Third Draft

Quantification of real risk

A element of a

UNDP/GEF Danube regional project

"Activities for Accident Prevention - Pilot Project - Refineries"

(RER/03/G31/A/1G/31)

September 2006

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1 Background

The fact is not contested that industrial activities can result in serious water pollution. A recent example of this was the accident at Baia Mare (Romania), where some 100 000 m³ of cyanide contaminated water flowed from a mining company from the tributary Rivers Somes and Theiss into the Danube. But also the events of the Sandoz accident over 10 years ago have not been forgotten.

The ICPDR developed a method for assessing potential dangers from environmentally relevant industrial plants. On the basis of this it was possible to establish the WRI (water risk index) and the Accidental Risk Spots (ARS).

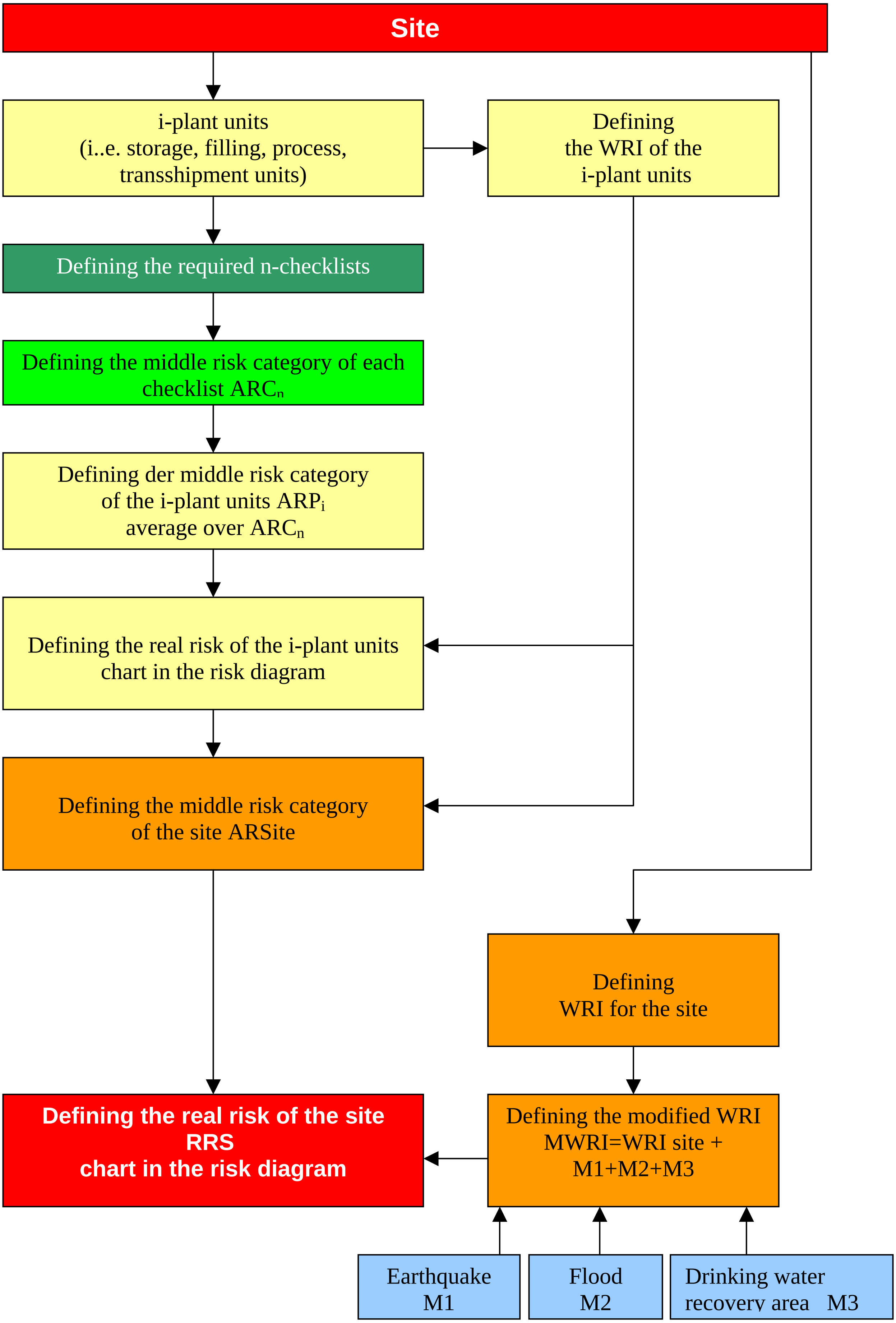
However, the problem here is, that this Water Risk index takes into consideration only the volume and the water danger of the substances, but not the type of safety level. Thus a company, in which all recommendations of the river basin commissions are converted, is evaluated exactly the same, like a company with serious safety-relevant faults. That makes necessary an evaluation of a plant regarding the current risk.

