ATTACHMENT 1:
ISCO Site Characterization Data Needs

The following pages contain a suggested checklist of data to be used as a basis for ISCO screening and design. It is acknowledged that not all sites will initially have this extensive of a dataset. It is recommended, however, that the dataset for determining ISCO viability include, at a minimum, those items in **bold** type. Data needs that are not in bold type may still be important to ISCO screening and conceptual design. Depending on site-specific conditions and the oxidant to be used, design may still be quite sensitive to these parameters and data regarding these parameters may need to be collected in later phases. The checklist includes parameters that are needed for design of almost any in situ remediation technology, in addition to a few ISCO-specific parameters.

It also must be appreciated that there are various degrees or levels of refinement for many of these parameters that will vary depending on the stage of the project. For example, to delineate the extent of contamination for a remedial investigation (RI), monitoring wells spaced every 300 ft. may be adequate for very large sites. But this type of spacing may not be adequate for remedial design where the radius of influence of an injection well may only be 25 ft. The RI information may be used for screening, but additional design characterization may be needed to complete the conceptual and final design.

A conceptual site model (CSM) should be developed and include the major components listed below and the following general site activity information:

A. Site history considering past, current, and future uses
B. Age, type, and location of release(s)
C. Site geology and hydrology
D. Previous remediation activities and remedial progress made at the site
E. Applicable regulatory program under which remediation is being conducted
F. Current site management plan and exit strategy

The CSM can be prepared in a multitude of different ways ranging from purely graphical to text supplemented with some key graphics such as a contamination delineation map and a conceptual cross section of hydrogeology and contamination distribution. While graphical means are typically more effective, the preferred presentation format to best serve a project team is left to their discretion.

Projects with lacking datasets can proceed with the ISCO Protocol; however, data gaps will likely introduce uncertainty in ISCO design and ability to meet the ISCO treatment goals (i.e., the desired post-ISCO remediation endpoint with respect to changes in COC concentration and/or mass). The acceptable level of uncertainty in the CSM is a function of project owner's desires and will vary from site to site depending upon many factors including the rigidity of the remedial action objectives.

Additionally, if the Observational Approach is followed throughout the technology screening, design, and implementation processes, much of the additional data can be collected on an as-needed basis to fill important data gaps and address the related uncertainty. It may be in the project team's best interest to collect excess soil and groundwater (and store using proper procedures) from the site for later analyses if ISCO emerges as a viable remedy. This technique will save costs for future deployment for sample collection. An example of such sampling would be to collect enough soil for a natural oxidant demand (NOD) test during the RI if chlorinated solvents are presumed to be present; storing the sample; and running the NOD test later should permanganate emerge from the screening stage as the preferred oxidant.

Table A1-1. Site Characterization Data Needs Checklist

Site plan

- ☐ **Plan should be to scale**
- ☐ **Topography and ground surface elevations**
- ☐ **Lateral extent of contaminant source zone(s) and plume(s) delineated**
- ☐ **Location of major site infrastructure identified with emphasis on implications for site access (e.g., buildings, roadways, utilities, fencing, tanks, etc.)**
- ☐ **Locations of monitoring wells, soil cores, or other characterization sampling activities should be clearly identified**
- ☐ Location of potential risk receptors (e.g., wells, surface water bodies, residences, etc.)
- ☐ Regulatory compliance locations (e.g., wells that are point of compliance, property lines, etc.)

Contaminant of Concern (COC) data

- ☐ **Identification of COCs**
- ☐ **Estimate of lateral and vertical extent of contamination (source and plume areas)**
- ☐ **Approximate information on source mass and/or phase distribution (dissolved-phase only, significant sorbed mass, NAPL suspected or known to exist, pooled NAPL, etc.)**
- ☐ **Approximate age of the spill or release**
- ☐ Historic summary of COC concentrations at each sampling location (soil and groundwater), where available
- ☐ Historic extent and concentrations of co-contaminants

Hydrogeology data

- ☐ **Identification (e.g., continuous log) of all significant lithologic layers present within and immediately adjacent to the contaminated zone**
- ☐ **Identification of prominent confining or semi-confining layers that govern groundwater flow**
- ☐ **Aquifer material characteristics**
  - **If site is consolidated, determine / estimate the following:**
    - ☐ **Estimate of permeability (primary / secondary)**
    - ☐ Fracture aperture, spacing, attitude, and continuity
    - ☐ Porosity (primary / secondary)
    - ☐ Transmissivity
  - **If site is unconsolidated, determine / estimate the following:**
    - ☐ **Hydraulic conductivity as measured by field tests (if hydraulic conductivity is obviously high (e.g., coarse uniform sand) or obviously low (e.g., clay), measurement is not necessary for screening)**
    - ☐ **Characterization of heterogeneity (e.g., is formation primarily permeable or impermeable, assessment of likely variation in K between distinct strata, evaluation of interconnection of high K zones, evaluation of whether fractures or other preferential pathways exist)**
    - ☐ **Depth to confining layer**
    - ☐ Porosity
- ☐ **Estimation of groundwater elevations, hydraulic gradients (horizontal and vertical), flow direction,** and potential for transience during seasonal or storm-related atmospheric weather events
- ☐ Grain size analysis on significant lithologic layers
- ☐ Major surface lithology features and their implications for the groundwater environment (i.e., faults, ridges, sinkholes, etc.)

