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Brief review of the pipeline construction in the Makarovskiy Region under the Sakhalin II project (Operating and environmental issues)

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1. Preface

This paper was drawn up by Ph. D. in Geography Afanasiev V. V., the member of the Committee for Natural Resources and Environment of the Sakhalin Region. This review is based on the field study of current geology-geomorphologic processes related any way to the pipeline construction under the Sakhalin II project. Study has been carried out from August 21 to August 25 during the pipeline inspection, jointly with Rosprirodnadzor of the Sakhalin Region. The up-to-date information about design and survey was used when drawing up.

This review was drawn up to inform national and municipal authorities about operating and environmental issues of the nature management when constructing the pipelines in the landslide sectors of the 3rd and 4th (partially) building lines **from kilometer 341 to kilometer 464** along the pipeline route under the Sakhalin II project. This paper doesn't purport to cover the problem comprehensively, but under more thorough researches, the main findings, likely, will be the same. **2. Brief Analysis of Results of Design and Survey Works**

Engineering survey in the sector from kilometre 341 to kilometre 464 in the Makarovskiy and Dolinskiy Rayons of the Sakhalin Region was carried out by Rosstroyizyskaniya JSC Inzhzaschita Ltd. according to changes #5 and #7 to the sub-contract agreement #693000/000/SUB/11.10/0281 on an engineering survey of the object: "Design and construction of the pipelines on landslide sections of the 3rd and 4th building lines from kilometer 341 to kilometer 464. Sakhalin II project".

On the basis of integrated analysis of researches conducted, ranging and general conclusion on data of researches from past years Inzhzaschita Ltd., Sochi City, concludes following:

1. **There are 183 places** where hazardous geological processes of various origins, scales, and, thus, levels of engineering-geological and building risks have been occurred on the section of kilometers 341–464 (Appendix I. Summary Registry of Hazardous Geological Processes). The re-routing and trace optimizations of **38 percents** of the section concerned have been carried out.

2. Events of hazardous geological processes were ranged in following levels of engineering risks:

- I (low) — low-active erosive processes (it can be activated during construction), solifluction, landslides — earthflow up to 1.5–2.5 meters. **The engineering protection starts just after the most part of the construction works have been completed.**
- II (medium) — erosive processes are active in the native state, liquefaction slides and block slides up to 4.0 meters. **Engineering protections are being provided along with construction.**
- III (high) — liquefaction slides and block slides over 4.0 meters, mudflows, landslide-danger slopes of significant extension and steepness. **The engineering protection is being provided on the stage of the construction preparation.**

3. Engineering-geology conditions of the oil and gas pipeline section under exploration are ranged in complex and very complex conditions.

The detail designing of engineering protection facilities for protection of onshore pipelines under the Sakhalin II project on the landslide areas of 3rd and 4th building lines from kilometer 341 to kilometer 466 was drawn up by Inzhzaschita Ltd. (Sochi City) according to agreement with Starstroy Ltd. and it is completed in general just now. **The designing results in following:**

1. In total, there are 472 areas required some engineering solutions, including: 340-350 km — 19 areas, 350-360 km — 46 areas, 360-370 km — 54 areas, 370-380 km — 42 areas, 380-390 km — 41 areas, 390-400 km — 41 areas, 400-410 km — 51 areas, 410-420 km — 50 areas, 420-430 km — 30 areas, 430-440 km — 26 areas, 440-450 km — 32 areas, 450-460 km — 29 areas, 460-470 km — 11 areas.

2. There are 20 areas of engineering risk level II and III that require to develop separate execution plans for engineering protection (see table below):

List of separate designs of engineering protection from hazardous geology processes for the pipeline

