Work Plan

Thorium Remediation Project
Tulsa, Oklahoma

March 2004

Prepared by:

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Thorium Remediation Project
Tulsa Facility
Tulsa, Oklahoma

Work Plan

Remedial Construction Services, L.P.

Houston, Texas

March, 2004

Project No. 2-1719

Prepared for:

Kaiser Aluminum & Chemical Corporation
Baton Rouge, Louisiana

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3-31-04
Date:

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List of Acronyms and Abbreviations

ACM	Asbestos Containing Material
C/L	Center Line
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOT	U.S. Department of Transportation
El.	Elevation
F/L	Flow Line
HASP	Health and Safety Plan
HDPE	High Density Polyethylene
I.D.	Inside Diameter
NRC	U.S. Nuclear Regulatory Commission
Kaiser	Kaiser Aluminum & Chemical Corporation
OSHA	Occupational Health and Safety Administration
Penn	Penn Environmental & Remediation, Inc.
PPE	Personal Protective Equipment
QA/QC	Quality Assurance/Quality Control
RECON/Recon	Remedial Construction Services, L.P.
RHASP	Radiation Health and Safety Plan
RI	Remedial Investigation
ROW	Right of Way
TOB	Top of Bank
TOS	Top of Slope
TSD	Transportation, Storage and Disposal Facility
UP	Union Pacific Railroad

1. *PROJECT OVERVIEW*

The former Kaiser Aluminum Specialty Products facility is located at 7311 East 41st Street in Tulsa, Oklahoma (Figure WP B 1). It is situated in Tulsa County, Oklahoma, about 5 miles southeast of the downtown center of the City of Tulsa. The site initially occupied approximately 23 acres of land on both sides of 41st Street. Currently, a 3-acre parcel south of 41st Street contains an active aluminum extrusion and fabrication facility. North of East 41st Street are several parcels of land previously devoted to refining, processing, and waste disposal functions. This acreage is split by the Union Pacific Railroad (UP) right-of-way. An approximate 3.5-acre parcel south of the railroad (known as the former operational area) houses an active office building and several inactive industrial structures. An approximate 14.0-acre land area (known as the pond parcel) located north of the railroad contains a freshwater pond, a retention pond, a former reserve pond area, and the Flux Building area. The Thorium Remediation Project involves the former operational area and the pond parcel.

The Retention Pond currently occupies 8 acres of the 14-acre land parcel north of the railroad. The water level in the Retention Pond varies, based on seasonal precipitation. The Retention Pond is surrounded by a well-maintained berm and there are no surface water discharges from the pond. The Retention Pond is permitted by the Oklahoma Water Resources Board. Occupying approximately 4 acres on the western portion of this parcel is the area of the former Freshwater Pond. The Freshwater Pond was backfilled in October and November 2002. Northeast of the Retention Pond is the area of the former Reserve Pond (approximately 1.5 acres). The Reserve Pond was backfilled in the late 1960s and is currently covered with grass.

Extensive site characterization activities have been conducted since 1994 within the 14.0-acre land area of the facility known as the pond parcel. These characterization activities have indicated the presence of residual radioactive material within a 10-acre portion of the pond parcel. The radioactive material identified within this portion of land is thorium-bearing dross containing the isotopes Th-232, thorium-230 (Th-230), and thorium-228 (Th-228). The affected portion of the parcel contains the Retention Pond and former Reserve Pond area. The unaffected portion of the pond parcel contains a former Freshwater Pond area.

The pond parcel area considered for remediation is bounded by the south fence line, the former Fresh Water Pond embankment on the west, Fulton Creek ditch on the north, the east fence line, and the northern and eastern edges of the Flux Building and paved area. A central feature of this area is the Retention Pond and associated embankments. Thorium-bearing dross was present on land adjacent to current Kaiser Property along the east and south fence lines and represented the margins of the material. Kaiser has remediated the adjacent land by excavation and storing affected soil within the pond parcel. Affected soil generated during remediation of the adjacent land is considered as part of the on-site decommissioning.

I.A WORK PLAN COMPONENTS

The following Sections identify specific activities that will occur during the project. The Work Plan contains the following components:

- Pre-Work Submittals and Permits;
- Mobilization;
- Site Preparation;
- Site Management Plan;
- Water Management Plan;
- Excavation Plan;
- Radiation Sorting and Material Handling;
- Transportation and Disposal Plan;
- Backfill Operations (Below Criteria and Clean Offsite Materials);
- Demolition Plan;
- Site Restoration; and
- Demobilization.

Details on each component are provided below.

I.A.1 PRE-WORK SUBMITTALS AND PERMITS

Prior to mobilization and before any intrusive activities begin at the site, RECON, with the assistance of the oversight engineer and the owner, will prepare the following submittals;

- Railroad Access Agreement - The agreement will need to be executed prior to performing any work on Union Pacific (UP) ROW. RECON will work with Kaiser and PENN Environmental to expedite the processing of the agreement.
- Storm Water Pollution Prevention Plan (SWP3) and Earth Change Permit - RECON will be submitting the permit application with the assistance of A&M Engineering. The permit will be in place prior to earthmoving activities.
- EHASP and RHASP - A site specific Environmental Health and Safety Plan, and a Radiation Health and Safety Plan have been submitted and approved under separate cover to the owner.

- Water Management Plan – The water management plan will identify how water from the site will be managed. Tasks that will require specific handling procedures will be identified in this plan and referenced in the Work Plan Procedures Manual (submitted under separate cover) and applicable permits.
- Others – As identified by the contract, required by the City of Tulsa, and established in the project submittal register.

I.A.2 *MOBILIZATION*

Following acceptance of the pre-work submittals or as approved by the owner, RECON will identify where the office trailers and temporary facilities will be installed. The Kaiser Site Administrator or his designee will approve these locations.

RECON will procure the services of a local RLS (Surveyor) who will establish property boundaries, monuments, identify limits of excavation as well as establishing/verifying a topographic survey of the site. A grid system will be laid out to identify specific areas of excavation for tracking purposes. See Figure WP B 2.

I.A.3 *SITE PREPARATION*

Immediately upon notification of Kaiser's approval of the Work Plan and the pre-work submittals/permits, RECON will initiate the field mobilization of personnel, equipment, and materials necessary to comply with the Work Plan. Initial mobilization and site preparation activities will include:

- Pre-mobilization activities
- Mobilization of field personnel to set up temporary facilities
- Installation of erosion control features
- Installation of the dewatering trench
- Installation/upgrade of vehicular and personnel decontamination station
- Construction of a temporary holding tank(s)
- Installation of the rail switch and rail spur for material loading
- Construction of the material sorting system

I.A.3.1 PRE-MOBILIZATION ACTIVITIES

Radiation training will be performed initially in Houston with the core group of employees that will be on the project. The radiation-training program will be submitted under separate cover to Kaiser for review and comment.

Additional pre-mobilization activities involve the setup of administration offices and some of the temporary facilities as determined feasible by Kaiser and Penn Environmental.

I.A.3.2 Mobilization of personnel/temp facilities

RECON will locate an office trailer east of the Maintenance Building for the administrative personnel as shown on Figure No. WP B 3. It is RECON's intent to utilize the Flux Building for holding tailgate safety meetings, a location for signing personnel in and out of the project, and part of the building will be used as Access Control. The Flux Building will be gross decontaminated (swept and pressure washed by Recon) prior to utilizing for the purposes listed above. RECON will demolish the Flux Building upon receipt of clearance from owner and/or and remove the debris at the end of the project as discussed in section I.A.10. Another office trailer for the Recon Radiation Safety Officer (RSO) and Health and Safety Officer will be located near the Flux Building as shown on Figure No. WP B 3. Additional storage boxes, equipment, Port-O-Cans, and materials will be mobilized as needed for Construction.

A local licensed electrician will connect the trailers to the electrical system currently active at the site. In addition, a high-speed internet connection will be installed at the site.

As discussed in previous sections, the surveyor will be mobilized to lay out the site as per the plans and specifications.

Local, area, and state pre-excavation calls will be made to ensure that all underground and aboveground obstructions are located prior to any excavation tasks.

I.A.3.3 EROSION CONTROL FEATURES

Erosion controls will be installed around the Site in areas of soil disturbance in order to control erosion and to reduce the potential for impacted material migrating offsite. These controls include berms, silt fencing, and soil barriers. Figure WP B 4 shows some of the proposed locations of erosion controls for construction. These controls will be monitored on a regular basis to ensure they are maintained and functioning properly.

A majority of the storm water at the Site currently drains towards the Fulton Creek either by sheet flow or by existing drainage-ways. The storm water will be allowed to follow the existing drainage ditches until it affects work in a particular area. Diversion systems will be installed so that storm water from non-affected areas does not come in contact with radiologically affected material.

I.A.3.4 INSTALLATION OF DEWATERING TRENCH

The selected "One pass" contractor will be mobilized to the Site once site controls are established. The contractor will be required to attend a site-specific orientation and a radiation awareness briefing as per the RHASP (provided under separate cover). The lines of installation will be laid out by RECON as per Figure No. WP B 5. The materials that are excavated during the trenching operation will be used as backfill during the trenching activities. Any excess materials will be placed in an area within the retention pond. A detailed work plan and procedure is under separate cover.

I.A.3.5 Decontamination Stations

Decontamination pad will be located in the affected area and runoff directed to the retention pond. Prior to leaving site, equipment that is used in the restricted area will be decontaminated at the decontamination station. The equipment shall then conform with the unrestricted release procedure, REC-WP-3-03 and the NRC Regulatory Guide 1.86, Table 1. The average and the maximum release criteria are 230 alpha dpm per 100 cm^2 maximum 700 alpha dpm per 100 cm^2. Orange barricade fencing or existing fencing will be used to demark the Restricted Area from the Radiological Buffer Area to the Access Control Area as per the RHASP (provided under separate cover).

Most of the Site will be located within the Restricted Area. A decontamination area within the Radiological Buffer Area will be used for equipment and personnel leaving the site or entering the Access Control Area (See Figure WP B 6).

The procedure for personnel leaving the Restricted Area is:

Restricted:

Proceed to boot wash station and wash rubber boots.

Radiological Buffer Zone:

Remove rubber boots and place in designated location.
Remove coveralls (Tyvek) and place in marked container.
Remove respirator (if applicable)
Remove gloves and place in marked container.

Access Control Area:

Wash both face and hands.
Perform personal contamination survey (frisking).
Surrender dosimeter.
Sign out on the Access Control Log.

The procedure for equipment leaving the restricted area is:

Notify HPA/RSO that an equipment survey is required.
Move equipment to decontamination area.
Conduct visual inspection and remove suspect material.
HPA/RSO (or designee) will conduct survey for fixed and removable contamination utilizing proper instrumentation.
HPA/RSO (or designee) will complete the required Entrance/Unrestricted Release Form.

I.A.3.6 INSTALLATION OF TEMPORARY HOLDING TANK

Prior to the installation of the temporary holding tanks a secondary containment area will be constructed with a minimum capacity of 110% of the storage tank. The secondary containment will be constructed of clean off-site material and have a 60 mil. HDPE liner to create a water tight, zero discharge area. The temporary holding tank will then be assembled according to the manufacturer's specifications. The temporary holding tank(s) will be located at the Fresh Water Pond Area as shown in Figure WP B 8.

I.A.3.7 *INSTALLATION OF RAILROAD SWITCH AND SPUR*

The Rail Spur must be brought in from the west, just south of the Fresh Water Pond. The Rail Switch will be installed by UP. This will require a detailed work plan and engineering to be submitted to UP (Real Estate) by the installation contractor and specific insurance requirements be submitted. The railroad subcontractor will then install the spur at the location specified by the engineered drawings that have been approved by the UP. Approximately 620 feet of rail just north and parallel of the existing tracks will be built to implement the loading of above-criteria material i.e. Th-232, > 31.1 pCi/g net above background to < 55 pCi/g gross above background. A drawing that depicts the planned location of the spur is located on Figure WP B 7.

An asphalt-loading ramp will be installed adjacent to the newly installed spur, just south of the existing adjacent land area stockpile.

A railroad access agreement will be obtained by Recon prior to any construction in the UP ROW.

I.A.3.8 *CONSTRUCTION OF THE SEGREGATION SYSTEMS*

Recon has contracted with Shonka Research and Associates Inc. (SRA) to build, operate, and summarize data from the radiation monitors that will be described in detail in the SRA Work Plan (under separate cover).

I.A.4 *SITE MANAGEMENT PLAN*

I.A.4.1 *SITE SECURITY*

The perimeter fence will be maintained to ensure site security. Before excavation begins around the old spillway area that is outside the perimeter fence a temporary fence will be constructed around the outer limits of the excavation area prior to the existing fence being breached. The Field Superintendent or his designee will check that all gates are locked before leaving the site at the end of each workday.

I.A.4.2 *SITE ACCESS*

Site personnel will be allowed access to all areas of the site after they have completed the site orientation per the site specific Radiation and Environmental Health and Safety Plans and completed all the safety training as specified in the EHASP and RHASP (provided under separate cover).

Visitors - Persons visiting or conducting work at the Kaiser facility are required to be familiar with Recon's health and safety requirements for this site. Visitors will be required to review the Visitor Synopsis located in the RHASP provided under separate cover. Visitors will be accompanied by facility personnel while on the site.

I.A.4.3 HAUL ROADS

One way haul roads will be utilized wherever feasible. Haul roads will be of sufficient width with good visibility. Haul roads will be maintained throughout the project and a water truck will be utilized to control dust. When Recon moves to the old "Operations Area" on the south side of the site, a flag person may be posted at the railroad crossing to ensure safe passage.

I.A.4.4 DUST CONTROL

Dust will be controlled by spraying with water truck(s) to control dust from the excavation and loading areas, stockpiles, haul roads and backfill operations during the project. Stockpiles may also be covered utilizing plastic sheeting to control dust. Administrative controls such as equipment operation (speed) will be put in place to minimize the generation of dust. Monitoring of dust is described in detail in the EHASP which has been provided under separate cover.

I.A.5 WATER MANAGEMENT

I.A.5.1 DEWATERING TRENCH

Recon will employ the services of a trenching contractor to install a dewatering trench and attached sumps around the areas to be excavated as identified in Figure WP B 5. The trench will consist of the following:

- Excavation up to 18 feet below existing grade.
- Installation of a perforated pipe within an erosion protecting sock placed along the bottom of the excavation.
- The bottom 3 feet of the trench will be backfilled with clean, washed gravel.
- The remaining portions of the trench will be backfilled with excavation spoils and compacted.
- Six sumps will be installed to collect water.

A detailed work plan and procedure is located in Mersino Trenching LLC.'s Work Plan (under separate cover).

I.A.5.2 *TEMPORARY STORAGE TANK SYSTEM*

Two weir tanks (clarifiers) with the capacity of 20,000 gallons each and two 125,000 gallon temporary storage tanks will be used for temporary storage of groundwater/storm water encountered during the remediation project and will be located as identified in Figure WP B 8. These tanks will be located in the former Fresh Water Pond area. Prior to the installation of the temporary storage tanks a secondary containment berm will be constructed with a minimum capacity of 110% of the storage tanks. The secondary containment berm will have a 60 mil. HDPE liner to create a water tight, zero discharge area. The temporary storage tanks will then be assembled according to the manufacturer's specifications. The two weir tanks will be plumbed into the temporary holding tanks and the piping from the sumps in the de-watering trench will be connected to the weir tanks as shown in Figure WP B 8.

A pump and transfer line (4 inch HDPE) will be installed from the holding tanks to the sanitary sewer system inlet located by the Flux Building for discharge of the effluent (upon approval from the City of Tulsa) as shown in Figure WP-B-8.

I.A.5.3 *GROUNDWATER/STORM WATER REMOVAL*

After the dewatering trench and the temporary storage tanks are installed, Recon will begin dewatering. Recon expects to pump from the dewatering trench for a period of 4 to 6 weeks while pre-excavation activities are ongoing. Systems will be in place to divert as much of the storm water as possible around the excavation area. When the excavation begins, groundwater/storm water is expected to be encountered; a sump and pump will be used to transfer these waters to the weir tanks. Pumping will not affect any surface features.

I.A.5.4 *TEMPORARY STORAGE TANK SAMPLING*

Once the first 125,000 gallon tank is filled to a predetermined limit representative samples will be collected (per procedure REC-WP-4-03) for laboratory analysis of the following City of Tulsa discharge criteria.

