U.S. EPA Region 8
RCRA Corrective Action Program

RCRA Cleanup Reforms
Success Story

Containment / Stabilization of Subsurface Hydrocarbon Contamination at Texaco Refinery Casper, Wyoming

Prepared by: Tom Aalto, EPA RPM, (303) 312-6949, aalto.tom@epa.gov

February 2001

Summary of Success Story

Two major containment / stabilization projects have recently been conducted at the former Texaco refinery in Casper, Wyoming. These include installation of a state-of-the-art subsurface barrier wall, and removal of subsurface piping and hydrocarbon source areas. Other corrective action activities, such as preparation of a CAMU for clean-up wastes, have also been undertaken. These innovative and state-of-the-art projects have, in keeping with the recent RCRA reforms, accelerated the implementation of corrective action goals at this GPRA facility, including meeting the Environmental Indicator (EI) for ground water. The following is a summary of these significant and highly successful projects. Attachment A contains a detailed description of these projects.

The state of Wyoming is the lead regulatory agency pertaining to RCRA corrective action at the facility which ceased operations in 1982, and has been dismantled. The facility is typical of many refinery sites (e.g. has significant subsurface hydrocarbon contamination) and is conducting overall corrective activities under a 3008(h) order issued by the state. Also, the state issued an equivalent to a 7003 order to address subsurface hydrocarbon contaminants migrating to the nearby North Platte river. However, some of the corrective action activities being conducted by Texaco are not specifically required in the orders or formal work plans. As such, some of the projects being conducted by Texaco can be considered voluntary and cooperative in nature. The WDEQ has worked closely with the facility as these projects are implemented to ensure overall consistency with long-term corrective action objectives. EPA's role has been to provide oversight and technical assistance. Also, recently a partnership has been formed with Texaco, WDEQ, and EPA to look into innovative technologies to address remaining subsurface hydrocarbon contamination. This effort is part of a broader RTDF partnership with industry recently formed to address subsurface hydrocarbon contamination at refinery sites. The facility is currently in the RFI phase of the corrective action process, and no final clean up requirements have yet been determined. The facility is close to meeting its EI for human health; potential onsite worker exposures are the only remaining issues for the human health EI.

To date, Texaco has expended roughly $10,000,000 in implementing these containment / stabilization projects and has effectively communicated its activities to the public. Through these and other continuing efforts, Texaco plans to be able to return the site to many potential future land uses in the community. As a side note, the facility has been nominated to receive the Interstate Oil and Gas Compact Commission (IOGCC) Environmental Stewardship Award for these projects. In addition, Texaco received the EPA Region 8 Regional Administrator's External Award for these projects in 2000.

The first project was conducted in association with Texaco's ambitious four-year program to completely decommission the inactive refinery. In addition to removing all buildings, tanks, processing units and other above-ground structures, the decommissioning program included a creative process for removal of all subsurface refinery components, including over 200 miles of subsurface refinery piping, thousands of tons of concrete, and thousands of cubic yards of petroleum contaminated soils. The primary objective of the subsurface decommissioning work was to identify and remove, up-front, as many potential subsurface contaminant sources as practical. By implementing this stabilization project, Texaco has already removed many significant subsurface source areas of hydrocarbon contamination.

The second project was conducted in association with Texaco's efforts to stabilize, contain, and remove residual groundwater contaminants underlying the refinery site. The project involved installation of a state-of-the-art steel sheet piling barrier wall to protect water quality in the North Platte River. The river forms the northern, down-gradient border of the 200-acre refinery site and is a regional source of municipal, agricultural, and industrial water supplies; the river is also very important in terms of its wildlife resources and recreational value. The Waterloo Barrier sheet piling used to construct the barrier wall is specially manufactured using a patented design that allowed each joint between the sheet piling panels to be individually grouted and sealed. With an overall length of 3,400 feet and surface area of more than 87,000 square feet, the sealed-joint barrier wall at the Texaco Casper Refinery is one of the largest and best of its kind in the world. The successful installation of the barrier wall has allowed Texaco to meet its EI for ground water, thus providing greatly increased protection to the North Platte river.

Lessons Learned

These successful projects, implemented in a cooperative manner, are the types of projects being promoted in the RCRA Reforms. By implementing these projects up-front, the facility has made great strides in its RCRA corrective action activities.

The most important, common sense, lessons learned from these projects are:

1) Emphasis can and should be placed first on containment and stabilization including source reduction utilizing available technologies.
2) Interim goals should be to achieve EIs.
3) A phased approach to implementing long-term remedies should be employed in close coordination with the public with potential future land use in mind.

