

Lower Passaic River Restoration Project



Revised Preliminary Draft Field Sampling Plan Volume 3

July 2005



LOWER PASSAIC RIVER RESTORATION PROJECT
REVISED PRELIMINARY DRAFT FIELD SAMPLING PLAN, VOLUME 3
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1.0 INTRODUCTION

Field Sampling Plan (FSP) Volume 3 presents the technical approach for conducting site characterization activities for the Lower Passaic River Restoration Project (LPRRP). This FSP document addresses the following programs:

- Bathymetric and aerial surveys.
- Supplemental land surveys.
- Geophysical surveys.
- Soil and sediment investigations (outside of the main river).
- Water quality investigations (outside of the main river).
- Hydrologic and hydrodynamic investigations (outside of the main river).
- Cultural resource investigations.
- Socioeconomic investigations.
- Real estate investigations.

FSP Volume 3 was developed to define studies that will characterize candidate restoration sites within the Study Area, to support the Lower Passaic River Feasibility Study (FS), and to prepare an Environmental Impact Statement (EIS) to comply with the National Environmental Policy Act (NEPA). FSP Volume 3 is one part of the overall FSP, which is comprised of three volumes as described below.

Volume 1: FSP Volume 1 (Malcolm Pirnie, 2005a) includes investigations to characterize sediment and surface water quality in the Passaic River and in major tributaries. These investigations are being done to gain chemical and physical data necessary to evaluate the spatial extent of contamination, to prepare human and ecological health risk assessments, and to develop the Hydrodynamic, Sediment Transport, and Fate and Transport Models. The investigations will include measurements of hydrodynamic and sediment transport characteristics of the Lower Passaic River and major tributaries.

Volume 2: FSP Volume 2 includes investigations that relate to the biota and biological aspects of the Lower Passaic River and the surrounding watershed. Investigations are to include taking inventory and cataloging the species found within and around the Lower Passaic River and obtaining tissue samples to determine potential contaminant concentrations. FSP Volume 2 is scheduled to be developed from Fall 2005 to Spring 2006.

Volume 3: FSP Volume 3 (this document) includes additional investigations on candidate restoration sites, upland areas, and wetland areas in the Study Area but outside the main stem of the Passaic River. FSP Volume 3 also includes the 17-mile bathymetric survey of the Lower Passaic River conducted in 2004 (USACE, 2004a). Data obtained from candidate restoration site screening will also be used to support the FS where appropriate.

Together, all three FSP volumes support the objectives for the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Water Resource Development Act (WRDA) programs. The field data collected from sampling activities associated with the FSP will be used to:

- Prepare the combined CERCLA Remedial Investigation/Feasibility Study and WRDA Feasibility Study report for the LPRRP.
- Develop human health and ecological risk assessments for the Lower Passaic River Study Area to determine whether the risk range identified in the National Contingency Plan (NCP) is exceeded and warrants further assessment of remedial actions via the FS.
- Support a comprehensive, watershed-based plan to restore the functional and structural integrity of the Lower Passaic River ecosystem and to support broader, watershed-wide restoration efforts under WRDA.
- Support development of a natural resource damage assessment (NRDA) under CERCLA by the Passaic River/Newark Bay Trustees for Natural Resources [New Jersey Department of Environmental Protection (NJDEP), U.S. Fish and Wildlife

Survey (USFWS), and National Oceanic and Atmospheric Administration (NOAA)] to provide restoration for natural resources injured by contaminants and to compensate for the public's lost use of those resources.

In addition to the field data collected during the field sampling activities, historical data will also support the FS effort, where appropriate. To date, numerous historical investigations, including environmental sampling, have been conducted in parts of the Lower Passaic River by various entities having differing objectives. Therefore, it was imperative that the available information be compiled and evaluated (see Section 3.0 "Existing Data Gaps") prior to advancing in additional work associated with the completion of the FS. As such, the FS is being conducted in three major phases to facilitate a thoughtful, cost-effective, and time-efficient approach to reaching conclusions about remediation of the river in its broader environmental context. To the extent possible, this effort will involve all stakeholders in a meaningful way. The three phases are described as follows:

- Phase 1: Preliminary Data Evaluation and Site Characterization
- Phase 2: Remedial Investigations and Further Site Characterization
- Phase 3: Remedial Feasibility Studies

Phase 1 and Phase 2 activities are currently underway. Note that field investigations in Phase 2 center primarily on the 17 miles of the Lower Passaic River, but will also extend as appropriate into connected water bodies, such as the Hackensack River and tributaries, including Berry's Creek and Pierson Creek, Newark Bay, Arthur Kill, and the Kill van Kull. The FS will also take into account complementary work being conducted by Tierra Solutions, Inc. (TSI), which is under an Administrative Order on Consent (AOC) with the U.S. Environmental Protection Agency (USEPA) to conduct work in Newark Bay and its tributaries, as well as work being conducted at the direction of the USEPA in Berry's Creek (a tributary of the Hackensack River).

1.1. PROJECT BACKGROUND

The USEPA, NJDEP, U.S. Army Corps of Engineers (USACE), and New Jersey Department of Transportation – Office of Maritime Resources (NJDOT-OMR) have partnered to conduct a comprehensive study of the Lower Passaic River and its tributaries. The Lower Passaic River is the 17-mile tidal stretch of the river from the Dundee Dam south to Newark Bay. The LPRRP is an integrated, joint effort among state and federal agencies that will take a comprehensive look at the problems within the Lower Passaic River Basin and identify remediation and restoration options to address those problems. This multi-year study will provide opportunities for input from the public at all phases of development (see Section 1.3.2 “Federal and State Agency Involvement” and Section 1.4 “Community Involvement and Public Outreach” of the Work Plan; Malcolm Pirnie, 2005b). The project’s goals are to provide a plan to:

- Remediate contamination found in the river to reduce human health and ecological risks.
- Improve the water quality of the river.
- Improve and/or create aquatic habitat.
- Reduce the contaminant loading in the Passaic and the Hudson-Raritan Estuary.

The LPRRP Study Area (hereafter referred to as the Study Area) encompasses the 17-mile tidal reach of the Passaic River below the Dundee Dam, its tributaries (*e.g.*, Saddle River, Second River, and Third River), and the surrounding watershed that hydrologically drains below the Dundee Dam (116.2 square miles). Refer to Figure 1-1 for a Site Location Map. Investigations may also be conducted in major physically connected water bodies, including the Hackensack River up to the Oradell Dam, Berry’s Creek, Pierson Creek, Newark Bay, the Arthur Kill, and the Kill van Kull.

1.2. CONCEPTUAL SITE MODEL

A conceptual site model (CSM) was developed to examine the assumed sources of contaminants, routes of environmental transport, contaminated media, routes of exposure, and receptors (see Section 3.2 “Preliminary Conceptual Site Model” of the

Work Plan; Malcolm Pirnie, 2005b). Data gathered during the activities programmed in FSP Volume 1 and Volume 3 will be used to update the CSM, ultimately providing the basis to adapt and adjust field data collection.

In addition to the preliminary evaluation (Section 3.0 “Existing Data Gaps”), additional geochemical and sediment stability analyses are currently being conducted (Malcolm Pirnie, 2005b) to update the CSM and to provide guidance in determining sampling locations for the sediment field programs discussed in the FSP Volume 1 (Malcolm Pirnie, 2005a). These geochemical and sediment analyses include:

- Evaluation of historic changes in bathymetry.
- Evaluation of depositional record via radionuclide dating.
- Evaluation of historic sediment contaminant and physical properties data.

1.3. CANDIDATE RESTORATION SITES

The field sampling activities discussed in FSP Volume 3 are designed to characterize candidate restoration sites as well as upland and wetland areas. The process for selecting candidate restoration sites will be outlined in the *Restoration Opportunities Report*, anticipated to be published in late summer 2005. Note that FSP Volume 3 will be modified accordingly once candidate restoration sites are selected; these modifications will be presented in the Draft version of FSP Volume 3 and include specific sampling locations and sampling procedures.

It should be noted that not all of the candidate restoration sites will be investigated in the FSP Volume 3. However, in general, the candidate restoration sites include:

- Subtidal, intertidal, and riparian sites in the Lower Passaic River and along the river. These sites vary between predominantly marine, brackish, and freshwater.
- Large contiguous sites adjacent to the Lower Passaic River, including Oak Island Yards in Newark, New Jersey, and Kearny Point in Kearny, New Jersey.
- Main tributaries, including Second River, Third River, and Saddle River.
- Other areas in the watershed.

1.4. FIELD SAMPLING PLAN VOLUME 3 CONTENTS

FSP Volume 3 is organized into the following sections:

- Section 1.0, “Introduction,” briefly describes the field investigations and their relation to the candidate restoration site activities and FS.
- Section 2.0, “General Field Requirements,” outlines general field requirements including mobilization/demobilization, site facility, health and safety, equipment decontamination, and sample management.
- Section 3.0, “Existing Data Gaps,” provides a data gap evaluation pertinent to field tasks addressed in FSP Volume 3.
- Section 4.0, “Field Tasks,” describes the field tasks that will be conducted. For surveys and research tasks, subheadings are variable but generally consist of Data Needs and Objectives, Scope and Methods, and proposed Reporting.
- Section 5.0, “Acronyms,” contains a list of acronyms used in the document and their meanings.
- Section 6.0, “References,” provides citations for the references used in the document.

2.0 GENERAL FIELD REQUIREMENTS

2.1. MOBILIZATION/DEMOBILIZATION

Guidance for mobilization and demobilization procedures for field work will be added to this section when the field office site lease agreement is completed. The following major activities will be addressed in the Final Work Plan (based on the likely use of the field office location described in Section 2.2 “Site Facilities” below):

- Permitting, construction, and installation of a floating dock facility.
- Completion of a pre-occupancy surface sweep and wipe sample survey.
- Acquisition and launch of a field support vessel.
- Installation of an investigation-derived waste (IDW) storage facility.
- Installation of the lab benches, work stations, and equipment to be used to process sediment cores and manage sediment and aqueous samples.
- Installation of office, computer, and telephone equipment.

2.2. SITE FACILITIES

Locations and facility descriptions for the field office/sample processing facility, staging areas, and sampling/survey vessel docks have not yet been finalized. A field office location in a waterfront industrial park in East Rutherford, New Jersey at 1 Madison Street is currently under consideration. This space is an 8,700 square foot facility, consisting of a 7,200 square foot open warehouse with 20-foot ceilings and two roll-up loading dock doors, and an office area that is approximately 1,500 square feet. This space is located about 200 yards from the east bank of the Passaic River at approximately river mile (RM) 13.5.

The company that owns the industrial park also has riparian rights and is responsible for maintaining the bulkhead. The manager of the industrial park has given Malcolm Pirnie verbal permission to install a temporary floating dock against this new sheet pile bulkhead. Written authorization for the floating dock has been requested as a condition of signing the lease.

The USEPA, USACE-New York District, and NJDOT-OMR have agreed that leasing this facility is acceptable to their respective agencies.

2.3. HEALTH AND SAFETY

All FSP field tasks will be conducted in accordance with the site-specific Health and Safety Plan (HASP; Malcolm Pirnie, 2005c) and addenda, prepared in accordance with the Occupational Safety and Health Administration (OSHA) requirements contained in 29 Code of Federal Regulations (CFR) 1910 including the final rule contained in 29 CFR 1910.120. The procedures are also consistent with the guidance contained in the following documents:

- Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities [prepared jointly by the USEPA, National Institute for Occupational Safety and Health (NIOSH), OSHA, and the U.S. Coast Guard (USCG)].
- USACE's Safety and Health Requirements Manual, Engineering Manual (EM) 385-1-1, November 2003.

2.4. EQUIPMENT DECONTAMINATION

A description of equipment decontamination facilities and sequential decontamination procedures for non-dedicated equipment is provided as Standard Operating Procedure (SOP) 15 in Attachment 2 to FSP Volume 1 (Malcolm Pirnie, 2005a).

2.5. SAMPLE MANAGEMENT

Samples collected for laboratory analysis will be either driven directly to the laboratory or shipped by a commercial overnight delivery service to the laboratory on the day of collection for receipt the following morning. This process will follow proper identification, chain-of-custody, preservation, and packaging procedures. Sample packaging and shipping procedures are summarized below [for more information reference Section 2.0 "Data Generation and Acquisition" of the Quality Assurance Project Plan (QAPP; Malcolm Pirnie 2005d)]:

- Samples will be accompanied by a properly completed chain-of-custody form, which will be generated electronically. The sample identifiers will be listed on the chain-of-custody form. When transferring the possession of samples, the individuals relinquishing and receiving the samples will sign, date, and note the time on the record. This record documents transfer of custody of samples from the sampler to another individual, to the laboratory, or to/from a secure storage area.
- Samples will be properly packaged to avoid breakage, stored on ice at 4 degrees Celsius (°C) for shipment, and dispatched to the appropriate laboratory for analysis. In the event that samples will be held overnight prior to shipment, the temperature of the cooler and presence of sufficient ice will be checked and new ice will be added prior to shipment. A signed chain-of-custody form will be enclosed and secured to the inside top of each sample box or cooler. The chain-of-custody form, a cooler receipt form, and any additional documentation will be placed in a plastic bag to prevent them from getting wet.
- Shipping containers will be secured with strapping tape and custody seals for shipment to the laboratory. Signed custody seals will be covered with clear plastic tape. The cooler will be taped shut with strapping tape in at least two locations.
- It is anticipated that a courier from the selected laboratory will pick up samples from the site on a daily basis. In the event that the laboratory courier is unavailable, samples will be transported to the laboratory by a commercial overnight carrier (*e.g.*, Federal Express).
- Sample Containers and Labels. The selection of sample containers is based on the media sampled, the required analysis, and the requirements of the analytical laboratory. A non-removable (even when wet) label will be affixed to each sample container. Labels will be marked with waterproof indelible ink. The following information will be contained on each label, which will be generated electronically.
 - Project (site) name;
 - Sample identifier;
 - Company;

- Sample date and time;
- Sampler's initials;
- Sample preservation; and
- Analysis required.
- The electronic field application will automatically generate sample designations for environmental samples collected (see Section 6.4.3 “Data Upload and Validation” of the Work Plan; Malcolm Pirnie, 2005b). An example of the preliminary sample designation is “LPRP-AAAA-WBC-####”, where:
 - LPRP is the static text and stands for Lower Passaic River Project.
 - AAAA is the sample type ID.
 - WBC is the water body code.
 - #### is the 6 digit sequential number.
- The project QAPP (Malcolm Pirnie 2005d) will be referenced for sample management and recordkeeping procedures. If USEPA Contract Laboratory Program (CLP) laboratories are used for sample analysis, sample management will comply with Contract Laboratory Program Guidance for Field Samplers (USEPA, 2004).

2.6. STANDARD OPERATING PROCEDURES

SOPs will be added to this section of Draft FSP Volume 3 once field sampling activities and sampling locations are finalized.

2.7. QUALITY CONTROL AND QUALITY ASSURANCE

A quality control and quality assurance (QC/QA) program is essential for generating technically valid and legally defensible data. All aspects of the QC/QA procedure are outlined in the QAPP (Malcolm Pirnie, 2005d), including:

- Project Management Structure (QAPP Section 1.2.2).
- Project Data Quality Objectives (QAPP Section 1.5.1).
- Quality Control (QAPP Section 2.5).
- Data Validation and Usability (QAPP Section 4.0).

3.0 EXISTING DATA GAPS

To focus the field activities of FSP Volume 3, available historical data were evaluated to identify data gaps. Field tasks, which are further described in Section 4.0 “Field Tasks”, will be organized and conducted to complement the historical data and fill in data gaps. The historical data that were reviewed for this FSP included: bathymetry, topography, geophysical and geotechnical data, soils and sediment data, water quality, hydrology, cultural resources, socioeconomics, and real estate (see Section 1.3 “Site Background and History” of the Work Plan for information on site background and history; Malcolm Pirnie, 2005b).

3.1. BATHYMETRY

An array of bathymetric data is available for the Lower Passaic River (Table 3-1); however, the majority of the bathymetry data falls within the lower 8 miles of the Passaic River. The earliest data set available to Malcolm Pirnie [Geographical Information System (GIS) format] was surveyed in 1985 by the USEPA and IT Corporation and extends from the ConRail Bridge in Newark City to the Interstate 280 Bridge in East Newark (all depths were reported relative to mean low water). Five bathymetry data sets provided by TSI for 1995, 1996, 1997, 1999, and 2001 are also available. These data sets are formatted in Microsoft Excel ® and include northing and easting coordinates along with depth referenced to the USACE datum at mean low water. The approximate extent of the TSI data sets is from RM 1 to RM 6 of the Passaic River. The USACE 2003 bathymetry data set is provided in MicroStation ® DGN file format and includes bathymetric transects every hundred feet from the ConRail Bridge in Newark City (approximately RM 1) to the Erie Lackawanna Railroad Bridge in Kearny (approximately RM 8). The data do not extend the full-length of the federal navigation channel, which extends to RM 15.

Only two bathymetric data sets exist for the upper reaches of the Passaic River. A paper copy (handwritten) of the USACE November 1989 survey covers from the Erie

Lackawanna Railroad Bridge in Kearny (approximately RM 8) to the Eighth Street Bridge in Wallington (approximately RM 15). This November 1989 survey overlaps approximately 1,000 feet with the June 1989 survey [hard-copy in Computer Aided Design and Drafting (CADD) format] to cover the Passaic River from Newark Bay (RM 0) to the RM 15. Another data set (hard-copy in CADD format) provided by the USACE was surveyed in 1992, but only includes bathymetric transects for RMs 8 to 9 along the Passaic River.

Based on the review of existing data, the following data gaps were identified:

- No recent bathymetric data exist for the upper reaches (above RM 8) of the Passaic River.
- No bathymetric data exist for the tributaries of the Passaic River. An updated bathymetric survey of the 17-mile Passaic River will be necessary for model development, investigation planning, and feasibility analyses.
- No bathymetric data exist for the Hackensack River and its tributaries, Newark Bay, Arthur Kill, and the Kill van Kull.

3.2. TOPOGRAPHY AND OTHER MAP DATA

Different types of topographic data are available for the Study Area. Mapping prepared by Aerial Data Reduction (based on 1978 photography, revised with 1990 photography) provides elevations for the surrounding areas of the Passaic River from Newark Bay to the Crook Avenue Bridge (upstream of Dundee Dam) in Clifton. This aerial map also includes elevation data surrounding an unnamed tributary off the Passaic River, Saddle River, Third River, and Second River as well as elevations surrounding the Hackensack River from Newark Bay to the Route 7/Newark Road Bridge in Kearny City. U.S. Geological Survey (USGS) digital-elevation data from various dates are also available (GIS format) for the entire Passaic River watershed [30-meter digital elevation model (DEM) continuous data].

Other GIS-formatted maps available include: USGS digital raster graphics maps that cover the entire Passaic River watershed. This map includes data collected over

several years. The digital raster maps were constructed by scanning images of the USGS topographic 7.5-minute maps. Shoreline data for New Jersey is also available in GIS format for 1986 and 1995, characterizing the New Jersey coastline and other features including dikes, levees, and jetties.

Color infrared aerial imagery is available from the NJDEP for 1997 and 2002. Pixel resolution for the 1997 imagery is ± 1 meter, and for the 2002 imagery it is ± 1 foot. Horizontal accuracy for the 1997 data is not available, and for the 2002 data it is ± 4 feet. The New Jersey Geographic Information Network released the 2002 aerial imagery in 2004, and these data have been obtained for this project.

Based on the review of existing data, the following data gaps were identified:

- No aerial surveys are available to complete a mudflat delineation of the Lower Passaic River and candidate restoration sites.
- The State of New Jersey's 2002 aerial photography product consists of aerial photo mosaics only and does not include contour data or a digital terrain model. In addition, the 2002 aerial photography has only ± 4 foot horizontal accuracy. Updated aerial surveys of the Passaic River shoreline and land surveys to prepare planimetric and topographic feature maps of the candidate restoration sites are needed.

3.3. GEOPHYSICAL DATA

In general, geophysical data (*e.g.*, side-scan sonar data or sub-bottom profiling data) are not available for the Passaic River. The NJDOT-OMR did conduct a limited geophysical survey, including side-scan sonar, sub-bottom profiling, and magnetometer survey, along a 1,000-foot stretch of the Harrison Reach (RM 2.8) between the Jackson Street Bridge and the New Jersey Turnpike Bridge as part of the LPRRP's dredging and decontamination pilot study (TAMS, 2005).

Based on the review of existing data, the following data gaps were identified:

- Geophysical surveys of the Passaic River are required to investigate sediment texture and stratigraphy, to aid in the interpolation of sediment conditions between sampling locations, and to support engineering decisions required for the FS.

- No information pertaining to the Oak Island Yards Wetland, Kearny Point, or other candidate restoration site was found (it should be noted that candidate restoration sites have not been finalized).

3.4. GEOTECHNICAL DATA

Some geotechnical data provided by TSI are available on an internal project database and includes results on sediment testing in 1995 and 1996 for shear stress, erosion rate, density, consolidation tests, and pore pressure, among other data. Sediment grain size data for the Passaic River are also limited. In 1991, TSI characterized the Harbor Reach (RM 0 to RM 0.9) sediment as 8% clay, 17% silt, 71% sand, and 5% gravel. Similar results were reported by the USEPA in 1993, who reported a sediment distribution in the same area as 17% clay, 28% silt, and 54% sand. Only two other reaches of the Passaic River [Point No Point Reach (RM 0.9 to RM 2.2) and Newark Reach (RM 4.4 to RM 5.8)] were sampled in 1994 by TSI and the USEPA for sediment texture; however, these data only report the percentage of fine-grained sediment. Based on the review of existing data, it was found that no geotechnical data are available for the area of the Passaic River beyond RM 7 and its tributaries.

Based on the review of existing data, the following data gaps were identified:

- No geotechnical data exists to characterize candidate restoration site and to assess bank stability.
- No information pertaining to the Oak Island Yards Wetland, Kearny Point, or other candidate restoration site was found (it should be noted that candidate restoration sites have not been finalized).

