
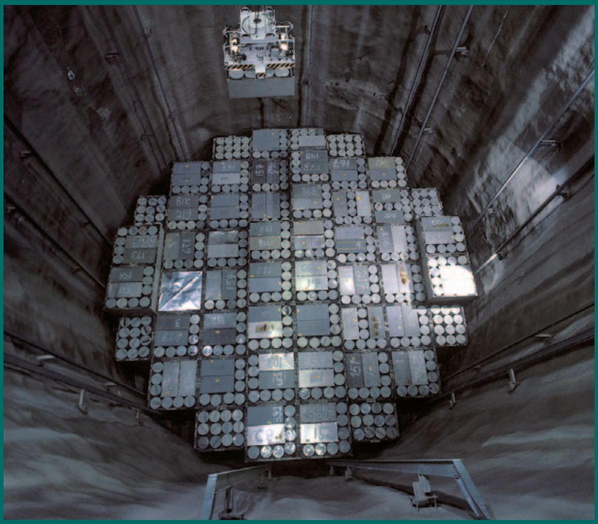

Nuclear waste management of the Olkiluoto and Loviisa power plants

Summary of the activities during 2010

Images in the cover demonstrate the construction work for maintenance waste hall 3 in Loviisa, waste silo of the repository for operating waste in Olkiluoto, construction work for Posiva's ventilation and hoist buildings and collecting aquatic vegetation samples in Olkiluoto.

Abstract

This report is a summary of nuclear waste management activities during 2010 for the Olkiluoto and Loviisa power plants. The summary includes a report of the status and actions of nuclear waste management by the power companies in 2010, as prescribed by the Nuclear Energy Act and Decree.

In 2000, the Government made a decision-in-principle regarding Posiva's application for final disposal of spent fuel in Olkiluoto, Eurajoki. In 2003, the Ministry of Trade and Industry decided that the construction license for the repository must be applied for by the end of 2012.

In 2010, the preparations for final disposal of spent fuel progressed in line with the TKS-2009 programme. The TKS-2009 programme contains an account of the planned actions related to nuclear waste management and their preparations during 2010–2012.

The expansion project for the spent fuel interim storage in Olkiluoto began in 2009, and a certain amount of site and construction work was carried out in 2010. At the end of 2010, the quantity of spent fuel in storage at the Olkiluoto power plant amounted to a total of 7,436 bundles containing an approximate total of 1,250 tonnes of uranium. At the same time, the quantity of spent fuel in storage at the Loviisa power plant amounted to a total of 4,153 bundles corresponding to an approximate quantity of 500 tonnes of fresh uranium.

Implementation planning for ONKALO has continued in parallel with the planning and design work for the repository so that, in the future, the underground research facility ONKALO can be annexed as part of the repository. Detailed plans for implementing the excavation of demonstration facilities in ONKALO were also prepared in 2010. The plans for the first stages of the ventilation and hoist buildings were also completed during the year, and construction work began in early 2010. During the year, the excavation of ONKALO progressed to chainage 4570. The bedrock quality has been good.

The EDZ09 project, divided into development of excavation techniques and testing of research methods, was implemented for the most part in 2009 with respect to research methods, and the results were analysed and reported in 2010. The EDZ09 project showed that the damaged zone caused by excavation can be controlled and that the ground penetrating radar method can be used to verify the physical dimension of the excavation damage from the bedrock surface.

The work carried out in the Olkiluoto survey site in 2010 included the drilling of two deep boreholes, the excavation of a short investigation trench and the cleaning of several places of exposed bedrock. During the year, six pilot holes of different lengths plus over 300 different research holes were drilled in ONKALO. During the year, research activities also began in all five Investigation niches excavated in ONKALO.

As in previous years, modelling of the Olkiluoto survey site is coordinated by the Olkiluoto Modelling Task Force, whose work involves interpretation and modelling work of the different research disciplines (geology, hydrogeology, geochemistry and rock mechanics), aimed at complementing the understanding of the site. During 2010, preparations began for Site Description 2011, a report that compiles the description of the site in a single document.

The long-term changes possibly caused by the construction of ONKALO are monitored using a special programme established for the purpose. The scope of the programme includes rock-mechanical, hydrological and hydro-chemical monitoring and the monitoring of the environment and foreign elements.

In 2010, the focus of planning and design work for both the encapsulation plant and the repository was on preparations for the construction licence application. The alternative where the encapsulation plant is linked to the repository through a canister shaft was chosen as the location for the encapsulation plant in Olkiluoto. The planning and design work for the repository has been carried out in cooperation with ONKALO as well as with the implementation planning for the ventilation and hoist buildings.

Posiva has produced a nuclear non-proliferation control manual that describes the nuclear non-proliferation control during the construction phase of ONKALO. In early 2010, the European Commission / Euratom issued a Material Balance Area Code for ONKALO, and international monitoring also officially began at that time.

The capabilities for implementing the bedrock facilities for the repository will be verified with the demonstration tunnels of ONKALO and with the implementation of deposition holes bored in them. The planning work for the implementation of demonstration facilities took place in 2010.

Regarding buffer bentonite, backfilling of the gap between buffer blocks and bedrock was studied in 2010. In addition, artificial wetting of the buffer was studied for the purpose of buffer design, and development work took place with respect to the humidity protection of buffers during installation as well as the structure of the deposition hole bottom. During 2010, a 1/3-scale buffer test was also constructed in ONKALO. The manufacture of buffer blocks was also

tested using different materials and manufacturing methods.

During 2010, the design work for the final disposal canister focussed on preparing a summary report on canister design work. The development work for canister manufacturing technology continued in cooperation with Svensk Kärnbränslehantering AB (SKB) of Sweden. During the year, different copper tube manufacturing methods were investigated and tested, and canister inserts for different fuel types were cast. Regarding canister sealing, the focus of development work for the electron beam welding method was on controlling residual stresses and on analysing the results of metallographic analyses made of the method optimisation tests. In canister weld inspections, Posiva and SKB were jointly concentrating on analysing the reliability of inspections, on developing surface inspection methods and on carrying out component inspections.

Several small-scale tests were carried out during 2010 as part of the studies on backfilling the deposition tunnels. The performance, size, shape and installation of pellets to be inserted between the deposition tunnel walls and backfill blocks were tested in cooperation with SKB. During the year, backfill block manufacturing tests were also carried out, and their installation techniques were developed using pre-assembled modules. The work related to closing the repository focussed on further specifying the closure plan.

One of the key objectives of producing the 2010 safety case was the preparatory work for a models and data report, a safety case summary report and a biosphere assessment report. The above reports were published in March 2010. In conjunction with the research on the performance of release barriers, Posiva cooperated with Finnish and foreign companies during the year and participated in several international projects. In biosphere-related work, the previous modelling round was reported in 2010. Preparations for the biosphere assessment for the construction licence phase also began during the year.

In parallel with the vertical disposal solution now constituting Posiva's reference solution, the horizontal disposal solution has been developed jointly with SKB. The Complementary studies of horizontal emplacement KBS-3H, a project established in 2008 for further development work on the horizontal disposal solution, was completed in 2010. The goal of the research phase now completed was to solve the problems identified during the earlier research phase and to prepare a plan for initiating the next phase.

In 2010, Posiva received the statements of the Ministry of Employment and the Economy and other parties, including the Radiation and Nuclear Safety Authority, regarding the TKS-2009 programme and preliminary construction licence documentation submitted in 2009. During the year now being reported, the Olkiluoto partial master plan, approved by the Municipality of Eurajoki in 2008, also became legally valid. In May 2010, the Government issued its decision-in-principle for an expansion of the spent nuclear fuel disposal facility to accommodate the fuel from the Olkiluoto 4 unit.

Posiva's management system was developed towards a process management model during 2010. In February 2010, the management system received a certificate based on environmental management standard ISO 14001:2004. The system underwent a periodic audit in October.

The well-established practical measures regarding operating waste from Olkiluoto and Loviisa were continued, as were the research and study projects on this subject. The total amount of operating waste accumulated at the Olkiluoto power plant by the end of 2010 was 6,534 m^3. Of the waste originating from Olkiluoto, 5,318 m^3 has been disposed of in the VLJ Repository in Olkiluoto. In October 2010, the construction work for maintenance waste repository hall 3 and the connecting tunnel began in the VLJ repository of Loviisa. The expansion will improve the interim storage capabilities for maintenance waste. The in-service studies on the Loviisa repository continued in 2010 in line with the monitoring programme. Of the waste originating from Loviisa, 1,658 m^3 has been disposed of in the VLJ Repository in Hästholmen.

A revised estimate was produced during 2010 regarding the cost of demolishing the non-active plant parts and buildings in Olkiluoto. During the year, work was also done in cutting into pieces used control rods from OL1 and OL2. The stem sections were taken to the VLJ repository and the blade parts to the spent fuel interim storage to wait for decommissioning. In Loviisa, the preparation of a risk assessment for decommissioning as well as the preparation of a decommissioning plan as a project were investigated in 2010.

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Introduction

Responsibilities and obligations

There are two companies using nuclear power to generate electricity in Finland: Teollisuuden Voima Oyj (TVO) and Fortum Power and Heat Oy (Fortum). According to the Nuclear Energy Act, TVO and Fortum are responsible for all procedures related to the maintenance of the waste they produce, and their appropriate preparation and related expenses.

According to the Nuclear Energy Act, the Ministry of Employment and the Economy (abbreviated as TEM in Finnish) decides on the principles to be followed in nuclear waste management. These principles were presented by the Ministry of Trade and Industry (abbreviated as KTM in Finnish; its duties are now looked after by TEM) in its decisions of 19 March 1991, 26 September 1995 and 23 October 2003, and these decisions form the basis for both the practical implementation of nuclear waste management and the R&D work concerning future operations.

Posiva Oy (Posiva) is a company jointly owned by TVO and Fortum. It is in charge of R&D work aimed at the final disposal of spent nuclear fuel as well as the construction and operation of the disposal facility at a later stage. TVO and Fortum will separately take care of all operations related to the handling and final disposal of low- and intermediate-level operating waste and the decommissioning of power plants.

Posiva is also responsible for producing the annual report on nuclear waste management operations at the Olkiluoto and Loviisa nuclear power plants. This is the report on operations in 2010; it contains the report required by the Nuclear Energy Act and Decree on the status of nuclear waste management at the said power companies in 2010.

Teollisuuden Voima Oyj has two boiling water reactors in Olkiluoto, Eurajoki. Olkiluoto 1 (OL1) was first connected to the national grid in September 1978, followed by Olkiluoto 2 (OL2) in February 1980. In 2010, the utilisation rate of OL1 was 91.8 % while that of OL2 was 95.2 %. The operating licences for the OL1 and OL2 power plant units and the low-level waste storage (MAJ storage), intermediate-level waste storage (KAJ storage) and interim spent fuel storage (KPA storage) are valid until the end of 2018. The operating licence for the Olkiluoto repository for operating waste (VLJ Repository) is valid until the end of 2051. TVO's third NPP unit, Olkiluoto 3 (OL3), is also under construction, and preparatory work for the next plant project, Olkiluoto 4 (OL4), began in 2010 in line with the decision-in-principle received in 2010.

During the year now being reported, OL1 underwent the most extensive annual maintenance in its history. Extensive modernisation work was among the most important operations during the maintenance outage. OL2 was due for a short refuelling outage. The rated power output of OL2 is 860 MWe, and the modifications carried out during the annual maintenance increased the rated power output of OL1 to 885 MWe.

The Loviisa power plant of Fortum Power and Heat Oy has two pressurized water reactors, both with a rated output of 488 MWe. The commercial operation of Loviisa 1 (LO1) began in May 1977, and that of Loviisa 2 (LO2) in January 1981. In 2010, the utilisation rate of LO1 was 93.1 % while that of LO2 was 89.1 %. LO1 had a short annual maintenance outage while LO2 had an extensive annual maintenance outage that is carried out every eight years. The operating licences for the LO1 and LO2 plant units and for their nuclear fuel and nuclear waste management facilities are valid until the end of 2027 for LO1 and until the end of 2030 for LO2. The operating licence for the operating waste repository (VLJ Repository) is valid until the end of 2055.

Schedules for disposal operations

In compliance with the Nuclear Energy Act and decisions of KTM, preparations are made for disposing of all spent fuel currently held at the Olkiluoto and Loviisa plants inside the Finnish bedrock. In its decision of 23 October 2003, KTM changed the schedule of preparations for the disposal of spent fuel so that the preliminary reports and plans required for the construction licence application for the disposal facility must be submitted in 2009. The final reports and plans must be available by the end of 2012 together with the application. The final disposal operations are scheduled to commence in 2020. Before that, the interim storage of spent fuel takes place on the power plant sites.

In December 2000, the Government made a decision-in-principle regarding Posiva's application for final disposal of spent fuel in Olkiluoto, Eurajoki. Parliament ratified the decision almost unanimously in May 2001. The decision-in-principle remains valid until 17 May 2016.

The decision-in-principle concerning Finland's fifth nuclear power plant unit (OL3) was made in 2002. At the same time, a decision-in-principle concerning the construction of the repository for spent nuclear fuel as an expanded facility was made so that spent fuel from OL3 can also be disposed of in the repository. The nuclear waste management obligation of the OL3 plant unit only begins when the plant is operational.

The preparations for final disposal of spent nuclear fuel will progress during 2010–2011 in line with the TKS-2009 programme published in September 2009.

Present status of storage operations

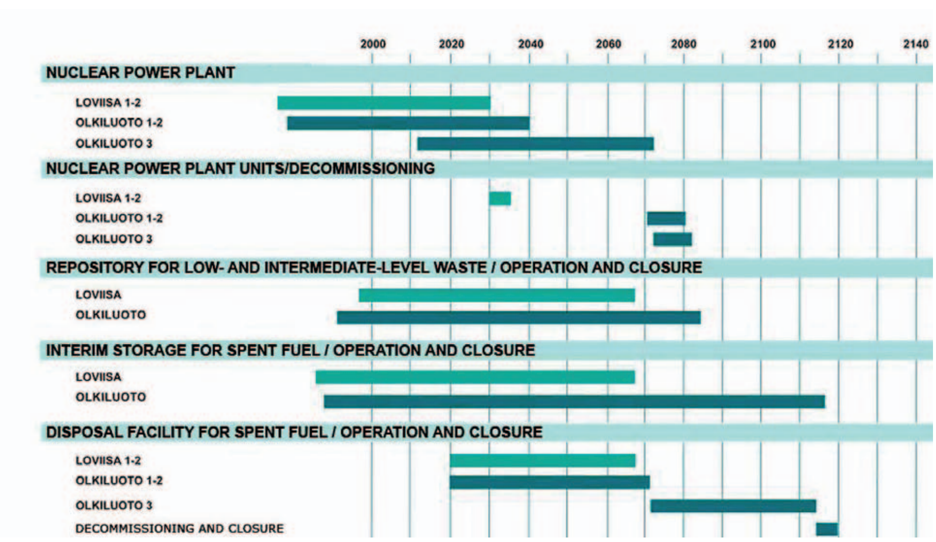
The fuel spent in Olkiluoto is temporarily stored in the power plant units and in the interim spent fuel storage (KPA storage) at the power plant site. The KPA storage facility can currently accommodate the spent fuel of approximately 30 years worth of production at the OL1 and OL2 units.

The KPA storage expansion project began in 2009. The site and construction work is scheduled for 2010–2013 so that the extension could be commissioned in early 2014. The bases of the expansion work are the exhaustion of storage capacity at the OL1 and OL2 plant units as well as the future needs of OL3. Three pools will be constructed in the expansion project. A new pool must be in operation for the OL1 and OL2 plant units in 2014, while the OL3 unit is expected to need its first pool in 2018. The expansion project is implemented as a structural alteration project of a nuclear facility. The OL1/OL2 operating licence has ample capacity for storing the fuel from these units. The permission for expanding the capacity and for storing fuel to accommodate for the needs of OL3 will be applied for in connection with the operating licence application for OL3.

During the year being reported, the 31st refuelling operation took place at OL1 and the 29th at OL2. At the end of the year, the quantity of spent fuel in storage amounted to a total of 7,436 bundles containing an approximate total of 1,250 tonnes of uranium. Of all the bundles in storage, 6,556 were placed in the KPA storage, 446 in the water pools of OL1 and 434 at OL2. Additionally, 500 assemblies were in use in the OL1 reactor, with another 500 in use in the OL2 reactor. The figures are inclusive of fuel placed in fuel rod racks (one per plant) used for the storage of damaged fuel rods (a total of 38 rods at the end of 2010).

Spent fuel produced in Loviisa is also stored at the power plant and in the interim spent fuel storages. New spent fuel storage pools were last constructed at the Loviisa site in 2000. A decision has been made to equip the current pools with high-density racks. This will provide additional capacity until 2020 when the transportation of spent fuel for disposal is expected to start. Two new racks were procured in both 2007 and 2009. Two more racks will be procured in each of the years 2011, 2015 and 2017.

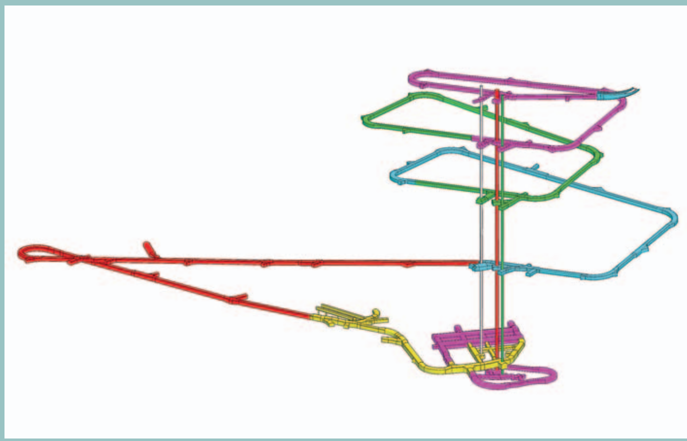
At the end of 2010, the quantity of spent fuel in storage at the Loviisa power plant amounted to a total of 4,153 bundles corresponding to an approximate quantity of 500 tonnes of fresh uranium. Of that number, 270 assemblies were stored at LO1 and 197 at LO2. Spent fuel storages 1 and 2 held 480 and 3,206 bundles, respectively. Additionally, 313 assemblies were in use in the LO1 reactor, with another 313 in use in the LO2 reactor.



Overall time schedule for nuclear waste management.

ONKALO

ONKALO, the underground research facility, provides accurate information for the detailed planning of repository facilities and for assessing the safety and construction engineering solutions. ONKALO allows for the testing of disposal techniques in actual conditions. The construction licence application for ONKALO was submitted to the Municipality of Eurajoki in May 2003, and the construction work began in June 2004. The construction phase now in progress has advanced to the final disposal level of -420 m. Two separate research tunnels will also be excavated at this level for studying the actual final disposal operation and its associated procedures. The technical facilities required for final disposal operations will be at level -437 m, and consequently, excavation work will continue to that level. Research has been conducted in ONKALO since the beginning of its construction.



Design work

Implementation design for ONKALO has continued in parallel with the planning and design work for the repository so that based on the solutions presented in implementation plans the underground research facility ONKALO can be annexed as part of the repository. During 2010, minor further specifications were made to the implementation plans for ONKALO on the basis of more detailed bedrock models. The biggest change from the 2009 layout for ONKALO is shifting the demonstration facilities from a west-east orientation to a NW-SE orientation.

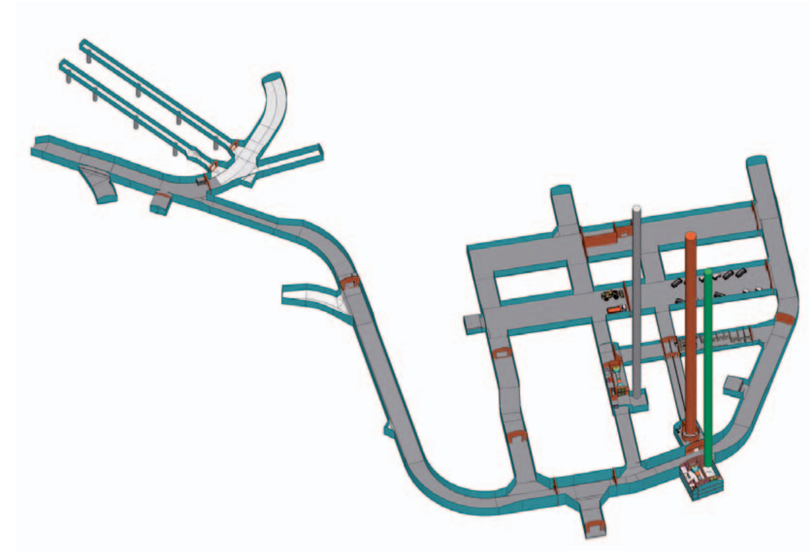
Implementation design has produced part of the plans for implementing the technical level structures that were further specified in 2010 to detail level. The prepared plans include the implementation plans for the concrete walls and floors as well as gallery structures to be constructed in ONKALO.

Detailed plans for implementing the excavation of demonstration facilities were also prepared during 2010. According to these plans, the demonstration facilities will be implemented using the same methods as the final deposition tunnels. The more detailed excavation plans for the technical level were submitted to the Radiation and Nuclear Safety Authority (STUK) for preliminary inspection after which they could be released for implementation of excavation work in the areas.

In implementation design, the plans for the first implementation stages of the ventilation and hoist buildings were also completed in 2010. The construction work for the first stages of the ventilation and hoist buildings began in early 2010. The initial utilisation of these buildings for the ONKALO stage has been taken into account in their design and planning. Later on, the buildings will serve the ventilation and personnel traffic needs of the repository.

Construction

During the year, the excavation of the access tunnel for ONKALO advanced to chainage 4570. The chainage number corresponds to the length of the access



2010 plan for the technical and demonstration facilities of ONKALO.

tunnel in metres. The personnel and ventilation shafts had already been bored to level -290 m, and preparations for raise boring were made during 2010 to the level of -437 m.

The bedrock quality has been quite good, and there has been little need for sealing fractures in it. During the year, the rock facilities were systematically reinforced using both bolts and the spraying of fibre-reinforced concrete. This is done in order to ensure appropriate strength properties in spite of increased stresses in the bedrock, among other things.

The HPAC and electrical work for the access tunnel progressed as planned and reached approximately chainage 3900 at the end of the year. There were no significant quality deviations or environmental damage during the year. The communication of construction work progress to public authorities has continued in compliance with what has been agreed.

Development of construction methods

The EDZ (Excavation Damage Zone) is one of the relevant factors when assessing the long-term safety of the bedrock surfaces in the underground repository. Posiva has implemented different EDZ-related research and development projects (such as the EDZ300 project) even before the excavation of ONKALO began, and also during the excavation work. In the EDZ09 programme, control of the excavation damage zone by developing the boring-blasting method was studied, and geophysical research methods were applied to test the suitability of ground-penetrating radar for verifying the formed fracture zone. The research phase of the EDZ09 project was mainly implemented in 2009, and the results were analysed and reported in 2010.

The EDZ09 programme was divided into two parts as follows: Work Package 1 (WP1) concerned the development of excavation methods, while Work Package 2 (WP2) concentrated on testing the research methods. The research programme did not include any assessment of the impact of the verified zone on the long-term safety of ONKALO. The research work was carried out in the EDZ tunnel (Investigation niche 3, ONK-TKU-3620), produced by the excavation work undertaken in WP1.

WP1 was responsible for having the technical plans drawn up, for excavation work planning, actual excavation work and the associated compliance assessment of operations and quality. Excavation work was carried out deploying two main concepts, by using combination charges of emulsion explosives and cartridges, and by using only cartridge-type explosives. The purpose of this approach was to compare excavation results as well as the differences in the impacts on excavation damage between the two concepts. The goal of the Work Package was to identify the critical factors which affect the success of the excavation process and which can be controlled to keep the extent of the fracture zone within the planned limits. The Work Package also included a separate mission of developing the calculation methods for predicting the creation of fracture zones. For this mission, an agreement was concluded with Swebrec, a Swedish research institute, because it has done a large amount of related research and development work. The significance of the results of the Work Package is emphasized because the control of creation and verification of fracture zones in the bedrock is based on the control and monitored verification of the production method and practices. Checklists and follow-up lists were created for controlling the work processes and for ensuring the traceability of results.

In WP2, investigations were carried out for assessing the excavation damage zone. The investigations involved borehole measurements before and after tunnel excavation, as well as borehole and surface measurements in the tunnel after excavation. The investigations carried out before excavating the EDZ tunnel served to determine the so-called baseline condition (undisturbed situation before excavation) of the surrounding bedrock (outside the planned tunnel profile), while the investigations after the excavation work served to establish the excavation-induced changes in measured parameters. Measurement results from boreholes and tunnel surfaces were compared with the petrophysical samples obtained from the core samples of holes bored in the floor of the EDZ niche.

Measurements made using a GPR (Ground-Penetrating Radar) formed an essential part of the research activities of WP2. GPR measurements were taken in the tunnel floor on 41 measurement lines that were 40 metres long and 10 cm apart. Measurements were taken at 1 cm intervals. Eleven lines on top of each other on the tunnel walls in the same location as the boreholes running parallel to the tunnel were measured for the entire tunnel length at 10 cm intervals. GPR measurements were also carried out at the end wall of the tunnel where 19 vertical lines, each 1.5 m long, were measured. These lines were also placed 10 cm apart from each other. Dispersion profiles were calculated using the GPR results. The results were also converted into 3D models by matching the measurement lines with the contour of the tunnel surfaces by utilising laser scanning results.

The differences in measurement results obtained before and after excavation were compared for the remaining stretches of borehole sections. The comparison shows how the measured parameters in the studied scale and angle changed as a result of excavation work. The differences in seismic measurement results provide a direct indication of excavation impacts. When comparing GPR results with other methods, it can be seen that the results have a good correlation, although there are certain differences due to differing electrical and acoustic parameters and measurement geometries.

The water loss and interference tests made in the area before excavation indicate that transmissivity (T) values were very small ($1.5 \cdot 10^{-12}$–$5 \cdot 10^{-12}$ m^2/s), and that hydraulic connections between the measurement holes did not exist. The measurements taken after excavation work indicate that excavation-induced fractures with small transmissivity values (10^{-12}–10^{-8} m^2/s) had been created. It can be said in conclusion regarding the results of the EDZ09 programme that EDZ could be controlled when implementing underground facilities provided that the excavation work proceeds in line with the plans made. The results also indicate that the GPR method can be used to verify the physical dimension of the EDZ from bedrock surface.

Characteristics and suitability of the repository site

Description of the bedrock and surface environment in Olkiluoto

FIELD SURVEYS

Two new deep boreholes (OL-KR54 and OL-KR55) were drilled in the Olkiluoto survey site in summer 2010. The holes were drilled in the north-eastern part of the survey site, south of the Kornamaa Island. The holes were about 500 m and 1000 m deep, respectively. They will provide information on the characteristics of the bedrock and groundwater in the area. The research material obtained from the boreholes will be used as input data for models and in the repository design work. The geophysical measurements in the holes, as well as the descriptions of holes, were by and large completed during 2010.

In 2010, a short investigation trench (OL-TK18) was excavated near an old borehole (OL-KR2), and several places of exposed bedrock were cleaned in the eastern part of the survey site. They were mainly surveyed for the purpose of obtaining input data for structural interpretation of the Olkiluoto bedrock. The surveys will be reported during 2011.

The borehole surveys concentrated on the eastern part of Olkiluoto. In the spring, a charged body potential measurement was carried out to supplement earlier surveys. Its objective was to investigate the continuity of electrical conduits cut through by boreholes OL-KR49–OL-KR53. The measurement results were used for modelling several electricity-conducting zones that coincided with known fracture zones. The measurements also provided indications of a few so far unknown zones.

The hydrogeological studies concentrated on measuring the flow characteristics in the eastern area using both Posiva Flow Log (PFL) and Hydraulic Testing Unit (HTU) equipment. The HTU measurements concentrated on the depth range of 300–700 metres. Transverse flow measurements (PFL TRANS) were made both in deep boreholes and as monitoring measurements for the recharging test in short boreholes OL-PP66–OL-PP69. The purpose of charging test-related measurements is to investigate the impact of pumping on the natural flow field in the area. The results obtained from hydrogeological studies are used in hydrogeological modelling as background data for the hydrogeological structure model and flow models and for planning other studies, such as water sampling programmes.

Locations of boreholes OL-KR1–OL-KR55.

RESEARCH CONDUCTED IN ONKALO

By the end of 2010, 4,570 metres of research tunnel ONKALO had been excavated, and almost all of it had been geologically mapped. As in previous years, geological mapping work was done so that the first phase charting was carried out immediately after excavating each section. The more detailed second phase of mapping followed a little later after the excavation process. In addition to these phases, the mapping work included measuring the exact locations of long fractures and fracture zones using a tachymeter, systematic photography and rock sampling. After checking, the geological mapping results will be entered in the database, but they will also be reported in the so-called outcome reports that by the end of 2010 had been produced from the beginning of the tunnel up to 3,116 metres.

Exploratory drilling

During 2010, pilot holes ONK-PH12–ONK-PH17 were core drilled in ONKALO. Of these, holes PH12 (length 124 m, PL4092), PH13 (140 m, PL4201), PH14 (151 m, PL4314) and PH15 (116 m, PL4483) were drilled in the access tunnel, while 85-metre holes PH16 and PH17 were drilled in the DEMO tunnel. The excavation work was suspended for the duration of drilling the access tunnel pilot holes and carrying out the associated borehole studies. Normally, the pilot holes are subjected to geophysical measurements included in the standard regime, acoustic and optical imaging, flow differential measurement, water loss tests and water sampling.

In addition to the pilot holes, over 300 metres of different investigation holes were drilled in ONKALO. Four 4.5-metre long holes (with a diameter of 76 mm) and two holes with a diameter of 800 mm were drilled in Investigation niche 1 for a preliminary study regarding bentonite buffers. Fifteen holes (lengths 1–7 m) were drilled in Investigation niche 3 for POSE studies. Two holes related to HYDCO studies (each 25 m long), one hole for a micro-seismic station study (12 m) and one hole for REPRO studies (5 m) were drilled in Investigation niche 4. In addition to a 15-metre niche pilot, a 120-metre characterization hole travelling towards the DEMO tunnels was drilled in Investigation niche 5. During the year, only one groundwater station, ONK-PVA8 (18 m), was drilled for SURE studies in the loading niche at chainage 2935.

Drilling of a dia. 800 mm test hole in progress in Investigation niche 1.

Investigation niche and other studies

During the year, research activities also began in all five Investigation niches excavated for research purposes. In Investigation niche 1, a bentonite study (BENTO) was initiated. Its purpose was to determine the functionality of instruments (such as thermocouples, piezometers and hygrometers) in the prevailing conditions, to specify suitable methods and to make preparations for future demonstrations at final disposal depth. More EDZ studies were performed in Investigation niche 2, focussing on determining hydraulic connections.

Excavation continued in Investigation niche 3 for making the niche suitable for rock-mechanical studies. Several holes were drilled in the niche for verifying the quality of the bedrock and for instrumentation purposes. In addition, three major research holes were drilled from the tunnel for studying the spalling strength of the bedrock. The reinforcement work carried out late in the year had the effect of slowing down the study activities.

Investigation niche 4 (for hydrology) is located in ONKALO at chainage 3748. During 2010, a detailed hydrogeological study (HYDCO) was initiated in the niche with the objective of obtaining information of the small-scale hydrogeological properties (such as connections between water-conducting fractures) of the bedrock similar to that found at the final disposal depth. The first two boreholes associated with the study were drilled in Investigation niche 4 during the year. They were used for single-hole studies, and the other research activities included monitoring the possible connections between the two holes by monitoring the pressure in the first hole while the other hole was being drilled.

Investigation niche 5 was excavated at chainage 4219, and the preliminary studies were completed during the past year. The niche is waiting for the reinforcement work to be completed. Research will continue in all Investigation niches in 2011.

Hydrogeological studies were performed in ONKALO by taking, among other things, flow measurements (PFL) in pilot and characterisation holes as well as in shaft injection holes and groundwater stations. In late 2010, hydrogeological interaction tests between the pilot holes of DEMO tunnels (ONK-PH16 and 17) and charged body potential measurements were carried out.

Leakage water mapping and measurements were carried out at regular intervals as the tunnel progressed. Measuring weirs were utilised for leakage water measurements; they are used for metering the volumes of accumulated water as well as its chemical properties (pH, conductivity). Leakage waters in the shafts of ONKALO were also separately measured using collection chutes at the bottom of shaft sections.

Probe holes are bored in the tunnel profile at approximately 20-metre intervals. Measurements related to leakage water, water loss and flow rates, as well as water sampling are performed in the holes in accordance with separate plans. The flow rates of probe holes are measured manually if the hole output exceeds 30 ml/min. All flow measurement results obtained from ONKALO are utilised when producing a more detailed hydrogeological model of the Olkiluoto bedrock.

Rock-mechanical studies were also carried out during the year in the exhaust air shaft and access tunnel. The focus of these studies is on measuring the state of stress; these measurements were taken at four depths in the exhaust air shaft and in five points in the access tunnel. The results are used for further specifying the orientation and magnitude of the stress field in different parts of the tunnel.

MODELLING

The Olkiluoto Modelling Task Force (OMTF) coordinates the geo-scientific modelling work of the Olkiluoto survey area. The purpose of the work performed by OMTF is to produce a geological, hydrogeological, geochemical and rock-mechanical description of Olkiluoto. Each field of research has its own modelling team working under the OMTF. During 2010, preparations began for Site Description 2011, a report that compiles the description of the site in one document.

Geological and geophysical modelling

Version 2.0 of the geological model of Olkiluoto was completed in 2010. The model was reported as a working report. At the same time, the geological modelling work continued. The next version (2.1) will be included in Site Description 2011 where it is combined with the modelling results of other fields of research. Geological fracture network modelling was also carried out in 2010. Its purpose is to apply statistical methods to describe the characteristics of fracture formation in the Olkiluoto bedrock, such as its density, orientation and fracture lengths.

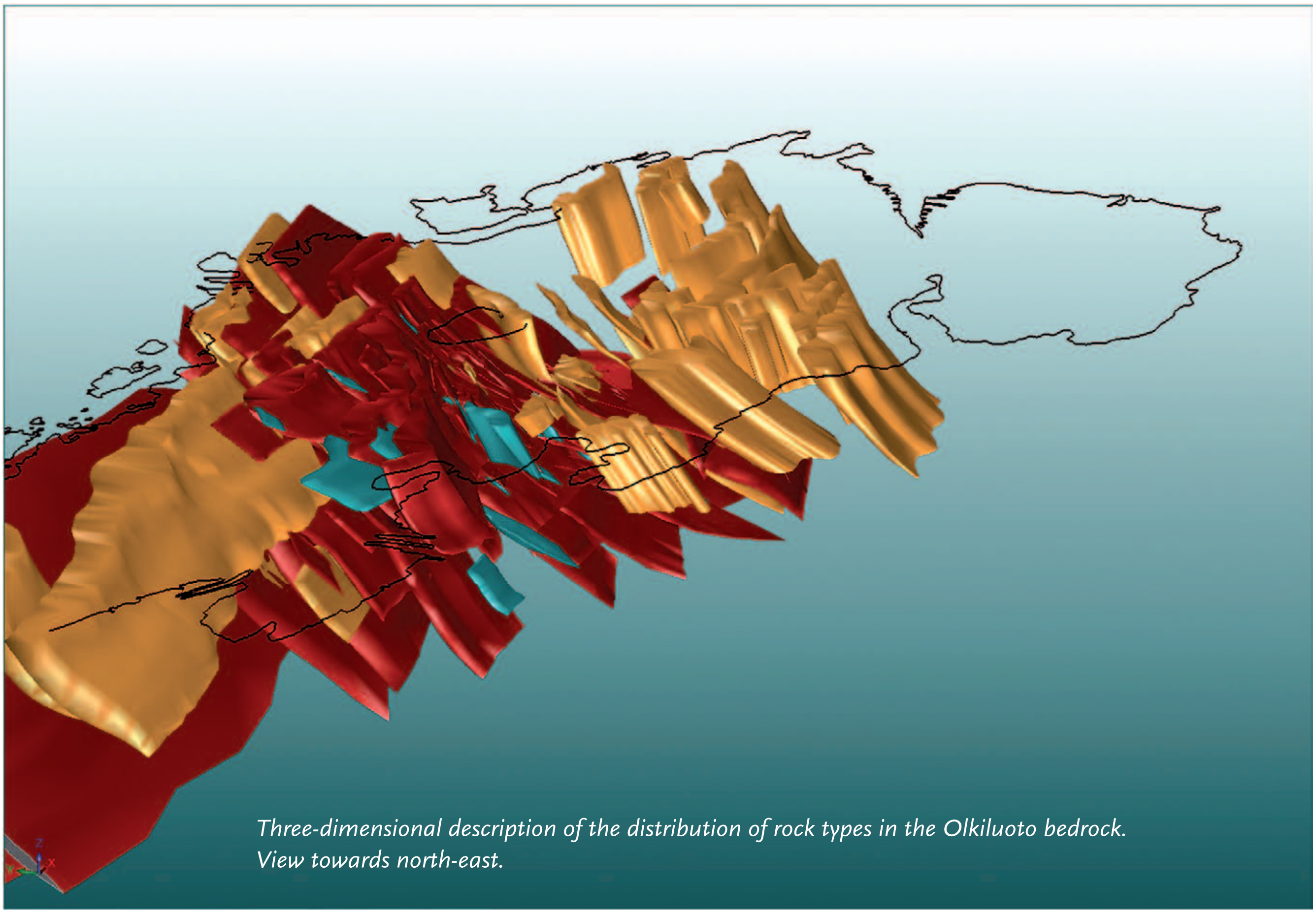
Geological modelling is further divided into partial models: the ductile deformation model, rock type model, alteration model, brittle deformation model and fracture network model. The purpose of the ductile deformation model is to present the history of plastic deformation in and the prevailing characteristics of the Olkiluoto bedrock. The most prominent of these texture characteristics is the foliation of the bedrock. Data on this orientation data, together with mapping results of exposed bedrock, bore core surveys and tunnel mapping, are also utilised for modelling the three-dimensional distribution of rock types in the Olkiluoto bedrock. When this is complemented with an understanding of the way different types of rock have been created, a comprehensive description of rock types, a lithological model, is produced. During 2010, further studies were carried out and interpretations were developed so that the present model versions of ductile deformation and rock types are more holistic than the previous ones and provide a better explanation of the history of the bedrock and the textural characteristics observed in it.

In 2010, a study on the metamorphic petrology, i.e. mainly on the development of pressure and temperature conditions in the bedrock was completed to assist in the interpretation of ductile deformation and lithology. The said development of pressure and temperature conditions is in turn linked to the creation of migmatitic rocks in Olkiluoto. At the time of the so-called peak of metamorphosis, some 1.8 billion years ago, the bedrock of Olkiluoto experienced a temperature of almost 700 °C and a pressure of 4 kbar.

The purpose of the alteration model is to use borehole data to produce a three-dimensional model of the hydrothermal metamorphosis observed in the bedrock. The current understanding is that the hydrothermal alteration of rocks in Olkiluoto was mainly created about 1.6 billion years ago as a result of penetration of rapakivi granite into the bedrock of the nearby areas. The current model version is more detailed than the previous ones, and the information on changes that have taken place in mineralogy and chemistry linked to the model is more accurate.

The brittle deformation model describes the geometry and other properties of brittle dislocation and fracture zones. It seems that the faults in the Olkiluoto area were originally so-called overthrow faults that were re-activated by later occurrences in the bedrock hundreds of millions of years ago. The new zones found in 2010 were described and previously found zones corrected on the basis of new research data. In addition, the brittle deformation modelling work involved an intensive dialogue with hydrogeological modelling.

The second version of fracture network modelling, the reporting of which was not quite completed in 2010, has for the first time been more clearly linked with other geological understanding. The fracture network model describes the statistical properties of fractures in the bedrock blocks of Olkiluoto and allows predicting the formation of fractures even in areas where no direct geological observations have been made. The blocks used for modelling are based on the so-called tectonic units of the ductile deformation model.



Three-dimensional description of the distribution of rock types in the Olkiluoto bedrock. View towards north-east.

In addition to actual geological observations, many geophysical methods and interpretations of material obtained with them were utilised for geological modelling. The results of charged body potential measurements and seismics, for example, were used for determining the connections and continuums of fault zones between boreholes and outside the survey site. The new materials allowed developing the geometric models of the zones and making them more accurate.

In addition to modelling describing the entire survey site in Olkiluoto, small-scale modelling was also performed in 2010. Modelling was performed for the DEMO facilities area to be excavated to an approximate depth of 400 metres. These premises will in many respects correspond to the repository, and they will be used for demonstrating many processes deployed in final disposal. Among other things, the rock suitability criteria will be applied and tested for studying the facilities. The purpose of detailed modelling is to produce a detailed geo-scientific description of a small area that can be used, for example, to make a suitability assessment with respect to fractures, dislocation zones and water leakages.

In 2010, the first reports and interpretations were produced regarding the high-resolution deep reflection seismic reflection imaging measurements (HIRE) carried in the area in 2008. The HIRE material is one of the important sets of geophysical material used for producing the three-dimensional description of the Olkiluoto bedrock.

Hydrogeological modelling

In 2010, surface hydrogeological modelling in Olkiluoto concentrated on assessing the impacts of ONKALO, on modelling the impacts of the recharge test and on paleo-hydrological simulation. For the purpose of assessing the impacts of ONKALO, short-period forecasts were also developed for groundwater level fluctuations; these forecasts are being regularly updated.

In 2010, a major exercise of updating the hydrogeological model was initiated with the aim of producing a site-specific model description of groundwater flows as part of the background material for the construction licence documentation. The hydrogeological structure model was updated in 2010 on the basis of new research material originating mainly from the eastern area.

Hydrogeological fracture network modelling work continued. The existing model was utilised, among other things, for analysing the requirements set for the acceptable fractures in the bedrock surrounding deposition tunnels and holes and for the leakage water flows in bedrock facilities. The study was reported as a working report.

Hydrogeochemical modelling

The hydro-geochemical modelling part of the Olkiluoto Site Description 2011 will need the support of certain background materials, and work in 2010 concentrated on producing them. The paleo-hydrogeochemical model describes the evolution of groundwater chemistry in the course of geological changes and climatic history. The model is based on a geological model, fracture mineral analyses, results from the pore waters of rock matrices and groundwater chemistry as well as on flow simulations. The paleo-hydrogeochemical model is also used for studying the flow behaviour of groundwater as a result of past environmental changes, and the results can also be utilised in future modelling work for the Safety Case.

The salinity model describes the current distribution of salinity in groundwater in the bedrock fracture network. The model is based on, besides the samples taken from groundwater, electrical conductivity measurements of groundwater in individual fractures that are used for calculating the total salinity of water. The salinity model also provides information on the movements of groundwater inside the bedrock.

Geo-microbiological studies on groundwater have been carried out in the Olkiluoto bedrock since the late 1990s. A summary of all material collected over a period of more than ten years has been compiled during 2010. In favourable chemical conditions, the microbes start and maintain oxidation-reduction processes. This allows using the data on the presence of microbial species to detect groundwater zones where all the oxygen, for example, is consumed from the infiltrating groundwater or where anaerobic redox processes are active.

Rock-mechanical modelling

The rock-mechanical modelling work initiated in 2009 continued by adding new research data to the earlier block model. In addition, combined modelling of state of stress and geological structures was also initiated. The purpose of this modelling work is to study, among other things, the effect of fracture zones on the orientation or magnitude of stress fields. The modelling work will be reported both in separate reports and in Site Description 2011.

BEDROCK CLASSIFICATION

The Rock Suitability Criteria (RSC) programme defines the criteria for classification of bedrock volumes suitable and unsuitable for disposal purposes. The first version of RSC was published in 2009, and work for developing the criteria continued in 2010. Particular attention was also paid to testing the criteria and to developing and practising the process used for host rock classification. The research data obtained from the access tunnel of ONKALO and the POSE Investigation niche (Investigation niche 3) were utilised for testing the criteria, and the results of these tests were then utilised for further development of the criteria.

In the later part of 2010, RSC work concentrated on the preliminary suitability classification of the rock volumes of DEMO tunnels to be excavated at disposal depth. In the classification work, particular use was made of the research data collected from the pilot holes drilled in locations of the planned tunnels. The classification work of DEMO facilities will continue in 2011 after the tunnels have been excavated. At that time, the bedrock volumes suitable and unsuitable for locations of the test canister holes to be drilled in the tunnels will be identified.

As part of the RSC development work in 2010, the groundwater impacts of ONKALO and the repository were numerically modelled. One question, for example, concerns the extent of the rising of the saline groundwater towards the planned repository facilities due to the bedrock construction work. The results indicate that the salinity of groundwater can in localised areas increase to rather high levels, particularly below the access tunnel and shafts because they will be kept open throughout the entire operating phase of the repository. There is less increase of salinity below the deposition tunnels because they are only kept open for a short period. Another important question concerns the expected water inflow in the deposition tunnels and holes. The results indicate that over 85% of the deposition holes are without a single bedrock fracture leaking water.

Olkiluoto monitoring programme

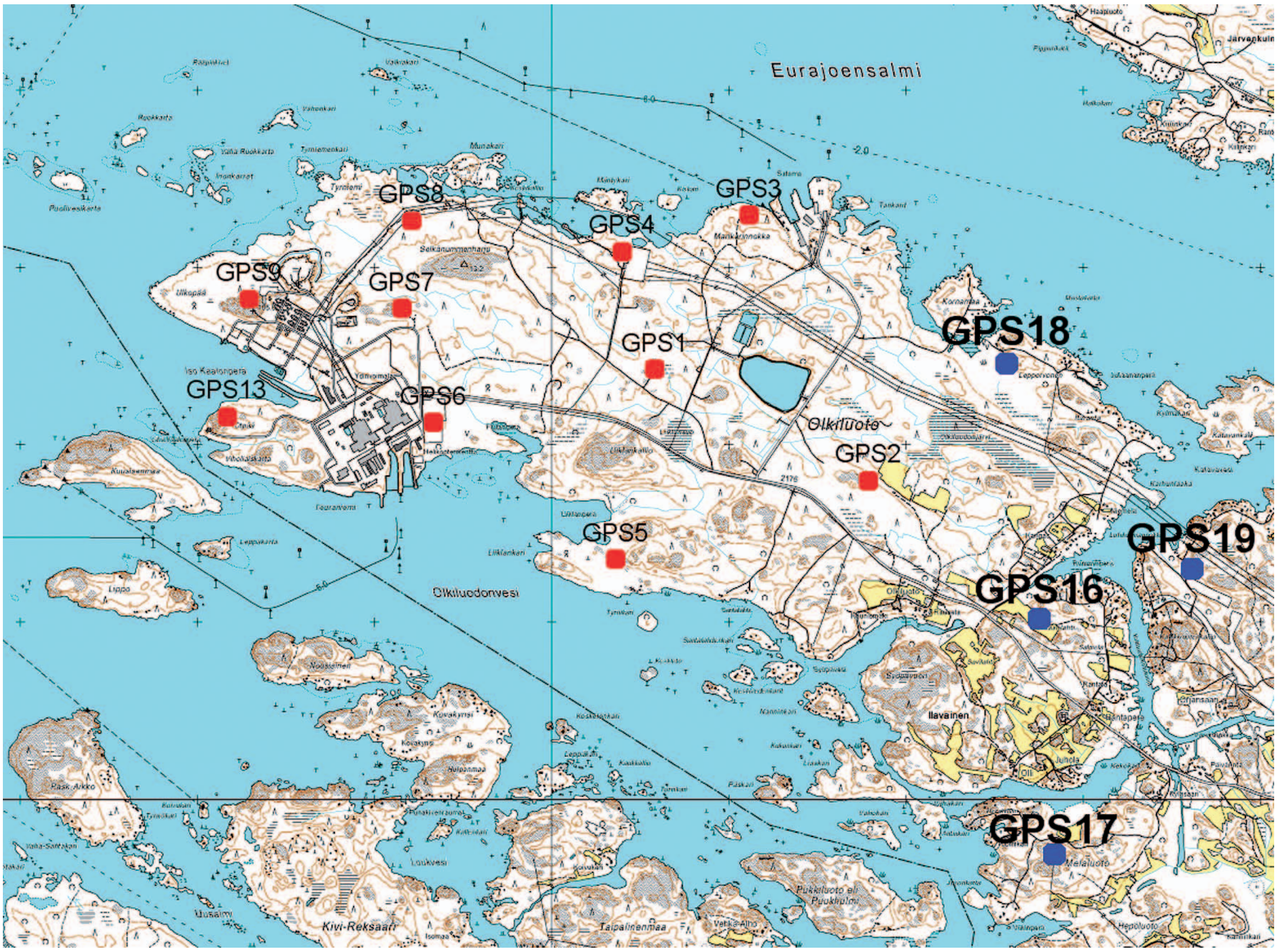
The long-term changes possibly caused by the construction of ONKALO are monitored using a special programme (OMO) established for the purpose (Posiva 2003–05). The scope of the programme includes rock-mechanical, hydrological and hydro-chemical monitoring and the monitoring of the environment and foreign materials. The results of monitoring studies are published separately for each field of research as part of the series of Posiva's working reports.

ROCK MECHANICS

In 2010, rock-mechanical monitoring continued as in previous years. Microseismic data was continuously analysed and monitored. Each year, the seismic station network detects over one thousand events, most of these explosions during the blasting work in ONKALO. The other seismic events are typically caused by construction work either above or below ground. The station network was developed in 2009 and 2010 by installing two underground metering stations in the ONKALO access tunnel at depth levels -280 m (ONK-OS1) and -370 m (ONK-OS2). In addition, four local stations were installed to support the rock-mechanical studies carried out in ONKALO's Investigation niche 3. They monitor any small bedrock movements possibly occurring during the test. The local stations are included in the station network albeit that they contribute little additional information to the monitoring programme.

GPS measurements in Olkiluoto and its surrounding area were taken in the spring and autumn as in previous years. Precision levelling of the fixed points in the bedrock was also performed in the vicinity of ONKALO and the VLJ Repository and across the Olkiluoto Straits. The purpose of these measurements was the same as that of the microseismic measurements, i.e. to further reinforce the opinion regarding the stability of the Olkiluoto bedrock and to assess the variations in the land uplift rate in Olkiluoto and its neighbouring areas. The expansion of the GPS station network began in 2010 with the construction of concrete fixture pillars for four new GPS measuring points. The actual antenna installation work will take place in 2011. Of the new points, two are located on Olkiluoto Island (GPS16 and GPS18) while two are located east of the island, in Melaluoto (GPS17) and Orjansaari (GPS19). The development work will both expand the observation area and improve the accuracy of observations.

Displacement measurements were carried out in ONKALO around Investigation niche 3 in conjunction with the expansion excavation work. Displacement measurements were made both using



Location of GPS station points in Olkiluoto and its immediate surroundings. Blue dots denote new stations GPS16–GPS19. Red dots denote the existing stations GPS1–GPS9 and GPS13 on Olkiluoto Island. The points GPS11 in Kuivalahti, GPS12 in Iso-Pyrekari, GPS14 in Hankkila and GPS15 in Haapasaari are also part of the network, but they are outside the area covered by the figure.

extensometers and as convergence measurements. The deformations taking place during the excavation work were very small and largely in line with the predictions. The measured deformations were less than 1 mm, whereas the predicted deformations were about 1 mm. On the basis of the experience and results obtained, similar measurements can also be carried out in the technical facilities area. The convergence measurements planned for the shaft areas of technical facilities were abandoned on the basis of earlier shaft measurement results. Deformations were also measured with strain gauges on the wall of a large research hole drilled in Investigation niche 3. The purpose of this exercise was to monitor the increase of stress in the pillar while another research hole was being drilled. The results obtained support the results of other measurements in the area and the interpretation of the state of stress.

HYDROLOGICAL FEATURES

Hydrological monitoring continued in 2010 mainly following the same programme as in 2009. The biggest change from previous years was in the change of focus from monitoring the flow conditions in boreholes to monitoring pressures.

Groundwater level observations were made in both shallow groundwater tubes and boreholes and in deep open boreholes using manual methods once a month. The monitoring of pressure heads took place using an automatic pressure monitoring network of multiple-plugged boreholes (GWMS). The supply of GWMS data by e-mail and its online monitoring operated in 2010 as planned, and at the end of the year, raw data transmissions were switched from e-mail to the POTTI system. The processing and analysis of data was further developed in 2010. The mathematical analysis of observation data was developed, inter alia, by taking into account the interference caused by natural fluctuations in groundwater (sea, tide, rainfall), by developing the automatic analysis of groundwater level decreases from time series and by establishing the correlation between seawater level and the observations with the objective of detecting any hydraulic connections to the sea.

By the end of 2010, a total of 24 deep boreholes had been fitted with multiple plugs and added to the monitoring network. During 2010, plugging devices were temporarily removed from holes OL-KR11 and OL-KR39, and the plugging of hole OL-KR44 was started. Plugging was also planned for hole OL-KR40. The need to increase the number of holes with plugs, expressed in R&D plan TKS-2006, was in the main filled during 2007 and 2008 when all deep boreholes located near ONKALO and penetrating major water-conducting structures were fitted with plugs. Increasing the number of plugged boreholes has significantly improved the accuracy of pressure monitoring and prevented the conveyance of pressures through open holes. Now geochemical observations also have indications of the positive effects of plugging related to the reduced mixing of waters from different water-conducting structures. The major water-conducting HZ20 structures were penetrated by the access tunnel in late 2008 and at the turn of 2008–2009. During 2009 and 2010, the same structures have often been penetrated by grouting holes in the shafts. The impacts of structure penetration-related leaks on groundwater pressure were monitored and analysed during 2010.

A quarterly memorandum was compiled during 2010 as planned, discussing the results of level and pressure head measurements and analysing the short-term impacts of other field events and ONKALO construction work on pressure heads.

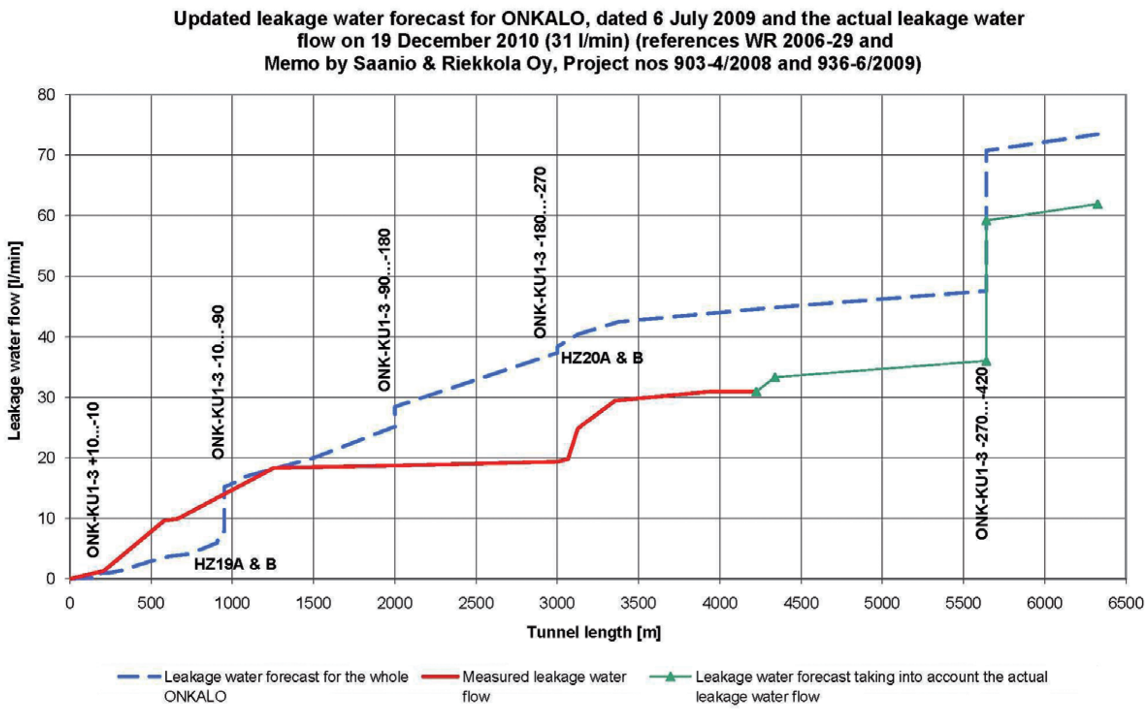
Furthermore, the following parameters were monitored in 2010: flow conditions (Posiva Flow Log) in open holes, water conductivity both in deep boreholes (Hydraulic Testing Unit) and short boreholes and groundwater pipes (SLUG method), the salinity of groundwater (conductivity), runoff surface water volumes, seawater levels and leakage waters in ONKALO. Transverse flow measurements have so far only been made in conjunction with site surveys. Of the parameters included in the hydrological monitoring programme, the runoff surface water volumes, rainfall (including snow), thickness of ground frost and leakage are reported in the annual environmental monitoring report.

The monitoring activities in ONKALO continued during 2010 with measurements of total leakage water volumes taken approximately every two weeks. The measurements are taken, as far as possible, for the entire length of the tunnel and from measuring weirs, the total number of which at the end of 2010 was eight (at chainages 208, 580, 1255, 1970, 3003, 3125 3356 and 3941). The HZ20 structures are located between measuring weirs 3125 and 3356. During 2010, the average total leakage water volume of ONKALO has been the same as in the previous year (33 l/min), because there were very few water-conducting fractures or structures in the access tunnel section excavated during 2010. A visual inspection of leakage water volumes covering the entire length of the tunnel was carried out twice in 2010 in order to identify the location of leaking fractures and zones and to monitor any changes taking place in them.

HYDRO-GEOCHEMISTRY

In 2010, the hydro-geochemical monitoring programme was, in the main, implemented in line with the sampling plans. The studies focussed on the state of and possible changes in deeper (> 500 m) groundwater characteristics. In addition to surveying deep groundwaters, the studies were also focussed on fractures and fracture zones with poor water conductivity.

The sampling results of 2010 indicate a high change in hydraulic gradient caused by ONKALO, and consequently, local changes in the salinity of groundwater could be observed in a few boreholes. The diluting effect of the Korvensuo basin on groundwater has been observed in particular in groundwater pipes and bore holes in its vicinity. The monitoring results will be reported in the autumn of 2011, and the plan is also to analyse the reasons for changes in that connection. The changes in groundwater composition



Result of leakage water measurement on 19 December 2010, 31 l/min up to ONKALO chainage 4225.

may have been caused by the construction of ONKALO or other construction works in the area.

Groundwater samples have been taken in ONKALO according to the programme, primarily from groundwater stations. Seven groundwater stations were regularly monitored during the year. Studies of groundwater chemistry and microbiology have been conducted on the groundwater stations. The composition of groundwater has remained the same in the areas near ONKALO.

The studies on the immediate impacts of ONKALO construction work continued with water sampling from fractures and fracture zones leaking water and from waters pumped from ONKALO. The construction of ONKALO, in particular shotcreting, causes from time to time considerably high pH values (10–12) in waters pumped from ONKALO. However, it has been found that the pH of water pumped from ONKALO neutralizes quickly in the sedimentation pool and the drain ditch leaving it, and no harmful effects on the environment have been observed.

THE ENVIRONMENT

The work of monitoring the ground level environment in Olkiluoto continued in 2010, primarily in line with the planned research programme. In addition to the regular studies, several campaign-style studies were carried out. In addition to the actual monitoring studies, other environmental studies were also conducted, as in previous years, among others for the purpose of describing the current state of the area.

The regular monitoring of the state of forests continued throughout the year on four intensive testing areas when the latest testing area was made fully operational. The research on the intensive testing areas includes observations on the vegetation, forest litter, root systems, microclimate, wet deposition and grove water.

The surface water sampling programme included, among other things, the runoff water from the dumping site of waste rock excavated from ONKALO, the four largest ditches near ONKALO as well as the Korvensuo basin and Olkiluoto's raw water inlet point in the Eurajoki River. The water levels and water quality in three privately-owned bored wells was also monitored. Samples of animal plankton were taken from the sea for the third year in a row for the purpose of supplementing the monitoring programme that TVO is obligated to operate.

A seasonal survey of game stock was conducted by interviewing local hunters. Posiva also participated in the nationwide archipelago birdlife monitoring programme on small islets and islands far out on the sea.

Outside the actual monitoring programme, samples were taken from the soil, shore vegetation and seabed fauna, and an extensive water sampling campaign was carried out in the surroundings of Olkiluoto Island on three occasions during different seasons of the year. The two-year study initiated in 2009 regarding the sedimentation conditions of the Eurajoensalmi straits continued with an observation programme on water quality, water movements and sediments carried to the water area by rivers.

The environmental surveys commissioned by TVO and other parties in the area were also monitored in addition to the above environmental studies carried out by Posiva.

FOREIGN MATERIALS

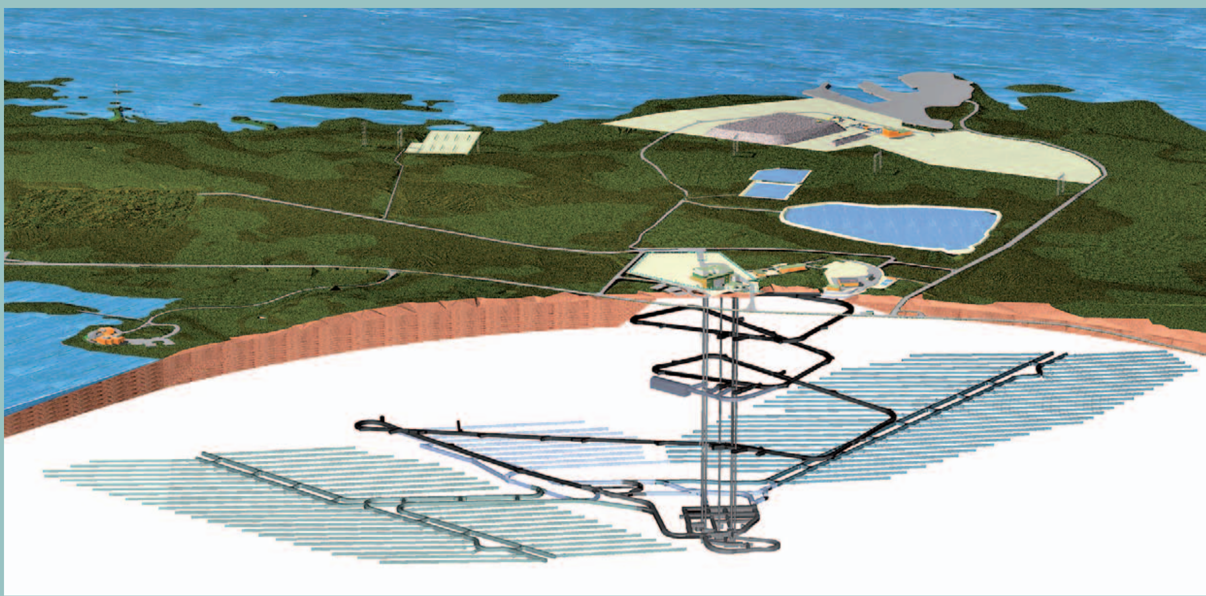
The monitoring and control of foreign materials is part of Posiva's monitoring programme. Foreign materials refer to all those materials and substances used for constructing ONKALO that are not part of the disposal system. Records were kept during 2010 of foreign materials, and the materials manual was updated with respect to the permitted (21 materials) and prohibited (7 materials) construction materials.

During 2010, the quantities of construction materials used were monitored in compliance with the agreed practice. The records submitted by contractors allow calculating the usage of cement both for grouting and for shotcreting. The quantities of explosives, paints and different metal bolts used in construction work are also monitored.

Water sampling from a deep borehole.

Plant design

The disposal facility consists of an encapsulation plant to be constructed at ground level, other auxiliary buildings and structures at ground level and the underground repository. The construction work for the disposal facility will begin when the construction licence has been granted. The operations of the facility are scheduled to start in 2020 after the operating licence has been granted.
The spent fuel brought from the interim storage is packaged into canisters in the encapsulation plant and transferred to the repository in a lift. The current plans involve excavation of the repository facilities on one level at -420 m. Access to the underground facilities is through the access tunnel and shafts. Deposition holes will be bored in the floors of the deposition tunnels for inserting the canisters. The canisters will be completely surrounded by bentonite blocks that will swell considerably when becoming water-saturated. The facilities will be expanded as the disposal operations progress by excavation of more deposition and central tunnels. The planning and design work for the disposal facility progresses in three-year periods.



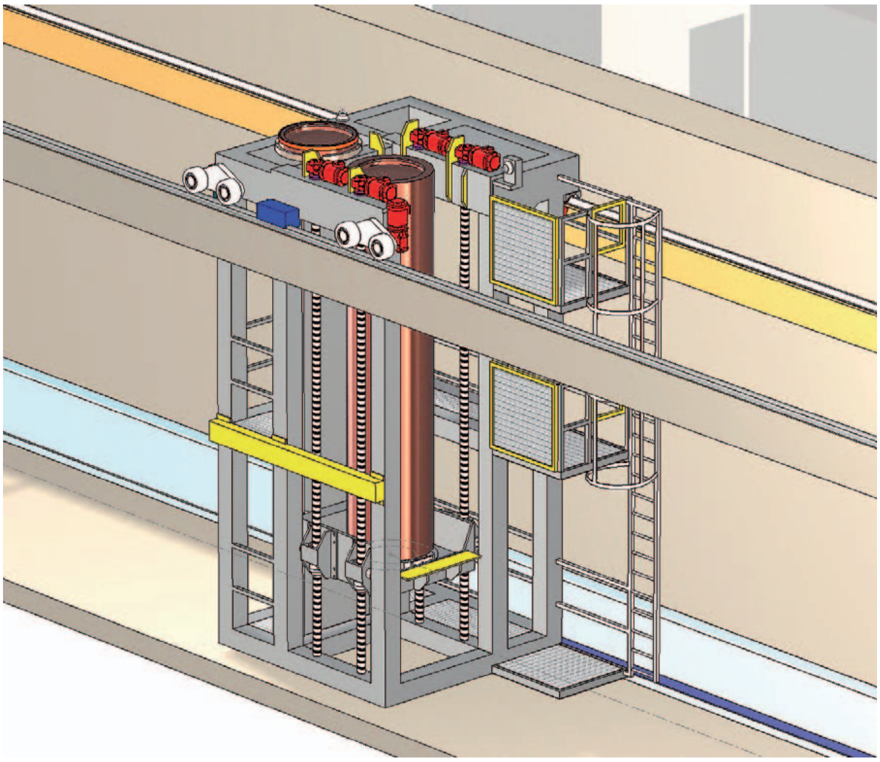
Encapsulation plant

The main focus of design work for the encapsulation plant has been on preparing for the construction licence application and in particular on producing the documentation to be submitted to the authorities in conjunction with the application. The system descriptions being produced will also be utilised later for defining the detailed design of the system.

The alternative where the encapsulation plant is linked to the repository through a canister shaft has been chosen as the location for the encapsulation plant in Olkiluoto. That was already the primary alternative during earlier planning stages.

An updated plan for the canister transfer trolley has been produced as part of the equipment design work for the encapsulation plant. The transfer trolley will be used to move the disposal canister inside the encapsulation plant along the canister transfer corridor between different stages of the encapsulation process. The updated plan includes further improvements regarding the operating reliability of the trolley, and the design has been taken to a more detailed level. The earlier plans regarding the canister welding station and inspection station were also taken into account in the update in order to ensure compatibility between different systems. The new plan will be used as the basis for the licensing documentation to be produced.

The plans for the equipment to be positioned in the transfer corridor were also analysed in conjunction with designing the transfer trolley. The canister top sampling and cleaning device and weld machining station are among the



The canister transfer trolley.

equipment placed in the corridor. The purpose of the sampling and cleaning device is to ensure that the top end of the canister that may have been contaminated in the fuel processing chamber can be cleaned of any contamination, thus preventing the spread of contamination to other parts of the encapsulation plant. At the weld machining station, the welded top of the canister is machined before inspecting the welding seam at the inspection station.

Repository

The focus of design work for the repository has also been on preparations for the construction licence application. The planning and design work for the repository has been carried out in close cooperation with the implementation planning of ONKALO and the ventilation and hoist buildings in order to ensure the compatibility and interoperability of facilities and systems.

The systems design for the repository has been developed with respect to the design of ventilation systems. The ventilation systems have been modelled and simulated using APROS software. With the model, the different operational states of the system can be viewed and the capacity of the system verified. The results obtained from modelling can also be utilised for planning the implementation of the system.

In addition to planning the operating activities of final disposal, a simulation model was created for simulating the operational activities of the repository throughout its planned service life. The model can be used, among other things, for analysing the impact of different steps of the work on the overall schedule and plant logistics. In addition, different alternative solutions regarding, for example, the expansion and closure of facilities can be compared. In the future, the intention is to use the model for more detailed operations planning.

Installation and transfer techniques

The planning of installation and transfer techniques includes the design work for the canister transfer and installation vehicle, buffer installation device and tunnel backfill installation rig.

The implementation planning for the prototype of the canister transfer and installation vehicle has been initiated. Implementation of the prototype has been divided in different phases. In the first phase, the focus is on the canister manipulation mechanism and in the latter phase, on the actual vehicle that the manipulation mechanism is to be attached to. The purpose of building the prototype is to verify the functionality of equipment design and fulfilment of the requirements regarding canister installation. The other equipment is at a preliminary design stage where their functions and requirements are being determined.

Control of nuclear materials and nuclear non-proliferation control

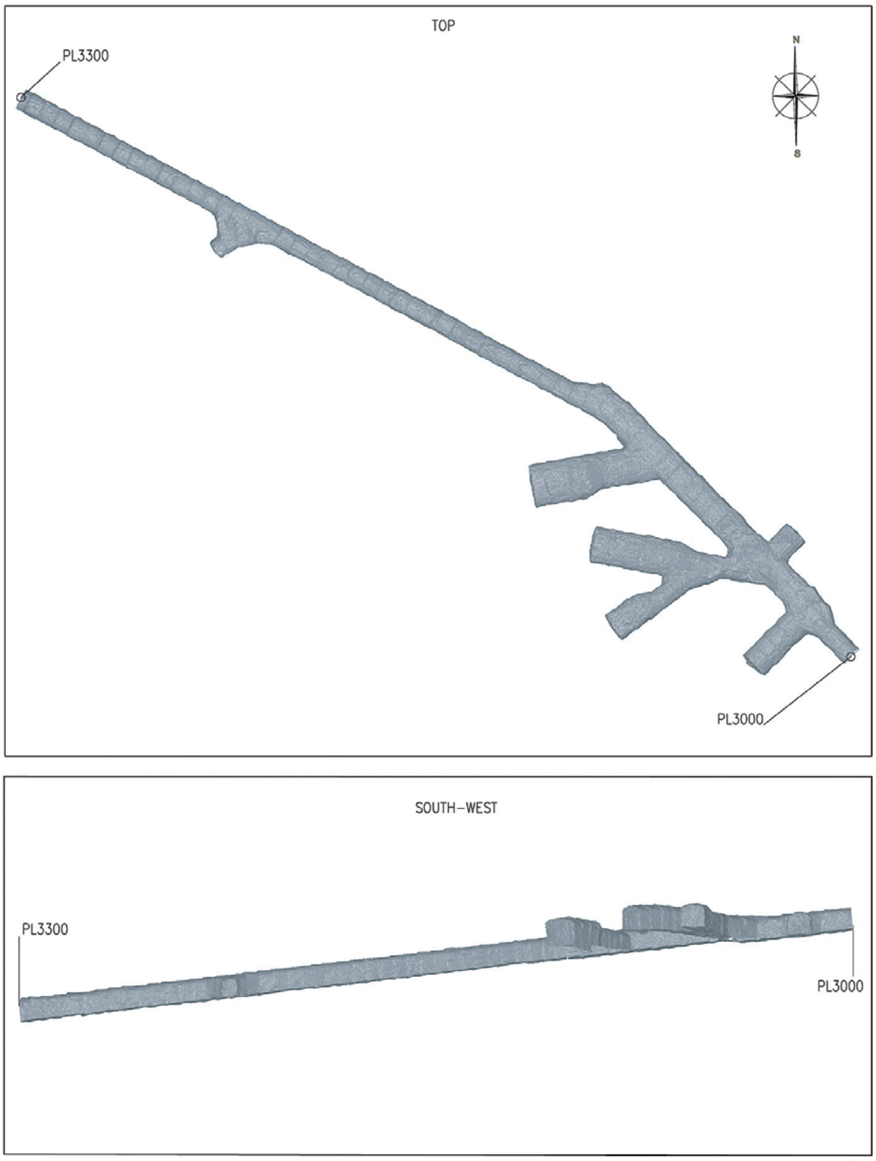
The purpose of nuclear non-proliferation control by Posiva is to ensure compliance with the relevant legislation and international treaties governing the matter during the construction phase of ONKALO.

Posiva has produced a nuclear non-proliferation control manual that describes the nuclear non-proliferation control during the construction phase of ONKALO. The nuclear non-proliferation control manual has been updated as required. The latest update took place in 2010. The manual defines the preliminary, actual and monitoring data concerning ONKALO that is reported three times a year to STUK. In addition, STUK carries out inspections, including the inspections of the ONKALO rock facilities and periodic inspections of the entire nuclear non-proliferation control system. During 2010, STUK performed three periodic inspections of nuclear non-proliferation control measures in ONKALO, plus one inspection of the entire nuclear non-proliferation control system. Representatives from the IAEA and Euratom participated in the inspections as observers. No objections concerning ONKALO nuclear non-proliferation control were raised in these inspections.

In February 2010, the European Commission / Euratom announced that it has, on the basis of a report by STUK, issued to ONKALO a Material Balance Area Code (MBA code) of which it has also notified the International Atomic Energy Agency (IAEA). The international monitoring began officially on 5 February 2010, and on 15 June 2010, the representatives of IAEA and Euratom carried out an unscheduled inspection pursuant to the Protocol Additional to the Safeguards Agreement (INFCIRC/193/Add.8: INFCIRC/193/Add.8: Complementary Access) in ONKALO. No objections were raised in this inspection.

The control and monitoring of excavation work in underground rock facilities is based on the requirement to demonstrate that ONKALO does not include any facilities which are not indicated in the design data. The control produces as-built images describing all excavation and construction work carried out in four-month periods. The as-built images are supplemented by beam measurement images showing all ONKALO contours with an accuracy of a few millimetres. The laser beam measurement images are produced in 300-metre sections.

Monitoring makes use of the micro-seismic station network built in Olkiluoto; the surveillance data of the network provides up-to-date information about blasting in Olkiluoto and in the nearby area.



Laser beam measurement image for chainage section 3 000 – 3 300. The report image is supplied in electronic form to allow the viewing of details.

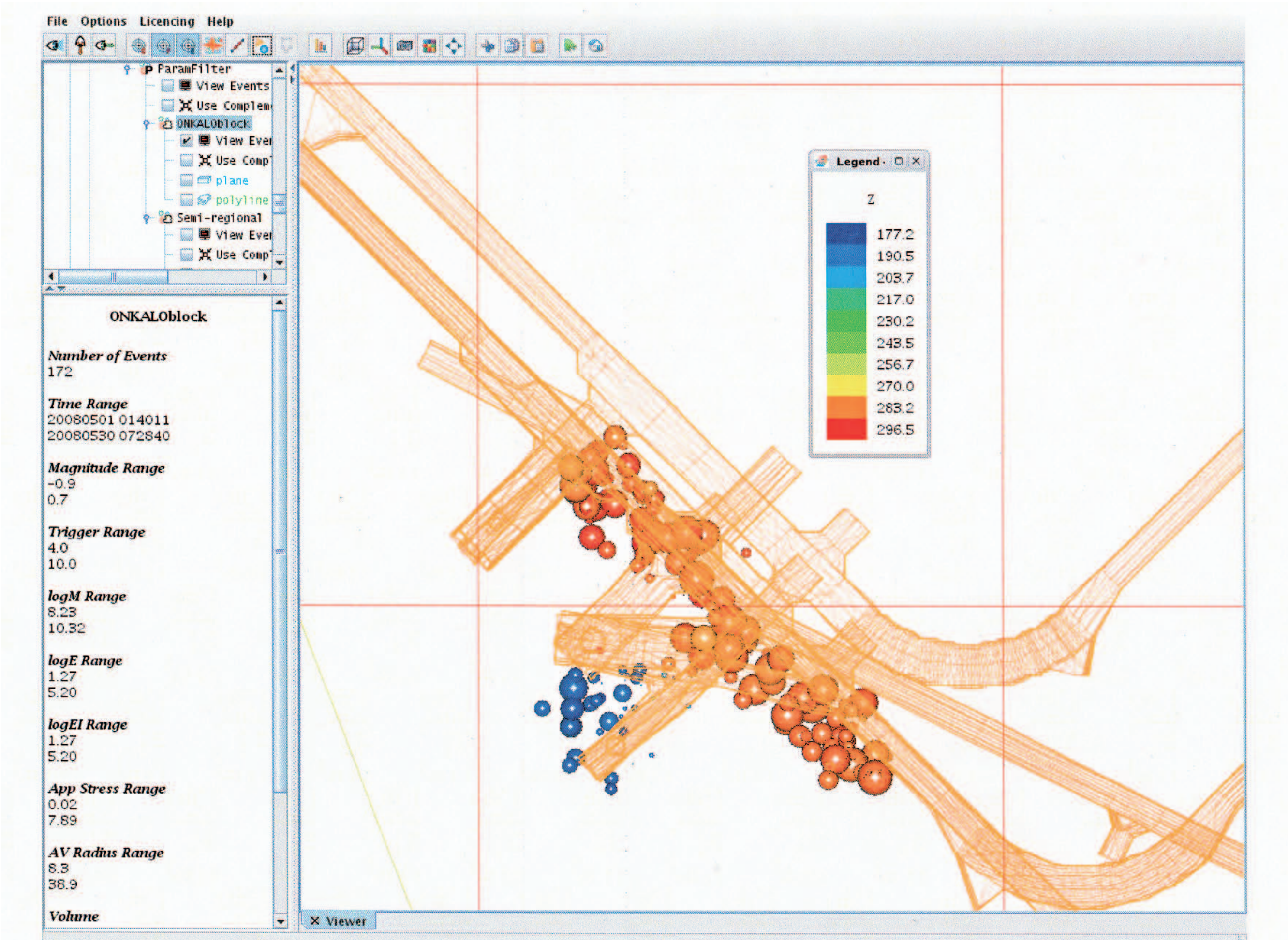


Image printout from micro-seismic monitoring. The spheres denote explosions, the colour indicates the depth. The computer image of ONKALO is shown in orange.

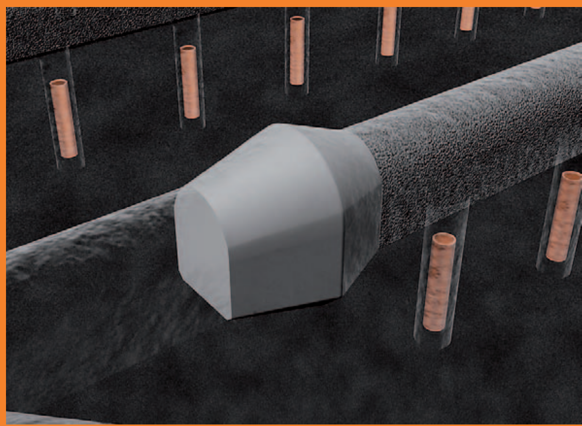
This system has proven to be a good, and so far the only, method available to date for monitoring the excavation operations from the outside.

The as-built and laser beam measurement images together with monthly reports for micro-seismic monitoring make up the quarterly interim reports for nuclear non-proliferation control.

Disposal system

The disposal solution designed for the spent fuel produced by TVO and Fortum is originally based on the KBS-3 solution developed by Svensk Kärnbränslehantering AB (SKB). The spent fuel bundles are inserted into copper-cast iron canisters and placed hundreds of metres deep inside the bedrock. Compressed bentonite blocks are placed in the deposition holes between the rock and the canister. When the disposal operations are finished, all excavated facilities and access routes to the repository are backfilled and sealed off.

The canister, bentonite and bedrock form a multi-barrier against the release of radioactive elements. The copper shell of the canister has excellent resistance against groundwater-induced corrosion, and the cast iron insert ensures mechanical durability. Bentonite restricts the access of groundwater to the canister surface and protects the canister from minor bedrock movements. The conditions surrounding the canister deep inside the bedrock will remain stable for long periods of time. The bedrock also protects the deposited fuel from external interference.



Underground openings

The Underground openings process of Posiva is deployed to produce preparedness for implementing the bedrock facilities of the repository. This is done by implementing the demonstration tunnels of ONKALO and the deposition holes bored in them. The time schedule for implementing the DEMO tunnels follows the overall schedule of Posiva and in particular the overall schedule of the ONKALO project that is aimed at submitting the construction licence application in 2012. The schedule also includes the agreed deadline targets for separate programmes, such as the RSC programme, with the aim of ensuring their realisation. The schedule of DEMO facilities is roughly divided so that the work was planned in 2010 and will be implemented and reported in 2011. The DEMO tunnels are excavated and constructed as part of the construction works of the ONKALO project.

The design of the DEMO facilities is based on the plans for ONKALO produced by plant design and on the layout plans for the future repository. The implementation planning began by collecting all necessary initial data related to the DEMO tunnels and their future usage. The initial data was primarily obtained from previously produced plan reports and other working reports as well as from the specified customer needs and requirements. The requirements were determined in compliance with Posiva's requirements management principles. Particular attention has been paid to long-term safety when producing the plans.

The plans for the demonstration area were drawn up in line with the agreed layout. It was ensured that the size of the area will meet the space requirements of future demonstrations and tests. It was ensured that sufficient and comprehensive research data are available for the area, and their possible influence on the orientation and layout of the facilities was assessed. The rock engineering plans were drawn up by taking into account the bedrock conditions; the plans cover the excavation work, grouting and reinforcement in accordance with the bedrock forecasts.

Before starting the excavation work, the implementation plans were reviewed and presented to all involved parties before the approval procedure. After the approval procedure, the plans were delivered to STUK for processing.

A rock classification method is being developed in the RSC programme. The method will be tested when the DEMO is being implemented. The method involves several steps, and its functionality and suitability for future disposal operations can be assessed during this work.

Buffer

The plans for the buffer have been further specified during the year. Different filling methods for the gaps between buffer blocks and bedrock using bentonite pellets and bentonite materials were studied in a separate project in 2010. The investigated filling methods included free gravity filling, spraying and vibration-assisted filling. This work produced information on suitable materials and filling methods for aiming at an optimal gap filling density. The results can be utilised for the buffer design work.

In addition, artificial wetting of the buffer was studied for the purpose of buffer design, and development work took place with respect to the humidity protection of buffers during installation as well as the structure of the deposition hole bottom.

During 2010, a 1/3-scale buffer test was also being constructed in ONKALO. For the test, two holes with a diameter of 800 mm and a depth of 3 metres were drilled in Investigation niche 1 (chainage 1475) in ONKALO. The buffer blocks for the test were made of MX-80 bentonite using isostatic compaction and the currently known design values. The canister used for the test is equipped and can be heated. The purpose of the test is to produce information for the planning and construction of a full-scale test. The test will begin in early 2011, and the plan is to keep up the test arrangement at least till the end of 2012.

Buffer block manufacturing tests were performed using different materials and a 75 % scale (both cylinders and rings were made). MX-80 sodium bentonite as well as IBECO RWC and Minelco calcium bentonites were used for materials. Good results have been obtained. The measured results indicate that the properties of blocks manufactured on a 75 % scale correspond to those of blocks made on a smaller scale. The manufactured blocks have homogenous density and humidity values, and the target densities can be easily achieved. The blocks are also sufficiently durable to withstand transportation, machining and installation. Parallel to the manufacture of large blocks, the manufacturing details have been developed on a smaller scale. At the same time, finishing of the manufactured blocks has been tested by machining them to target dimensions.

The uniaxial manufacturing technique for buffer blocks was developed during the year by manufacturing small-scale test blocks using different moulds. The purpose of this work was to increase the height-to-width ratio of the blocks. In addition, the impact of different lubricants on the desired properties was tested in the work. The results of the work have allowed defining ways of achieving the design goals. The obtained information can be utilised for further development of the manufacture of backfill blocks.

The joint LUCOEX project application by Posiva, SKB, ANDRA and NAGRA was submitted to the European Commission as part of the 2010 applications for the 7th framework programme. The project application was approved, and the project agreement has been signed. Posiva's part in this partially EU-funded project involves development work for the buffer block installation equipment.

Canister

DESIGN WORK

During 2010, the design work for the canister focussed on preparing a summary report entitled Structural Design of Disposal Canister. The draft report was completed at the end of the year. The design report contained a compilation of all factors affecting the design of canister types, the design requirements and the studies carried out for demonstrating the fulfilment of these requirements. The very cross-scientific background materials for the report have been prepared for several years. They consist of analyses of natural phenomena, theoretical modelling exercises and analyses, measurements, empirical tests, manufacturing exercises and material studies. The design report describes the entire life cycle of the canister from initial design requirements to the moment it is installed in the repository, and provides details of the canister properties for safety analysis. These details allow the safety analysis to predict the behaviour of the canister over a very long period of time.

The requirements, dimensioning analyses, manufacture and the verification of properties by demonstrations constitute a chain through which the canister's performance, qualitative and functional validation and the expected initial state at the time of disposal can all be established.

As part of the work for demonstrating the mechanical durability of the canister, analyses and material studies aimed at establishing the durability of the insert were carried out in cooperation with SKB during the period 2009–2010. This study package was completed and reported in SKB's report series in autumn 2010 (Design analysis report for the canister. SKB report TR-10-28. ISSN 1404-0344. 2010.).

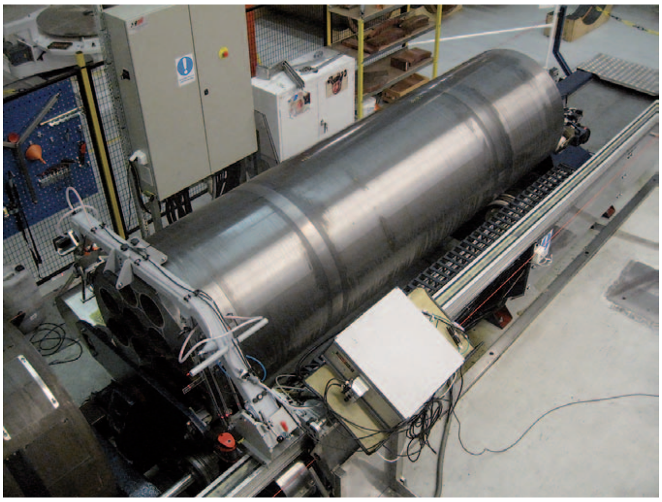
MANUFACTURING

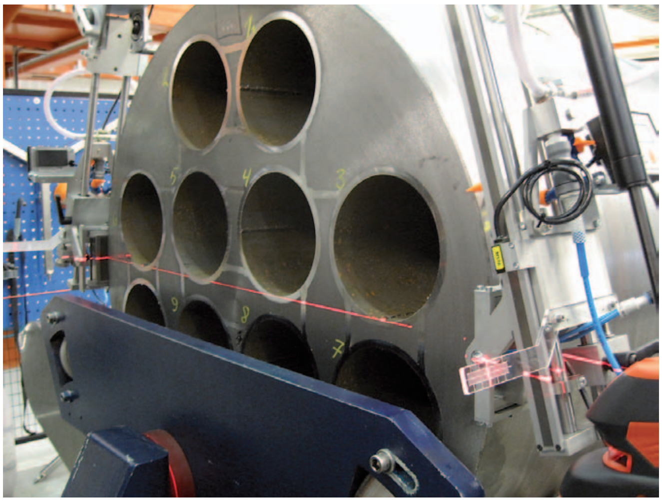
The development work for canister manufacturing techniques continued in cooperation with SKB. Two copper blanks were cast for copper tube manufacturing tests using the pierce and draw method. In connection with the casting work, the method for eddy current testing of surface properties and the casting approval criteria were developed. These activities will be presented in the canister component inspection report.

The purpose of the pierce and draw tests was to optimise the process, to gain manufacturing experience and to produce copper tube material compliant with the requirements for the welding tests. Both tubes were subjected to non-destructive tests at SKB's canister laboratory in Oskarshamn, Sweden. The results of mechanical tests, microstructure analyses and non-destructive tests will be reported in 2011.

During 2010, the copper tube extrusion process was modelled, and laboratory-scale extrusion tests were carried out on the basis of this modelling work. The aim was to produce a more homogenous crystalline structure for the tube. On the basis of the results obtained, two full-scale extrusion tests were carried out in Scotland in November 2010. The modelling and test results will be reported in 2011.

In Finland, one BWR canister insert designed for Olkiluoto fuel was cast in 2010. It fulfilled the requirements for mechanical properties. The channel set of the canister insert had become bent during the casting process, and molten iron had entered the channels, so the insert did not pass the channel set





Mechanised ultrasonic inspection of a VVER type insert using a penetration technique.

gauging test. The results of ultrasound inspection indicated that the fuel channels were acceptable at the top section of the insert, but the lower section had become indented during the casting process. The preliminary NDT results indicate that the cast insert has some internal casting defects, which nevertheless do not affect the acceptability of the canister insert. The outer surface fulfilled the acceptance criteria of visual inspection. The NDT results will be reported during 2011.

The first VVER canister insert designed for Loviisa fuel was cast in the same foundry in late September 2010. After machining, the insert still had some surface defects, and tension tests also revealed slag inclusions and gas pores, so the insert did not comply with the set requirements. The NDT inspection process was also developed for VVER inserts. The inspections revealed defect indications both on the surface and inside the insert. The quality of the VVER insert was also assessed by a visual inspection of the outer surface and the inner surfaces of channels. The development work for the VVER insert casting process will continue in collaboration with the foundry.

The PWR insert cast in Germany in April did not pass the gauging test of fuel channels, nor did it fulfil the requirements regarding mechanical properties.

One PWR insert was cast in Sweden in June, and the aim was to produce an insert that would fulfil the requirements regarding dimensions, straightness of channels, microstructure of casting and mechanical properties. The preliminary investigation results indicated that the cast insert met the requirements. The results will be reported during 2011.

SEALING

During 2010, the focus of development work for the electron beam welding (EBW) method was on controlling the residual stresses and on analysing the results of metallographic analyses made of the EBW method optimisation tests.

Earlier results indicated that the residual stresses were considerably higher than the yield strength of the copper material. This is why the studies on residual stresses were initiated for the purpose of investigating two areas: the effect of the welding process on residual stresses, on the one hand, and the effect of stress-relief annealing on the residual stresses, on the other. As a preliminary exercise, the Finite Element Method (FEM) was used to estimate the effect of material plasticization on the residual stress measurement results. The results indicate that the measurement method used gives residual stress values that are 15–20 % too high when the state of stress approaches the yield strength. The plasticity correction for residual stresses well beyond the yield strength could not be calculated using the FEM.

Another preliminary exercise involved recovery tests carried out for the purpose of estimating the stress-relieving annealing of welds at different temperatures. In nearly all cases, the stress level was reduced by about 30 % during the test. The results can be used for assessing the used stress relief annealing process.

The impacts of the welding and annealing processes on residual stresses have also been investigated using hole-drilling measurement methods. These results suggest that the level of residual stresses is significantly lower than the earlier results obtained with other methods indicated. The residual stress is now at the 40 MPa level, i.e. close to the yield strength of copper when earlier results were more than twice as high. The results suggest that so-called cosmetic welds substantially increase the stresses. The measurement of residual stresses on the inspected sheets using the so-called contour method is still in progress. The results of both measurement methods will be reported during 2011.

The Finite Element Method was earlier used for calculating the heat transfer in sheet welding test pieces during the welding process, and deformations and residual stresses were modelled in 2010 on the basis of these results. The early results of this modelling indicate that the residual stresses do not exceed the approximate level of 55 MPa; this is consistent with the hole drilling measurement results obtained in 2010. The modelling will produce unambiguous information on the effect of welding speed and power as well as cosmetic welds on the residual stresses. The FEM modelling results will be reported in early 2011.

Lid welds produced in the optimisation tests performed in previous years were inspected and analysed as part of the welding process development work. The Taguchi method of industrial test planning was used in the tests. The results of destructive tests indicate that the penetration of the weld can be easily adjusted and the variation of penetration depth can be significantly reduced, which improves the weld quality. These results were used together with the results from residual stress measurements as the basis when a lid weld was performed in December where the lid design, installation and omission of cosmetic weld were all aimed at achieving optimal weld parameters. The tests indicated that the lid can be installed without preheating, but the welding parameters will need some further adjustment to reduce the weld surface defects. The defects closest to the surface are eliminated from the final weld because the weld surface is machined smooth for NDT inspections.

One lid was welded in SKB's canister laboratory in Oskarshamn, Sweden, using the friction stir welding (FSW) method. The lid was then subjected to eddy current and ultrasonic (US) inspections in the same laboratory. No defect indications were detected in the weld.

A compilation report entitled Welding of the Lid and the Bottom of the Disposal Canister (Posiva 2010-05) was produced of the weld development work carried so far. The report contains a method description, a description of weld QA procedures, the requirements for welding and welds as well as the main results achieved by 2010 in weld development. The report also describes the alternative friction stir welding method and the results that SKB has achieved using it. The results indicate that both methods produce welds that meet the requirements.

INSPECTION WORK

The co-operation on inspection activities between SKB and Posiva continued in 2010. The cooperation concentrated on analysing the reliability of inspections, on developing surface inspection methods and on carrying out component inspections. The reliability analysis concentrates on assessing the component inspection results, on producing the Probability of Detection (POD) graphs illustrating the reliability and on assessing the influence of human factors.

The work for collecting the defect lists initiated earlier was continued for all canister components and welds. The defect lists are used for developing inspection procedures, for training inspectors and as support for the qualification of inspections.

The metallographic studies on defect indications detected using NDT methods was continued. The selection of defect indications observed in EBW welds will be completed in early 2011. The reliability of the NDT methods applied will be assessed, in part, on the basis of these results. This project will continue in 2011.

A total of four copper tubes, manufactured using the extrusion and pierce and draw methods, were inspected in 2010 by US and eddy current testing methods and visual inspections. The inspections revealed a few surface defects but no internal defects. The development work for eddy current techniques was concentrated on developing the analysis and defect size determination of defect indications observed in earlier NDT inspections.

Determination of the defect size is the key area for development in weld inspection techniques. The assessments of defect size determinations and their

Testing of the tunnel backfill operation.

inclusion in inspection programmes was initiated in 2010 for all inspection methods in use. A report entitled Inspection of Bottom and Lid Welds for Disposal Canisters (Posiva 2010-04) has been produced of weld inspection methods and of the results of development work in this area achieved so far.

The POD graphs showing the detection probability of defects in EBW welds were developed for US, eddy current and visual inspection methods. These results will be presented in the report entitled Probability of Detection of Posiva's Electron Beam Weld to be published in 2011. The project will be continued till the end of 2012 by updating the POD graphs on the basis of the latest results.

Inspection experience was gained by carrying out inspections on full-scale components. The defect indications observed in inspections on the inserts were studied using metallographic methods, and the studies will continue in 2011. Furthermore, a new sensor holder developed for the inspections of castings between the channels in the inserts was completed. The holder allows bringing the sensors used for penetration measurements as closely on the same spot as possible. The US sensors (transmitter-receiver) used for the measurement are placed on opposite sides of the outer surface of the insert 950 mm apart from each other.

Tunnel backfill

In 2010, through-flow tests were carried out for the selected backfill solution in 1/3-scale in a miniature tunnel made of concrete. The purpose of these tests was to observe the behaviour of materials immediately after installation by varying, among other things, the block materials, the salinity of water and the duration of the tests.

Half-scale tests were carried out in cooperation with SKB in a steel tunnel located in SKB's underground rock laboratory in Äspö. These tests have allowed studying the way in which different fracture conditions in the bedrock can affect the performance of the backfill after installation.

The geotechnical properties of backfill materials, such as water conductivity and swelling pressure, were studied in conditions that the backfill materials may be exposed to in the repository after for example permafrost-induced freezing, thawing or cracking.

The performance, size, shape and installation of pellets to be inserted between the deposition tunnel walls and backfill blocks are being tested in cooperation with SKB. The work started in 2010 and will be completed in early 2012.

The manufacture of backfill blocks was tested at the production plant, and the test results show that the industrial-scale production of backfill blocks is feasible. Due to production-related reasons, the size of the blocks has been smaller than the final size to be actually used, but there was no need to manufacture full-scale blocks at this stage.

The water leaking from the bedrock during the tunnel backfilling operation makes the operation more challenging. The even distribution of water and the importance of the pellet layer surrounding the backfill for the even distribution of water and its functioning were studied in cooperation with SKB in a project initiated in 2010. The results will be available in early 2012.

The installation of backfill blocks in pre-assembled modules was further developed, and to that end, an installation head design was created, paying particular attention to the operational reliability of the installation head and to the positioning of block modules.

The details of the plug to be placed at the mouth of the deposition tunnel were further specified. In addition to this, the plug materials and the performance of the plug are being further assessed, the requirements of the plug are being specified in closer detail, and the excavation methods used in the plug area are being developed in cooperation with SKB.

Closure of the repository

The work related to closing the repository focussed on further specifying the closure plan. The closure plan to be published in early 2011 will present the plan for closing down the facilities, based on the conditions at the site.

Posiva started planning work with SKB regarding the dismantling of the outer part of Prototype Repository, a full-scale disposal demonstration model located in Äspö. The purpose of the project is to study the interactions between the deposition tunnel plug, backfill, buffer and bedrock and to establish how they can be dismantled. The information thus gained will be utilised for planning the backfill and closure of the facilities, as support for assessing the performance of, for example, the backfill materials, and as a demonstration of the retrieval operation. The project is coordinated by SKB, and other nuclear waste organisations are also likely to participate in it.

The safety case and the production process

Plan for the production of evidence in support of the Safety Case

In keeping with the schedule confirmed by the Ministry of Trade and Industry in 2003, Posiva is making preparations for submitting its application for the construction licence for a disposal facility for spent nuclear fuel towards the end of 2012. In the licence application, the long-term safety of disposal is discussed as the so-called Safety Case. According to an internationally adopted definition, "Safety Case" refers to all the technical-scientific documentation, analyses, observations, tests and other evidence that are used to substantiate the safety of disposal and the reliability of the assessments thereof. The main reports included in the Safety Case and their foreseen schedule up to 2012 are shown in the Safety Case Plan 2008 (Posiva 2008-05).

One of the key objectives for 2010 was the preparation of a report on models and initial data, entitled Models and Data Report (Posiva 2010-01), the report entitled Interim Summary Report of the Safety Case – 2009 (Posiva 2010-02) and the report entitled Biosphere Assessment Report (Posiva 2010-03). The above reports were published in March 2010.

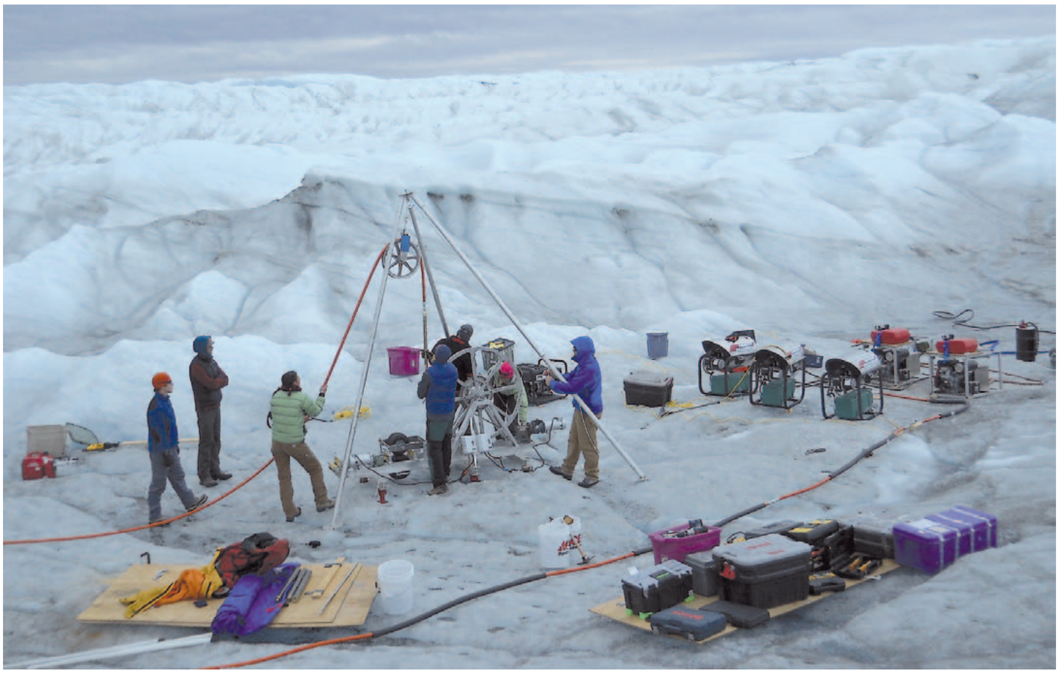
The report portfolio of the Safety Case and the schedule of reports were changed during 2010. The report entitled Features, Events and Processes (FEP) describes the FEP database and the process reports, and preparations for it continued in 2010. The report will be completed in 2011. The work for producing the Formulation of scenarios report also continued, preparations for the Supplementary analyses report was initiated in 2010, as were the preparations for the report entitled Description of Disposal System. These reports are scheduled for publication in 2012. A new report entitled Performance assessment was also added to the report portfolio of the Safety Case; preparations for this report were initiated in 2010.

The FEP report presents a description of significant features, events and processes and the interactions between them. The Formulation of scenarios report presents the systematic selection of sequences of events in the disposal site and the repository for scenario analysis. The Supplementary analyses report discusses natural and anthropogenic analogies, calculations made using simple methods as well as the observations regarding the geological history of the disposal site and other possible analyses in support of the Safety Case.

Performance of release barriers

EXTERNAL CONDITIONS

In 2009 Posiva started, in co-operation with SKB and NWMO of Canada, the three-year Greenland Analogy Project (GAP) with the main objective of establishing the effects of the ice sheet on the circulation and chemical properties of groundwater. The results of this project will be required for assessing the safety of disposal deploying the KBS-3 solution in ice age conditions. The results of this project will also help analyse the degree of realism in the existing ice age models and modelling of groundwater chemistry during an ice age. The main focus of studies conducted in 2010 was on the formation of melt waters from the glacier and their migration to the bottom of the glacier, as well as on groundwater sampling from the borehole drilled in 2009. The results of 2010 from fieldwork and analyses in the GAP project will be reported by September 2011.



Drilling of holes in the ice on the Issunguata Sermia glacier near Kanglerussuagi. Photo: Joel Harper.

Posiva is working with the Finnish Meteorological Institute on an update of the climatic scenario for Olkiluoto. The purpose of this update work is to assess the duration of cold periods (ice ages), i.e. the extent of their impacts in Olkiluoto on a time scale spanning 120,000 years. The update work also takes into account the probability of such cold periods occurring, as well as any warm periods that may occur. The material accumulated from the climatic scenarios will be utilised for the safety analysis studies concerning Olkiluoto, including the modelling of the formation of permafrost and the evolution of ground level hydrology, biosphere and groundwater deep inside the bedrock. A Posiva Working Report was completed on this work in 2011.

The GeoSatakunta project was a co-operation project with the objective of producing a model describing the structure of the Kokemäenjoki River and its estuary, maps of suitability for construction as well as information on brittle deformation in the Satakunta region. The project began in 2000 and continued in 2008 under the title InnoGeo. The concluding seminar of the project was organised in Pori in April 2009. The final report for the project will be published as part of the report series of the Geological Survey of Finland in early 2011.

SPENT FUEL

In 2010, Posiva joined the REDUPP (Reducing Uncertainty in Performance Prediction) project included in the 7th framework programme of the EU. The purpose of the project is to improve the understanding of how representative the results obtained in laboratory conditions are of the phenomena and processes taking place in final disposal conditions. In addition, Posiva initiated investigations regarding studies related to high fuel burn-up that may be required and will be carried out jointly with its owners and other nuclear waste organisations (SKB and Nagra).

Understanding the release processes of radionuclides is important to all national nuclear waste organisations planning the direct final disposal of waste. These organisations have jointly established the international Spent Fuel working group that meets at approximately eighteen-month intervals. In 2010, the meeting was held in Spain, and Posiva also attended.

CANISTER

During 2010, Posiva and SKB continued the studies regarding the corrosion of copper in water. The tests have sought to reproduce the results published by Hultquist and Szakálos in 2008. Stress corrosion tests on copper were also performed in 2010 for studying the effect of corrosion potential on the creation of stress corrosion. The work will be reported during 2011 as a Posiva Working Report.

The work for assessing the long-term safety implications of residual stresses possibly remaining in EB welds was continued in 2010. In addition, the copper creep tests initiated in 2006 still continued in 2010, and the first interim results will be reported in a Posiva Working Report in early 2011.

THE BUFFER, BACKFILLING AND CLOSURE OF THE REPOSITORY

The studies on buffer behaviour and processes assumed to be detrimental will produce estimates of the compliance of technical solutions with the requirements as well as initial data for future safety assessments and development of design requirements.

The BENTO programme, aimed at developing expertise on the use of bentonite, concentrated on the buffer and on deposition tunnel backfilling. Its purpose is to support planning and design, the associated development work as well as the processing of uncertainties associated with the Safety Case. During 2010, the BENTO programme continued the development of mineralogical and chemical characterisation of bentonite as well as the development of numerical methods by also including backfill materials in the programme. The main individual areas for investing resources were:

- Saturation with water in general,
- Erosion of buffer materials possibly associated with the early stage of water saturation,
- Erosion of buffer material in dilute waters,
- Repeated freezing and subsequent thawing of saturated bentonite and backfill materials,
- Interaction between saturated bentonite and concrete,
- Interaction between saturated bentonite and iron,
- Cementation of saturated bentonite caused by salts and silicates,
- The effect of high salinity on the swelling pressure of saturated bentonite,
- The change in volume, self-healing ability and homogenisation of backfill materials.

The BENTO programme has served to increase the competence, resources and research equipment for bentonite-related R&D work, in particular at B+Tech and VTT.

During 2010, Posiva participated in several international research projects on the behaviour of bentonite as well as in the preparatory work of these projects. These included projects under the 7th framework programme of the EU, entitled FORGE (Fate Of Repository GasEs), the CFM (Colloid Formation and travel) project by the Grimsel Rock Laboratory, and the FEBEXe (Collaboration in the Full Scale Engineered Barrier Experiment in Crystalline Host Rock), which all began in 2009. The FORGE-related work concentrated in 2010 on monitoring, as planned, the Large Scale Gas Injection Test (LASGIT). In CFM, the work for developing a method for estimating the degree of erosion in clay caused by dilute waters was continued. The results indicate that the factors limiting and controlling the phenomenon are independent on the set-up used for the test. The FEBEXe project continued the monitoring of the long-term test and collection of data from it.

In addition to the above, Posiva has also participated in SKB-coordinated work in the EBS Task Force for the development of assessment procedures and modelling tools for clay materials. The new test cases were defined in 2010, and their analyses started.

In 2010, Posiva participated in the ABM (Alternative Buffer Materials) project in progress at Äspö, and which has been running for several years. Its purpose is to study the long-term processes taking place in different bentonite materials in a full-scale test. The first actual samples were analysed in autumn 2010, and the results will be reported in 2011.

Posiva participated, in the role of an expert, in an international study of natural analogue, the purpose of which was to accumulate knowledge on the long-term stability of bentonite under high pH conditions. The studies take place in Cyprus. The third phase of the study started in 2010 with sampling of the subjects selected in the previous phases (in 2008 and 2009). The results of this work will be reported in 2011.

Posiva has concluded an agreement with SKB on the initiation in early 2011 of a cooperation project for the purpose of further development of the deposition tunnel plugging process. The methods for assessing the performance of the plugging solution were investigated during 2010.

A systematic approach was developed for assessing the performance of the plant closure solution, and the requirements for the solution were further defined.

BEDROCK AS A RELEASE BARRIER

Planning work continued in 2010 for the REPRO test to be carried out at Investigation niche 5 of ONKALO, aimed at determining the matrix diffusion characteristics of Olkiluoto bedrock. The equipment for the two first tests (diffusion of water vapour and diffusion in the water phase) was prepared, and the pre-testing of water vapour diffusion began in ONKALO.

International co-operation in the Task Force for Groundwater Flow and Solute Transport at the Äspö Rock Laboratory continued. In that work, the model descriptions of channelled flows were giving the finishing touches on the basis of observations made in bedrock fractures cutting across the shafts of ONKALO. In 2010, the work for modelling SKB's so-called BRIE test also continued, and associated modelling assessments applying the up-and-down method were carried out. The BRIE test involves studying the hydraulic interaction between the bentonite buffer and bedrock at final disposal bedrock conditions.

The so-called reference water report, explaining the rationale behind the future groundwater conditions in Olkiluoto and the associated assumptions, was prepared in 2010. It will be published as a Posiva Working Report during 2011. The reference water conditions will be used for determining the solubility and sorption properties of radionuclides on the basis of literature surveys and laboratory tests, for choosing the input data for radionuclide migration modelling (both in the near-field and bedrock) and for the performance assessments of technical barriers. The modelling group of the Safety Case project (the so-called Assessment Group) produced a strategy report on radionuclide migration modelling; it will be published in early 2011 as a Posiva Working Report. Preparations in support of the practical implementation of migration modelling were also carried out. These preparations are aimed at implementing the radionuclide migration modelling work required for the Safety Case within the schedule of Posiva's preparations for submitting the construction licence application and in compliance with the instructions of STUK and YVL Guides in 2011.

The cement studies related to long-term safety continued with Nagra, JAEA and NDA in the LCS (Long-term Cement Studies) project aimed at studying the interactions of grouting cement with bedrock in situ in Grimsel, Switzerland. The purpose of the laboratory tests conducted in support of the field tests is to model the dissolving of cement and its interactions with the bedrock. The results of laboratory and field tests are also modelled by utilising the information obtained from natural analogy studies. The first phase of the project ended at the turn of 2008/2009, and the work for reporting its results is still in progress. The second phase of the LCS project has begun, and it is scheduled to continue during 2009–2013.

The spent fuel safety analysis will include an estimate of the behaviour of radionuclides in the geosphere. As part of this estimate, the migration of radionuclides as well as their retention in the rock material and surfaces of bedrock fractures will be analysed. The magnitude of retention of dissolved radionuclides is described by the distribution factor. The value of the distribution factor depends on the conditions, which is

The seabed fauna studies forming part of the monitoring programme of the power plants were supplemented by Posiva's own sampling campaign in the autumn. The picture shows sampling in progress using an Ekman sampling device.

why the values best describing the distribution in the analysed chemical and physical environments (types of rock and minerals present in Olkiluoto and the composition of its groundwater) are selected for the transport estimates. The empirical work for updating the values of these parameters for the most important radionuclides began in 2008, and it continued in keeping with the planned schedule in 2010. The work for reporting its results is still in progress, and it will continue for the first half of 2011.

BIOSPHERE

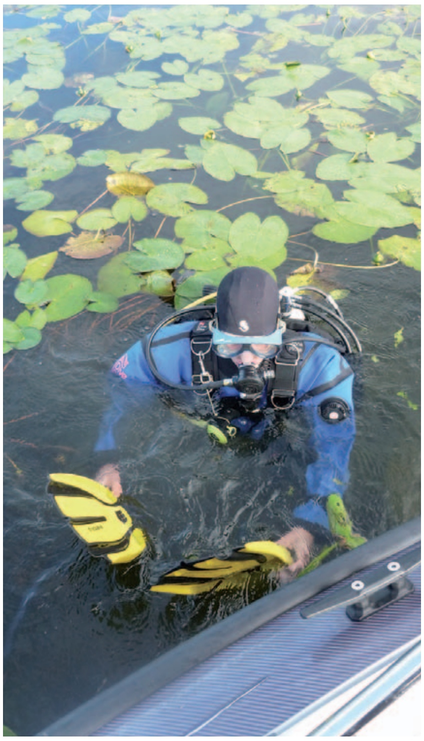
Biosphere-related work took place during 2010 in keeping with the TKS-2009 programme and the latest Safety Case plan (POSIVA 2008-05). The previous modelling round was reported in 2010. The preparation of biosphere assessment for the construction licence phase also began in 2010, primarily with the preparation of a skeleton description of the current state of surface environment and sequences of developments as well as with planning and preparatory work for the modelling phase. This work will continue in 2011 with actual modelling, to be followed with the completion of reports in 2012.

The project initiated in 2009 for developing the numerical methods used for estimating the uncertainties associated with the terrain model and land uplift model continued, as did the extensive research project regarding the retention of radionuclides in soil and sediments. The automatic measurement campaign spanning many years, intended for studying the sedimentation conditions at the sea areas, was continued. A runoff water model was produced for the Eurajoki and Lapinjoki areas for taking into account any changes occurring in the catchment area of these rivers. Samples of water and shore vegetation, sediments and seabed fauna were collected from Olkiluoto and a few Satakunta lakes similar to the ones that will in the future be formed in the vicinity of Olkiluoto for use as basic data for material circulation modelling. In August, a combined mapping exercise of peat layer and vegetation was carried out at the Lastensuo swamp in order to supplement the swamp area data collected in Olkiluoto.

Aquatic vegetation samples were collected in August 2010 from the vicinity of Olkiluoto, among others, by diving.

In order to improve the modelling of land uplift, Posiva organised in June 2010 jointly with the Pori Unit of the Tampere University of Technology a Nordic seminar where the reasons and mechanisms of and modelling alternatives for land uplift were discussed. The seminar publication will be released in 2011 as part of Posiva's series of Working Reports.

Posiva has also actively participated in the operations of the international BIOPROTA forum – for example, by heading the joint project for testing the methods for assessing ambient radiation levels – for which a Working Report was published in 2010. A study tour to Olkiluoto was organised in connection with the annual general meeting of the forum for showing Posiva's biosphere work at the practical level to the experts in the field. On the municipal level, Posiva participated in, among others, a project surveying the diversity of underwater nature.



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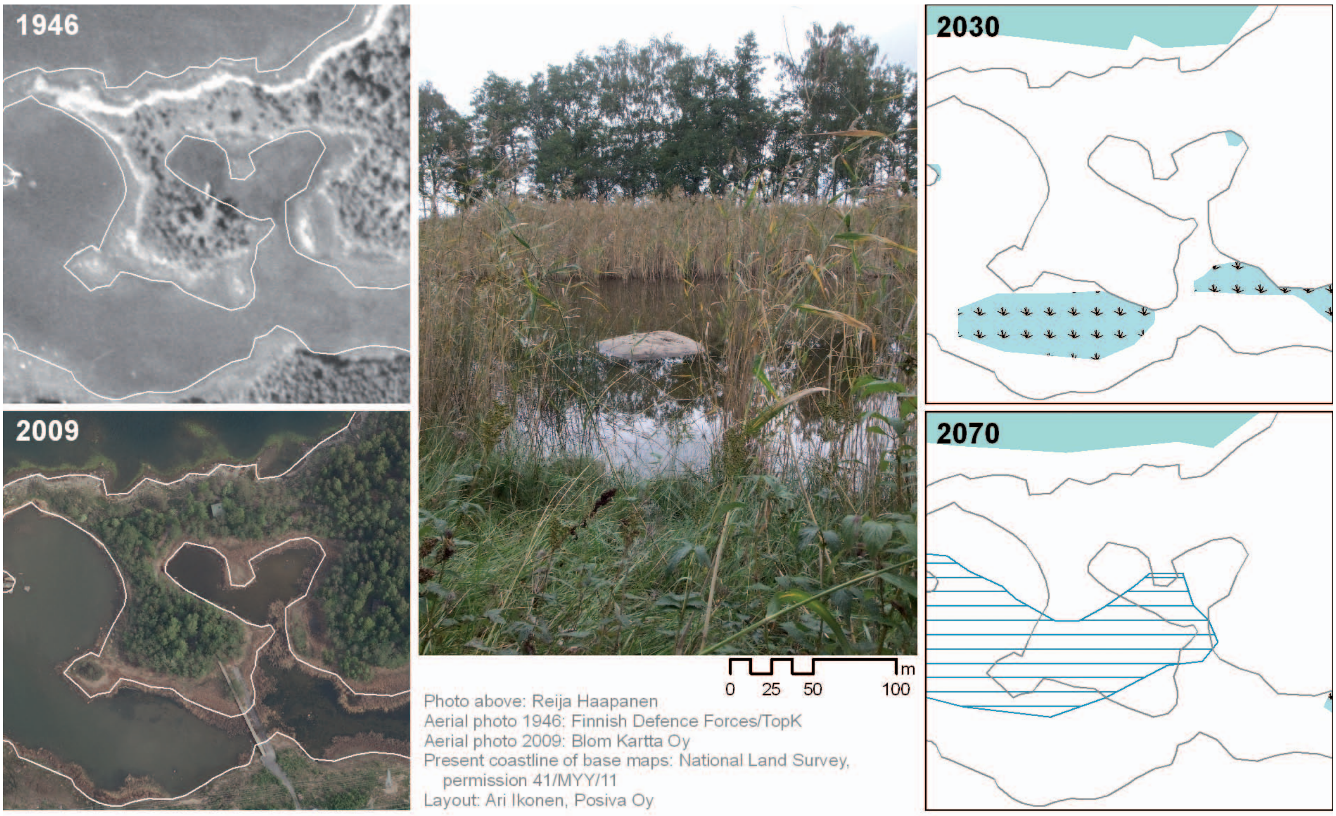


Series of pictures of land uplift in Munakari, Olkiluoto. According to the model produced by Posiva for land uplift and evolution of ecosystems, in 2030 the narrow and shallow straits between Munakari and Olkiluoto will have been separated from the sea, partially dried up and partially an overgrown pond. In 2070, the ponds will have dried up as well, and the area will have begun turning into a swamp – there will have been a few centimetres of peat.

Development of the horizontal disposal solution

In parallel with the vertical disposal solution (KBS-3V) now constituting Posiva's reference solution, the development work for the horizontal disposal solution (KBS-3H) has continued with SKB.

The Complementary studies of horizontal emplacement, a project established in 2008 for further development work on the horizontal disposal solution, was completed in 2010. The final report will be finalised in early 2011. The goal of the research phase now completed was to solve the problems identified during the earlier research phase and to prepare a plan for initiating the next phase. The next phase (update of the KBS-3H description and performance of full-scale tests) will include full-scale tests of the system components, preparation of the final technical plan and Safety Case (for Olkiluoto and Forsmark, Sweden) during 2011–2014. The work for solving the open questions regarding the buffer will also continue during the next phase to the extent that these questions could not be fully settled during the phase now ended. A few new questions have also been identified, and answers will be sought for them during the next phase. Some of the questions to be solved are common with the KBS-3V alternative.

The main focus of the Safety Study sub-project during the now ended phase of the project was to accumulate sufficient information on the effects of iron, titanium and copper on bentonite to allow making, with the support of technical studies, a holistic assessment of which material should be used for the protective cylinder of the supercontainer. The tests carried out for studying the interactions between protective cylinder material and bentonite have concentrated on the physical, mineralogical and chemical properties of bentonite. On the basis of the results, titanium was selected for the material. The choice of material also applies to the partitioning plugs. Determining the long-term safety requirements of the horizontal disposal solution was an important part of the work.

The main goal of the Planning sub-project during the now ended project phase was to resolve the questions identified as important during the previous phase of the study. Many of these questions are related to the buffer and its behaviour, and to understanding the same. All questions have not been answered yet, although the project has succeeded in increasing knowledge regarding the buffer and its behaviour. The issues related to buffers have been studied in laboratory conditions, by modelling and in theoretical analyses. Of the design alternatives DAWE (Drainage, Artificial Watering and Air Evacuation) and STC (Semi Tight Compartment), DAWE was chosen as the reference alternative. In that alternative, an artificial wetting method is used to ensure the wetting and swelling process of buffer material.

The buffer-related detailed plans for the spacer plug and the buffer to be inserted between the supercontainer and the copper canister and at the ends of the canister have now been completed. The backfilling components used for backfill solutions near the plugs as well as in tunnel sections unsuitable for depositing supercontainers have also been designed during the project phase now completed. The backfill components will be made of buffer material. The detailed design of the end plug for the deposition drift was also completed. The new solution is based on the use of titanium, and it replaces the steel partitioning plug and concrete end plug included in the earlier plan. Less complex solutions than before were found for the design of the deposition drift.

The design basis was updated using new site data (such as hydraulic conditions) and the increased understanding regarding the buffer. The analyses on bedrock spalling in Olkiluoto will be updated during the next project phase when the results of the POSE (Posiva Spalling Experiment) field test carried out in Investigation niche 3 of ONKALO (regarding spalling strength, etc.) are available.

The two other sub-projects of the horizontal disposal solution development project are entitled Production and operation and Demonstration and planning of full-scale tests. The objective of the first sub-project is the development of production lines, plants and system descriptions. Tests on the installation device were continued, and the results indicated that the device functioned well. The device still needs further development work, though. The geometrical requirements related to boring techniques and the measuring technology were re-assessed, and recommendations on areas for development were produced. The operational and industrial safety analyses regarding the KBS-3H solution have been carried out. As Posiva's own exercise, the layout of Olkiluoto repository was updated to correspond to the KBS-3V layout implemented in 2009. This sub-project will be responsible for manufacturing components and production equipment and their installation and testing in Äspö, as well as for the planning for the next project phase. Full-scale testing of the partitioning plug was completed during 2010. The test results were very encouraging with regard to the leak-tightness of the plug and the gap-sealing effect of bentonite pellets.

During 2010, Rock Suitability Classification work was initiated for the horizontal disposal solution.

Layout alternative with the orientation of deposition drifts at 90/270 degrees.

Licensing and other activities

Capabilities required for the construction licence

Posiva and its owners want to start the final disposal of spent nuclear fuel in Olkiluoto, Eurajoki, during 2020. This schedule is supported by the wide consensus of society, also recorded in the decision taken by the Ministry of Trade and Industry in 2003 regarding the time schedules for preparing the final disposal of spent nuclear fuel. At that time, the Ministry emphasised the importance of adhering to the schedule by requiring that the parties under the nuclear waste management obligation shall, either separately, jointly or through Posiva Oy, prepare to present all reports and plans required to obtain a construction licence for a disposal facility for spent nuclear fuel, on the basis of which disposal can be started in 2020 approximately. The decision of 2003 also required that the preliminary reports and plans required for the construction licence must be submitted in connection with the waste management reports to be submitted in 2009. The reports shall show which parts of the documents required by the construction licence are incomplete and in which way and on what schedule the documents will be supplemented.

Fortum and TVO, the two parties under the nuclear waste management obligation, submitted a report on their nuclear waste management activities for 2009–2012 to the Ministry or Employment and the Economy in September 2009 (the TKS-2009 programme) together with a report on their preparedness to submit the construction licence application for the spent fuel disposal facility by the end of 2012. At the same time, Posiva submitted the above reports to the Ministry of Employment and the Economy in conjunction with the construction licence application. Draft versions of other documentation to be submitted to authorities with the construction licence application were also sent to STUK.

During 2009, the Ministry invited statements from several different parties regarding the material submitted to it. The Ministry forwarded the received statements to Posiva in autumn 2010. Of these statements, those submitted by STUK were the most significant for Posiva. In December 2010, the Ministry of Employment and the Economy issued its own statements regarding both the TKS-2009 programme and the preliminary construction licence documentation. In its statements, the Ministry emphasised its view that the allocation of responsibilities and duties must be defined and clearly described between Posiva and the power companies. Furthermore, the Ministry is of the opinion that all plans for different technical alternatives must be brought to the same level. In its comments, the Ministry relied on views expressed by STUK.

Posiva will take into account the views expressed by the Ministry of Employment and the Economy, the Radiation and Nuclear Safety Authority and other parties that submitted their statements when preparing its application for a construction licence. It is the view of Posiva that the work for preparing the application will progress so that it can be submitted in 2012.

In addition to the preparations for the application, Posiva is also preparing for the actual construction of the disposal facility and later disposal operations by restructuring its organisation and by recruitment supporting that restructuring. The construction of ONKALO as well as the competence, experience and detailed information on the Olkiluoto bedrock accumulated in the process are an essential element of preparations for the construction of the repository.

Other licences, permits and decisions required

LAND USE PLANNING

The primary objective of land use planning is to maintain the land use prerequisites at the largest energy production site in Finland and to reserve space for the implementation of final disposal of spent nuclear fuel so that the safety requirements set by Finnish legislation and operations are fulfilled.

During 2010, the Olkiluoto partial master plan, approved by the Municipality of Eurajoki in 2008, also became legally valid. The partial master plan superseded parts of the Eurajoki master shore plan. The plan became legally valid in spring 2010 after the Supreme Administrative Court rejected the two appeals against it.

In summer 2010, the Municipality of Eurajoki approved the local plan of the disposal site and an amendment to the local plan. The decision also included the partial abolishment of the local plan and the shore plan. The area to be covered by the local plan includes the middle and part of Olkiluoto Island and the eastern part apart from the shore area. The local plan area also includes some of the water area in front of the Olkiluoto port. The plan is not legally valid yet.

ENVIRONMENTAL IMPACT ASSESSMENT

Posiva implemented an Environmental Impact Assessment (EIA) procedure regarding the expansion of its repository during 2008–2009. In its statement issued in 1999, the Ministry of Trade and Industry stated that the construction licence application must be accompanied by the EIA report and an account of the design principles that the applicant intends to monitor in order to avoid environmental damage and to reduce the environmental load. According to the

Ministry, this will in practice mean that the application has to be accompanied by a report equivalent to the EIA report, updated with the conditions and level of knowledge available at that time.

DECISIONS-IN-PRINCIPLE

Posiva submitted an application to the Government for a decision-in-principle concerning the extension of the spent fuel repository for the Olkiluoto 4 power plant unit in spring 2008, and concerning the extension of the spent fuel repository for the Loviisa 3 power plant unit in spring 2009. On 6 May 2010, the Government decided that expansion of the repository for the Olkiluoto 4 unit is in line with the overall good of society whereas its expansion for the Loviisa 3 plant unit is not. These decisions are in line with what the Government decided regarding the respective power plant applications by TVO and Fortum. The expansion will increase the capacity of the Olkiluoto repository by a maximum of 2,500 uranium-tons of spent nuclear fuel. According to the decisions-in-principle ratified by Parliament, spent nuclear fuel containing a maximum of 9,000 tonnes of uranium may thus be finally disposed of at Olkiluoto.

Management of quality and the environment

MANAGEMENT SYSTEM

Posiva's management system was developed towards the process management model. In this development process, most of the work carried out by Posiva was identified and described as processes and the allocation of duties and interactions between them were defined. The process management model is deployed in order to enhance the use of resources and attainment of goals during the different phases of Posiva's disposal project. The revised operations management system is scheduled to become effective in early 2011 after approval by the relevant authorities.

The role of ONKALO's monitoring group was partially redefined in connection with the process reform. The group was given a standing order to ensure that the main processes have up-to-date design bases in place that fulfil the safety requirements and that the processes are conducted accordingly. The group acts as the decision-making and steering body for Posiva's project activities. In addition to the above processes, the activities of the group also cover the associated processes set up for quality and safety management.

In 2010, STUK controlled the construction of ONKALO in keeping with the agreed procedures. STUK carried out its inspection plan RTO2009 regarding the construction of ONKALO as planned. Regular STUK follow-up meetings were held between STUK and Posiva, and separate site inspections were performed. The STUK-approved schedule for submitting ONKALO design documents and the plan for giving information on construction details were observed in the ONKALO construction project.

CONTROL OF ENVIRONMENTAL IMPACT

Environmental matters are managed in line with Posiva's operations management system and annual environmental program. In February 2010, the operations management system received a certificate based on the environmental management standard ISO 14001:2004. The periodic audit of the system was held in October 2010. Posiva's assessment of environmental aspects was updated in the autumn. According to the assessment, the major environmental aspects in normal operations were related to ONKALO's construction, waste management and the use of energy. An analysis of potential problem situations revealed that chemical spills pose the most significant environmental risk.

The excavation work in ONKALO produced some 60,000 m^3 of rock waste in 2010, most of which was used for building works in the area. A total of 25,000 m^3 of water was used in constructing the tunnel. The average rate of water leakage in ONKALO was approximately 33 l/min. The waters pumped from the tunnel (operational water and leakage waters) were first led to sedimentation and oil separation and then to the sea via an open ditch. The quality of the water was regularly monitored.

During the year, there was one occurrence of environmental damage, and the environmental authorities were duly contacted concerning this. Some water containing environmentally harmful tracer (NaI) escaped into the soil. The area was cleaned in compliance with the instructions of environmental authorities.

The purpose of the environmental programme is to mitigate any negative environmental impact that may be caused by the company's operations. The actions carried out as part of the 2010 programme included development of ONKALO's waste management and a continuation of the development work for preventing and controlling environmental incidents. The previous summer's investigation trench was landscaped with tree saplings, and one new drilling site (OL-KR54, OL-KR55 and OL-KR55B) and investigation trench were planned and implemented with minimal environmental impact.

Information management

KNOWLEDGE MANAGEMENT

The information in an organisation consists of tacit information and explicit information, i.e. information expressed in written form, for example.

Knowledge management often concentrates on the systematic management of explicit information required for the operations of a company or organisation. In its wider application, knowledge management also includes areas of HR and competence management, such as transfer of information from one generation to the next using different procedures before people retire or move to different positions.

Posiva and its interest groups intend to ensure that basic knowledge is preserved over the coming decades and the coming century as employees and generations change. The threat is the discontinuation of disposal activities if doubts are raised for whatever reason that the Safety Case contains flaws, and the bases of the analyses are no longer recalled and understood.

Posiva will submit the construction licence application for the repository by the end of 2012. In order to ensure that the used information is correct and to avoid unnecessary repeats of already conducted studies, both Posiva personnel and external actors must have the possibility to access information that is essential for the construction licence application.

For the purpose of improving the availability of information contained in Posiva's reports and possibly also SKB's reports, A KMS project was initiated and given the task of design and implementing a search portal for both internal use and external use that will be restricted using existing identification tool technology. The information content or the reports produced in the research activities will also be organised to better facilitate searches, and the published reports only available in printed form will be scanned and subjected to an OCR process and then stored in the document management system. The project will be implemented during 2011, after which the required further development actions regarding knowledge management will be assessed.

REQUIREMENTS MANAGEMENT

The VAHA requirements management project was established in 2006 for the purpose of planning and implementing a systematic procedure for managing the requirements concerning the disposal project. When implementing the project, Posiva's earlier projects related to requirements management (in particular management of the requirements concerning the ONKALO project) were taken into account, as was the experience accumulated elsewhere, in particular at SKB.

The goal of the project has been to create a data system for collecting all requirements concerning disposal and their grounds, details of solutions for meeting the requirements, as well as information on the linkages between different requirements.