The current risk can only be established and assessed on the basis of a thorough testing and evaluation of the relevant plant. The checklist method that has been developed is outstandingly suitable for this purpose. The most complex industrial plant can be checked and evaluated simply, in structured form and in accordance with international recommendations by means of this method.

Based on this methodology a possibility was developed for characterising the current risk resulting from a plant.

2 Method for assessing the real risk

This method is used for an entire industrial site. The flowchart on the following page gives an overview of the method.


Site
i-plant units
(i..e. storage, filling, process,
transshipment units)
Defining
the WRI of the
i-plant units
Defining the required n-checklists
Defining the middle risk category of each
checklist ARC_n
Defining der middle risk category
of the i-plant units ARP_i
average over ARC_n
Defining the real risk of the i-plant units
chart in the risk diagram
Defining the middle risk category
of the site ARSite
Defining
WRI for the site
Defining the real risk of the site
RRS
chart in the risk diagram
Defining the modified WRI
MWRI=WRI site +
M1+M2+M3
Earthquake
M1
Flood
M2
Drinking water
recovery area M3

2.1 Determining the potential risk of the plant

(Determining with checklist 1)

Water **R**isk **I**ndex .... WRI_s =

2.2 Calculation of the modified WRI

The environment of the location must also be taken into consideration at the determination of the real risk.

It is very important if the facilities are endangered by natural events, respectively if, in case of a breakdown, the drinking water supply will be endangered or not. This means, that also the surrounding environment must be checked. Naturally, this requires an exact delimitation, e.g. when an earthquake becomes dangerous and when danger of flooding should be taken into consideration.

It is important to realize, that the real potential danger must be considered only in relation to the risks of the surrounding environment. This is why the modified Water Risk Index is introduced.

$$MWRI = WRI_S + M1 + M2 + M3$$

MWRI	modified Water Risk Index
WRI_S	Water Risk Index of the site
M1	Earthquake danger
M2	Flooding danger
M3	Drinking water recovery areas

2.2.1 Earthquake

The danger of earthquake must be taken into consideration if in the area can happen a type

4 intensity earthquake on the Richter scale. Intensity 4 on the Richter scale means:

It is noticed by most of the population; swinging of a free pendulum; rattling of glasses and dishes; swinging of shutters; loose swing of parked cars; minimum damage.

If this is the case, we can give one modification point.

M1 = 0,1

M1 = 0 (no earthquake danger)

2.2.2 Flood

Flooding events are events that happen when rivers overflow or in case of flooding of lake

and sea areas. Here we have to analyse the last 100 years to see if the event happened. If we can answer this question with "yes", we have to give one modification point.

M2 = 0,1

M2 = 0 (no flooding danger)

2.2.3 Drinking water recovery areas

Water recovery areas are areas where the drinking water for the population is ensured. National parks are also included here. In case of spilling water hazardous substances the danger represents a high influence on the population and environment. Therefore, in this cases, we can give one modification point.

M3 = 0,1

M3 = 0 (no drinking water recovery area)

2.3 Plant split

It is well known that one entire plant can not be assessed at once. A plant consists of many different small facilities and units. We can have transshipment units, filling systems, storage units and processing units. Because the various units are connected through pipelines we must do a useful delimitation, that means we have to perform a plant split.

To perform a plant split we have to clarify the term plant.

Plants are independent and stationary or immobile functional units, where water hazardous substances are handled. The plants include the entire equipment, containers, pipelines and areas required for the proper running of the operation.

