FracRisk

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Deliverable summary text: This deliverable presents a software design document (SDD) describing the architecture and system design of a Shale Gas RBCA software- SG-RBCA.	
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Risk Based Corrective Action Software for Unconventional Shale Gas Hydraulic Fracturing

Software Design Document

March 2018

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1. INTRODUCTION

1.1 Purpose of software design document (SDD)

This deliverable presents the architecture and functionality of the SG-RBCA (Shale Gas Risk Based Corrective Action) software developed by EWRE in the frame FRACRISK for the assessment of environmental risks resulting from the activities related to the development and or operation of shale gas reservoirs. We can associate risks to the release and migration towards sensitive areas of hazardous chemicals (chemicals of concern or COC) and or via the generation of unwanted processes such induced seismicity, over pressure etc. (Factors of Concern or FOC).

1.2 Scope

One of the key objectives of FRACRISK is to develop a user-friendly software platform for risk analysis assessment in relation to Shale Gas operations (Development and Production), SG-RBCA. SG-RBCA aims at providing a technically defensible, consistent and objective risk assessment and decision-making framework for operations of shale gas hydraulic fracturing. The SG-RBCA relies on the Risk-Based Corrective Action (RBCA) standards developed by the American Society for Testing and Materials (ASTM) E1739-95 (1995a) and E2081-00 (2000a, 2015). The advantage of SG-RBCA is that it allows a "common language" for the industry and the regulatory authorities. It comprises a comprehensive set of tools to assess the actual or the potential risks associated Shale Gas activities, either pressure and or the presence of chemicals of concern (COCs) in environmental compartments (e.g., soil, groundwater and surface water) resulting from Shale Gas activities, such as hydraulic fracturing.

The SDD describes the adaptation of the RBCA paradigm to the specific case of shale gas. SG-RBCA provides a methodology to conduct site-specific characterization. It will calculate risk-based target levels (RBTLs) protective of human health and the environment. It will also suggest appropriate risk management activities. The embedded models will provide guidance in determining the required operating, monitoring and mitigation activities. We expect SG-RBCA to be used by a broad spectrum of professionals – from stakeholders through gas industry managers to environmental stakeholders.

1.3 Acronyms

COC	Chemical of Concern
FOC	Factor of concern (induced seismicity, over-pressure)
CSM	Conceptual Model
EM	Exposure Model
RBTLs	Risk Based Target Levels

2. SYSTEM OVERVIEW

The RBCA paradigm developed by the ASTM is widely applied for assessing risks and required levels of treatment for soil and groundwater pollution. RBCA’s methodology can also ideally applied, for shale gas activity. RBCA relies on the identification of the Sources, Pathways and Receptors (or Targets) with various degrees of sensitivity to the conveyed pollution. Identifying the sources includes location, geological elements and intensity. Identifying the pathways is by means of predictive models capable of estimating the migration of pollutants or pressure waves towards sensitive areas. In short capable of identifying and assessment the impact of the release of COC's or the generation of FOC's. Identifying the sensitivity of the receptors and quantifying them, is done after the impact is determined. The risk can be determined for each receptor (human health, groundwater quality, air quality, soil quality and others).

This approach can be used either for forward mode meaning predicting what could be the risk subsequent to a shale gas production site or for backward mode that means how the site should be operated in order to protect specific identified receptors, characteristic of the overall integrity of the environment (Figure 1).

