Quantification and Monitoring of Water and Contaminant Migration to Sediment via Groundwater-Surface Water Interaction

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Introduction: Many terrestrial contaminated and hazardous waste sites are located adjacent to harbours, bays, estuaries, wetlands and other coastal environments (Chadwick et al., 2003a). Whilst soil and groundwater impacts are often studied, characterization and risk assessment often ends at the water's edge. There are emerging recognition and requirements to determine if contaminants from these sites are migrating into marine and surface water systems at levels that could pose threats to aquatic ecosystems and services. The complexity of these interactions dictates the need for adaptive characterization methods and new technologies to adequately identify zones of interaction, determine if these zones are contaminated, and quantify the rates of migration and flux to surface water systems. Here we describe a methodical yet adaptive procedure, along with new technologies to improve the ability to characterize these sites.

Methods: The approach utilizes three progressive and adaptive phases of characterization that build toward a quantitative representation of migration in sediments. In the first phase, direct-push sensor technology is used to rapidly map areas of potential groundwater discharge. In the second phase, areas of potential discharge are assessed using low-flow, subsurface porewater samplers to determine if contamination is associated with discharge zones. In the final stage, areas of contaminant discharge are evaluated using ultrasonic seepage meters to determine rates of discharge and contaminant flux. Two new technologies were developed to support this approach; a direct-push screening probe for determining where groundwater may be discharging and sampling those zones (the Trident Probe), and a seepage detection system (the UltraSeep; Figure 1). The Trident rapidly distinguishes differences in conductivity and temperature that indicate areas where groundwater discharge is occurring; the integral porewater sampler can then be used to rapidly confirm the presence of target chemical constituents. The UltraSeep is an integrated seepage meter and water sampling system that allows for direct quantification of discharge rates and chemical loading (Chadwick et al., 2003b).

Fig. 1: UltraSeep deployment at a site in northern California, USA.

Results: Results from a range of demonstrations and applications are summarized to illustrate the methodology and capabilities of the new technologies. Case studies include examples of identification of discharge zones based on subsurface conductivity and temperature distributions, mapping of subsurface contaminant distributions at the groundwater surface water interface, quantification of temporally varying groundwater discharge rates, and measurement of chemical discharge concentrations and mass flux. Trident configurations for multiple-depth sensors and sampling, and deployment in conditions ranging from shallow, quiescent waters, to deep, fast moving rivers are illustrated. Results from seepage meter deployments ranging from relatively steady discharge in lakes, to coastal areas of strong tidal influence are also presented.

Discussion: The procedures and technologies presented provide a coherent strategy for assessment of coastal sites where groundwater-surface water interaction may be an important pathway of exposure and risk. The method provides an efficient means of focusing the assessment to key areas of potential concern, and developing quantitative exposure and loading estimates in those areas. Application of these technologies over a broad range of sites and conditions indicates the robust nature of the method.

References: [1] Chadwick et al. (2003a) *Technical Report #1898, SSC San Diego, US Navy.*; [2] Chadwick et al. (2003b) *Technical Report #1903, SSC San Diego, US Navy.*