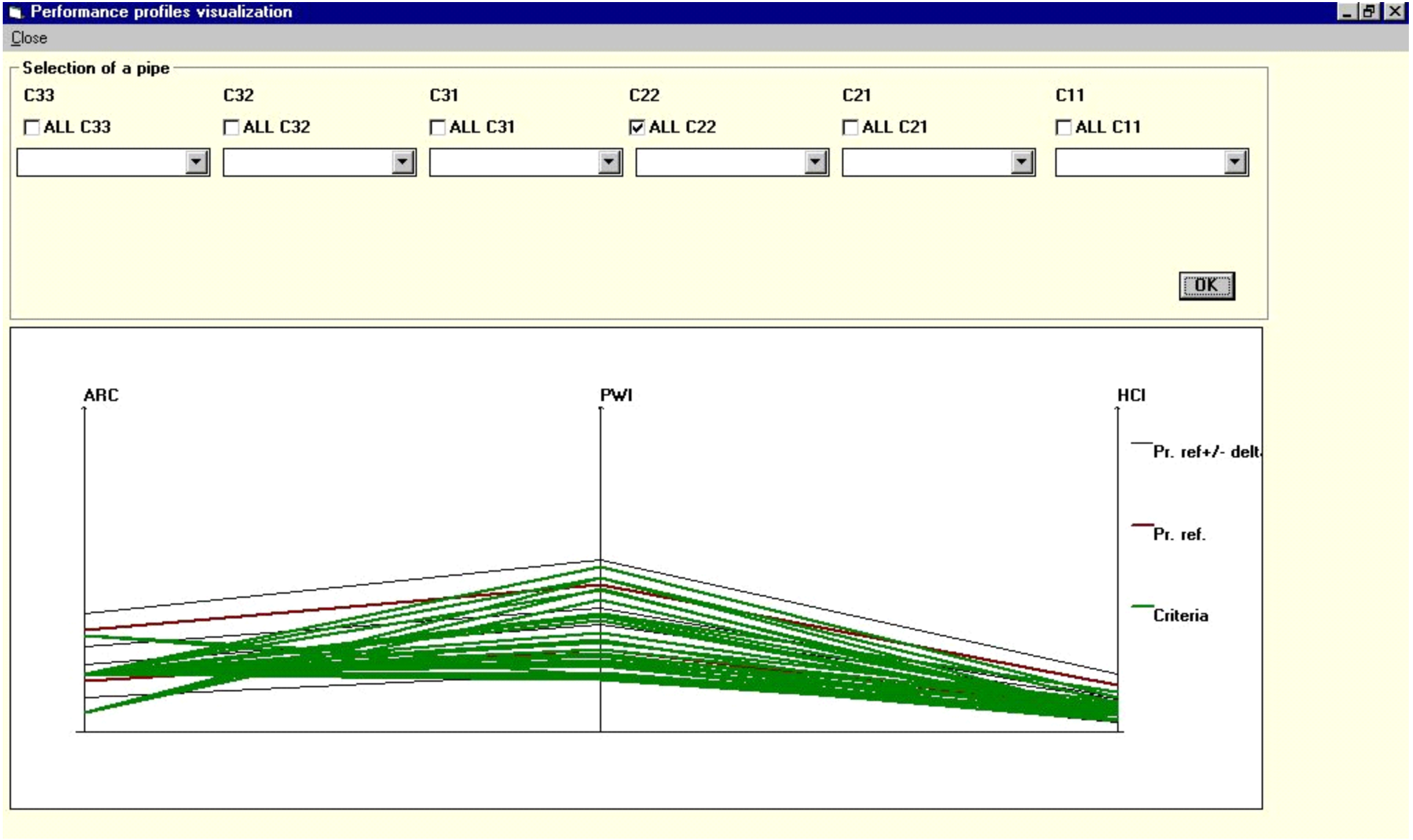
PERFORMANCES PROFILES VISUALISATION

All C33
All C32
All C31
All C22
All C21
All C11

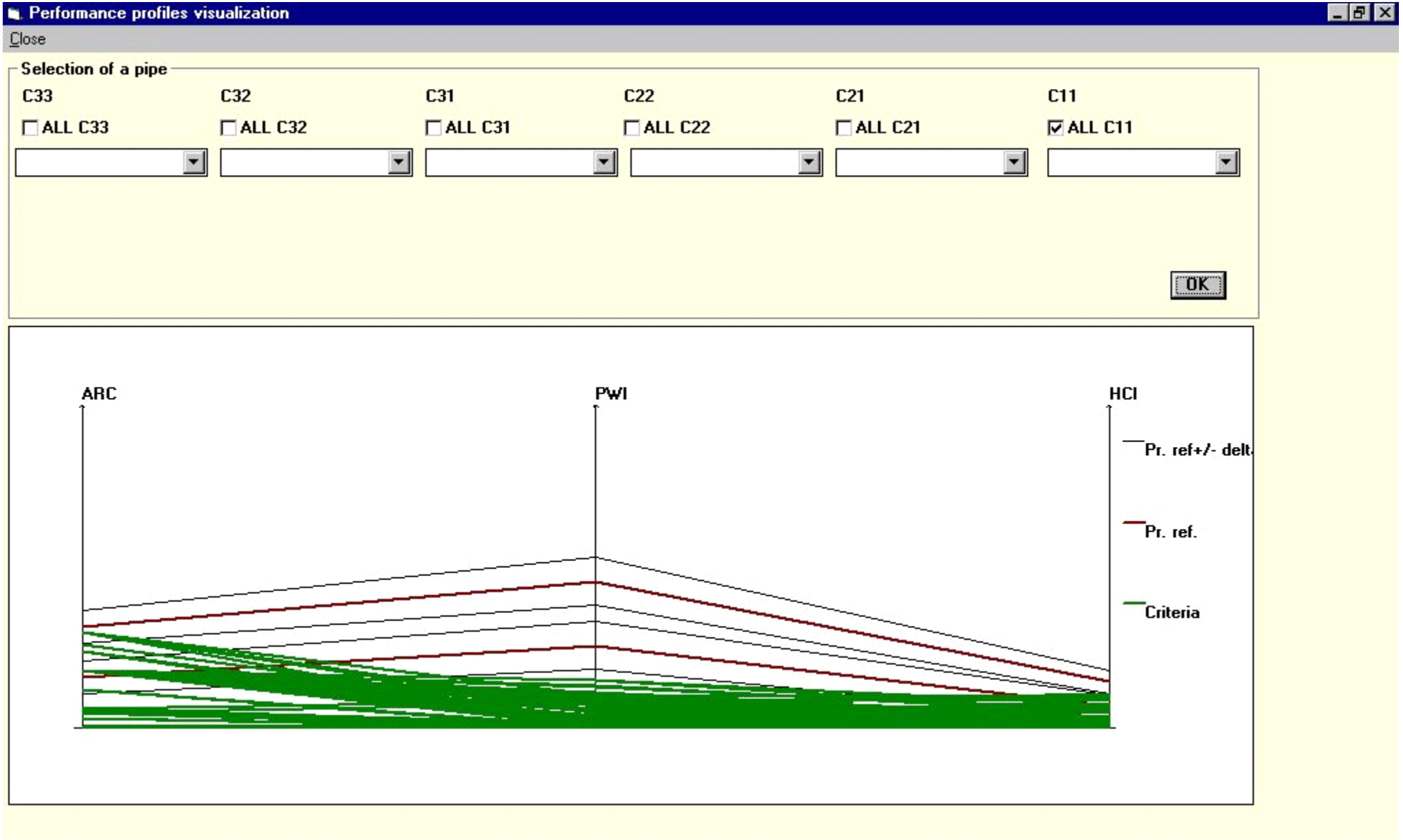

Performance profiles visualization
Close
Selection of a pipe
C33
ALL C33
C32
ALL C32
C31
ALL C31
C22
ALL C22
C21
ALL C21
C11
ALL C11
OK
ARC
PWI
HCl
Pr. ref+/- delt
Pr. ref.
Criteria