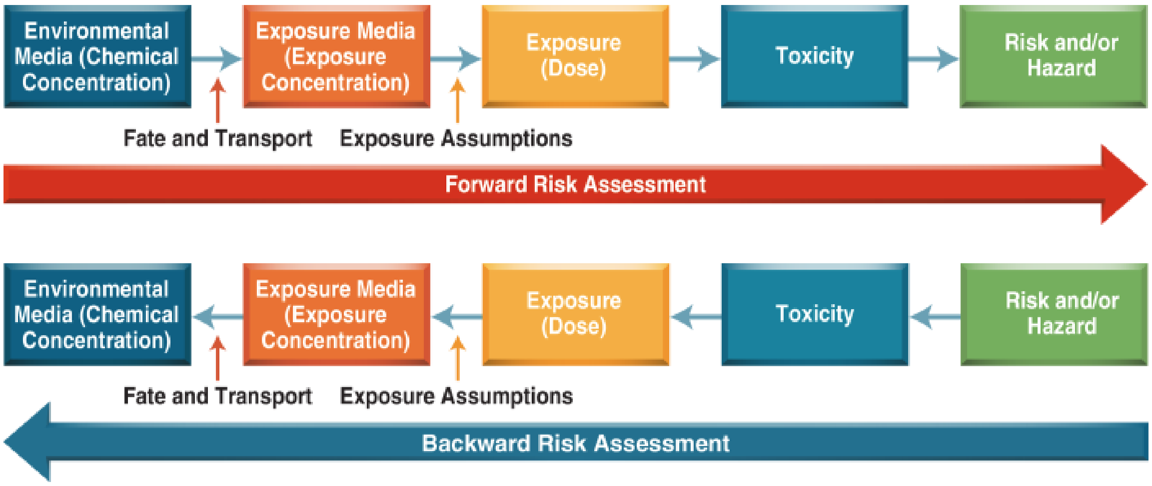

Figure 2-2. Backward risk assessment process.

Figure 1: Forward and backward risk assessment process (same approach can be adopted for FOC's).

This approach is also hierarchical (multi-tier) in the sense that it allows coarse and fast analysis, by means of simplified models and tools (tier 1) through to highly sophisticated – site specific analysis by means of high-resolution models and data (tier 3, Figure 2). SG_RBCA will address Tier 1 and 2 levels.

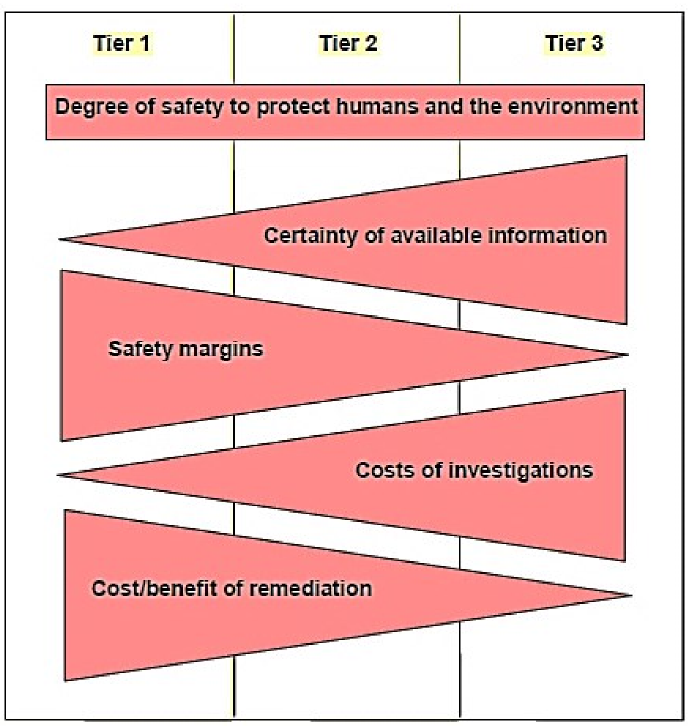

Figure 2: forward and backward risk assessment process

Another advantage of this approach resides in the fact that it is widely used by regulators and operators and therefore the adaptation of the suggested platform would be much smoother than any newly developed and tailored approach. Models for the multiple tier approach taken from the extensive modelling effort that carried out in the frame of "FracRisk 2015".

3. SYSTEM ARCHITECTURE

The workflow diagram of SG-RBCA is presented in Figure 3. First, there is a need to characterize the different components of the candidate site where the drilling activities will take place. This would include geographical location, the geological section and the structure of the well. Then identify the chemicals to be used for drilling, fracturing and production. When all this information is ready, SG_RBCA will suggest the specific scenarios with bearing a risk potential. The scenarios would include source of the risk (pressure and or chemicals), expansion pathways and potentially affected receptors. Then, a report summarizing the relevant risk scenarios and their potential risks is generated.

