MAW AND SPENT HTR FUEL ELEMENT TEST STORAGE IN BOREHOLES IN ROCK SALT

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ABSTRACT

The Bundesminister für Forschung und Technologie (BMFT, Federal Ministry for Research and Technology) is sponsoring a project at the Kernforschungsanlage Jülich (KFA, Juelich Nuclear Research Centre) entitled "MAW and HTR Fuel Element Test Disposal in Boreholes". The aim of this project is to develop a technique for the final disposal of (1) dissolver sludge, (2) cladding hulls/structural components and (3) spent HTR fuel elements in salt, and to test this technique in the abandoned Asse salt mine, including safety calculations and safety engineering demonstrations. The project is divided into the sub-projects I "Disposal/sealing technique" and II "Retrievable disposal test". In sub-project I, prototypical components for the disposal of MAW packages in boreholes and for the sealing of these boreholes in a final repository will be developed, fabricated and tested inactively in the Asse. The conceptual design of the components will be completed at the end of 1986. In sub-project II, the gas release from the MAW packages will be determined in a hot-cell experiment, and the safe underground handling of MAW and spent HTR fuel elements will be demonstrated by a retrievable test disposal with real waste packages in the Asse, using well-known or slightly modified handling components. Installation of the hot-cell experiment is being completed, the start of the retrievable test disposal is scheduled for the middle of 1987. The overall project comprises a period from 1983 to 1992. Implementation of the project involves the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR, Federal Geological Survey), the Physikalisch-Technische Bundesanstalt (PTB, Physical-Technical Fed. Inst.), the Deutsche Gesellschaft für Wiederaufarbeitung von Kernbrennstoffen (DWK, German Company for Spent Fuel Element Reprocessing), and the Gesellschaft für Strahlen- und Umweltforschung (GSF, Radiation and Environmental Research Company), under scientific and technical guidance of KFA.

INTRODUCTION

The evidence of the basic safety engineering feasibility of final disposal concepts for radioactive waste requires the development and prototype testing of new techniques. Final disposal techniques for low and medium active waste (LAW, MAW) with negligible heat generation have been developed and are part of the Federal Republic of Germany's conceptual design for the final disposal of those types of waste. For radioactive waste with perceptible heat generation like high-active waste (HAW), certain types of MAW, and spent fuel elements from high-temperature reactors (HTR-FE), corresponding techniques still have to be provided for final disposal in salt formations (Ref. 1). The corresponding R&D programmes are conducted by GSF and KFA, with the Inst. für Tieflagerung (Deep Disposal Inst.) of GSF being responsible for the HAW disposal test in the Asse mine (Ref. 2).

With respect to the final disposal of heat-generating MAW (dissolver sludge, cladding hulls/structural components) from reprocessing and of spent HTR-FE, the BMFT has charged the Institut für Chemische Technologie der Nuklearen Entsorgung (Institute of Chemical Technology for Nuclear Waste Management) at the KFA with the development of the so-called MAW borehole technique. In this connection work is being performed in a project entitled "MAW and HTR Fuel Element Test Disposal in Boreholes".

OBJECTIVES AND BOUNDARY CONDITIONS

The main objective of the project mentioned above is to develop a technique for the final disposal of heat-generating MAW and spent HTR-FE in untubed vertical boreholes in salt, and to test this technique under real conditions in a salt mine.

In order to achieve this objective, the project has been divided into two sub-projects with the following main working items:

I Disposal/sealing technique
- development of components for the MAW borehole technique which may be used in Germany's final repository at Gorleben
- cold testing (i.e. without real waste) of the prototypic components in the Asse.

II Retrievable disposal test
- determination of gas release from MAW packages
- retrievable test disposal with real waste packages in the Asse.

The technical boundary conditions and the timetable of the project are determined by the plans for the Gorleben repository, the conditions in the Asse test facility, and the waste packages available.

From PTB's timetable made up for the repository in Gorleben involving presentation of the safety report in 1992, it follows that basic results of the project must be available in early 1990.

Due to the specific licensing conditions of the Asse salt mine it must be guaranteed that the radioactive waste packages disposed of experimentally can be reliably retrieved at all times, and that they will be removed from the Asse after termination of the 5 years test disposal.