3.5. SOILS AND SEDIMENTS GEOCHEMISTRY

The majority of available surface and subsurface soils data are derived from site investigations at 80 and 120 Lister Avenue [Diamond Shamrock Chemical Corporation (DSCC) sites], or surface soil-sampling that occurred throughout the Ironbound section of the City of Newark (NUS, 1986). Note that soils presented in the following discussion are currently entombed on-site following remedial action at the DSCC site.

In 1985, a site evaluation of 80 Lister Avenue was performed (DSCC, 1985a) that encompassed 21 near-surface soil locations and 8 soil-borings locations. From this program, 154 soil samples were collected ranging from 0 to 24 inches in depth and were analyzed for 2,3,7,8-tetrachlorodibenzodioxin (TCDD) and other priority pollutants. The TCDD concentration in the near-surface samples ranged from 200 µg/kg to 19,500 µg/kg. Samples from the soil borings had TCDD concentrations that ranged from nondetected values to 3,510 µg/kg. Finally, additional silt zone samples were analyzed (8 samples), and reported TCDD concentrations ranging from nondetected values to 11.8 µg/kg.

Soil samples from 120 Lister Avenue (DSCC, 1985b) consisted of samples collected during the installation of 3 monitoring wells, 24 surface soil samples, and 23 borings sampled at various depths. A total of 95 soil samples were collected (ranging from 0 to 11 feet) and analyzed for organic and inorganic contaminants. TCDD analysis was the main focus of this sampling effort and indicated that TCDD concentrations generally decreased with depth and ranged from 0.23 µg/kg to greater than 490 µg/kg.

In 1986, an addendum to the 80 and 120 Lister Avenue Site Investigations was provided to NJDEP (DSCC, 1986). At 80 Lister Avenue, an additional 7 borings were drilled for subsurface lithology and well installation. At 120 Lister, 9 borings were installed with an additional 13 samples collected for TCDD analysis. Based on the review of these additional results, no changes to the stated ranges of TCDD or priority pollutant concentrations were found. Within the nearby Ironbound section of Newark (NUS, 1986), approximately 1,367 soil samples were analyzed in 1985. Results from this sampling indicate TCDD concentrations ranged from nondetected values to 645 µg/kg.

Based on the review of existing data, the following data gaps were identified:

- No information pertaining to soils along the tributary banks of the Lower Passaic River was found.
- No information pertaining to the Oak Island Yards Wetland, Kearny Point, or other candidate restoration site was found (it should be noted that candidate restoration sites have not been finalized).

Note that available sediment data for the Passaic River were not evaluated for this FSP Volume 3 since proposed sediment sampling is anticipated to focus on sediments that may be present on candidate restoration sites. The *Draft Technical Memorandum: Historical Data Evaluation* (Malcolm Pirnie, 2005e) summarizes available sediment data for the Passaic River. As a result of this review of historical data, it is recommended that soil and sediment sampling be conducted to fully characterize each candidate restoration site with emphasis on the presence/absence and extent of environmental contaminants as well as nutrient levels (nitrate and phosphate) and total organic carbon.

3.6. WATER QUALITY

Available data regarding surface water quality and groundwater quality are evaluated in this section.

3.6.1. Surface Water Quality

Conventional surface water quality parameters have been monitored in the lower 6 miles of the Passaic River (TSI, 2004), and a few measurements were collected by NOAA in 1999 during the caged bivalve study (NOAA, 1999). In addition, two surface water samples for chemical analysis were collected during the 80 Lister Avenue Site Investigation (DSCC, 1985a).

In 1995, TSI conducted various surface water characterization efforts (TSI, 2004). As part of sediment mobility modeling, 1,317 total suspended solid (TSS) samples and measurements of physiochemical parameters, including temperature, pH, and conductivity profiles, were collected from 8 transects during 3 rounds of sampling. In addition, TSI conducted a surface water characterization investigation to evaluate water quality in relation to the rest of New York/New Jersey Harbor. For this investigation, physiochemical parameters including temperature, pH, and conductivity profiles were collected at each mudflat sampling station within the Lower Passaic River. Based on these studies, TSS ranged from less than 5.0 mg/L to 4,540 mg/L while for the physiochemical parameters (6,515 readings per parameter), temperature ranged from

6.65°C to 29.39°C, pH ranged from 5.3 to 8.2, and conductivity ranged from 0.002 S/m to 3.746 S/m.

In August 1999, NOAA collected water quality parameters (temperature, dissolved oxygen, salinity, pH, and conductivity) as part of a bivalve mussel deployment in the Lower Passaic River (NOAA, 1999). Data for this sampling event showed temperatures ranging from 25.7°C to 27.6°C, dissolved oxygen ranging from 4.41 mg/L to 6.72 mg/L, pH from 7.41 to 7.89, salinity (in units of parts per thousand or “per mil,” ‰) from 6.9‰ to 21.6‰, and conductivity from 12.1 S/m to 34.1 S/m.

The two surface water samples that were collected during the 80 Lister Avenue Site Investigation (DSCC, 1985a) indicated that TCDD was at nondetected levels (note that the detection level was not provided in the report) and some metals (arsenic, chromium, copper, nickel, and zinc) were less than 0.05 µg/L.

3.6.2. Groundwater Quality

At 80 Lister Avenue 8 monitoring wells were installed during the 1985 site investigation (DSCC, 1985a). TCDD concentrations ranged from nondetected values to 10.4 µg/L. Dichlorodiphenyltrichloroethane (DDT), its metabolites, and herbicides [such as, 2,4-dichlorophenoxyacetic acid, 2,4,5-trichlorophenoxyacetic acid, and 4-(2,4-dichlorophenoxy) butyric acid] ranged from 6.9 µg/L to 27,000 µg/L (depending on the contaminant) in the groundwater. However, most semivolatile compounds were not detected in the groundwater. Meanwhile, the site investigation at 120 Lister Avenue (DSCC, 1985b) reported no TCDD in the three monitoring wells installed.

In 1986, an addendum to the 80 and 120 Lister Avenue Site Investigations was provided to NJDEP (DSCC, 1986). At 80 Lister Avenue, an additional 7 borings were drilled for subsurface lithology and well installation only. At 120 Lister Avenue, 4 additional monitoring wells were installed. Based on the review of these additional results, no changes to the range of TCDD, or priority pollutant concentrations were found. Note that a groundwater collection system is currently in place as a result of remedial action on the DSCC site.

3.6.3. Water Quality Data Gaps and Recommendations

Based on the review of existing data, the following data gaps were identified for surface waters and groundwater:

- Limited surface water field parameter and analytical data (*e.g.*, TSS, salinity, pH, and dissolved oxygen) exist for the Lower Passaic River.
- Limited groundwater data are available for the 80 and 120 Lister Avenue Sites.
- No information pertaining to the tributaries of the Lower Passaic River was found.
- No information pertaining to the Oak Island Yards Wetland or other candidate restoration sites was found.

The following recommendations for additional evaluation of surface water and groundwater quality are provided:

- Surface water quality may require investigation at candidate restoration sites. Note that surface water samples are being collected from the main stem of the Lower Passaic River as part of FSP Volume 1 (Malcolm Pirnie, 2005a). If historic data exist for a site, then a specific list of water quality parameters will be developed to complement historical data. If no historic data exist, then a full suite of field parameters and sample analyses will be conducted to characterize surface water quality.
- Additional sampling is needed to fully characterize the presence, absence, and extent of groundwater contaminants and groundwater quality at each candidate restoration site. Groundwater flow direction in the unconsolidated aquifer will be determined at each candidate site. The extent of hydraulic influence between the tidal fluctuations in the river and the unconsolidated aquifer will also be investigated at each candidate site.

3.7. HYDROLOGY AND HYDRODYNAMICS

As part of the 1995 Remedial Investigation, TSI performed velocity measurements along 8 transects using an Acoustic Doppler Current Profiler (ADCP; TSI

2004). In addition, current meters were moored at 3 locations in the Passaic River, and tide gauges were installed at 3 locations in the Lower Passaic River. The moored current meters were monitored from July-August 1995, April 1996, and April-May 1996. The tide gauges were monitored from April 1995 to May 1996 and yielded 299,081 records. Additional hydrodynamic data were collected in 2004 by Rutgers University (<http://marine.rutgers.edu/cool/passaic/>), which included the results from two dye studies; data collected from a conductivity, temperature, depth, and current surveys; and data from a fixed-time series monitoring of conductivity, temperature, depth, current, and turbidity (using optical backscatter sensors (OBS)) at moored locations. Based on these and other available studies, the following hydrological characteristics of the Lower Passaic River can be determined:

- The Lower Passaic River is influenced by tidal flows, and saline water conditions exist throughout the Lower Passaic River. The available information from the literature, and the current data provided by TSI (2004), suggests that average flows on the Passaic River are about 0.7 feet per second and that peak tidal flows reach approximately 2.5 feet per second for short intervals. (Note that the cross-sectional average river velocity due to freshwater flow in the Lower Passaic River is approximately 1 foot per second). The mean tidal range (difference in height between mean high water and mean low water) at the New Jersey Turnpike Bridge (approximately 1.5 miles upstream from Newark Bay) is 5.1 feet (NOAA, 1972) with a mean tide level (midway between mean low water and mean high water) at elevation 2.5 feet (NOAA, 1972). The mean spring tide range (average semi-diurnal range occurring during the full and new moon periods) is 6.1 feet.
- Coastal storms make up the dominant source of floods within the Lower Passaic River watershed. The Flood Insurance Study for the Town of Harrison indicates an annual tide elevation of 5.7 feet with respect to the National Geodetic Vertical Datum of 1929 (NGVD29). For a 2-year recurrence interval, the predicted tide was 6.2 feet on the NGVD29. Additional predicted tide elevations were 6.9 feet for a 5-year recurrence, 7.5 feet for a 10-year recurrence, 8.2 feet for a 20-year recurrence, 9.3 feet

for a 50-year recurrence, and 10.2 feet for a 100-year recurrence interval (tide elevations are referenced to the NGVD29). The maximum-recorded tide level on the Passaic River is 8.33 feet, measured at East Newark on September 12, 1960, and is equivalent to a flood with a 20-year recurrence interval (DSCC, 1985a). During the record flood of October 1903, the Passaic River crested between 9 and 10 feet in the vicinity of Harrison, New Jersey.

- The Lower Passaic River can be considered partially stratified with sufficient difference in surface and deep-water salinities to provide a barrier to complete vertical mixing. Recent data presented in January 2005 by the Coastal Ocean Observation Laboratory of Rutgers University shows surface to deep salinity gradients of 4 ‰ (parts per thousand) to 10 ‰, based on five separate sampling events. These data indicate that differences in water density due to salinity may cause bi-directional flow, or at least differential movement of surface and deep water. The presence of a gradient has been confirmed by the analyses performed by TSI in 1995 and 1996, which found salinity gradients ranging as high as 14.4 ‰, although the typical gradient was approximately 4 ‰. Concurrent variations in water density were also observed, with density gradients as high as 11.27 σ_t (where σ_t equals [density (units of g/mL) – 1] \times 1000).
- The salt field is highly sensitive to both river discharge and spring neap variability. For example, waters in RM 3 and RM 4 can become fresh at spring tide during ebb even at moderate discharge (50 m³/s). Meanwhile, intrusion of the salt field during low flow conditions is hindered during spring tide conditions.
- Near bottom sediment transport appears to be upriver during low flow conditions and downriver during high flow conditions– suggestive of active sediment pool. Material (re)suspended from surface sediment in RM 3 and RM 4 during a high-discharge ebb event is transported to Newark Bay within several hours.

Regional groundwater includes the bedrock of the Brunswick Formation and unconsolidated glaciofluvial sand and gravel aquifers. Bedrock groundwater yields are 35 to 400 gallons per minute while the glaciofluvial sand and gravel wells yield between

175 and 600 gallons per minute. Local heavy pumping of these aquifers has caused saltwater intrusion near 80 and 120 Lister Avenue (DSCC, 1985a). Groundwater levels are generally a few feet below the ground surface. Tidal fluctuations in the fill, near the river, are in close communication with the river.

Based on the review of existing data the following data gaps were identified:

- No information pertaining to the tributaries of the Lower Passaic River has been found.
- No information pertaining to the Oak Island Yards Wetland, Kearny Point, or other candidate restoration site was found (it should be noted that candidate restoration sites have not been finalized).

As a result of this review of available historical data, it is recommended that additional sampling be conducted to fully characterize the hydrology and geohydrology at each candidate restoration site.

3.8. CULTURAL RESOURCES

Cultural resource investigations (Phase IA) will be conducted for all candidate restoration sites and the main stem of the Lower Passaic River. The initial surveys will include background research followed by limited fieldwork consisting primarily of a pedestrian survey. The site survey report will provide information on potential cultural resources and will guide the need for, and direction of, further cultural resource investigations (Phase IB, Phase II, etc.). The New Jersey State Historic Preservation Officer (SHPO) will be consulted through every stage for Section 106 comments.

Based on the review of existing data the following data gaps were identified:

- No cultural resource information pertaining to the Lower Passaic River has been found.
- No information pertaining to the Oak Island Yards Wetland, Kearny Point, or other candidate restoration site was found (it should be noted that candidate restoration sites have not been finalized).

3.9. SOCIOECONOMICS AND REAL ESTATE

Both the socioeconomic and real estate studies will make use of data available to the public, such as U.S. Census (www.census.gov) data and municipal real property tax records (refer to data needs in Section 4.8 “Task 8 – Socioeconomics” and Section 4.9 “Task 9 – Real Estate” for a list of data sources to be evaluated). These data have not yet been obtained by project staff, and the quality and usability of local records (*e.g.*, municipal real property records) are not currently known. The procurement and evaluation of these data will be conducted as part of the studies under Section 4.8 “Task 8 – Socioeconomics” and Section 4.9 “Task 9 – Real Estate.”

Based on the review of existing data the following data gaps were identified:

- No socioeconomic or real estate information pertaining to the Lower Passaic River has been found.
- No information pertaining to the Oak Island Yards Wetland, Kearny Point, or other candidate restoration site was found (it should be noted that candidate restoration sites have not been finalized).

4.0 FIELD TASKS

A summary of the surveys, field investigations, and research tasks addressed in FSP Volume 3 is provided in Table 4-1 along with an overview of the task objectives, sampling procedure, and data generation. Individual tasks are further described below along with their corresponding Project Management Plan (PMP) task identification number and the DQO question that the task addresses or satisfies [refer to Attachment 1 in the Draft QAPP (Malcolm Pirnie, 2005d) for a complete list of DQO questions]. Note that two tasks from FSP Volume 3 have been completed to date, including:

- Bathymetric Survey conducted in fall 2004 and extended along the entire 17-mile stretch of the Lower Passaic River.
- Geophysical Survey conducted in spring 2005, including the survey, confirmation core collection, and sediment profiling. Laboratory analysis of samples is currently underway.

Other FSP Volume 3 investigations are anticipated to commence in 2006 (e.g., the prioritization and timing of tasks are provided in Section 9.0 “Project Schedule” of the Work Plan (Malcolm Pirnie, 2005b).

4.1. TASK 1 – BATHYMETRIC AND AERIAL SURVEYS (PMP TASKS JAA AND JDE)

4.1.1. Data Needs and Survey Objectives

Bathymetric data and shoreline mapping for the Lower Passaic River and Newark Bay are required to support the following data needs, which address DQO questions 4, 5, 28, and 29:

- Evaluate the river’s configuration and geomorphology (refer to DQO tasks 4A and 4C).
- Develop hydraulic analyses, which will aid in the future design of the re-grading plan to soften and modify shorelines at candidate restoration sites (refer to DQO task

29A). Note that the re-grading plan will be developed once candidate restoration sites are selected.

- Identify potential sediment scour and deposition areas in the Passaic River (refer to DQO task 4B).
- Determine whether historical sediment core data can be used to represent current conditions (refer to DQO tasks 4A and 4C).
- Support FS analyses and dredging alternative evaluations (refer to DQO task 29A).
- Delineate mudflats and shoreline with aerial survey (refer to DQO tasks 5C, 5D, and 28F).

The objectives of the bathymetric and aerial surveys are to obtain recent, detailed geographic data and to develop mapping of the Passaic River and Newark Bay bathymetry and shoreline to address these data needs.

4.1.2. Bathymetric and Aerial Surveys Scope

The scope of this task will consist of a series of bathymetric surveys for the 17-mile stretch of the Lower Passaic River as well as Newark Bay and the Hackensack River.

- The 17-mile bathymetric survey of the Lower Passaic River was completed in 2004 by the USACE (USACE, 2004a). Data are provided in MicroStation ® DGN file format referenced to the New Jersey State Plane North American Vertical Datum of 1983 (NAD83) coordinate system in feet, and soundings and/or elevations are referenced to the NGVD29 vertical datum. A comparison of the 2004 bathymetric survey with a survey conducted in 1989 is presented in the *Draft Technical Memorandum: Preliminary Geochemical Evaluation* (Malcolm Pirnie, 2005e).
- A preliminary bathymetric survey of Newark Bay and the kills will be conducted by TSI under their remedial investigation. It is anticipated that this Newark Bay bathymetric survey will have transects every 0.25 mile to confirm the locations of various geomorphic units, such as sub-tidal flats, intertidal flats, navigational channel, etc.

- A 1992 bathymetric survey of the Hackensack River is also anticipated to be provided by the USACE. Surveys were digitized by the USACE from a series of aerial photography performed in March 1992 by Aerial Data Reduction Associates, Inc.; data are in feet referenced to the New Jersey NAD83 horizontal plane, and the vertical datum is NGVD29.

For the USACE bathymetric survey of the Lower Passaic River, an analysis was conducted to estimate the maximum transect spacing that would provide bathymetric data appropriate to meet the project objectives. The analysis consisted of preparing semivariograms using existing bathymetric data. The analysis revealed that a transect spacing of 100 feet, with data collection every 10 to 15 feet along the transect, would minimize the nugget effect (*e.g.*, nugget effect quantifies the sampling errors and the short scale data variability) and facilitate effective contouring of the bathymetric data. Spot-elevation data (approximately 1,900 spot elevations) will be collected from the riverbanks for each bathymetric transect. The locations of the spot elevations may range from the toe of a bulkhead to a vegetation line.

The bathymetric information gathered will be digitized in an American Standard Code for Information Interchange (ASCII) file, showing x, y, and z coordinates in New Jersey State Planar Coordinates NAD83. Elevations will be measured to 0.1 foot, referenced to the NGVD29. Time and date of the survey and survey benchmark referenced will be noted on the plan view sheets. A New Jersey licensed land surveying company will be subcontracted to produce the necessary mapping. The location of flood control, storm water, and combined sewer outfall structures is critical to the alternative plan analysis for this project. Therefore, the locations of all flood control, storm water, and combined sewer outfall structures along the Lower Passaic River will be obtained (see aerial survey below). The locations (x and y coordinates) of such structures will be placed on the final bathymetric-topographic map; type and size of such structures will be noted on the plan map and provided as attribute data within the electronic deliverables.

To survey outside the channel of the Passaic River and upland adjacent areas, an aerial survey will be conducted for a 0.5 mile buffer on either side of the lower 17 miles

of the river. The aerial survey will be flown during low tide and again at high tide to capture the mudflat areas of the river and the surrounding topography outside the banks. The aerial survey will be used to delineate mudflats, delineate the shoreline, and construct topographic maps with 0.5-foot contours. The aerial survey along with complimentary municipal maps and field verification will also be used to locate outfall structures.

Overlapping of some points will occur with the bathymetric condition survey and aerial survey. The photography will be collected with enough accuracy and ground control to produce 0.5-foot contours on one inch equals thirty feet ($1'' = 30'$) scaled maps (although initial submittal may be $1'' = 100'$). Features to be located on the survey include, but are not limited to: walkways, buildings, bulkheads, vegetation lines, bridges, and roadways. After completion of the aerial survey, the bathymetric and aerial mapping data will be combined and overlaid to the full 17-mile condition survey for a complete map.

4.1.3. Bathymetric and Aerial Survey Reporting

- Plan View Plots. The bathymetric survey (the extended condition survey and spot elevations) will be plotted in plan view with 1-foot contours on a $1'' = 100'$ horizontal scale on standard size sheets. Plan view plots will show 1-foot contours above and below zero referenced to the NGVD29 vertical datum, on the New Jersey State Plane NAD83 grid including zero foot on NGVD29. Electronic copies of the survey will be provided in Environmental Systems Research Institute (ESRI) shape file format and CADD formats (AutoCAD 2004 or later and MicroStation Version 8 or later).
- Digital Files. Digital plan view plots will be compiled in the Intergraph Graphic Design System (IGDS) file format (.DGN), using the Intergraph/Bentley System MicroStation ® software, Intergraph InRoads software, and provided in both AutoCAD and ArcView file formats [ESRI Triangulated Irregular Network (TIN) and GDB format]. The digital map files will be created in three-dimensional format with the survey elements placed at their correct x, y and z locations. The maps will comply with the requirements for Survey/Mapping as presented in “Standards Manual

for U.S. Army Corps of Engineers Computer Aided Design and Drafting Systems” EM 1110-2-1807 (USACE, 1990a). The data will be developed by feature into individual levels within the design files as outlined in EM 1110-2-1807. All survey data will be submitted on Compact Disc, Read-Only Memory (CD ROM).

- Bathymetric Survey. The bathymetric data will be provided in ASCII “x, y, z” format on a CD ROM. The locations of flood control, storm water, and combined sewer structures will be provided on separate files, respectively, showing their ASCII “x, y, z” format and the distance-elevation pairs, and any necessary comments to identify the points.
- Aerial Survey. The bathymetric data will be combined with the aerial survey plots on 1" = 100' scale (1-foot contours) maps with enough accuracy to produce 1" = 30' mapping at a later date.
 - Plan View of Surveyed Area.
 - Electronic copies of the survey in Intergraph/Bentley format (Intergraph InRoads software compatible) with three-dimensional, digital terrain model (DTM) and in ArcView format.
- Metadata Generation. The surveyor will provide metadata file(s) compliant with the Federal Geographic Data Committee (FGDC) content Standards for Digital Geospatial Metadata. Metadata will be provided in HTML format. The Tri-Services Standards for data content (A/E/C/CADD and Spatial Data Standards) will be used (Tri-Services Standards can be downloaded from <http://tsc.wes.army.mil>).
- Bathymetric Requirements.
 - Vertical datum will be the NGVD29. Horizontal Datum will be the New Jersey State Coordinate Plane (NAD83).
 - *Edge matching*: All map sheets will be both visual and coordinate edge matched with adjacent sheets. No edge match tolerance will be accepted.
 - *Point Criteria*: All point features will be digitized as a single x-y coordinate pair at the visual center of that graphic feature in New Jersey State Planar Coordinates.

