ENVIRONMENTAL ASPECTS OF HYDRAULIC FRACTURING PROCESS IN POLAND

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Environmental Impact Assessment

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Procedure for planned projects:

Projects that may have a significant impact on the environment
are defined in the Regulation of the Council of Ministers of 9 November 2010, which divides such projects into the following groups:

- projects which can always have a significant impact on the environment (group I) – the EIA is obligatory,
- projects with a potential significant impact on the environment (group II) – the EIA is optional (screening).

All the above-mentioned projects always require a **decision on the environmental conditions**.

If the planned project also affects the Natura 2000 sites, **the impact assessment on Natura 2000 sites will be a part of EIA**.

Proposed projects not defined in the above-mentioned regulation may require an **assessment of the impact of the project on a Natura 2000 area.**

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Decision on the environmental conditions

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- **defines the conditions** for the use of the area at the stages of the implementation, operation or use and closure of the project, with a particular consideration given to the necessity to protect special natural values, natural resources and cultural heritage sites and to reduce the disturbances for the adjacent areas.

- **imposes an obligation to prevent, reduce and monitor** the environmental impact of a project.

- is issued after an assessment of the environmental impact by the competent authority - **Regional Director of Environmental Protection** or local authority **after the approval of Regional Director of Environmental Protection**

- **has to** be granted **before** obtaining other necessary administrative decisions and its conditions constitutes legal requirements for subsequent decisions.

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Required administrative decisions

for the implementation of projects related to exploration and exploitation of unconventional gas deposits:

- **Decision on the environmental conditions**
- Localization decision (if no local land-use plan)
- Building permit
- Water permits
- Decision approving the waste management plan
- Other decisions, including those related to waste management
- **Concession for prospecting and exploration of minerals from deposits**
- **Concession for exploitation of minerals from deposits**

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Directions and expectations
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Estimated shale gas resources in Poland

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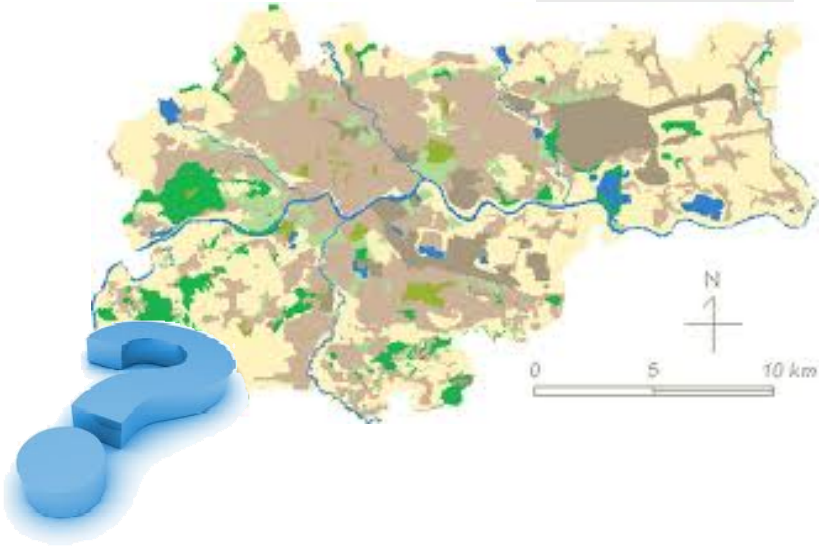

3000 bcm – Advanced Res. Int., 2009

1400 bcm – Wood Mackenzie, 2009

1000 bcm – Rystad Energy, 2010

5300 bcm – EIA – US Department Energy, 2011

35 bcm – USGS – US Department of Interior, 2012

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Estimated shale gas resources in Poland

The first Polis report prepared and presented by
Polis Geological Institute – National Research Institute:

„Assessment of shale gas and shale oil resources of the lower paleozoic Baltic-Podlasie-Lublin Basin in Poland” - March, 2012

Shale gas recoverable resources:
- **1920 bcm** – maximum
- **346 – 768 bcm** – highest probability range

Shale oil recoverable resources:
- **535 Mmtons (3905 MMB**) – maximum
- **215-268 Mmtons (1569-1956 MMB)** – higher probability range

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Estimated shale gas resources in Poland