Other Contacts:
Randy Jewett, Manager, Texaco (818) 736-5562
Jeff Hostetler, Consultant, Trihydro Corporation (307) 745-7474 (major contributer to this write-up)
Ali Tavelli, Lead RPM Wyoming DEQ (307) 777-5447, atavel@state.wy.us
Randy Breeden, Geohydrologist, EPA (303) 312-6522

Attachment A

Detailed Description of Texaco Containment / Stabilization Projects
(Note: Photographs attached)

Subsurface Piping and Contaminant Source Removal

Texaco began decommissioning its former Casper Refinery during mid 1996. As part of that process, Texaco has removed all inactive underground piping, concrete foundations and other subsurface structures that were associated with the operating plant. Texaco decided to remove the underground piping and structures as the first major phase of its overall efforts to eliminate possible sources of environmental contamination. In addition, Texaco developed and implemented a program to identify, field screen and remove petroleum contaminated soils (PCS) that meet certain criteria. The PCS removal program is intended as a voluntary corrective action to reduce average concentrations of petroleum hydrocarbons in subsurface soils through additional source removal, thus providing an added measures of risk reduction to human health and the environment.

Texaco informed the Wyoming Department of Environmental Quality of its plans to remove the underground piping and structures in late 1996 and worked closely with the agency to ensure that its plans would dovetail with other environmental protection and restoration projects underway at the facility. The first step in the process involved field checks and review of refinery drawings, piping location maps and aerial photos to identify all known or suspected piping and subsurface structures throughout the refinery. Such drawings included process piping maps, the plant water system map, and the plant fire water system map.

Following field verification of the locations of piping runs and other structures to be removed, equipment and crews were mobilized to open exploratory excavations at the end points and sides of target structures. Further field checks were then conducted to determine if fluids were present in the piping and identify other conditions that would need to be considered in order to conduct the work safely.

Depending on results of the field inspections, additional equipment and crews were mobilized to prepare the piping and structures for removal. Such activities frequently required deployment of vacuum trucks, liquid containment devices and special cold-cutting tools used to completely drain and/or remove the contents of subsurface piping and structures. Exploratory excavations were also carefully inspected for the presence of petroleum-contaminated soils, side-wall stability and other conditions that could influence the manner in which removal activities were performed. All hydrocarbons recovered from the piping were transferred to on-site storage tanks for later resale; recovered water, if present, was transferred to the on-site water treatment system for processing.

After the piping and structures in a specified area had been isolated and drained, excavation equipment was used to completely expose all piping and structures to be removed from the subsurface. Depending on the types of piping and structures present, additional equipment including hot and cold cutting tools, track mounted shears, track mounted demolition hammers and conventional excavating equipment were deployed to cut and/or break the piping and structures into pieces of manageable size. Most of the piping larger than three-inch nominal diameter was carefully removed in segments up to 40 feet long, sorted by size and type, and then delivered for reconditioning and resale to used piping suppliers. Other metal material such as small-diameter piping, re-bar and structural steel were segregated and sorted by size and type for recycling. Concrete structures such as slabs, curbing, footings and foundations were broken up, removed, and crushed into gravel for use in maintaining on-site roadways, erosion controls and drainage systems. Based on plant drawings, measured weights and other information gathered during this phase of the project, Texaco estimates that more than 210 miles of piping were removed from the subsurface and approximately 100,000 tons of concrete were excavated, crushed and beneficially re-used onsite.

Following removal of piping and subsurface structures, open excavations and exposed piping corridors were visually inspected for the presence of petroleum-contaminated soils and other potential contaminant sources. If identified, such soils and materials were flagged and evaluated using qualitative and/or quantitative field screening criteria. Texaco then used results of these evaluations to determine if the soils should be removed or documented and left in place. At the close of this phase of the project, Texaco had successfully removed approximately 90,000 cubic yards of petroleum contaminated soils from the former refinery site.

Completion of the project involved a three-step program to verify that all subsurface piping and structures had been successfully identified and removed. This final clearance program began by back-filling open excavations and piping corridors with clean soil within areas targeted for final clearance. Preliminary grading was then conducted to provide relatively flat terrain. Following this step, conventional excavating equipment was used to conduct random cross trenching at right angles to the direction of prevailing piping corridors. The purpose of the cross trenching step was to add redundancy with respect to identification of any piping or structures that may have been missed due to limitations of available plant drawings and maps. Piping, structures and petroleum contaminated soils identified during the cross trenching were then marked and managed using the aforementioned procedures.

Following the cross-trenching step, a large dozer equipped with three 42-inch ripping teeth was used to bi-directionally cross-rip areas designated for final clearance. The bi-directional cross-ripping process was developed in order to provide “fence-to-fence” identification of any remaining subsurface process piping and structures within the upper three to four feet below ground surface. Based on Texaco’s experience, this ripping depth is adequate to reach essentially all process piping burial depths, as well as most other piping and subsurface structures associated with petroleum refineries. As with the cross-trenching step, any subsurface piping or other demolition materials identified or brought to the surface during cross-ripping were marked and removed as appropriate. The majority of items identified and removed during cross-ripping included small pieces of piping, scrap metal, concrete rubble, re-bar and other demolition debris.