- Quality Control. All products will be reviewed internally for quality control prior to submittal. Included with each review will be a separate Quality Control section indicating the quality control processes performed together with an extent of compliance. This extent of compliance will include the producer of the product, the internal reviewer, the original QC/QA review comment and its date, the comment response, and where the product changes, if any, were made. A certification that the QC process was performed satisfactorily will also be included.

4.2. TASK 2 - SUPPLEMENTAL LAND SURVEY (PMP TASK JAAA)

In addition to the bathymetry and aerial survey tasks described in Section 4.1 “Task 1 Bathymetric and Aerial Surveys,” additional land surveying will be required to prepare base maps of candidate restoration sites to support restoration design. This section describes the data needs, survey objectives, and the proposed scope of work, methods and map deliverables.

4.2.1. Data Needs and Survey Objectives

Supplemental land surveys are required to support the following data needs, which address DQO questions 2, 5, and 28:

- Determine the elevation and topography of candidate sites to support restoration design (refer to DQO tasks 5A, 5B, 28A, and 28E).
- Determine the grades of the side slopes of the Passaic River and tributaries to support design of bank stabilization or future re-grading measures that may be necessary during restoration (refer to DQO tasks 5C and 28C).
- Determine site access and location of utilities and other objects (refer to DQO tasks 2A, 2B, and 28D).

The land survey objectives are to obtain data, develop mapping, and understand constraints for portions of candidate restoration sites not already addressed by existing data and Section 4.1 “Task 1 - Bathymetric and Aerial Surveys.” The proposed scope for this survey work is described below.

4.2.2. Land Surveying Scope

The scope for the land surveying and detailed site mapping for the candidate restoration sites includes establishment of benchmarks, collection of survey data, and development of electronic deliverables including surface generation/contouring, planimetrics, and base-map drawing preparation (*i.e.*, field-to-finish topographic and planimetric mapping effort).

- Intervisible Reference Locations (Benchmarks) Installation and Survey. Benchmarks will be installed to establish intervisible Global Positioning System (GPS) pairs along the river to be used by both the aerial survey and land surveyors as well as the bathymetric and geophysical surveyors (refer to Section 4.1 “Task 1 - Bathymetric and Aerial Surveys” and Section 4.3 “Task 3 – Geophysical Survey”). Benchmarks will be established as required to complete the work. The actual number of benchmarks will be determined in the field by location and line of sight. The requirements of the various surveys will be dependent on the location of the candidate restoration sites under study. The monuments will be installed below the frost penetration depth and be surveyed to First Order accuracy. The markers will be installed in accordance with the “Engineering and Design - Survey Markers and Monumentation” EM 1110-1-1002 (USACE, 1990b).
- Shoreline Survey. The candidate restoration site shorelines will be surveyed to augment the information obtained during the bathymetric and aerial survey described in Section 4.1 “Task 1 - Bathymetric and Aerial Surveys.” The surveyor will survey the shoreline into the river to a water depth of a minimum of 3 feet. The survey will provide a vertical profile of all fixed structures crossing the river including bridges and overhead wires. The profile will include clear vertical distance from structure to water surface. Shoreline information will be provided as a feature of the detailed mapping described below.
- Detailed Site Mapping. A professional land surveyor licensed in New Jersey will be retained to conduct topographic and planimetric detail surveys in support of restoration design. The base map deliverables are expected to include each entire

restoration site under study, including shoreline information as discussed above. Data layers will consist of topographic information and planimetric features [e.g., storm drainage, combined sewer overflow (CSO), and flood control features and structures, bridges, culverts, utility boxes, power poles, railroad tracks, building footprints, etc.]. Topographic and planimetric feature detail maps will be compiled at a target scale of one inch equals thirty feet (1" = 30'). All data collected and prepared will meet or exceed the American Society for Photogrammetry and Remote Sensing (ASPRS) "ASPRS Accuracy Standards for Large-Scale Maps (ASPRS, 1990)" for Class 3, 1" = 30' scale mapping with 0.5-foot contours. All data collected and prepared will meet or exceed the "Engineering and Design - Photogrammetric Mapping" EM 1110-1-1000 (USACE, 1993), or "Engineering and Design - Topographic Surveying" EM 1110-1-1005 (USACE, 1994a). Planimetric feature detail will be compiled in accordance with the horizontal accuracy standards set for this class. Contours will be developed at 0.5-foot intervals in accordance with the vertical accuracy standards for this class. Electronic deliverables will be provided in GIS (ESRI shape file for planimetric features and contours; TIN and grid formats for topographic features) and CADD (AutoCAD 2004 or higher and MicroStations Version 8 or higher), and will comply with data layer standards: Spatial Data Standards for Facilities, Infrastructure and Environment (SDSFIE). Each data layer will be prepared as a seamless dataset covering the Study Area.

4.2.3. Preliminary Land Survey Methods

The selected surveying and mapping subconsultant will be required to:

- Use appropriate instrumentation and procedures, consistent with accepted professional surveying and mapping industry standards and practice, to achieve the required accuracy as described in FSP Volume 3.
- Mobilize a fully-equipped, professional survey crew and implement adequate supervision and quality control measures.
- Furnish all equipment, including tools and accessories of the type, quantity, capacity, and condition suitable for performing the land survey work.

- Establish appropriate controlling points to obtain the required horizontal and vertical control (suitable control monumentation will be set as required).

The primary coordinate system will be the New Jersey State Plane Coordinate system in feet referenced to NAD83. Vertical elevation will be the NGVD29. DTM data will comply with “Digital Data Product Accuracy Standards” EM 1110-1-1000 (USACE, 1993).

4.2.4. Land Survey Reporting

Digital data files (in GIS and CADD formats) will be checked by the surveyor for completeness, topologic accuracy, unclosed polygons, missing segments, multiple or missing label points, and other extraneous segments (dangling). Vector files will meet National Map Accuracy Standards when field verified.

The following map deliverables will be produced: hard copy Mylar sets of the detailed site mapping (planimetrics and contours), shoreline and planimetric electronic data in GIS (ESRI shape file format) and CADD (AutoCAD 2004 and MicroStation Version 8 formats), and the DEM elevation data in format(s) directly compatible with the latest versions AutoCAD Land Development and ESRI Spatial Analyst applications, and will be delivered on CD-ROM.

- While the drawing format will depend on the size of each restoration site, it is expected that standard size 24" x 36" drawings will be provided in the hardcopy deliverable.
- Vector data will be provided in both GIS (ESRI shape file format) and CADD (AutoCAD 2004 and MicroStation Version 8) file formats.
- Elevation data will be provided as vector (contour lines) and as a DEM compatible with the latest versions of AutoCAD Land Development and ESRI Spatial Analyst applications.
- Electronic data will be delivered on CD-ROM media. Raster data and vector data are to be delivered on separate CDs, and will be accompanied by a printout identifying the files that they contain.

- For GIS, continuous seamless coverage and separate files for each planimetric, topographic, and DEM data layer will be created. For CADD files (DWG and DGN), separate map sheets with seamless coverage (non-overlapping match lines) will be created in model space at a scale of 1" = 30' in engineering units where 1 unit equals 1 foot. Contours, all layers, and entities will terminate at the map sheet match line and will be picked up at continuous sheets.
- All electronic files will be accompanied by a metadata descriptor file compliant with FGDC metadata standards, and provided in a hypertext markup language (HTML) format.
- Maps, in accordance with the United States National Map Accuracy Standards (USNMAS) will include the following statement: *"THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS."*
- Maps (or the appropriate digital design file metadata) produced to meet the ASPRS standard will include the following statement: *"THIS MAP WAS COMPILED TO MEET THE ASPRS STANDARD FOR CLASS 3 MAP ACCURACY."*
- If the map was field checked and found compliant, the following additional statement will be added: *"THIS MAP WAS CHECKED AND FOUND TO CONFORM TO THE ASPRS STANDARD FOR CLASS 3 MAP ACCURACY."*
- For digital products, the descriptor level will also contain the original target mapping scale along with the absolute horizontal and vertical accuracies intended or checked.
- A Map Sheet Index will be provided showing in a rigid matrix grid format the layout of the maps specified in this section. The grids will be annotated with alphanumeric key codes that correspond with the complete map area. The map sheet index will be provided in digital GIS and CADD formats (ArcView shape file, AutoCAD 2004, and MicroStation Version 8 formats).

The features in Table 4-2 (to be used for guidance on content) are to be developed. These features will be compliant with the SDSFIE.

4.3. TASK 3 – GEOPHYSICAL SURVEY (PMP TASK JAAD)

4.3.1. Data Needs and Survey Objectives

The purpose of the geophysical survey is to aid in the interpolation between sediment core sampling locations to reduce uncertainty regarding sediment texture and profile, and potentially, contaminant concentrations, to support engineering decisions required for the FS. In general, geophysical data are not available for the Passaic River. The NJDOT-OMR did conduct a limited geophysical survey, including side-scan sonar, sub-bottom profiling, and magnetometer survey, along a 1,000-foot stretch of the Harrison Reach (RM 2.8) as part of a dredging and decontamination pilot study (TAMS, 2005). Future geophysical surveys are required to support the following data needs, which address DQO questions 3, 4, 21, and 22:

- Determine the texture of the surficial sediment to understand the characteristics of the Passaic River bottom, characterize existing benthic habitat, and inform the feasibility of restoration activities (*e.g.*, wetland rehabilitation or benthic habitat restoration) and remedial actions (*e.g.*, capping, dredging) at various locations along the river (refer to DQO tasks 3A, 4E, 4F, and 21B).
- Determine the amount/extent of debris and other targets (*e.g.*, utilities, wrecks) in the Lower Passaic River to enable an assessment of remedial activities (*e.g.*, dredging, capping; refer to DQO tasks 4D, 4G, and 22A).
- Determine the sediment types and depths of geological layers to evaluate the locations and lengths of sediment cores that will be collected for chemical analysis (*i.e.*, support field investigation design) and to support FS engineering analyses (refer to DQO task 4H).
- Obtain interpretive diagrams of sediment layering over time in the riverbed as one crucial input into the estimation of whether the most highly contaminated sediments in the Lower Passaic River may be located in stable areas or whether they may be transported into Newark Bay (refer to DQO tasks 3B, 4D, and 4H).

The objectives of the geophysical surveys are to be comprehensive, to the degree known, to gather all geophysical data needed for the project. Note that the geophysical surveys discussed below and the sediment sampling efforts discussed in FSP Volume 1 (Malcolm Pirnie, 2005a) are being conducted as separate investigations because geophysical data is necessary prior to sediment sampling to choose sampling locations and plan accordingly.

4.3.2. Geophysical Surveying Scope

The geophysical survey will include side-scan sonar and sub-bottom profiling, among other acoustical techniques, to characterize the river bed. Supplemental tasks will be implemented based on input from project stakeholders and the results of Section 4.3.3.1 “Geophysical Prove-Out Survey.” Note that the geophysical survey and associated confirmation core collection and sediment profiling was completed in spring 2005. Laboratory analysis of these samples is currently underway.

Side-scan sonar provides mosaic images of the investigation area while sub-bottom profiling investigates diagrams of sediment layering in the riverbed. Together, acoustical techniques and potentially ground penetrating radar (GPR), supplemented by sampling, will be used to derive interpretive diagrams of sediment layering in the riverbed, and to identify sediment characteristics of the riverbed and active sedimentation processes. The obtained geophysical data can be used to develop site-specific models and maps.

4.3.3. Preliminary Geophysical Survey Methods

Field crew teams will use shallow draft survey vessels to tow the equipment along the river to obtain the data. One or more test areas will be surveyed first to determine the data quality and applicability of the geophysical techniques to the various reaches of river (see Section 4.3.3.1 “Geophysical Prove-Out Survey”). Geophysical data recorded will be digitally acquired using geophysical survey equipment positioned on each survey vessel in a manner that minimizes potential interference, or cross-talk, between the various types of equipment. Positioning of this equipment will be optimized in the field

during the field mobilization and prove-out phases of the geophysical investigation. In addition to being equipped with Real Time Kinematic Differential Global Positioning System (RTK DGPS) navigation equipment, each geophysical survey vessel will be equipped with a digital compass to continuously record the orientation of the various geophysical sensors used. Depth of each sensor below the water surface and above the river bottom will also be digitally recorded continuously throughout each survey. Each geophysical sensor will be towed over river bottom sediments at a constant rate of between 1.5 knots (or 1.7 miles/hour or 2.5 feet/second) and 2.0 knots (or 2.3 miles/hour or 3.4 feet/second). This requirement becomes particularly important in areas of high river flow where geophysical survey lines will be run against the current whenever possible.

Only linear geophysical data without time-variable gain compensation will be recorded. Calibrated equipment and sensor gains will be logged throughout the survey so that signal amplitudes collected in one area can be accurately correlated and compared with signal amplitudes obtained in different areas. Equipment and sensor gains will be kept fixed along each geophysical survey line and similar gain will be maintained for similar survey areas. Record time will be linked to RTK DGPS-provided navigation time and the navigation string will be recorded on the each data trace header. All digitally recorded geophysical data will be made available in a standardized format [*e.g.*, a tape format standard of the Society of Exploration Geophysicists (SEG-Y) or similar non-proprietary format to allow for additional data analysis].

It is anticipated that the following equipment (or equivalent) will be required (at a minimum) for the performance of the geophysical investigation:

- RTK DGPS (or equivalent).
- Survey vessels (including shallow draft vessels such as Zodiacs and/or John Boats).
- Dual frequency (100 to 150 kHz and 500 to 600 kHz) side-scan sonar.
- Echosounder (200 kHz).
- High power 3.5 to 7.0 kHz pinger with independent receiving transducer.
- Swept frequency (chirp) 2 to 16 KHz and 4 to 24 kHz sub-bottom profiler.

- Adjustable power level boomer and receiving array.
- 1 inch air gun for use in high gas content areas – only selective use.
- Adjustable filters for noise reduction and signal optimization.
- Digital pentium-based sonar recording systems (or equivalent).
- RADARTEAM SWEDEN AB TW-100 directive borehole transducer (or equivalent).
- Geophysical Survey System, Inc. (GSSI) Model 5106 200 MHz transducer (or equivalent).
- GSSI SIR System 10 (or equivalent) GPR control and data logging system with associated power signal cable and antenna cable adapter.
- Dielectric constant meter.
- Geotek Multi-Sensor Track (MST) core logging system.
- Underwater camera system.
- Sediment sampling and coring equipment.

4.3.3.1. GEOPHYSICAL PROVE-OUT SURVEY

Since studies conducted for other contaminated sediment sites have indicated that penetration through gaseous river bottom sediments may be somewhat problematic using acoustical technologies, it is prudent to conduct a Geophysical Prove-Out Survey in order to fully assess the geophysical techniques and equipment planned for use in the geophysical investigation, especially in regard to sub-bottom profiling. The Geophysical Prove-Out Survey will be conducted and will consist of the collection of side-scan sonar and sub-bottom profiling data in areas of the river deemed representative of river bottom environments anticipated to be encountered during the full geophysical investigation. These data will be collected within each prove-out area using the same geophysical methods and techniques planned for use in the geophysical investigation.

The objective of the Geophysical Prove-Out Program is to demonstrate the best currently available geophysical technologies for incorporation into the geophysical investigation. Both sub-bottom geophysical data and confirmatory shallow and deep sediment core sample data will be collected in each prove-out area. Additionally, it will

be useful to correlate the new sub-bottom profile data with existing sediment property data. The areas of the river selected for the Geophysical Prove-Out Survey are to be determined by the project team.

To further correlate the geophysical data recorded during the Geophysical Prove-Out Survey with potential geophysical marker beds, a representative number of confirmatory shallow sediment samples (approximately 10) and confirmatory deep sub-bottom sediment core samples (approximately 5) will be collected from each prove-out area.

An optional requirement for the geophysical investigation will be to estimate the degree of error in the geographical position of side-scan sonar data may be evidenced in areas of the river where the shape of the river bottom is complex and the water is deeper than about 15 to 20 feet. Considerable error in the reported shape of the riverbed from the side-scan sonar data may also be evidenced in shallow areas. These problems can be identified and possibly remedied by collecting precision bathymetry and backscatter data using a shallow-water multi-beam system. As an option, multi-beam bathymetric and backscatter data may be collected in Geophysical Prove-Out Survey to evaluate the degree to which the side-scan sonar data may be affected by these sources of error and to evaluate the potential incorporation of the multi-beam bathymetric method into the geophysical investigation.

Preliminary analyses of these data will be completed to an extent sufficient to make a qualified determination regarding the best currently available and cost effective geophysical technologies for final incorporation into the geophysical investigation. Final analyses of these data will be incorporated into the data analysis phase of the overall geophysical investigation. Geophysical technologies that provide the most accurate and consistent resolution of geophysical marker beds within the estimated depth of contamination in river bottom sediments in a cost-effective manner will be selected for the incorporation into the geophysical investigation.

A preliminary determination of appropriate technologies will be made during the course of the Geophysical Prove-Out Survey and will serve as the basis for program

direction. A draft letter report detailing the results of the Geophysical Prove-Out Survey and the selected technologies will be submitted after the completion of the preliminary data analyses phase of the Geophysical Prove-Out Survey.

4.3.3.2. SIDE-SCAN SONAR SURVEY

Side-scan sonar data will be collected along geophysical survey lines parallel to the direction of river flow over the entire 17-mile tidal stretch below the Dundee Dam. The operating range of the side-scan sonar will be 50 meters to each side using a nominal line spacing of 40 meters. This spacing will yield five along-flow survey lines in a river section 600 feet (180 meters) across. At this spacing, the survey will obtain 200 percent coverage for most river areas. It also yields complete coverage of the areas along the ship's track since the area immediately beneath the boat cannot be surveyed directly from above. A dual frequency side-scan sonar system using frequencies of 100 kHz and 400 kHz will be used in the survey. Data at the two frequencies will be digitally recorded simultaneously in a standard Extended Triton Format (XTF) format (16 bit samples with 1024 points per side), or a similar non-proprietary format to make separate mosaics for insonification towards the two riverbanks. With each spot on the riverbed thus insonified from opposite directions, at different grazing angles, and at two frequencies, multiple parameters can be obtained for input to classification algorithms for sediment texture estimations.

The acquisition of side-scan sonar data will be used to further estimate the physical conditions of river bottom sediments between sediment coring locations, and may allow a correlation between physical composition and chemical composition to be developed and advanced. These data will also be used in conjunction with the bathymetric data to refine the existing knowledge of river bottom morphology and evaluation of benthic habitats.

4.3.3.3. SUB-BOTTOM PROFILING

Sub-bottom geophysical profile data will be collected for river bottom sediments using the acoustic geophysical techniques and, where needed and feasible,

electromagnetic energy (*i.e.*, GPR). Sub-bottom geophysical profiling will be conducted along profile lines conducted both parallel to and perpendicular to the direction of river flow. The acquisition of sub-bottom profile data within these sediments will be used to examine the subsurface structure of the sediments, specifically sediment stratigraphy. Sediment stratigraphy will be correlated with the physical and chemical composition of sub-bottom river sediments obtained from sediment coring locations to infer conditions between cores.

Sub-bottom geophysical profile lines conducted parallel to the direction of river flow will be more widely spaced than the cross-river sub-bottom geophysical profile lines and will generally be obtained in conjunction with and on the same line as the side-scan sonar data spacing (*i.e.*, approximately 40 meters).

In areas where dredging is likely, cross-river, sub-bottom profile lines will be conducted at intervals less than 40-meters. The actual distance between lines will be determined after an initial examination of the prove-out results, where the success of the technique can be assessed. Cross-river, sub-bottom profile data in near shore areas where river depths are shallower than approximately 5 feet will be digitally acquired using smaller, shallow draft survey vessels (*e.g.*, Zodiacs) that have been outfitted with the aforementioned geophysical survey equipment. GPR, if used, will be limited to the freshwater portion of the river, since the signal is hampered by saltwater.

Sub-bottom data are to be obtained with a simultaneous reading of river bathymetry and be vertically referenced to the NGVD29 as well as mean low water.

4.3.3.4. ACOUSTIC METHODS

Since knowledge of acoustic velocities within uncontaminated river bottom sediments is fairly well established, the acoustic profiling provides useful information regarding sediment layer type and thickness. Prior experience using high frequency acoustic sub-bottom profiling equipment (*i.e.*, 7 kHz pinger) indicated that gases accumulated within river bottom sediments tend to absorb much of the higher frequency acoustic energy, thereby limiting survey results. Lower frequency acoustic profiling equipment will be used in this geophysical investigation to achieve sufficient penetration

within these sediments. A summary of potential acoustic geophysical profiling equipment planned for use in this survey is provided as follows:

- Boomer The boomer is used on extremely high gas content sediments. It covers the frequency range of 500 Hz to 1500 Hz and is capable of penetrating compacted fine-grained sediments. The boomer can also be used with velocity move out corrections in shallow water areas to further enhance survey results.
- 3.5 KHz High Power Pinger. The adjustable pulse width of this acoustic system covers the frequency range of 1.5 kHz to 4.5 kHz. The shorter the pulse width of the pinger, the wider the bandwidth and the better the absorption measurement accuracy. This system can penetrate through low to medium gaseous sediments and compacted fine-grained sediments at a resolution finer than that attainable with the boomer.
- Swept Frequency (Chirp) Sub-bottom Profiler. The chirp profiler can operate with either a 2 kHz to 16 kHz or 4 kHz to 24 kHz frequency range and is capable of penetrating non-compacted, coarser gas-free sediments at finer resolutions than attainable with the boomer or pinger. The absorption characteristics of river bottom sediments will be mapped using this higher frequency acoustic device in order to gain insight into sediment type. The chirp profiler used will be capable of digitally recording the frequency of the received signal versus time.
- Air Gun. For those areas exhibiting extremely high gas content and large amounts of peat accumulations within the sediments, a small air gun will be used as the acoustic source. This source can use the same receiver array as the boomer. Although designed for maximum penetration within sediments of this type, this low frequency device will, however, yield lower resolution geophysical data.