Table 1
Maximum Allowable Discharge Concentrations

Pollutant	Limitation	Pollutant	Limitation
Arsenic (Total)	1.0 mg/l	Nickel (Total)	3.25 mg/l
Cadmium (Total)	0.60 mg/l	Zinc (Total)	3.00 mg/l
Chromium (Total)	4.0 mg/l	Cyanide (Total)	0.75 mg/l
Copper (Total)	2.0 mg/l	Silver (Total)	1.20 mg/l
Lead (Total)	0.70 mg/l	Oil & Grease	100 mg/l
Mercury (Total)	0.04 mg/l	PH	6.0 to 10.5 S.U.

Any water discharged to the City of Tulsa's sanitary sewer system will comply with the requirements specified in the City of Tulsa Ordinance 19991 and with the requirements and limitations set by 10 CFR Part 20 (Standards for Protection Against Radiation).
Once the results are received from the laboratory they will be forwarded to the City of Tulsa prior to any discharge. Per the City of Tulsa, discharge will be done on a batch basis until a pattern of consistency for sample results can be demonstrated; once that has been achieved a continuous discharge may be approved. Upon notice from the City of Tulsa that continuous discharge will be allowed the sampling frequency will be once a week for the first six weeks and then once a month for the duration of the project.

Table 2
NRC Allowable Thorium and Radium Concentrations to Sewers

Radiological Analyte	10 CFR , 20 Appendix B, Table 3 - Avg. Monthly Concentrations-Sewage Disposal (pCi/l)
Ra-226	600
Ra-228	600
Th-228	2,000
Th-230	1,000
Th-232	300

1.A.5.5 MEASUREMENT OF DISCHARGE VOLUME

Recon will install an inline flow meter along with two 4 inch butterfly valves to control and monitor the discharge volume. The net and gross volume will be recorded every time water is discharged and a record of analytical results and water volumes will be kept on site. If pumping or discharge activities are performed at times other than the normal work schedule, two Recon employees will be onsite to ensure safe operations.

I.A.6 *EXCAVATION PLAN*

I.A.6.1 *EXCAVATION SAFETY OVERVIEW*

Excavation is one of the most hazardous construction operations. Therefore, under no circumstances are employees allowed to enter an excavation unless the requirements for trenching and excavation found in OSHA regulation 29 CFR 1926 are followed. The general procedures for excavations or trenching sites where no people will be entering include, but are not limited to:

- Prior to excavation, determine the location of utility installations-sewer, telephone, fuel, electric, water lines or any other underground installation that could be encountered during digging. The limits of the excavation areas should be probed to the depth of the excavation.
- If employees are exposed to public vehicular traffic, they should be given warning vests before digging begins.
- If materials or equipment could fall or roll into an excavation site, either keep them at a minimum of 2 feet (0.61 meters) from the edge of excavation or provide restraining devices.
- Place spoils far enough from the edge of the excavation so that they do not fall back, also a minimum of 2 feet from the edge.
- Provide warning systems such as barricades, hand or mechanical signals, stop logs, reflecting horses and/or post appropriate signage. If such warning is not possible, post a guard constantly to attend to the opening.
- Prohibit employees from working on faces of sloped or benched excavations.
- Ensure that personnel working near heavy equipment maintain a safe distance.
- Should water accumulate in an excavated area, diversion ditches, dikes, or other drainage mechanisms should be built.
- Curtail pedestrian traffic in areas where heavy equipment is operated for excavation purposes.
- If excavation occurs at night, ensure there is proper lighting.

I.A.6.2 *EXCAVATION SEQUENCING*

Figure WP B 9 depicts the excavation sequencing. Recon will begin excavating in cell D-6 on the south side of the site due to the location of the railroad spur, south of the existing fence, just north of the existing railroad tracks. This is required in order to avoid placing an asphalt loading platform on top of material that requires excavation. The excavation will be backfilled with clean off-site material that meets or exceeds the requirements as specified in Section 02220 Part 2, 2.01.B. The following cells will be excavated in order to provide "clean" loading conditions on the south side of the site;

Cells No.: D-6, D-5, E-5, E-4

To expose the old spillway there is a small area outside of the perimeter fence in cells F-4, F-5 & E-5. The perimeter fence will be opened and a temporary fence will be installed on the outside limits of the excavation to maintain security. This excavation area will also be backfilled with clean off-site material.

Once these cells are excavated and surveyed the following excavation areas can begin;

A-0, A-1, A-2, B-0, B-1, B-2, C-0, C-1, C-2, A-3, B-3, C-3, D-0, D-1, D-2, D-3, F-0, E-0, F-1, E-1, F-2, E-2, F-3, E-3, F-4, D-4, C-4, B-4,

The excavator(s) digging in cells will be equipped with a Dig Face Characterization Tool (DFCT) mounted on the boom so when the bucket is in the curled position it will detect whether it is below criteria or above criteria (setting to be determined). The DFCT is explained in detail in Shonka Research and Associates Inc (SRA) work plan and associated operating procedures (provided under separate cover.)

The operator will begin the excavation at the bottom of the cell; these materials will be lifted in a manner that will maintain a consistent density throughout the excavation depths. Once a reasonable homogenous mixture is observed, then the operator will pre-sort the material with the DFCT and determine where the load should be transported, either to a drying pile, a pile identified for above criteria (Th-232, >31.1 pCi/g net), or a pile for below criteria (Th-232, <31.1 pCi/g net), in addition, the material may be utilized for bridging over the next cell for excavation safety or be used for processing. Excavation will cease when Th-232, 3 pCi/g net limit is reached. A surveying tool, discussed under separate cover.

Concrete removal in the Operational Area as described in section 02070 of the project specifications and as shown on Figure 6 of the Contract Drawings or as directed by the engineer will be saw cut in approximately 30 square foot sections or as appropriate for managing. Concrete slabs will then be carefully turned over so that a radiological survey can be conducted, scabbling and or decontamination will occur based upon survey results. When concrete is free of contamination it will be disposed of at an approved disposal facility.

Once concrete is removed in the identified demolition areas, the soils will be excavated and moved to the sorting process area. Digging will start in G-5, G-6, F-6, F-7, E-6, E-7, D-6, D-7, C-7, B-6, B-5, C-5, and C-6. Once the area is excavated to below Th-232 3 pCi/g net, a sample will be sent to an approved laboratory for final verification before any backfill is placed. Field changes are anticipated for the grid sequencing and will not be considered a modification to the Work Plan.

I.A.6.3 SOIL SAMPLING AND ANALYSIS

Soil samples will be collected as required by the Decommissioning Plan and the Specifications. The samples will be collected in accordance with procedure REC-WP-4-01. A Chain of Custody will be filled out in accordance with procedure REC-WP-6-01 and the samples will be taken to Outreach Laboratory in Broken Arrow for analysis to ensure that the excavated area being tested is below the Th-232, 3 pCi/g net limit. These samples are not part of the Final Status Survey (FSS). The FSS will be conducted by others in accordance with Final Status Survey Plan.

I.A.6.4 EQUIPMENT

Equipment that will be utilized for the excavation portion of the project will include but not be limited to: Excavators, Dozers, Skid Steers, Articulated Dump Trucks, and Front End Loaders.

I.A.7 RADIATION SORTING AND MATERIAL HANDLING

Excavated soils will be tested in accordance with ASTM D 4643-00 (microwave moisture test) to ensure that prior to sorting operations the moisture content is within the optimum moisture range as determined by Standard Proctor Test for compaction. If materials are found to be too wet, then drying operations will be conducted before the material is stockpiled near the soil sorting system. Once enough material is on hand to start the sorting process, an excavator will place material on a vibrating screen to remove all debris and any material over 6 inches in diameter. The material that passes thru the vibrating screen will be carried to the conveyor that has the Conveyor Mounted SMCM on the vibrating screens' conveyor. Before it passes under the Conveyor Mounted SMCM, material will be leveled with a leveling bar placed across the conveyor to ensure that material is spread evenly across conveyor belt and that only 6-8 inches of material will pass under the Conveyor Mounted SMCM as per SRA requirements. Once material is found to be either below Th-232, 31.1 pCi/g net or above Th-232, 31.1 pCi/g net, it will fall into a pants leg chute. A gate inside the chute will be electronically controlled by the Conveyor Mounted SMCM, if material is below Th-232, 31.1 pCi/g it will be directed to a stacker conveyor to be stockpiled with other below Th-232, 31.1 pCi/g net material, if material is found to be above Th-232, 31.1 pCi/g net it will be directed to another stacker conveyor to be stockpiled and placed in the loading or blending area.

I.A.8 TRANSPORTATION AND DISPOSAL PLAN

Once the material has been sorted and is found to be within the range for offsite disposal, the material will be stockpiled in approximately 100 ton units that will be separated by jersey barriers or other means if not directly loaded into rail cars. The rail cars will be loaded with a front end loader that will be equipped with a bucket scale to maintain a consistent tonnage per rail car. A manifest will be generated for each rail car and a radiological screening will be conducted by the Transportation and Disposal Manager before being allowed to leave the site. US Ecology has been contracted for the Transportation and Disposal of the above criteria material that will be sent offsite. A Transportation and Disposal Manager will be onsite from US Ecology for the duration of this portion of the project. A Transportation and Disposal work plan and associated procedures which will include waste packaging and shipping is in progress from US Ecology and will be incorporated into this work plan (under separate cover).

I.A.9 BACKFILL OPERATIONS (BELOW CRITERIA AND CLEAN OFFSITE MATERIALS)

I.A.9.1 BACKFILL OVERVIEW

Once cells that have been excavated and Th-232, 3 pCi/g net have been verified in the field, samples will be taken as per procedure REC-WP-4-01 and a chain of custody will be completed as per REC-WP-6-01 before being sent to a lab for final results. Once analytical verification and Final Status Survey clearance has been obtained backfill operations will begin using below criteria material or clean offsite material. The fill will be placed in 8 inch lifts and compacted to a minimum of 95 percent of the maximum dry density as determined by laboratory analysis in accordance with Standard Proctor Method and as per section 02220 of the specifications. One compaction test is required for every 10,000 ft^2 per lift as per section 02220 of the specifications. After the below criteria material has been placed and Final Status Survey clearance has been obtained as per section 14, 14.12 of the Decommissioning Plan, clean offsite material that has been tested (one test every 15,000 tons for common earth backfill and one test every 1,000 tons for topsoil) to meet the requirements provided in section 02220 of the specifications, will be used to place a 10 ft. cover over the below criteria material previously placed. This cover will include 6 inches of topsoil. All topsoil will be fine graded to the final contours as shown on the contract drawing and per the specifications. Recon will place topsoil in all disturbed areas as per the specifications.

I.A.9.2 GEOTECHNICAL TESTING

A geotechnical testing subcontractor will be contracted to perform all testing required by the specifications i.e., Gradation, Atterburg Limits, Proctor, Compaction, and Moisture.

I.A.9.3 RADIOLOGICAL ANALYSIS

Radiological soil sample analysis on off-site backfill material will be performed by Outreach Laboratory of Broken Arrow. Radiological characterization will be defined through gamma spectrometry method, DOE HASL 300. Chemical characterization will be defined as follows: Resource Conservation and Recovery Act (RCRA) metals, method SW 846 6010B, Mercury will be analyzed utilizing method SW 846 7470A. Target Compound List (TCL) Volatile Organic Compounds, method SW 846 8260. Semi-Volatile Organic Compounds, method SW 846 8270C. Polychlorinated biphenyls (PCB's), method SW 846 8081, and pesticides, method SW 846 8082.

I.A.9.4 EQUIPMENT

Equipment that will be utilized for the backfilling portion of the project will include but not be limited to: Dozers, Compactors, Excavators, Dump Trucks and Water Trucks.

I.A.10 *DEMOLITION*

An experienced Demolition Contractor will perform all demolition activities discussed in section 02070 of the specifications. The Demolition Contractor's detailed Work Plan (under separate cover).

The Flux Building is to be demolished during construction activities. This building is considered to be radiologically affected and must be cleared by the owner and or the engineer before demolition can begin.

Coordination of sequential activities will be critical in efficiently completing the demolition of existing structures located at the Site. Activities to be completed prior to and during demolition activities include:

- De-energize/lock out tag out of building
- Removal or relocation of equipment, materials, and debris in and around buildings to be demolished
- Power washing of dust and remaining debris
- Management of wash water and sediments
- QA/QC check
- Demolition of building by subcontractor
- Sizing and loading of scrap metal by subcontractor
- Radiation scan of metal
- Transportation of concrete and wood debris to an approved disposal facility.
- Offsite shipment of metal debris for recycling by subcontractor

I.A.11 *SITE RESTORATION*

Site Restoration will be completed in phases so that weathering is minimized. All temporary erosion and sediment control features will be kept in place until permanent features can be established and/or constructed. Site restoration will include seeding and mulching, permanent surface water controls and permanent erosion and sedimentation controls as per the specifications and the Decommissioning Plan.

I.A.12 DEMOBILIZATION

The majority of the work will be complete before demobilization begins, as the project winds down personnel and equipment no longer needed to perform the remainder of the work will be de-mobilized. All equipment that has been in a controlled area will be decontaminated and pass the Unrestricted Release Criteria before being permitted to leave the site. See procedure REC-WP-3-03.

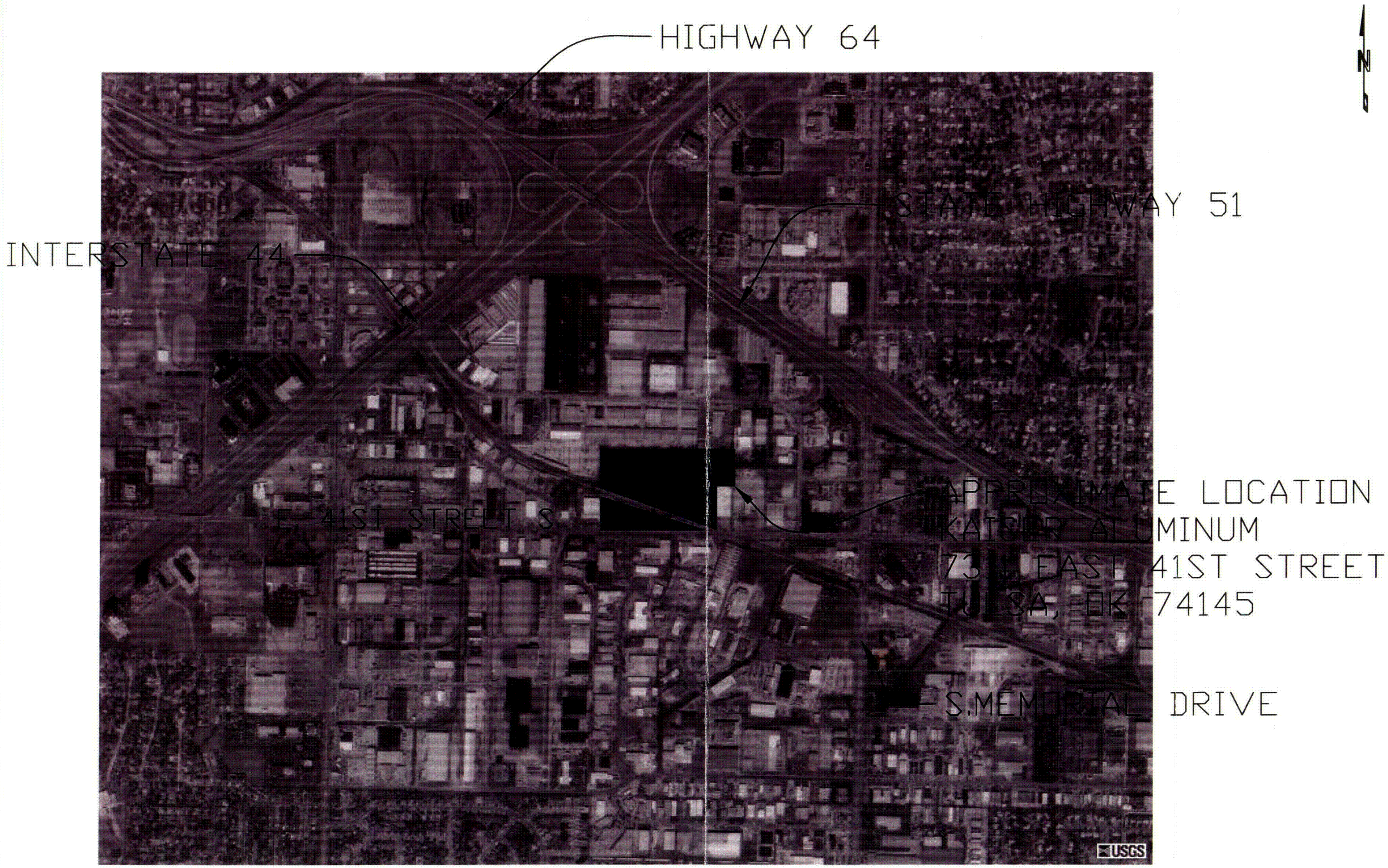
I.A.13 WORK PLAN MODIFICATION

Modifications to the Work Plan may occur during this project. Prior to any changes being made to the Work Plan a written request for a change will be submitted to the Recon Project Manager for his approval. Upon his approval, a written request will be made to the appropriate Kaiser Management Personnel for review and approval prior to the actual change being made.