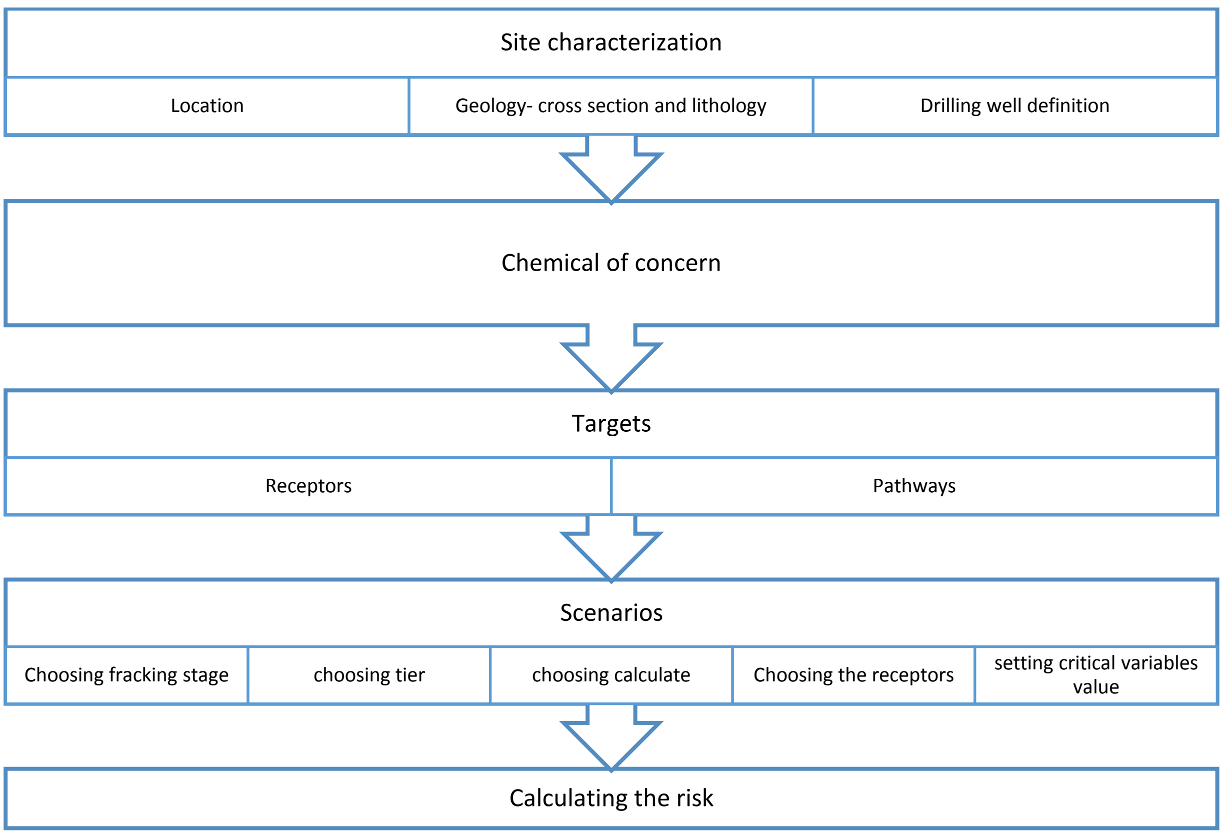

Figure 3: conceptual structure of SG-RBCA.

4. Database Management System (DBMS)

SG-RBCA comprises a number of data layers organized in a MS-ACCESS based structure. The DBMS includes a number of tables:

1. **Geological data**: Lithology, porosity, density, permeability, Young's modulus, Poisson's ratio.

2. **Chemical data**: Chemicals used in the shale gas process, with their chemical name, structure formula, CAS ID, toxicological and chemical properties etc.

The software allows updating existing records and/or adding new records to the tables. These changes, together with the original data are stored in a new DBMS linked to the specific project or workspace. It is always possible to return to the original DBMS. A user with adequate privileges (A super User) can update the original DBMS.

5. COMPONENT DESIGN

5.1 Working environment

SG-RBCA is programmed using the Microsoft Dot.Net 4.5. This platform allows web deployment and updating and local installation of the software, while all the databases reside in the server. Basically, this approach allows local work and global access to data and updating. Only the MS-Windows (preferably version 10) environment is targeted.

5.2 User Interface

SG-RBCA will include six pages or tabs:

1. **Site** – a geographical location map, sub-classing the google map application programming interface (API);
2. **CSM conceptual site model** – where the geological information and well structure are loaded;
3. **COC - chemicals of concern** – where the user can chemicals that are planned to be used in the candidate site, during all phases of the activity (development and production).
4. **Sources Receptors & Exposure pathways** – where the software suggests, based on the input, the risk scenarios that are relevant to the candidate site, including the source of the risk and the exposure pathways. The user can then identify the receptors at risk.
5. **Run or Calculate** – conduct the relevant calculations and provide the values of the variables to which the receptors are exposed.
6. **Results, Reports and recommendations** – display (tabular and graphic) of the results for the scenario simulation, uncertainties, summarizing reports and recommendations, with regard to the environmental suitability of the site and preventive/mitigation steps to be adopted.

Remark: We have not included in DBMS threshold values for FOC's.

5.3 Workflow

SG-RBCA allows defining a working environment, project or workspace. A SG-RBCA workspace records all the data and operations performed by the user during a working session. These can be saved (using the xml file format) reloaded when work on the workspace resumes. All the files in a workspace are local, saved in the user's computer.

5.4 Geographical location

SG-RBCA will allow the user to set the geographical location of the candidate site. This will be done using the API (the application programming interface) offered by Google Maps. Using this API allows the identification of potential problems and opportunities for the candidate site, prior to the undertaking of any activity. Sites could be preliminary screened by checking the vicinity of the candidate sites, in terms of receptors (populated areas, sensitive areas etc) and in terms of supporting infrastructures (such as supply routes, available land etc.).

5.4 Geological information

The relevant geological cross section can then be provided to the software. This can be done in two modes: 1) creating a schematic yet relevant representation of the geological cross-section using the geological database and local information (on the geological structure); 2) choosing from a pre-defined library of geological structures, characteristic of specific locations. Either way, the software produces a graphical representation of the geological structure.

5.6 Well information

Well information can then added on the geological cross-section. Well data includes vertical depth, horizontal span, length of perforated area and diameter.

5.7 Selection of the chemicals used for the stimulation

The user can then select from the chemical databases, the materials that will be used for the drilling and or hydraulic fracturing and their quantities.

5.8 Identification of the factors of concern

According to the relevant risk scenarios SG-RBCA will identify and preliminary quantify the factors of concern (occurrence of induced seismicity and or over-pressure).

5.9 Risk sources and their impact

Based on the information provided by the user (Geology, well structure and chemicals to be applied), the software will suggest the relevant and plausible sources of risk, based on the risk bearing scenarios developed in the frame of FRACRISK. It will automatically generate the input needed for the evaluator engine: hydraulic, mechanical and chemical properties boundary conditions and exposure pathways. The results of the evaluator (in terms of pressure, stress, fluxes, concentration of chemicals) will then be tested with sensitivity of identified receptors along the pathways.

5.10 The evaluation engine

Usual implementations of RBCA involve the use of one dimensional models with analytical solutions and or 2D vertical or horizontal models with numerical solutions. These correspond to Tier 1 and 2 evaluations. In the case of shale gas, and more specifically for the risk scenarios adopted in the FRACRISK, analytical solutions are not suitable to the configuration of the risk scenarios. Numerical models, even in their simplest structure are too complex to be run in real time since they involved multi-phase complex processes (hydro-mechanical). The solution of this type of models would require substantial computer resources as well as relatively long waiting times. Also, some of the models are commercial and can not be deployed without proper licensing, while others require specific computer configurations and operating systems. In order to avoid these challenges, SG_RBCA uses the PCM (Polynomial Chaos Expansion) approach, which is explained in Deliverable D5.5. In simple words, the results of a simulation model are represented by a much simpler function of polynomial structure. By running the simulation model a sufficient number of times, varying the values of key parameters, it is possible to achieve a relatively consistent response with the polynomial surrogate, which is simple to implement and allows fast calculations. It is possible to exploit the speed of the PCM calculations to provide an estimation of the uncertainty of the calculated values. This represents a substantial improvement of the quantitative risk assessment procedures.

5.11 Risk Evaluation

Once the values and the uncertainty of the key risk bearing parameters are calculated it is possible to estimate the exposure and the risk incurred by identified receptors. This completes the risk assessment procedure.

5.12 Reporting and recommendations

SG-RBC will generate a report, outlining all the relevant information as well as the outcome of the risk analysis. Recommendations will be issued in terms of "go-nogo" with regard to a specific site. In case of a "go" additional recommendations with regard to precautionary measures (such as monitoring and early warning system) near the source, along the pathway exposure or at the vicinity of the receptors will be issued.

ASTM E2081-00(2015), Standard Guide for Risk-Based Corrective Action, ASTM International, West Conshohocken, PA, 2015, www.astm.org. DOI: 10.1520/E2081-00R15.