Environmental assessment of the dismantling of 12 Russian nuclear submarines

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Abstract

The project to dismantle 12 out-of-service nuclear submarines ("the dismantling project") consists of all operations and activities that are required for the defuelling and recycling of 12 Russian nuclear submarines at Zvezdochka shipyard in Severodvinsk, northwest Russia. The dismantling began in late 2004 and will continue over the next four years. The dismantling project will secure the highly-enriched spent nuclear fuel (SNF) currently onboard the 12 submarines by re-incorporating it into the Russian nuclear fuel cycle, thereby combating the proliferation of weapons and materials of mass destruction.

The assessment was conducted over a two month period in 2004, including a study team visit to the dismantling site. A systemic multi-step screening approach was used to focus a team visit to the site and allow production of a thorough Screening Report on an accelerated schedule. Potential effects were methodically assessed and opportunities for environmental performance improvement identified. Methods and procedures for conducting EAs on Canadian nuclear projects were applied in this challenging international project.

The assessment concluded that the project is not likely to result in any significant adverse effects on the environment, taking into account identified mitigation measures. A follow-up program is planned to confirm the validity of this conclusion.

Background

The Project to Dismantle 12 Out-of-service Nuclear Submarines ("the dismantling project") consists of all operations and activities that are required for the defuelling and recycling of 12 Russian Victor class nuclear submarines at Zvezdochka shipyard in Severodvinsk, Russia, with Canadian financial assistance. Figure 1, below, shows the location of the shipyard. Figure 2 includes a figure of a Victor class submarine.

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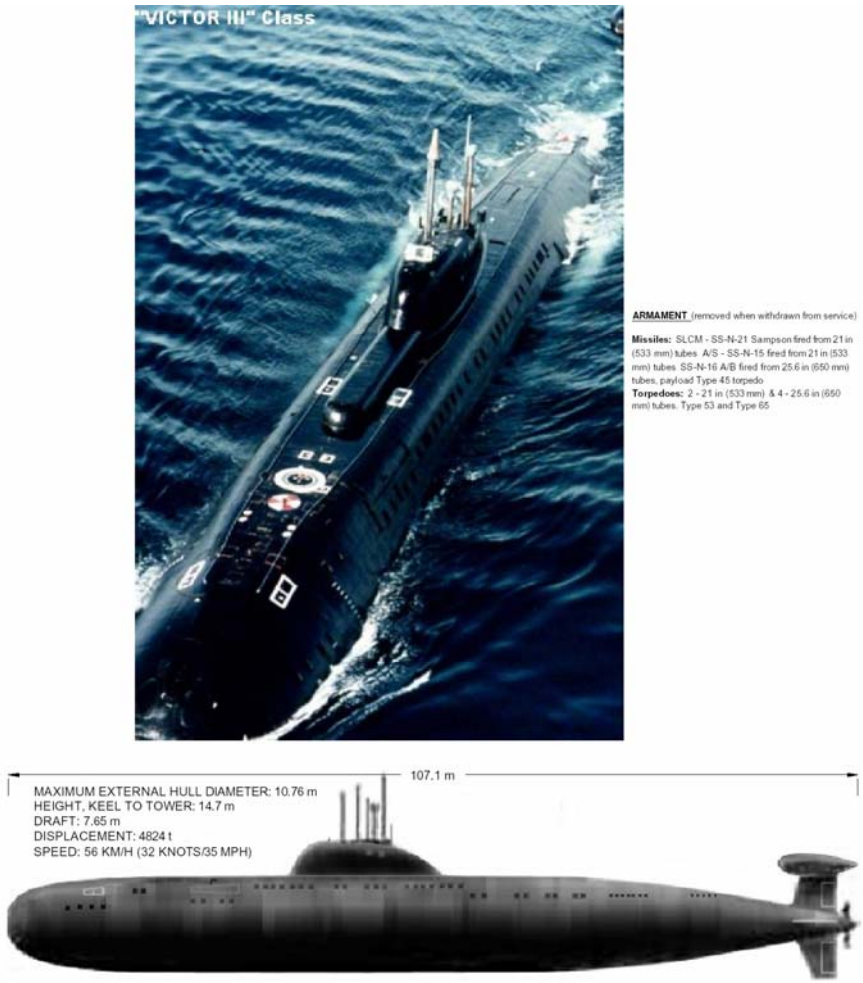
Figure 1: Location of the Zvezdochka Shipyard

Figure 2: Victor Class Submarine



The dismantling project will safely secure the highly-enriched spent nuclear fuel (SNF) currently onboard the 12 submarines by re-incorporating it into the Russian nuclear fuel cycle, thereby combating the proliferation of weapons and materials of mass destruction. In addition, the project will enhance the Arctic environment through the removal of a threat of radioactive and chemical pollution from deteriorating submarines stored afloat.