2

Figures

March, 2004
Job No. 2-1719



1

1

No	By	Revisions Description	Date

TITLE

FIGURE WP B 1
GENERAL LOCATION DRAWING

KAISER ALUMINUM
Tulsa, Oklahoma

9720 Derrington
Houston, TX 77064
Phone: (281)955-2442 Fax: (281)890-5172
www.recon-net.com

FIELD BOOK:
DRAWN: Josh Buchheit
DATE: 3-24-04
CHECKED: RL
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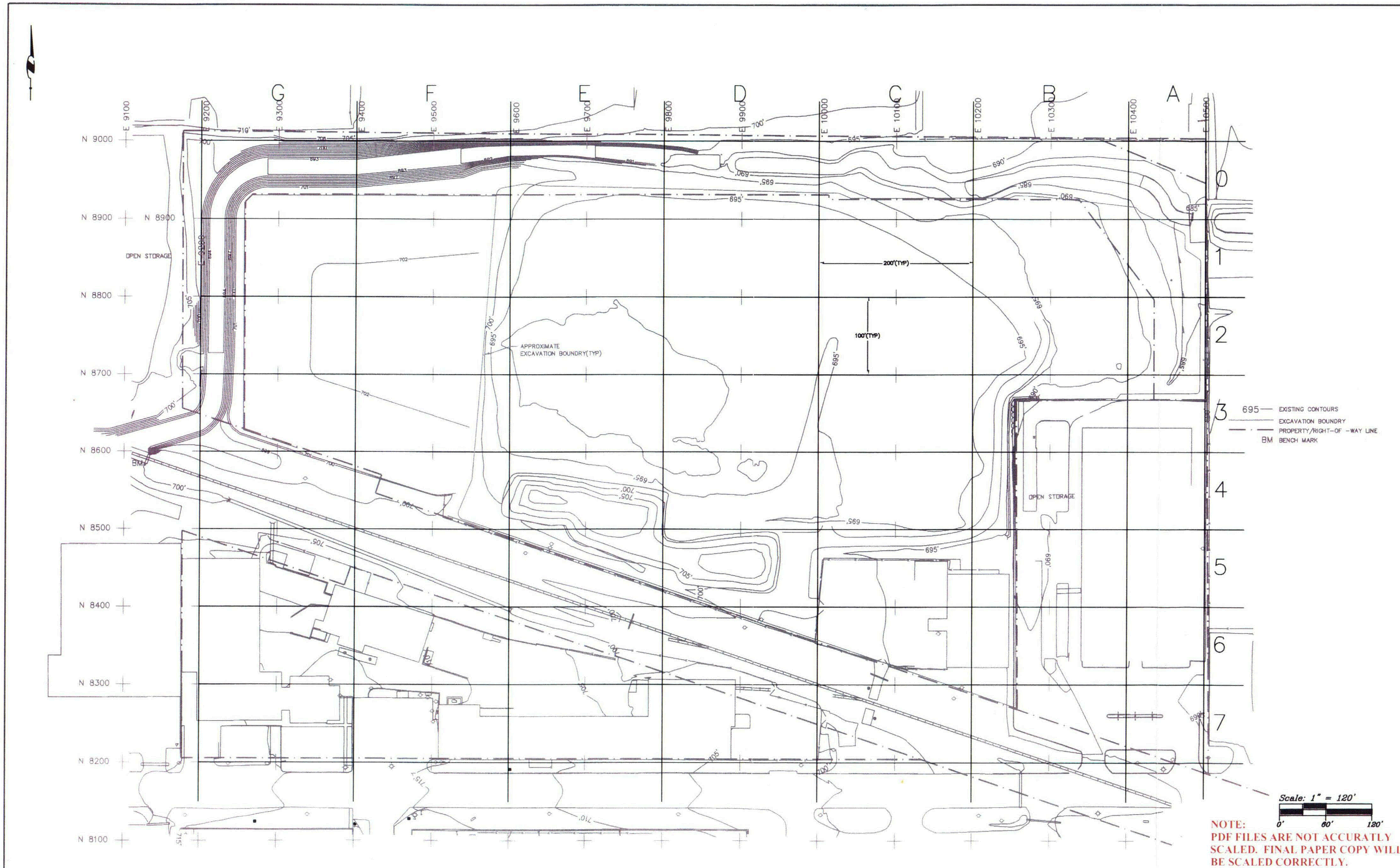
RECON
Remedial Construction Services, L.P.

SIGNED BY:

C01



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Remedial Construction Services, L.P.

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9720 Derrington
Houston, TX 77064
Phone: (281)955-2442 Fax: (281)890-5172
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FIELD BOOK:
DRAWN: Joshua Buckholt
CHECKED:
DATE: 3-24-04
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CAD File Name: \\Kaiser\info\kaiser\figures\grid_layout.dwg

TITLE

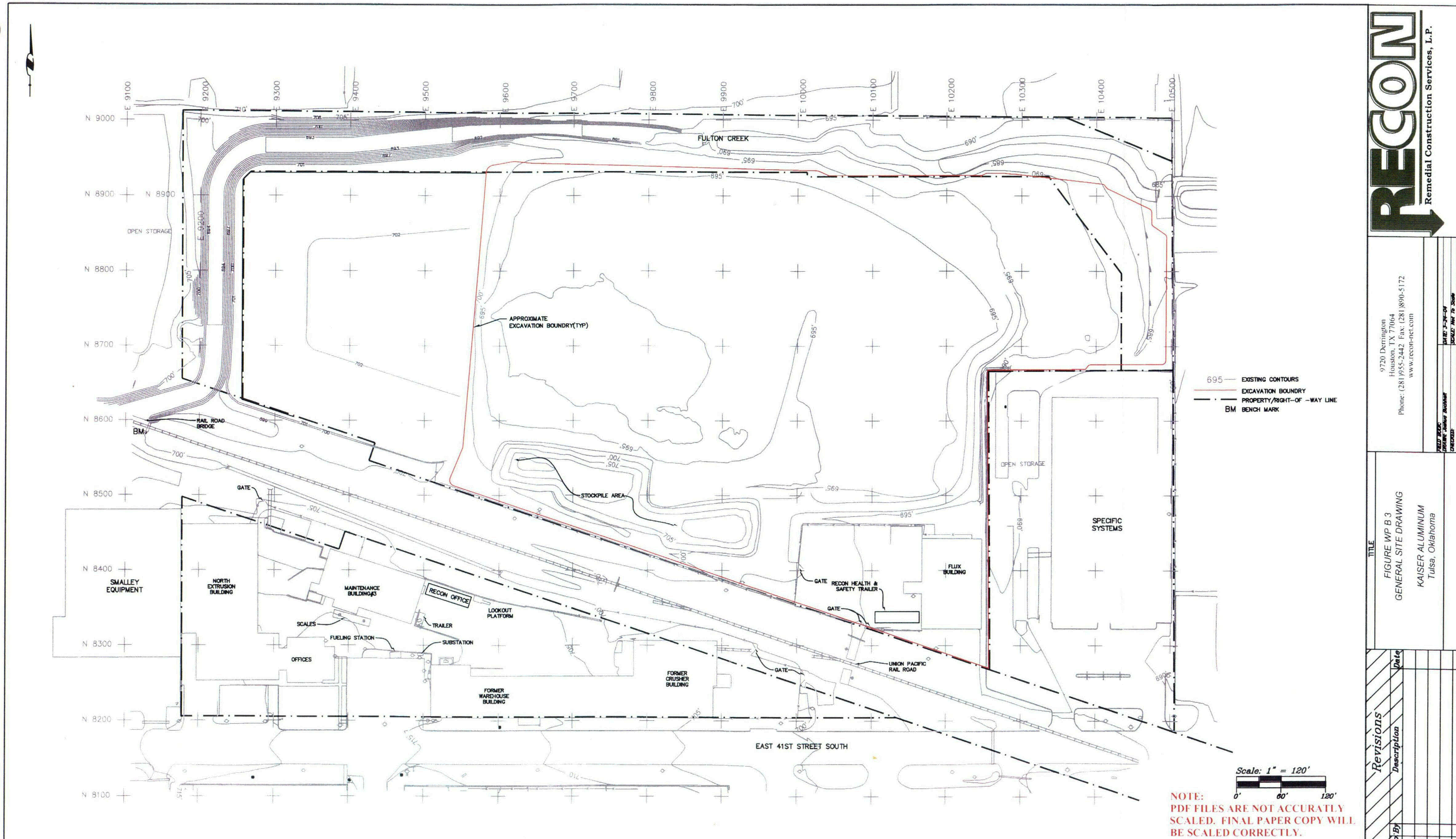
FIGURE WP B 2
GRID LAYOUT DRAWING

KAISER ALUMINUM
Tulsa, Oklahoma

Revisions

No	By	Description	Date

C02


FULTON CREEK
APPROXIMATE EXCAVATION BOUNDRY(TYP)
OPEN STORAGE
RAIL ROAD BRIDGE
BM
STOCKPILE AREA
GATE
SMALLEY EQUIPMENT
NORTH EXTRUSION BUILDING
MAINTENANCE BUILDING#3
RECON OFFICE
LOOKOUT PLATFORM
TRAILER
SCALES
FUELING STATION
SUBSTATION
OFFICES
FORMER WAREHOUSE BUILDING
FORMER CRUSHER BUILDING
RECON HEALTH & SAFETY TRAILER
FLUX BUILDING
SPECIFIC SYSTEMS
UNION PACIFIC RAIL ROAD
EAST 41ST STREET SOUTH
695 EXISTING CONTOURS
EXCAVATION BOUNDRY
PROPERTY/RIGHT-OF -WAY LINE
BM BENCH MARK
Scale: 1" = 120'
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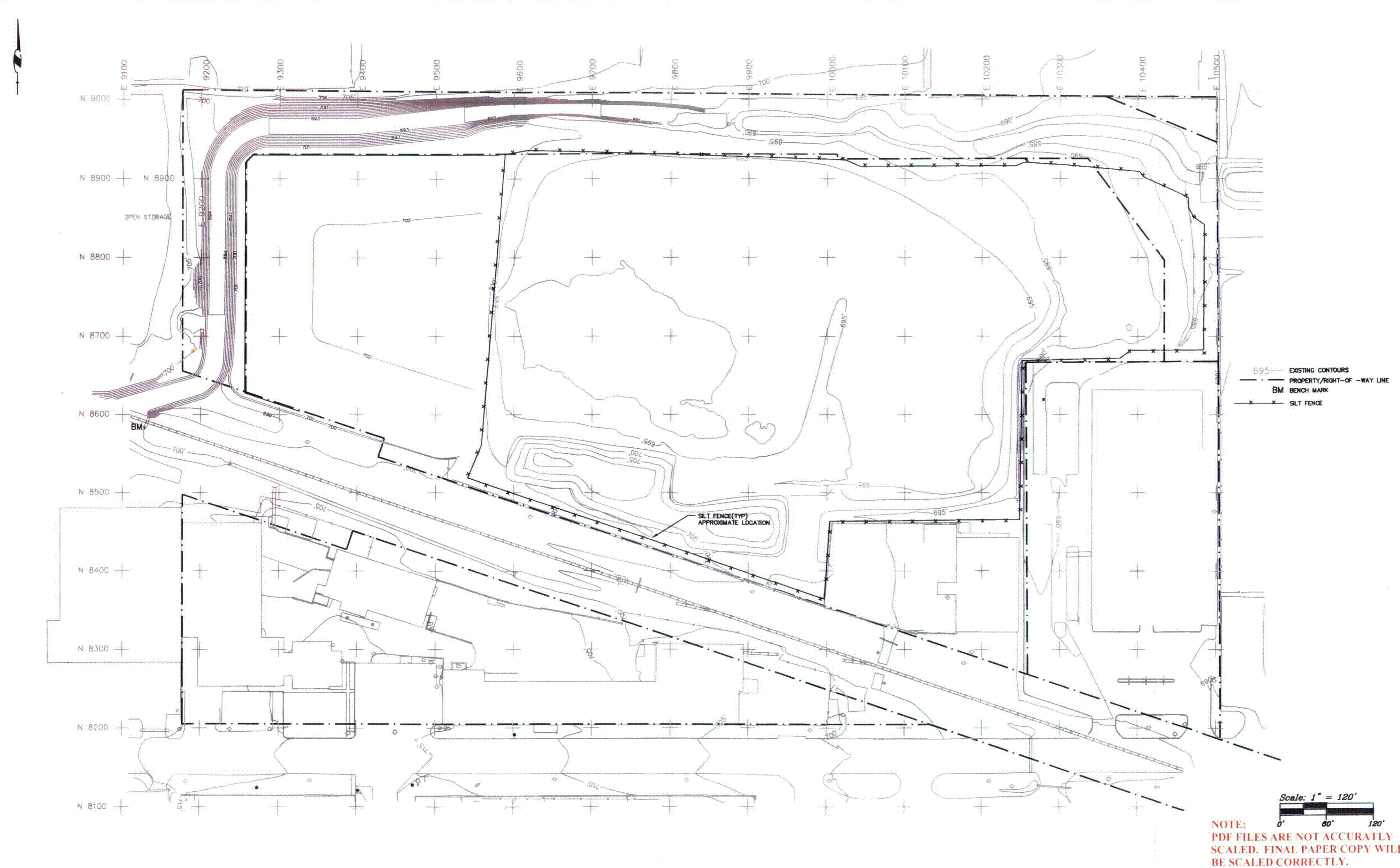
GENERAL SITE DRAWING
KAISER ALUMINUM
Tulsa, Oklahoma
Revisions
No. By
Description
Date

C03



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TITLE
FIGURE WP B 4
EROSION CONTROL DRAWING
KAISER ALUMINUM
Tulsa, Oklahoma