Design area number	Picket of design area	Combined section plan number (CSP)	Location	Main design solutions	Number of the detailed drawing
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	gas	oil				
1	2	3	4	5	6	7
340/15	3471+23-3472+88	3473+05 - 3474+70	5050-G-37-41-D-3347-00 5000-G-36-41-D-3347-00	Bottom of north-east and south-west slopes of the valley of the Kormovaya River	Forming of relief, surface flowing, drainage, bank protection	C-9651
						D-9651
350/24	3555+20-3556+70	3557+20 - 3558+70	5000-G-36-41-D-3356-00 5050-G-37-41-D-3356-00	Bottom of right-hand slope of the valley of the Pulka River and the crossing through the river	Forming of relief, surface flowing, bank protection	C-9655
						D-9655
360/15	3617+55-3621+81	3619+77-3624+05	5000-G-36-41-D-3362-00 5050-G-37-41-D-3362-00	The valley of the Varvarka River	Re-routing, bank protection, terracing, lowering of pipeline	C-9671
						D-9671
370/28	3760+05-3762+50	3765+50-3765+00	5050-G-37-41-D-3377-00 5000-G-36-41-D-3377-00	Bottom of the right-hand slope of the valley of the Pulka River	Forming of relief, surface flowing, bank protection, drainage	C-9659
						D-9659
370/35	3771+00-3773+55	3773+50-3776+00	5050-G-37-41-D-3377-00 5050-G-37-41-D-3378-00 5000-G-36-41-D-3377-00 5000-G-36-41-D-3378-00	Watershed of the Smuglanka River–Linek Stream	Surface flowing, terracing, drainage	C-9660
						D-9660
380/01	3795+90-3798+40	3798+50-3801+00	5050-G-37-41-D-3380-00 5000-G-36-41-D-3388-00	Right side of the valley of the Lazovaya River	Surface flowing, terracing, drainage, bank protection	C-9661
						D-9661
380/08	3810+27-3812+27	3813+00-3815+00	5050-G-37-41-D-3381-00 5000-G-36-41-D-3381-00	Middle and bottom of the right-hand slope of the valley of the unnamed stream	Re-routing, forming of relief, surface flowing, bank protection, drainage	C-9662
						D-9662
420/20	4251+44.5-4255+46	4255+00-4259+00	5000-G-36-41-D-3427-00 5050-G-37-41-D-3427-00	Slope of the valley of the Mostovaya River	Forming of relief, surface flowing, drainage, bank protection	C-9669
						D-9669
420/30	4281+00 - 4283+80	4284+80-4287+65	5000-G-36-41-D-3430-00 5050-G-37-41-D-3430-00	Foot of the Zhdanko Ridge	Re-routing, mudflow discharge facilities, surface flowing	C-9670
						D-9670
350 15-16-17	3529+80-3540+00	3531+88 - 3542+00	5000-G-36-41-D-3353-00 5050-G-37-41-D-	Pulka River	Re-routing, bank protection, terracing, surface	C-9680

Design area number	Picket of design area		Combined section plan number (CSP)	Location	Main design solutions	Number of the detailed drawing 5600-C-90-12-X-NNNN
	gas	oil				
1	2	3	4	5	6	7
			3353-00		flowing, lowering of pipeline	D-9680
360/03 360/04 360/05	3594+88- 3601+56	3596+67 - 3603+85	5050-G-37-41-D-3360-00 5000-G-36-41-D-3360-00 5050-G-36-42-D-3360-00 5000-G-37-41-D-3360-00	Ridge in the valley of the Sosnovka River	Forming of relief, surface flowing, bank protection, drainage	C-9681 D-9681
400/15 400/16 400/19	4018+61 - 4025+25	4021+60 - 4028+18	5050-G-37-41-D-3403-00 5000-G-36-41-D-3403-00	Watershed of the Rudnaya River – unnamed stream and right-hand side of the unnamed stream valley	Re-routing, forming of relief, surface flowing, bank protection, drainage	C-9682 D-9682
400/31 400/32	4038+20 - 4043+114	4041+15 - 4046+118	5000-G-36-41-D-3404-00 5050-G-37-41-D-3404-00 5000-G-36-41-D-3406-00 5050-G-37-41-D-3406-00	Watershed of the Smuglanka River – the Uspenka River	Re-routing, forming of relief, surface flowing, drainage	C-9683 D-9683

Thus, the most part of the route belongs to an area with high damage risk, and just few fragments in the north and south explored area has a middle and increased risk. At the same time, it should be noted that this evaluation characterizes normal operation of the pipelines. **In emergency, the damage risk is ranked as high level throughout the area explored. As a result of this:**

1. The **sparing methods of construction** should be used in the designing, construction, and operating of pipelines **to prevent negative changes in geology environment**.
2. When specifying a topographic land-survey and choosing a method of and measure for the engineering protection, one needs to take into account that the data mentioned in the document characterize native state of the environment without man-caused impact. **The pipeline construction will inevitably activate landslide processes affecting new areas not affected yet.**

3. Principles of Decision-Making on Engineering Solution

Landslide and erosive processes

The main technical solution on stabilization of hillside processes within the right-of-way is **the forming of the relief, surface and subsoil drainage with relevant soil-saving measures**. The main goal is to deepen the pipelines into soil that doesn't undergo critical shifts during the operating period estimated taking into account seismic, hydro-geology and hydro-meteorology factors.