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346 – 786 bcm

- **2,5** to **5,5 times higher** than **documented** conventional gas fields in Poland (**145 bcm**)

- equivalent of **35 – 65 years** of **cumulative gas consumption** on Polis market (incl. documented resources of gas from conventional resources)

- equivalent of **110 – 200 years** of **Poland's gas production without decreasing of import** (incl. documented resources of gas from conventional resources)

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Concession Map

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Conventional oil and gas

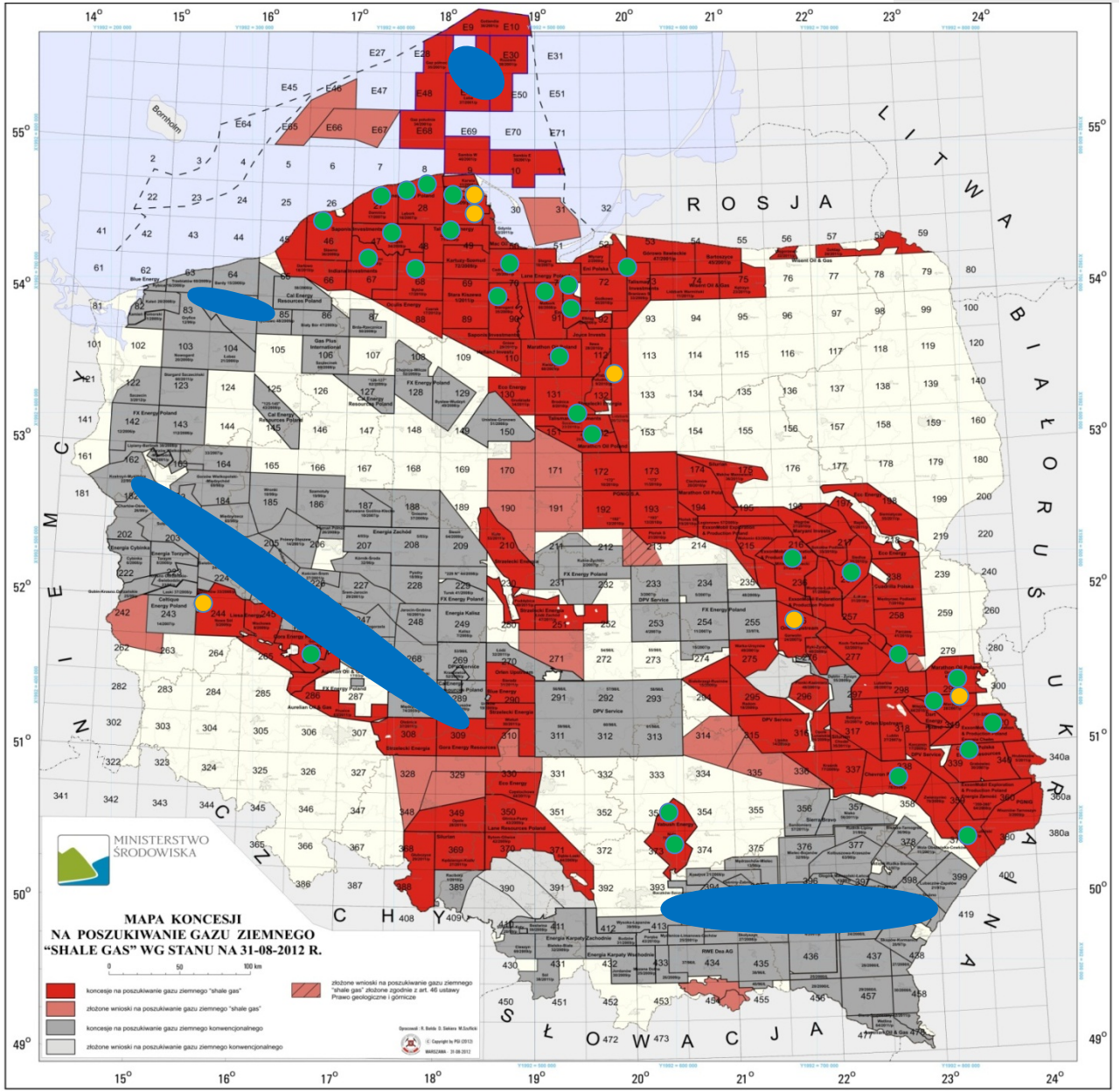
ca. 250 concessions for production since 1950
- more than 9 000 exploration wells