Performance profiles visualization
Close
Selection of a pipe
C33
ALL C33
C32
ALL C32
C31
ALL C31
C22
ALL C22
C21
ALL C21
C11
ALL C11
OK
ARC
PWI
HCI
Pr. ref+/- delt
Pr. ref.
Criteria


Performance profiles visualization
Close
Selection of a pipe
C33
ALL C33
C32
ALL C32
C31
ALL C31
C22
ALL C22
C21
ALL C21
C11
ALL C11
OK
ARC
PWI
HCI
Pr. ref+/- delt
Pr. ref.
Criteria

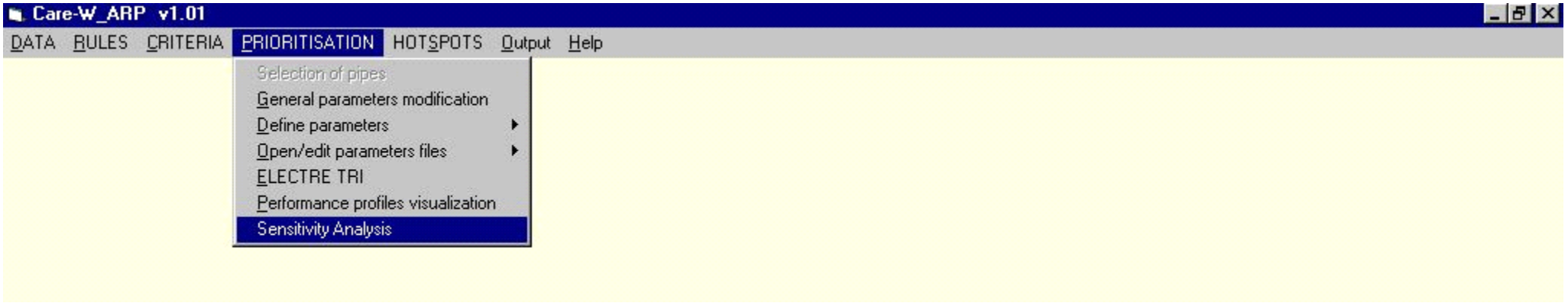

Performance profiles visualization
Close
Selection of a pipe
C33
ALL C33
C32
ALL C32
C31
ALL C31
C22
ALL C22
C21
ALL C21
C11
ALL C11
OK
ARC
PWI
HCI
Pr. ref+/- delt
Pr. ref.
Criteria