Designers recognize that under conditions of broken ground and unfavorable physical-mechanical state of soil this technical solution results in significant earth handling which can entail following negative geotechnical and environmental consequences:

- Changes in stress condition of soil at the slopes with subsequent activation of landslide processes;
- Changes in flowing of the surface and subsoil water with development of linear and sheet wash, piping in the filled unconsolidated soil, mudflow events;
- Impacts on ecological systems that appeared as significant exceeding of solid flow rate in the temporary and permanent water courses due to development of erosive processes.

Mudflows

Execution plan for section between kilometers 352 and 357 (Pulka River) provides for the pipelines being placed 0.5 meters deeper than the theoretical level of mudflow wash-out, bank protection for the Pulka River, derivation of surface and ground waters.

Execution plan for section between kilometers 428 and 431 (Zhdanko Ridge, st. Tzapko) provides for a construction of two mudflow discharge facilities, derivation of surface water.

On the other sections there will be typical solutions implemented.

Displacement and stockpiling of the building soil

Inzhzaschita's designers pointed out that the following engineering package for prohibiting or minimizing negative after-effects of displacement and stockpiling of soil should be implemented:

1. Determination of dumping and stockpiling sites that are not situated on:

- Landslide and landslide-danger slopes
- Ravines of erosive trenches
- Impounded or flooded areas
- Mudflow and landslide location
- Sites of native discharge of groundwater (springs)
- Areas with special landscape and environmental value

2. Initial site preparation for soil dumping by felling, construction of service roads, removing and stockpiling of soil-vegetable layer to allow further using

3. Preparation of basement for soil dumping by terracing slopes where the lengthwise inclination of the slopes exceeds 10 degrees

4. When arranging the dump in the lowlands one needs to provide drainage facility according to typical design

5. Layered sealing of dumped soil with getting at least 80 percents of native density of the dumped soil

6. Slope ratio should not exceeded 1:1.5, where the horizontal layer of the slope is more than 11 meters, terracing with the berm width at least 4.0 meters should be provided.

7. Forming of the surface flowing by arrangement of open conduits according to typical designs

8. Erosion-prevention facilities for the forming slopes according to typical designs with recovery of soil-vegetable layer from reserves and silvicultural reclamation

Hydrology processes

According to the designers, in the separate designs, mentioned above, there are sufficient engineering measures provided for prohibiting of the ground and side wash-outs on the watercourse crossings in the right-of-way area.

Facilities formed by wired boxes (gabions) are linked with specific sections and their geometrical parameters are defined according to hydrology and hydraulic evaluations for all sections.

On the other sections of watercourses crossings the choice of engineering solutions is based on applicability criteria which is stated in typical design. Geometrical parameters of the facilities, methods, and scope of works should be defined when developing operational design for each

typical design of watercourse crossing. At the same time, one should take into account geological and hydrological conditions at the start of the construction.

Temperature regime of soil

A depth of seasonal frost penetration was calculated on the base of monthly average negative air temperature near the Makarov City. This is 158 cm for clay soil; 193 cm for clay sand, sandy silt and fine sand; 206 cm for gravel sand, coarse and medium sand ; 234 cm for pebble gravel and macadam. Along the pipeline, clay soil, sandy soil, large-scale soil and peat have significant frost heaving.

The Environmental Monitoring is a significant part of protection measures.

Monitoring system of Inzhzaschita Ltd. includes:

- System of depth and soil bases in and out the landslide body along with organizing of operating land-surveying observation for body movement;

- System of observation wells for groundwater level and logging control;

- Operating geodynamic observation for hazardous geology processes on the key areas with inspection interval of once per month to evaluate changes in the landslide body intenseness;

- Installation of tensor sensors with telemetric signal transmission to allow observations over the landslide body intenseness;

- System of tensor sensors installed in the pipe with telemetric signal transmission to enable control of the critical stresses which can break the pipe.

Monitoring system should have been created during the construction of the pipelines and the landslide-prevention facilities, and the creation should continue when the pipelines will start operating. It is expected that creation of the monitoring system will allow applying opportunely engineering solutions, if the landslide activity will be increased.

