[Form 2 (to be reported to Committee on Countermeasures for Contaminated Water Treatment and to be disclosed to public)

Technology Information	
Area	5& 6 (Select the number from "Areas of Technologies Requested")
Title	
Submitted by	British Geological Survey (part of Natural Environment Research Council)

1. Overview of Technologies (features, specification, functions, owners, etc.)

BGS uses innovative technology to understand the sub surface particularly where traditional methods can't be deployed.

In order to deploy effective countermeasures for contaminated water it is vital to understand in detail the flow of water through the site. These pathways are defined by the underlying geology and therefore there is a clear need to investigate the geological structure and hydrogeological parameters (permeability, groundwater levels and saturation, hydraulic gradients) of the Fukushima catchment.

We would recommend the use of groundwater tracers and non-invasive and minimally destructive geophysical methods such as ALERT, the use of GSI3D geological modeling and building from this unique geological model to develop a hydrogeological model of the catchment and then use the modeling in scenario development for remedial measures to be identified.

Tracers

Tracers such as the chlorofluorocarbons (CFCs) are the result of man-made inputs to the environment and are best suited to dating young groundwaters, which is likely to be the case in this particular catchment. In some cases such anthropogenic compounds can also be used to trace groundwater flowpaths. These tracers could be used to help identify specific recharge points in the catchment and subsequent groundwater flowpaths and therefore support groundwater flow modeling.

Geophysical Monitoring –ALERT

Geo-electrical imaging and monitoring methods (e.g. electrical resistivity tomography, ERT) are suitable for generating 3D volumetric images of the subsurface beneath the nuclear plant and monitoring changes in groundwater/contaminant flow remotely and over long periods of time. Such methods are also appropriate to monitor in 3D/4D the success of proposed mitigation measures, such as the fence of abstraction boreholes upgradient from the reactors, barriers and a cryogenic barrier surrounding the reactors.

ALERT uses permanent *in situ* electrode arrays and intelligent instrumentation to remotely capture volumetric images using wireless telemetry (GSM, GPRS, WiFi or satellite telecommunications).

Sites may be interrogated 'on demand' from office-based PCs, thereby avoiding the need for expensive repeat surveys and manual intervention. This development has involved the design of a new instrument, a customised relational database to handle the unprecedented data streams, finite-element numerical modelling and novel time-lapse image reconstruction algorithms.

Geological Modelling

A geological modelling approach should be undertaken using a system called GSI3D which has been implemented to build models of the shallow subsurface, which can then be used to understand geologically related issues such as hydrogeological properties. The geological models constructed in GSI3D integrate surface data, including Digital Elevation Models, boreholes and other subsurface data (e.g. structure contour plots, geophysical sections). Using this data and information, a geological cross section network is constructed as the basis for 3D models. Geologists draw their sections based on facts such as borehole logs correlated by expert geological knowledge to inform where the sections are made. The network of geological cross sections is then used to construct the 3D model through mathematical interpolation between the nodes along the drawn sections. This method draws on the geologists' wealth of understanding of earth processes gathered over a career in geology. The models are then attributed with geological data and integrated with a variety of other data including geotechnical and physical properties.

3D geological models have been constructed from site to regional scale and to any level of detail required, from correlated sections characterising one geological unit, up to hundreds of sections depicting many different geological units. Using the models it is possible to predict not only the types of rocks beneath a site, but also the engineering properties, hydrogeological properties (such as permeability, porosity and thickness of the unsaturated zone) and geohazard potential and to develop a risk based approach to understand groundwater resources and flow paths

Hydrogeological Modelling

Further to this there is a clear need for a range of numerical solutions based on the 3 D geological modelling that can be used to establish a full water balance for the site including recharge calculations based on landuse evapo-transpiration, overland routing, calculation of recharge, and simulation of groundwater flows to features such as rivers, springs, pumped boreholes. These models are available and designed to simulate groundwater flow processes at

different scales through grid refinement. In terms of recharge calculation, this will permit the inclusion of the whole catchment using a coarse mesh for a full calculation of water balance while also providing recharge values at a finer scale mesh that overlay the groundwater model. In terms of flow processes, mesh refinement allows the representation of processes at specific features such boreholes and trenches without compromising the run time of the model.
There is also expertise needed in linking models of different natures to improve process simulation. This flexible model linking technology is used to improve the simulation of groundwater / surface water interaction by linking a surface water model to a groundwater model. It is also used to improve the simulation of groundwater flow to boreholes under different recharge rates or land use within a catchment rather than a site context. Scenarios involving changing the routing directions of overland flows to study the impact of drainage schemes on groundwater elevations can then be undertaken.

Combining Technologies
It would be most effective to use the four technologies described above in an integrated way with the geological model providing the basis for the hydrogeological model and the geophysical monitoring and tracers informing the initial geological understanding but importantly being used for the duration of the project to monitor and inform hydrogeological models and monitor the effects of counter measures put in place.

GeoVisionary visuaisation could be used to demonstrate the results of the site conceptualisation and is a persuasive medium to communicate to non-technical specialists.
It is also a powerful engine in which to integrate and display very different data formats into one environment.
GeoVisionary was developed by Virtalis in collaboration with the British Geological Survey as specialist software for high-resolution visualisation of spatial data. The initial design goal was to ensure that data sets for large regions, national to sub-continental, could be loaded simultaneously and at full resolution, while allowing real-time interaction with the data. One of the major advantages GeoVisionary offers over other visualisation software (3 & 4D GIS) is its ability to integrate very large volumes of data from multiple sources, allowing a greater understanding of diverse spatial datasets.

2. Notes (Please provide following information if possible.)
- Technology readiness level (including cases of application, not limited to nuclear industry, time line for application)

All of the technologies described above have been used on commercial research projects and

could be readily deployed at the site.
ALERT- currently applied to UK nuclear industry.

3D Geological Modelling used by NDA in current active project. . 3D geological modelling is carried out routinely in the UK and has been undertaken also in Libya, Germany, United Arab Emirates and Tajikistan.

Hydrogeological Modelling used in the UK and internationally to understand Groundwater resource issues and pollution pathways

- Challenges

- Others (referential information on patent if any)

We have all necessary IPR to use these technologies on commercial and scientific projects and can supply outputs in a range of formats to suit the user.

【Areas of Technologies Requested】

(1) Accumulation of contaminated water (Storage Tanks, etc.)
(2) Treatment of contaminated water (Tritium, etc.)
(3) Removal of radioactive materials from the seawater in the harbor
(4) Management of contaminated water inside the buildings
(5) Management measures to block groundwater from flowing into the site
(6) Understanding the groundwater flow