The last step in the final clearance program involves fence-to-fence application of continuous-profiling electromagnetic (EM) geophysical surveys coupled with a global positioning system (GPS) to detect and map the positions of any buried objects composed of or containing metal (both ferrous and non-ferrous). EM surveying was chosen as the preferred technique because it has the ability to identify both large and small targets (literally the size of nuts and bolts) to depths as great as 12 feet, with a high degree of certainty and reliability. It is also relatively simple to use and can be applied over relatively large areas within fairly short time frames. In addition, continuous profiling EM does not require that the survey equipment directly contact the ground, and, when coupled with GPS, there is no need to establish or stake out an extensive survey grid containing a large number of discrete measurement locations. Following the data processing step, the operator can simply use the GPS to back-navigate to the positions of any identified subsurface objects and mark the position for exploratory excavation and target removal.

Based on experience to date, Texaco has found that the cross-trenching and cross-ripping steps of the final clearance program are very thorough in terms of identifying and removing subsurface piping and structures. While the EM surveys performed at the Casper refinery have successfully identified numerous metal and metal-containing objects in the subsurface, subsequent excavation work has shown that the vast majority of such objects have been small pieces of concrete rubble, re-bar, and scrap metal; any isolated larger objects have been removed. Follow-up EM surveys are then conducted to confirm that there are no remaining objects capable of containing more than deminimus quantities of potential contaminants.

Following completion of the underground piping and structures removal program, Texaco embarked on the next major phase of its voluntary corrective action program for the former Casper Refinery. This next phase will involve design, permitting, construction and operation of a Corrective Action Management Unit (CAMU) designed to provide a permanent repository and containment system for remediation wastes generated in conjunction with a number of future corrective action activities that are proposed at the facility. These future activities will involve excavation, stabilization, consolidation and containment of waste material and contaminated soils and sediments associated with several Solid Waste Management Units (SWMUs) and other areas of interest that were not subjects of the underground piping and structures removal program. In addition to decommissioning of the refinery, Texaco has determined that voluntary removal of the subject SWMUs and impacted media will be effective to further protect human health and the environment, and further increase the potential for future land use and redevelopment. Texaco's objective in construction of the CAMU will be to provide a feasible means to conduct the removal actions in a manner that is safe for human health and the environment, over both the short and long terms. The CAMU has passed from the initial design phase into the permitting phase. Texaco anticipates that construction of the CAMU will begin during the 2001 construction season.

In addition to the above-described activities, Texaco is working with representatives of U.S. EPA, the Wyoming Department of Environmental Quality and other industries to form a Remediation Technology Development Forum (RTDF). The mission of the RTDF will be to establish a collaborative alliance among interested and experienced industrial, governmental and academic entities to develop an improved scientific and technical approach to remediation of groundwater and soils at large sites that have been contaminated by petroleum hydrocarbons. The alliance will create and test an improved decision-making framework, built upon scientific principles and the utilization of the most effective and appropriate technologies, to attain specific cleanup goals that will be acceptable to the appropriate regulatory agencies and public interests. Texaco anticipates that the umbrella framework of the alliance will be in place by the end of the first quarter of 2001, and that technical working groups within the alliance will then begin to work around specific sites and projects that are offered up by industry. Texaco expects that the former Casper Refinery will be the first member site within the RTDF.

Steel Sheet Piling Barrier Project

Between 1993 and 1997 Texaco installed an extensive network of groundwater interceptor trenches along the south bank of the North Platte River and operated them to successfully contain and remove subsurface contaminants that exhibited potential to adversely influence surface water quality in the river. Texaco launched the barrier project in mid 1997 to provide an added measure of protection for the river, while maintaining operation of the interceptor trenches as part of the company's overall efforts to clean up and restore groundwater quality. Most of the barrier-project area lies adjacent to the south bank of the North Platte River. Beginning at its western terminus, the barrier alignment extends in a northerly direction for approximately 800 feet, traversing from the northwest corner of Texaco property onto an adjacent piece of property that had been used by the Town of Evansville for landfilling of municipal waste. Texaco voluntarily developed this segment of the barrier alignment in order to isolate an area of impacted soils and groundwater on the Evansville landfill property. The barrier meets the south bank of the river at a point approximately 250 feet upstream from the Texaco-Evansville property line and then extends parallel to the south bank of the river, downstream for a distance of approximately 2,600 feet. The barrier wall has an overall length of approximately 3,400 linear feet, an overall surface area of more than 87,000 square feet and extends into the original river channel as much as 40 feet. The barrier fully penetrates the alluvial aquifer throughout its entire alignment and is keyed into shale bedrock underlying the alluvium at depths of 10 to 40 feet below ground surface.

Texaco began the barrier design process with a feasibility study in late 1997. The initial phase of the feasibility study involved a technical evaluation to identify various barrier technologies and determine which might be best suited to accomplish project objectives. Several different barrier design concepts, including conventional steel sheet piling, several types of synthetic barriers and various slurry wall technologies were evaluated. In addition, Texaco conducted groundwater modeling to evaluate the hydraulic effects that a fully penetrating barrier could have on groundwater flow within the project area. These phases of the study indicated that Waterloo Barrier, a patented form of steel sheet piling with sealable joints, would likely provide the most effective solution, and that Texaco would be able to successfully manage any changes in groundwater hydraulics associated with a fully penetrating barrier of the anticipated design.