The dismantling project is a component of Canada's contribution to the broader Global Partnership Initiative against weapons and materials of mass destruction. Canada now joins other international partners, including the United States, Norway, Japan and the United Kingdom in the securing of SNF and the broad international initiative to rid the world's oceans of old, retired nuclear submarines.

Regulatory Framework

Foreign Affairs Canada (FAC) is responsible for the project through the provision of funds. FAC will carry out the Canadian commitments flowing from the Russian nuclear submarine dismantling initiative. The Zvezdochka shipyard, which has successfully dismantled ten nuclear submarines with foreign financial assistance, will carry out dismantling with Canadian oversight and in accordance with a comprehensive environmental management plan.

Because the project is not described in the *Canadian Environmental Assessment Act* (*CEAA*) Exclusion List Regulations, FAC determined that a screening must be conducted for the project and that a Screening Report must be prepared, pursuant to paragraph 14 of the *CEAA Projects Outside Canada Environmental Assessment Regulations*. As the responsible agency for the environmental assessment (EA) under *CEAA*, FAC determined the scope of the project and the scope of the assessment, in accordance with the *CEAA* and best current practice. FAC employed qualified specialists to conduct the assessment, supervised the assessment, conducted stakeholder and public consultation throughout the assessment, and reviewed the results of the assessment.

Environmental Assessment Process

In accordance with the scope of the assessment, the process to conduct and document the EA involves the following major steps:

- Describing the physical works and activities that constitute the project and identifying those that have a potential to interface with the environment;
- Assessing the likely environmental effects of the project, identifying mitigation measures and residual effects, and determining the significance of residual effects; and
- Conducting public and stakeholder consultation in Canada and developing a plan for follow-up to verify the conclusion of the EA.

The assessment is conducted for normal operations and for malfunctions and accidents with a reasonable probability of occurring.

Project Works and Activities

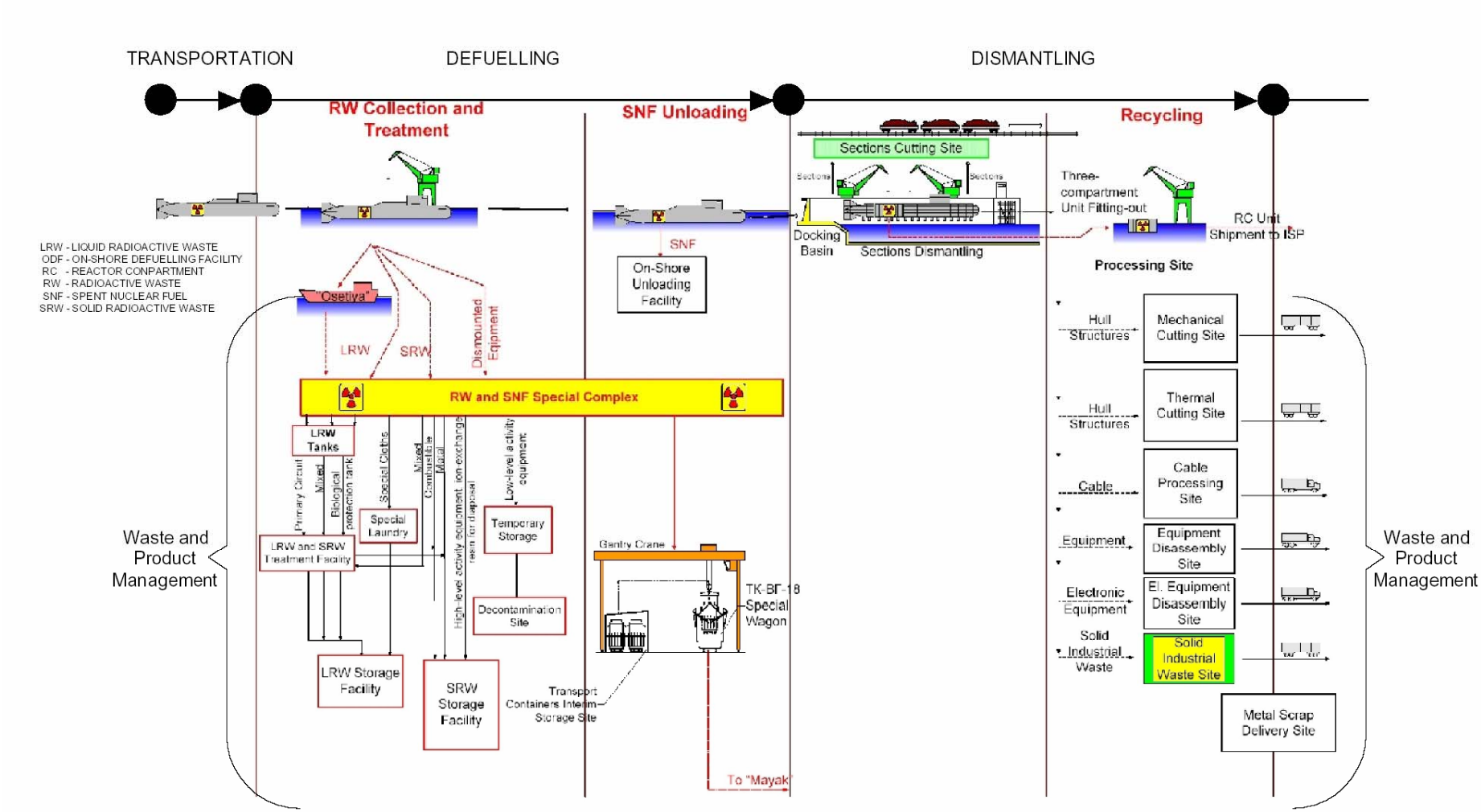
The dismantling project encompasses a chain of activities beginning with the preparation of a submarine for transport to Zvezdochka and ending with the salvage of uncontaminated materials,

