THE ROLE OF CONSTRUCTION QUALITY ASSURANCE (CQA) IN SEDIMENT REMEDIATION

E. P. Hedblom[1], G. M. Partch[2], and M. J. Costello[3]

ABSTRACT

The St. Louis River/Interlake/Duluth Tar (SLRIDT) Superfund Site is located in Duluth, Minnesota, on the St. Louis River, an estuary and international port at the southern tip of Lake Superior. Its three bays contain approximately 400,000 m^3 of fine-grained sediments, contaminated with polycyclic aromatic hydrocarbons at concentrations up to 35,000 mg/Kg. The selected response action includes dredging with on-site disposal and capping. This paper describes how quality is assured during the complex construction of the remedy.

Once contractors are selected and the remedy is ready to be implemented, the Owner is best served by a third-party who measures compliance with performance or method specifications and monitors environmental conditions during operations. While this role can be seen as adversarial, in the best of conditions the construction quality assurance (CQA) engineer provides independent measurements of performance useful to both the contractor and the owner.

This paper describes the CQA activities and values brought to a contaminated sediment remediation project. Documentation of compliance with specifications on supplied materials capping, dredging, best management practices, water treatment, water quality controls, geotechnical instrumentation, environmental restoration, surveying and effects on air, water and noise during remediation provides value to contractors and owners alike.

At the SLRIDT Site, these activities are detailed in a Quality Assurance Project Plan (QAPP) and a Construction Quality Assurance Plan. This paper describes the types of issues that arise during construction that are best managed in real time by collaborative work and timely attention to the details of construction as they compare to project requirements.

Matters covered include: site security, remote video documentation, material testing and acceptance surveying, sand cap layer placement thickness verification and approval, sheet pile and pipe pile placement, rock fill dam construction, consolidation evaluation, foundation stability, normal dredge residue management, dredge prisms, water quality, air emissions and noise monitoring.

Keywords: Dredging, capping, polycyclic aromatic hydrocarbons (PAHs), contaminated sediment remediation, contained aquatic disposal (CAD).

INTRODUCTION

How is the role of Construction Quality Assurance (CQA), which is ensuring that a project is constructed in accordance with design specifications, successfully completed without impacting schedule and/or budget on a site with multiple designers, contractors, regulators and owners, and a project that is completed over several years? This paper presents a case study of how CQA was completed for the first year of a four-year sediment remediation project at the St. Louis River/Interlake/Duluth Tar (SLRIDT) Superfund Site in Duluth, Minnesota.

The SLRIDT Site Sediment Operable Unit (SedOU) remediation includes a hybrid of dredging and capping to remediate approximately 400,000 m^3 of polycyclic aromatic hydrocarbon (PAH)-impacted sediment in Duluth, Minnesota, on the St. Louis River, approximately six kilometers from its confluence with Lake Superior. In order to complete this sediment remediation project, the following tasks must be completed:

- Contained aquatic disposal (CAD) facility construction, including a rock fill dam end dike, in an existing shipping slip;
- Surcharge cap placement within a sheetpile wall;

[1] Eric P. Hedblom, Principal Scientist, SERVICE Engineering Group, 675 Vandalia Street, Saint Paul, Minnesota 55114, USA, T: 651-644-6680, F: 651-644-7008, Email: EricH@servicegrp.com.

[2] Guy M. Partch, Staff Scientist, SERVICE Engineering Group, 2314 West Michigan Street, Suite 4, Duluth, Minnesota 55806, USA, T: 218-727-8186, F: 218-727-8411, Email: GuyP@servicegrp.com.

[3] Michael J. Costello, President, SERVICE Engineering Group, 675 Vandalia Street, Saint Paul, Minnesota 55114, USA, T: 651-644-6680, F: 651-644-7008, Email: MikeC@servicegrp.com.