The Waterloo Barrier sheet piling is similar to conventional steel sheet piling. It is formed from sheet steel into Z-shaped panels to increase its structural load bearing capacity, and is available in two different profiles and wall thickness. Each sheet-piling panel has slip-together joints at both edges, male at one edge and an over-sized female at the other, allowing the panels to interlock. A special foot plate, welded to the bottom of the female part of each joint, prevents the joints from being filled with sediment during driving. The panels are driven vertically to depth using percussion and/or vibratory hammers mounted on a conventional crane or hydraulic boom. Once in place, the oversized joint cavities are flushed clean from the surface to total depth using a water jetting system. In this manner, each joint can be individually inspected and measured to verify that it is clear and intact through its entire length, prior to sealing and grouting operations. In addition, a submersible fiber-optic camera can be used to video log individual joints. These capabilities provide the highest level of quality assurance and integrity verification available among all the barrier types considered. Following flushing and quality assurance inspections, a tremmie pipe and packer assembly are used to pressure feed grout through the foot plates along the base of the piling to seal the barrier where it keys into bedrock. The grouting system is then raised in stages while grout is injected into the oversized joint cavities themselves, allowing each joint to be completely sealed from below the bedrock surface to the ground surface.

Based on these performance and installation advantages, Texaco conducted a field demonstration to verify that test panels of the Waterloo Barrier could be successfully driven and keyed into bedrock along the full length of the anticipated alignment. The field demonstration involved installation of 40 test panels of the sheet piling at eight different test locations selected to represent the range of subsurface driving and installation conditions anticipated to occur within the project area. Results of the demonstration were favorable and indicated that it would be feasible to construct a Waterloo Barrier that would meet project objectives. However, significant design effort would have to be applied in order to control and/or mitigate any potential adverse impacts to river channel hydraulics, adjacent riparian environments and groundwater flow conditions. Texaco also learned that one very important aspect of the barrier design and permitting process would be identification and selection of a barrier alignment that would achieve the optimal balance between protection of the river and any environmental/ecological impacts associated with construction and maintenance of the barrier itself.

Given the favorable outcome of the feasibility study, Texaco decided to proceed with design and permitting to construct a full-scale barrier. The first step in the design process was to select and finalize the barrier alignment. To accomplish this, Texaco evaluated the results from three separate environmental investigations that were implemented to assess the nature and extent of subsurface contaminants along and near the south bank of the river. Results of the evaluation indicted that portions of the barrier would need to extend into the main river channel as much as 40 feet in order to maximize its effectiveness. Given these alignment parameters, the design and permitting phase would involve extensive coordination and planning with numerous permitting and review agencies including WDEQ, USEPA, US Army Corps of Engineers, the Bureau of Reclamation, the Wyoming Game and Fish Department, Natrona County and the cities of Evansville and Casper.

In addition to the extensive planning and permitting effort, the selected barrier alignment dictated that a number of challenging design elements be investigated and thoroughly addressed during development of plans and specifications for its construction. First and foremost, detailed hydraulic models of the river were developed and used to establish design parameters such that the overall water conveyance and flood carrying capacity of the main river channel would be conserved. Results of the modeling effort revealed that it would be necessary to widen the river channel along the north bank of the river in order to compensate for conveyance capacity that would be lost in association with barrier encroachments along the south bank. In conjunction with development of the compensatory river-channel enlargements, it was also necessary to develop and implement a plan to identify and mitigate fringe wetlands that would be impacted within the barrier project area. Based on these design elements, Texaco carefully planned and executed a re-contouring program along the north bank of the river during initial stages of the barrier construction. The re-contouring program included more than 20,000 cubic yards of compensatory excavation work and complete, in-kind replacement of approximately three acres of wetlands. The program also involved selective placement of more that 6,000 cubic yards of protective rip-rap in order to control erosion along the north side of the modified river channel.

Another key element of the design and construction process involved buildup and extension of the south bank of the river in order to provide safe, effective access for construction equipment and crews to install the sheet piling and related earth works. This program was developed using the knowledge of construction companies that have extensive experience with placement of earthen structures in marine and near-shore environments. Because the earthworks extended into the river channel as much as 40 feet beyond the existing water's edge, extra care had to be exercised in order to ensure that construction activities would not adversely influence water quality in the river. Prevention of increased water turbidity, sedimentation, bank erosion and other types of impacts were of utmost importance. This required that Texaco construct the earth embankments using selected, relatively coarse-grained, native alluvial sediments, and that the material be placed very carefully. In addition, Texaco developed and implemented an extensive pollution prevention program; the program included deployment of various erosion control devices and booms. The program also included provisions for deployment of contingency measures and equipment, as well as full-time visual inspection of the river during construction activities, and collection and analysis of surface water samples under an aggressive routine schedule.