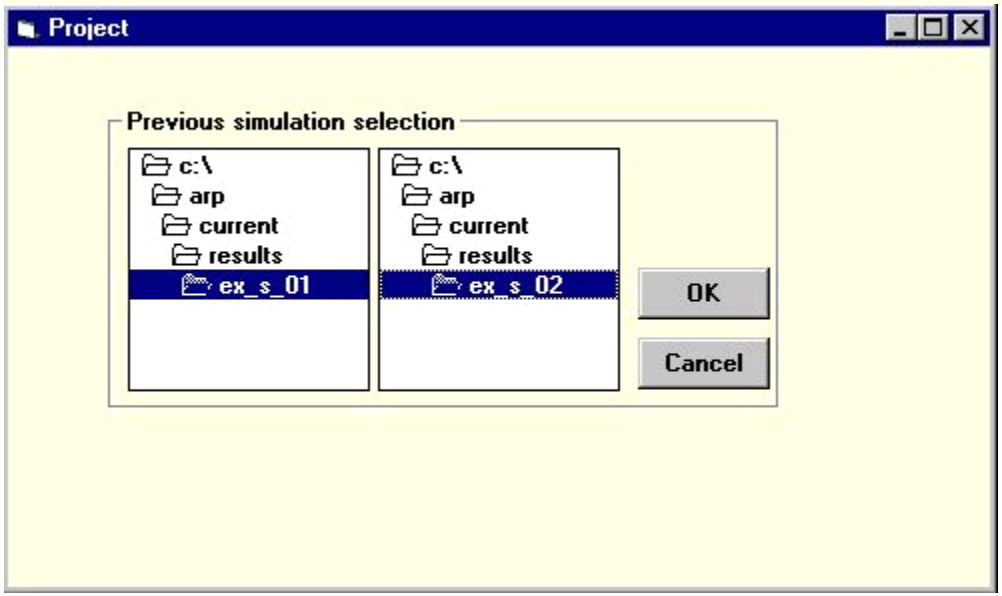

Performance profiles visualization
Close
Selection of a pipe
C33
ALL C33
C32
ALL C32
C31
ALL C31
C22
ALL C22
C21
ALL C21
C11
ALL C11
OK
ARC
PWI
HCl
Pr. ref+/- delt
Pr. ref.
Criteria


Performance profiles visualization
Close
Selection of a pipe
C33
ALL C33
C32
ALL C32
C31
ALL C31
C22
ALL C22
C21
ALL C21
C11
ALL C11
OK
ARC
PWI
HCl
Pr. ref+/- delt
Pr. ref.
Criteria

EXAMPLE 2: WORK ON AN EXISTING PROJECT AND ADD SIMULATIONS

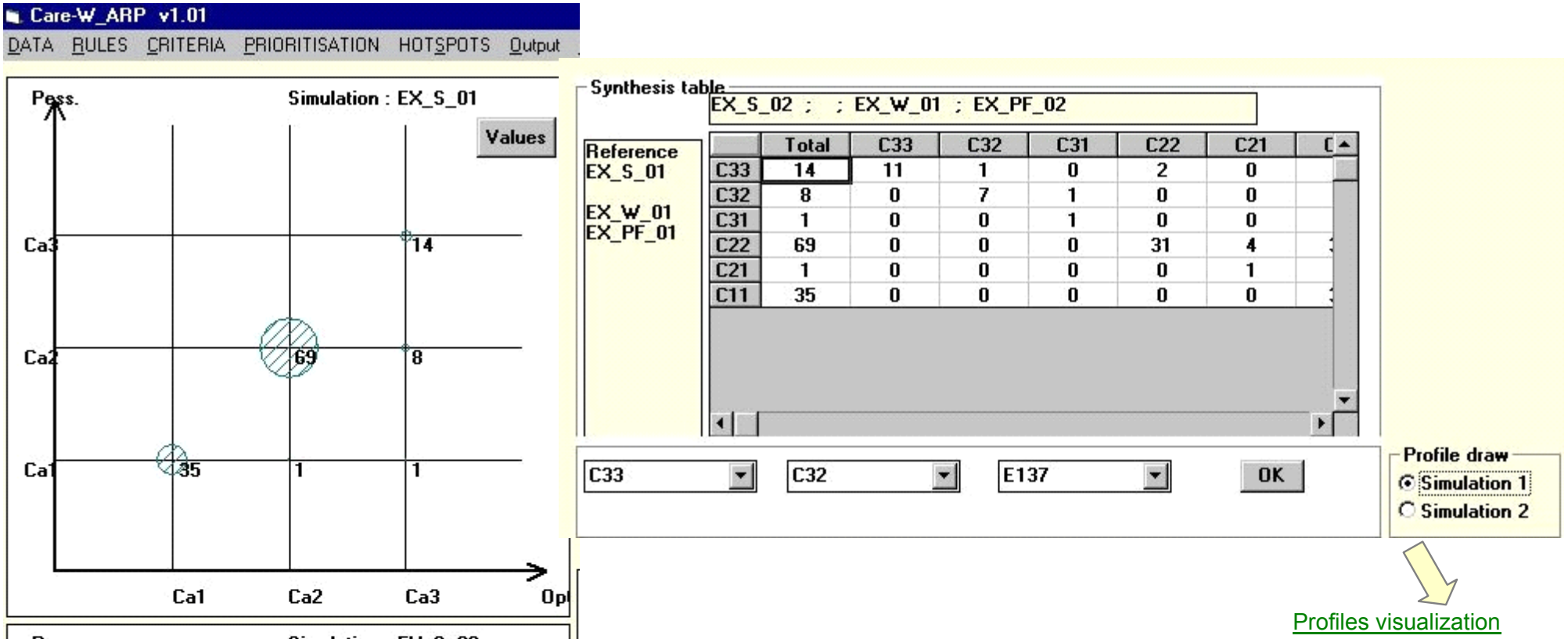
PRIORITISATION / SENSITIVITY ANALYSIS >> CHOOSE 2 SIMULATIONS



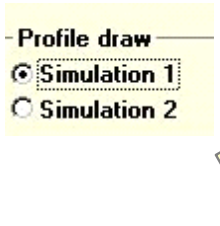


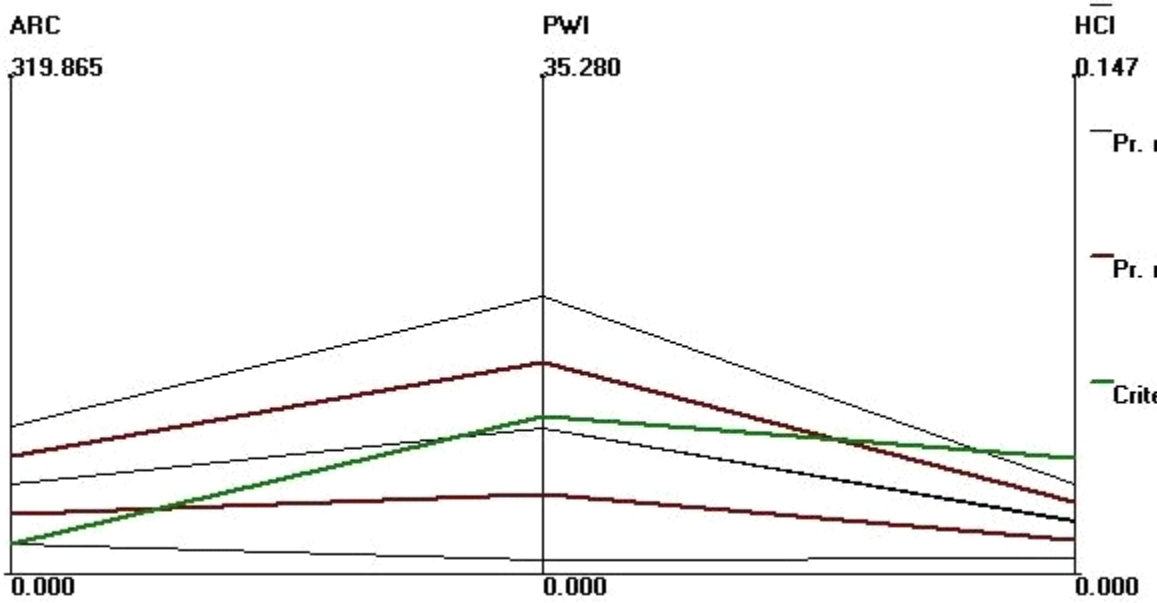
Display results

PRIORITISATION / SENSITIVITY ANALYSIS >> DISPLAY RESULTS



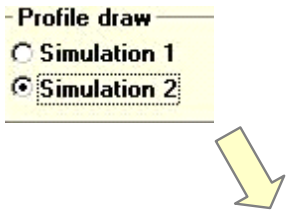
1)

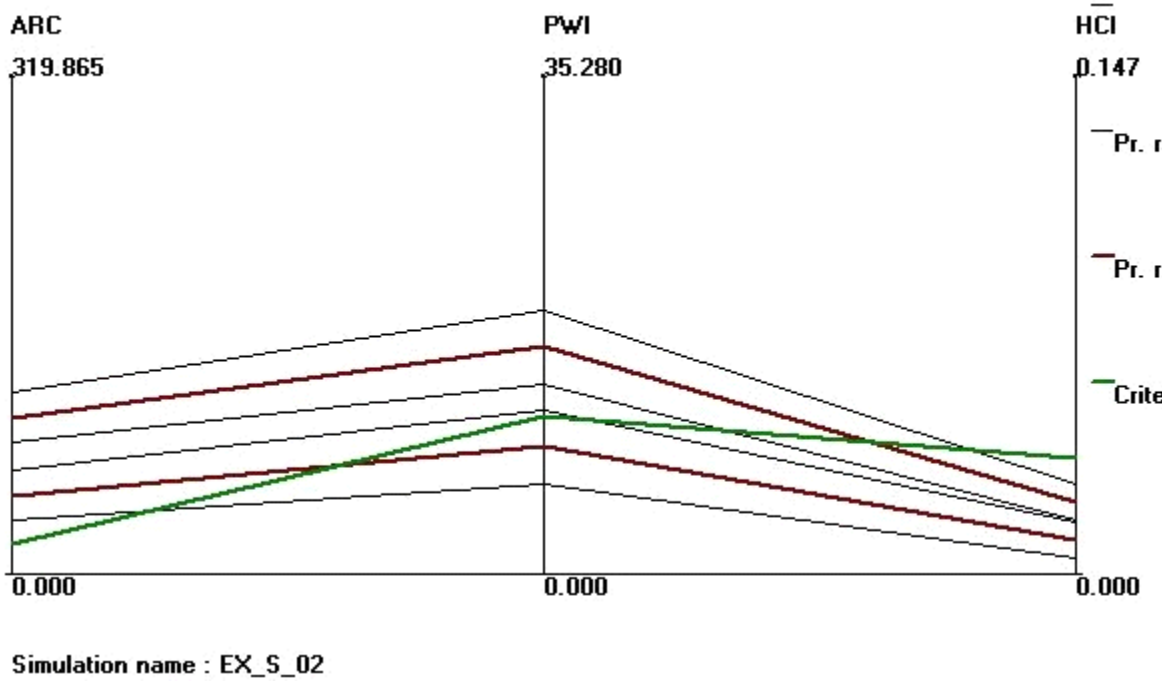




Simulation name : EX_S_01

2)

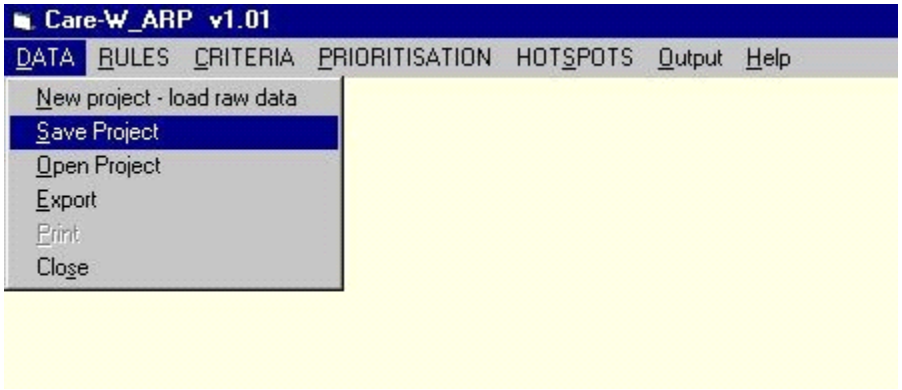

Profile draw
Simulation 1
Simulation 2


ARC
319.865
PWI
35.280
HCl
0.147
Pr. r
Pr. r
Crite
0.000
0.000
0.000
Simulation name : EX_S_02

