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

Technology Information	
Area	2, 5, 6 (Select the number from "Areas of Technologies Requested")
Title	Remote geophysical monitoring of groundwater flow and remediation efficacy
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1. Overview of Technologies (features, specification, functions, owners, etc.)

Quantification of subsurface hydrological and geochemical properties and their change over space and time is needed to design and assess the success of remedial treatments. Techniques for characterizing the subsurface have conventionally relied on 'point' measurements acquired at the land surface or through borehole access to the subsurface (such as through core or log analyses). Given the heterogeneous nature of the subsurface, the inability to characterize controlling properties at a high enough spatial resolution and over large enough regions using conventional approaches has limited the successful implementation of remediation or containment strategies that honor subsurface variability and thus that are efficacious for long periods of time.

To better address such limitations, LBNL has pioneered the development of the fields of hydrogeophysics (Hubbard and Rubin, 2005; Hubbard and Linde, 2011) and biogeophysics (e.g., Williams et al., 2009), which integrate geophysical and point measurements to quantify shallow subsurface hydrological, geochemical, and microbiological properties over large spatial extents and in a minimally invasive manner. When collected in a time-lapse sense, these geophysics-based approaches have been successfully used to track infiltration (Kowalsky et al., 2005), groundwater flow and the mixing of fresh and contaminated groundwaters (Kowalsky et al., 2011; Gasperikova et al., 2012), and the onset and spatial distribution of geochemical products resulting from remediation treatments (Flores Orozco et al., 2013; Hubbard et al., 2008). Hydrogeophysical inverse methods have also been used to successfully estimate parameters that control subsurface flow and transport (e.g., Kowalsky et al., 2005; Murakami et al., 2010). This hydrogeophysical and biogeophysical expertise is recognized as a US Department of Energy core competency for environmental remediation of metals and radionuclides. Implemented across the US at key Department of Energy contaminated sites, the capability has led to vastly improved understanding of shallow subsurface heterogeneity and subsurface responses to remediation treatments as well as to improved predictions of subsurface flow and transport (Scheibe et al., 2006).

Implementation of these advanced geophysics-based approaches at the Fukushima Daiichi nuclear site are expected to be useful for both characterization (e.g., delineating subsurface stratigraphic relationships of relevance to contaminant mobility, including the distribution of sand- vs. silt/clay-rich facies, permeability and other transport parameters) and remote monitoring of natural and reclamation-induced subsurface processes (e.g., water table, groundwater salinity). Of note, prolonged monitoring using such approaches can be done in a remote, autonomous fashion not requiring direct exposure of personnel to potentially hazardous conditions in the vicinity of the plant and its environs. Integration of time-lapse borehole-to-borehole and surface-to-borehole geophysical datasets (including seismic, radar, and/or electrical) with discrete point-based (hydrological, geochemical, physical) is expected to be invaluable for illuminating (a) the spatiotemporal distribution of and response to a remediation treatment; (b) the efficacy of installed groundwater barriers; and (c) the flow and mixing of upgradient (fresh) groundwater with contaminated groundwaters and marine waters. The high-resolution quantification of subsurface processes and properties will in turn enable improved remediation, control of subsurface flow and transport and prediction of subsurface processes.

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

The subsurface imaging and data fusion approaches are ready to be deployed.

- Challenges

The presence of metal infrastructure in general hinders the ability to use electrical methods. Other methods (such as seismic) are not sensitive to the presence of metal in the ground or at the ground surface. An assessment of the location of site infrastructure relative to the imaging targets (plumes, treatments, barriers, etc.) would need to be performed to determine which method or combination of methods are likely to be most successful, as would assessment of infrastructure requirements (e.g., electrical power and cellular phone networks) enabling remote, autonomous data collection.

- Others (referential information on patent if any). NO RELATED PATENTS

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