Revisions

No	By	Description	Date

C04

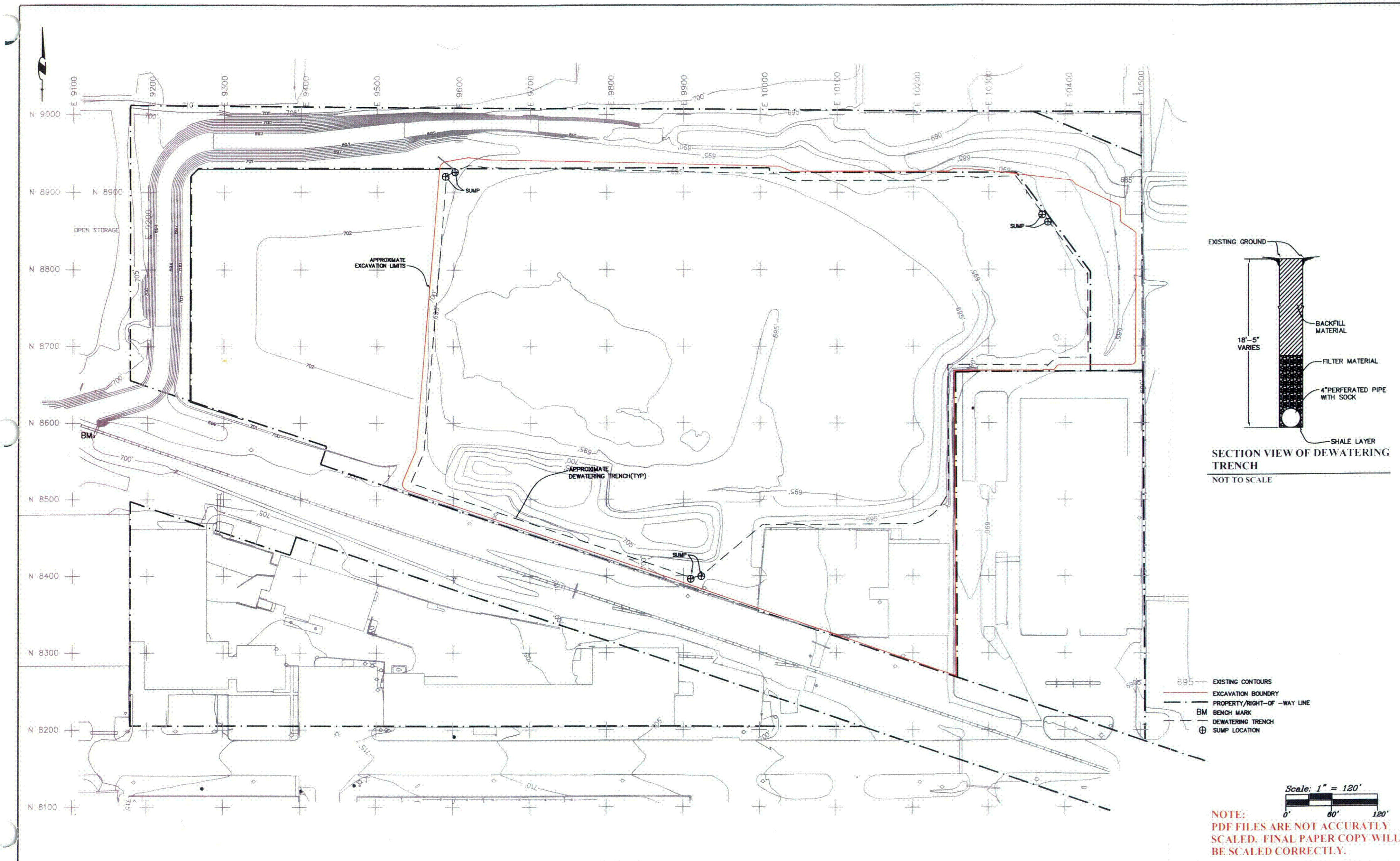

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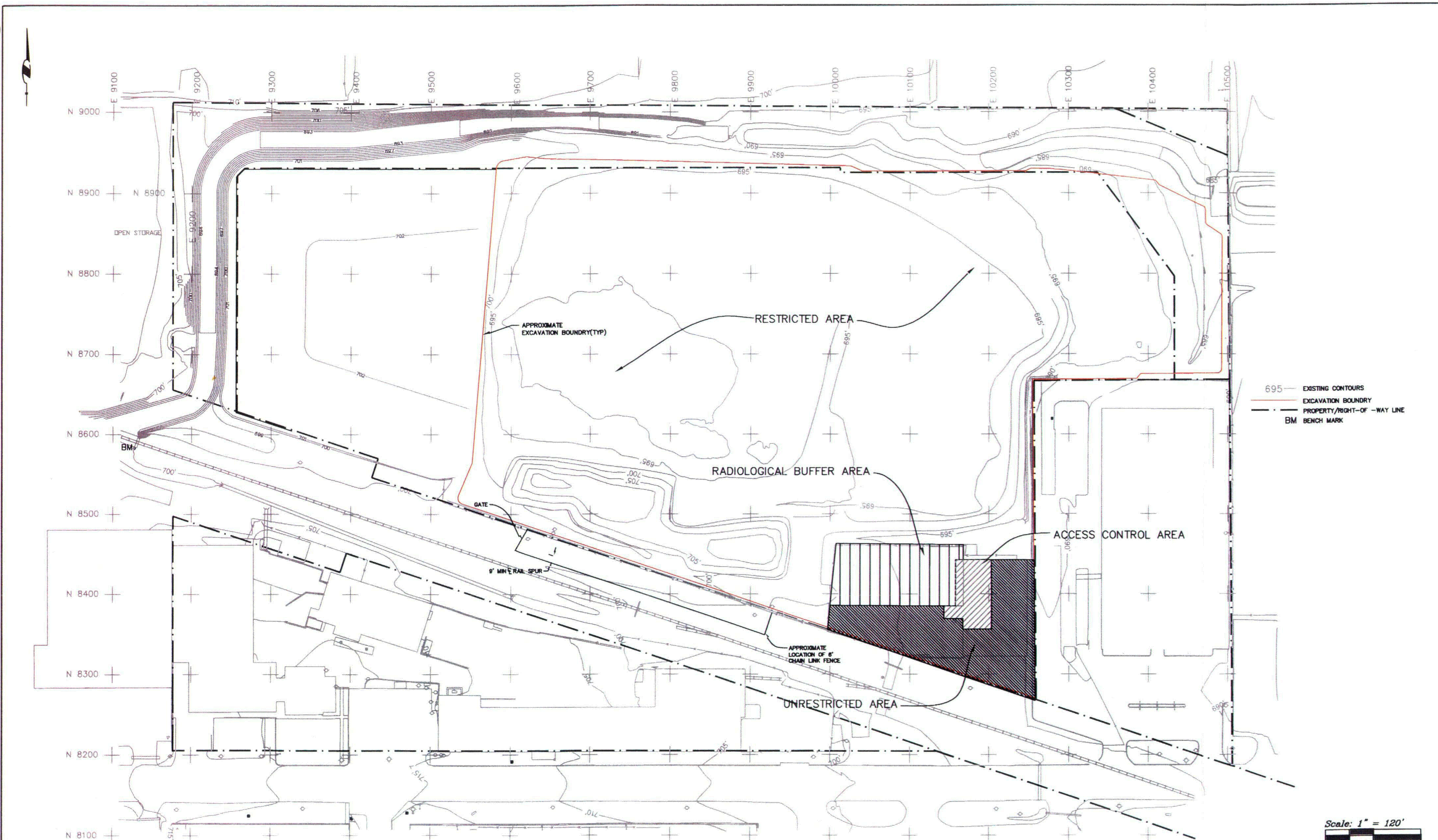
FIGURE WP B 5
DEWATERING TRENCH
LOCATION DRAWING

KAISER ALUMINUM
Tulsa, Oklahoma

Revisions

No.	By	Description	Date

C05



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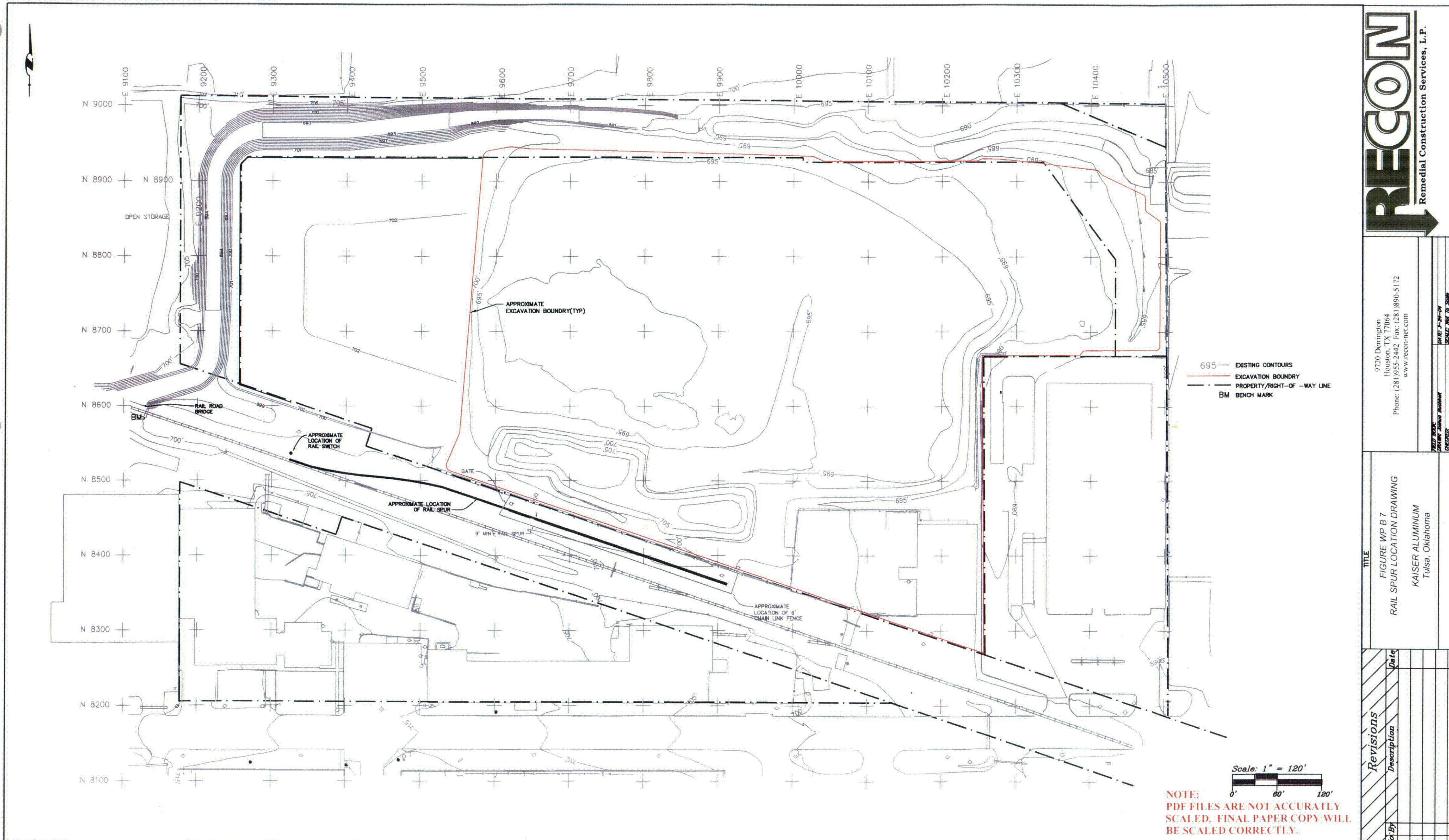
TITLE
FIGURE WP B 6
ACCESS CONTROL DRAWING

KAISER ALUMINUM
Tulsa, Oklahoma

Revisions			
No.	By	Description	Date

C06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N 8100
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E 9400
E 9500
E 9600
E 9700
E 9800
E 9900
E 10000
E 10100
E 10200
E 10300
E 10400
E 10500
OPEN STORAGE
APPROXIMATE EXCAVATION BOUNDRY(TYP)
RAIL ROAD BRIDGE
BM
APPROXIMATE LOCATION OF RAIL SWITCH
GATE
APPROXIMATE LOCATION OF RAIL SPUR
9' MIN. RAIL SPUR
APPROXIMATE LOCATION OF 6' CHAIN LINK FENCE
695 EXISTING CONTOURS
EXCAVATION BOUNDRY
PROPERTY/RIGHT-OF-WAY LINE
BM BENCH MARK
Scale: 1" = 120'
0' 60' 120'
NOTE:
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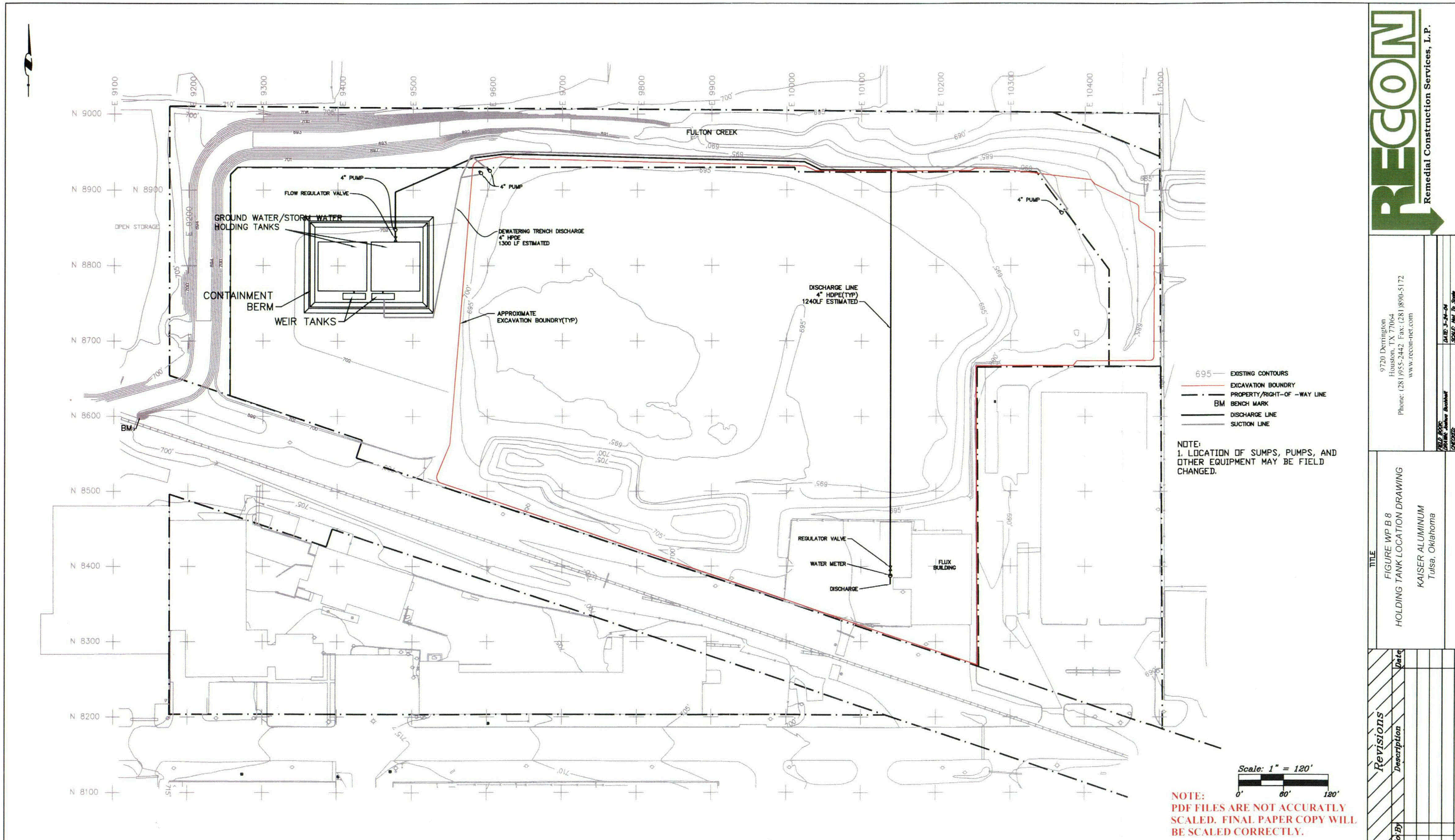
TITLE
FIGURE WP B 7
RAIL SPUR LOCATION DRAWING
KAISER ALUMINUM
Tulsa, Oklahoma
Revisions
No. By Description Date