Installation of the sheet piling commenced at the western terminus of the barrier in mid July 1999. Construction of earth-fill work platforms commenced along the south bank of the river at approximately that same time, and had advanced downstream, approximately to the Texaco Bridge, by the time sheet piling crews had reached the south bank of the river in mid August. Sheet pile driving and earth work progressed downstream in this staged fashion until reaching the eastern terminus of the project in mid September. Although sheet-piling installation progressed exactly as planned in most areas, certain aspects of the alignment and subsurface environment presented some challenges during the work. One of the more interesting challenges was the requirement to completely disassemble the south approach to the Texaco bridge, drive the piling along its design alignment (approximately 20 offshore at that point) and then put the bridge back in service, all within 24 hours. The need to do this was dictated by the fact that the bridge is the primary structural support for a water transmission line that could not be out of service for more than the 24 allotted hours. Texaco accomplished this by fabricating a short joint of transmission piping to cross over the barrier alignment, such that it could be quickly removed and replaced in order to minimize the amount of time the water line was out of service. In addition, a temporary bridge approach that could be lifted in and out using a heavy crane was fabricated and used successfully to minimize the amount of time the bridge was out of service for barrier construction activities.

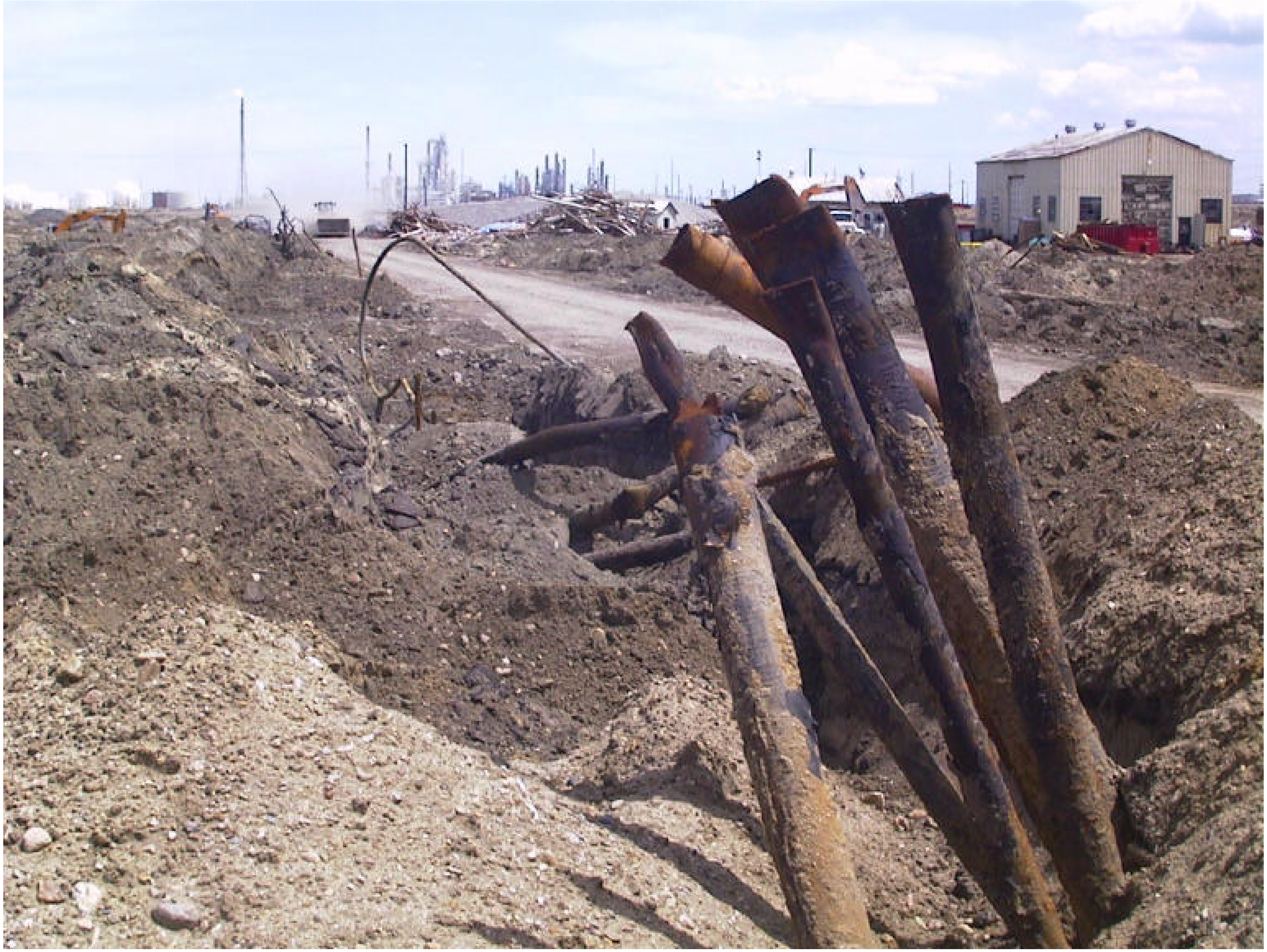
Another interesting challenge involved identification and removal of large subsurface boulders along certain portions of the alignment downstream of the bridge. Although the occurrence of such obstructions was anticipated, their exact position and size could not be fully mapped without partially driving the panels. It was therefore necessary to fabricate and use special support structures and temporary welds in order to keep the partially driven panels properly aligned and plumb, while allowing the boulders to be safely excavated and removed from underneath.