- Dredging in a shallow bay and deep Federal shipping channel;
- Excavation of contaminated sediment from wetlands;
- Contaminated sediment placement within the CAD;
- CAD and storm water management, filtration and discharge to the St. Louis River;
- Post-dredge cover placement over dredge residue;
- Sand cap placement in non-dredging areas;
- Surcharge sand removal and placement on CAD;
- Armoring of placed sand cap in riverine environment; and,
- Placement of several geotextile materials: root barrier, activated carbon mat (ACM) with integrated root barrier, and geotextile clay liner (GCL) within CAD end dike.

Environmental monitoring is another important role related to CQA on a sediment remediation project because all of the project construction tasks must be completed in a manner that does not adversely effect the environment or the public health. SERVICE Engineering Group (SERVICE), the CQA and environmental monitoring engineer on the SLRIDT project, is charged with monitoring air, noise, and surface water to ensure that construction activities undertaken at the site do not cause exceedance of regulatory limits for any of these media.

The CQA/environmental monitoring engineer's role may, at first glance, appear to be at odds with the goals of the various contractors that are motivated to complete the project within budget and time constraints. Through proper planning and communication these apparently contrary roles – construction contractor vs. CQA/environmental monitoring engineer – can be successfully completed in a cooperative manner.

COMMUNICATION OF PROJECT GOALS

An important first step is to make sure that the owners, project construction manager and CQA/environmental monitoring engineer are on the same page. The owner's project goals must be communicated to the rest of the project team. For the SLRIDT site, the project team is comprised of Hard Hat Services Inc. (HHSI), the project construction manager; and SERVICE, the CQA/environmental monitoring engineer. With four owners, with varying degrees of involvement on the project, XIK Corp. acted as the lead owner, communicating with the other owners to present the project goals to HHSI and SERVICE. The project goals for the SLRIDT site were communicated in three documents prepared by SERVICE: the Remedial Design/Response Action Plan (RD/RAP) (SERVICE 2005), which presented the conceptual design; the Quality Assurance Project Plan (QAPP), which presented quality assurance goals related primarily to environmental monitoring and was included as an appendix to the RD/RAP; and the Construction Quality Assurance Plan (CQAP) (SERVICE 2006), which defined project roles and established a communication structure to allow field decisions with minimal project impact. The owners and project/construction manager reviewed each of these documents to ensure that they presented a common set of project goals, prior to submittal to the regulators and potential contractors.

The project goals have to be consistent with the requirements of the regulators, which on the SLRIDT site, consist of the Minnesota Pollution Control Agency (MPCA) as the primary regulatory agency and author of the Record of Decision (ROD) (MPCA 2004), the legal document that establishes the regulatory requirements of the project; the Minnesota Department of Natural Resources (MDNR); the Wisconsin Department of Natural Resources (WDNR); the United States Army Corps of Engineers (COE); and the City of Duluth. After the project documents (RD/RAP, QAPP and CQAP) are approved by the appropriate regulator(s), in this case the MPCA, the project goals have to be communicated to the project contractors, after their selection by the owners.

Two response action contractors (RACs) were involved with the 2006 construction: Envirocon for placement of a surcharge sand cap and Marine Tech Inc. (MTI) for construction of the CAD end dike. The remainder of the paper will discuss how the CQA/environmental monitoring role was successfully completed with each of the 2006 RACs.

The Shaw Group has been contracted to complete remediation activities including dredging, capping, post-dredge cover, wetland excavation, and water filtration plant operation during 2007 and 2008. The remediation project will be completed in 2009, with surcharge cap removal and placement on the CAD, and dredging of mud from an off-site source for use as benthic habitat in remediated areas of the site. These activities will not be discussed in this paper because the work has not yet been performed, however, the same principles of project communication and cooperation are planned to make the remaining three years of the project as successful as the first.