C07


FULTON CREEK
GROUND WATER/STORM WATER HOLDING TANKS
CONTAINMENT BERM
WEIR TANKS
4" PUMP
FLOW REGULATOR VALVE
DEWATERING TRENCH DISCHARGE 4" HPDE 1300 LF ESTIMATED
APPROXIMATE EXCAVATION BOUNDRY(TYP)
DISCHARGE LINE 4" HDPE(TYP) 1240LF ESTIMATED
REGULATOR VALVE
WATER METER
DISCHARGE
FLUX BUILDING
OPEN STORAGE
BM
695 EXISTING CONTOURS
EXCAVATION BOUNDRY
PROPERTY/RIGHT-OF -WAY LINE
BM BENCH MARK
DISCHARGE LINE
SUCTION LINE
NOTE:
1. LOCATION OF SUMPS, PUMPS, AND OTHER EQUIPMENT MAY BE FIELD CHANGED.
Scale: 1" = 120'
0' 60' 120'
NOTE:
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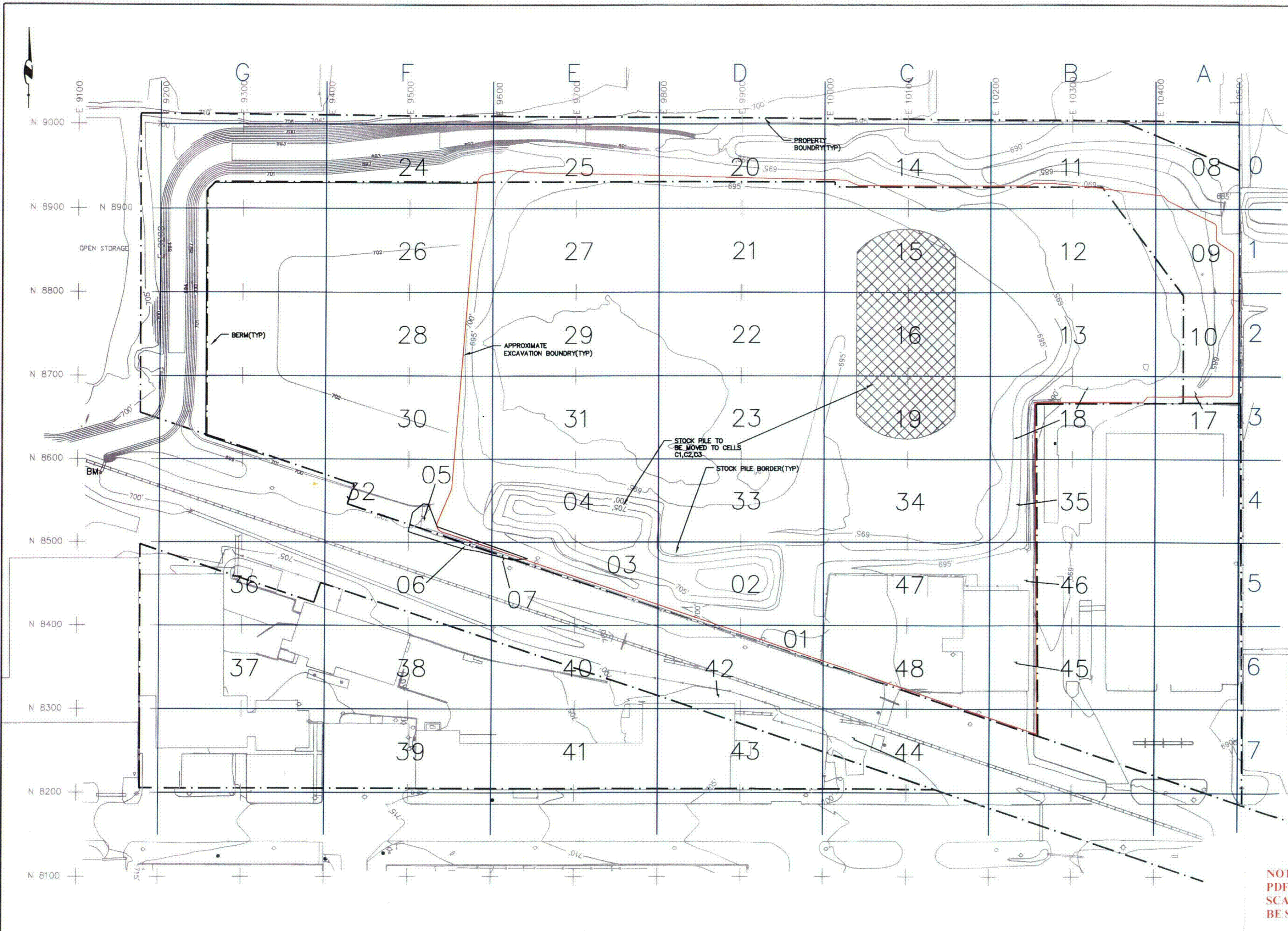
TITLE
FIGURE WP B 8
HOLDING TANK LOCATION DRAWING
KAISER ALUMINUM
Tulsa, Oklahoma
Revisions
No. By
Description
Date

C08



SEQUENCE OF EXCAVATION

#	GRID #	#	GRID #
01	D-6	25	E-0
02	D-5	26	F-1
03	E-5	27	E-1
04	E-3	28	F-2
05	F-4	29	E-2
06	F-5	30	F-3
07	E-5	31	E-3
08	A-0	32	F-4
09	A-1	33	D-4
10	A-2	34	C-4
11	B-0	35	B-4
12	B-1	36	G-5
13	B-2	37	G-6
14	C-0	38	F-6
15	C-1	39	F-7
16	C-2	40	E-6
17	A-3	41	E-7
18	B-3	42	D-6
19	C-3	43	D-7
20	D-0	44	C-7
21	D-1	45	B-6
22	D-2	46	B-5
23	D-3	47	C-5
24	F-0	48	C-6

NOTE:
1. FIELD CHANGES IN SEQUENCING OF GRIDS IS EXPECTED AND WILL NOT BE CONSIDERED A WORK PLAN MODIFICATION.

695 — EXISTING CONTOURS
EXCAVATION BOUNDRY
PROPERTY/RIGHT-OF-WAY LINE
BM BENCH MARK

Scale: 1" = 120'
0' 60' 120'

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TITLE
FIGURE WP B 9
EXCAVATION SEQUENCING DRAWING
KAISER ALUMINUM
Tulsa, Oklahoma

Revisions
No. | By | Description | Date

C09

3

Tables

March, 2004
Job No. 2-1719

Table 1
City of Tulsa Maximum Allowable Discharge Concentrations

Pollutant	Limitation	Pollutant	Limitation
Arsenic (Total)	1.0 mg/l	Nickel (Total)	3.25 mg/l
Cadmium (Total)	0.60 mg/l	Zinc (Total)	3.00 mg/l
Chromium (Total)	4.0 mg/l	Cyanide (Total)	0.75 mg/l
Copper (Total)	2.0 mg/l	Silver (Total)	1.20 mg/l
Lead (Total)	0.70 mg/l	Oil & Grease	100 mg/l
Mercury (Total)	0.04 mg/l	PH	6.0 to 10.5 S.U.

Table 2
NRC Allowable Thorium and Radium Concentrations to Sewers

Radiological Analyte	10 CFR , 20 Appendix B, Table 3 - Avg. Monthly Concentrations-Sewage Disposal (pCi/l)
Ra-226	600
Ra-228	600
Th-228	2,000
Th-230	1,000
Th-232	300

4

RECON
Remedial Construction Services, L.P.

Procedure Numbers and Descriptions

Thorium Remediation Project

Procedure No.	Title	Effective Date	Revision No.
REC-WP-1-01	PROCEDURES	March 2004	00
REC-WP-1-02	CHANGES TO PROCEDURES	March 2004	00
REC-WP-1-03	COMPLETION OF FORMS	March 2004	00
REC-WP-2-01	BASIC INSTRUMENT OPERATION	March 2004	00
REC-WP-2-02	INSTRUMENT MDC CALCULATION	March 2004	00
REC-WP-2-03	LUDLUM MODEL 2224 w/ 43-93	March 2004	00
REC-WP-2-04	LUDLUM MODEL 3 w/ 44-9	March 2004	00
REC-WP-2-05	LUDLUM MODEL 19	March 2004	00
REC-WP-2-06	LUDLUM MODEL 177 w/ 44-9	March 2004	00
REC-WP-2-07	LUDLUM MODEL 2929 w/ 43-10-1	March 2004	00
REC-WP-2-08	LUDLUM MODEL 2221 w/43-5	March 2004	00
REC-WP-2-09	DOSIMETER ISSUANCE/TRACKING	March 2004	00
REC-WP-3-01	GROSS GAMMA SURVEY	March 2004	00
REC-WP-3-02	PERSONNEL RADIATION SURVEY	March 2004	00
REC-WP-3-03	ENTRY/UNRESTRICTED RELEASE	March 2004	00
REC-WP-3-04	EXPOSURE RATE SURVEY	March 2004	00
REC-WP-3-05	REMOVEABLE ALPHA BETA/GAMMA SURVEY	March 2004	00
REC-WP-4-01	SURFACE SOIL SAMPLING	March 2004	00
REC-WP-4-02	AIR SAMPLING PROCEDURE	March 2004	00
REC-WP-4-03	STORAGE TANK WATER SAMPLING	March 2004	00
REC-WP-5-01	CHECK SOURCE ACCOUNTABILITY	March 2004	00
REC-WP-6-01	CHAIN OF CUSTODY	March 2004	00
REC-WP-7-01	DISCHARGE WATER FROM HOLDING TANK	March 2004	00
REC-WP-7-02	EXCAVATION	March 2004	00
REC-WP-7-03	BACKFILL	March 2004	00
REC-WP-7-04	LOADING VIBRATING SCREEN	March 2004	00
REC-WP-7-05	LOADING RAIL CARS	March 2004	00

5

PROCEDURE: REC-WP-1-01

Procedures

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: MARCH 2004

Approved, Bill Vinzant ____________________ 3-31-04 ____________

J. W. (Bill) Vinzant
Kaiser Aluminum &Chemical Corporation

Date:

PROCEDURE: REC-WP-1-01

Procedures

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: MARCH 2004

[signature]	7/29/01	[signature]	3/29/04
Prepared by:	Date:	Quality Control Manager:	Date:

Remedial Construction Services, L.P. (Recon)
9720 Derrington
Houston, TX 77064
(281) 955-2442

Procedure: REC-WP-1-01

Title: Procedures

1.0 PURPOSE

The purpose of this procedure is to provide a written reference on the organization of the Work Plan Manual.

2.0 DEFINITIONS

NA

3.0 PREREQUISITES/PRECAUTIONS/LIMITATIONS

NA

4.0 EQUIPMENT

NA

5.0 PROCEDURE

Procedures are broken down into categories and are presented in this manual as chapters. These are:

- REC-WP-1 – General Practices
- REC-WP-2 – Instrumentation
- REC-WP-3 – Surveys
- REC-WP-4 – Sampling
- REC-WP-5 – Quality Assurance
- REC-WP-6 – Chain of Custody
- REC-WP-7 – Field Practices

6.0 REFERENCES

NA

7.0 ATTACHMENTS

NA

6

PROCEDURE: REC-WP-1-02

Changes to Procedures

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: MARCH 2004

Approved, Bill Vinzant

J. W. (Bill) Vinzant
Kaiser Aluminum &Chemical Corporation

3-31-04

Date:

PROCEDURE: REC-WP-1-02

Changes to Procedures

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: MARCH 2004

[signature] 3/29/04		[signature] 3/29/04	
Prepared by:	Date:	Quality Control Supervisor:	Date:

Work Plan Procedures Manual

Remedial Construction Services, L.P. (Recon)
9720 Derrington
Houston, TX 77064
(281) 955-2442

Procedure: REC-WP-1-02

Title: Changes to Procedures

1.0 PURPOSE

The purpose of this procedure is to provide written guidelines for revising existing procedures prior to implementing these changes.

2.0 DEFINITIONS

NA

3.0 PREREQUISITES/PRECAUTIONS/LIMITATIONS/RESPONSIBILITIES

3.1 Radiation Safety Officer or his designee is responsible to review and approve proposed field changes, when appropriate.

3.2 Site personnel are responsible to request a field change and receive authorization for such changes prior to implementation of the changes, when appropriate.

4.0 EQUIPMENT

NA

5.0 PROCEDURE

5.1 Major Field Changes

5.1.1 A major field change has the potential to affect one or more of the following:

1. Adversely affect the quality of the data.
2. Adversely affect the consistency of the data.
3. Cause significant change in the cost of the field effort.
4. Create a major change in the scope of the field effort.
5. Cause significant delays in the schedule of the field effort.

5.1.2 Organizations that originally reviewed and approved the procedure will review and approve the major field changes.

5.2 Minor Field Changes

5.2.1 A minor field change is one which does not do one or more of the following:

1. Adversely affect the quality of the data in the field.
2. Affect the rationale for field procedures or sampling locations.

5.2.2 Organizations that originally reviewed and approved the procedure will review and approve the minor field changes.

5.2.3 The only exception to the requirements of Substeps 5.2.2 and 5.2.3 is a minor change to a document, such as inconsequential editorial corrections. These corrections will not require review and approval.

5.2.4 Field Change Requests will be maintained as part of the project files.

6.0 REFERENCES

NA

7.0 ATTACHMENTS

NA

7

PROCEDURE: REC-WP-1-03

Completion of Forms

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: MARCH 2004

Approved, Bill Vinzant

J. W. (Bill) Vinzant
Kaiser Aluminum &Chemical Corporation

3-31-04

Date:

1.0 PROCEDURE: REC-WP-1-03

Completion of Forms

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: MARCH 2004

[illegible signature]	3/29/04	[illegible signature]	3/29/04
Prepared by:	Date:	Quality Control Supervisor:	Date:

1.0 PURPOSE

The purpose of this procedure is to provide instruction on the proper completion of forms, including survey and instrumentation forms that are required for the project.

2.0 DEFINITIONS

Form Field: A space on a form where information is to be entered.

3.0 PREREQUISITES/PRECAUTIONS/LIMITATIONS

3.1 Additional guidance on performing surveys, taking samples, or instrument use can be found in the appropriate Work Plan procedure.

3.2 The forms used to record data are generic, i.e., designed for recording data from various instruments. Record "N/A" in any fields that are not applicable to the instrument.

4.0 EQUIPMENT

4.1 Appropriate form(s) for the work being performed.

4.2 Black pen.

5.0 PROCEDURE

5.1 General Information

5.1.1 Information should be entered in the appropriate manner and in the appropriate form field.

5.1.2 Information should be entered using black ink.

5.1.3 A form field where information is not available or not applicable should be filled with "N/A."

5.1.4 An entire column with repeating information may be filled with a line from top to bottom. The line should begin immediately below a completed form field with the proper information and have definitive markings where the information ceases to apply. The next form field should be properly filled with new information.

5.2 Dates and Times

5.2.1 Dates should be entered in a format that clearly identifies the day, month, and year (e.g., 1/1/02; 01/01/2002; Jan 1, 2002).

5.2.2 Times should be entered in a format the clearly identifies the hour and minutes (e.g., 8:00 a.m.; 0800; 1:30 p.m.; 1330).

5.3 Signatures, Personnel, and Contact Information

5.3.1 Signature lines should be filled legibly. Include a printed name where necessary.

5.3.2 Initials may be used in a form field if the full name appears elsewhere on the form.

5.3.3 Contact information should include a full name, address, zip code, and telephone number with area code.

5.4 Abbreviations

5.4.1 The use of nonstandard abbreviations should be avoided unless the full wording appears elsewhere on the form and it clearly identifies the abbreviation to be used.

5.5 Result Form Fields

5.5.1 Result form fields should be completed utilizing units that are specified on the form. Form fields that identify units are to be filled clearly utilizing standard notation for the information requested.

5.6 Form Attachments

5.6.1 Attachments to forms should be appropriately labeled to indicate the specific form they accompany.

5.6.2 The accompanying form should clearly reference the attachment (e.g., see Attachment A).

5.7 Corrections

5.7.1 Corrections to form fields shall be made by entering the correct information next to the proper form field and placing a single line through the incorrect entry along with the initials of the person making the correction and the date of correction.

6.0 REFERENCES

NA

7.0 ATTACHMENTS

NA

8

PROCEDURE: REC-WP-2-01

Basic Instrument Operation

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: MARCH 2004

Approved, Bill Vinzant — 3-31-04

J. W. (Bill) Vinzant
Kaiser Aluminum &Chemical Corporation

Date:

PROCEDURE: REC-WP-2-01

Basic Instrument Operation

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: MARCH 2004

3-29-04 3/29/04

Prepared by: Date: Quality Control Supervisor: Date:

Work Plan Procedures Manual

Remedial Construction Services, L.P. (Recon)
9720 Derrington
Houston, TX 77064
(281) 955-2442

1.0 PURPOSE

The purpose of this procedure is to provide instruction on the basic operation of radiological survey instruments.

2.0 DEFINITIONS

Calibration source: A National Institute of Standards and Technology- (NIST) traceable source of a known value used to calibrate an *instrument.*

Check source: A radiological source, not necessarily calibrated, which is used to confirm the continuing satisfactory operation of an instrument

Detector: The portion of an *instrument* that transmits a signal to a *meter* based upon the radioactive activity present. Some detectors are contained within a *meter.*

Instrument: A meter-detector combination that has been calibrated as a single unit. Some instruments are capable of being calibrated with several detectors simultaneously.