Texaco completed the sheet piling installation with construction of the structural shoring system required along the eastern portion of the barrier alignment. Depths to bedrock are shallow in that portion of the project area and the added structural support is necessary in order to withstand differential loading of earthen materials on either side of the alignment. The shoring system includes a steel waler, rock anchors placed on 20-foot centers along the inboard side of the piling, and corresponding structural tie rods to fasten the piling to the anchors. Installation of the shoring system was completed in mid October.

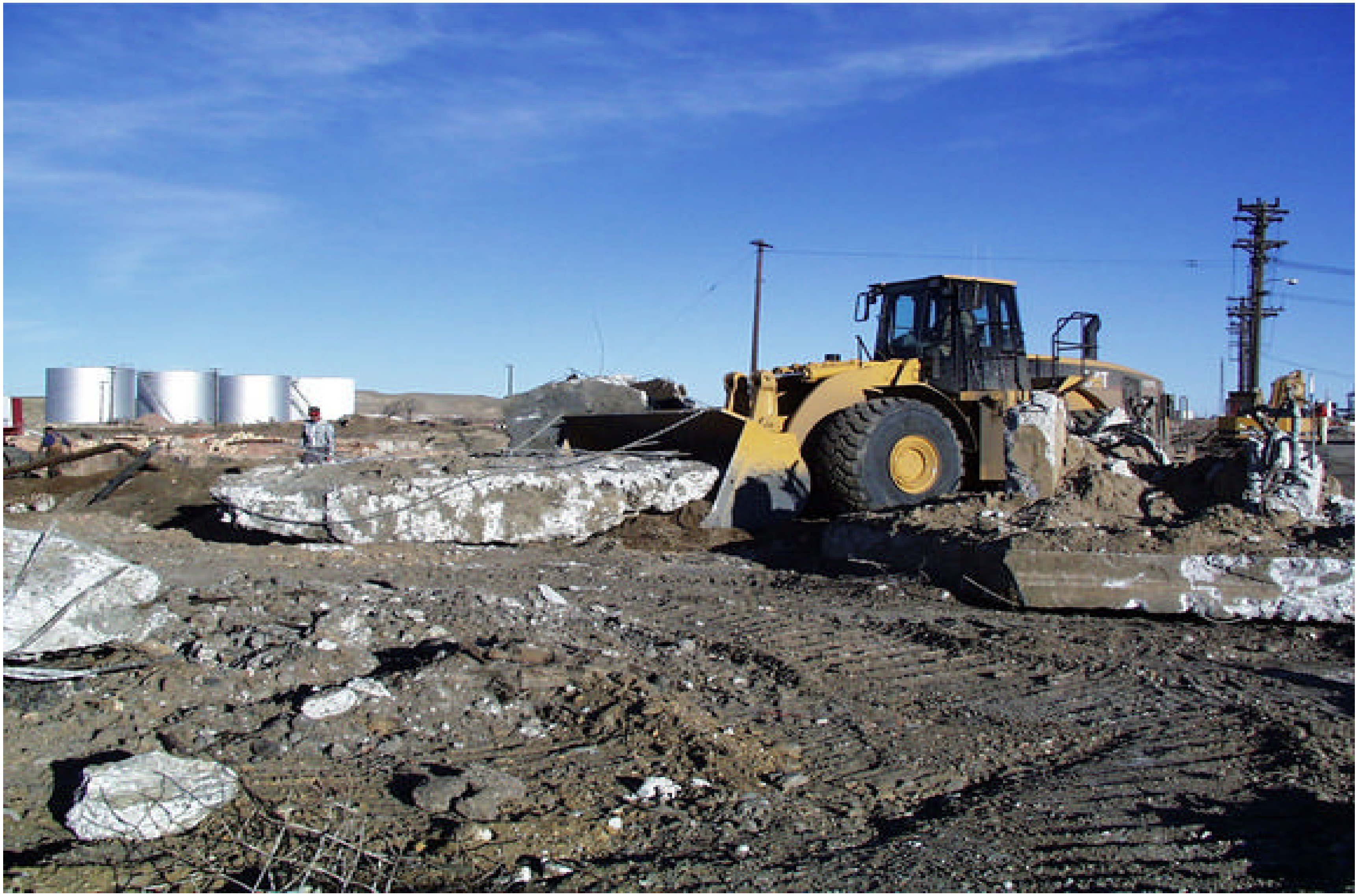
Jetting, quality assurance inspections and sealing operations for the sheet piling joints were staged such they remained at least 400 feet behind all driving operations and other work that could result in minor movement or vibration of the installed sheet piling panels. This staging was necessary in order to ensure that the integrity of sealed joints would not be compromised by other construction activities. In addition to the joint-depth measurements collected during jetting and flushing, Texaco video logged every 50th panel joint in order to provide an added measure of quality assurance to the joint inspection and sealing process. The inspection and sealing operations were completed by late October with a 100 percent success rate in sealing every joint to total depth. Based on bedrock profile data and driving logs for the sheet piling panels, the barrier is keyed from one to four feet into the shale bedrock underlying the alluvial aquifer.

Texaco completed the project with installation of finish courses of rip-rap on the outboard side of the barrier and construction of barrier performance monitoring systems. Replacement of topsoil, reseeding, painting and other reclamation work was completed by the end of December 1999.

Operations and monitoring data gathered during 2000 indicate that the barrier is meeting all of the original monitoring and performance criteria that were established during its design. One of the more important design and performance considerations was the need to establish and maintain a positive-head differential against the outboard side of the barrier at all times. In essence, this means that groundwater elevations along the inboard side of the barrier need to be controlled such that they are at least six inches lower than surface water elevations along the outboard side. Weekly monitoring data gathered from the 12 stations that were installed to track this information reveal a flawless record over the past 13 months, with minimum head differentials typically more that double the original expectation. This is significant given the fact that surface water elevations in the river are heavily influenced by factors outside of Texaco's control, including upstream dam operations and seasonal changes in river flow. In addition, Texaco's close monitoring of surface water quality in the North Platte River has indicated the absence of any measurable adverse influence on surface water quality over the last three years, attesting to the effectiveness of the interceptor trenches and barrier wall systems.



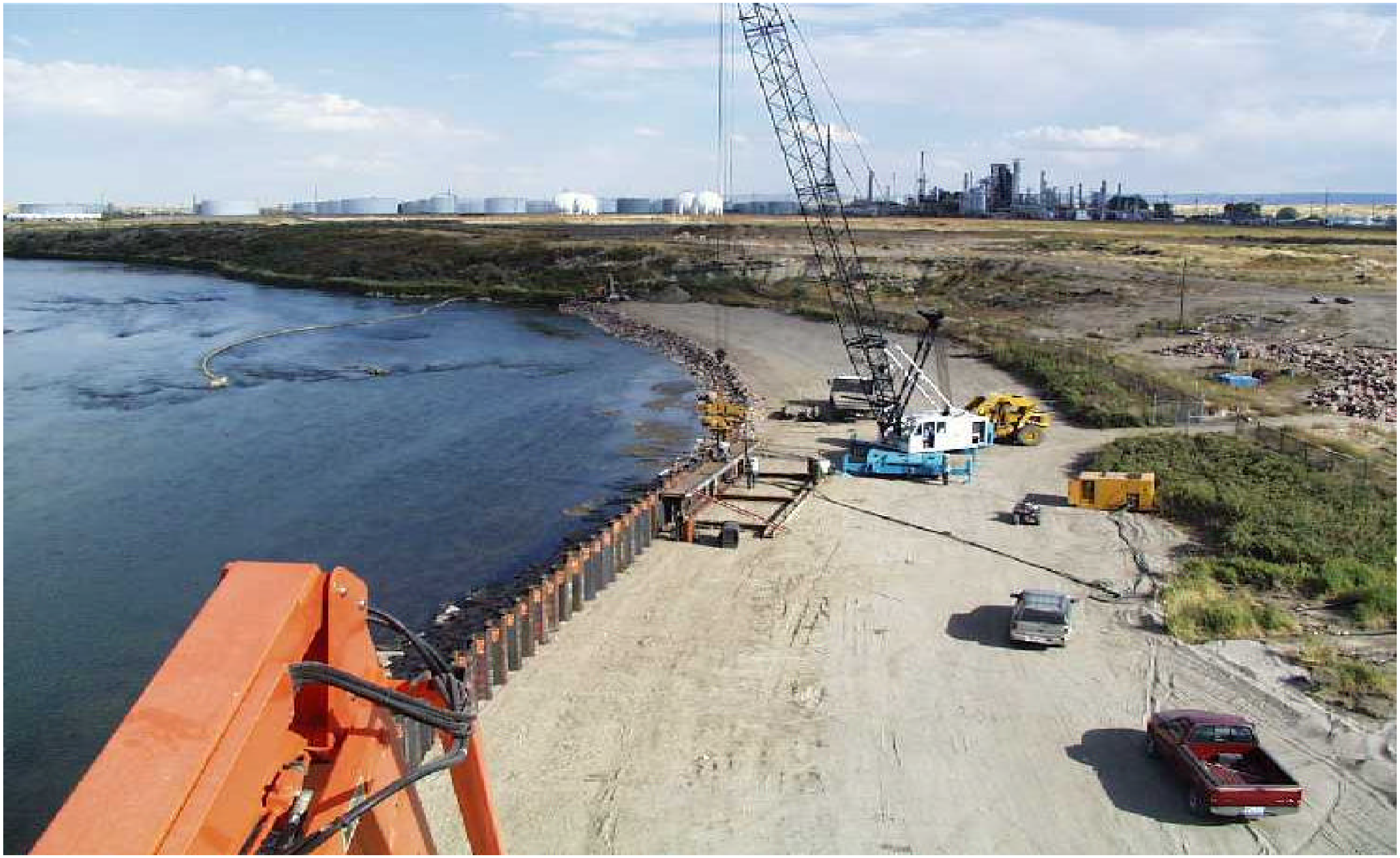
Underground piping removal in progress, Former Texaco Casper Refinery



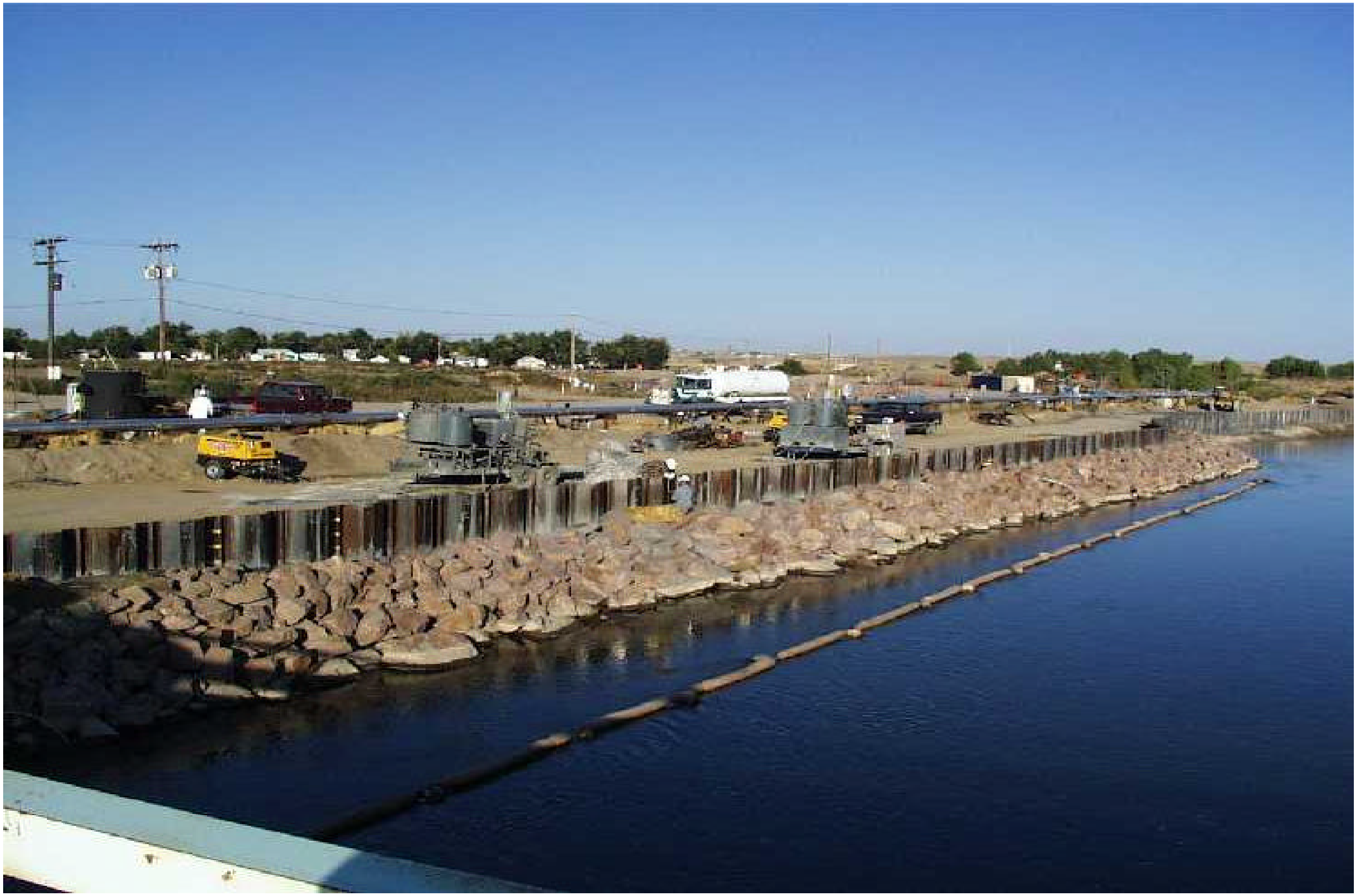
Excavation and removal of subsurface footings and foundations in progress, Former Texaco Casper Refinery

Concrete crushing operation in progress, Former Texaco Casper Refinery

Construction of Sealed-Joint Piling Barrier along south bank of the North Platte River, Former Texaco Casper Refinery



Construction of Sealed-Joint Piling Barrier along south bank of the North Platte River, Former Texaco Casper Refinery



Grouting and sealing operation in progress for sealed joint piling barrier, Former Texaco Casper Refinery