2006 CONSTRUCTION ACTIVITIES

CQA and environmental monitoring tasks performed for the 2006 construction activities included:

- Review of RAC work plans, including proposed means and methods, for compliance with the RD/RAP, QAPP, and CQAP;
- Inspection of all project materials delivered to the site, including applicable measurements and/or testing;
- Observation and documentation of all RAC activities related to construction of the end dike and surcharge cap, including formal and informal inspections documented on a Daily QA Monitoring Form;
- Weekly RAC progress meetings to ensure issues are raised, discussed and settled in a timely manner, and to allow the RACs, project/construction manager and CQA/environmental monitoring engineer to anticipate potential future issues to avoid project delays during problem-solving;
- Surface water quality monitoring to ensure site contaminants didn't impact the St. Louis River at concentrations above MPCA requirements, including inspection of turbidity curtains installed by the RACs;
- Noise monitoring to ensure site activities were conducted in accordance with MPCA regulations;
- Acute air emission monitoring, using real-time naphthalene monitors – Aromatic Specific Laser Ionization Detectors (ArSLIDs) to ensure neighborhood residents and non-remediation workers on and near the site were not exposed to naphthalene concentrations above MPCA-specified acute concentrations;
- Real-time presentation of the ArSLID data via the site web page to aid in community and regulatory relations;
- Chronic air emission monitoring to determine construction-season-long air emission concentrations from site remediation activities; and,
- Communication with regulators to obtain approval of RAC means and methods alterations.

The CAD end dike and surcharge cap construction activities completed in 2006 at the SLRIDT site were on different portions of the site, approximately 400 meters apart, so CQA monitoring often involved having to be in two places at once. In addition to having field personnel observing the RAC activities, the CQA/environmental monitoring engineer installed, operated and maintained two pole-mounted CQA cameras (Figure 1). One camera was installed to observe the CAD end dike construction and one camera was installed to observe the surcharge cap construction. Two additional cameras were installed at the project entrances for site security purposes. The site security cameras were programmed to record based on motion sensors built into the camera. The cameras were integrated with an on-site mesh network used to collect and upload the real-time air quality data to the web page, to allow viewing of the cameras by authorized users. The air monitoring data and camera images were transmitted to the project site computer via the same network but each had a different end use. The air data was available for viewing by anyone who visited the www.slridt.com web page, but the camera images were only for authorized project personnel, whether on-site or in their office.

Contained Aquatic Disposal (CAD) End Dike Construction

MTI completed construction of the CAD end dike, based on a design prepared by the SERVICE consisting of a rock-fill dam constructed across the southern end of a 600-meter-long existing shipping slip, which will be used to dispose of the dredged contaminated sediment.

Figure 1. Construction quality assurance cameras were used to supplement observations by field personnel.

Materials used to construct the CAD end dike included rock, gravel, pipe piles, and geotextile clay liner (GCL). All borrow material (aggregate) used on site must be approved by the MPCA, based on testing specified in the QAPP. The RAC proposed use of several aggregate sources in order to obtain approximately 16 million kilograms of rock and approximately 6 million kilograms of gravel to construct the end dike. The CQA/environmental monitoring engineer performed site visits to each of the proposed rock sources to evaluate the contamination potential and propose an appropriate parameter list and sampling frequency to the MPCA for review and approval. No significant contamination potential was identified, so an alternative ASTM neutral leaching method to ensure the rock used to construct the end dike would not adversely impact the river. The grain size of the dike rock, consisting of angular basalt with an acceptable diameter between 15 and 80 cm, was determined using a tape measure on rocks selected by the CQA inspector.

Pipe piles were installed below the CAD end dike for stability, due to soft sediment conditions (Figure 2). In addition to approving the pipe piles prior to use, the CQA/environmental monitoring engineer provided the RAC with the coordinates for each pile, which were entered into the RAC's onboard GPS software. A GPS antenna on the tip of the crane, directly in line with the suspended pile and hammer, allowed the CQA/environmental monitoring engineer to observe and verify the pipe pile placement locations in real-time on the GPS computer screen used by the crane operator.

Figure 2. A crane barge with on-board GPS capabilities was used to install the pipe piles – and subsequently to place rock and gravel, which comprised the CAD end dike.

Installation of geotechnical instrumentation, including vibrating wire piezometers and settlement cells, required to measure settlement and strength (pore pressure) of the sediments within the footprint of the end dike was a cooperative effort, with the RAC assisting the CQA/environmental monitoring engineer. These delicate instruments could not survive the placement of dike material above them without armoring and special care during installation. The CAD end dike design and CQAP identified that the RAC would accommodate the CQA/environmental monitoring engineer during installation of the instrumentation, but due to the cooperative nature of the work, the RAC volunteered to design and fabricate the armor and coordinated their schedule to allow diver placement of the instruments.

Use of the RAC's on-board GPS allowed the CQA/environmental monitoring engineer to monitor placement of a 2.5-meter rock base and the rock-gravel mix, which comprised the bulk of the end dike. The RAC produced a daily printout of the location of each rock skip (a piece of equipment used to place large diameter rock) placed, based on the GPS, for review by the CQA inspector.

The RAC identified that they would require placement of an asymmetrical cross section as a temporary construction condition, prior to re-shaping the end dike to the final symmetrical cross section, because the crane barge could not reach the northern-most slope of the end dike without temporarily altering the shape. The RAC proposed this temporary asymmetrical construction stage approximately three weeks before a decision was required. This allowed sufficient time for a geotechnical evaluation and determination to be made by CQA/environmental monitoring engineer, and for both parties to perform additional engineering analysis to determine sediment strength, safety factors and contingency plans for implementation of this temporary construction condition. The temporary, asymmetrical loading during construction was approved, without causing construction delays, because of the cooperation of the project members and early identification of the potential issue by the RAC.

Figure 3. An alternative geotextile clay liner (GCL) tie-in and CAD end dike top completion was successfully approved through cooperative project management channels.

A GCL was installed on the CAD side of the end dike to ensure hydraulic isolation and containment of the contaminated sediments (Figure 3). The design called for this liner to completely cover the north face of the End Dike, with a minimum 60 centimeter overlap of each of the 4.5-meter GCL panels, and 6 meters of GCL past the toe of the End Dike slope and wrapping around the each edge of the CAD End Dike onto the pre-existing land. The GCL was placed on a 30-centimeter bed of gravel to prevent pressure points from the underlying rock, and covered with an additional 30 centimeters of gravel for ballast and surface protection. The GCL panels were held in place at the top by digging a trench along the top of the CAD end dike and keying-in the GCL. Because much of the GCL installation was completed in deep water, the CQA/environmental monitoring engineer could not observe the installation to document and approve overlaps and ballast coverage. The RAC utilized divers to ensure the overlaps were carried the length of the slope and out past the toe, and the divers provided video and audio of the installation for the CQA/environmental monitoring engineer to review. The CQA/environmental monitoring engineer surveyed the top elevation of the end dike during liner key-in to ensure that the proper elevations would be achieved and approved an alteration of the completion to allow a wider top for long-term project traffic considerations, allowing small trucks and equipment (less than 2.5-meter-wide) to access each side of the completed CAD.

Through early identification of potential construction issues, cooperative problem-solving, and weekly CQA meetings, the CAD end dike construction was completed ahead of schedule and within budget parameters.

Stryker Bay Cap and Surcharge Construction

Construction of a surcharge cap in Stryker Bay was unique because SERVICE designed the surcharge cap and sand placement specifications, and Envirocon designed the sheet pile wall to contain the cap and proposed the means and methods for sand placement. In addition to the design roles of each organization, Envirocon was charged with building the surcharge cap and SERVICE was charged with project CQA.

This project consisted of isolating an approximately 45,000-square-meter surcharge cap area from the rest of the bay, which will be dredged in 2007, by installing a 600-meter-long sheet pile wall, placing cap sand in sub-aqueous and land-applied lifts, sub-aqueous installation of an Activated Carbon Mat (ACM), and the installation of various geotechnical instruments.

An identified discrepancy between the project documents and the RAC's work plan required resolution prior to initiation of field activities. The RAC's proposed location of the submerged slurry feed hopper for subaqueous sand placement was in an area containing contaminated sediments. The RAC indicated that moving the slurry feed hopper to an area without contaminated sediments would require a complete overhaul to the project logistics. Working together with the project construction manager and the CQA/environmental monitoring engineer, the RAC relocated their intake operation outside of the bay in an area with contaminated sediment at lower concentrations than the original proposed location. In order to ensure that the placed sand material did not contain PAHs, the CQA/environmental monitoring engineer monitored the sand for potential contamination using fluorescence technology. The testing, which confirmed that the placed sand did not contain PAHs at a concentration of concern, was completed within approximately two hours of collection using an instrument provided by Dakota Technologies and located in SERVICE's Duluth office.

The first phase of construction consisted of the sheet pile wall installation (Figure 4), for which the CQA/environmental monitoring engineer conducted visual monitoring of the wall construction, and received detailed daily summaries of sheet numbers and locations from the RAC. Issues arose such as wall alignment and shoreline tie-ins, and were resolved through weekly CQA meetings and daily on-site discussions with the project construction manager, the CQA/environmental monitoring engineer and the RAC.

Figure 4. Environ designed and installed a sheet pile wall, which was constructed to contain a surcharge sand cap designed by the SERVICE.

Due to historic low water levels in the St. Louis River, the RAC requested that the slurry feed hopper be lowered into the sediment in order to maintain sufficient head to pump slurry to the placement barge. The project construction manager and CQA/environmental monitoring engineer reviewed the RAC's request and assisted with obtaining MPCA approval to dredge a small amount of the contaminated sediments and dispose them at the north end of the to-be-completed CAD.

Figure 5. The CQA/environmental monitoring engineer and the RAC worked cooperatively to evaluate the first, critical sand cap lift.

The cap and surcharge design called for an initial 15-centimeter sand lift prior to placement of the ACM. The CQA/environmental monitoring engineer and the RAC performed approximately 100 cores to define the degree of sand/sediment mixing and determine that a sufficient initial 15-centimeter cap lift thickness was attained (Figure 5). Portions of the initial cap lift, which were not sufficient, based on the drop core evaluation, were supplemented by additional sand placement by the RAC, re-cored, and approved.

Specialized techniques for sand placement at and near the shoreline using long-stick excavators to place sand without disturbing the soft, contaminated sediments, were developed by the RAC, presented and approved by the project construction manager and CQA/environmental monitoring engineer for implementation to ensure a uniform cap (Figure 6).

Figure 6. An alternative shoreline cap placement method, approved by the CQA/environmental monitoring engineer, included placement of uniform lifts by the RAC using a long-stick excavator.

After approval of the first sand lift, the entire surcharge cap area was covered with ACM, placed by the RAC (Figure 7). This fabric was designed to filter contaminated pore water from consolidating sediments. The ACM panels, manufactured by CETCO, were approximately 5 meters wide by 26 meters long. The design called for an approximately one-meter overlap along the shoreline, and an approximately 30-centimeter overlap in the remainder of the surcharge cap area. The CQA/environmental monitoring engineer visually observed and mapped each panel, ensuring that the appropriate overlaps were achieved, and performed in-place inspections of the ACM after it sank below the water surface.

Figure 7. Activated carbon mat (ACM) was installed by the RAC after the first sand cap lift, based on the CQA/environmental monitoring engineer's cap design.

Geotechnical instruments, including vibrating wire piezometers, settlement cells, settlement profilers and settlement plates, were installed by the RAC on top of and through the ACM. The RAC was responsible for procurement and installation of the instruments, and running the instrument cables to a central shoreline location. The CQA/environmental monitoring engineer observed that each instrument was installed according to manufacturer's recommendations, and tested each instrument cable at the shoreline to verify that it was functioning properly, which required extensive schedule coordination.

Subsequent sand lifts could not be cored for thickness verification due to the presence of the ACM, which could not be compromised, so the CQA/environmental monitoring engineer performed surveying, combined with extensive settlement measurements, to identify lift thicknesses for approval (Figure 8). Since sub-aqueous capping operations were performed 24 hours per day, 7 days per week, the RAC, CQA/environmental monitoring engineer and project construction manager coordinated survey and capping activities to minimize sand-placement equipment downtime. Typically, surveys could be completed and interpreted in one portion of the surcharge cap area, while capping equipment was operating elsewhere.

Figure 8. The CQA/environmental monitoring engineer surveyed each cap lift thickness to ensure compliance with project specifications.

As additional sand cap lifts were placed, the CQA/environmental monitoring engineer collected and distributed geotechnical data collected from the instruments (Figure 9) so the project engineers could keep a close watch on the data for signs of sediment weakness or sheet pile wall movement. Once it was determined that the sediments were not gaining strength sufficient for wall stability, sand placement procedures were modified as necessary to ensure sheet pile wall integrity. The modified sand placement procedures included a joint determination by the RAC and CQA/environmental monitoring engineers, in consultation with the project construction manager, that a management zone (MZ) should be delineated. The RAC determined the size and shape of the MZ and the appropriate thickness of sand to be applied after several meetings and teleconferences with the project construction manager and CQA/environmental monitoring engineer, who evaluated the slope stability to calculate the appropriate taper slope from the MZ to the full cap thickness areas. Coordination between SERVICE and Envirocon engineers was critical to institute these safety factors in order to ensure the integrity of the sheet pile wall while not impacting project schedule goals, with winter fast approaching in Duluth (Figure 10). The project engineers are maintaining the cooperation during on-going sheet pile wall alignment, cap settlement and sediment strength gain monitoring over the winter, with the goal of placing the remaining surcharge cap in Spring 2007.

Figure 9. The CQA/environmental monitoring engineer monitors geotechnical instruments installed by the RAC weekly, with data submitted for analysis by engineers from both organizations.

Figure 10. The integrity of the sheet pile wall is monitored by the CQA/environmental monitoring engineer due to soft underlying sediments.

SUMMARY

The CAD end dike and Stryker Bay surcharge cap construction for the SLRIDT SedOU construction project succeeded through the collaborative efforts of two RACs (MTI and Envirocon), the project construction manager (HHSI) and the CQA/environmental monitoring engineer (SERVICE). In order to ensure that the owner's (XIK Corp.) project goals were met for each of the project remediation tasks, the project construction manager and CQA/environmental monitoring engineer operated as an integrated team, with common goals and nearly continuous communication. Project goals were communicated in three crucial documents: the MPCA ROD, the CQAP and the RD/RAP, which included the QAPP as an appendix. The project construction manager and CQA/environmental monitoring engineer were housed in a common site trailer and used field radios and cell phones to maintain open communications during all RAC activities. Through foresight and cooperation of the entire project team, CQA issues were identified and resolved with little effect to the project's schedule and budgets. Based on the successful completion of the response actions completed in 2006, this approach to CQA monitoring and management will be implemented during the remaining response actions at the SLRIDT site.

REFERENCES

MPCA (2004). "Record of Decision for the Sediment Operable Unit, St. Louis River/Interlake/Duluth Tar Site, Duluth, Minnesota, Under the Minnesota Environmental Response and Liability Act, Minn. Stat. §§ 115B.01-115B.24," Minnesota Pollution Control Agency, St. Paul, Minnesota.

SERVICE (2005). "Final Remedial Design / Response Action Plan, St. Louis River/Interlake/Duluth Tar Site, Sediment Operable Unit," SERVICE Engineering Group, St. Paul, Minnesota.

SERVICE (2006). "Construction Quality Assurance Plan, St. Louis River/Interlake/Duluth Tar Site, Duluth, Minnesota," SERVICE Engineering Group, St. Paul, Minnesota.