After clarifying the term plant we can proceed to the split. The split of each functional unit is performed by the plant operator and is normally directed according to the operational purpose. Dependent functional units that are connected to form an operational unit make up a plant.

Following rules have to be taken into consideration when performing a plant split:

- The plant must be split according to the functional units, that is L (Storage), A (Filling), U (Transshipment) and processing facilities.
- For a plant split it is important to know the manufacturing purpose under proper operation conditions. One big criteria is the substance flow (the material flow) for achieving the manufacturing purpose.
- Separate containers, also those that are located closely one to another but serve different filling or process plants, are considered as belonging to separate plants. This is also valid for various containers with common aerating and venting pipes, if no inadmissible over- or underpressure develops during all operating conditions and no liquids can enter the aerating and venting pipes. A common secondary containment does not mean that the containers installed in it belong to the same plant.
- One processing plant that manufactures, handles or uses a product still remains a process plant even if waste water occurs.
- A plant that uses liquid waste for handling the waste is considered a processing plant, provided that it deals with water hazardous substances even if during the operation waste water occures.
- A plant that handles waste water only for the purpose of treatment is considered a water treatement plant and will be here not further discussed.

Example of a plant:

1. To a tank storage facility also belong safety systems like overfill system, leakage indicator, etc. and also pipelines and fittings as well as a secondary containment.
2. To a transshipment facility belong pumps, pipelines with fittings, secondary containments, places and areas where the transshipment process is taking place.

Examples for immobile functional units are:

- Vehicles that are not used for the usual driving, but are used for handling containers with water hazardous substances.
- Barrels, because they do not move by themselves.

Examples for immobile and stationary functional units, that are exclusively used temporary and on permanent changing places (mobile units), are:

- gas stations on construction sites,
- transport vehicles,
- heating systems for renovation purposes of buildings

We will not further discuss them here, but they are still subject to the minimum requirements and the general care rules (mobile secondary containments, like drain pans and oil sealing material; permanent supervision at filling and emptying).

2.4 Determining the potential risk of each unit

For each unit there has to be determined the potential risk, meaning the Water Risk Indexes (WRI_i), with the help of checklist 1.

2.5 Determining the required checklists

Only the relevant checklists will be chosen for a facility. Due to the fact that the cheklist method has a modular structure, the actual questionnaires vary according to their use.

For example, a tank storage facility can use the followings:

1 Substances
2 Overfill safety system
3 In-plant pipeline safety
4 Joint storage
5 Sealing systems
6 Waste water split flows
8 Fire protection strategy
11 Industrial plant in areas with a risk of flooding
13 Storage
14 Equipment of tanks

On the other hand the list for a barrel storage is much shorter.

1 Substances
4 Joint storage
5 Sealing systems
6 Waste water split flows
8 Fire protection strategy
11 Industrial plant in areas with a risk of flooding
13 Storage

2.6 Determining the average risk category of each checklist

The plant unit be checked and evaluated only after determining which checklist will be used. Each single checklist will be worked out and tested, to what extent the recommendations of the international river basins commission were put into practice.

It must be also evaluated if the individual sub-points of the recommendations were applied.

For this purpose are introduced risk categories:

Sub-point of the recommendation is applied (normal risk)............................RC = 1

Sub-point of the recommendation is partially applied (medium risk)........... RC = e.g. 5

Sub-point of the recommendation is not applied (high risk).....................… RC = e.g. 10

Each sub-point of the recommendation has the possibility of three values, of which we can choose the risk category that best applies to this sub-point. If one sub-point is not applicable then we do not take it into consideration at the evaluation. (for example: a recommendation for underground pipelines. However, the unit has only overground pipelines, therefore this point will not be evaluated.)

At the end of each checklist we will calculate the average risk category of each evaluated sub-point.

$$ARC_n = \frac{\sum_m RC_{SP}}{m}$$

ARC_n	Average Risk of the Checklist n
M	Number of the evaluated sub-points of the recommendation
SP	Sub-point (of the recommendation)
RC	Risk category

2.7 Determining the average risk category of each plant

After determining the average risk category with the help of the checklist, we can now assess the average risk of the plant.

$$ARP_i = \frac{\sum_{CL} ARC_n}{CL}$$

ARP_i	Average Risk of the plant i
ARC_n	Average Risk of the checklist n
CL	Number of the evaluated checklists

2.8 Determining the real risk of each plant

The real risk of each plant can be defined as the logarithm of the product between the equivalent of water risk class 3 of the plant I and the average risk of the plant.