4.3.3.5. QUALITY CONTROL

The geophysical investigation at the Study Area has several objectives. Geophysical Data Quality Objectives (GDQOs) will be developed and included in the QAPP to provide that the geophysical data collected during the investigation are of sufficient quality and quantity to meet the investigation objectives.

The purpose of data QC/QA procedures is to plan and implement a comprehensive set of project controls and systematic procedures to provide that geophysical data collected are of a sufficient quality to fulfill the GDQOs. Guidelines for the implementation of these procedures are presented in Appendix B of the FGDC “Engineering and Design - Hydrographic Surveying” EM 1110-2-1003 (USACE, 2002). Geophysical QC/QA methods used in the performance of this geophysical investigation will exceed those mandated by the FGDC Standard.

Typical Measurement Quality Objectives (MQOs) necessary to fulfill GDQOs are summarized in Table 4-3. MQOs presented in the table assume that the equipment gain, system linearity, source level, receiver level, and source wavelet are precisely known to within a predetermined range for all acoustic and GPR geophysical survey equipment. These MQOs also assume that these equipment parameters will be optimized during the mobilization phase of the program. Accurate measurement of these parameters prior to geophysical data acquisition allows for impedance characteristics of river bottom sediments to be absolutely determined based upon the geophysical data recorded. All digitally recorded geophysical data will be reviewed within 48 hours of acquisition and deviations from acceptable MQO criteria presented in Table 4-3 will be addressed as required.

Project controls and systematic procedures that will be instituted by the geophysical survey crew during the geophysical investigation to provide that geophysical data collected will be of a sufficient quality to fulfill the GDQOs will include, but may not be limited to:

- Survey speed consistency checks – constant checks of vessel speed will be conducted at approximate 15-minute intervals to ensure that the survey vessel(s) maintain a constant speed of between 1.5 knots (or 1.7 miles/hour or 2.5 feet/second) and 2.0 knots (or 2.3 miles/hour or 3.4 feet/second) while digitally recording geophysical data.

- Daily acquisition of repeated navigational and geophysical data along a representative portion of one geophysical survey line. Not less than 4 hours will be allowed to elapse between the original and repeat survey line measurements.
- Sensor position corrections (vertical, sensor layback and offsets, vessel draft, and altitude).
- Geophysical equipment confidence checks (using river bottom targets of known location and depth to verify proper system tuning and operation of each sonar channel at outer limit of the range scale being used).
- Contact correlation (between successive side-scan sonar coverage).
- Review of physical properties analytical results and correlation with geophysical data recorded in the area.
- Daily inspection and calibration of side-scan sonar, sub-bottom, and GPR profiles collected.

USACE and USEPA have, through their contractors, developed a detailed database for non-site-specific geophysical data calibration (Caufield, 2001). It is desired to acquire the geophysical field data with maximum accuracy so that selected site reflection coefficients, velocities, and absorption for both the sub-bottom and GPR systems can be entered into the USACE-USEPA geophysical database to further refine the analysis of geophysical data collected.

In order to obtain these measurement parameters with accuracy, calibrated geophysical survey equipment (McGee and Ballard, 1995; Caufield, 2001) will be used along with documented logging procedures of all survey equipment status such as gains, filter settings, linearity, etc. Daily inspection procedures to be followed in order to ensure that the equipment is meeting the desired accuracy and repeatability during the survey are addressed in the QAPP.

Special QC/QA acquisition equipment and calibration hydrophones will also be supplied to perform the field calibrations outlined in the plan that are necessary to obtain the desired acquisition accuracy along with detail instructions for the recording of data logs for gain, system operation (power or pulse lengths), and inline filters settings.

Typical sources of error that may affect MQO standards and will be avoided include, but are not limited to, the following:

- Vessel Position. The minimum permissible deviation from the survey line will be determined prior to geophysical data acquisition and will not be exceeded. This deviation is normally within the beam pattern of the geophysical systems. Failure to maintain the minimum deviation from the survey line will necessitate the reacquisition of geophysical data along the survey line(s) in question.
- Data Clipping. Setting of receiver gains too high results in the clipping of digitally recorded geophysical data, thereby resulting in the incorrect measurement of signal amplitudes and compromising the integrity of the results of the analyses of the data recorded. Random single ping clipping is acceptable for acoustic data; however, severe clipping warrants the reacquisition of geophysical data along the survey line(s) in question.
- Field Notes and Log Header Information. Failure to properly record time, gain settings, or navigation logging will necessitate the reacquisition of geophysical data along the survey line(s) in question.
- Standards. Failure to meet the standards outlined in Table 4-3 will necessitate the reacquisition of geophysical data along the survey line(s) in question.

4.3.3.6. CONFIRMATORY RIVER BOTTOM SEDIMENT SAMPLING

Confirmatory shallow sediment core (0.5 foot) and deep sediment core (to refusal depth) sampling of river channel sediments will be conducted to calibrate and verify the results of the geophysical investigation. Note that these confirmation cores and the sediment cores collected as part of FSP Volume 1 (Malcolm Pirnie, 2005a) will be collected during separate investigations since the geophysical data is needed to plan other coring programs.

- Confirmatory Shallow Sediment Core Sampling. During the side-scan sonar survey, confirmatory shallow sediment core sampling and/or grab samples of river-bottom sediments will be conducted at transects using a hand-coring device. These transects

will be spaced at half-mile intervals, totaling 35 transects with 5 cores collected at each transect (yielding 175 samples). An additional 100 samples to be collected at discrete locations based on the results of the side scan sonar survey, for a maximum of 275 samples. If the river bottom sediment is too consolidated to be sampled with the hand-coring device, a grab sample of the river bottom surface sediments material will be collected as a last resort. Grab sampling of the river bottom sediment will require that the sample be transferred to a sample container upon collection, rather than being left in the sample tube of the hand-coring device.

Each confirmatory shallow sub-bottom sediment core sample will be visually classified with the USCS and submitted for physical properties analysis. Grain size analysis of each shallow sediment core sample will be conducted in accordance with American Society for Testing and Materials (ASTM) D422 “Standard Test Method for Particle-Size Analysis of Soils” (ASTM, 2002) with hydrometer analyses conducted all samples. Grain size analysis will be reported in percentile by diameter as well as by percent gravel, sand, silt, and clay. Samples for hydrometer analyses will be selected based on the observed presence of a fine-grained fraction and will be reported at 16 grain size intervals below the silt-sand boundary. Each of the shallow sediment core samples will also be analyzed for percent moisture content and total organic carbon (TOC).

- Confirmatory Sub-bottom Sediment Core Sampling. Upon completion of the sub-bottom profile surveys, the sub-bottom profile data will be supplemented by collection and visual classification or physical property analysis of deep sediment cores. These cores will be obtained by means of vibracoring. The core data will be used to correlate prominent signatures observed in the sub-bottom data with observed stratigraphic features or marker beds. A total of 51 sub-bottom cores will be collected (3 cores from 17 transects). Cores will be advanced along transects located at each RM along the study area, however, prior to the commencement of any coring activities, all proposed coring locations will be compared to existing cable crossing

mapping, and verified to be clear of submerged utilities with a magnetometer. The number and location of these confirmatory sub-bottom sediment cores will be identified, and they will be processed in the same fashion as the confirmatory shallow sediment cores. Each confirmatory shallow sub-bottom sediment core sample will be visually classified using the USCS system with up to 50 discrete sediment samples to be collected and submitted for physical properties analysis, including grain size with hydrometer, TOC, Atterberg Limits, bulk density, moisture content, and solid specific weight. Grain size analysis of the collected sediment samples will be conducted in accordance with ASTM D422 “Standard Test Method for Particle-Size Analysis of Soils” (ASTM, 2002) and hydrometer analyses. Grain size analysis will be reported in percentile by diameter as well as by percent gravel, sand, silt, and clay. Samples for hydrometer analyses will be selected based on the observed presence of a fine-grained fraction and will be reported at 16 grain size intervals below the silt-sand boundary.

4.3.4. Geophysical Survey Reporting

Post-processing, analysis, and interpretation of all field data collected will be completed prior to the completion of a Geophysical Survey Report. Maps and cross-sections depicting interpretative river bottom geomorphology and sediment structure will be prepared and included in both the Draft and Final Reports. An internal project database will be populated with all final digitally recorded navigational and geophysical data generated for this project. All maps and cross-sections generated for this project will be generated in ArcView and referenced to New Jersey Plane Coordinate System NAD83 and the NGVD29. A list of deliverables for the geophysical survey includes:

- Side-scan sonar survey coverage map(s).
- Side-scan sonar mosaic maps(s) or plot(s).
- Side-scan sonar contact list.
- Sub-bottom profile survey coverage map(s).

- Sub-bottom cross-section plot(s) referenced to NAD83 and the NGVD29 (with individual sediment layers delineated, organic and contaminated regions indicated with initial analytical findings displayed and summarized).
- Confirmatory sample location maps.
- Sediment texture map(s).
- Digital data files in SEG-Y or XTF format with complete documentation of all file formats.
- Detailed field logs of all equipment system gains used and navigation files generated.
- Results of bottom loss determinations at 10-foot intervals along each survey line for each geophysical source.
- Impedance and attenuation versus travel time at 10-foot intervals along each survey line for each geophysical source.
- Paper copies of each sonargram annotated with time, date, line number, etc.
- Graphic files of digital geophysical data collected along each geophysical survey line for later incorporation into a GIS.

A geophysical report will then be generated, which will address, at a minimum, the following:

- Sediment distribution patterns and layer thicknesses.
- Stability of the river bottom and how likely river bottom morphology is to change. [Note that sediment bed erosion and SedFlume studies will be addressed as part of FSP Volume 1 (Malcolm Pirnie, 2005a) “Hydrodynamic and Sediment Transport Sampling Plan for 2004-2005.”]
- Area that may require special consideration during remediation.
- Benthic habitat characteristics for consideration in the design of dredging programs.

4.4. TASK 4 –SOILS AND SEDIMENTS INVESTIGATIONS (PMP TASKS JAC AND JFB)

4.4.1. Data Needs and Sampling Objectives

Except for the data summarized in Section 3.5 “Soil and Sediment Geochemistry,” no other site-specific soil/sediment data were found on an internal project database. Future soil and sediment investigations are required to support the following data needs, which address DQO questions 3, 7, 27, and 28:

- Determine whether candidate restoration site soil/sediment contaminant concentrations exceed appropriate ecotoxicological benchmarks or NJDEP Site Remediation Criteria, or they are likely to have an adverse impact on candidate site restoration (*e.g.*, plantings, biota; refer to DQO tasks 3B, 7A, and 27A). Note that applicable or relevant and appropriate requirements (ARARs) will be referenced in future versions of FSP Volume 3 once the ARARs have been developed for the Lower Passaic River.
- Determine candidate restoration site soil/sediment geotechnical properties to support restoration feasibility analyses (refer to DQO tasks 3A, 3C, and 28B).
- Determine soil geotechnical properties in Passaic River bank areas to evaluate slope stability and whether bank stabilization measures may be required during remedial dredging (refer to DQO tasks 3C and 3D).
- Provide data necessary for the affected environment section of the NEPA-EIS (refer to DQO tasks 3E and 28L).

Once candidate restoration sites are selected, a detailed sampling program will be developed in consideration of site-specific conditions and based on the above data needs. The Quality Assurance Coordinator will ensure that soil and sediment sampling outlined in FSP Volume 3 will be well coordinated with sampling efforts discussed in FSP Volume 1 (Malcolm Pirnie, 2005a). An overview of studies and sampling methods that are likely to be performed at candidate restoration sites is presented in the following subsections.

4.4.1.1. GEOTECHNICAL INVESTIGATION

Site-specific geotechnical testing will be performed to quantify in-situ soil and sediment properties at areas selected for shoreline softening and public access, and also for areas selected for wetland restoration or rehabilitation. Geotechnical engineering studies will be performed for slope stability analysis of the shoreline, re-contouring of wetlands sediment, construction of bulkheads along the riverbanks, the removal of riprap and contouring of the riverbank. Geotechnical analyses may also be conducted in areas other than candidate restoration sites where information is necessary to assess the potential impacts of contaminated sediment dredging on shoreline slope stability. Soil samples will be obtained from borings for physical properties analysis as described below.

The geotechnical program will include: collection of split spoon samples by hollow stem auger (HSA) drilling rig with performance of the standard penetration test (SPT); undisturbed sampling using Shelby tubes, if soft ground conditions are encountered; and/or a minimum of 5 feet of rock coring where bedrock is encountered. Any borings on water will be installed using a truck-mounted rig on a floating platform or barge. Borings on land will be installed using a truck or all-terrain-vehicle mounted rig depending on the site conditions and accessibility of the proposed boring locations.

The geotechnical laboratory testing program will include, but not be limited to, grain size analysis (sieve and hydrometer), moisture content, TOC, determination of plasticity indices (Atterberg Limits), and corrosivity testing. If potentially compressible soils are encountered, then undisturbed samples taken during the field exploration program will be tested to determine strength and compressibility parameters. Field permeability tests may be performed as required at potential shoreline softening and wetland restoration sites. Re-compacted permeability tests will be performed in the laboratory if required.

It may be necessary to collect geotechnical data to support engineering analyses to analyze the stability of the shoreline area due to loss of lateral restraint as a result of dredging; bearing capacity and settlement of proposed structures; the design of anchors,

tie-backs, and deep or shallow foundations; design of excavation support and dewatering systems; and the characterization of the wetland sediment and rip-rap.

4.4.1.2. HAZARDOUS/TOXIC/RADIOLOGICAL WASTE INVESTIGATION

Hazardous/toxic/radiological waste (HTRW) investigations will be coordinated with field investigations in FSP Volume 1 (Malcolm Pirnie, 2005a) and will be conducted in accordance with guidance provided in the “Water Resources Policies and Authorities - Hazardous, Toxic and Radioactive Waste Guidance for Civil Works Projects” EM 1165-2-132 (USACE, 1992), “Engineering and Design - Requirements for the Preparation of Sampling and Analysis Plans” EM 200-1-3 (USACE, 2001a), and the CERCLA remedial investigation guidance “Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA EPA/540/G-89/004 (USEPA, 1988). A report will be prepared which describes detected HTRW occurrences within, or nearby, the project areas. It will include a preliminary determination of the nature and extent of detected contamination as well as quantitative and qualitative analyses of contamination impacts in the absence of response actions. HTRW site inspections will be conducted for the ecosystem restoration projects in support of alternative plan development. Soil samples may be collected using conventional drilling rigs, or direct push technology (DPT).

4.4.2. Sampling Locations and Frequency

Site-specific sampling locations and frequency of sampling will be determined once potential restoration opportunities are determined. Sampling locations will be selected based on a review of site history, probable restoration activities, and the development of a conceptual site model for the candidate site that identifies likely contaminant migration pathways and impacted media. It is assumed that approximately 4 to 8 soil borings will be required per acre to investigate each candidate restoration site, depending on the location of potential areas and features of concern. Some sites along the river may be small enough that additional allowance per acre will be needed. Geotechnical borings will be advanced at a frequency that complies with local municipal codes, and where possible, geotechnical and environmental data gathering will be

combined in a single boring. At potential shoreline softening and wetland restoration sites, or where slope stability analyses are required to support dredging design, a geotechnical boring may be required every 50 to 100 feet along the shoreline, depending on site conditions and variability and specific data needs.

4.4.3. Preliminary Soil and Sediment Methods

Based on the potential for sampling upland soils and wetland soils/sediments several sampling methods may be implemented on a site-specific basis. These sampling methods include HSA drilling rig and split spoons, Shelby tube, DPT, and hand-driven coring devices. The following sections present an overview of the prospective sampling methods that may be implemented during this program.

4.4.3.1. SOIL SAMPLING AND MONITORING WELL/PIEZOMETER BORING PROCEDURES

Drilling rigs will be set up and operated in accordance with standard drilling practices, and in a manner consistent with the safe and efficient operation of the equipment. In addition to the general USACE and USEPA guidelines, borehole drilling and soil sample collection will be performed in accordance with the latest “Soil Investigation and Sampling by Auger Borings” ASTM D-1452 (ASTM, 2000a), “Penetration Test and Split-Barrel Sampling of Soils” ASTM D-1586 (ASTM, 1999), and “Thin-Walled Tube Sampling of Soils” ASTM D-1587 (ASTM, 2000b), where appropriate. Rock core descriptions will follow the guidelines set forth in the “Engineering and Design - Monitoring Well Design, Installation, and Documentation at Hazardous Toxic, and Radioactive Waste Sites” EM 1110-1-4000 (USACE, 1998a). Hydraulic system leaks, as well as lubricant and fuel leaks, will be eliminated or prevented. Safety measures are to be followed during equipment operation and are addressed in the Health and Safety Plan (HASP; Malcolm Pirnie, 2005c).

Subsurface soil samples will be collected during drilling for visual classification, analytical laboratory analysis and geotechnical analysis. Most subsurface soil samples will be collected via the HSA drilling method. The HSA method includes using a drilling

rig to advance 4¼-inch inner diameter augers. For monitoring well soil borings, this method will result in a borehole diameter that is greater than 8 inches, or at least 4 inches larger than the outside diameter of the monitoring well casing and well screen. The borings will be advanced by rotating the augers to the desired depths into the subsurface soils. The borings will be advanced incrementally to permit soil sampling, as required. Split spoon samples will be collected at each new monitoring well boring location. Soil samples for lithologic logging of monitoring well soil borings will be collected continuously from the ground surface to a pre-determined depth or the groundwater table, whichever comes first. If groundwater is encountered, and the overburden is present, then sampling will be performed at 5-foot intervals to the pre-determined depth.

If heaving sands are encountered in a monitoring well soil boring, then clean and potable water of known chemical quality will be added to maintain a positive hydraulic head inside the auger. In the event the overburden material cannot be penetrated using the HSAs, then the use of temporary steel casing and a tri-cone roller bit or other method, approved by the geologist or engineer may be employed. If temporary casing is used, the casing may be advanced by rotation as described above, or by driving (which may include air percussion hammer). Overburden materials may then be reamed out by using water or air rotary drilling methods. Drilling water will not be re-circulated. If air rotary methods are used, then a suitable hydrocarbon pre-filter will be utilized between the air compressor and the borehole.

The shallow monitoring wells and piezometers are intended to be screened across the unconfined water table in the overburden. In the event unconfined water is not encountered in the overburden, then the borehole will be advanced into bedrock until unconfined water is encountered. If unconfined water is encountered in the overburden or uppermost bedrock, then the well screen will be installed to take into consideration normal seasonal fluctuations in water elevation so that monitoring will be possible throughout the year. In general, the 10-foot-long well screen is expected to be set with about 2 to 3 feet of the screen above the water table. Well screen slot size and filter pack gradation are estimated based on available information. For wells installed in the

bedrock aquifer or in aquifer units below an upper, unconfined aquifer, it may be necessary to use double-cased or other well construction techniques to prevent migration of groundwater contaminants between aquifer units.

4.4.3.2. LOGGING OF SOIL BORINGS

Soil-boring logs will be prepared in the field as borings are drilled by a qualified, experienced geologist or geotechnical engineer. Boring logs will be prepared on an electronic version of a HTRW drilling log form. A sample HTRW drilling log form is provided in Appendix A (noted that this form will be completed electronically). The logs will be completed and signed by the preparer. Soil borings will be logged at a scale of 1 inch equals 1 foot (1" = 1') with each type of material encountered being described on the log form. All relevant information in the log heading and body will be completed. If surveyed horizontal control is not available at the time of drilling, location sketches referenced by distances to permanent surface features will be shown on or attached to the log.

Each material type encountered will be described on the log form. Descriptions of unconsolidated materials will include Unified Soil Classification System (USCS) classification in accordance with "Standard Practice for Description and Identification of Soils" ASTM D-2488-84 (ASTM, 1984). The description will also include consistency of cohesive materials or apparent density of non-cohesive materials, moisture content assessment, color, other descriptive features such as bedding characteristics, organic materials, macrostructure of fine-grained soils, and depositional type. A Soil Description Summary Sheet will accompany the logger for easy reference to the USCS. A copy of the Soil Summary Sheet is provided in Appendix B. Pocket penetrometer tests may also be conducted in the field and recorded in the field log.

Depth information will be from direct measurements accurate of ± 0.1 foot. Stratigraphic and/or lithologic changes will be identified by a solid horizontal line at the appropriate scale depth on the log, which corresponds to changes at the measured borehole depth. Gradational changes identified from cuttings will be identified by a horizontal dashed line at the appropriate scale depth based on the best judgment of the

logger. Lines will be drawn with a straight edge. Boring logs will clearly show the depth interval from which all samples are obtained. Logs will also indicate the presence or absence of water in boreholes, the depth at which water is first encountered, the depth to water at the completion of drilling, the stabilized water depth, and the time allowed for the levels to stabilize.

Boring logs will show drilling detail, including borehole and sample diameters, the depth at which changes occur in drilling or sampling methods or equipment, and the total depth of penetration and sampling. "Bottom of Hole" will identify the bottom of the hole clearly on the log. The logs will also identify any drilling fluid losses, including depths at which these losses occur, rate of loss and total volume lost. Drilling fluids used will be shown on logs and will include the source of make-up water, drill fluid additives by brand and product name, mixture proportions, and type of filter for compressed air. Depth and type of temporary casing used, intervals of hole instability, intact soil sampling attempts, depth, and sample recovered from each attempt will also be shown on the log.

Any drilling or sampling problems will be noted on the logs, including descriptions of resolutions. Logs will include all other information relevant to the investigation, including odors, field screening and test results, and any evidence of contamination of samples, cuttings, or drilling fluids. Drafted boring logs will be submitted in the Draft and Final Report.