Table A1-1. Site Characterization Data Needs Checklist (cont.)

Hydrogeology data (cont.)

- ☐ Evaluation of hydraulic connections with surface water body risk receptors such as seeps or streams
- ☐ Determination if other overlying or underlying aquifers are present, and their implications for the hydrologic environment

Cross Section of Hydrogeology and Contamination

- ☐ **Profile to scale and located along the primary source / plume core alignment**
- ☐ **Contaminant source zones and plumes delineated laterally and vertically**
- ☐ **Major site surface and subsurface infrastructure identified with emphasis on implications for site access (e.g., buildings, roadways, utilities, fencing, tanks, etc.).**
- ☐ **Prominent geologic layers identified to the base of the contaminant plume**
- ☐ **Confining or semi-confining lithologic layers identified**
- ☐ **Piezometric surface for aquifer(s) of concern**
- ☐ **Risk receptors (e.g., wells, surface water bodies, residences, etc.)**
- ☐ **Regulatory compliance locations (e.g., property lines, etc.)**
- ☐ **Locations of monitoring wells, soil cores, or other characterization sampling activities clearly identified**

Geochemistry data

- ☐ **Groundwater ORP/Eh**
- ☐ **Soil / groundwater pH**
- ☐ **Dissolved oxygen**
- ☐ **Temperature**
- ☐ Alkalinity
- ☐ f_{oc} of soil within saturated and unsaturated zones of the contaminated zone
- ☐ Other geochemical indicators of natural biodegradation including nitrate, sulfate, ferrous iron, methane, dissolved organic carbon, and contaminant degradation by-products (e.g., ethene for chloroethene-contaminated sites)

Fate and transport analysis and natural attenuation (NA) evaluation

- ☐ Evaluation of the effectiveness of NA mechanisms (biodegradation, diffusion, dispersion, adsorption, and volatilization)
- ☐ Assessment of current and potential future plume stability
- ☐ Trend graphs of routine groundwater monitoring data from key source and downgradient wells
- ☐ Estimated timeframe required for remediation via NA

Preliminary remedial goals (PRGs) and/or remedial action objectives (RAOs)

- ☐ **Analysis of applicable regulations**
- ☐ **Identification of numeric and non-numeric RAOs**
- ☐ **Identification of numeric PRGs needed to meet RAOs**
- ☐ **Determination of the necessary endpoint to be achieved as a result of ISCO (the ISCO Treatment Goal) that is needed to attain the PRGs and/or RAOs**
- ☐ Risk assessment results including land use, receptors, major exposure pathways, and resultant current and potential future human health and environmental risk

Table A1-1. Site Characterization Data Needs Checklist (cont.)

Figures showing preliminary target treatment zone

- ☐ Identification of lateral and vertical extent of zone of PRG exceedance
- ☐ Identification of lateral and vertical extent of ISCO target treatment zone
- ☐ Identification of lateral and vertical extent of no-construction zones that can’t be accessed for treatment (e.g., active manufacturing building or mission-critical flight line at a USAF base)

ISCO-specific data

- ☐ **Health & safety and other issues**
- ☐ Permanganate natural oxidant demand (e.g., 48 hour test in ASTM method D7262-07) for chlorinated ethene-contaminated sites (i.e., where permanganate is a likely candidate)*
- ☐ Soil and groundwater metals concentrations
- ☐ Mineralogy – general / basic mineral composition
- ☐ Presence of “obvious” reducing agents (e.g., petroleum spills, bioremediation amendments)
- ☐ Anions/cations
- ☐ Current site uses that would constrain ISCO design (e.g., risk of gas migration into buildings, active USTs and fuel pipelines, areas of active operation that can’t be hindered)
- ☐ Subsurface utilities or open conduits for fugitive emission migration

* NOTE: a similar evaluation at this screening stage is not necessarily recommended for other oxidants because there will not be a limit to the extent of oxidant consumption. With oxidants that autodecompose when activated (via contact with natural minerals in soil or via engineered activation system), 100% of the oxidant will be depleted, albeit at varied rates of decomposition. It is prudent and economical, however, to collect enough media for later kinetic tests with oxidants for any site where ISCO may be viable.