Dioxin Remediation at the Da Nang Airport Using the Incremental Sampling Methodology for Soil and Sediment Confirmation Sampling

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Background/Objectives. From 1962 to 1971, the United States military used herbicides such as Agent Orange to defoliate forests and kill crops in Viet Nam. Dioxin is a persistent pollutant, and has remained in soils at the Da Nang, Viet Nam airport until remediation activities began in 2012. The Da Nang airport was a former U.S. military installation where large volumes of Agent Orange were handled. The concentrations of dioxin in soil and sediment ranged from 674 picograms per gram (pg/g) to 361,000 pg/g, which exceed the Vietnamese guidelines for dioxin of 150 pg/g in sediment and 1,000 pg/g in soil. This airport was selected by the Government of Vietnam as a priority remediation area to limit dioxin exposure to humans.

The objective of this project was to remediate dioxin contamination from Agent Orange and verify that concentrations of large volumes of treated soil and sediment, and large volumes of soil and sediment remaining after excavation met project goals. The remediation of dioxin contamination at the Da Nang airport represents one of the largest such treatment projects in the world, whether measured by area, volume or cost. A significant challenge was estimating a true, defensible mean concentration over such large volumes. The solution was to use the Incremental Sampling Methodology (ISM) to characterize large areas (some larger than 1 hectare) and volumes (up to 7,500 m3) of treated or remaining soil and sediment.

Approach/Activities. ISM is a statistically-based, composite sampling and processing method. The goal of ISM is to decrease variability and determine mean concentrations of contaminants, while limiting potential sampling or analytical bias. Determination of appropriate decision units (DUs) based on the conceptual site model is a critical step in the planning process. A minimum of 30 increments are collected from each DU, composited and processed into one sample. When compared with discrete samples, in which each increment would need to be analyzed separately, using the ISM can save more than 90% of the analytical costs at the laboratory. After excavation was complete in each DU at Da Nang, confirmation sampling was performed using ISM. Excavated soils were treated using thermal technology, and confirmation sampling was performed for treated soils. More than 400 DUs were sampled as part of this project. More than 40 triplicate samples were collected to allow determination of variability and confidence level.

Results/Lessons Learned. Application of ISM decreased analytical costs and showed with high confidence whether areas contained residual contamination requiring further action. ISM significantly reduced variability relative to conventional sampling, averaging 33% between samples. ISM helped to guide excavation through the use of sub-decision units of various sizes, and did **not** underestimate levels of contamination based on concentration averaging when compared with traditional sampling methods. Ultimately ISM demonstrated that all soil and sediment exceeding project goals was removed and successfully treated thermally, or in some cases contained ex situ.