Meter: The portion of an *instrument* that receives and translates signals from the *detector* into a user observable result.

Efficiency: A measure of the instrument's ability to detect radiological activity. It is calculated by using the formula:

$$E_i = ((C-B_r)/D)$$

Where:

- E_i = Instrument efficiency
- C = Displayed value from the instrument count of the calibration source (count rate)
- B_r = Background count rate
- D = Known decay-corrected disintegrations per minute (dpm) value of the calibration source. This value is geometry dependent and should be noted on the calibration certificate, e.g., 2π or 4π geometry. (Note that for gamma detection, the value of D may be provided in different units, e.g., μR/hr.)

3.0 PREREQUISITES/PRECAUTIONS/LIMITATIONS

3.1 Any person operating a radiological survey instrument must be trained in its use or supervised during its operation by a qualified instructor.

3.2 Failure of any preoperational check will result in the instrument being removed from operation and repaired as necessary.

3.3 An operator repair such as replacing batteries or cables does not require the instrument to be recalibrated. However, the efficiency of the instrument should be recalculated.

3.4 Any operator repair that may affect the efficiency response of the detector requires that the new efficiency response be within 20 percent of the calibration value but does not necessarily require a new calibration. If the new efficiency response is not within 20 percent of the calibration value, the instrument will be removed from operation and recalibrated.

3.5 Manufacturer's recommendations regarding use, calibration, and/or maintenance of an instrument will be followed unless otherwise documented in this or other written procedure(s).

3.6 Additional guidance for operating an instrument can be found in the appropriate procedure and/or the manufacturer's manual for that instrument.

3.7 The forms used to record instrument daily check data are generic, i.e., designed for recording information from various instruments. Record "N/A" in any fields that are not applicable to the instrument check.

4.0 EQUIPMENT

4.1 Appropriate check source(s) or calibration source(s), as necessary.

5.0 PROCEDURE

5.1 Preoperational Checks (All instruments before use)

5.1.1 Verify the calibration is current and applicable to the meter-detector combination.

5.1.2 Verify the instrument is capable of detecting the desired activity (e.g., alpha or beta/gamma detector) and that the instrument range encompasses the expected activity.

5.1.3 Inspect any cables for exposed wires, cracks, loose connectors, etc.

5.1.4 Connect any necessary cables or power cords.

5.1.5 Turn instrument on and perform a battery check or verify that the power is on. Replace batteries (or charge battery as appropriate), if necessary.

5.1.6 Hold the detector in the air away from any potentially contaminated surface. Observe the digital and/or analog output and allow the reading to stabilize. Record the resulting background value on the appropriate form for each specific model.

5.1.7 Expose the detector to an appropriate check source and allow the response to stabilize. Verify that the response value is acceptable. Enter the response result on the appropriate form for the instrument being used.

5.1.8 While the detector is exposed to the check source, turn up the volume or turn on the speaker (as appropriate) and check for audible response.

5.2 Establish Performance Check Values (Scaler instruments/postcalibration)

5.2.1 Perform necessary preoperational checks to ensure the instrument is operating properly.

5.2.2 Using a repeatable-count geometry, expose the detector to an appropriate check source for the type of radiation required (e.g., alpha, beta, gamma). Perform a minimum of 10 consecutive 1-minute counts of the check source and record the results on the appropriate form.

5.2.3 Calculate the average of the consecutive counts (x) using the formula provided on the appropriate form.

5.2.4 Calculate the standard deviation of the consecutive counts (s) using the formula provided on the appropriate form.

5.2.5 Calculate the minimum number of source counts required (n) based on 10 percent accuracy at the 95 percent confidence level using the following formula. The values of t corresponding to the degrees of freedom (df) can be looked up in Table 1. Degrees of freedom is equal to the number of counts minus 1 (e.g., if 10 counts were performed the df is equal to 9).

$$CD=(S.D./MEAN)x100$$

5.2.6 If n is less than or equal to 10, proceed to the next step. If n is greater than 10, perform the additional

5.2.7 number of counts required (i.e., n –10) and return to Substep 5.2.3.

5.2.8 Calculate the acceptance criteria for daily source checks by adding and subtracting two standard deviations from the average. Record the results on the appropriate form.

5.2.9 Repeat Section 5.2 each time the instrument is recalibrated.

5.3 Establish Performance Check Values (Ratemeter instruments)

5.3.1 Perform all necessary preoperational checks to ensure the instrument is operating properly.

5.3.2 Using a repeatable-count geometry expose the detector to an appropriate check source for the type of radiation required (e.g., alpha, beta, gamma). Perform a minimum of 10 consecutive 1-minute counts of the check source and record the results on the appropriate form.

5.3.3 Calculate the average of the consecutive counts (x) using the formula provided on the appropriate form.

5.3.4 Calculate the standard deviation of the consecutive counts (s) using the formula provided on the appropriate form.

5.3.5 Calculate the minimum number of source counts required (n) based on 20 percent accuracy at the 95 percent confidence level using the following formula. The values of t corresponding to the df can be looked up in Table 1. Degrees of freedom is equal to the number of counts minus 1 (e.g., if 10 counts were performed the df is equal to 9).

$$n = \left[\frac{t_{95,df} \cdot s_x}{0.2 \cdot \bar{x}}\right]^2$$

5.3.6 If n is less than or equal to 10, proceed to the next step. If n is greater than 10, perform the additional number of counts required (i.e., n –10) and return to Substep 5.3.3.

5.3.7 Calculate the acceptance criteria for daily source checks by adding and subtracting 20 percent of the average from the average. Record the results on the appropriate form.

5.3.8 Repeat Section 5.3 each time the instrument is recalibrated.

Table 1
t-Values

df	t-Value 95%	t-Value 97.5%		df	t-Value 95%	t-Value 97.5%
1	6.314	12.706		36	1.689	2.029
2	2.920	4.303		37	1.688	2.027
3	2.353	3.182		38	1.687	2.025
4	2.132	2.776		39	1.685	2.023
5	2.015	2.571		40	1.684	2.021
6	1.943	2.447		41	1.683	2.020
7	1.895	2.365		42	1.683	2.019
8	1.860	2.306		43	1.682	2.018
9	1.833	2.262		44	1.681	2.017
10	1.812	2.228		45	1.681	2.016

11	1.796	2.201		46	1.680	2.015
12	1.782	2.179		47	1.679	2.014
13	1.771	2.160		48	1.679	2.013
14	1.761	2.145		49	1.678	2.012
15	1.753	2.131		50	1.677	2.010
16	1.746	2.120		51	1.677	2.009
17	1.740	2.110		52	1.676	2.008
18	1.734	2.101		53	1.676	2.007
19	1.729	2.093		54	1.675	2.006
20	1.725	2.086		55	1.674	2.005
21	1.721	2.080		56	1.674	2.004
22	1.717	2.074		57	1.673	2.003
23	1.714	2.069		58	1.672	2.002
24	1.711	2.064		59	1.672	2.001
25	1.708	2.060		60	1.671	2.000
26	1.706	2.056		120	1.658	1.980
27	1.703	2.052		140	1.649	1.966
28	1.701	2.048		∞	1.645	1.960
29	1.699	2.045				
30	1.697	2.042				
31	1.696	2.040				
32	1.694	2.038				
33	1.693	2.036				
34	1.692	2.034				
35	1.690	2.031				

6.0 REFERENCES

6.1 Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), NUREG/CR-1575, August 2000, Rev. 1.

7.0 ATTACHMENTS

Form REC-WP-2-01-1 Performance Check Values

Form REC-WP-2-01-1

Remedial Construction Services, L.P. (Recon)
9720 Derrington
Houston, TX 77064
(281) 955-2442

Form REC-WP-2-01-1
Performance Check Values

Project Number:		Project Name:	
Instrument Model:		Technician:	
Instrument S/N:		Date:	
Calibration Due:		Detector Model:	
Radiation Detected:		Detector S/N:	
Source Isotope & S/N:		Detector Type:	
Bkg Count Rate:			

Data Point	Gross Count	Net Count	DPM
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Average Net Count:		
Standard Deviation of Net Count (Scalers):		
20% of Net Count (Ratemeters):		
Average minus 2 X standard deviation (Scalers):		
Average plus 2 X standard deviation (Scalers):		
Average minus 20% (Ratemeters):		
Average plus 20% (Ratemeters):		

Formulas

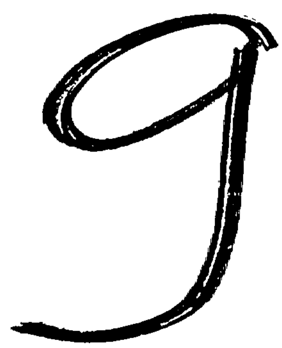
Where: n = number of 1 min the counts (20)

$\overline{x}$ = average of (20) 1 min counts

x_i^2 =each count result squared

$$StdDev=\sqrt{\frac{n\sum_{i=1}^{n}x_i^2-\left(\sum_{i=1}^{n}\overline{x}_i\right)^2}{n(n-1)}}$$

Comments:	
Prepared By:	Date:
Reviewed By:	Date:



PROCEDURE: REC/WP-2-02

Instrument Minimum Detection Concentration Calculation

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: MARCH 2004

Approved, Bill Vinzant　　　　3-31-04

J. W. (Bill) Vinzant　　　　Date:
Kaiser Aluminum &Chemical Corporation

PROCEDURE: REC/WP-2-02

Instrument Minimum Detection Concentration Calculation

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: MARCH 2004

Prepared by: Date: 3-29-04 Quality Control Supervisor: Date: 3/29/04

PROCEDURE: REC/WP-2-02

Instrument Minimum Detection Concentration Calculation

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: MARCH 2004

Prepared by:	Date:	Quality Control Supervisor:	Date:

1.0 PURPOSE

The purpose of this procedure is to provide instruction on the calculation of the Minimum Detectable Concentration (MDC) value of a radiation detection instrument/detector as required for survey activities at the Thorium Remediation Project in Tulsa, Oklahoma. Instruction for the calculation of the sample count time (t_s) required to achieve the MDC value is also provided.

2.0 DEFINITIONS

Calibration source: A National Institute of Standards and Technology- (NIST) traceable check source of a known value used to calibrate or verify the response efficiency of an *instrument*.

Detector: The portion of an *instrument* that transmits a signal to a *meter* based upon the radioactive activity present. Some detectors are contained within a *meter*.

Instrument: A meter-detector combination that has been calibrated as a single unit. Some meters are capable of being calibrated with several detectors simultaneously.

Meter: The portion of an *instrument* that receives and translates signals from the *detector* into a user observable result.

Instrument Efficiency: A measure of an instrument's ability to detect radiological activity. It is calculated by using the formula:

$$E_i = ((C-B_r)/D)$$

Where:

E_i = Instrument efficiency
C = Displayed value from the instrument count of the calibration source (count rate)
B_r = Background count rate
D = Known decay-corrected disintegrations per minute (dpm) value of the calibration source. This value is geometry dependent and should be noted on the calibration certificate, e.g., 2π or 4π geometry.

Note that, for gamma detection, the value of D may be provided in different units (e.g., μR/hr).

3.0 PREREQUISITES/PRECAUTIONS/LIMITATIONS

3.1 The MDC value should be calculated at a minimum each month or as directed by the RSO.

3.2 The calculation of MDC is background dependent Therefore, if background is known to change (e.g., the instrument is moved to a new location for use), the background count rate should be re-determined and the MDC value recalculated.

3.3 For static (fixed-count time) measurements, the MDC value is count-time dependent. The MDC value corresponding to each count time used should be calculated.

3.4 When the calculated MDC value for a static measurement is calculated always ensure that the MDC value is adequate for the survey (e.g., the MDC value is a fraction of the acceptance criteria). If the MDC value is not adequate for the survey, increase the background count time and/or the sample count time and recalculate the MDC value.

4.0 EQUIPMENT

4.1 Calculator or spreadsheet with calculation built in.

5.0 PROCEDURE

5.1 Determination of Counting Times and Minimum Detectable Concentrations

Minimum counting times for background determinations and counting times for measurement of total and removable contamination will be chosen to provide a MDC that meets the acceptance criteria required by the site specific survey plan or other technical basis documents. The Multi-Agency Radiation Survey and Site Investigation Manual's (MARISSM) equations have been modified to convert to units of disintegrations per minute (dpm)/100 square centimeters (cm^2). Count times and scanning rates are determined using the following equations:

5.1.1 Static Counting of Alpha or Beta/Gamma Radiation

Static counting MDC at a 95 percent confidence level is calculated using the following equation, which is an expansion of NUREG 1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*, Equation 6-7 (Strom & Stansbury, 1992):

$$MDC_{static} = \frac{3 + 3.29\sqrt{B_r \cdot t_b \cdot (1 + \frac{t_s}{t_b})}}{t_s \cdot E_{tot} \cdot \frac{A}{100}}$$

Where:

MDC_{static} = minimum detectable concentration level in dpm/100 cm^2
B_R = background count rate in counts per minute
t_B = background count time in minutes
t_S = sample count time in minutes
A = detector probe physical (active) area in cm^2
E_{tot} = total detector efficiency for radionuclide emission of
= $E_I \times E_s$, Where:

E_i = 2π instrument efficiency in counts per disintegration (cpd)
E_s = source (or surface contamination) efficiency

Note: Es values can be determined or the default values provided in NUREG-1507 can be used as follows: 0.25 for all alpha energies and beta maximum energies between 0.15 and 0.4

MeV, 0.5 for all beta maximum energies greater than 0.4 MeV. All calculations will be recorded on the Monthly Static MDC and Count Time Calculation Form REC-WP-2-02-1.

5.1.2 Beta Ratemeter Scanning

Beta scanning MDC at a 95 percent confidence level is calculated using the following equation which is a combination of MARSSIM Equations 6-8, 6-9, and 6-10:

$$MDC_{scan} = \frac{d'\sqrt{b_i}\left(\frac{60}{i}\right)}{\sqrt{p}\cdot E_{tot}\cdot\frac{A}{100cm^2}}$$

Where:

MDC_{scan} = minimum detectable concentration level in dpm/100 cm^2
d' = desired performance variable (usually 1.38 corresponding to alpha and beta errors of 0.05)
b_i = background counts during the residence interval
i = residence interval in seconds
ρ = surveyor efficiency (0.5 – 0.75, 0.5 is conservative)
A = detector probe physical (active) area in cm^2
E_{tot} = total detector efficiency for radionuclide emission of
= E_i x E_s , Where:
E_i = 2π instrument efficiency in cpd
E_s = source (or surface contamination) efficiency

Note: Es values can be determined or the default values provided in NUREG-1507 can be used as follows: 0.25 for all alpha energies and beta maximum energies between 0.15 and 0.4 MeV, 0.5 for all beta maximum energies greater than 0.4 MeV. All calculations will be recorded on the Monthly Static MDC and Count Time Calculation Form REC-WP-2-02-1.

5.1.3 Alpha Ratemeter Scanning

There are two equations used to determine the alpha scanning Derived Concentration Guideline Values depending on the background level:

For a background level of <3 cpm, the probability of detecting a single count while passing over the contaminated area is:

$$P(n \geq 1) = 1 - e^{\frac{-GEd}{60v}}$$

Where:

$P(n \geq 1)$ = probability of observing a single count
G = activity (dpm)
E = 4π detector efficiency (cpd)
d = width of detector in direction of scan (cm)
v = scan speed (cm/s)

Increase the value of G until the corresponding probability equals the desired confidence level (e.g., 95 percent).

For a background level of 3 cpm to about 10 cpm, the probability of detecting two or more counts while passing over the contaminated area is:

$$P(n \geq 2) = 1 - \left(1 + \frac{(GE + B)d}{60v}\right)\left(e^{-\frac{(GE+B)d}{60v}}\right)$$

Where:

$P(n \geq 2)$ = probability of observing two or more counts
G = activity (dpm)
E = 4π detector efficiency (cpd)
B = background count rate (cpm)
d = width of detector in direction of scan (cm)
v = can speed (cm/s)

Increase the value of G until the corresponding probability equals the desired confidence level (e.g., 95 percent).

Note: All calculations will be recorded on the Monthly Static MDC and Count Time Calculation Form REC-WP-2-02-1.