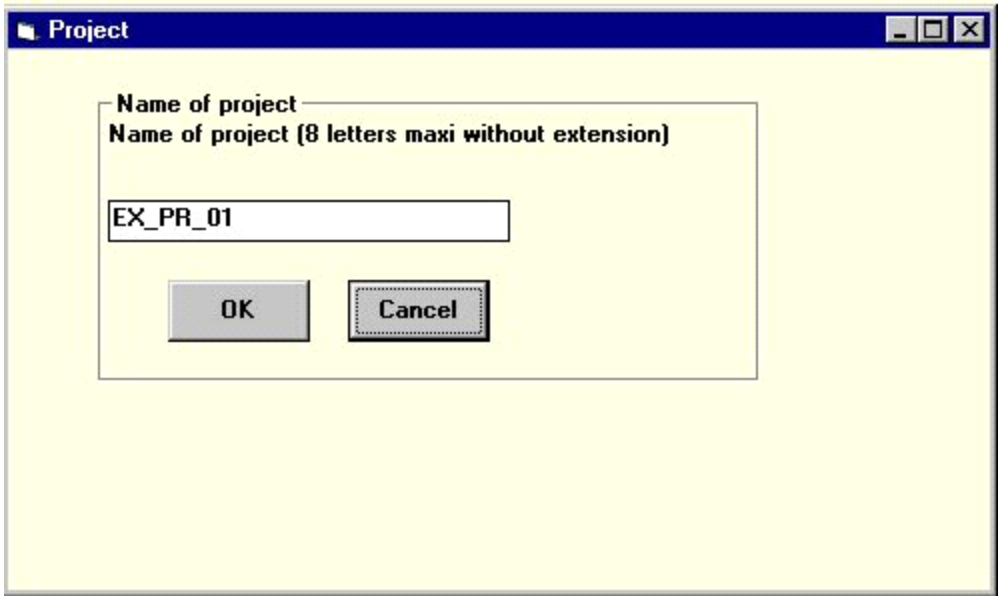
EXAMPLE 2: WORK ON AN EXISTING PROJECT AND ADD SIMULATIONS

DATA / EXPORT

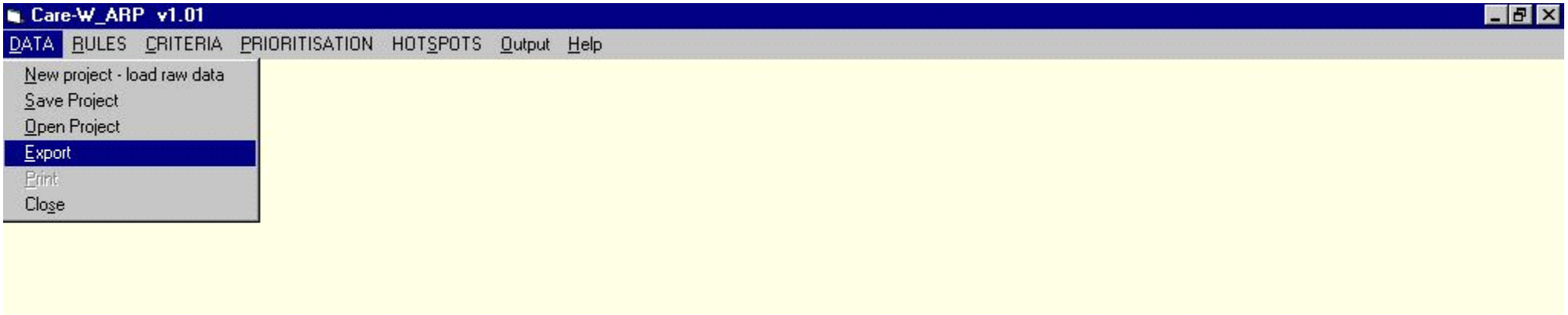
1)



2)



3)


Care-W_ARP v1.01
DATA
RULES
CRITERIA
PRIORITISATION
HOTSPOTS
Output
Help
New project - load raw data
Save Project
Open Project
Export
Print
Close