Waste packages for the retrievable disposal test are available from the Wiederaufarbeitungsanlage Karls-

ruhe (WAK, Karlsruhe reprocessing plant) and from the high-temperature gas-cooled AVR reactor in Juelich.

IMPLEMENTATION

The project is being jointly planned and implemented by KFA and GSF, under the scientific and technical guidance of KFA. GSF is acting as applicant for implementation of the in-situ test in the Asse and is responsible for mining and geotechnics. PTB (planning of the Gorleben repository) and DWK (operator of the reprocessing plant) are also involved. This guarantees that the results of the project can be included to the fullest possible extent in planning the Gorleben final repository. In addition, BGR is responsible for geomechanical computations.

In-situ testing will be conducted in the abandoned Asse salt mine near Wolfenbuettel in the State of Lower Saxony in the northern part of Germany. Figure 1 represents a simplified view of the 800 m-level of the Asse, where the tests will take place. Two separate MAW test drifts "EV" and "BV" for the two sub-projects are foreseen there in the older rock salt Na2. Depth and surroundings correspond to the plans for the Gorleben repository. Although being nearby, the HAW test field doesn't have any thermal influence on the MAW test.

Disposal/Sealing Technique

The technique for the final disposal of MAW and HTR-FE packages in vertical boreholes in salt and for the sealing of these boreholes is designed bearing in mind its commercial application in a final repository. The basis for the design are the plans for the Gorleben repository and the reference concepts for the MAW packages developed by the DWK as waste producer.

It is assumed that the spent fuel elements arising from the two gas-cooled HTR's being in operation in Germany will be disposed of in the type of package mentioned above. Hence, the same disposal/sealing technique can be used.

In order to simplify the operation of the planned final repository, the MAW borehole technique and the HAW borehole technique, the latter of which is subject of the HAW disposal test (Ref. 2), will have to be standardized.

Figure 2 illustrates the disposal and sealing technique for MAW with its main components, which will be designed, fabricated, and tested: 400 l standard drums with cemented waste are lowered out of a transport cask into a 300 m-deep vertical borehole, using a disposal machine, which is equipped with a grapple

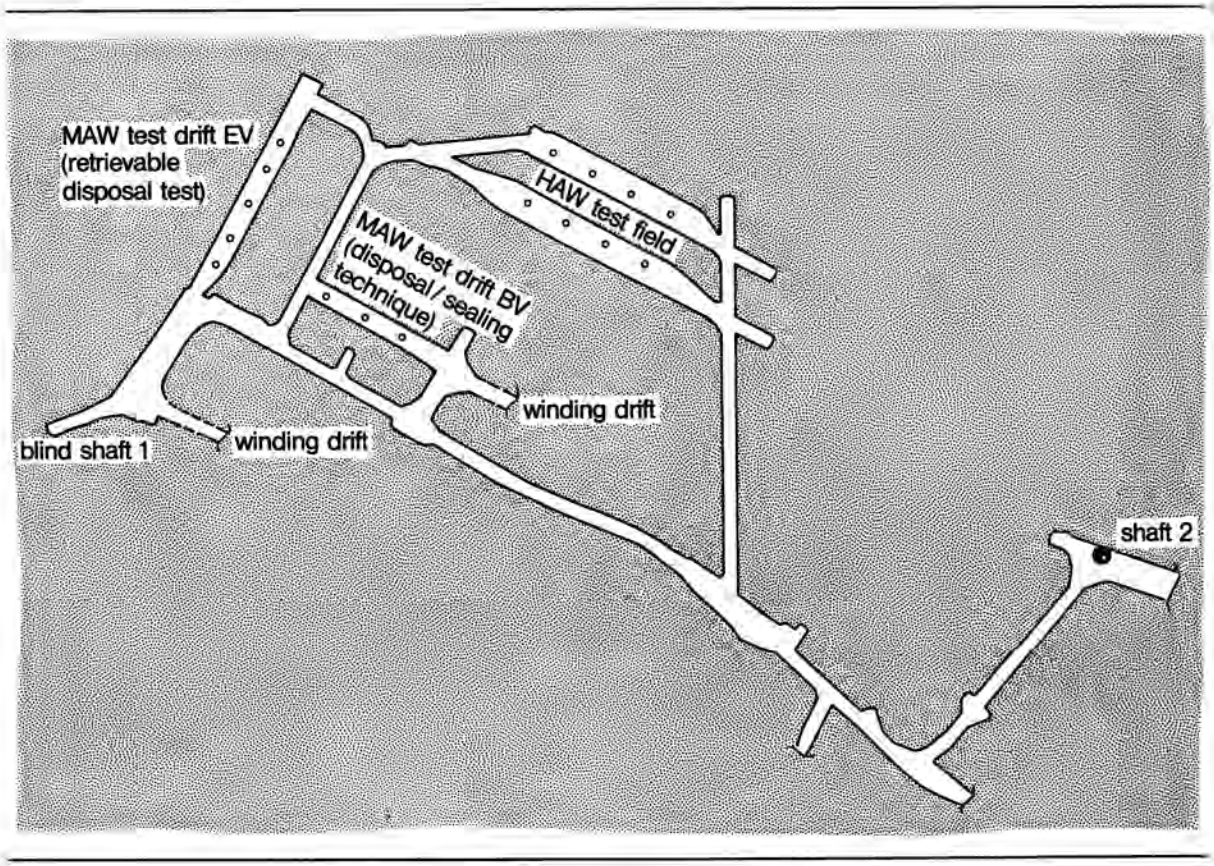

Fig. 1. Test Drifts at the 800 m Level of the Asse Salt Mine.

system. Apart from the lowering-phase, the borehole is closed with a slide. If necessary, the annular gap between the drum and the wall of the borehole may be filled with crushed salt, and the stacking forces may be dissipated into the borehole wall, using a simple spreading device positioned between a certain number of packages.

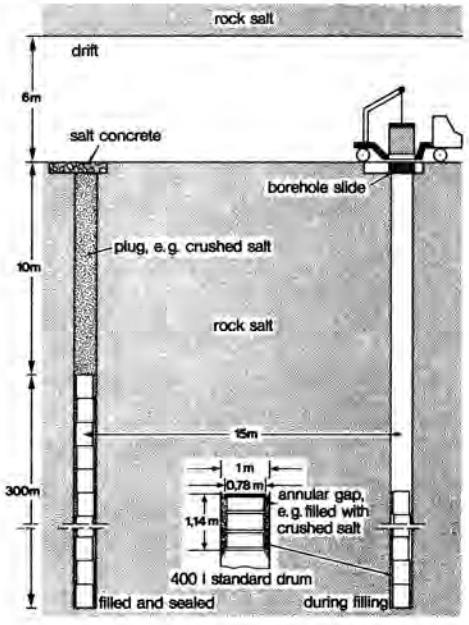

Fig. 2. Untubed Vertical Boreholes for Final Disposal of Heat-Producing MAW and HTR-FE.

When the borehole is filled with waste drums up to 10 m below the drift, the slide will be removed, and a plug will be inserted. The plug has to provide for radiation shielding as well as sealing against radioactive gases (during normal operation) and brine (in case of an accident). As indicated in Fig. 2, the plugging system may simply consist of crushed salt covered with a slab of salt concrete, but more complex constructions might become necessary for reasons of radiation protection of the personnel.

This MAW borehole technique will be tested in situ in the MAW test drift BV with its 3 boreholes V1-V3, using prototypic components for handling and inactive dummies for the MAW packages.

Borehole V1, having a depth of 10 m, serves to demonstrate the gas tightness of the final disposal plug as a function of time at a relevant temperature. For this purpose, inactive test gases like hydrogen and krypton will be injected at the bottom of the borehole, and the migration of these gases through the plug will be measured.

Borehole V2 will be operated without a plug and is envisaged for control measurements.

Borehole V3 has a depth of about 30 m and serves to demonstrate the commercial feasibility of the disposal and sealing technique. Inactive 400 l-drums will be emplaced using the prototype technique, and the borehole will be sealed with the plug. The mechanical properties of the plug will be determined from samples taken by core drilling.

In order to simulate a temperature level of about 70°C in the salt relevant for the final repository during the operating phase of a MAW disposal drift, electric heaters will be installed around the boreholes. Pressure built-up, borehole convergence and temperatures will be measured and compared with computations predicting these parameters.

Retrievable Disposal Test

The safe underground handling and emplacement of MAW and HTR-FE is demonstrated in a retrievable disposal test with a limited number of radioactive waste packages. The test design is influenced by the specific situation in the Asse salt mine and the waste packages available. As far as possible, well-known components which have already been applied in the Asse will be used.

Two hundred 1 standard drums with MAW are available from reprocessing of PWR fuel with a burn-up of 39 GWd/t. As an example, Fig. 3 shows schematically one of two drums with cladding hulls. The hulls are fixed with cement in a removable insert, which is used due to the inevitable surface contamination during the filling procedure in the WAK. The outer drum is equipped with a lid having a lifting ring, which is compatible with an existing grapple system.

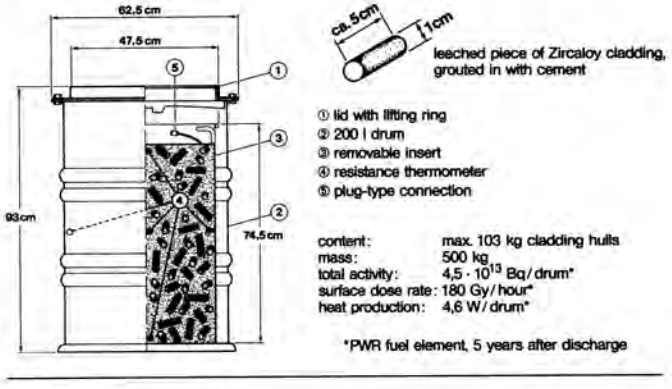

Fig. 3. Retrievable Disposal Test: 200 l Standard Drum with Cladding Hulls Fixed with Cement.

With the same design, one drum with structural components from two PWR fuel elements, and three drums with dissolver sludge on a filter unit will be available for the disposal test.

In addition, four stainless-steel cans with spent spherical fuel elements from the german high-temperature test reactor AVR will be available for the retrievable disposal test. Figure 4 illustrates the design of the can which is currently being used for dry intermediate storage, and gives characteristic data.

One main objective of the project's investigations is to quantify the release of radioactive and non-radioactive gases from the waste packages, which could affect the radiological as well as the working safety of the personnel and the environment. Tritium, krypton-85 and hydrogen have to be taken into

consideration. Hence, prior to the in-situ disposal test the reprocessing waste packages will be checked for at least one year in an hot-cell experiment in the KFA (Fig. 5). The six inserts of the 200 l-drums will be put separately into gas-tight overpacks and checked for the gases mentioned above. Electrical heating of the overpacks to simulate the temperature in a borehole in a final repository is provided, the temperature inside the waste drums will be checked by resistance thermometers. Similar measurements have already been done for the fuel element cans.

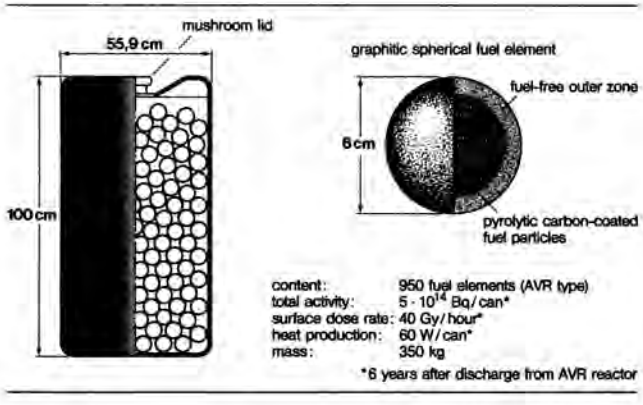

Fig. 4. Retrievable Disposal Test: Stainless Steel Can (AVR-TL Type) with Spent HTR Fuel Elements.

After the hot-cell testing, the waste packages will be emplaced for up to five years during the retrievable disposal test. Figure 6 illustrates the MAW test drift EV, where the in-situ testing will take place. Five boreholes with a depth of 10 m each and a diameter of 1 m are foreseen.

Borehole E5 (precursory test) serves for optical inspection of the borehole convergence. Inspection will start at least one year before the start of the radioactive in-situ test itself. As well as borehole E1 (reserve), this borehole is operated without radioactive waste.

The remaining boreholes accomodate the radioactive waste packages with dissolver sludge (three in borehole E2), cladding hulls and structural components (three in borehole E3), and spent HTR fuel elements (four in borehole E4), which will be removed from the Asse after the completion of the test. These boreholes are closed with a slide. Measuring lines are led into cabinet racks, which are connected to a computer-supported data logging in an air-conditioned measuring container.

Figure 7 shows as an example the equipment of borehole E3. The reliable retrieval of the disposed MAW packages at all times during the test has to be guaranteed. Due to the relatively small borehole convergence expected at a temperature less than 55°C, this is achieved by stacking the packages in an open storage rack, and with a sufficiently dimensioned

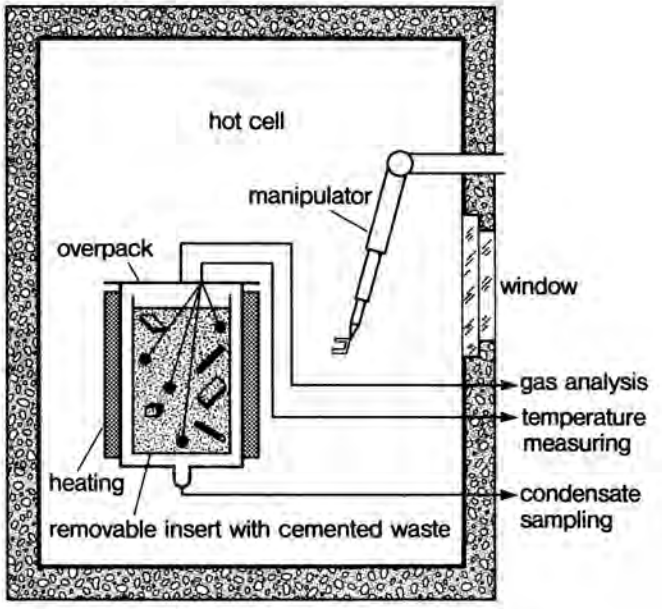

Fig. 5. Hot-Cell Experiment Concerning Analysis of Gases Released from Cemented Waste Packages.

annular gap between the rack and the untubed borehole wall. Convergence has been pre-calculated by geomechanical computation, the diameter of the remaining gap will be surveyed during the disposal test by redundant distance meters. Temperature and concentration of gases (hydrogen, tritium, krypton) in the borehole will be measured together with the inclination of the rack during the disposal test.

TIMETABLE

The general timetable of the project is given in Fig. 8. It is oriented towards the PTB structure plan for the Gorleben repository, which requires presentation of basic results of this project in early 1990. The status of the project as of March 1986 is as follows:

In sub-project I, the conceptual design of prototypic components will be finished in most parts at the end of this year. Inactive testing of the prototypes in the Asse is scheduled to start in late 1987.

In sub-project II, the modified components are designed and in parts fabricated. The hot-cell experiment is installed and ready for starting. The test drift EV in the Asse is being excavated. According to current planning, starting of the fully-active disposal test is scheduled for the second half of 1987.