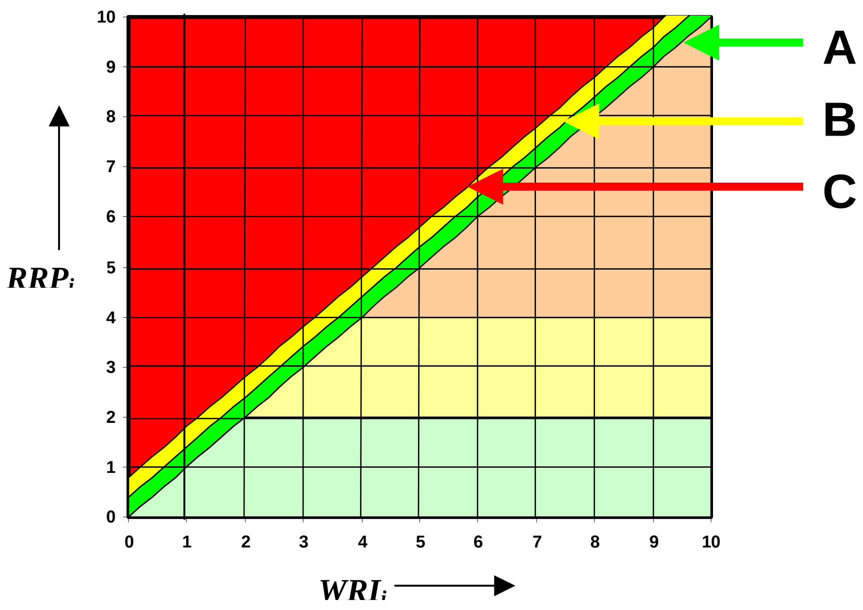
$$RRP_i = \lg(10^{WRI_i} \bullet ARP_i) = \lg(EQ3_i \bullet ARP_i)$$

RRP_i	Real Risk of the Plant i
WRI_i	Water Risk Index of the plant I
$EQ3_i$	Equivalent of water risk class 3 of the plant I
ARP_i	Average Risk of the Plant i

The following evaluation was defined:

$(RRP_i - WRI_i) \leq 0{,}4$	The safety level is either good enough. Still, this classification does not mean that there are no measures required for improvement of the situation
$0{,}4 < (RRP_i - WRI_i) \leq 0{,}8$	Important safety systems do not exist or are not sufficient. Measures for improving the situation have to be taken.
$(RRP_i - WRI_i) > 0{,}8$	The safety level regarding the water protection is very low. Measures for improving the situation have to be taken immediately, and afterwards the evaluation will be reviewed

This result can be also represented as a chart.



The real isk of the plant can be evaluated as follows.

$RRP_i \leq 2{,}0$	**Small risk.** A small risk was determined.
$2{,}0 < RRP_i \leq 4{,}0$	**Medium risk** A medium risk was determined.

RRP_i > 4,0	**High risk** A high risk was determined. .

2.9 Determining the average risk category of a site

For determining the real risk of a site all plants must be added. For this purpose we need the average risk category of the site. This average is based on the WRI of the plants.

$$ARSite = \frac{\sum_k \left(10^{WRI_i} \bullet ARP_i\right)}{\sum_k 10^{WRI_i}} = \frac{\sum_k (EQ3_i \bullet ARP_i)}{\sum_k EQ3_i}$$

ARSite	Average Risk of the industrial Site
ARP_i	Average Risk of the plant I
RRP_i	Real Risk of the plant i
WRI_i	Water Risk Index of the plant I
$EQ3_i$	Equivalent of water risk class 3 of the plant I
K	Number of plants

2.10 Determining the real risk of the site

The real risk of the site can be determined as follows.

$$RRS = M1 + M2 + M3 + \lg(10^{WRI_S} \bullet ARSite) = M1 + M2 + M3 + \lg(EQ3_S \bullet ARSite)$$