4.4.3.3. SUBSURFACE SOIL SAMPLING FROM SOIL BORINGS

- Split Spoon Sampling. Stainless steel split spoons will be used (to the extent available) to collect soil-boring samples that will be submitted for chemical analyses. Since the identification of samples to be submitted for chemical analysis may require collection and screening of ten or more split spoon samples per boring, it is likely that conventional carbon steel split spoons will also be utilized to supplement the driller's available stainless steel split spoons. Split spoon samplers used for collection of samples for chemical analysis (both stainless and carbon steel) will be decontaminated and in good condition on the interior (*i.e.*, free of pitting and

scratches which could prevent adequate sampler decontamination). If undisturbed samples are required, then Shelby tubes will be used to sample the subsurface soils.

- Direct-Push Technology – Soil Sampling. Collection of soil samples for analytical testing may be advanced using DPT equipment. DPT equipment involves the use of a hydraulically powered, percussion driving system. To begin the boring, the DPT rig will be positioned at a boring location, and an exclusion zone will be established in accordance with the HASP. The drilling unit will be stabilized and leveled. The driller will inspect the tools for excessive wear, and will use tools deemed suitable by the field representative. The borehole will be advanced using DPT methods with a dual-tube apparatus (*i.e.*, dedicated, disposable core liners advanced within steel probe rods). Soil samples may be collected to verify the subsurface stratigraphy and for laboratory analyses. Groundwater samples for screening analyses may also be collected using screened probe rod sections.

4.4.3.4. WETLAND SOILS AND SEDIMENT SAMPLING

Wetland soil and sediment samples will be obtained using an Automation System Interconnect, Inc., (ASI) multi-stage core-sampling device, piston coring devices, or via DPT (if accessible). The ASI sampling device includes a 16-pound slide hammer and a 2-inch diameter, 12-inch long core sampler. Two 12-inch long sampler tube extensions will be placed at the end of the device to allow sampling up to a maximum depth of 3 feet. At each sample location, an attempt will be made to collect up to 3 feet of core material, or to the depth of refusal. If at any individual sample location the substrate is such that 3 feet of sample cannot be retrieved, then the core sample will be collected to the deepest depth practicable. If deeper samples are required, then an all terrain drill rig will be employed and split spoon samples will be collected.

The interior of the core sampler will have a stainless steel liner. Upon retrieving the core sample in the field, the sample will be removed from the sampling device and placed within a core holder (*i.e.*, a half piece of polyvinyl chloride (PVC) approximately 3 to 4 feet in length). The core will then be sub-sampled in the desired increment for the later chemical and geotechnical analysis.

It is expected that two cores will need to be collected at each location to gather sufficient material for the requisite chemical and physical analyses. For sampling within soft sediments (*e.g.*, ponded areas, etc.) sampling will be conducted at or near low tide, when little, if any, water is present. It is also anticipated that plywood sheeting will be placed on the sediments to allow sampling personnel a firm base to perform sampling operations.

4.4.4. Sample Analysis and Reporting

The chemical analyses to be performed on soil and sediment samples include: polychlorinated biphenyls (PCBs; as Aroclors and congeners); target compound list (TCL) volatile organic compounds, TCL semivolatile organic compounds (base-neutral fraction; polycyclic aromatic hydrocarbons (PAHs) compounds only), TCL pesticides and herbicides, target analyte list (TAL) metals and cyanide; and polychlorinated dibenzodioxins (PCDD) and polychlorinated dibenzofurans (PCDF).

The geotechnical laboratory-testing program will include, but not be limited to, grain size analysis (sieve and hydrometer), determination of plasticity indices (Atterberg Limits), moisture content, TOC, and corrosivity testing. Consolidation tests and triaxial shear strength tests may also be conducted, based on specific investigation data needs. If potentially compressible soils are encountered, undisturbed samples taken during the field exploration program will be tested to determine strength and compressibility parameters. Field permeability tests may be performed as required at potential shoreline softening and wetland restoration sites. Re-compacted permeability tests will be performed in the laboratory if required.

Post-processing, analysis, and interpretation of all field and laboratory data will be completed prior to the completion of a Soils and Sediments Investigation Report. Maps, analytical data, and geotechnical results will be prepared and included in both the Draft and Final Reports.

4.5. TASK 5 –WATER QUALITY INVESTIGATIONS (PMP TASKS JAAB AND JFB)

4.5.1. Data Needs and Sampling Objectives

Except for the data summarized in Section 3.6 “Water Quality”, no site-specific water data were found on an internal project database. Future water quality investigations are required to support the following data needs, which address DQO questions 7, 27, and 28:

- Determine whether candidate restoration site groundwater/surface water contaminant concentrations exceed appropriate ecotoxicological benchmarks, National Ambient Water Quality Criteria, or NJDEP Site Remediation Criteria, or they are likely to have an adverse impact on site restoration (e.g., plantings, biota; refer to DQO tasks 7B, 27B, and 27C). Note that applicable or relevant and appropriate requirements (ARARs) will be referenced in future versions of FSP Volume 3 once the ARARs have been developed for the Lower Passaic River.
- Provide data necessary for the affected environment section of the NEPA-EIS (refer to DQO tasks 7C and 28L).
- Determine groundwater contaminant data adjacent to Passaic River to support modeling efforts (refer to DQO task 27B).

The Quality Assurance Coordinator will ensure that water sampling outlined in FSP Volume 3 will be well coordinated with sampling efforts discussed in FSP Volume 1 (Malcolm Pirnie, 2005a).

4.5.2. Sampling Locations and Frequency

Site-specific sampling locations and frequency of sampling will be determined once candidate restoration sites are determined. Monitoring well construction locations will be selected based on a review of site history, probable restoration activities, and the development of a CSM for the candidate restoration site that identifies likely contaminant migration pathways and impacted media. It is assumed that at least three monitoring

wells and/or piezometers will be required to investigate each candidate restoration site, depending on the location of potential areas and features of concern.

4.5.3. Preliminary Water Quality Methods

The following sections describe well and/or piezometer installation and development procedures and surface water sampling procedures.

4.5.3.1. SHALLOW MONITORING WELL/PIEZOMETER INSTALLATION

The monitoring well boring will be advanced using drilling methods described. The final depth of the monitoring well boring and the interval of well screen will be selected such that well construction meets the project quality objectives. Once the geologist or engineer determines the appropriate completion depth of the monitoring well boring, the drilling subcontractor will flush the drill casing with potable water to remove any debris that may have collected inside the casing prior to installation. Water recirculation will not be allowed. The drilling subcontractor will then install the monitoring well screen and riser to the depth determined by the geologist or engineer.

The wells will be constructed of 2-inch diameter stainless steel while the piezometers will be constructed from 2-inch Schedule 40 PVC continuous (wire wrapped) pipe. Slot size will be determined based on subsurface data and designed such that the screen is compatible with the aquifer and gravel pack material. It is presently anticipated that the shallow monitoring wells will be constructed using a 20-slot (0.020-inch), 10-foot section screened interval with approximately 2 to 3 feet of the screened interval set above the water table to allow for observation of water table fluctuations.

The filter pack will consist of clean, silica, sand sized to perform as a filter between the formation material and the well screen. The grain size of the filter pack will be selected to be compatible with the native soil. The filter pack material will be tremied into place to avoid bridging and to provide a continuous filter pack throughout the screened interval of the well. The filter pack will extend approximately 1 foot below and 2 to 4 feet above the well screen.

During backfilling of the monitoring well, the HSA or drilling casing will be withdrawn in increments such that the filter material is, at all times, no more than 0.5 feet below casing bottom. Furthermore, no natural materials (*e.g.*, sand or gravel) will be permitted to fill the space around the well screen or riser. In the event the borehole wall collapses during installation of the well, the drilling subcontractor will be required to take measurements necessary to correct this situation.

The well riser will be constructed of stainless steel and the piezometers of PVC pipe. Riser sections will be joined by threaded, flush joint couplings to form watertight unions. Adhesive or solvents will not be used to join the casing or screen sections. Risers will be set round, plumb, and true to line. A 10-foot long section of pipe, 0.5-inch less in diameter than the well riser pipe, will be run through the entire length of the well to check the alignment. The result of this test will be recorded on the well construction log. If the pipe does not pass freely for the entire length of the well, the well will be repaired or replaced. Prior to the test, the pipe section will be steam cleaned. Adequate precautions will be taken to prevent cross-contamination of wells with cable or rope used to conduct the well alignment test.

A minimum 2-foot thick bentonite seal will be tremied into place in the annular space above the well screen and filter pack sand. The seal will consist of commercially manufactured sodium bentonite pellets, not to exceed 0.5-inch diameter, or sodium bentonite granules. The seal will be allowed to hydrate for a minimum of 4 hours before grouting begins. If the seal is positioned above the water table, granular bentonite will be installed in 6-inch lifts with each lift hydrated for a minimum of 30 minutes between lifts. Clean, potable water will be added to hydrate the bentonite. Following placement of the final lift, the bentonite seal will be allowed to hydrate for an additional 2 hours prior to grouting.

A cement-bentonite grout mixture will then placed to the ground surface prior to final drill casing or auger removal. As the casing is removed, this backfill will be continuously "topped off" to preclude breaches in the seal caused by caving of natural materials. The cement-bentonite grout will consist of Portland Cement [“Standard

Specification for Portland Cement” ASTM C 150 (ASTM, 2004)] and water in the proportion of not more than 7 gallons of water per bag (94 pounds) of cement, and 3 percent by weight of sodium bentonite powder. The grout will be tremied by pumping through a side discharging tremie pipe with the lower end of the tremie pipe within 3 feet of the top of the bentonite seal. Grout will be tremied until it flows from the boring at the ground surface.

Precautions will be taken during well placement to prevent tamping of backfill materials and to prevent run-off or foreign objects from entering the well. Upon well completion, a vented cap will be installed to prevent the entrance of foreign objects into the well. The riser will be protected by a larger diameter protective steel casing, rising 2 to 3 feet above ground level and set an equal distance below ground level to the elevation of the cement grout backfill. The casing will be installed so as not to hinder well access. Wells will be provided with a locking cap and a brass, non-rusting lock. The locks will be keyed alike and three duplicate keys will be provided to the USACE Project Manager.

A concrete pad, 3 feet by 3 feet by 4 inches thick, sloped away from the well, will be constructed around the well casing with the top outer edge at the final ground level elevation. Three 2-inch diameter steel posts will be installed around the monitoring well and will be cemented in place outside the concrete pad. Monitoring well installation diagrams will be electronically prepared on-site detailing the as-built configuration. Well diagrams will be included in the draft and final reports. A sample HTRW Well Installation Diagram is provided in Appendix C. Note that this form will be completed electronically.

Information presented on well installation diagrams will include the project and site names, well number, total depth of completed well, depth of grouting, the amount of cement and bentonite used, the total boring depth, depth and type of well casing, static water level upon well completion, water level after well development, installation date(s), and the driller’s and geologist’s names. The preparer will sign the installation diagrams.

Construction details, such as the depth to and a description of the backfill materials, gradation of gravel pack, length, location, diameter, slot size and material of

screen and riser, manufacturer of well screen, position of centralizers and location of any blank pipe inside the well, will be shown on the well installation diagram. Also to be included in the installation diagram are a description of surface completion, protective steel casing, pipes, surface seal, difficulties encountered during well installation, surveyed coordinates and elevation of top of riser and top of ground, and a brief stratigraphy log showing depths to and descriptions of major lithologic changes encountered in the boring.

Any well that is temporarily removed from service or left incomplete due to a delay in construction will be capped with a watertight cap and equipped with a vandal proof cover. The wells will be identified in the field by attaching a corrosion resistant, permanent tag to the outer-steel casing of each well. Tags will include the following information: well number, depth, and date of installation.

4.5.3.2. WELL DEVELOPMENT

The monitoring wells will be developed and will consist of mechanical surging, bailing, and over-pumping until little or no sediment enters the well. Sediment that enters the well during this process will be removed. At the end of that time, the well will be continuously pumped using an electric submersible, or pneumatic drive positive displacement, or bladder pump. Water lost during the advancement of the borings through the monitoring interval will be removed. Temperature, pH, specific conductivity, and turbidity will be monitored during pumping (about one reading per well volume). Pumping will continue until these parameters have stabilized (less than 0.2 pH units, or a 10 percent change for the other parameters among four consecutive readings). The goal for turbidity is <50 nephelometric turbidity units (NTU).

The field team will collect approximately 1L of the last water withdrawn from the well during development in a clear glass jar. The depth of any sediment, which collects in the bottom of the jar after the sample is allowed to settle, will be noted on the Well Development Form. The turbidity of the water will be determined in accordance with “Standard Test Method for Turbidity of Water” ASTM D-1889 (ASTM, 2000c). The well development procedure will include washing of the well cap and the interior of the

well casing above the water table using only water from that well. An example of the Well Development Form that will be completed electronically for each new monitoring well installed is provided in Appendix D. Note that this form will be completed electronically. Information provided on the Well Development Form will include, but not be limited to, the following:

- Name of project and site, well identification number, and date(s).
- Date, time and elevation of the static water level and bottom of well prior to development.
- Development method and equipment used.
- Volume and physical character of water removed.
- pH, specific conductance, temperature and turbidity of water removed.

4.5.3.3. MONITORING WELL SAMPLING

A complete round of water levels will be collected at the beginning of groundwater sampling for each site. It is anticipated that a minimum of two well gauging events will be conducted during the field investigation for each site. Water level measurements will be taken to the nearest 0.01-foot interval to the marked location on each well riser (*e.g.*, top of casing).

An oil/water interface probe will be used for well gauging. The measurement probe will be lowered until water is detected. This depth will be measured from the top of casing where the well elevation was surveyed and recorded in the field logbook. The probe will then be lowered to the bottom of the well and the well depth will be measured, recorded, and compared to the original value to detect silting of the well. If encountered, the thickness of any non-aqueous phase liquids (either at the top or bottom of the water column in the well) will be measured and noted in the field logbook. Well-gauging equipment will be decontaminated as specified in FSP Volume 1 (Malcolm Pirnie, 2005a).

Groundwater samples will be collected from all monitoring wells. Prior to sampling, the monitoring wells will be allowed to equilibrate after well development.

Equipment used for groundwater sampling may vary and depends on the following factors:

- Type of well.
- Depth of well.
- Diameter of well casing.
- Depth to water.
- Contaminants likely to be encountered and analysis to be completed.
- Slot size of screen, screen type and length.
- Naturally occurring turbidity of aquifer.
- Quality of well development.
- Quality and type of screen filter pack.
- Expected recharge rate.

The monitoring wells will be purged prior to sampling using the low flow technique. The field team will select the most efficient method of pumping the well, depending upon the depth to water and volume of standing water. It is anticipated that well purging and sampling will be completed using a peristaltic pump with dedicated ‘silastic’ pump tubing and dedicated disposable polypropylene tubing, which is inserted into the well, or by using submersible pumps. Low flow sampling practices [outlined in “Ground Water Issue: Low Flow Groundwater Sampling Procedure” EPA/540/S-95/504 (USEPA, 1996)] will be used with a flow rate of 0.25 gallons per minute (about 1 liter/minute or less). Bailers will only be used if slow recharge makes using the low flow pump impossible or impractical. A “flow-through sampling cell” may be connected to the pump discharge line and used to facilitate collection of field parameter measurements.

The water level at each monitoring well will be measured prior to beginning the low flow purging. The total depth of each well will not be measured prior to pumping since this action may disturb sediments in the well, which defeats the purpose of the low flow procedure. Water level data will be recorded on the low flow sampling form.

Each well will be purged until field parameters have stabilized over three consecutive readings. Field parameters to be measured during well purging include pH,

temperature, specific conductivity, dissolved oxygen, oxidation-reduction potential, and turbidity. Measurements will be recorded at the start of purging activities and once every 5 minutes until the readings have stabilized (within 0.2 pH units or less than, or equal a 10 percent difference in other field parameters for three consecutive measurements). These measurements and other relevant information will be recorded electronically on the HTRW Well Sampling Form for each well, provided in Appendix E. Note that this form will be completed electronically.

Pumps, or bailers, may be used to collect samples after purging as dictated by site-specific sampling conditions. The Redi-Flo 2-inch variable speed submersible pump meets the same objectives of a peristaltic pump with the distinct advantage of being able to pump from greater depths. Peristaltic pumps typically can only pump from depths no greater than 25 feet to 28 feet. The submersible pump provides continuous flow from deeper depths. Because pump materials are stainless steel and Teflon, decontamination procedures are easy and thoroughly accomplished. The solid-state converter used with the pump can handle flow rates ranging from 9 gallons per minute to as little as 100 mL/minute.

If the submersible pump is used for sample collection following purging, it will be decontaminated as described in FSP Volume 1 (Malcolm Pirnie, 2005a). Decontamination of the peristaltic pump and tubing will not be necessary since all tubing and pump lines are dedicated. Additionally, no pump parts come in contact with the sample so the possibility of cross-contamination is eliminated.

Following well purging, samples will be collected and will be placed in the appropriate laboratory containers. If the peristaltic pump is used, the pump will remain running and only the pump tubing will be disconnected from the flow-through cell so that the sample may be directed into the sample containers. During the collection of groundwater samples for volatile organic compound analyses, care will be taken to avoid trapping air in the bottle. The containers will then be labeled, and placed in a cooler chilled to 4°C for shipment to the analytical laboratory. Groundwater sampling

information, including location, sample time, designation, and matrix will be documented electronically in the Field Log Book, Well Sampling Form, and the Chain-of-Custody.

4.5.3.4. DIRECT-PUSH TECHNOLOGY – GROUNDWATER SAMPLING

Collection of groundwater samples for analytical testing may also be conducted using DPT equipment. For groundwater sampling, the DPT rig will advance probe rods until the selected groundwater-sampling interval is reached, and then a temporary PVC well screen will be inserted into the probe rods. The temporary screen will consist of a 2-foot-long section of flush-threaded schedule 40 PVC screen, 0.010-inch slot size, and riser. A PVC drive point will be threaded onto the bottom of the temporary screen to facilitate driving the screen several inches into the formation. The probe rods will then be retracted to allow the formation to collapse around the screen. Groundwater samples from DPT borings will be collected using a peristaltic pump fitted with dedicated Teflon-lined tubing. Alternately, the DPT equipment may include an integral screen section that can be advanced along with the probe rods for collection of groundwater samples.

Multiple groundwater samples may be attempted from each DPT boring. For example, various sampling intervals may be established as: near the top of the groundwater table, mid-depth, and the bottom of boring. At locations where the available aquifer depth is less than approximately 20 feet, it is likely that only two samples would be obtained from the boring (at the water table and at the bottom of the boring).

These samples are anticipated to be very turbid. If sufficient water is available from the sampling location, water will be removed prior to sampling in an attempt to clear some turbidity from the water. Once the sample containers are full, the PVC screen will be removed from the probe rods and the borehole will be advanced to the next groundwater-sampling interval. The above procedure will then be repeated until all vertical delineation samples have been collected.

Both filtered and unfiltered samples will be collected for the metals analysis. Samples will be filtered in the field using dedicated 0.45-micron filters (or similar equipment) prior to preservation. Decontamination of DPT sampling equipment used in

groundwater sampling will follow the decontamination procedures set forth in FSP Volume 1 (Malcolm Pirnie, 2005a).

4.5.3.5. SURFACE WATER SAMPLING

Due to the shallow nature of most wetland areas, surface water samples will be generally collected directly into the sample jars by dipping the containers into the water. If necessary, long-handled stainless steel dippers may be used to collect and transfer surface water samples to laboratory containers. Sample labels will be completed after the jars have been filled, to minimize potential volatile contamination from the marker pens. Latex or nitrile gloves will be worn during sample collection. Jars will be filled upstream of where the sampling personnel are standing in the stream. For multiple samples in a stream, collection will start at the most down-gradient location and end at the most upgradient location, which will prevent disturbed and entrained sediments from impacting downstream surface water sampling locations. The following in-situ readings will be obtained after samples are collected at each surface water sampling location:

- pH;
- Dissolved oxygen;
- Specific conductance and salinity;
- Oxidation-reduction potential;
- Temperature;
- Turbidity; and
- Eh (if monitoring sonde is capable).

Surface water sampling from the main stem of the Lower Passaic River is discussed in FSP Volume 1 (Malcolm Pirnie, 2005a) along with the collection of particulate organic carbon, dissolved organic carbon, and nutrient data.

4.5.4. Sample Analysis and Reporting

The chemical analyses to be performed collectively for groundwater and surface water samples include PCBs (as Aroclors and congeners), TCL volatile organic compounds, TCL semi-volatile organic compounds (base-neutral fraction; PAHs

compounds only), TCL pesticides and herbicides, TAL metals, PCDDs/PCDFs, and TOC. At each of the surface water sampling locations, field measurements will be collected (see Section 4.5.3.5 “Surface Water Sampling”).

Post-processing, analysis, and interpretation of all field and laboratory data will be completed prior to the completion of a Water Quality Investigation Report. Maps, analytical data, and field measurements will be prepared and included in both the Draft and Final Reports.

4.6. TASK 6 –HYDROLOGIC & HYDRODYNAMIC (PMP TASKS JAB AND JFB)

This section only addresses potential hydrologic and hydrodynamic investigations for restoration of wetland habitat and areas along the tributaries of the Lower Passaic River. For other types of restoration opportunities at locations along the main stem of the river, the hydrologic and hydrodynamic model developed for the contaminant fate and transport model will be used (refer to the Draft Modeling Plan; HydroQual, 2005). Note that although the Draft Modeling Plan does not directly address WRDA-related issues, it is anticipated that the main issues for the Passaic River will apply to the investigation of the candidate restoration sites. For example, the hydrodynamic models developed under CERCLA will include: the restoration of water quality, sediments and watershed drainage areas, and possibly nearby wetlands in the upper Newark Bay; the protection of river biota from contact with concentrations of multiple chemicals in the river sediments to help restore aquatic habitat; and the reduction and control of pollutants now entering the river from storm water runoff, outfalls, and atmospheric deposition to assist with restoration and to maintain the restored habitat.