In addition, the system to be implemented will allow quick viewing of compatibility between individual specifications and different requirements, systematic analysis and documentation of the impacts of changes in requirements, as well as requirements management as part of the normal work of the organisation.

The first version of the requirements database for disposal operations was introduced in the autumn of 2007, the contents have been revised during 2008–2010, and this work will continue in 2011–2012.

RESEARCH DATA SYSTEM

Posiva has a large amount of research data, collected over a few decades in Olkiluoto and other localities where Posiva has previously conducted studies and surveys. This extensive collection includes research data on the area's bedrock, water areas in the surrounding environment, animal population and weather conditions.

In order to ensure that all users can quickly access the same verified and accepted data, Posiva has in place a single centralised system, the POTTI research data system, which will store all research data produced and make it available to all authorised users.

The work on specifying the POTTI system began in 2004 with the specification of data to be stored, intended uses of the database, the operating environment and the extent of database usage. The production use of the POTTI system began in March 2007, and different areas of research (hydro-geochemistry, hydrology, environmental monitoring, geology, geophysics, excavation documentation, rock mechanics) have gradually increased its use during 2007–2010. Among others things, the POTTI system has interfaces with the automatic groundwater measuring system in ONKALO, the HYPERDATA borehole data system and the Surpac geological modelling system. The work for developing the system and storing research data will continue further during 2011–2012.

PROCESSING OF OLKILUOTO BOREHOLE DATA

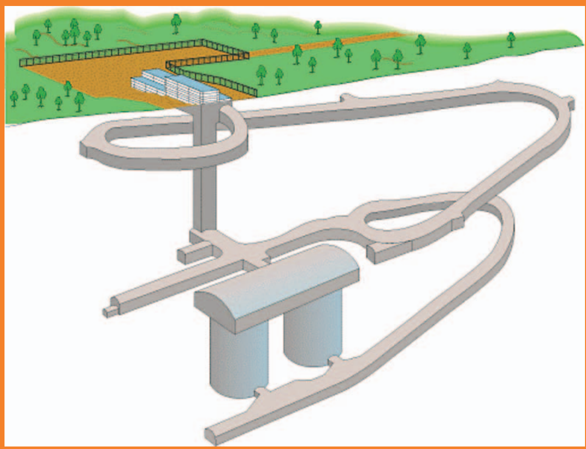
Posiva's HYPERDATA system is intended for viewing and visualising Olkiluoto borehole data stored in the POTTI system. The images of bore core box contents from Olkiluoto and ONKALO boreholes and the images of borehole walls were processed and stored in the POTTI system during 2008–2010. The system also has available tunnel images from ONKALO.

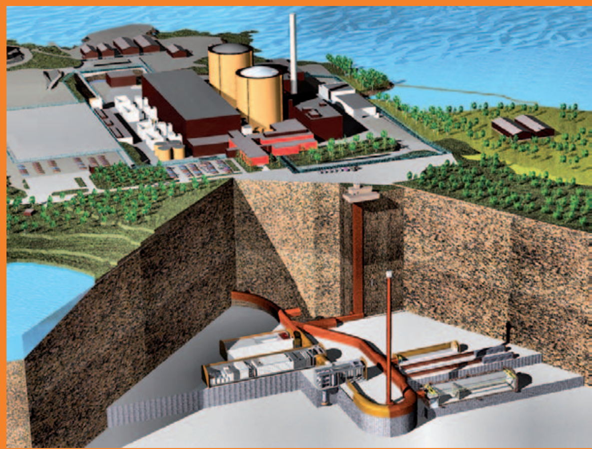
PROCESSING OF ONKALO EXCAVATION DATA

The construction of ONKALO began in June 2004. The excavation operations carried out so far were divided into five site contracts (TU1–TU5).

A separate project entitled LOHI-2 was initiated in October 2009 for storing data related to site contract TU4 as part of the work for storing planning and as built-data related to the POTTI database and rock excavation operations. The project will be completed in January 2011.

Operating waste management





The Olkiluoto repository for operating waste (VLJ Repository) was commissioned in 1992. The repository consists of two rock silos, a hall connecting the two and auxiliary facilities constructed at a depth of 60–100 metres inside the bedrock in the Ulkopää peninsula of Olkiluoto Island. The facilities can be accessed both via the vehicle access tunnel and a shaft. Low-level waste is deposited in the rock silo inside a concrete box, while a silo of steel-reinforced concrete has been constructed for intermediate-level waste in the other rock silo. The silo for low-level waste has a capacity of about 5,000 m³, while the capacity of the intermediate-level waste silo is about 3,500 m³. A preliminary design for the extension of the VLJ Repository has been prepared, aimed at the new repository facilities that will be required around the 2030s. The extension will correspond to the increase in the operating life of OL1 and OL2 from the initial 40 years to the current 60 years, and allows for the implementation of the disposal plan for operating and decommissioning waste from the OL3 plant unit now under construction. The needs of the planned new power plant unit (OL4) will also be taken into account when planning the expansion of the repository.

Low-level and intermediate-level operating waste generated at the Loviisa power plant is finally disposed of in facilities built in the bedrock of Hästholmen Island. Construction work on the repository began in 1993, and its first phase was completed at the end of 1996. The repository received its operating licence in 1998 and was put to disposal use in 1999.

The Loviisa disposal facility consists of a 1,170-metre-long access tunnel and hall facilities built at a depth of about 110 metres and of personnel and ventilation shafts. The facility was built in two stages. The first construction stage involved the excavation of most facilities and access routes. Two deposition tunnels were excavated for maintenance waste, and a repository hall was excavated for solidified waste. The second deposition tunnel and solidified waste hall were completed during the second construction phase that ended in 2007.

The Olkiluoto power plant

PRINCIPLE OF OPERATIONS

The majority of operating waste is immediately packed for processing, storage and disposal. The intermediate-level ion exchange resins used for the purification of circulating water are solidified in bitumen, and the composition is poured into steel drums. A part of the low-level waste (compressible miscellaneous maintenance waste) is compacted in steel drums using a hydraulic press, while another part (scrap metal and filter rods) is packed, without compaction, in steel and concrete cases and steel drums. The drums containing compressible waste are compressed so that the final height of the drum is approximately one-half of the original, with the diameter of the drum remaining unchanged. Scrap metal may also be processed before packing to reduce its volume. Scrap chopped up with a metal chopper may be used to fill up any empty space in the concrete cases transported to the repository. This improves the packing efficiency of metal waste.

Miscellaneous liquid waste and slurry is solidified by mixing the waste with a binding agent in a drum that forms the packaging of the solidified product. If applicable, the volume of liquids and slurries is reduced through evaporation prior to solidification.

Operating waste is temporarily stored in the storages and fuel pools of the power plant units, the low- and intermediate-level waste interim storage facilities (the KAJ and MAJ storages) and, in small quantities, in the KPA storage at the Olkiluoto power plant site. Low and intermediate-level waste generated during the operation of the power plant is disposed of in the current waste silos of the repository for operating waste (the VLJ repository). Waste with very low activity concentration is exempted from control and taken to the landfill area located at the Olkiluoto power plant site or handed over to another party for recycling or other purposes.

The first experience of processing low-level operating waste abroad was also gained in 2010. This was made possible by an amendment of the Nuclear Energy Act in 2008. The interim superheaters of OL1 and OL2, replaced in 2005 and 2006, respectively, were chopped up and melted in Studsvik, Sweden. The resulting compacted waste is returned and disposed of in the MAJ silo of the VLJ repository in Olkiluoto.

CURRENT STATUS OF STORAGE AND DISPOSAL

The status of storage and disposal at the end of 2010 is shown in the table below. The waste is packed in barrels (200 litres in each, about 100 litres when compressed), to steel crates (1.3 or 1.4 m³ in each) and in concrete crates (5.2 m³ or 3.9 m³ net in each).

The barrels and crates are stored, when required, in storage facilities of plant units and the KAJ storage before their final disposal in the VLJ Repository. Before transferring them to the VLJ Repository, the barrels and steel crates are placed in large and small concrete crates as follows: 16 barrels, or a combination of seven barrels and two steel crates, are placed in each large concrete crate and 12 barrels are placed in each small concrete crate. The number of barrels accommodated by each concrete box can be doubled by compacting the barrels.

Dismantling waste from the reactor interior, such as core lattices and steam separators, is included in the waste packed in crates of 1.8 m³ for long-term storage in the fuel pools of plant units.

Large contaminated metal components are stored in the KAJ storage and in the MAJ storage extension. In addition, unpacked operating waste such as used ventilation filters and resins without bitumen, are stored at the plant units, while waste oil is stored at the interim spent fuel storage (KPA storage). Part of the scrap metal is packed in the concrete crates used in the VLJ Repository. Part of the unpacked waste is to be later exempted from control for recycling use or dumping on landfill sites. The waste buildings at the plant units can accommodate about 1,000 barrels each. Mostly only very low-level maintenance bags and scrap to be exempted from control is kept at the MAJ storage. The KAJ storage can accommodate barrels, crates and large contaminated metal components corresponding to a total volume of some 6,000 barrels.

The capacity of the intermediate-level waste silo in the VLJ Repository (expressed in 200-litre barrels) is 17,360 barrels while that of the low-level waste silo is 24,800 barrels. In other words, the total storage capacity of these two silos is about 8,400 m³ of operating waste packed in barrels. This corresponds to the quantity of waste generated by the two plant units now in operation in Olkiluoto during 40–60 years.

The small waste items held by STUK are stored, by separate agreement, in the Olkiluoto VLJ Repository. These small waste items mainly consist of radioactive sources used in hospitals, research institutes and industrial plants. So far, about 57 m³ of small waste items have been accumulated in the VLJ Repository.

Expressed in terms of disposal volume, the filters of OL1 and OL2 plant units and waste containers in the waste building have a total of 29 m³ (computational figure) of resin powders and granules.

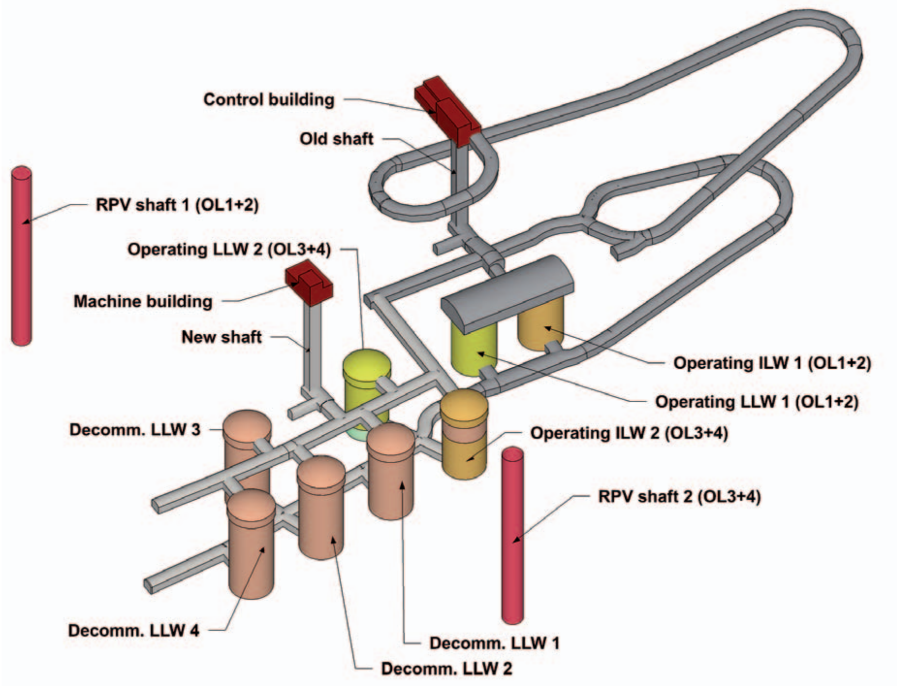
OPERATING WASTE GENERATED BY THE OLKILUOTO POWER PLANT

	Reactor buildings (m³)		VLJ repository (m³)			Other storages (m³)			Total
	OL1	OL2	KAJ silo	MAJ silo	Others	KAJ	MAJ	Spent fuel interim storage	
LOW-LEVEL WASTE									
Scrap		0,2		2504		42			**2546**
Unpacked scrap						18	1040		**1058**
Maintenance waste	23	18		937	3,2				**981**
Miscellaneous waste	2	2,4		0,6					**5**
Solidified liquids	1	0,2		97					**98**
Waste oil								0	**0**
INTERMEDIATE-LEVEL WASTE									
Scrap			247						**300**
Resin powders	32	35	1264						**1331**
Resin granules	3		266						**269**
TOTAL	**61**	**55**	**1777**	**3538**	**3**	**60**	**1040**	**0**	**6534**

IN-SERVICE STUDIES REGARDING THE VLJ REPOSITORY

In-service monitoring of the VLJ Repository rock facilities continued in 2010 in compliance with the VLJ Repository bedrock research and monitoring programme for 2006–2017. The research and monitoring programme allows verifying the sufficiency and correctness of the input data used for the safety analysis of the VLJ Repository, other factors affecting industrial safety and the in-service stability of the bedrock. 2010 was a year of more extensive research in the research and monitoring programme. The programme is to be revised in 2015 at the latest to correspond to any changes in the requirements for research results and in order to continue the programme.

The results of the rock-mechanical and hydrological measurements and analyses carried out in 2010 regarding the VLJ Repository will be reported in May 2011. The previous results for 2009 were reported in May 2010 (VLJ-1/10, VLJ-2/10). In 2010, STUK performed an E2 inspection regarding all in-service research activities on the VLJ Repository and studies related to operating and decommissioning waste. No deviations were found in the inspection (Käytön tarkastusohjelman vuoden 2010 tarkastus: Olkiluodon voimalaitos: Tarkastus E2: Jätteiden loppusijoitustilat. 9/C455551/2010.) (2020 inspection of the operating activities inspection programme: Olkiluoto NPP: Inspection E2: Waste repositories. 9/C455551/2010.).



The Olkiluoto VLJ Repository in its extended state, seen from south-west. The two silos seen in the background (Operating ILW 1 and LLW 1) belong to the part of the VLJ Repository in use. The expansion plan also has space reserved for the operating waste of the OL3 and OL4 plant units and decommissioning waste of all four plant units.

Rock-mechanical monitoring

The stability of bedrock has been monitored from the early stages or excavation work for the VLJ Repository with continuous rock displacement and rock bolt loading measurements as well as with measurements of changes in the span dimensions of excavated facilities utilising convergence measurement bolts. The extensometers used for bedrock dislocation measurements operated well in 2010 with the exception of one extensometer that had to have its broken reading head replaced. No deviations were detected in the measurements. Furthermore, the inclination and depression measurements on the KAJ silo and an inspection of the sprayed concrete surface in the VLJ Repository were also carried out in 2010. The measurements on the KAJ silo did not reveal any deviations, nor were any new cracks detected in the sprayed concrete surface of the hall ceiling. A conference presentation entitled Two decades of rock monitoring experiences at the two underground repositories for operating waste in Finland was prepared regarding the long-term rock-mechanical and groundwater monitoring of the VLJ Repositories in Olkiluoto and Loviisa. It is to be presented in the 2011 World Tunnel Congress to be organised in Helsinki in the spring.

In spring 1993, ten test bolts were installed in the research tunnel of the Olkiluoto VLJ Repository for the purpose of determining the rate of corrosion in rock bolts. The purpose of the study is to produce information of the corrosion resistance of zinc-plated rock reinforcement bolts in the conditions prevailing at the Olkiluoto VLJ Repository assuming that the cement plaster protecting the bolts has totally lost its protective properties. The first test bolt was drilled out in 1996 and the next in 2004. The results for the latter bolt were reported in 2006. The results indicate that the rate of corrosion is negligible which is why the decision was taken to further postpone the next removal boring until 2014.

Hydrological monitoring

The leakage water flow in the VLJ Repository was monitored during 2010 with the help of discharge pump flow rates and manual measurement weir measurements. The long-term trend matching indicates that the total flow of leakage water is on the decline. In 2010, the average total flow rate of leakage water was 39.2 l/min, of which about 19% (7.4 l/min) originated from the excavation tunnel area. The hydraulic head of groundwater was measured at the automatic groundwater stations and manual measurement points. The air quality in the repository was monitored by radon concentration measurements at various measurement points and by exhaust air radioactivity measurements. In the radon measurements, the limit value for regular work (400 Bq/m^3) was exceeded in the storage facilities for STUK's small waste items (800 Bq/m^3) and at the measurement point located on the left-hand side of the door to the KAJ silo (412 Bq/m^3). However, nobody works on a regular basis in these facilities. The temperature, relative humidity and carbon dioxide concentration of repository air was also monitored. Furthermore, the leaking points on the walls of the access to the repository were photographed.

Extensive monitoring samples were last collected from the groundwater stations of the VLJ Repository in spring 2008. The most significant changes in groundwater quality were the decrease in sodium and chloride concentration and the halving of potassium concentration in two years. The next extensive groundwater sampling campaign is scheduled for 2011 in the VLJ Repository bedrock research and monitoring programme.

RESEARCH RELATED TO OPERATING WASTE

Microbiological decay of low-level maintenance waste in repository conditions is being studied in a large-scale gas generation test performed with test equipment erected in the VLJ Repository excavation tunnel. The study serves to further specify the estimate on the amount and generation rate of gas generated from maintenance waste and to improve knowledge of the impact of microbial activity on the whole decay process under conditions, which are similar to those after the VLJ Repository has been sealed off. In addition, the travel of activity from the waste barrels to surrounding water is also monitored.

The most important parameter value obtained in this test is the rate of gas generation in maintenance waste; this parameter is needed for the VLJ Repository safety analysis that was last updated in 2008. In the long-term, the rate of gas generation has been of the order of 60–90 dm3/month, which is one order of magnitude lower than what was estimated in the original safety analysis.

The pH of the test equipment has clearly decreased during the test. At the beginning of the test in 1999–2002, the pH was of the order of 10–11 whereas it has in 2003–2010 been of the order of 7–9. An interim assessment of test results was carried out in 2010 for the purpose of establishing the changes in test tank conditions as well as any future development or actions required. The gas generation test is permitted to continue until 2017. In the future, at the latest when deciding on the test programme, the need for microbiological analysis work has to be assessed. The interim assessment of test results will be reported in early 2011 (The status of the large-scale gas generation test at the end of 2010).

The article on gas generation modelling entitled Experimental and modelling investigations of the biogeochemistry of gas production from low and intermediate level radioactive waste was published in the Applied Geochemistry magazine. The modelling work was suspended for 2010.

RESEARCH RELATED TO DECOMMISSIONING WASTE

Long-term durability of concrete

The long-term behaviour of concrete structures is investigated in a project entitled Betonin pitkäaikaiskestävyys (Long-term durability of concrete), initiated in 1997 in cooperation with Fortum Power & Heat Oy. Up to December 2010, the pilot-scale simulated test was in progress in Myyrmäki, in the facilities of former IVO. After the intended use of the facilities changed, the decision was taken to move the test to the research facility of the VLJ Repository at a level of -60 m. In connection with the change of test site, the test concrete under the simulated conditions was subjected to extensive sampling covering the entire test matrix. The purpose of this sampling is to investigate the penetration profiles of aggressive ions and the changes in microstructure and strength properties in order to determine the state of transition.

In addition to the pilot test, similar test pieces are being studied under actual groundwater conditions in the Olkiluoto VLJ Repository in boreholes VLJ-KR20 and VLJ-KR21. The results of the study are used for estimating the impact of the long-term behaviour of concrete on the solubility and migration of radionuclides under repository conditions as well as the weathering of concrete under groundwater conditions corresponding to actual operating conditions. The purpose of the study is to identify concrete formulations that are the most durable under the prevailing conditions so that the requirement of 60 years' service life set for the VLJ Repository can be achieved, and to produce information for the modelling of long-term durability of concrete materials and for developing these models.

This study involves monitoring the behaviour of nine concrete formulations with different binding materials and aggregate-to-binding material ratios in seven different solutions simulating groundwater conditions. No samples were taken of the test pieces in the boreholes in 2010, but the water chemistry of boreholes (pH, oxygen content, redox potential and conductivity) was monitored, besides monthly manual pH and conductivity measurements, also by the annual cell array measurement campaign lasting one month. Water samples were also taken for chemical analyses. The pH of borehole water samples has been very stable at about 8 for a long time now. The conductivity in borehole KR20 has varied between 2.2–2.6 mS/cm while conductivity in borehole KR21 has been 2.4–5.4 mS/cm. The results of basic tests for solutions simulating saline groundwater and concrete formulations will be reported in early 2011. The research results related to the damage mechanisms of concrete structures will be reported later in 2011. The preliminary damage mechanisms of concrete structures under the prevailing conditions have been identified. During the operating phase, the properties of concrete will deteriorate as a result of carbonate formation, and the aggressive ions contained in groundwater will cause corrosion in the concrete reinforcement steel after the closure of the facility. The results of long-term durability tests have been put at the disposal of the KYT2010 programme, and they will also be offered to the new KYT2014 programme.

Dissolution of decommissioning waste metals

The purpose of the decommissioning waste metal dissolution test initiated in 1998 is to study the dissolving of carbon steel under repository conditions in order to obtain a realistic picture of the corrosion rate of steel under the conditions prevailing in the Olkiluoto VLJ Repository after its closure. The tests are implemented both under simulated conditions in a laboratory (VTT's monitoring study) and in actual groundwater conditions at the Olkiluoto VLJ Repository using carbon steel samples placed in boreholes VLJ-KR19 and VLJ-KR21. Furthermore, samples of zinc plates and zinc-coated steel plates have been installed in borehole VLJ-KR9 since 2002.