5.1.4 Gamma Soil Scanning

Gamma soil scanning MDCs are calculated for scanning instruments using the method provided in MARSSIM for calculating MDC that controls both Type I and Type II errors (i.e., elimination of false negatives and false positives), as follows:

$$\text{Scan MDC}_{surveyor} = \frac{d'\sqrt{b_i}(60/i)}{\sqrt{p}\,\epsilon_i}$$

Where: Scan $MDC_{surveyor}$ is the MDC in uR/hr, and

ϵ_i = instrument efficiency in cpm/µR/hour, radionuclide specific, see table below

ρ = surveyor efficiency. Based on laboratory studies documented in References 6 and 7, the value of ρ has been estimated to be between 0.5 and 0.75. The value of 0.5 is conservative

d' = is the value selected from MARSSIM Table 6.5 based on the required true positive and false positive rates, usually 1.38 corresponding to 5 percent false positives and 40 percent false negatives.

b_i = the number of background counts in the interval i

i = the scan time interval usually 1 second

In accordance with MARSSIM, the Scan $MDC_{surveyor}$ can be converted to Scan MDC in volumetric units of picocuries per gram by use of a radionuclide specific conversion factor calculated by use of the code MICROSHIELD. Some of the factors are listed below for 2-inch-by-2-inch sodium iodide detectors.

Radio-nuclide	ϵ_i (cpm/ µR/hr)	CF (pCi/g / µR/h)
Cs-137	900	3.81
Co-60	430	0.97
Am-241	13,000	271
Ra-226*	760	1.41
Th-232*	830	0.99

*In equilibrium with all progeny.

Note: All calculations will be recorded on the Monthly Static MDC and Count Time Calculation Form REC-WP-2-02-1.

6.0 REFERENCES

6.1 NUREG-1575, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), December 1997

6.2 NUREG-1507, Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions, December 1997

7.0 ATTACHMENTS

Form REC-WP-2-02-1	Static MDC and Count Time Calculation
Form REC-WP-2-02-2	Beta Scan MDC Calculation
Form REC-WP-2-02-3	Alpha Scan MDC Calculation
Form REC-WP-2-02-4	Gross Gamma Scan MDC Calculation

Form REC-WP-2-02-1

Remedial Construction Services, L.P. (Recon)
9720 Derington
Houstont, TX 77064
(281) 955-2442

Form REC-WP-2-02-1
Monthly Static MDC and Count Time Calculation

Instrument Serial Number:		Cal. Due:
Detector Serial Number:		Cal. Due:
Radiation Detected:		

E_i (Instrument Efficiency):		(cpd)
E_s (Source Efficiency):		(-)
E_{tot} (Total Efficiency):		(cpd)
A (Active Probe Area):		(cm^2)

$$MDC_{static} = \frac{3 + 3.29\sqrt{B_r \cdot t_s \cdot (1 + \frac{t_s}{t_b})}}{t_s \cdot E_{tot} \cdot \frac{A}{100}}$$

	D date	B background (counts)	t_b background count time (min)	B_r background count rate (cpm)	t_s sample count time (min)	MDC_{static} min. detectable concentration (dpm/100cm^2)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						

Comments:	
Prepared By:	Date:
Reviewed By:	Date:

Notes:
1. $E_{tot} = E_i \times E_s$.
2. Source Efficiency (E_s) is also refered to as Contamination Source Efficiency or Surface Efficiency.
3. E_s is equal to 0.25 for all alpha emissions and beta emissions with maximum energy between 0.15 and 0.4 Mev. For maximum beta energies > 0.4 MeV, E_s is equal to 0.5.

Form REC-WP-2-02-2

Redmedial Construction Services, L.P. (Recon)
9720 Derrington
Houston, TX 77064
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Form REC-WP-2-02-2
Monthly Beta Scan MDC Calculation

Instrument Serial Number:	Cal. Due:
Detector Serial Number:	Cal. Due:
Radiation Detected: Beta	

E_i (Instrument Efficiency):	(cpd)
E_s (Source Efficiency):	(-)
E_{tot} (Total Efficiency):	(cpd)
A (Active Probe Area):	(cm^2)

$$MDC_{scan} = \frac{d' \sqrt{b_i} \sqrt{(60/i)}}{\sqrt{p} \cdot E_{tot} \cdot \frac{A}{100cm^2}}$$

	D date	b_i background count rate (cpm)	I scan time (seconds)	ρ surveyor E (0.5 - 0.75) (-)	d' MARSSIM Table 6.5 (-)	MDC_{scan} min. detectable concentration (dpm/100cm²)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						

Comments:	
Prepared By:	Date:
Reviewed By:	Date:

Notes:
1. $E_{tot} = E_i \times E_s$.
2. Source Efficiency (E_s) is also refered to as Contamination Source Efficiency or Surface Efficiency.
3. E_s is equal to 0.25 for all alpha emissions and beta emissions with maximum energy between 0.15 and 0.4 Mev. For maximum beta energies > 0.4 MeV, E_s is equal to 0.5.
4. ρ = surveyor efficiency, ranges from 0.5 to 0.75, 0.5 is conservative.
5. d' = desired performance variable (usually 1.38 corresponding to alpha and beta errors of 0.05).

Form REC-WP-2-02-3

Remedial Construction Services, L.P. (Recon)
9720 Derrington
Houston, TX 77064
(281) 955-2442

Form REC-WP-2-02-3
Monthly Alpha Scan MDC Calculation

Instrument Serial Number:		Cal. Due:	
Detector Serial Number:		Cal. Due:	
Radiation Detected:	Alpha		

Probability of observing 2 or more counts:

$$P(n \geq 2) = 1 - \left(1 + \frac{(GE+B)d}{60v}\right)\left(e^{-\frac{(GE+B)d}{60v}}\right)$$

Probability of observing a single count:

$$P(n \geq 1) = 1 - e^{\frac{-GEd}{60v}}$$

	D date	G Activity (dpm)	d Detector Width (cm)	E Instrument Efficiency (cpm)	v Scan Speed (cm/s)	B Background Countrate (cpm)	P Probability (-)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							

Comments:

Prepared By:	Date:
Reviewed By:	Date:

Note:
1. Instrument efficiency is the 4p instrument efficiency.

Form REC-WP-2-02-4

Remedial Construction Services, L.P. (Recon)
9720 Derrington
Houston, TX 77064
(281) 955-2442

Form REC-WP-2-02-4
Gross Gamma Scan MDC Calculation

Instrument Serial Number:		Cal. Due:	
Detector Serial Number:		Cal. Due:	
Radiation Detected:	Gamma	Type of Detector:	

$$MDCR = \frac{d' \sqrt{b_i}(60 / i)}{\sqrt{p}}$$

$$Scan\ MDC_{surveyor} = \frac{d' \sqrt{b_i}(60 / i)}{\sqrt{p} \in_i}$$

$$Scan\ MDC = \frac{d' \sqrt{b_i}(60 / i)}{\sqrt{p} \in_i CF}$$

D date	Radio-nuclide	b_i background count rate (cpm)	E_i	I scan time (seconds)	r surveyor E (0.5 - 0.75) (-)	d' MARSSIM Table 6.5 (-)	MDCR min. detectable countrate (cpm)	Scan $MDC_{surveyor}$ min. detectable concentration (mR/hr)	CF conversion factor (pCi/g / mR/hr)	Scan MDC min. detectable concentration (pCi/g)

Comments:	
Prepared By:	Date:
Reviewed By:	Date:

Notes:

CF = Conversion factor (Microshield/NUREG-1507).
ncpm = Net counts per minute.
mR/h = microRoentgen per hour.
E_i = Instrument efficiency (from Table 6.7 of MARSSIM).
pCi/g = Picocuries per gram.

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PROCEDURE: REC-WP-2-03

Ludlum Model 2224 Scaler/Ratemeter with the Model 43-93 Detector

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: MARCH 2004

Approved, Bill Vinzant

J. W. (Bill) Vinzant
Kaiser Aluminum &Chemical Corporation

3-31-04

Date:

PROCEDURE: REC-WP-2-03

Ludlum Model 2224 Scaler/Ratemeter with the Model 43-93 Detector

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: MARCH 2004

3-21-04 3/29/04

Prepared by: Date: Quality Control Supervisor: Date:

1.0 PURPOSE

The purpose of this procedure is to provide basic operational instruction for the Ludlum Model 2224 Scaler/Ratemeter with the Model 43-93 Detector.

2.0 DEFINITIONS

Background: A measurement taken by this instrument to determine the amount of naturally occurring radiation at a given time at a given location.

Calibration source: A National Institute of Standards and Technology- (NIST) traceable check source of a known value used to calibrate or verify the response efficiency of the *instrument.*

Detector: The portion of this *instrument* that transmits a signal to a *meter* based upon the radioactive activity present. The model 43-93 detector is attached to the model 2224 *meter*.

Instrument: A meter-detector combination that has been calibrated as a single unit. Some instruments are capable of being calibrated with several detectors simultaneously.

Meter: The portion of this *instrument* that receives and translates signals from the *detector* into a user observable result.

Efficiency: A measure of this instrument's ability to detect radiological activity. It is calculated by using the formula:

$$E = ((C-B_r)/D)$$

Where:

E = Instrument efficiency
C = Displayed value from the instrument count of the calibration source (count rate)
B_r = Background count rate
D = Known decay-corrected disintegrations per minute (dpm) value of the calibration source

3.0 PREREQUISITES/PRECAUTIONS/LIMITATIONS

3.1 Any person operating a radiological survey instrument must be trained in its use or supervised during its operation by a qualified instructor.

3.2 Failure of any preoperational check will result in the instrument being removed from operation and repaired as necessary.

3.3 Any operator repair that may affect the efficiency response of the detector requires that the new efficiency response be within 10 percent of the calibration value but does not necessarily require a new calibration. If the new efficiency response is not within 10 percent of the calibration value, the instrument will be removed from operation and recalibrated.

3.4 An operator repair such as replacing batteries or cables does not require the instrument to be recalibrated. However, the efficiency of the instrument should be recalculated by using the formula listed above.

3.5 All manufacturer's recommendations regarding use, calibration, and/or maintenance of an instrument will be followed unless otherwise documented in this or other written procedure(s).

3.6 Additional guidance for operating an instrument can be found in the appropriate procedure and/or the manufacturer's manual for that instrument.

3.7 Basic Instrument Operation - See Procedure REC-WP-2-01

3.8 Instrument Minimum Detectable Concentration Calculations – See Procedure REC-WP-2-02

4.0 EQUIPMENT

- Ludlum Model 2224 Scaler/Ratemeter, or equivalent
- Ludlum Model 43-93 Detector, or equivalent

5.0 PROCEDURE

5.1 Preoperational Checks

5.1.1 Turn the instrument on and perform a battery check or verify that the power is on. Replace batteries (or charge battery as appropriate) if necessary.

5.1.2 Adjust the audible volume so that the alpha and beta/gamma clicks can be easily heard.

5.2 Operational Checks

5.2.1 Prior to using the counting system, the source check acceptance criteria of the average response will be determined. If the instrument is recalibrated at any point, the source check acceptance criteria will need to be re-established, in accordance with Procedure REC-WP-2-01.

5.2.2 Each day the instrument is used, determine ambient background and record on appropriate form.

5.2.3 Each day that a counting system is used, the response will be checked using an appropriate source, as follows.

5.2.4.1 Perform the source count by placing the appropriate source (alpha or beta) beneath the detector in a fixed-count geometry. This count is performed on both alpha and beta sources.

5.2.4.2 The net counts per minute value is compared to the acceptance criteria to determine a pass or fail status.

5.2.4.3 Record the source check readings on the appropriate form.

5.2.4 Check the source check result against the established postcalibration acceptance criteria. Failed source checks will be repeated. Consecutive failures will result in additional testing of the instrument. Refer to instrument manual.

5.2.5 Survey data acquired prior to an instrument failing a source check will be reviewed to determine the validity of the data. This review will be documented.

5.2.6 Determine the minimum detectable concentration for the instrument as required, in accordance with Procedure REC-WP-2-02.

6.0 REFERENCES

NA

7.0 ATTACHMENTS

Form REC-WP-2-03-1 Daily Check for Ludlum Model 2424 with a 43-93 Detector

Form REC-WP-2-03-1

Remedial Construction Services, L.P. (Recon)
9720 Derrington
Houston, TX 77064
(281)955-2442

Form REC-WP-2-03-1 Daily Check Log
Ludlum Model 2224 with 43-93 Detector

Instrument/SN: Ludlum Model 2224 /		***Check Source(s) Used:***
Detector/SN: Model 43-93 /		Date Calculated:
EFF % α = %, β= %	Total EFF % α = %, β= %	Calc. By: Alpha Beta
CALIB. SOURCE USED:		**Comments:**
DATE OF CALIB.:		
CALIB. DUE DATE:		
PERFORMED BY:		

TECHNICIAN'S NAME	ALPHA / BETA	DATE	TIME	background count time (minutes)	background counts	GROSS READING	NET READING	BATT. CHECK	NEEDS CALIB.
	α								
	β								
	α								
	β								
	α								
	β								
	α								
	β								
	α								
	β								
	α								
	β								
	α								
	β								
	α								
	β								
	α								
	β								
	α								
	β								

Prepared By:	Date:
Reviewed By:	Date:

11

PROCEDURE: REC-WP-2-04

Ludlum Model 3 Scaler/Ratemeter with the Model 44-9 Detector

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: MARCH 2004

Approved, Bill Vinzant

J. W. (Bill) Vinzant
Kaiser Aluminum &Chemical Corporation

3-31-04
Date:

PROCEDURE: REC-WP-2-04

Ludlum Model 3 Scaler/Ratemeter with the Model 44-9 Detector

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: MARCH 2004

Prepared by:	Date: 3-29-04	Quality Control Supervisor:	Date: 3/29/04

1.0 PURPOSE

The purpose of this procedure is to provide basic operational instruction for the Ludlum Model 3 Scaler/Ratemeter with the Model 44-9 Detector.

2.0 DEFINITIONS

Background: A measurement taken by an instrument to determine the amount of naturally occurring radiation at a given time at a given location.

Calibration source: A National Institute of Standards and Technology- (NIST) traceable check source of a known value used to calibrate or verify the response efficiency of an *instrument.*

Detector: The portion of an *instrument* that transmits a signal to a *meter* based upon the radioactive activity present. The model 44-9 detector is attached to the model 3 *meter*.

Instrument: A meter-detector combination that has been calibrated as a single unit. This instrument is capable of being calibrated with several detectors simultaneously.

Meter: The portion of this *instrument* that receives and translates signals from the *detector* into a user observable result.

Efficiency: A measure of this instrument's ability to detect radiological activity. It is calculated by using the formula below:

$$E = ((C-B_r)/D)$$

Where:

E = Instrument efficiency
C = Displayed value from the instrument count of the calibration source (count rate)
B_r = Background count rate
D = Known decay-corrected disintegrations per minute (dpm) value of the calibration source

3.0 PREREQUISITES/PRECAUTIONS/LIMITATIONS

3.1 Any person operating a radiological survey instrument must be trained in its use or supervised during its operation by a qualified instructor.

3.2 Failure of any preoperational check will result in the instrument being removed from operation and repaired as necessary.

3.3 Any operator repair that may affect the efficiency response of the detector requires that the new efficiency response be within 10 percent of the calibration value but does not necessarily require a new calibration. If the new efficiency response is not within 10 percent of the calibration value, the instrument will be removed from operation and recalibrated.

3.4 An operator repair such as replacing batteries or cables does not require the instrument to be recalibrated. However, the efficiency of the instrument should be recalculated by using the formula listed above.

3.5 All manufacturer's recommendations regarding use, calibration, and/or maintenance of this instrument will be followed unless otherwise documented in this or other written procedure(s).

3.6 Additional guidance for operating this instrument can be found in the appropriate procedure and/or the manufacturer's manual for that instrument.

3.7 Basic Instrument Operation - REC-WP-2-01

3.8 Instrument Minimum Detectable Concentration Calculations - REC-WP-2-02

4.0 EQUIPMENT

- Ludlum Model 3 Scaler/Ratemeter, or equivalent
- Ludlum Model 44-9 Detector, or equivalent

5.0 PROCEDURE

5.1 Preoperational Checks

5.1.1 Turn the instrument on and perform a battery check or verify that the power is on. Replace batteries (or charge battery as appropriate) if necessary.