4. State of affairs as of August 21–25, 2006

Reconnaissance survey of oil and gas pipeline route (24” and 48”) under the Sakhalin II project and analysis of the side-erosion, wash-out, and impoundment protection on the constant and temporary watercourses of the freshets and floods, and erosive, mudflow, landslide protection during the construction and operating have **showed following**.

There are no engineering facilities on route section explored. At the same time, according to nonpublic documents of the Starstroy Company, at least in 20 areas **the engineering protection should be implemented on the preparatory stage of construction.**

Changes in the Starstroy Company’s construction policy — i.e. a shift from initial solutions which require large-scale ferroconcrete works to the relief forming, surface and ground flowing with attended erosion control measures — requires significant increasing a soil extraction and displacement, as well as extending of the right-of-way throughout all hazardous areas. We think that in this situation one needs to carry out an examination of geotechnical and environmental consequences of these new solutions supposed by the designers. These consequences include: changes in stress state of the soil on the slopes with further activation of landslide processes; changes in surface and ground flowing conditions along with linear and sheet wash, piping in the filled unconsolidated soil, mudflow propagation; impacts on ecological systems evidenced by significant exceeding of sediment load rate in the constant and temporary watercourses as a result of erosion progress.

The right-of-way expansions etc. should be coordinated. In some cases, consequences of the pipeline burying into soil without critical dislocations during operational period estimated (on the depth up to 10 meters) are not clear and require serious attention as they cannot provide pipeline reliability anytime.

Unfoundedly little attention has been paid to the analysis of consequences of the frost heaving (the strain can be up to 10–15 tons per 1 m²). The calculations for the frost zones have been

implemented over undisturbed soil in the native conditions. Changes in hydrogeological conditions, physical-mechanical properties of accommodating soil, impacts of the pipes themselves and backfill soil are not considered in the calculations.

Now there are no landslide-preventive measures at all (See Appendices 2, 3, 4).

The outrageous situation with construction and engineering protection of service roads and along-route driveways and communications has arisen (See Appendix 3). In addition to the fact that some roads were constructed without construction documents, in most cases they seriously aggravate geotechnical conditions of pipelines construction and operating.

Today, none of the conditions of the soil stockpiling declared in the construction documents was met (See Appendix 4). Situation has got out of hand. If this issue will not be addressed, this may cause very serious negative consequences for spawning rivers and inhabitants living near these rivers.

At this time, there are no pipelines bank stabilization measures implemented on the hard-to-reach river crossings. The construction of silt screens is very selective. Some waterways are blocked by road embankment indeed (See Appendix 5). Earlier, in the Review "On Environmental and Engineering Safety for Pipeline Communications on the River Crossings", we considered in detail faults in Sakhalin Energy's and their contractors' technical policies with a riverbank stabilization. It should be mentioned here that stabilization measures virtually have no sense in the right-of-way. Therefore, riverbank protection issues appear just now. Thereupon, now surveys should aim not to the development of efficient alternative for river channel control, alas, but the substantiation of the recommended mitigation measures for negative impacts on channel processes.

Based on all mentioned above, we can describe the situation with considered problems on this route section as unsatisfactory.

Findings:

1. We consider that the changes in the technical solution policy for the engineering protection are caused by the failure of operator and their contractors to meet the deadline while implementing construction-and-assembling operations. During the inspection, Starstroy Ltd. expressed absolutely opposite views on the issue without any justification.

2. Geotechnical conditions on the pipeline route along with number of existing environmental issues require addressing the issues with protection of pipelines and road network in the area of impacts of hazardous geological processes (landslides, erosion, mudflows). We recommend paying special attention to an analysis of a possible destruction of the Makarov City caused by huge mudflows coming down into the valley of the Makarova River. The possibility of above-mentioned processes is extremely strong because of outrageous activity on soil dumping, road and pipeline construction with full ignoring landslide-prevention and erosion control measures.

3. The design documents (these are already available) that should contain solutions on displacement of high volumes of soil require technical appraisal of the project solutions applicability in the new technologically modified geotechnical conditions.

4. The monitoring system for hazardous geology processes and events declared as a part of protection measures have not been developed yet. I believe that there is no sense to develop and implement the monitoring system without the Committee of Natural Resources and Environment of the Sakhalin Region protected the public and national interests on the regional level.

This Review was drawn up on **September 1, 2006**.