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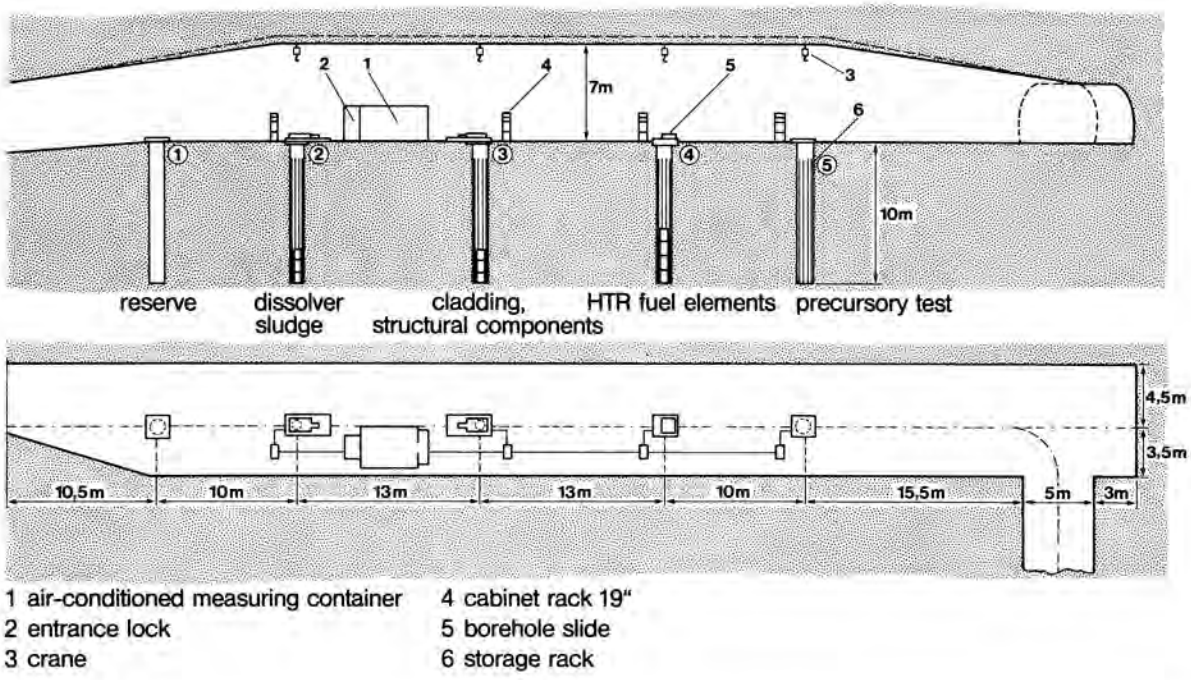

Fig. 6. Schematic View of the MAW Test Drift EV (Retrievable Disposal Test).

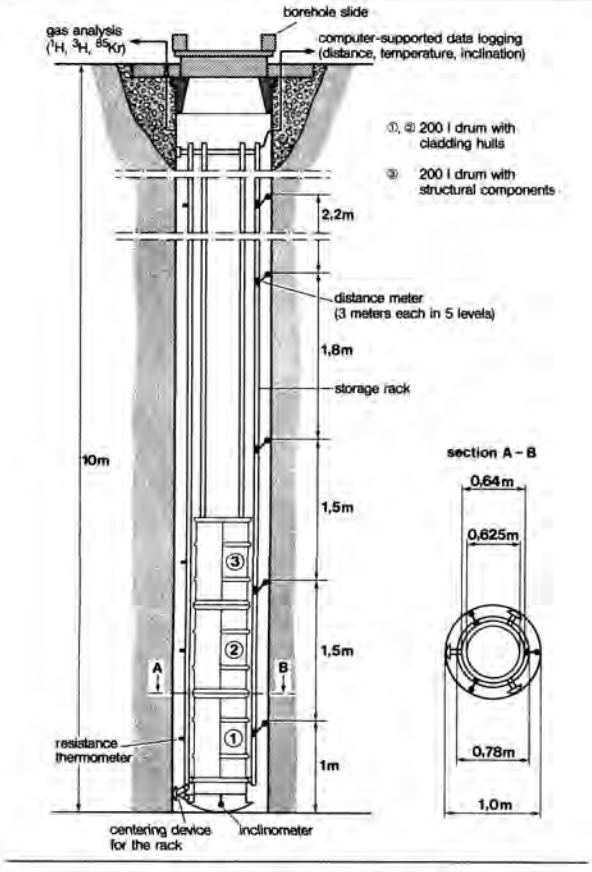

Fig. 7. Equipment of Borehole E3 in the MAW Test Drift EV.

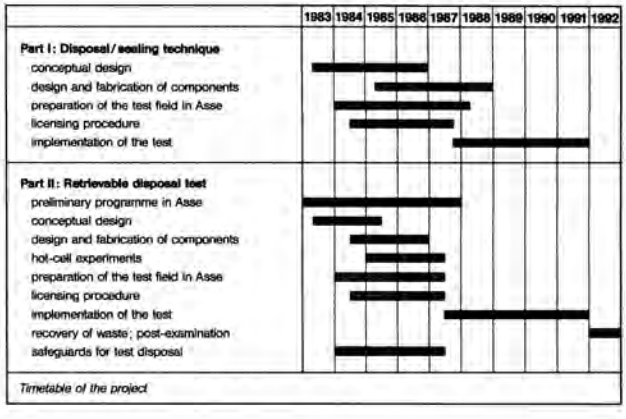

Fig. 8. Timetable of the Project.