4.6.1. Data Needs and Sampling Objectives

Except for the data summarized in Section 3.7 “Hydrology and Hydrodynamics,” no other site-specific hydrological or hydrodynamic data were found on the internal project database. Future hydrologic and hydrodynamic investigations are required to support the following data needs, which address DQO questions 1, 9, and 28:

- Determine groundwater and surface water elevations, fluctuations, and flow directions or regimes to understand the hydrologic and hydrodynamic factors that may affect restoration feasibility analyses (refer to DQO task 28G).
- Define channel layout and other design parameters required for the successful establishment of a salt or brackish wetland (refer to DQO tasks 1A, 1B, and 1C).
- Simulate the hydraulics and the water quality characteristics of the proposed wetland system (refer to DQO tasks 1A, 1B, and 1C).
- Determine that suitable surface or subsurface hydrology exists to sustain the intended restoration design and foundation (refer to DQO tasks 1A, 1B, 1C, and 9A).
- Provide the basis for the horticultural design and planting of the wetland (refer to DQO task 28G).
- Provide the basis for maintaining aesthetics at a site (refer to DQO task 28G).
- Study the flooding potential in offsite areas adjacent to the restoration area (refer to DQO task 28G).
- Provide information required for the evaluation of alternatives in the NEPA-EIS (refer to DQO task 28L).

4.6.2. Sample Locations and Frequency

A site-specific hydrologic investigation will be determined once candidate restoration sites are determined. It is likely that each candidate restoration site will require the installation of three or more monitoring wells and/or piezometers, staff gauges, and the installation of water-level data-loggers to record water level data.

4.6.3. Preliminary Hydrologic & Hydrodynamic Methods

To monitor tidal fluctuations in the unconsolidated aquifer, wetland, and stream channels due to tidal influence in the nearby Lower Passaic River, several monitoring methods may be implemented on a site-specific basis. These methods include the installation of piezometers and staff or tide gauges. In addition, there could be a need to develop a geomorphic map for use in modeling wetland and tributary hydrodynamics.

The following presents an overview of the prospective methods that may be implemented during this program.

For candidate restoration sites and Lower Passaic River tributaries, a hydrologic features map will be prepared (scale 1 inch = 100 feet) from aerial photographs that show stream or drainage channels with areas of ponded water and/or mudflats. A set of quantitative measurements and calculations will be prepared from this map, including: channel classification (order); total number of channels in each order; and the calculation of bifurcation ratio, channel frequency, total length (sinuous length), total linear length, average channel length, channel length ratio, average channel sinuosity, and drainage density. The methods and calculations will be based on Chow *et al.* (1988), Chow (1964), and Horton (1945). A field reconnaissance will be conducted to confirm the map. The hydrogeologic features data will be prepared in a separate layer for electronic use (AutoCAD 2004 format).

A hydrologic-hydraulic analysis will be made of the Lower Passaic River and adjacent contributory drainage areas based on a tidal storm comparable with existing control measures for the surrounding community and the 100-year fluvial storm event. This analysis will be performed with the refined Contaminant Assessment and Reduction Program (CARP) model; however, if this water quality model cannot perform the required simulations, then alternative models may be implemented. [Note refer to the Draft Modeling Work Plan (HydroQual, 2005) for more information on the revised CARP model.] Alternative models include a USACE or in-house hydrodynamic models (*e.g.*, LATIS; TAMS, an Earth Tech Company) and mathematical simulations to characterize existing and proposed hydrologic and hydraulic conditions. Both of these alternative models require the following data: salinity, temperature, water elevation, current, meteorological data, and river discharge.

The LATIS has been in use for more than 25 years in studying unsteady-state tidal hydraulics at their restoration sites along the Hackensack River. This model is a Quasi-2D, finite difference model used in simulation of tidal channels through wetland restoration sites. If necessary, another USACE or in-house model (*e.g.*, WASP5; TAMS,

an Earth Tech Company) may be used for water quality simulations if the water quality model being developed by USEPA cannot perform the required simulations. A design report will be prepared and submitted that presents the modeling assumptions and criteria, the results of the hydrologic and hydraulic analysis, and criteria for the design of the proposed water management facilities to meet the project's mitigation potential, habitat enhancement and flood protection objectives.

Installation of piezometers will follow the construction methods outlined in Section 4.4.3.1 "Soil Sampling and Monitoring Well/Piezometer Boring Procedures." Groundwater elevations will be used to evaluate the hydrogeologic regime in the vicinity of the candidate restoration site. Due to the potential for influence from tidal fluctuations on the unconfined aquifer, a staff gauge with a self recording tide gauge connected to a submerged atmospheric compensated transducer will be installed in the river to obtain river stage elevations. These staff gauge readings will then be compared with groundwater elevations from the piezometers fitted with similar self-recording pressure transducers to quantify tidal effects at the restoration site. A staff gauge will be installed adjacent to each restoration site to identify and/or confirm tidal fluctuations.

4.6.4. Hydrologic & Hydrodynamic Reporting

Post-processing, analysis, and interpretation of all field data will be completed prior to the completion of a Hydrologic & Hydrodynamic Report. Hydrologic and geomorphic maps, field measurements, and modeling results will be prepared and included in both the Draft and Final Reports.

4.7. TASK 7 – CULTURAL RESOURCES (PMP TASK JG)

The cultural resource investigations will be conducted on candidate restoration sites as well as within the main stem of the Lower Passaic River. Section 106 of the National Historic Preservation Act of 1966 (as amended) requires Federal agencies, or project sponsors, seeking Federal funding and/or permits to take into account the effect of any undertaking on any cultural resource included in, or eligible for inclusion in, the National Register of Historic Places (NRHP). As a Federal agency the USACE is

responsible for the identification, protection and preservation of significant cultural resources within the Area of Potential Effect (APE) of any proposed project. (The APE refers to the boundaries of the project where cultural resources could be impacted. The APE boundaries are determined by identifying direct physical impacts to resources such as digging and demolition of building, secondary impacts like access roads for construction, long term impacts like inundation and root penetration from new plantings, and visual impacts including unsightly elements of the constructed project that could undermine a historic landscape.) Significant cultural resources are any material remains of human activity that are listed on, or eligible for inclusion on the NRHP. Other statutes and regulations authorizing the USACE to undertake these responsibilities include Section 101 (b) (4) of the National Environmental Policy Act of 1969 and the Advisory Council Procedures for the Protection of Cultural Properties (36 CFR Part 800).

4.7.1. Data Needs and Study Objectives

Cultural resource investigations will be conducted to identify potentially significant resources on or near candidate restoration sites and within the main stem of the Lower Passaic River. Cultural resource investigations will also evaluate their eligibility for inclusion on the National Register of Historic Places. These investigations are required to support the following DQO tasks: 6A, 22B, and 28H.

Restoration planners will then be able to evaluate how to best avoid or minimize any impacts to eligible resources. An evaluation of the impact of alternative plans on eligible properties will be developed as part of the cultural resources investigation in consultation with the New Jersey SHPO. If eligible resources cannot be avoided, a Memorandum of Agreement (MOA) will be developed in consultation with the New Jersey SHPO to mitigate for unavoidable impacts. Any work stipulated in the MOA will be undertaken prior to initiation of project construction unless otherwise agreed with the New Jersey SHPO.

4.7.2. Preliminary Cultural Resource Methods

Cultural resources identified during the initial phase of the survey (Phase 1A, Phase 1) as potentially eligible for inclusion on the NRHP that are within the APE will be investigated further (Phase II and III) through additional research and fieldwork. Fieldwork may entail subsurface testing, geomorphological sampling, and remote sensing. The fieldwork will be tailored to each restoration alternative proposed and will be based on site topography, fill depths, anticipated resources, and proposed project actions. At this phase, if resources are identified, their eligibility for listing on the NRHP will be evaluated. Recommendations will be made for avoiding significant sites and possible mitigation measures will be suggested, if sites cannot be avoided. A Memorandum of Agreement may need to be developed in consultation with the New Jersey SHPO to mitigate for adverse effects. Topographic maps with preliminary project designs will be needed before a scope of work for cultural resource work can be developed. Cultural resource considerations that may influence the selected plan will be summarized and clearly set forth in the FS report and in the candidate restoration site design documents.

Remediation may include sediment removal, capping, and decontamination and restoration goals may include benthic habitat restoration, tidal wetland restoration, vegetative buffer creation, shoreline stabilization, and aquatic habitat improvement. Multiple types of cultural resource survey and archeological recovery techniques will be employed in order to investigate in wet, dry, and tidal environments. For dry upland areas, conventional archaeological techniques will be employed including ground reconnaissance, test pitting and trench or unit excavations. A ground reconnaissance survey of the area will be conducted to identify any extant historic structures or anomalous features along the ground indicating buried remains that could be impacted by the project. The ground reconnaissance and a review of historic maps will provide guidance for the subsurface testing portion of the survey. If the reconnaissance and map documentation indicate the likelihood for buried cultural resources, a testing plan will be developed based on the nature of the project in each area. Cultural resources that are

potentially threatened by the project will be reviewed by the project team and the New Jersey SHPO, and through coordination with the New Jersey SHPO, a mitigation plan will be developed, depending on the nature and level of the impact that is anticipated. Archaeological resources that will be completely demolished or destroyed could be fully excavated or thoroughly documented prior to construction. Some extant structures could be relocated or the project plans could be altered to avoid impacting the resource.

To identify sub-aquatic or sub-bottom prehistoric resources, documentary research will be conducted, which focuses on existing geomorphological studies of the area to determine locations that are potentially sensitive for prehistoric resources. Side-scan sonar and sub-bottom profiling survey data can be used to identify buried and submerged landforms, such as old river valleys, which might have been attractive to prehistoric cultures. The data obtained from sub-bottom profiling surveys might also indicate whether any such landforms were associated with preserved geologic strata containing land surfaces, which might have been available for human occupation.

In the event that potential prehistoric land surfaces were identified, additional information about their age and ecology could be obtained through sedimentary coring as part of the site-specific data collection for geotechnical purposes. As traditional archaeological data recovery is not feasible in these deeply submerged conditions, a coring program and subsequent analysis of the recovered columns may be used as mitigative measures to compensate for any adverse effects to prehistoric resources. Study of cores could include grain-size, pollen, foraminifera and geochemical analyses. The cores can also be used to assess the potential utility of more intensive sampling and data recovery of those locations. If adopted as a mitigative measure, a coring program could obviate the need for additional work or the avoidance of those areas in the siting of a restoration area.

To identify historic resources documentary research will be conducted. This work will focus on several existing surveys of shipwrecks on the East Coast, and in the North Reach of Newark Bay. Primary sources such as Maritime Registers and Life-Saving Service records may be consulted. Remote sensing techniques can be used to identify the

locations of shipwrecks or other isolated artifacts lost or dumped in the Passaic River and Newark Bay. The side-scan sonar and sub-bottom profiling survey data collected for prehistoric landforms can also be used to identify buried historic structures and vessels. Once restoration sites are determined, a magnetometer survey of these more defined areas can be undertaken. Remote sensing targets can then be evaluated for potential significance based on their type, size, appearance and correlation with historic data. Recommendations can be made at that time as to the potential eligibility of the target and as to the need for further investigations. Diving on the target by a qualified underwater archaeologist may be necessary to identify the nature of the target and determine its significance. If no historic properties are identified in the area of potential effect, then depending on SHPO review, no further cultural resources investigations would be required. If historic properties are present, then the potential impacts of the alternatives on eligible sites will be identified and alternatives for avoidance or impact minimization will be developed. Mitigation for unavoidable adverse impacts could entail a variety of alternatives based on the type of resource and may include such measures as detailed recording of a structure or vessel, detailed documentary research or conservation of selected elements of the resource.

To identify near shore resources, documentary research and a review of historic maps, including an evaluation of historic landfilling and dredging activities in the project area, will be undertaken. Research will be followed by a survey of the property on foot or by boat. This survey will determine the presence of historic structures and landscapes. A preliminary assessment of archaeological potential will be undertaken which will be based primarily on existing maps and coring data. This preliminary work will determine the need for further cultural resources studies. If necessary, a program of borings may have to be conducted to determine the presence or absence of potential archaeological deposits. If project activities are proposed on-shore, excavations by mechanical means, such as a backhoe, may be required. Further studies may be needed to assess the eligibility of identified architectural or archaeological resources. If no eligible resources are identified in the area of potential effect then, depending on SHPO review, no further

cultural resources investigations would be required. If historic properties are present the potential impacts of the alternatives on eligible sites will be identified and alternatives for avoidance or mitigation will be developed. Mitigation can entail a variety of alternatives based on the type of resource and may include such measures as detailed recording of a structure or vessel, detailed documentary research, conservation of selected elements of the resource or detailed archaeological investigations. Avoidance of resources eligible for the NRHP is recommended but particularly for submerged resources where the costs associated with documenting sites and recovering, conserving, maintaining and storing artifacts can be high.

4.7.3. Cultural Resource Reporting

Interim, draft, and final reports will be prepared by the USACE or the contractor. The report produced by a cultural resource investigation is of potential value not only for its specific recommendations, but also as a reference document. To this end, the report can be used as a basis for any future cultural resources work, and will meet both the requirements for cultural resource protection and scientific standards of current research as defined in 36 CFR Part 800 and the Councils Handbook and the Advisory Council on Historic Preservation's Handbook.

4.8. TASK 8 – SOCIOECONOMICS (PMP TASK JB)

The objective of socioeconomic analyses is to measure the cost effectiveness, social fairness, and institutional implementability of each restoration plan proposed for the contaminated environmental media in the Lower Passaic River and the candidate restoration sites. The restoration plans to be evaluated are expected to address the CERCLA objectives of removal of site contaminants or remediation of contaminated sediments and the FS objective of environmental restoration for candidate restoration sites. The study period for all evaluations will be 50-years to be consistent with the FS requirements.

4.8.1. Data Needs and Objectives

The objective of the socioeconomic analysis is to assess and prioritize proposed restoration alternatives according to the criteria described above to support decision-making. The socioeconomic investigation is required to support the following DQO questions: 28 and 29.

- Habitat units for each alternative from Project Management Plan: Task JDE: Environmental Resource Inventory Report (USACE *et al.*, 2003) by project feature (refer to DQO tasks 28I and 29C).
- “Report of Channel Conditions: For Channels 400 Feet Wide or Greater” (Engineer Form 4020) documenting channel conditions since initial construction (refer to DQO tasks 28I and 29C).
- Dredging sounding maps of Lower Passaic River for times and projects determined after reviewing “Report of Channel Conditions: For Channels 400 Feet Wide or Greater” Engineering Form 4020-R (USACE, 1990c) data (refer to DQO tasks 28I and 29C).
- Historic dredging costs since last significant project deepening (refer to DQO tasks 28I and 29C).
- Property values adjacent to environmentally restored shorelines (refer to DQO tasks 28I and 29C).
- Demographic data (refer to DQO tasks 28I and 29C).
- Project cost estimates, including operation and maintenance, project cost outlay schedule by project feature, project implementation schedule, financing plan, and statement of financial capability (refer to DQO tasks 28I and 29C).

4.8.2. Preliminary Socioeconomic Methods

4.8.2.1. ECONOMIC ANALYSIS

Remediation or restoration plans will have two types of benefits: Those that can be quantified in terms of monetary value and ecological benefits. The latter type will be developed in “Task JDE: Environmental Resource Inventory Report” (Project

Management Plan; USACE *et al.*, 2003). Estimating only those benefits with monetary value is within this scope.

For CERCLA plans, Implementation Guidance (CECW-P/CECW-O memorandum dated April 25, 2001, Subject: Implementation Guidance for Section 312 of the Water Resources Development Act of 1990, Environmental Dredging, as amended by Section 224 of the Water Resources Development Act of 1999) limits the monetary benefits to operations and maintenance cost savings. Note that most of the anticipated saving would actually occur at the New York and New Jersey Federal Navigation Channels. The non-monetary benefits from “Task JDE: Environmental Resource Inventory Report” are also included. Quantifying operation and maintenance cost savings will require extensive coordination with the USACE-New York District. The District will provide historic dredging costs, each Engineer Form 4020 (“Report of Channel Conditions: For Channels 400 Feet Wide or Greater”) documenting channel conditions, and pre- and post-dredging sounding maps. The most promising potential monetary benefit may be eliminating the need for upland disposal of contaminated sediments and allowing open-water disposal or upland beneficial use placement options.

For FS plans, the only benefits (usually termed “outputs”) are again non-monetary benefits from “Task JDE: Environmental Resource Inventory Report”. However, other monetary benefits can be used to offset costs in the analysis. Such monetary benefits or cost offsets typically include the value of recreation provided, but are not limited by type. As this study area is intensely developed, it is expected that cost offsets may include the anticipated increase in property values adjacent to environmentally restored shorelines. “Planning Guidance Notebook” Engineering Release Form (ER) 1105-2-100 (USACE, 2000) provides the guidance followed in FS.

Recreation benefits depend on the amount of increased recreation activity and the value of the recreation activities. The value will be based on either unit day values or contingent values, depending on the level of increase. Contingent values would likely require surveys of likely users. Unit day values are usually combined with capacity estimates, while the contingent valuation method provides a basis for estimating demand.

The analysis of environmental restoration projects uses Cost Efficiency and Incremental Cost Analysis (CE/ICA). This will be accomplished using the Institute of Water Resources (IWR) PLAN Decision Support Software. The CE/ICA will require six steps.

- Step 1. Display outputs and costs. Calculate average annual outputs (not discounted) and equivalent annual costs (discounted) based on inputs from the planning team over the 50-year planning horizon. Net Ecosystem Restoration (NER) costs will include operation and maintenance, and interest during construction. The NER costs are reduced by offsetting monetary benefits.
- Step 2. Identify combinable management measures. In this step, planners formulate all possible combinations of management measures and scales.
- Step 3. Calculate outputs and costs of combinations. All possible combinations of management measures and scales are sorted in terms of output. This provides the basis for developing a supply curve.
- Step 4. Conduct cost effectiveness analysis. A plan is cost effective if no other plan provides the same level of output for less cost and if no other plan provides more output for the same or less cost. This step identifies the best solution for a given amount (or range) of outputs. This essentially creates a supply curve and eliminates economically ineffective solutions.
- Step 5. Incremental cost analysis. Incremental cost analysis identifies the subset of cost effective plans that are superior financial investments, called “best buys.” Best buys are the most efficient plans at producing the output variable. They provide the greatest increase in the value of the output variable for the least increase in cost. The first best buy plan is the most efficient plan, producing output at the lowest incremental cost per unit. If a higher level of output is desired than that provided by the first best-buy plan, the second best buy plan is the most efficient plan for producing additional output, and so on. That is the same as identifying the plans with the lowest incremental cost per habitat unit. This is a marginal cost analysis. This step considers the most cost effective plans by scale of output, beginning with the Existing Condition.

- Step 6. Recalculate incremental costs. This step uses iterative incremental cost analysis to identify plans where there is a significant change in incremental costs and identify the potential NER plans. This step first looks at the incremental costs and outputs for plans larger than the first “Best Buy” plan. This step continues to iteratively consider only plans larger (*i.e.* providing more output) than the last best buy plan with the incremental costs and outputs relative to that last plan. This process continues until the plan formulated to provide the most outputs is identified as a best buy.

4.8.2.2. SOCIAL STUDIES

The existing social, economic, and demographic characteristics of study area populations will be documented. The 2000 census data are expected to be the basis for most of this information. These characteristics can be obtained by community and by block group level from the U.S. Census Bureau website (www.census.gov). Block group data will be aggregated for areas of interest, such as by reach.

Social impacts to consider include: income distribution; employment distribution; population distribution and composition; the fiscal condition of the state and local governments; the quality of community life; life, health, and safety factors; displacement; long-term productivity; and energy requirements and energy conservation. The measurement of social impacts requires projections into the future with and without the project. Projections will be coordinated with County government or, more typically, with the local Council of Governments. Human Health and Ecological risk assessments will be carried out by the USEPA as part of “Task JFB: HTRW Site Inspection and Sediment Characterization Report.” The social analysis of impacts will also make use of information gathered as part of the public involvement program.

Environmental Justice Criteria include the concept of an appropriate comparison group. The social analysis can be used to help define an appropriate comparison group. Environmental Justice Issues can arise from the choice of area to remediate, restore, or used for treatment or confinement.

4.8.2.3. INSTITUTIONAL STUDIES

The institutional analysis will consider the constraints and opportunities in implementing proposed restoration efforts. Unlike environmental sample analytical results and demographics, the data gathered will be legal and institutional information frequently not quantified with numerical values.

The institutional analysis will identify relevant government jurisdictions and interview appropriate contacts to identify relevant legal requirements. A practicing attorney will review the requirements and prepare a summary addressing their potential effects on remediation and restoration plan formulation.

Cost sharing formulation among potentially responsible parties (PRPs) may be problematic. For instance, some PRPs might enter bankruptcy proceedings. The institutional analysis will assess the certainty of funds from PRPs and other sources. An example framework will be developed for the commitment of funding from the PRPs on a timely basis. The example framework will also incorporate reasonable opportunities for the PRPs to review the progress of plan implementation. This framework will specify a method for dealing with cost variances and scheduling changes. It will also provide a mechanism for the escrow of funds. Provision will be made to allow for public review and comment on the broad outline of the framework.

While there are multiple possible non-Federal sponsors for the construction phase, non-governmental organization (NGO) funding will also be considered. (Note that the non-federal sponsors have not been identified yet.) For example, the Passaic River Coalition has indicated a willingness to provide funding or assets for selected projects. The institutional analysis will work to take advantage of such opportunities while evaluating the responsibility for perpetual operation and maintenance of any alternatives recommended for implementation.

The institutional analysis is considered to be an ongoing effort intended to facilitate achievement of environmental and socioeconomic goals that might otherwise be compromised by the self-interest of groups and institutions.

4.8.2.4. ABILITY TO PAY

The cost sharing for Flood Control projects can be adjusted to reflect limitations on the ability of some communities to pay. As this project is not expected to include flood control, this activity will not be undertaken.

4.8.2.5. FINANCIAL ANALYSIS

The requirements for a conducting a Financial Analysis are contained in Appendix D of “Planning Guidance Notebook” ER 1105-2-100 (USACE, 2000). The local sponsor will provide a Financing Plan based on comprehensive cost estimates and a Statement of Financial Capability. The Financial Analysis Report will draft the District Commander’s assessment of the non-Federal sponsor’s financial capability.

4.8.3. Socioeconomic Reporting

Reporting for this task will include identification of a recommended restoration alternative, based on the output of the analyses described above, and a prioritized listing of the possible alternatives in decreasing order of socioeconomic effectiveness. The affects of these alternatives on Environmental Justice will be displayed. The institutional and financial implementability of these alternatives will be assessed.

Documentation will be provided regarding the various inputs to the socioeconomic model for each alternative, along with a discussion of potential uncertainties in the model input and their impacts on the prioritization of the alternatives.

4.9. TASK 9 - REAL ESTATE (PMP TASK JC)

According to “Real Estate Handbook” ER 405-1-12 (USACE, 1985), a Real Estate Plan (REP) is the real estate work product that supports project plan formulation. It identifies and describes the lands, easements, and rights-of-way (LER) required for the construction, operation, and maintenance of a proposed project, including those required for relocations, borrow material and dredged or excavated material disposal.

4.9.1. Data Needs and Objectives

A real estate investigation is required to support the data needs for DQO task 28J. As part of the real estate investigation, a project plan formulation is necessary, where properties will be identified for possible LER. To accomplish this task, a structure inventory, for improved and unimproved parcels, will be developed. The structure inventory will have parcel data including owner name, owner address, owner city and state, parcel address, land use type (zoning), land and building value, parcel size and estates type. Additional data fields may include anticipated mineral extraction and determination if such activity is permitted by law and identification of all public utilities located within the project area. Structure inventory datasets are typically derived from county, city, or township real property tax records. The information provided in the GIS database included aerial photography of parcels; however, no parcel data were provided. Therefore, a structure inventory of those parcels in the study area will be implemented. The data will be obtained from county, city, or township real property tax records and will include the above fields along with a parcel identifier. These data will be compiled into a Microsoft Excel ® spreadsheet or Access ® database and attached to each parcel for GIS viewing. The data will include all parcels in the study area and any site later identified outside the study area as potential remediation or confinement sites for disposal of contaminated material dredged from the Passaic River. Note that these confinement sites have not been identified yet.

After the development of the structure inventory database, a land use study will be performed to determine the parcel types, total parcel values and other parcel characteristics. This structure database will also be utilized to determine the amount of vacant land in the study area that may be available for acquisition. The structure inventory database will be utilized in completing the REP in accordance with the “Real Estate Handbook” ER 405-1-12 (USACE, 1985).

4.9.2. Preliminary Real Estate Methods

4.9.2.1. GROSS APPRAISAL/REPORT

According to the Project Management Plan (USACE *et al.*, 2003), the USACE New York District's Real Estate Division will evaluate the selected ecosystem restoration project and conduct a Gross Appraisal, which includes the preparation of a Baseline Cost Estimate For Real Estate in the Micro Computer-Aided Cost Engineering System (MCACES) format and a Real Estate Supplement. The Baseline Cost Estimate for a project is the estimated total costs to implement the project. It includes estimated costs for the costs for lands, easements, rights-of-way, relocations and disposal areas (LERRD), planning and design, construction management, construction, contingencies, etc. Civil Tech Engineering, Inc. (Houston, Texas) will compile these costs for input into MCACES in accordance with "USACE Business Process" ER 5-1-11 (USACE, 2001b), "Accounting and Reporting Civil Works Activities CH 1-89" ER 37-2-10 (USACE, 2004b), "Civil Works Cost Engineering" ER 1110-2-1302 (USACE, 1994), and the Civil Works, Work Breakdown Structure (WBS).

4.9.2.2. PRELIMINARY REAL ESTATE ACQUISITION MAPS

According to the Project Management Plan (USACE *et al.*, 2003), the USACE New York District's Real Estate Division, in conjunction with its Engineering and Planning Divisions, will perform this task.

4.9.2.3. PHYSICAL TAKINGS ANALYSIS

This task includes a discussion of whether there will be flooding induced by construction operation and maintenance of the project. If induced flooding is anticipated, then the REP will also describe the nature and extent thereof and whether additional LER will be acquired as a result. Where significant induced flooding anticipated, or where otherwise required, a written Physical Taking analysis separate from the REP will be prepared with the conclusion of the analysis included in the REP. The information will be obtained from the structure inventory database and will include the owner's name,

address, size of parcel and estate. This is to comply with the “Real Estate Handbook” ER 405-1-12 (USACE, 1985).

4.9.2.4. PRELIMINARY ATTORNEY’S OPINION OF COMPENSABILITY

Due to the legal nature of this task, it is understood that the USACE New York District is responsible for this task.

4.9.2.5. RIGHTS OF ENTRY

Documents which evidence permission from the landowner to temporarily use owner(s) lands for a specific time and purpose will be obtained for the purpose of environmental investigations, cultural assessments, core sampling, surveys, explorations, etc. Government, Contractor or the non-Federal Sponsor may obtain the Rights-of-Entry (ROE). The “Department of the Army Right-of-Entry for Survey and Exploration” Engineering Form 1258-R; (USACE, 1998) will be used by the District to obtain Rights-of-Entry.

4.9.2.6. OTHER REAL ESTATE DOCUMENTS / EXTERNAL TECHNICAL REVIEW

Civil Tech Engineering will perform this task in accordance with the “Real Estate Handbook” (ER405-1-12; USACE, 1985) and will include the following additions to the REP.

- A discussion of any relocation assistance benefits anticipated being required in accordance with the Uniform Relocation Assistance Act (PL 91-646), including the number of persons, farms and businesses to be displaced and estimated costs. It will describe the availability of replacement housing and the need for last resort housing benefits, if required.
- A discussion of the present or anticipated mineral activity in the vicinity of the proposed project that may affect construction, operation, maintenance of the project together with a recommendation, including rationale, regarding acquisition of mineral rights or interests. The REP will also discuss other subsurface minerals or timber activity if applicable.

- A thorough assessment of the non-Federal sponsor's legal and professional capability and experience to acquire and provide the LER for the construction, operation and maintenance of the project, including condemnation authority and quick-take capability. The REP will indicate whether the non-Federal sponsor was advised of the Uniform Relocation Assistance requirements and the requirements for documenting expenses for credit purposes. An Assessment of Non-Federal Sponsor's Real Estate Acquisition Capability checklist will be prepared as required by Project Guidance Memorandum Letter No 12, dated May 2, 1996.
- A discussion of the type of ordinance proposed, its intended purpose, and whether enactment and enforcement of the ordinance will result in a taking of a real property interest for which compensation will be paid, if enactment of zoning ordinances is proposed in connection with the project.
- A reasonably detailed schedule of all land acquisition milestones, including LER certification. Real Estate, the Project Manager, and the sponsor will agree upon the dates reflected in the schedule.
- A concise discussion of the impacts on the real estate acquisition process (*e.g.* values, schedules) due to known or suspected presence of contaminants that are located in, on, under, or adjacent to the LER required for the construction, operation or maintenance of the project including LER that is subject to the navigation servitude. The discussion will include the status of the District's and USEPA's investigation for such contaminants, whether such contaminants are regulated under CERCLA, other Federal statutes [*e.g.* Resource Conservation and Recovery Act (RCRA)] or specified state law. The REP will also disclose whether clean up, or other response action will be required to implement the project, and who will be responsible for performing, and paying the costs of performing such work as between the Government and the sponsor.
- A discussion of known or anticipated support for, or opposition to, the project by landowners in the project area and any known or anticipated landowner concerns

related to issues that could impact the acquisition process (*e.g.* estate selection, amount of acreage, etc.).

- A statement that the non-Federal sponsor has been notified in writing about the risks associated with acquiring land before the execution of the Project Cooperation Agreement.
- A description of any other real estate issue relevant to planning, designing or implementing the project.

In addition to the foregoing, these tasks also will require:

- External technical review and response to Project Guidance Memorandum, Formal Review Conference, or other comments.
- Adherence to Corps of Engineers Financial Management System funding requirements and Real Estate Management Information System (REMIS) management information systems requirements.

5.0 ACRONYMS

‰	per mil, or part per thousand
°C	degree Celsius
σ_t	density (units of g/mL) – 1] \times 1000
ADCP	Acoustic Doppler Current Profiler
AOC	Administrative Order on Consent
APE	Area of Potential Effect
ASCII	American Standard Code for Information Interchange
ASI	Automation System Interconnect, Inc.
ASPRS	American Society for Photogrammetry and Remote Sensing
ASTM	American Society for Testing and Materials
CADD	Computer Aided Design and Drafting
CD-ROM	Compact Disc, Read-Only Memory
CE/ICA	Cost Efficiency and Incremental Coast Analysis
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CSM	Conceptual Site Model
CSO	Combined Sewer Overflow
DDT	Dichlorodiphenyltrichloroethane
DEM	Digital Elevation Model
DPT	Direct Push Technology
DSCC	Diamond Shamrock Chemical Company
DTM	Digital Terrain Model
EIS	Environmental Impact Statement
EM	Engineering Manual
ER	Engineering Release Form

ESRI	Environmental Systems Research Institute
FGDC	Federal Geographic Data Committee
FS	Feasibility Study
FSP	Field Sampling Plan
GDQOs	Geophysical Data Quality Objectives
GIS	Geographic Information System
GPR	Ground Penetrating Radar
GPS	Global Positioning System
GSSI	Geophysical Survey System, Inc.
HSA	Hollow Stem Auger
HASP	Health and Safety Plan
HTRW	Hazardous/Toxic/Radiological Waste
HTML	Hypertext Markup Language
IDW	Investigation-Derived Waste
IGDS	Intergraph Graphic Design System
IWR	Institute of Water Resources
LER	Land, Easement, and Right of Way
LERRD	Costs for lands, easements, rights-of-way, relocations and disposal areas
LPRRP	Lower Passaic River Restoration Project
MCACES	Micro Computer-Aided Cost Engineering System
MOA	Memorandum of Agreement
MQOs	Measurement Quality Objectives
MST	Multi-Sensor Track
NAD83	North American Vertical Datum 1983
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NER	Net Ecosystem Restoration
NGO	Non-Governmental Organization
NGVD29	National Geodetic Vertical Datum of 1929

NIOSH	National Institute for Occupational Safety and Health
NJDEP	New Jersey Department of Environmental Protection
NJDOT-OMR	New Jersey Department of Transportation – Office of Maritime Resources
NOAA	National Oceanic and Atmospheric Administration
NRDA	Natural Resource Damage Assessment
NRHP	National Register of Historic Places
NTU	Nephelometric Turbidity Units
OSHA	Occupational Safety and Health Administration
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCDD	polychlorinated dibenzodioxin
PCDF	polychlorinated dibenzofuran
PMP	Project Management Plan
PRP	Potentially Responsible Parties
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
QC/QA	Quality Control and Quality Assurance
RCRA	Resource Conservation Recovery Act
REMIS	Real Estate Management Information System
REP	Real Estate Plan
RM	River Mile
ROE	Right of Entry
RTK DGPS	Real-Time Kinematic Differential Global Positioning System
SDSFIE	Spatial Data Standards for Facilities, Infrastructure, and Environment
SEG-Y	A tape format standard of the Society of Exploration Geophysicists
SHPO	State Historic Preservation Officer
SOP	Standard Operating Procedure
SPT	Standard Penetration Test
TAL	Target Analyte List

TCL	Target Compound List
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TIN	Triangulated Irregular Network
TOC	Total Organic Carbon
TSI	Tierra Solutions, Inc.
TSS	Total Suspended Solids
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USCS	Unified Soil Classification System
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Services
USGS	U.S. Geological Survey
USNMA	U.S. National Map Accuracy Standards
XTF	Extended Triton Format
WBS	Work Breakdown Structure
WRDA	Water Resource Development Act

6.0 REFERENCES

ASPRS, 1990. "ASPRS Accuracy Standards for Large Scale Maps."

ASTM, 2004. Standard Specification for Portland Cement. ASTM C150-04. 20042.

ASTM, 2002. Standard Test Method for Particle-Size Analysis of Soils. ASTM D422-02. 2002.

ASTM, 2000a. Standard Practice for Soil Investigation and Sampling by Auger Borings. ASTM D1452-80. January 2000.

ASTM, 2000b. Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes. ASTM D1587-00. August 2000.

ASTM, 2000c. Standard Test Method for Turbidity of Water. ASTM D-1889-00. 2000.

ASTM, 1999. Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils. ASTM D1586-99. January 1999.

ASTM, 1984. Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). ASTM D2488-84.

Caufield, DD, August, 2001. Absorption Estimation in Marine Sub-bottom Layers Summary – An overview of the Historical Database and Typical Processed Records. SEA Technology.

Caulfield, DD, August, 2000. "Survey and Analysis Procedures for the Detection of PCB's in Marine Sediments". Report No. 3075, Caulfield Engineering Services, Ocean Data Equipment Corporation.

Chow, Ven Te, *et al.*, 1988. Applied Hydrology. McGraw-Hill Book Company, New York.

Chow, Ven Te, and Ed, 1964. Handbook of Applied Hydrology. McGraw-Hill Book Company, New York. (Strahler, Arthur N. Section 4-II, Geology, Part II. Quantitative Geomorphology of Drainage Basins and Channel Networks).

DSCC, 1986. Site Evaluation Addendum 80 & 120 Lister Avenue. February 1986.

DSCC, 1985a Site Evaluation 80 Lister Avenue. February 1985.

DSCC, 1985b Site Evaluation 120 Lister Avenue. May 1985.

Horton, RE, 1945. Erosional development of streams and their drainage basins; hydrophysical approach to quantitative morphology. In Bulletin of The Geological Society of America, Volume 56, Number 3.

HydroQual, 2005. "Draft Modeling Plan." Prepared by HydroQual under contract to Malcolm Pirnie, Inc. (White Plains, NY) for the USEPA Region 2 and USACE-New York District. April 2005.

Malcolm Pirnie, 2005a. "Draft Field Sampling Plan, Volume 1." Lower Passaic River Restoration Project. Prepared in conjunction with Battelle and HydroQual, Inc. April 2005. DACW41-02-D-0003

Malcolm Pirnie, 2005b. "Draft Work Plan." Lower Passaic River Restoration Project. Prepared in conjunction with Battelle and HydroQual, Inc. April 2005. DACW41-02-D-0003

Malcolm Pirnie, 2005c. "Health and Safety Plan." Lower Passaic River Restoration Project. January 2005. DACW41-02-D-0003

Malcolm Pirnie, 2005d. "Quality Assurance Project Plan" Lower Passaic River Restoration Project. Prepared in conjunction with Battelle and Hydroqual, Inc. April 2005. DACW41-02-D-0003

Malcolm Pirnie, 2005e. "Draft Technical Memorandum: Preliminary Geochemical Evaluation." Lower Passaic River Restoration Project. April 2005. DACW41-02-D-0003

McGee, RG and RF Ballard, 1995. A Technique to Assess the Characteristics of Bottom and Sub-bottom Marine Sediments. USACE Waterways Experiment Station, Technical Report DRP-95-3.

NOAA, 1999. Technical Memorandum. Passaic River Study Area Sampling Station-Bivalve Mussel Deployment August 5, 1999 and Weekly Bivalve Deployment Check, August 10, 1999. October 22, 1999.

NOAA, 1972. Tide Tables, High and Low Water Prediction, East Coast of North American and South America Including Greenland, U.S. Dept. of Commerce, National Oceanic Survey, Rockville, Maryland. (As cited in USEPA, 1995).

NUS Corporation, 1986. Sampling Results 80 Lister Avenue, Newark, New Jersey. June 1986.

TAM, 2005. "Final Data Summary and Evaluation Report." Lower Passaic River Restoration Project. May 2005. 2001-NJMR02

TSI, 2004. Passaic River Study Data CD, February 2004.

USACE, 2004a. Bathymetric Survey. Prepared by Rogers Surveying, P.L.L.C. for the USACE in September-November 2004.

USACE, 2004b. Accounting and Reporting Civil Works Activities CH 1-89. ER 37-2-10 Department of the Army, U.S. Army Corps of Engineers, Washington, D.C.

USACE *et al.*, 2003. Project Management Plan: Lower Passaic River, NJ, Investigation and Feasibility Study for Remediation and Ecosystem Restoration." U.S. Army Corps of Engineers, New York District.

USACE, 2002. Engineering and Design – Hydrographic Surveying, EM 1110-2-1003. Department of the Army, U. S. Army Corps of Engineers, Washington, D.C.

USACE, 2001a. Engineering and Design - Requirements for the Preparation of Sampling and Analysis Plans. EM 200-1-3 Department of the Army, U.S. Army Corps of Engineers, Washington, D.C.

USACE, 2001b. Business Process. ER 5-1-11. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C.

USACE, 2000. Planning Guidance Notebook. ER 1105-2-100. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C.

USACE, 1998a. Monitoring Well Design, Installation, and Documentation at Hazardous and/or Toxic Waste Sites. EM 1110-1-4000. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C.

USACE, 1998b. Department of the Army Right-of-Entry For Survey and Exploration. Engineering Form 1258-R

USACE, 1994a. Engineering and Design - Topographic Surveying. EM 1110-1-1005. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C.

USACE, 1994b. Civil Works Cost Engineering. ER 1110-2-1302 Department of the Army, U.S. Army Corps of Engineers, Washington, D.C.

USACE, 1993. Engineering and Design – Photogrammetric Mapping. EM 1110-1-1000 Department of the Army, U.S. Army Corps of Engineers, Washington, D.C.

USACE, 1992. Water Resources Policies and Authorities - Hazardous, Toxic and Radioactive Waste (HTRW) Guidance for Civil Works Projects. EM 1165-2-132. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C.

USACE, 1990a. Standards Manual for U.S. Army Corps of Engineers Computer Aided Design and Drafting (CADD) Systems. EM 1110-2-1807. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C.

USACE, 1990b. Engineering and Design - Survey Markers and Monumentation. EM 1110-1-1002. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C.

USACE, 1990c. Report of Channel Conditions: For Channels 400 Feet Wide or Greater. Engineering Form 4020-R.

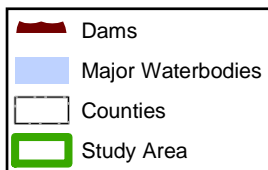
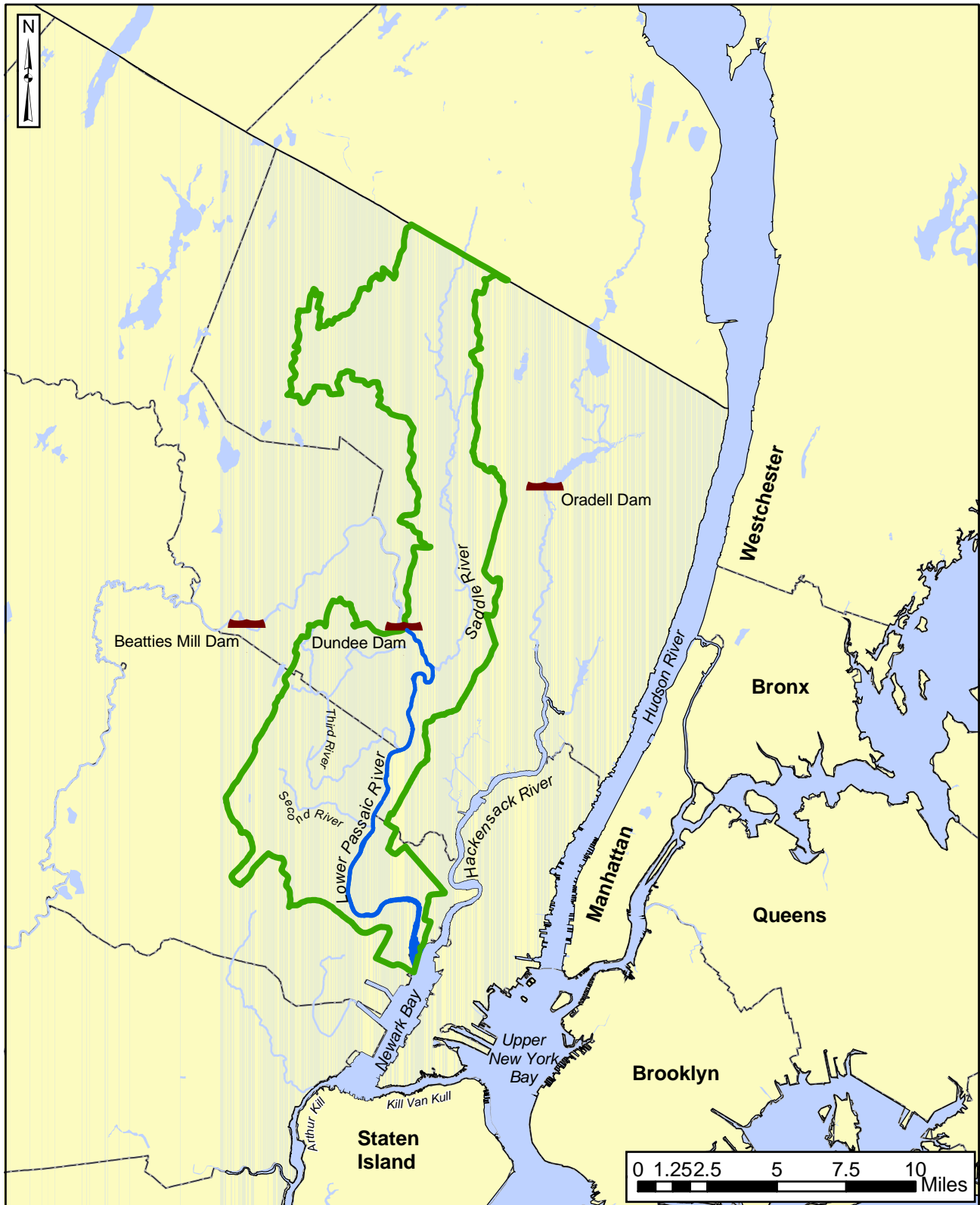
USACE, 1985. Real Estate Handbook. ER 405-1-12. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C.

USEPA, 2004. Contract Laboratory Program Guidance for Field Samplers.

USEPA, 1996. Ground Water Issue: Low-Flow Ground-Water Sampling Procedures. Office of Research and Development and Office of Solid Waste and Emergency Response. EPA/540/S-95/504. April 1996.

USEPA, 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, EPA/540/G-89/004. October 1988.

FIGURE AND TABLES



Restoration Study Area
Lower Passaic River Restoration Project

July 2005

Figure 1-1

Field Sampling Plan Volume 3
Table 3-1: Available Bathymetric Data

Date of Survey	Organization	Start of Survey	End of Survey	Coordinates	Source
1985	USEPA & IT Corp	ConRail Bridge in Newark City mile 1	Interstate 280 Bridge in East Newark mile 6	UTM zone 18 NAD 83	GIS format
June 1989	USACE	Newark Bay mile 0	Erie Lackawanna RR Bridge in Kearny mile 8	Feet; refer to NJ Mercator System	Paper - CADD printout
November 1989	USACE	Erie Lackawanna RR Bridge in Kearny mile 8	Eighth Street Bridge in Wallington mile 15	Feet; refer to NJ Mercator System	Paper - handwritten
June 1992	USACE	Erie Lackawanna RR Bridge in Kearny mile 8	Belleville Turnpike in N. Arlington mile 9	Feet; refer to NJ Mercator System	Paper - CADD printout
1995	Tierra Solution	Approximately ConRail Bridge in Newark City mile 1	Approximately Interstate 280 Bridge in East Newark mile 6	Feet; refer to the NJS Plane (NAD27)	Premis Excel format
1996	Tierra Solution	Approximately ConRail Bridge in Newark City mile 1	Approximately Interstate 280 Bridge in East Newark mile 6	Feet; refer to the NJS Plane (NAD27)	Premis Excel format
February 1996	USACE	ConRail Bridge in Newark City mile 1	Route 1 Bridge in Newark City mile 2	Feet; refer to the NJS Plane (NAD27)	Paper - CADD printout
1997	Tierra Solution	Approximately ConRail Bridge in Newark City mile 1	Approximately Interstate 280 Bridge in East Newark mile 6	Feet; refer to the NJS Plane (NAD27)	Premis Excel format
1999	Tierra Solution	Approximately ConRail Bridge in Newark City mile 1	Approximately Interstate 280 Bridge in East Newark mile 6	Feet; refer to the NJS Plane (NAD27)	Premis Excel format
1999	USEPA	ConRail Bridge in Newark City mile 1	Erie Lackawanna RR Bridge in Kearny mile 8	UTM zone 18 NAD 83	GIS format
February 2000	USACE	ConRail Bridge in Newark City mile 1	Erie Lackawanna RR Bridge in Kearny mile 8	Feet; refer to NJ Mercator System (NAD83)	Premis DGN format
2001	Tierra Solution	Approximately ConRail Bridge in Newark City mile 1	Approximately Interstate 280 Bridge in East Newark mile 6	Feet; refer to the NJS Plane (NAD27)	Premis Excel format
June 2001	USACE	ConRail Bridge in Newark City mile 1	Erie Lackawanna RR Bridge in Kearny mile 8	Feet; refer to NJ Mercator System	Premis DGN format
November 2001	USACE	ConRail Bridge in Newark City mile 1	Erie Lackawanna RR Bridge in Kearny mile 8	Feet; refer to NJ Mercator System (NAD83)	Premis DGN format
July 2002	USACE	ConRail Bridge in Newark City mile 1	Erie Lackawanna RR Bridge in Kearny mile 8	Feet; refer to NJ Mercator System (NAD83)	Premis DGN format
July 2003	USACE	ConRail Bridge in Newark City mile 1	Erie Lackawanna RR Bridge in Kearny mile 8	Feet; refer to NJ Mercator System	Premis DGN format

Field Sampling Plan Volume 3
Table 4-1: Summary of Field Tasks

Task	Objectives	Sampling Locations and Frequency	Data Generated
Bathymetry Surveys	<ul style="list-style-type: none"> Determine bathymetry of 17-mile stretch of Passaic River from Newark Bay to Dundee Dam Support hydraulic analyses and environmental modeling analyses with detailed, current data Identify scour/depositional areas Support dredging and restoration design 	<ul style="list-style-type: none"> Bathymetry at transects Spot elevations at each transect on each bank 	<ul style="list-style-type: none"> Bathymetric data for Lower Passaic River, Hackensack River, and Newark Bay Spot elevation data for each river bank at each transect Digital map deliverables (Intergraph and ArcGIS) Digital terrain model
Aerial Surveys	<ul style="list-style-type: none"> Obtain aerial photography of Lower Passaic River and candidate restoration sites Prepare shoreline map and mudflat delineation Support restoration design 	<ul style="list-style-type: none"> Aerial survey of Lower Passaic River Study Area 	<ul style="list-style-type: none"> 1 inch = 100 feet (1 foot contours) and 1 inch = 30 feet (0.5 foot contours) survey plots of Passaic River shoreline integrated with bathymetric data Digital map deliverables (Intergraph and ArcGIS) Digital terrain model
Supplemental Land Survey	<ul style="list-style-type: none"> Determine elevation, topography, and other physical features of candidate restoration sites to support restoration design Determine grades of side slopes of Passaic River to support design of bank stabilization/re-grading measures that may be necessary during dredging and restoration Determine site access and location of utilities 	<ul style="list-style-type: none"> Topographic survey or ground truthing of each candidate site (including shoreline to a water depth of 3 feet) Monument installation 	<ul style="list-style-type: none"> 1 inch = 40 feet (0.5 foot contours) topographic and planimetric feature maps of candidate sites Digital map deliverables (AutoCAD and ArcGIS) Digital elevation model
Geophysical Surveys	<ul style="list-style-type: none"> Determine texture of surficial sediment to characterize Passaic River bottom Determine amount/extent of debris/other targets for dredging FS Identify significant geological layers in the sediment 	<ul style="list-style-type: none"> Geophysical prove-out (side scan and subbottom) at limited number of locations to evaluate survey technique usability Side scan sonar survey of 17-mile study area at 40 meter line spacing Subbottom survey (acoustic and GPR methods) of 17-mile study area at 40 meter line spacing (subject to prove-out results) "Ground truth" sediment grab sampling at a rate of 16 samples per river mile (approximately 275 samples) Subbottom program sediment cores 	<ul style="list-style-type: none"> Prove-out Findings and Recommendations Report Side scan sonar sediment texture maps, contact lists, and interpretation Subbottom profile sediment stratigraphy maps and interpretation (subject to prove-out results) Descriptions of stratigraphy from subbottom program sediment cores
Soil/Sediment Investigations	<ul style="list-style-type: none"> Characterize environmental (HTRW) quality of soils/sediments at candidate sites Evaluate soil geotechnical properties to support restoration design, slope stability issues, and bank stabilization measure design 	<ul style="list-style-type: none"> Environmental sampling of hollow stem auger and/or DPT borings (approx. 2 to 8 borings per acre) at each candidate site Geotechnical soil sampling of soil borings at shoreline softening, wetland restoration, and/or bank stabilization sites at a rate of one boring per 50-250 feet of shoreline Wetland soil/sediment sampling via hand coring device and/or DPT boring at a frequency to be determined 	<ul style="list-style-type: none"> Field measurements (e.g., USCS classification, pocket penetrometer tests, SPT) Soil sample or wetland soil/sediment sample chemical data (e.g., TCL/TAL, PCBs, PCDD/Fs) Soil sample geotechnical data (e.g., grain size, Atterberg limits, moisture content)

Task	Objectives	Sampling Locations and Frequency	Data Generated
Water Quality Investigations	<ul style="list-style-type: none"> Characterize groundwater/surface water quality at candidate sites Potentially provide input data for Passaic River model 	<ul style="list-style-type: none"> One round of groundwater sampling per candidate site, generally from a minimum of 3 monitoring wells One round of surface water sampling (where applicable) per candidate site Multiple rounds (seasonal) of water level measurements Staff gauges 	<ul style="list-style-type: none"> Field parameter measurements (e.g., pH, DO, turbidity) Groundwater and surface water sample chemical data (e.g., TCL/TAL, PCBs, PCDD/Fs) Surface water sample chemical data
Hydrologic Investigations	<ul style="list-style-type: none"> Support feasibility analysis for restoration sites 	<ul style="list-style-type: none"> Determine groundwater and surface water elevations, fluctuations and flow regimes via monitoring wells, piezometers, and staff gauges Determine channel layout and other design parameters Provide the basis for the horticultural design and planting of the wetland Study the flooding potential in offsite areas adjacent to the candidate restoration area 	<ul style="list-style-type: none"> Groundwater and surface water elevation data Geomorphic and hydrologic features maps Hydrologic-hydraulic analyses and models (e.g., studies of flooding potential in off-site areas adjacent to the candidate restoration site).
Socioeconomic Investigation	<ul style="list-style-type: none"> Support feasibility analysis for restoration sites 	<ul style="list-style-type: none"> Review of habitat units for each restoration alternative, reports of channel conditions, dredging sounding maps, historic dredging costs, property values adjacent to candidate sites, demographic data, restoration project cost estimates, schedules, financing plans, and statement of financial capability Economic analyses of restoration alternatives using Cost Efficiency and Incremental Cost Analysis via Institute of Water Resources PLAN Decision Support software. Documentation of social, economic, and demographic characteristics of the study area population. Institutional analysis of constraints/opportunities for remediation and restoration efforts 	<ul style="list-style-type: none"> Prioritization of restoration alternatives according to socioeconomic effectiveness Evaluation of effects of restoration alternatives on environmental justice Assessment of institutional and financial implementability of restoration alternatives Documentation of modeling tools used to assess
Real Estate Investigation	<ul style="list-style-type: none"> Support feasibility analysis for restoration sites 	<ul style="list-style-type: none"> Review of costs for lands, easements, rights-of-way, relocations, and disposal areas in USACE baseline cost estimate Preparation of Physical Takings Analysis in regard to potential induced flooding Evaluation of relocation assistance benefits, mineral rights, feasibility of obtaining lands, easements and rights-of-way (LER) for the project 	<ul style="list-style-type: none"> Real Estate Plan (REP) including structure inventory, land use study, Physical Taking analysis (if required), rights-of-entry for environmental investigations, a detailed schedule of land acquisition milestones, a discussion of the impacts of contamination on the real estate acquisition process, an assessment of local landowner support/opposition, and descriptions of other relevant real estate issues.

Field Sampling Plan Volume 3
Table 4-2: Guidance for Land Surveying

Feature	Format Type	GIS (ArcView) Attributes	CADD Layers
Index grids depicting extents of map and orthophoto tiles	Polygon	Grid ID	Map Tile Ortho Tile
Waterbodies	Polygon		Waterbody
Wetlands	Polygon		Wetlands
Treeline/Foliage outlines	Polygon		Vegetation
Shoreline	Polygon		
Islands	Polygon		
Hydrologic features: stream, shoreline	Line	Fields: 1. Continuous Flow 2. Intermittent Flow	Hydrology (Use dashed lines for Intermittent Flow)
Fences	Line		Fences
Roads (curbline)	Line		Roads
Dirt Roads/Trails	Line	Unpaved	Unpaved- dashed line
Edge of Pavement	Line	Paved	Paved- full line
Railroad centerlines	Line		Railroads
Buildings/Structures	Polygon	Structure Type	Separate Layer per Type: 1. Building 2. Shed 3. Foundation 4. Tank/Silo 5. etc...
Topography ⁽¹⁾⁽²⁾ (contours)		Fields: 1. Elevation (Numeric, 2 decimal) 1. Index (Boolean):every 5 th contour Annotation (CADD & GIS) 3. Obscured (Boolean)	1. Intermediate 2. Index (every 5 th contour) (Used dashed line style where ground is obscured. Elevation of the contour must equal ground elevation.)
Utility Structures: (hydrants, manholes, catch basin, etc.)		Structure Type (One GIS theme)	Utility Structure Symbolize (hydrant, manhole MH, catch basin CB, etc.) (One CADD Layer)
Dams/Locks	Polygon		Separate Layer per Type
Utility Poles	Point		Separate Layer
Control Points	Point		(x-y-z used for survey control)
Gridlines (Gradicules)	Line		The grid will be shown on the topographic mapping at no less than 200' intervals; coordinates for both easting and northing will be shown on the topographic mapping at no less than 1000' intervals with easily recognizable ties and will be based on NAD83 (NJ requirements). Vertical elevation will be the NGVD 1929.
Breaklines ⁽³⁾	Line	Hard or Soft	

⁽¹⁾ Includes detailed survey of shoreline slope and shallow water to a water depth of 3 feet.

⁽²⁾ A contour will be defined as an imaginary line of constant elevation on the ground surface. All contours derived from photogrammetric methods will be recorded in this data set. A contour which intersects a manmade feature such as a house will be recorded as a straight line from the point at which it enters the structure to the point at which it exits the structure. These contours will be coded as hidden contours. Contours will not be 'stacked' at vertical objects but will terminate at the beginning of such objects and continue from the end. Contours that may be obscured by vegetation are to be coded as approximate. Contour lines should be smooth and not appear broken. Contour accuracy will be checked by conventional field observation methods.

⁽³⁾ Breaklines are linear features used to define and control surface smoothness and continuity in relation to the digital orthophotography and the contour data set. Breaklines contain x, y, and z values. The z value along a breakline can be constant, or can vary throughout its length. The data set will contain both soft breaklines and hard breaklines.

Field Sampling Plan Volume 3
Table 4-3: Measurement Quality Objective

Parameter	Acceptable Criteria	Unit of Measure	Validation Frequency	Corrective Action
Source level	+/- 2.5%	decibel	Beginning and end of each survey line	Re-survey if out of compliance
Amplifier Gain	+/- 1.0%	decibel	Same as above	Same as above
Receiver Gain	+/- 2.5%	decibel	Same as above	Same as above
Receiver Signal/Noise	Greater than 5	ratio	Continuous	Re-survey if not immediately corrected
Navigation (Horizontal)	+/- 1	meter	Continuous	Re-survey if not immediately corrected
Navigation (Vertical)	+/- 0.1	meter	Continuous	Re-survey if not immediately corrected

APPENDIX A
HTRW DRILLING LOG FORM

HTW DRILLING LOG			PROJECT					SHEET 1 OF		SHEETS	
1. LOCATION				10. NO. OF OVERBURDEN SAMPLES			DISTURBED		UNDISTURBED		
2. COMPANY				11. SAMPLES FOR ANALYSIS			12. SAMPLE ANALYSIS				
3. DRILLING COMPANY				13. SURFACE ELEVATION AT HOLE			14. ELEVATION DATUM				
4. MANUFACTURER'S DESIGNATION OF DRILL				15. DEPTH OF GROUNDWATER ENCOUNTERED							
5. SIZE AND TYPE OF EQUIPMENT				16. DATE HOLE STARTED			17. DATE HOLE COMPLETED				
6. NAME OF DRILLER				18. TOTAL NO. OF CORE BOXES							
7. THICKNESS OF OVERBURDEN				19. DISPOSITION OF HOLE							
8. DEPTH DRILLED INTO ROCK				20. NAME OF INSPECTOR							
9. TOTAL DEPTH OF HOLE				21. SIGNATURE OF INSPECTOR							
ELEV- ATION	DEPTH (FEET)	LEGEND	CLASSIFICATION OF MATERIAL	% REC.	SAMPLE No. (TIME)	BLOW COUNT	FIELD SCREEN RESULT	REMARKS			
	1										
	2										
	3										
	4										
	5										
	6										

HOLE NO.

HTW DRILLING LOG			PROJECT					SHEET		SHEETS	
								2		OF	
1. LOCATION					20. NAME OF INSPECTOR						
2. COMPANY					21. SIGNATURE OF INSPECTOR						
ELEV- ATION	DEPTH (FEET)	LEGEND	CLASSIFICATION OF MATERIAL		% REC.	SAMPLE No. (TIME)	BLOW COUNT	FIELD SCREEN RESULT	REMARKS		
	6										
	7										
	8										
	9										
	10										
	11										
	12										
	13										
	14										

APPENDIX B
SOIL SUMMARY SHEET

UNIFIED SOIL CLASSIFICATION SYSTEM
SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYM	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION <u>RETAINED ON No.4 SIEVE</u>	CLEAN GRAVELS (LITTLE OR NO FINES)	GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
			GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
MORE THAN 50% OF MATERIAL IS LARGER THAN No. 200 SIEVE SIZE	SAND AND SANDY SOILS	CLEAN SAND (LITTLE OR NO FINES)	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			SP	POORLY-GRADED SANDS GRAVELLY SANDS, LITTLE OR NO FINES
	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	SM	SILTY SANDS, SAND-SILT MIXTURES	
		SC	CLAYEY SANDS SAND-CLAY MIXTURES	
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS AND ORGANIC CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

Dual symbols are used to indicate borderline classifications
WELL GRADED - All size fractions are equally represented
POORLY GRADED - One size fraction is dominant
PARTING - 1/16 in.
SEAM - 1/16 in. to 1/2 in.
LAYER - 1/2 in. to 12 in.
STRATUM - Greater than 12 in.
POCKET - Small erratic deposit
LENS - Lenticular deposit
VARVED - Alternating seams or layers of sand, silt or clay
OCCASIONAL - One or less per foot of thickness
FREQUENT - More than one per foot of thickness

Trace - 1% to 12% of total sample
Some - 12% to 30% of total sample
Gravelly, sandy, silty, clayey - 30% to 50% of total sample

Gravel

c = 3/4" - 3"

f = 3/4" - 3/16"

Sand

c = 3/16" - 5/64"

m = 5/64" - 1/64"

f = 1/64" - 0.0029"

U.S. Standard

Sieve Size

4 - 10

10 - 40

40 - 200

Plasticity

Nonplastic - crumbles with light finger pressure

Low plasticity - crumbles with some finger pressure

Medium plasticity - breaks into pieces or crumbles with considerable finger pressure

High Plasticity - can't be broken with finger pressure, will break into pieces between thumb and a hard surface

Very plastic - can't be broken between thumb and a hard surface

Smear Test

gritty or rough

rough to smooth

smooth & dull

shiny

very shiny & waxy

Thread Size

cracks

1/4 - 1/8"

1/16"

1/32"

1/64"

APPENDIX C
HTRW WELL INSTALLATION DIAGRAM

WELL No.

HTW WELL INSTALLATION DIAGRAM			PROJECT	
LOCATION			DATE WELL STARTED	
COMPANY			DATE WELL COMPLETED	
DRILLING COMPANY, DRILLERS NAMES			NAME OF INSPECTOR	
START DATE			SIGNATURE OF INSPECTOR	
COMPLETION DATE			SURVEYED ELEVATIONS (MSL)	
WELL STATUS			DEPTH OF WATER	
STATUS DATE			DATE / TIME	
WELL SKETCH - NOT TO SCALE			WELL TYPE: SCREEN - MULTIPLE SCREEN - OPEN HOLE - NESTED - PROBE	
DEPTH (ft bgs)			CASING: SINGLE - DOUBLE - TRIPLE	
WELL CODE			COMPLETION: FLUSH - PROT - VAULT - CAP - NA	
			TOTAL NO. OF SCREENS/WELLS: SCREEN/WELL NO.	
			WELL USE: DOM - PUB - IRR - FIR - MON - HYD - EXT - DEW - RCH - VEW - INJ - OTH:	
			WELL DESIGN CONSTRUCTION	
			CASING #1: DIAMETER: IN / CM INTERVAL: TO FT / M BGS	
			(INNERMOST)	
			TYPE: PVC - STN - LCS - GAL - SCHEDULE: 5 - 10 - 20 - 40 - 80 -	
			CASING #2: DIAMETER: IN / CM INTERVAL: TO FT / M BGS	
			TYPE: PVC - STN - LCS - GAL - SCHEDULE: 5 - 10 - 20 - 40 - 80 -	
			CASING #3: DIAMETER: IN / CM	
			(OUTERMOST)	
			TYPE: PVC - STN - LCS - GAL - SCHEDULE: 5 - 10 - 20 - 40 - 80 -	
			STICKUP: INNER CASING: FT / M INNER CASING: FT / M	
			GROUT: TYPE: CMT - C/B - BEN - HSB - OTH:	
			INTERVAL: TO FT / M BGS	
			PLACEMENT: TRM - PRS - GRV CENTRALIZERS: NON - 1 - 2 - 3 - OTH:	
			SEAL: TYPE 1: INTERVAL: TO FT / M BGS	
			TYPE 2: INTERVAL: TO FT / M BGS	
			SAND PACK: TYPE: INTERVAL: TO FT / M BGS	
			SCREEN	
			OR DEVICE DIAMETER: IN / MM INTERVAL: TO FT / M BGS	
			TYPE: PVC - STN - LCS - TEF - CER - HOP - OTH:	
			SLOTS: CON - SLM - SLV - BRG - CUT - OTH:	
			SLOT SIZE: 5- 10 - 20 - 30 - 40 - 40 - SLOT	
			STRAT UNIT MONITORED:	
			ESTIMATED WELL YIELD: M / LPM DRAWDOWN: FT / M BMP	
			WATER SAMPLING SYSTEM: NON - PMP - PKR - MLS TYPE:	
			SEAL INTERVAL: TO FT / M BGS INTAKE DEPTH: FT / M BGS	
			NOTES:	
			OPEN HOLE: DIAMETER 1: IN / CM INTERVAL: TO FT / M BGS	
			DIAMETER 2: IN / CM INTERVAL: TO FT / M BGS	
			SILT TRAP/SUMP: YES - NO INTERVAL: TO FT / M BGS	
			INSIDE WELL T.D.: FT / M BGS COLLAPSE/BACKFILL: COL - BFL - BTH - NON	
			COLLAPSE INTERVAL: TO FT / M BGS	
			BACKFILL INTERVAL: TO FT / M BGS TYPE:	
WELL CONSTRUCTION CODES			COMMENTS:	
GRS - ground surface TSC - top of screen				
BPC - bottom of casing TST - top of silt trap				
TBS - top bentonite seal WTD - total depth inside well				
TOB - top of bedrock BTD - borehole total depth				
BOC-bottom outer casing TOC - top of casing				
TSP - top of sand pack BGS - below ground surface				

APPENDIX D
WELL DEVELOPMENT FORM

WELL NO.

[illegible]

APPENDIX E
HTRW WELL SAMPLING FORM

WELL NO.

[illegible]