Unconventional oil and gas

concessions for exploration

completed exploration wells

exploration drillings in progress



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Shale gas in Poland – exploration phase

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Drilling progress for unconventional gas (as at the date of 19th Nov 2012):

- **33** exploration wells completed
- another **7** exploration drills in progress

Hydraulic fraction progress (as at the date of 19th Nov 2012):

- **8** vertical boreholes fractured
- **2** vertical and horizontal boreholes fractures

Future:

- another **170** exploration wells planned till 2020

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Environmental aspects of hydraulic fracturing

Assessment of hydraulic fraction process conducted in Łebień

Information about the drilling:
•concession owner: **Lane Energy Poland of the 3 Legs Resources Group**
•location of mining plant: **Łebień**
•exploratory well: **LE-2H**
•time period: **August 2011**

Information about the Report:
•pulblished on: 2nd March 2012
•prepared by:

- **Polish Geological Institute – National Research Institute,**
- **Polish Academy of Sciences,**
- **Regional Inspectorate for Envi. Protection,**
- **Oil and Gas Research Institute**

Environmental aspects of hydraulic fracturing

Main aims of the Report:

•**Identification of potential risks for the environment** (analysis of all the stages of operations performed on well) is scope of:

- possibilities of shale gas migrations,
- seismic events,
- waste management,
- radioactivity,
- serious technical accidents and natural hazards.

•**Identification of environmental elements exposed to influence**:

- air,
- landscape,
- land surface,
- soils,
- surface waters,
- groundwater,
- human factor.

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Environmental aspects of hydraulic fracturing

Research schedule:

Period	Stages of field works	Stages of research works
13.06 - 18.07.	Completion of the drilling process; rig removal.	**Stage I** – field visit, study of existing data, preparation for the research.
19.07 - 31.07.	Site preparation for fracturing treatment.	**Stage II** – determination of the „zero condition" of atmosphere, land surface, ground air, surface and groundwaters. Beginning of seismic research.
01.08 - 18.08.	Transportation and installation of equipment for fracturing; safety tests.	
19.08 - 28.08.	Performance of hydraulic fracturing.	**Stage III** – measurements of the air pollution and noise level, seismic analysis, water sampling of groundwater and technological fluids for the laboratory examination.
31.08 - 07.09.	Drill-out of plugs; pressure removal in the borehole.	
08.09 - 22.09.	Production tests; injection of nitrogen.	**Stage IV** – the study of ground air, gas sampling, emissions' measurements, sampling of groundwater and technological fluids, chemical analysis of groundwater samples, chemical and toxicological analysis of technological fluids.
23.09 - 13.10.	Dismantling of equipment; securing the borehole and drilling pad; waste disposal.	**Stage V** – groundwater and technological fluids sampling, continued chemical and toxicological analysis of sampled water and fluids, analysis of gas samples, further emissions' measurements.

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Environmental aspects of hydraulic fracturing

SEISMICITY

•**Monitoring of seismic fracturing process** (conducted by the Institute of Geophysics of Polish Academy of Sciences)

- measurements – 15th July – 30th September 2011
- **before** the hydraulic fracturing treatments, **during** it, as well as **after**
- **10** mobile seismic stations (located: 1 – 25 km from the Łebień LE-2H wellbore)

•**Findings**:

- **no seismic events** have been registered,
- **paraseismic signal** generated by the equipment used for the fracking (mainly pumps) has been recorded in the closest seismic station (approx. **1 km**)
- **vibrations** generated by devices operating at the time of fracturing process **did not pose a risk** to people or buildings in the area,