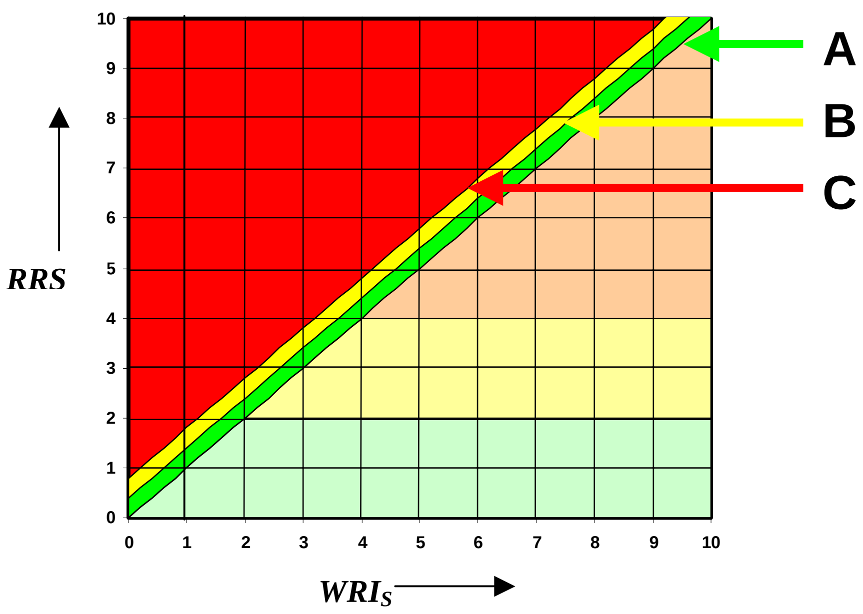
RRS	Real Risk of the industrial Site
ARSite	Average Risk of the industrial Site

WRI_S	Water Risk Index industrial Site
$EQ3_i$	Equivalent of water risk class 3 of the plant I
M1	Earthquake danger
M2	Flooding danger
M3	Drinking water recovery areas

The evaluation is performed as described in chapter 2.8.

(*RRS* - WRI_S) ≤ 0,4	The safety level is either good enough. Still, this classification does not mean that there are no measures required for improvement of the situation
0,4 < (*RRS* - WRI_S) ≤ 0,8	Important safety systems do not exist or are not sufficient. Measures for improving the situation have to be taken.
(RRS - WRI_S) > 0,8	The safety level regarding the water protection is very low. Measures for improving the situation have to be taken immediately, and afterwards the evaluation will be reviewed

This result can be also represented as a chart.



The real isk of the industrial site can be evaluated as follows.

$RRP_i \leq 2,0$	**Small risk.** A small risk was determined.
$2,0 < RRP_i \leq 4,0$	**Medium risk** A medium risk was determined.
$RRP_i > 4,0$	**High risk** A high risk was determined. .

By introduction of the modified Water Risk Index there is the possibility that a site, where all plant units are still in the low real risk area, will suddenly find itself in the medium risk area. That means that a plant located in one of the sensitive areas must increase the investment in safety equipments.

3 Description of a plant

Until now the plant was described by the means of the potential risk. As we know that does not say anything about the real risk. For this purpose the following method was developed.

But how can the real risk be indicated? One possibility would be the indication of the determined RRS. But this would only pretend accuracy that does not exist, because this method is based on many stipulations.

That is why the persons who developed this method are in favour for the common indication of the potential risk combinated with the indication of the group of the real risk.

For ex. WRI_S = 6 and the real risk is in group B (medium risk). The plant could now be described with the following combination:

6B

4 Abbreviations

ARC_n	Average Risk of the checklist n
ARP_i	Average Risk of the plant i
ARSite	Average Risk of the industrial site
CL	Number of the evaluated checklists
$EQ3_i$	Equivalent of water risk class 3 of the plant I
K	Number of the plant units
M	Number of the evaluated sub-points of the recommendation
M1	Earthquake risk
M2	Flooding risk
M3	Drinking water recovery area
MWRI	Modified Water Risk Index
RC	Risk category
RRP_i	Real Risk of the plant i
RRS	Real Risk of the industrial Site
SP	Sub-point (sub-point of the recommendation)
WRI_i	Water Risk Index of the plant unit I
WRI_S	Water Risk Index of the site