shipment of SNF for reprocessing at the Mayak Chemical Combine ("Mayak"), and receipt of a reactor compartment at Saida Bay for long-term, secure management. Figure 3 presents the major aspects of the project schematically.

For the purposes of the EA, 13 project works and activities for the project are identified for the assessment of effects:

- **Preparation for Transit**, which includes crew training, draining and depressurizing systems in preparation for transport and the inspection and modification of a submarine to ensure buoyancy during towing;
- **Transportation of Submarine**, which includes towing of a submarine from its point of origin to Zvezdochka;
- **Arrival and Acceptance**, which includes mooring of a submarine at Zvezdochka;
- **Preparations for Reactor Defuelling**, which includes removal of flammable materials and some radioactive waste from a submarine and metal work in preparation for bringing crane-borne defuelling tools to the reactor;
- **Reactor Defuelling**, which includes opening reactor lid, removing SNF from the reactor and transferring the fuel to specially-designed transport containers;
- **Management of Spent Fuel**, which includes loading special rail cars with filled transport containers to transport SNF by rail to the reprocessing facility at Mayak in the Southern Urals;
- **Preparation for Submarine Dismantlement**, which includes moving the defuelled submarine to either the docking basin (and its slipways) or to a floating dock, final clean-out of the submarine and preparation for major cutting and disassembly;
- **Construction of Three-Compartment Unit**, which includes cutting out the reactor compartment and one compartment to either side to create a seaworthy package containing the remaining radioactive components of the submarine;
- **Dismantlement of Fore & Aft Compartments**, which includes processing the submarine components remaining after formation of the three-compartment unit;
- **Preparation of Reactor Compartment for Transportation**, which includes outfitting the three-compartment unit for towing;
- **Transportation of Reactor Compartment**, which includes towing the three-compartment unit from Zvezdochka to Saida Bay, near Murmansk, for long-term management;
- **Management of Radioactive Wastes**, which includes the processing of radioactive wastes by existing facilities at Zvezdochka; and
- **Management of Non-Radioactive Wastes & Products**, which includes the processing of non-radioactive wastes and saleable products by existing facilities at Zvezdochka.

Figure 3: Schematic of Major Aspects of the Project



In addition, the Screening Report describes two accident categories:

- **Conventional Accidents**, which includes representative accidents with a reasonable probability of occurrence which do not result in a release of radioactivity (sinking, fire, spill of hazardous liquid); and
- **Nuclear Accidents**, which includes representative accidents with a reasonable probability of occurrence which do result in a release of radioactivity.

Existing Environment

The existing environment is described by focusing on areas where there are known or likely effects of the project. The spatial boundaries of EA study encompass the city of Severodvinsk, Kola Peninsula and adjacent areas of the Barents Sea and White Sea (see Figure 1) and the existing environment is described for this area. The existing environment is described in detail for the local study area, shown on Figure 4, and includes a description of the conditions with respect to the six environmental components defined for the EA study, as follows:

- **Radiation** (represents environmental radiation and radioactivity, including radionuclide emissions and doses to humans and biota). This includes five sub-components: radioactivity in air, radioactivity in water, dose to workers, dose to members of the public, and dose to biota.
- **Atmospheric Environment** (represents air quality with respect to non-radiological parameters, including noise, and considers meteorological and climatic conditions). This includes two subcomponents: air quality and noise.
- **Surface Water Resources** (represents surface water quality and conditions). This includes one subcomponent: water quality.
- **Aquatic and Terrestrial Ecology** (represents aquatic and terrestrial biota and habitat). This includes two subcomponents: aquatic habitat and biota, and terrestrial habitat and biota.
- **Geology and Hydrogeology** (represents soil and groundwater quality with respect to non-radioactive parameters, and considers geological and hydrogeological conditions). This includes two subcomponents: soil quality and groundwater quality.
- **Socio-Economic, Health and Cultural Considerations** (represents populations, economic base, services, communities, occupational and public health, land use, cultural and heritage resources, and traditional use of lands and resources by Aboriginal persons). This includes four subcomponents: occupational health, economic base, residents and communities and cultural and heritage resources.

Figure 4: Local Study Area

Assessment of Project-Related Effects under Normal Conditions

An initial screening of each of the project works and activities is carried out individually for the six environmental components and their subcomponents. A total of 208 possibilities for project interfaces with the environment are evaluated.

The results of the initial screening are summarized on a matrix that identifies 155 potential interactions between the project and the environment. A second screening step evaluates each of the identified potential interactions to determine which of them are likely to result in a measurable change in the environment, compared with existing conditions. A total of 65 interactions between the project works and activities and the environment resulting in possible measurable change are identified for detailed assessment. These include radiation doses to

workers and releases to the atmospheric environment as well as a number of effects from the identified representative malfunctions and accidents.

The likely effects associated with each of these 65 measurable changes are considered and mitigation measures to eliminate, reduce or control any adverse effects are identified.

The detailed assessment identifies no residual adverse effects once mitigation is applied. Fifteen positive effects are identified, including sustaining high-skill employment at Zvezdochka and reducing real and perceived risks related to the out-of-service submarines.

Assessment of the Effects of Potential Malfunctions and Accidents

Twenty-four possible conventional accident scenarios and sixteen nuclear accident scenarios are screened to identify conservative, representative accident types for detailed assessment with respect to each of the six environmental components.

Detailed assessments of nuclear and conventional accidents are carried out for:

- Submarine sinkings;
- Fires; and
- Large spills.

Changes in the environment are determined to be local and temporary. Detailed analysis shows that, taking into account mitigation measures, representative accidents, both nuclear and non-nuclear, are unlikely to lead to residual adverse effects.

Uncontrolled criticality in SNF is shown to have a probability of less than one in a million per decommissioned submarine because of multiple safeguards against its occurrence and a dearth of possibilities for initiation.

Assessment of the Effects of the Environment on the Project

Just as the project has an effect on the environment, the environment may have effects on the project. The project comprises sea transport of seaworthy vessels along well-established sea routes and dismantling at an existing, experienced facility. Many mitigating factors are included in the project that address natural hazards. The project is subject to an environment management plan, a towing plan, and safety analyses as well as an extensive framework of Russian and international regulations.

Screening and assessment of the possible interactions between the project and ice, extreme weather, tsunami, storm surge, biota and earthquake show that the environment is unlikely to have an adverse effect on the project when mitigation measures are considered.

Assessment of Cumulative Effects

Other projects and activities with the potential to create similar effects as the dismantling project in the same effective area and timeframe are identified. Overall shipyard environmental performance is considered.

As no significant residual adverse effects are anticipated from the project, no residual adverse cumulative effects are predicted. Monitoring of environmental media is expected to continue as part of research and regulatory oversight in the region. It is anticipated that cumulative effects would detected through monitoring of environmental media, allowing modification of the project and/or remediation.

Public and Stakeholder Consultation

Throughout the EA, FAC carried out a focussed consultation program using multiple means to solicit input and engagement from stakeholders.

An initial press release and backgrounder was issued to the media, including wire services, on August 4th 2004. FAC maintains a website for the dismantling project, at http://www.dfait-maeci.gc.ca/foreign_policy/global_partnership/submarine-en.asp (English) and http://www.dfait-maeci.gc.ca/foreign_policy/global_partnership/submarine-fr.asp (French).

On August 23, 2004, FAC also distributed an initial notification letter (Foreign Affairs Canada Document 4025-03/SOW3) to potentially interested stakeholders, ensuring that they were aware of the EA. The letter also confirmed FAC's commitment to disseminating copies of the Final EA Screening Report.

Follow-up Program

A follow-up program is identified to assist in determining if the direct and cumulative effects of the project are as predicted in the EA. Follow-up will also confirm whether identified mitigation measures are effective and, thus, determine if new mitigation strategies are required.

As a condition of Canadian financial assistance for dismantling, FAC is requiring that a comprehensive environmental management plan be implemented at Zvezdochka. The plan will conform to accepted international norms and standards (ISO 14001).

EA follow-up requirements will be incorporated into a formal Environmental Management Plan. FAC will verify implementation through required shipyard reporting and periodic inspections by FAC personnel and contractors. Canadian financial assistance for dismantling, i.e., the dismantling project, is contingent on continuous demonstration of Zvezdochka's adherence to sound environmental practices and continuous improvement as documented in the Environmental Management Plan.

A preliminary list of required follow-up activities is identified and includes the following:

Focus	**Follow-Up Activity**
Workers/Public	Set up a system to automatically collate and analyse worker dose data and reduce the radiation exposure of workers by introducing the ALARA principle and removing the link between worker exposure and benefits
	Review training, emergency preparedness, emergency response plans, and worker medical monitoring data
	Verify appropriate workplace ventilation and PPE use

Focus	Follow-Up Activity
	Dissemination of risk analyses and project information to the public (to the degree allowed by security and commercial interests)
Air/Water	Identify the source of the tritium leak on site and implementation of measures to stop the leakage
	Confirm the implementation of best practices for handling volatiles at Zvezdochka and improvements in surface conditions in cutting areas
	Maximize mechanical cutting, as opposed to thermal cutting, in order to limit air emissions
	Verify air emissions control performance for ventilation systems and that there are negligible conventional contaminants in high pressure gas systems requiring venting
	Periodic review of air quality data to optimize monitoring efforts and target any necessary corrective actions, and discharged effluent and stormwater data to optimize monitoring efforts and target any necessary corrective actions
	Confirm that tug engines for towing activities are in good operating condition, to limit emissions
	Confirm the Russian commitment to expeditious recovery of sunken submarine if monitoring data warrants
Wastes	Review of procedures for collating waste inventory data
	Verify that there are plans for the long-term management and disposal of solid radioactive wastes and that appropriate waste management facilities and practices are used at facilities where submarines are prepared for transport (note that this information is available for Zvezdochka)
	Confirm planned improvements in containment and isolation of waste storage areas

Conclusion

Taking into account the findings of the assessment, including identified mitigation measures, it is FAC's conclusion that the project is not likely to result in any significant adverse effects on the environment. A planned follow-up program will confirm the validity of this conclusion. The lack of likely significant adverse effects is complemented by three key benefits from project implementation:

1. Transfer of highly-enriched SNF from a floating submarine to Russian fuel cycle facilities ashore, which ensures appropriate safeguards.
2. Removal of environmental risks associated with open-ended long-term storage of nuclear powered vessels afloat.
3. Provision of employment at Zvezdochka shipyard in Severodvinsk and in the locations in Murmansk region where the submarine will be prepared for towing.

With the completion of the EA, FAC proceeded with the implementation of the decommissioning project. Decommissioning of the first submarine was begun in late 2004 and is scheduled for completion by mid-2005.

Acknowledgements

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References

Foreign Affairs Canada. (2004). Environmental Assessment Screening Report for Nuclear Submarine Dismantling (Global Partnership Program), Project to Dismantle 12 Out-of-Service Nuclear Submarines. NSS Document Registry No. GC005/RP/003.