[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	Coupled modelling to support ground freezing strategy, and development of longer-term groundwater management strategy
Submitted by	Quintessa Ltd

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

TEPCO are planning to use ground freezing to develop a hydraulic barrier up gradient of the o.p. 10m area. The installation of such a barrier will have significant effects on the ground conditions, resulting from thermal, mechanical and other processes. Properly understanding the implications will be key to the successful implementation of the scheme.

Codes exist that can model such conditions, but the QPAC code is novel due to its very flexible structure, enabling processes to easily be added or removed from models. This makes it particularly suitable for rapidly developing models, or simulating new or unusual situations. Of immediate relevance is the ability to couple groundwater flow, heat, mechanical effects and contaminant transport, including: variable density flow; the impacts on freezing on salinity and hence flow and the energy required for complete freezing; coupled changes in open porosity and permeability with partial and complete freezing; coupled changes in the volume of water and rock with temperature and the impacts on porosity, pressures and the amount of water in storage; and the effects of latent heat.

These capabilities are of direct benefit:

- To help design the ground freezing system e.g. required spacing of wells for liquid nitrogen injection.
- To determine the liquid nitrogen injection rate needed to maintain the barrier.
- To help control the extent of frozen ground – ensure a continuous barrier; ensure the barrier does not extend into areas where it might damage engineered facilities and infrastructure.
- To assess monitoring data and the performance of the barrier post-installation.
- To determine the impacts of ground freezing (and any other barriers) on contaminant migration.

An iterative process of site investigation / monitoring and modelling can be used to improve understanding of the groundwater system, and target further investigation / monitoring where it will be most effective, making best use of available resources and minimising worker doses.

In the future, once the spent fuel in the reactor cores and ponds has been retrieved, cooling using water will not be required. At this time TEPCO might wish to implement a different long-term groundwater management strategy to ground freezing, for example pumping groundwater to reduce heads in the o.p. 10m area to basement level to prevent discharge into the reactor basements. The model can be used to design and assess these alternative longer-term strategies.

2. Notes (Please provide following information if possible.)

- Technology readiness level (including cases of application, not limited to nuclear industry, time line for application)

QPAC is available immediately, including existing modules for modelling groundwater flow, heat and contaminant transport. QPAC has been applied to a wide range of coupled modelling problems for clients in the nuclear, CO_2 and industrial chemical sectors including JAEA, Andra, Nagra, NDA RWMD, EDF energy and LLWR Ltd.

- Challenges

Complex coupled models can have very long run times, in particular for models with large numbers of elements. To minimise run times and support rapid design and installation of ground freezing, an appropriate modelling strategy will be to start with simple models of key parts of the system, and subsequently progress to models of the whole system with a much larger number of elements. QPAC models of key parts of the system, which include all the processes of interest, can be used to complement detailed groundwater flow models developed using conventional groundwater flow codes that only consider a subset of the processes of interest.

- Others (referential information on patent if any)

QPAC is Quintessa Limited's Intellectual Property (IP). Licenses are not available, but we can supply models to clients using 'QPAC player', which enables specified input parameters to be varied, the model re-run, and the results interrogated. Alternatively, we can use QPAC to develop and prototype bespoke software for clients. Further information is available from:
http://www.quintessa.org/software/QPAC/index.html

【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