

ENVIRONMENTAL RESTORATION OF A STEEL MILL

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Abstract

This paper describes the regulatory and technical background of the successful remediation of a 32-hectare steel mill in Florida, USA. The project site had, over the early years of its 30-year operating history, become contaminated with by-products and wastes from the steel mill operations that, unknown to the company at the time, contained levels of lead and PCBs in excess of subsequently-established government limits. Starting with the initial discovery of the problem in 1986, a comprehensive investigation was undertaken consisting of more than 600 test pits and borings and the analysis of several thousand samples. The results of the nine-year study that characterized the extent, thickness and level of contamination showed conclusively that the problem was confined to approximately 200,000 cubic meters of fill material that had been deposited at varying thicknesses on top of the native soil across virtually the entire site. Because of the huge volume involved, negotiations with the State and Federal environmental agencies on cleanup criteria for the site and disposal options for the contaminated fill continued for over five years. This paper discusses the evolution of the cleanup criteria and treatment and disposal requirements for PCBs and lead, and the agreement that was finally reached between the owner and the regulatory agencies. The actual remediation and future use of the site will also be described. Our goal in presenting this case study is to show that the principal lessons learned as a result of our experience at the Tampa site, as well as several similar environmental cleanup projects we have successfully concluded, may be generally applicable to other types of industries and to the conditions experienced in nations other than the USA.

Introduction

The AmeriSteel Corporation Tampa Mill is located in a major industrial area in Tampa, Florida. Between 1958 and 1994, AmeriSteel manufactured new steel products at this facility by recycling scrap steel, principally junk automobiles, through the use of electric arc furnace technology. An aerial photograph of the Tampa Mill just prior to remediation is shown in Figure 1. Most of the Tampa Mill property and some adjacent areas had been filled with materials that were generated by the steel mill, primarily slag, with lesser but still significant amounts of mill scale and dust from the air pollution control system (referred to as EC dust from "emission control"), and residues from the scrap steel shredding operation. The fill had an average thickness of approximately 0.6 to 0.75 meters, and a volume of more than 200,000 cubic meters.

In the USA, neither the mill scale nor the slag is regulated as a hazardous waste because they are considered valuable by-products. However, since 1980, many years after the mill began operating, EC dust has been regulated as a hazardous waste. Prior to shutdown of the steel mill melt shop in 1994, an automobile shredder and scrap processing operation had been located in the western portion of the Tampa Mill facility to prepare scrap steel for the furnace. Most of the automobile shredder residue (ASR), sometimes called "fluff", was shipped off-site as it was generated; however, some ASR remained on the property. Analyses of the scrap processing residue showed it to exceed the permissible regulatory level for lead.

Another complication was the result of the discovery that there were polychlorinated biphenyls (PCBs) present in the soil in some areas of the site. These were the result of the fact that for a brief period in the early 1970s, the mill had used hydraulic shears to cut the hot steel from the continuous caster into billets and that some of the hydraulic oil used in the shears contained PCBs. Some of hydraulic oil had entered the cooling water system and thus contaminated the mill scale with PCBs. The mill scale was periodically removed from the process water system and used as fill on the site. In 1976 with the enactment of the Toxic Substances Control Act (TSCA), PCBs became a regulated hazardous waste.

More than 600 test pits/borings and several thousand samples were analyzed during the contamination assessment for the site. The results of the assessment indicated that the fill layer and the sediments in the existing stormwater ditches at the Tampa Mill contained elevated concentrations of lead and PCBs. The lead concentrations ranged from less than 200 to greater than 20,000 mg/kg, and the concentrations of PCBs ranged from less than 10 to greater than 2,500 mg/kg. The areas with lead concentrations greater than 1,000 mg/kg and PCB concentrations greater than 25 mg/kg are shown on Figures 2 and 3, respectively.

Hydrologic Setting

The Tampa Mill site is relatively flat with land surface elevations between +5 and +6 meters above sea level. Storm water runoff from the developed portion of the site was collected by a system of storm drains and ditches. The site is underlain by two aquifers separated by a confining stratum. The surficial aquifer consists of unconsolidated sediments, primarily fine sand with some silt and clay. The thickness of the surficial aquifer ranges from approximately 6 meters in the western part of the site to 3 meters in the eastern part. The surficial aquifer is not a source of potable water in the vicinity of the site. At the base of the surficial aquifer is a 2- to 4-meter thick clayey confining layer containing variable quantities of sand and silt. Below the confining layer is the confined Floridan Aquifer. The upper part of the Floridan Aquifer consists predominantly of variably weathered limestone with some silts and clays. The hydraulic connection between the surficial aquifer and the Floridan Aquifer is limited.



Groundwater in the surficial aquifer was generally encountered within 1 meter below land surface. Groundwater flow in the surficial aquifer was generally to the east toward the Tampa Bypass Canal; however, it also occurred toward the North Ditch and the South Ditch in their immediate vicinity. The general direction of groundwater flow in the Floridan Aquifer was to the southeast toward the tidal portion of the Tampa Bypass Canal.



The results of nine years of groundwater monitoring at over 20 locations on the property disclosed no evidence of dissolved lead or any other heavy metals or PCBs in either aquifer. In fact, despite the widespread contamination of the fill across almost the entire site, the most significant fact that emerged from the investigation was that the ground water had not been affected to the point that it violated any regulatory limit.

Remediation Costs

When the contamination was discovered in 1986, the Tampa Mill was in full operation. To excavate, separate, treat, and dispose of the contaminated portions of the fill while the mill was still active would have been a formidable undertaking. A wide range of alternatives was studied and preliminary cost estimates were developed for those considered the most feasible. These options included incineration of materials with high PCB concentrations (either on-site or at an offsite commercial incinerator) and chemical fixation of materials with high heavy metals concentrations prior to disposal in a hazardous waste landfill. Chemical fixation is sometimes also referred to as “solidification” or “fixation”. Both on-site and off-site treatment and disposal

were evaluated. There are no hazardous waste incinerators or hazardous waste landfills in Florida. All of the offsite options involved hauling the waste for distances greater than 1,000 km. Unit costs associated with the remediation tasks are shown in the following table:

Typical Unit Costs for Remediation Tasks

Task	Unit Cost (US\$ Per Metric Ton)
Excavation and On-Site Hauling	2 to 3
Screening and Stockpiling	3 to 4
Transportation (1,000 km) by Rail	40 to 70
by Truck	80 to 100
Incineration	150 to 200
Chemical Fixation	20 to 30
Disposal in Hazardous Waste Landfill	100 to 200

Cleanup Criteria and Disposal Requirements

Because of the large volume of contaminated material, it was critical that reasonable cleanup levels and disposal options be established for the site. Although the Tampa Mill site contained the largest volume of contaminated material, this was not AmeriSteel's first remediation project. AmeriSteel had gained experience with two smaller but otherwise similar sites. All of the lead-contaminated fill not meeting the cleanup criteria at the two previously remediated sites had been solidified/stabilized using Portland cement prior to disposal. Data collected for these two sites were consistent with studies performed for the Tampa Mill and confirmed that fill materials and soil with lead concentrations below 1,000 mg/kg generally complied with the federal leachability criteria as non-hazardous waste. Shredder residue even at concentrations in excess of 1,000 mg/kg also complied with the leachability criteria. In addition, groundwater concentrations even directly beneath the fill with the highest lead concentrations were consistently complied with the strict regulatory standards. For these reasons, a cleanup level for lead in the fill and soil of 1,000 mg/kg and chemical fixation prior to disposal of only those materials which failed the federal leachability criteria were proposed for the Tampa Mill site.



At the time the investigation began at the Tampa Mill, regulations stipulated that PCB-contaminated soils would have to be destroyed in a special type of incinerator prior to disposal. In 1987, AmeriSteel had used such an incinerator to treat some 20,000 tons of PCB-contaminated soil at another of its mills. However, even if incineration were limited to PCB concentrations exceeding 25 mg/kg, estimates of the cost to remediate the Tampa Mill site, assuming the precedent set at prior sites, were in excess of US\$45 million. If all of the PCB-contaminated material required incineration, cost estimates were in excess of US\$100 million. It was clear that the incineration option would have been prohibitively expensive for the Tampa Mill site.

Approved Remedy

After more than five years of collaboration, a remedial action plan was approved by the state and federal regulatory agencies. By this time, AmeriSteel had decided to close the mill for economic reasons. The approved remedy involved excavating and disposing of all fill within the remediation areas and all sediments in the storm water ditches. In addition, native soil that exceeded the cleanup criteria would also be removed. The native soil cleanup criterion for lead was 1,000 mg/kg. For PCBs, the criteria were 3.5 mg/kg within 0.6 meters of final grade and 44 mg/kg at depths greater than 0.6 meters. No separate criteria were established for other contaminants, such as other metals, because the studies had conclusively demonstrated that lead was the controlling heavy metal, i.e., if the criterion for lead were satisfied, the other metals would also be within approved limits.

The approved plan required chemical fixation prior to disposal of all excavated materials with a leachable lead concentration exceeding 5.0 mg/l. The final approved treatment standards for lead-contaminated material were: (i) a leachability lead concentration less than 5.0 mg/l; and (ii) an unconfined compressive strength equal to or greater than 340 kPa for the stabilized waste. Both the state and federal regulatory agencies agreed that if all of the fill were excavated and disposed of on-site in an approved landfill (discussed below), incineration would not be required prior to disposal.

A contractor was selected on the basis of competitive bidding for a lump sum contract to complete the approved remedy.

Excavation of Contaminated Materials

The average depth of excavation for removal of the artificial fill and underlying contaminated soils was approximately 0.75 meters. In some places, the excavation had to be extended to 1.5 meters. The boundary between the artificial fill and the underlying native soils was relatively distinct allowing a high degree of control in the field, as shown on the photograph in Figure 4.

Verification sampling of the native soils underlying the artificial fill was performed on a 15-meter square grid system. If the verification sample exceeded the cleanup requirements, an additional 15 cm of material from that grid was excavated and the procedure repeated until the requirements were achieved.



Vault Base Design and Construction

The on-site vault was designed to exceed all federal and state requirements for a hazardous waste landfill. It was constructed in the western part of the Tampa Mill property, where the automobile shredding facility once operated. The vault occupies an area of approximately 4 hectares. The bottom liner and leachate collection system consists of the following components in ascending order:

- A 30-cm thick compacted soil liner with a hydraulic conductivity less than 2.0×10^{-8} cm/sec
- Two 1.5-mm thick high density polyethylene (HDPE) geomembrane liners separated by a 5-mm thick geonet
- A 60-cm thick sand layer drained by HDPE prefabricated drainage panels on 7-meter centers.

Figure 5 is a photograph of the vault base under construction

Solidification/Stabilization

Portland cement was used to solidify/stabilize the excavated materials that exceeded the treatment standards. The operation involved screening of the excavated fill to remove particles larger than 2.5 cm, and mixing the screened material with 8% to 10% cement and water in a pug mill. The ratio of the mixture had been derived from the results of a long series of treatability tests. Prior to full scale production, test runs were performed using the field equipment to confirm the appropriate cement content and water-cement ratio. During the full-scale operation,

confirmatory testing was performed to document that the treatment criteria had been achieved. Less than 15,000 metric tons of the excavated material required treatment. A photograph of the pug mill operation is shown on Figure 6.

Final Cover Design and Construction

After the excavated and treated materials had been placed in the vault, a final cover was constructed to prevent infiltration. The grass layer of the final cover serves as an aesthetic cover and minimizes the potential for water and wind erosion. The final cover for the on-site vault consists of the following components in ascending order:

- A 30-cm thick compacted soil liner with a hydraulic conductivity less than 2.0×10^{-8} cm/sec. A 1-mm thick HDPE geomembrane.
- A 45-cm thick protective soil cover.
- A 15-cm thick topsoil soil layer with sod cover.

Figure 7 is a photograph of the top cover during construction. The height of the completed vault is approximately 11 meters.

QA/QC Program

A comprehensive construction quality assurance (CQA) program, which included full-time third-party inspection of all remediation and construction activities, and field and laboratory testing of the treated soil and all liner components, was implemented to assure that the remediation was performed in compliance with the remedial design.

Approximately 800,000 liters of leachate were removed from the leachate collection system approximately four months after the final cover was in place. The leachate collection system was checked again two months later, and was found to be empty. No leachate has been detected in the leak detection system.

Conclusions

The environmental restoration of the Tampa Mill site has been considered a huge success by the government, the community and AmeriSteel.

Remediation of the Tampa Mill was completed in approximately 15 months, approximately 9 months ahead of the original schedule, with a total remediation cost of approximately US\$7 million. This translates to an average cost of approximately US\$12 to \$15 per metric ton of excavated material, which is substantially lower than any of the remediation options that had originally been considered for the project. A photograph of the site after remediation is shown in Figure 8.

The restored site has been subdivided into nine parcels to form an industrial park. One of the parcels has been sold, and three other parcels have prospective buyers.

Several important lessons were learned from this project that can be applied to remediation projects in other countries, other regulatory contexts, and other industries.

- Cleanup projects that are under the control of one party will proceed more efficiently, more rapidly, and at lower cost than projects where several parties are involved.
- Cleanup projects where all operations can be confined to the affected property,

including final disposal, will be more acceptable to everyone involved, especially the local community, will cost less, and will proceed with fewer delays than projects where offsite operations such as incinerators, landfills, etc., are involved.

- Provided that additional capacity can be planned for in advance, having final disposal take place on the property will result in much lower total and marginal costs per unit of material disposed. This will allow the owner to make significant concessions with respect to the cleanup levels and thus provide a much more comprehensive cleanup than the minimum required by the regulators.
- When contaminated materials must be hauled off-site, the unit cost is so great that considerable effort must be expended to reduce the total quantity of excavated material to the absolute minimum required to satisfy the regulatory limits. The residual contamination will not only reduce the value of the property for future development, but will likely require ongoing surface and ground water monitoring.