Groundwater chemistry in the boreholes is regularly monitored with pH, oxygen, redox potential and conductivity measurements. Water samples are also taken every year for chemical analyses. The pH of borehole water samples has been very stable at about 8 for a long time now. The conductivity in borehole KR19 has varied between 2.3–4.4 mS/cm while conductivity in borehole KR9 has been in the range 2.4–3.0 mS/cm. Samples were also taken in 2010 of borehole water and test pieces for microbiological analyses. Samples were also removed from boreholes for weight loss tests in order to determine the rate of corrosion. The research results for 2010 were reported in January 2011 (VLJ-1/11). The corrosion rates calculated on the basis of weight loss measurements of carbon steel samples have been found to vary between boreholes, which is partly due to the differences in total test durations. The corrosion rate also varies from sample to sample, and local corrosion can considerably exceed the average rate. The research results indicate that both the local water chemistry and microbiological activity in boreholes affect the corrosion rate and consequently also the predictability of corrosion and therefore also the estimates on corrosion rates.

The Loviisa power plant

Low-level and intermediate-level operating waste generated at the Loviisa NPP is processed and stored at the plant. Spent ion exchange resins and evaporator bottoms are stored in tanks in the liquid waste storage. Trial runs of the liquid waste solidification plant based on cementation have been carried out since 2007, and the plant will be commissioned in 2012.

In the early 1990s, a method was introduced in Loviisa for separating radioactive cesium from evaporation residue into a very small waste volume. The removal of cesium reduces the activity of the evaporation residue to such a low level that it can be discarded using normal drainage procedures. By the end of 2010, a total of 1,460 m^3 of evaporation residue had been purified at the cesium separation plant using 34 ion exchange columns, each with a volume of eight litres. The cesium separation campaign initiated in 2010 will be continued in 2011.

Dry maintenance waste generated in power plant maintenance and repair work is packed into 200-litre steel drums. Compressible waste is pressed into the drums using a baling press; in this way, one drum may be made to hold five times more waste than without compression.

In 2010, 60 kg of battery waste released from control and 1 m3 of dry waste released from control was sent for recycling. Metal waste generated in the controlled area is exempted from control in campaigns, as the situation requires, and collected into suitable waste batches. Before official exemption from control, metal waste found uncontaminated in radiation monitoring is kept in interim storage in a storage hall located in the yard area. In 2010, a total of 62 tonnes of metal waste was released from control.

Interim storage of radioactive metal waste takes place in the storage facilities of the controlled area. The storage hall for maintenance waste barrels to be released from control also holds one ocean-freight container full of contaminated metal waste.

A project concerning the renovation of the low-level maintenance waste treatment and storage facilities is underway. In the autumn of 2007, the construction of a conventional storage and repair shop building, exempt from control, started. The electrical and machine repair shops have already moved to the new building. After the completion of the new building and removal of functions, the controlled area has been extended to the facilities that then became vacant. In the controlled area extension

Gamma-spectroscopic measuring equipment for drum waste undergoing trial operation (determination of gamma activity, automatic drum conveyor, weighing rotator, etc.). Photo: Ari Haimi.

at LO1, facilities for maintenance waste treatment, a decontamination facility and a repair shop facility have been implemented. For LO2, facilities for metal waste and recyclable metal handling will be implemented. The new facilities in the controlled area are to be put to full operational use in 2011. Gamma-spectroscopic measuring equipment for drum waste (determination of gamma activity, automatic drum conveyor, weighing rotator, etc.) was ordered in 2008 and was installed and put to trial operation in 2010. Trial operation will continue in 2011.

Low-level solvents were last solidified by absorption and packed into 200-litre barrels in 2009.

The status of storage and disposal at the end of 2010 is shown in the table below. Spent ion exchange resins and evaporation residues are stored in the liquid waste storage. In addition, 1.7 m³ of resins is kept in solidified form in barrel-shaped waste containers. The solvent waste solidified by absorption and maintenance waste is kept in 200-litre barrels.

OPERATING WASTE GENERATED BY THE LOVIISA POWER PLANT

	Total amount of waste		Activity
	At the plant/ in storage buildings (m³)	At the repository (m³)	(GBq)
Spent ion exchange resins	529		15100
Evaporation residues	687		1180
Solidified evaporation residues and ion exchange resins	19		< 1
Solvents solidified by absorption		24	< 1
Maintenance waste	471	1658	651

REPOSITORY

Low-level and intermediate-level waste generated in the operation of the Loviisa power plant is finally disposed of in facilities built in the power plant area bedrock. The first and second phases involved excavating the access tunnel, tunnel and hall facilities at the approximate depth of 110 metres, plus personnel and ventilation shafts.

The construction and installation work of the solidified waste repository (KJT) excavated during the first phase started in spring 2005, and they were completed in 2007 at the same time as the leakage water pool built in the repository facilities. Finishing work has been in progress in the KJT facility since 2008. The solidified waste repository will be needed for the disposal of waste packages to be brought from the solidification plant starting in 2012.

The construction work for maintenance waste hall 3 (HJT3) and the connection tunnel began in October 2010; the excavation work (about 15,000 m³) will be completed in early 2011, and the facilities will be totally completed by the end of 2011. The expansion will improve the interim storage capabilities for maintenance waste.

Separate research programmes have been compiled for in-service research concerning the access tunnel and hall facilities.

STUDIES ON SOLIDIFICATION METHODS

Storage testing of radioactive ion exchange resin solidified in half-scale disposal containers in 1987 continued. The waste packages have been stored in groundwater at the Loviisa power plant for 22 years and, as expected, they are still in good condition. No structural damage has been detected in the concrete surface of the containers, and the composition of the storage water has been relatively stable. Radioactivity monitoring of the storage water has not revealed any signs of nuclide release from the solidified product contained in the concrete containers. The test results obtained so far were reported in 2010.

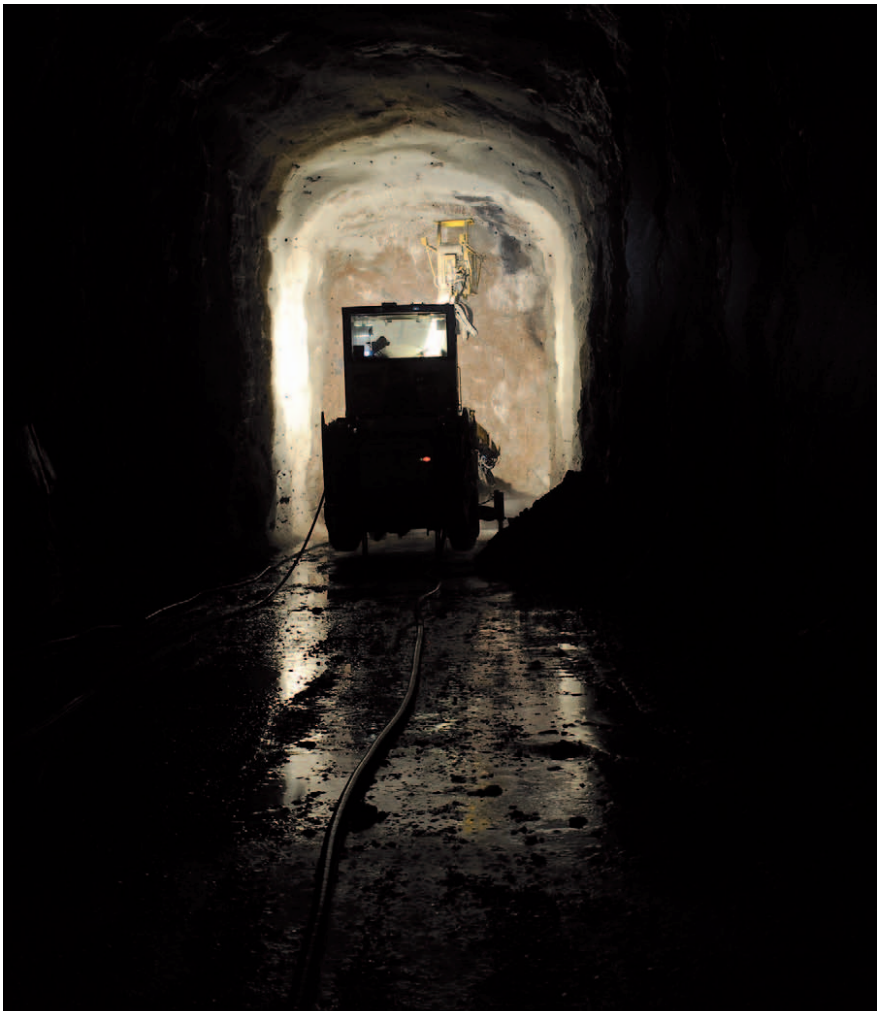
In 1980, old inactive ion exchange resin from the Loviisa power plant was solidified in a full-scale disposal container. The disposal container was kept in storage until mid-1983, and it has since then been kept in slowly flowing fresh water at the Pyhäkoski power plant. The condition of the disposal container has been monitored after 1, 3, 5, 9, 13, 15, 21 and 27 years of storage. Rusting can be clearly seen on the steel lifting lugs and fastenings but no structural damage has been detected on the container's concrete surface, and no corrosion has been detected in the concrete reinforcements of the container. The test results were reported in 2010 together with the test results for half-scale disposal vessels.

The long-term behaviour of concrete structures is investigated in a project initiated in 1997 in cooperation with TVO. The project is discussed in more detail in the section entitled 'The long-term durability of concrete'.

IN-SERVICE STUDIES REGARDING THE REPOSITORY

The in-service studies on the repository continued in 2010 in line with the monitoring programme. The aim of the programme is to investigate and monitor the characteristics and behaviour of groundwater and the bedrock in the immediate surroundings of the disposal facilities as well as long-term changes in their behaviour.

The monitoring programme has included the monthly monitoring of groundwater levels in ground-level research holes. The position of fresh and so-called saline groundwater in the holes was measured on four occasions during the year. The electrical conductivity and pressure of groundwater as well as the leakage water volumes have been measured at the repository fa-



Excavation work at the connection tunnel of the VLJ Repository in Loviisa. Photo: Ari Haimi.

cilities once a month. Some pressure and leakage water measurements have also run continuously. The measurements concentrated on the leakage water pools and on the five purpose-built groundwater stations. The monitoring of slow bedrock movements has been performed mainly using an automated rock-mechanical measuring system. Due to the obstacles caused by construction work, no groundwater samples were taken in 2010, nor were any visual checks carried out regarding the condition of bedrock facilities.

The groundwater in the island of Hästholmen is characterized by the fact that its level clearly depends on the seawater level. This is most evident in deep (> 30 m) boreholes where the groundwater level is close to the seawater level. In shallow holes, the level is a few metres higher, depending on the topography. During the construction works, the groundwater level sank locally by a few metres in the areas surrounding the facilities, but the slow rising of the levels has been observed since the facilities were completed. As a whole, no significant changes have taken place in water levels that seem to have stabilised roughly at the 1996 level. The borderline between fresh and saline groundwater has remained between levels -30 m and -80 m as in previous years, i.e. clearly above the repository facilities that are located roughly at level -110 m.

The conductivity measured in conjunction with leakage water measurements varies from one part of the facilities to another in the range of 300–1,300 mS/m. These values represent both the intermediate zone (100–1,000 mS/m) and the saline zone (> 1,000 mS/m). The electrical conductivity increases with increasing depth (and salinity) and reaches its maximum value at station LPVA5 (level -110 m). The conductivity of leakage water pumped into the sea (a mixture of all leakage waters) has been about 900 mS/m on average. As a whole, the conductivity values are slightly lower than in the previous year, i.e. the water at the groundwater stations is a bit closer to fresh water than before. The chemical composition of groundwater was not analysed in 2010, but on the basis of analysis results from previous years, the groundwater is classified as brackish water of Na-Ca-Cl-type.

The effects of seawater level variations and location are clearly evident in the groundwater pressure values. The pressure increases with increasing depth and reaches its maximum value bar at station LPVA5 located at the lowest point (at level -110 m) where it is about 10.3 bar, slightly lower than the theoretical value of 11 bar. Towards the end of the year, the pressure had decreased to 4.3 due to a leakage occurring in the equipment.

The amount of leakage water was measured, as usual, at seven different points around the disposal facilities. After excavation work was completed in 1996, total leakage was about 300 l/min at its highest, from which it has fairly constantly fallen to about 60 l/min by October 2010 when the facilities expansion work began. By the end of the year, the leakage had increased to about 80 l/min. The impact of the new facilities (some 15,000 m^3) on total leakage will be found out during 2011. About half of the leakage water amount still comes from the access tunnel and the other half from other facilities.

The results of rock-mechanical measurements show that the stability of the facilities has remained good and that, for example, the construction of the disposal facility for solidified waste has not diminished the stability of rock in the immediate surroundings either. During the construction work in 2005–2006, more variations were observed in bedrock movements, mainly as a result of the higher temperature in the hall, but now the movements have returned to their pre-construction level. Extensometer measurements indicate that

Geological mapping of HJT3 in progress. Photo: Ari Haimi.

the displacements taking place at the ceilings and walls of rock facilities have been of the same order as in previous years, below 0.1 mm. Bedrock movements in the vehicle access and connecting tunnel are monitored by convergence measurements that have a resolution of 0.5 mm. The results indicate that the movement has been smaller than 1 mm. The bedrock temperature near the facilities at a depth of -110 m is 8–12 degrees.

Rock-mechanical monitoring devices (convergence bolts, load sensors and extensometers) will be installed in the new facilities and connected as part of the current largely automatic monitoring system. Convergence measurements have in part been made already during the excavation work, but the intention is to put the whole system into operation in spring 2011.

The visual survey of bedrock facilities carried out in the autumns of previous years could not be carried out due to construction work. Instead, normal reviews were performed before the excavation work commenced. These will be repeated after excavation work has been completed so that any excavation damage can be detected. No damage had been observed by the end of 2010 at which time about half of the excavation work had been carried out, and excavation vibration has also been within the set limits.

SAFETY REPORTS REGARDING DISPOSAL OF OPERATING WASTE

The construction and installation work of the solidified waste repository (KJT) of the Loviisa power plant started in 2005, and they were completed at the end of 2006 at the same time as the leakage water pool built in the repository facilities. The work of updating the Safety Case for the repository began in spring 2004 and was completed in spring 2006. The Safety Case deals with phenomena, events and processes which affect long-term safety, such as groundwater flows, the release of radionuclides from waste, their travel in the bedrock and biosphere, and many other specific issues. According to the safety analysis, the radiation doses resulting from disposal are below dose limits, and the doses coming via waterways (lake, sea) are only a fraction of natural background radiation doses. Similarly, the deposited waste causes only a limited increase in total activity concentrations of radioactive elements in the environment. According to the Safety Case, it is not even possible to identify any fairly probable chains of events which could deteriorate the long-term safety of disposal to an inadequate level.

During the year being reported, international developments in operating waste disposal were monitored through conference visits and trade publications. In addition, a memorandum was produced regarding the impacts of ice age on long-term safety, the radioactive nuclides migration model PRONEFA was updated and AMBER 5.3 software was introduced for biosphere modelling.

Decommissioning reports

According to the Nuclear Energy Act, the NPP licence holder is also responsible for decommissioning the plant. In order to fulfil this obligation, the party responsible for waste management must produce a report on the decommissioning methods and schedule as well as on the storage and final disposal of decommissioning waste. The power companies have presented their updated decommissioning plans at five-year intervals until 2008 when the statutory requirement for the frequency of submitting updated decommissioning plans was changed to every six years. The most recent updated plan was completed late in 2008 for both the Loviisa and Olkiluoto nuclear facilities.

The Olkiluoto power plant

The decommissioning studies are aimed at the technical and economical development of the dismantling plan and at specifying the initial data for the safety analysis. The long-term safety analysis of the disposal of decommissioning waste from the Olkiluoto nuclear power plant was updated during 2008. The safety analysis takes into account the decommissioning waste of four plant units. Furthermore, in 2008 a principal plan was completed for an extension to the disposal facilities for reactor and decommissioning waste; here, too, the waste from the two new plant units was taken into account.

A report was produced during 2009 regarding the decommissioning costs of the OL3 plant unit. The results will be presented in the decommissioning plan for the OL3 plant unit that will accompany the application for the OL3 operating licence. A report was produced for the purpose of further specifying the decommissioning costs of the Olkiluoto NPP. It analysed the decommissioning costs in a case where the plants are decommissioned before the service life of 60 years foreseen for the OL1 and OL2 plant units had expired. The results obtained were used for estimating the nuclear waste management fund contributions paid in 2011. A revised estimate was produced during 2010 regarding cost of demolishing the non-active plant parts and buildings in Olkiluoto. The result will not affect the fund contributions, but the information is required for IFRS-compliant accounting.

Used interior parts of reactors, classified as intermediate-level waste, are mainly only disposed of in conjunction with decommissioning. The parts will be stored in plant unit water pools and a separate inventory for them will be kept. Intermediate-level and low-level waste generated in decommissioning and the spent reactor internals accumulated during the operation of the power plant will be disposed of in the planned extension part of the VLJ Repository.

During 2010, cutting of used control rods from OL1 and OL2 to pieces was also carried out. The stem sections and blade sections of the approximately 200 used control rods accumulated so far were severed from each other. The stem sections were taken to the MAJ silo in the VLJ repository and blade parts to the spent fuel interim storage to wait for decommissioning in line with the decommissioning plan.

A database application is available for planning the decommissioning of the contaminated part of the power plant. The database helps to calculate the amounts of material, the amounts of radioactive isotopes, working time necessary for dismantling, workers' dose rates, accumulative doses, and costs. The most recent update of the database was completed in summer 2008. The next update is foreseen after the reassessment of extent of decommissioning scheduled for 2011.

The Loviisa power plant

Part of the low-level and intermediate-level nuclear waste generated during the operation of the Loviisa power plant will only be deposited in connection with decommissioning. This waste includes, for example, used protective elements, absorbers, neutron flux detectors, connector rods of control rods and fission chambers.

At the end of 2010, there were 218 used protective elements, 220 absorbers, 262 neutron flux detectors, 142 connector rods and 27 fission chambers at the Loviisa power plant. Of these, the protective elements are in the spent fuel storage pools of the plant. The absorbers and fission chambers are kept in purpose-built channels at spent fuel store 1. The neutron flux sensors and connector rods are stored in similar channels in the reactor hall.

At the end of 2008, the latest update for the decommissioning plan for the Loviisa power plant was completed on the basis of a 50-year operating life. The plan includes, among other things, an activity inventory, dismantling actions, radiation dose estimates, the amounts of components and packages for disposal, a safety case for the disposal of waste and estimates of work and costs. The waste and cost estimates rose clearly from the previous 2003 decommissioning plan, mainly due to revised regulatory requirements (YVL 8.2). The decommissioning plan is based on the idea of dismantling immediately after the operation is finished with those radioactive parts which are not necessary for continuing the nuclear functions remaining at Hästholmen (spent fuel storing, wet waste solidification and disposal of low-level and intermediate-level waste).

A decision on decommissioning or continued operation will only be made towards the end of the planned operating life. Similarly, the decision on whether the plant will be dismantled immediately or according to a delayed schedule will be made towards the end of operation before starting decommissioning.

The preparation of a risk assessment for decommissioning as well as the preparation of a decommissioning plan as a project were investigated in 2010. The next decommissioning plan will be produced by the end of 2012.

Provisions for the cost of nuclear waste management

The funds required for nuclear waste management are collected in the governmental nuclear waste management fund. The target for accumulating funds is determined on the basis of the total liabilities of nuclear waste management, confirmed separately each year. The total liabilities of nuclear waste management include the future costs of all operations required for managing the quantity of nuclear waste accumulated by the end of the respective year.

TVO's funding target for nuclear waste management in 2010 was EUR 1,160.7 million, while that of Fortum was EUR 829.7 million.

The Ministry of Employment and the Economy confirmed EUR 1,179.1 million as TVO's total liabilities for nuclear waste management at the end of 2010, and EUR 1,123.4 million as its funding target for 2011. For Fortum, the Ministry of Employment and the Economy confirmed EUR 943.7 million as total liabilities for nuclear waste management, and EUR 885.6 million as its funding target for 2011.

List of reports

POSIVA 2010-01	**Models and Data Report 2010** Barbara Pastina, Saanio & Riekkola Oy Pirjo Hellä, Pöyry Finland Oy ISBN 978-951-652-172-8
POSIVA 2010-02	**Interim Summary Report of the Safety Case 2009** Posiva Oy ISBN 978-951-652-173-5
POSIVA 2010-03	**Biosphere Assessment Report 2009** Hjerpe Thomas, Saanio & Riekkola Oy Ikonen Ari T. K., Posiva Oy Broed Robert, Facilia AB ISBN 978-951-652-174-2
POSIVA 2010-04	**Inspection of Bottom and Lid Welds for Disposal Canisters** Jorma Pitkänen, Posiva Oy ISBN 978-951-652-175-9
POSIVA 2010-05	**Welding of the Lid and the Bottom of the Disposal Canister** Ismo Meuronen, Meurotech Timo Salonen, Posiva Oy ISBN 978-951-652-176-6
POSIVA 2010-06	**Laboratory Studies on the Effect of Freezing and Thawing Exposure on Bentonite Buffer Performance: Closed-System Tests** Tim Schatz, B+Tech Oy Jari Martikainen, B+Tech Oy ISBN 978-951-652-177-3
Fortum Power and Heat Oy	**Long-term durability experiments with concrete-based waste packages in simulated repository conditions** Ari Ipatti, Contesta Oy TJATE-G12-125 / B-7384 18.8.2010

Fortum Power and Heat Oy	**Hydrological monitoring of the Loviisa VLJ-Repository in 2009 [in Finnish]** Jouni Saari, ÅF-Consult Oy Working report 10-01 February 2010
Fortum Power and Heat Oy	**Rock mechanical monitoring of the Loviisa VLJ-Repository in 2009 [in Finnish]** Jouni Saari, ÅF-Consult Oy Working report 10-02 May 2010
VLJ-1/10	**Rock mechanics monitoring in the Olkiluoto VLJ repository for operating waste in 2009 [in Finnish]** Erik Johansson, Saanio & Riekkola Oy TVO working report
VLJ-2/10	**Hydrological monitoring in the Olkiluoto VLJ repository for operating waste in 2009 [in Finnish]** Petriikka Karttunen, Saanio & Riekkola Oy TVO working report
VLJ-1/11	**The dissolution of low and intermediate level decommissioning metal waste – experimental studies 2010 at Olkiluoto NPP site [in Finnish]** Leena Carpén, VTT TVO working report

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