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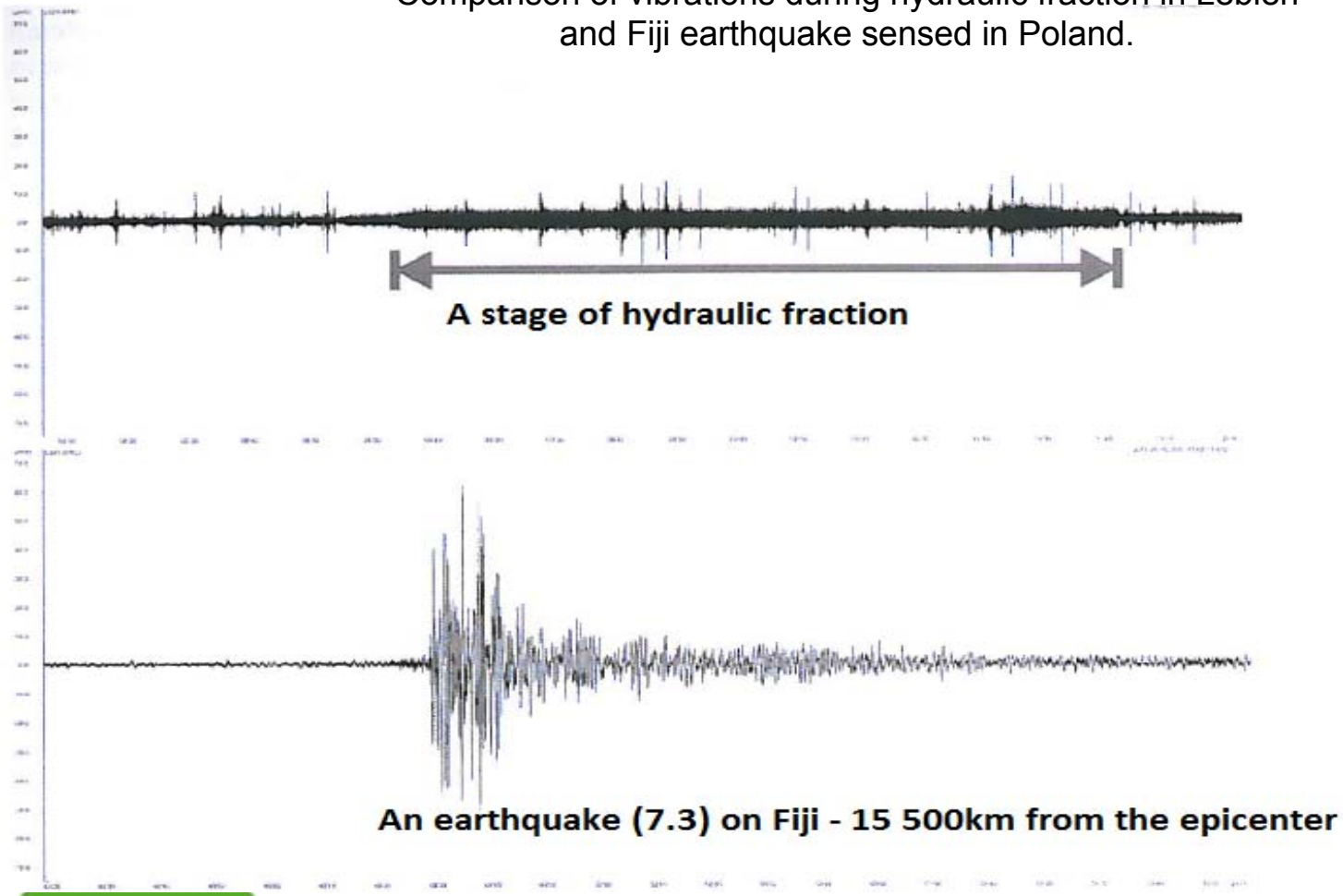
Environmental aspects of hydraulic fracturing

SEISMICITY

Comparison of vibrations during hydraulic fraction in Łebień and Fiji earthquake sensed in Poland.



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Environmental aspects of hydraulic fracturing

EMISSIONS

•**Measurements of concentration of gaseous pollutants in ambient air**
(conducted by Regional Inspectorate of Environment Protection in Gdańsk)
•Indicators:
- **sulfur dioxide, nitrogen oxides, benzene, methane, carbon monoxide, hydrogen sulfide**

•Equipment:
- mobile Draeger CMS Analyzer

•The series of measurements were **repeated three times**, on 19th July, 19th August and 30th August 2011 **in three different locations**.

•**Findings**:
- **negative result**,
- **all the substances did not achieve a concentration above the reference limits** set in the regulation of the Minister of Environment from 26 January 2010 on the reference values for certain substances in the air.

Exposure period: August-September 2011		
Indicator	Average concentration µg/m3	Reference concentration µg/m3
Sulfur dioxide	5,54	200
Nitrogen dioxide	9,61	350
Benzene	0,70	30

Source: Polish Geological Institute

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RADIOACTIVITY

•**Low levels of radioactivity** in shale layers at a depth of **3 500 – 4 500 meters**
- study of rocks from drill cores foram shale gas exploration boreholes in Markowola 1 (Lubelskie Province) and Lubocino 1 (Pomeranian Province).

•**Results comply the requirements** defined in the regulation of Council of Ministers on the requirements for the content of natural radioactive isotopes of potassium K-40, radium Ra-226 and thorium Th-228 in raw materials and materials used in buildings designed to accommodate people and livestock, as well as in industrial waste used in construction, and control the content of these isotopes

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Environmental aspects of hydraulic fracturing

SURFACE WATER QUALITY ASSESSMENT

Indicators (-/(mg/L))	Water intake – 30.08.2011	Water intake – 20.09.2011	Normative amounts
pH	7,7	7,8	6-8,5
Dissolved oxygen	10,19	9,87	>7
Chlorides	11,8	11,7	<200
Sulfates	36,9	33,7	<150
Sodium	5,69	5,67	Not normed
Potassium	1,76 1,8	1,86	Not normed
TOC	4,49	5,19	<10
Boron	<0,010	<0,010	<2
Sulfides	<0,04	<0,04	Not normed
Kjeldahl nitrogen	1,02	0,82	2

- studies conducted by **Inspectorate for Environmental Protection in Gdańsk**.
- measuring point: at Kisewska Struga.
  Samples were taken **three times** – 19th July, 30th August and 20th September 2011.

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Environmental aspects of hydraulic fracturing

GROUNDWATER QUALITY ASSESSMENT

- Samples for laboratory tests – from 9 selected locationsFor the purpose of determining the chemical status of groundwater prior to hydraulic fracturing, **samples from nine selected locations** have been collected for **laboratory tests**.

- To collect the samples 8 drilled wells and one dug well within a radius of up to 2 km from the borehole have been chosen.

- **Measurement points** have been located **concentrically relatively** to the **drilling site**, but with a particular reference to the direction south and south-east, as it is the direction of groundwater flow from the area of a drilling pad.

- The **results** of conducted **analysis** showed **no change in chemistry of aquifers**. The concentrations of the indicators examined have not changed, what indicates no impact of drilling and fracking on aquifers in the area of the drilling pad.

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GDEP Research Project

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„Risk assessment of prospecting, exploration and exploitation of unconventional hydrocarbons on the environment”

Source: Polish Geological Institute

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GDEP Research Project

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•implemented by **General Directorate for Environmental Protection** and financed by the **National Fund for Environmental Protection and Water Management**

•conducted on **5 different drilling sites**, selected from different regions of Poland, covering areas of different environmental and geological characteristics

General scope and aims:

•**impact assessment** of the exploration and exploitation of unconventional hydrocarbons on the environment, in particular of fracturing processes, underground infrastructure, ground and grid infrastructure

•development or creation of **detailed guidelines** for:

- the preparation of reports and environmental impact assessments
- reclamation of mining areas
- conducting environmental monitoring in the areas of exploration and exploitation of unconventional hydrocarbons in the different phases in relation to biotic and abiotic environment.

•development of **good practices** in directional drilling, casing and cementing.

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GDEP Research Project

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STAGE IN PROGRESS

•on-site studies, sampling, laboratory tests and preparing first reports
(August 2012 – May 2013)

Major goal:

•to analyze the potenctial influence or impact on the environment on all the stages of operations performed on well (from preparatory works, trough the hydraulic fracturing treatments to those connected with well shut-in) in full scope of aspects.

Main tasks:

•Exploration of geological structure and hydrogeological conditions in the areas of 5 drilling sites;

•Defining background for analyses in geological profile as well as on the land surface

•Monitoring of any changes in condition of environment i.e. in concentration of examined indicators, in noise level, vibrations' level or in case of seismic event.

•Detailed analyses of sampling technological fluids and ground water;

•Identification of possible negative consequences of exploitation and exploration process.

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