5.1.2 Adjust the audible volume so that the alpha and beta/gamma clicks can be easily heard in work area.

5.2 Operational Checks

5.2.1 Prior to using the counting system, the source check acceptance criteria of the average response will be determined. If the instrument is recalibrated at any point, the source check acceptance criteria will need to be re-established, in accordance with Procedure REC-WP-2-01.

5.2.2 Each day the instrument is used, determine ambient background and record on form REC-WP-2-04-1.

5.2.3 Each day that a counting system is used, the response will be checked using an appropriate source, as follows.

5.2.4.1 Perform the source count by placing the appropriate source (alpha or beta) beneath the detector in a fixed-count geometry. This count is performed on both alpha and beta sources.

5.2.4.2 The value of the net counts per minute is compared to the acceptance criteria to determine a pass or fail status.

5.2.4.3 Record the source check readings on the form REC-WP-2-04-1.

5.2.4 Check the source check result against the established postcalibration acceptance criteria. Failed source checks will be repeated. Consecutive failures will result in additional testing of the instrument. Refer to instrument manual.

5.2.5 Survey data acquired prior to the instrument failing a source check will be reviewed to determine the validity of the data. This review will be documented on form REC-WP-2-04-1.

5.2.6 Determine the minimum detectable concentration for the instrument as required, in accordance with Procedure REC-WP-2-02.

6.0 REFERENCES

NA

7.0 ATTACHMENTS

Form REC-WP-2-04-1	Daily Check for Ludlum Model 3 with a 44-9 Detector

Form REC-WP-2-04-1

Remedial Construction Services, L.P. (Recon)
9720 Derrington
Houston, TX 77064
(281) 955-2442

Form REC-WP-2-04-1
Daily Check Log for Ludlum Model 3 with 44-9 Detector

Instrument Model:	3
Instrument S/N:	
Detector Model:	44-9
Detector S/N:	
Calibration Due:	

Source S/N:	
Source DPM:	
Radiation Detected:	Beta/Gamma
Acceptable Range: (Refer to REC-WP-2-01-1)	

Date	Background Count Rate	Gross Source Count Rate	Net Source Count Rate	Technician	Comments

Comments:	
Prepared By:	Date:
Reviewed By:	Date:

12

PROCEDURE: REC-WP-2-05

Ludlum Model 19 ~~22~~U R Meter

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: MARCH 2004

Approved, Bill Vinzant

J. W. (Bill) Vinzant
Kaiser Aluminum &Chemical Corporation

3-31-04
Date:

PROCEDURE: REC-WP-2-05

Ludlum Model 19 μ R Meter

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: MARCH 2004

[signature]	3.29.04	[signature]	3/29/04
Prepared by:	Date:	Quality Control Supervisor:	Date:

Remedial Construction Services, L.P. (Recon)
9720 Derrington
Houston, TX 77064
(281) 955-2442

Procedure: REC-WP-2-05

Title: Ludlum Model 19 µR Meter

1.0 PURPOSE

The purpose of this procedure is to provide basic operational instructions for the Model 19 µR Meter.

2.0 DEFINITIONS

AEPR: Acceptable End Point Range, range of detection displayed on the instrument where the confidence of the meter is not in question. The AERP is generally the center three quarters of the analog meter face.

3.0 PREREQUISITES/PRECAUTIONS/LIMITATIONS

3.1 Basic Instrument Operation – See Procedure REC-WP-2-01

4.0 EQUIPMENT

- Ludlum Model 19 µR Meter
- Batteries

5.0 PROCEDURE

5.1 Installing Batteries

5.1.1 Open the lid and install two "D" size batteries. Note (+) (-) marks on the inside of lid. Match the battery polarity to these marks.

NOTE: To open the battery lid, twist the lid button counterclockwise one-quarter turn. To close, twist clockwise one-quarter turn.

5.1.2 Close the battery box lid.

5.2 Preoperational Checks

5.2.1 Adjust the audio (AUD) ON-OFF switch as desired.

5.2.2 Replace the batteries if the meter pointer is below the "BAT TEST" line. Check the battery by switching the power switch to "BATT".

5.2.4 Depress the Light Button (L). Check for light on the meter face.

5.2.5 Check the meter response in the "F" (fast) and "S" (slow) positions.

5.2.6 Check the audio indication with the "AUD ON-OFF" switch.

5.2.7 Check the instrument for the proper scale indication with a known source.

5.2.8 Depress the reset (RES) pushbutton. Check to see that the meter pointer returns to the zero position.

5.3 Operational Checks

5.3.1 Prior to using the Ludlum Model 19, the performance check value of the average response will be determined. If the instrument is recalibrated at any point, the performance check values will need to be re-established in accordance with Procedure REC-WP-2-01.

5.3.2 Each day the instrument is used, determine the ambient background and record on Form REC-WP-2-05-1.

5.3.3 Each day that the Ludlum Model 19 is used, the response will be checked using an appropriate check source as follows:

5.3.3.1 Place the check source on the front lower portion of the meter.

5.3.3.2 Allow for the meter face to stabilize.

5.3.3.3 Ensure that the meter reading is taken within the AEPR for accuracy and reproducibility.

5.3.4 Check the source check result against the established post-calibration acceptance criteria. Failed source checks will be repeated. Consecutive failures will result in additional testing of the instrument. Refer to the instrument manual.

5.3.5 Survey data acquired prior to an instrument failing a source check will be reviewed to determine the validity of the data. This review will be documented on form REC-WP-2-05-1 .

5.3.6 Record the source check reading on Form REC-WP-2-05-1.

6.0 REFERENCES

6.1 Instruction Manual - Ludlum Measurements, Inc., Sweetwater, TX, for Model 19 µR Meter, Revised July, 1997 for Serial Number138413 and succeeding serial numbers.

7.0 ATTACHMENTS

Form REC-WP-2-05-1 Daily Check Log for Ludlum Model 19 R µR Meter

Form REC-WP-2-05-1

Remedial Construction Services, L.P. (Recon)
9720 Derrington
Houston, TX 77064
(281) 955-2442

Form REC/WP-2-05-1
Daily Check Log for Ludlum Model 19 μR Meter

Instrument Model:	19 μR
Instrument S/N:	
Detector Model:	N/A
Detector S/N:	N/A
Calibration Due:	

Source S/N:	
Source DPM:	N/A
Radiation Detected:	Gamma
Acceptable Range: (Refer to REC-WP-2-01-1)	

Date	Background μR/hr	Gross Source μR/hr	Net Source μR/hr	Technician	Comments

Comments:

Prepared By:	Date:
Reviewed By:	Date:

13

PROCEDURE: REC-WP-2-06

Ludlum Model 177 Scaler/Ratemeter with the Model 44-9 Detector

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: MARCH 2004

Approved, Bill Vinzant ______________________ 3-31-04 ______________

J. W. (Bill) Vinzant
Kaiser Aluminum &Chemical Corporation

Date:

PROCEDURE: REC-WP-2-06

Ludlum Model 177 Scaler/Ratemeter with the Model 44-9 Detector

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: MARCH 2004

3-24-04 3/29/04

Prepared by: Date: Quality Control Supervisor: Date:

1.0 PURPOSE

The purpose of this procedure is to provide basic operational instruction for the Ludlum Model 177 Scaler/Ratemeter with the Model 44-9 Detector.

2.0 DEFINITIONS

Background: A measurement taken by this instrument to determine the amount of naturally occurring radiation at a given time at a given location.

Calibration source: A National Institute of Standards and Technology- (NIST) traceable check source of a known value used to calibrate or verify the response efficiency of an *instrument*.

Detector: The portion of the *instrument* that transmits a signal to a *meter* based upon the radioactive activity present. The model 44-9 detector is attached to the model 177 *meter*.

Instrument: A meter-detector combination that has been calibrated as a single unit. Some instruments are capable of being calibrated with several detectors simultaneously.

Meter: The portion of the *instrument* that receives and translates signals from the *detector* into a user observable result.

Efficiency: A measure of the instrument's ability to detect radiological activity. It is calculated by using the formula below:

$$E = ((C-B_r)/D)$$

Where:

E = Instrument efficiency
C = Displayed value from the instrument count of the calibration source (count rate)
B_r = Background count rate
D = Known decay-corrected disintegrations per minute (dpm) value of the calibration source

3.0 PREREQUISITES/PRECAUTIONS/LIMITATIONS

3.1 Any person operating a radiological survey instrument must be trained in its use or supervised during its operation by a qualified instructor.

3.2 Failure of any preoperational check will result in the instrument being removed from operation and repaired as necessary.

3.3 Any operator repair that may affect the efficiency response of the detector requires that the new efficiency response be within 10 percent of the calibration value but does not necessarily require a new calibration. If the new efficiency response is not within 10 percent of the calibration value, the instrument will be removed from operation and recalibrated.

3.4 An operator repair such as replacing batteries or cables does not require the instrument to be recalibrated. However, the efficiency of the instrument should be recalculated.

3.5 All manufacturer's recommendations regarding use, calibration, and/or maintenance of an instrument will be followed unless otherwise documented in this or other written procedure(s).

3.6 Additional guidance for operating an instrument can be found in the appropriate procedure and/or the manufacturer's manual for that instrument.

3.7 REC-WP-2-01, "Basic Instrument Operation"

3.8 REC-WP-2-02, "Instrument Minimum Detectable Concentration Calculations"

4.0 EQUIPMENT

- Ludlum Model 177 Scaler/Ratemeter, or equivalent
- Ludlum Model 44-9 Detector, or equivalent

5.0 PROCEDURE

5.1 Preoperational Checks

5.1.1 Turn the instrument on and perform a battery check or verify that the power is on. Replace batteries (or charge battery as appropriate) if necessary.

5.1.2 Adjust the audible volume so that the alpha and beta/gamma clicks can be easily heard.

5.2 Operational Checks

5.2.1 Prior to using the counting system, the source check acceptance criteria of the average response will be determined. If the instrument is recalibrated at any point, the source check acceptance criteria will need to be re-established, in accordance with Procedure REC-WP-2-01.

5.2.2 Each day the instrument is used, determine ambient background and record on appropriate form.

5.2.3 Each day that a counting system is used, the response will be checked using an appropriate source, as follows.

5.2.4.1 Perform the source count by placing the appropriate source (alpha or beta) beneath the detector in a fixed-count geometry. This count is performed on both alpha and beta sources.

5.2.4.2 The net counts per minute value is compared to the acceptance criteria to determine a pass or fail status.

5.2.4.3 Record the source check readings on the appropriate form.

5.2.4 Check the source check result against the established postcalibration acceptance criteria. Failed source checks will be repeated. Consecutive failures will result in additional testing of the instrument. Refer to instrument manual.

5.2.5 Survey data acquired prior to an instrument failing a source check will be reviewed to determine the validity of the data. This review will be documented.

5.2.6 Determine the minimum detectable concentration for the instrument as required, in accordance with Procedure REC-WP-2-02.

6.0 REFERENCES

NA

7.0 ATTACHMENTS

Form REC-WP-2-06-1	Daily Check for Ludlum Model 177 with a 44-9 Detector

Form REC-WP-2-06-1

Remedial Construction Services, L.P. (Recon)
9720 Derrington
Houston, TX 77064
(281) 955-2442

Form REC-WP-2-06-1
Daily Check Log for Ludlum Model 177 with 44-9 Detector

Instrument Model:	177
Instrument S/N:	
Detector Model:	44-9
Detector S/N:	
Calibration Due:	

Source S/N:	
Source DPM:	
Radiation Detected:	Beta/Gamma
Acceptable Range: (Refer to REC-WP-2-01-1)	

Date	Background Count Rate	Gross Source Count Rate	Net Source Count Rate	Technician	Comments

Comments:

Prepared By:	Date:
Reviewed By:	Date:

14

PROCEDURE: REC-WP-2-07

Ludlum Model 2929 Dual Scaler with the Model 43-10-1 Detector

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: MARCH 2004

Approved, Bill Vinzant 3-31-04

J. W. (Bill) Vinzant
Kaiser Aluminum &Chemical Corporation

Date:

PROCEDURE: REC-WP-2-07

Ludlum Model 2929 Dual Scaler with the Model 43-10-1 Detector

Thorium Remediation Project
Tulsa, Oklahoma

REVISION: 00

EFFECTIVE DATE: MARCH 2004

Prepared by:	Date: 3-29-04	Quality Control Supervisor:	Date: 3/29/04

1.0 PURPOSE

The purpose of this procedure is to provide basic operational instruction for the Ludlum Model 2929 Dual Scaler.

2.0 DEFINITIONS

Background: A measurement taken by an instrument to determine the amount of naturally occurring radiation at a given time at a given location.

Planchet: A tray onto which a *swipe* sample or *smear* is placed in order to be analyzed.

Swipe: A cloth or paper disc that is wiped on the surface of an area or object being surveyed. Also referred to as a *smear.*

3.0 PREREQUISITES/PRECAUTIONS/LIMITATIONS

3.1 REC-WP-2-01, "Basic Instrument Operation"

3.2 REC-WP-2-02, "Instrument Minimum Detectable Concentration Calculations"

4.0 EQUIPMENT

- Ludlum Model 2929 Dual Scaler
- Planchets
- Cloth Swipes

5.0 PROCEDURE

5.1 Preoperational Checks

5.1.1 Turn the instrument on.

5.1.2 Slide sample receiver into the base of the counting instrument and lock down the receiver by turning the locking mechanism clockwise.

5.2 Operational Checks

5.2.1 Prior to using the counting system, the source check acceptance criteria of the average response will be determined. If the instrument is recalibrated at any point, the source check acceptance criteria will need to be re-established, in accordance with Procedure REC-WP-2-01.

5.2.2 Each day the instrument is used, determine the ambient background and record on the form REC-WP-2-07-1.

5.2.3 Perform the background count for the predetermined duration by completely closing and locking the tray and pressing the count button. At the end of the time, record the results on form REC-WP-2-07-1.

5.2.4 Each day that a counting system is used, the response will be checked using an appropriate source, as follows.

5.2.4.1 Perform the source count by placing the appropriate source (alpha or beta) on a planchet. Place the planchet in the tray and insert the tray. Completely close the tray and lock the source into place. Begin the source count by depressing the count button. At the end of the time, record the results on form REC-WP-2-07-1. This count is performed on both alpha and beta sources.

5.2.4.2 The net counts per minute (cpm) value is compared to the acceptance criteria to determine a pass or fail status.

5.2.4.3 Record the source check readings on the form REC-WP-2-07-1.

5.2.4 Compare the source check result against the established postcalibration acceptance criteria. Failed source checks will be repeated. Consecutive failures will result in additional testing of the instrument. Refer to instrument manual.

5.2.5 Survey data acquired prior to an instrument failing a source check will be reviewed to determine the validity of the data. This review will be documented on form REC-WP-2-07-1.

5.2.6 Determine the minimum detectable concentration for the instrument as required, in accordance with Procedure REC-WP-2-02.

5.3 Counting Samples

5.3.1 Check and set the time indicator for the sample count guidelines.

5.3.2 Place the swipe sample on a planchet. Open the tray and insert the planchet. Completely close the tray and lock it into place. Press the count button.

5.3.3 At the end of the predetermined time period, record the alpha and beta/gamma counts on form REC-WP-2-07-1.

5.3.4 Remove the planchet and repeat, as necessary.

6.0 REFERENCES

NA

7.0 ATTACHMENTS

Form REC-WP-2-07-1 Daily Check for Ludlum Model 2929 with a 43-10-1 Detector

Form REC-WP-2-07-1

Remedial Construction Services, L.P. (Recon)
9720 Derrington
Houston, TX 77064
(281) 955-2442

Form REC-WP-2-07-1
Daily Check Log for Ludlum Model 2929 with a 43-10-1 Detector

Instrument Model:	2929
Instrument S/N:	
Detector Model:	43-10-1
Detector S/N:	
Calibration Due:	

Source S/N:		
Source Amount		
Radiation Detected:	Alpha	Beta
Acceptable Range:		
Background Count Time:		

Date	Background Count Rate Alpha (cpm)	Background Count Rate Beta (cpm)	Gross a Source Count Rate (cpm)	Gross b Source Count Rate (cpm)	Net a Source Count Rate (cpm)	Net b Source Count Rate (cpm)	Technician	Comments

Prepared By:	Date:
Reviewed By:	Date: