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ANTHONY J. THOMPSON, P.C.
(202) 663-9198

November 10, 1997

Ms. Marie Miller
Nuclear Regulatory Commission
Decommissioning and Lab Branch
Division of Nuclear Materials Safety
Region I
475 Allendale Road
King of Prussia, PA 19406-1415

Re: ERRATA

Dear ~~Ms. Miller~~ Marie:

The FSSP for Heritage Minerals, Inc. (HMI) which was forwarded to you under cover of my letter dated November 3, 1997 refers to the updated cost estimates for decommissioning of the HMI facility as Appendix I, Attachment I and Addendum I in three different places. I apologize if this error has caused any confusion. The important point is that all three references are to the same document -- the updated cost estimates.

Very truly yours,

Tony

Anthony J. Thompson

AJT/cls

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November 3, 1997

Ms. Marie Miller
Nuclear Regulatory Commission
Decommissioning and Lab Branch
Division of Nuclear Materials Safety
Region I
475 Allendale Road
King of Prussia, PA 19406-1415

Dear ~~Ms. Miller~~ Marie:

Enclosed is the "Final Status Survey Plan for License Termination of Heritage Minerals NRC License #SMB-1541 (hereafter FSSP)."

We believe the FSSP provides a detailed explanation of Heritage Minerals, Inc.'s (HMI) approach to decommissioning and decontamination of the mill buildings and monazite piles subject to the above-referenced license. The FSSP incorporates a variety of changes from the draft which you viewed at the recent inspection visit at the Heritage facility on September 16, 1997. I believe the FSSP is responsive to the comments received and the discussions among the attendees at that meeting. At your request, the FSSP also includes an updated cost estimate (Appendix I) for the decommissioning and decontamination of the licensed facilities and the monazite pile area. We understand you will review the FSSP and that a copy will be provided to the New Jersey Department of Environmental Protection, Region III of EPA and to the general public comment by any interested parties after notice in the Federal Register.

Should you have any questions at anytime regarding anything in the FSSP, please do not hesitate to contact me.

Very truly ~~yours,~~

Tony

~~Anthony J. Thompson~~

AJT/cls
Enclosure

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Final Status Survey Plan
for
License Termination of
Heritage Minerals
NRC License # SMB-1541

Table of Contents

1.0 Introduction

This decommissioning plan addresses the NRC licensed area and buildings on the Heritage Minerals (HMI) Site in Lakehurst, New Jersey. Beginning in 1987, on sands stockpiled from a previous company's operations, HMI processed several types of commercial minerals through gravimetric, conductive and magnetic separation. No chemicals were used in the process. Operations ceased in 1990. A detailed description of the operations and site history is provided in Appendix C.

One of the commercial minerals produced by HMI, monazite, contains thorium and uranium. Possession of this material, when greater than 0.05% by weight, is a licensed activity regulated by the Nuclear Regulatory Commission (NRC). This document presents a plan for proper removal of licensed material and survey of the site to demonstrate that the property and equipment is suitable for license termination and release for unrestricted use.

A decommissioning cost estimate is included as Attachment I.

2.0 Existing Data Review

The available data on post decontamination surveys consists of fixed and removable measurements obtained by HMI personnel at ten locations, five each in the wet mill and dry mill. The removable alpha and beta results are below any release limits discussed in NRC guidance documents, however the documentation and quality control procedures are not sufficient to satisfy the current requirements for decommissioning as put forth in NUREG-5849. Therefore, the available data on post decontamination measurements will not be suitable for inclusion in the final status survey report.

Another source of existing data is a radon flux mapping procedure developed by SENES Consultants Limited (SENES 95). However, the purpose of that study was "to provide a mapping procedure which calculates radon flux rates for the proposed residential site". The information does not pertain to decommissioning the buildings or affected outdoor areas, and will not be utilized in this plan.

A survey of the natural background levels of uranium and thorium, and the background exposure rate onsite was conducted in 1996 by Radiation Science Inc. Those values were established using sampling and statistical guidance from NUREG- 5849. The information from that study will be used to correct final survey soil samples and exposure rate measurements for the contribution due to background.

Samples of the monazite pile analyzed by Teledyne Isotopes in April of 1990, indicate Ra-226, Pb-214, and Bi-214, all daughters in the uranium series, to be in equilibrium. Likewise, three daughter nuclides in the thorium series, Ac-228, Pb-212, and Tl-208 were found to be in equilibrium. This data is used to support the assumption that all natural series decay chains are in equilibrium.

3.0 Decommissioning Activities

The following list of activities is proscribed in NUREG-5849 as requirements leading to the termination of an NRC license, and serve as a rough work plan for this project.

- Terminate the possession and storage of radioactive material.
- Remove radioactive material from the facility.
- Properly dispose of any radioactive material removed.
- Submit an NRC-314 "Disposition of Radioactive Materials" form.
- Conduct Final Site Survey.
- Submit report to the NRC.

4.0 Release limits

All limits discussed here are selected to allow unrestricted release of the site. HMI's license states "for measurement purposes all contamination may be assumed to be natural thorium in equilibrium with its daughters' Therefore, surface activity limits are based on alpha emissions from natural thorium. Soil concentration limits are based on total uranium (U-238 + U-234) and total thorium (Th-232 + Th-228) in equilibrium with progeny in their respective decay chains. Release limits stated here are above background, and are summarized in Table 2.

The background area in terms of dose rate and uranium and thorium soil concentrations is the unmined areas of the site. During May 1996 an extensive background determination was conducted following the guidance in NUREG-5849. (RSI 7/96) Those values will be used for "background" corrections of soil samples, and as the "baseline" dose rate. They are reproduced in Table 1. The report is included in its entirety in Appendix A.

To date there has been no background values established for equipment and buildings. The background area for surface activity measurements will be the unaffected buildings onsite, (refer to Figure 2). A separate background value will be established for concrete surfaces and metal surfaces, as part of the final site survey.

Parameter	Level
Total uranium Concentration	0.62 pCi/g
Total thorium Concentration	0.48 pCi/g
Exposure Rate	2.84 μR/hr

Table 1 - Background concentrations and exposure rate

4.1 Surface activity

The activity limits specified in HMI's materials license are based on thorium in equilibrium with its daughters. Those values are 1,000 dpm/100 cm^2 average fixed, 3,000 dpm/100 cm^2 maximum fixed and 200 dpm/100 cm^2 maximum removable. These release limits will be used for this decommissioning project.

4.2 Soil concentration

Condition 15 of Heritage Minerals' NRC license specifies "All areas ... on a map of the licensee's site attached to the letter dated September 27,1990 shall be decontaminated to meet the criteria for release for unrestricted use described in Option I of the Branch Technical Position "Disposal or Onsite Storage of Thorium or uranium Wastes from Past Operations". The limit for total thorium is 10 pCi/g, and the limit for total Uranium is also 10 pCi/g. As discussed in the next section, these soil activity limits will also demonstrate compliance with the exposure rate limit.

4.3 Exposure Rate

There are two methods for demonstrating compliance with the dose rate limits. The first method would involve direct measurements with a microRmeter or pressurized ion chamber. The "shine" from the nearby, unlicensed tailings would make this difficult without shielding the meter. However, to obtain readings at waist level would require an extremely large lead cone, which would be unmanageable in the field. The second method is to obtain post-remediation soil samples for laboratory analysis, and base the exposure rate on soil activity once background activity has been subtracted. This is the method that will be employed for this decommissioning. The NRC's Branch Technical Position Paper explicitly states " ..the concentrations are sufficiently low so that no individual may receive an external dose in excess of 10 micro-roentgens per hour above background" The concentrations referred to (Option 1, stated in section 4.2 above) are those selected here for the soil cleanup criteria. In the spirit of ALARA, HMI assumes final soil concentrations will be well below the 10 pCi/g (therefore 10 μr/hr) limits. A limited number of soil concentration- to- exposure calculations using computer software such as Microshield, will be conducted.

Parameter	Release Limit
Total thorium in soil	10 pCi/g
Total uranium in soil	10 pCi/g
Surface activity - max. fixed	3,000 dpm/100 cm^2
Surface activity - avg. fixed	1,000 dpm/100 cm^2
Surface activity - removable	200 dpm/100 cm^2
Exposure rate	10 μR/hr

Table 2 - Release limits above background

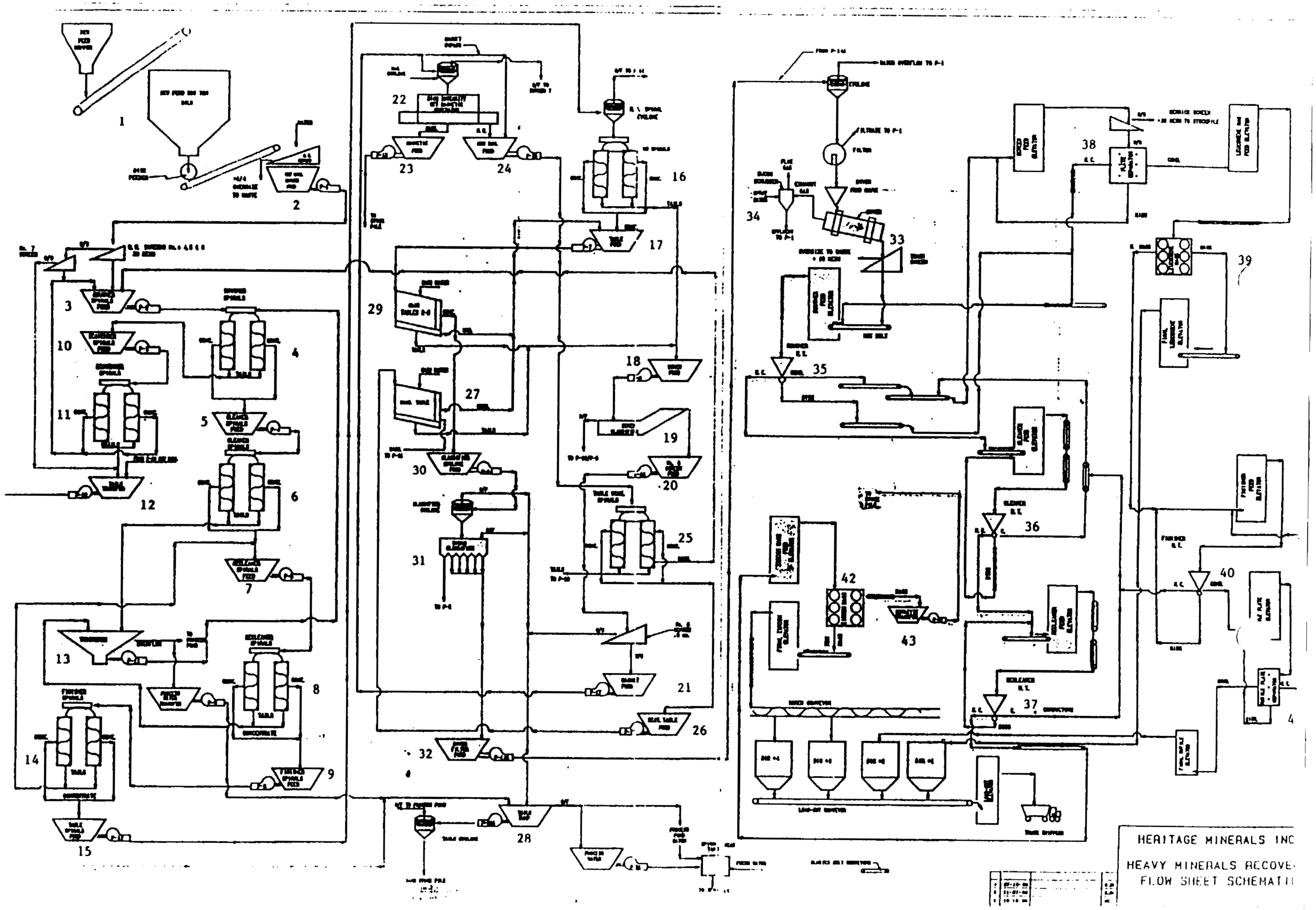
5.0 Affected / Unaffected Survey Units

The basic rationale for dividing the site into affected and unaffected areas is provided in this section. Appendix C provides a detailed description of the operating history used to identify the affected process trains. The site at Heritage Minerals, while no longer processing sands for the concentration of various naturally occurring minerals, remains in a shutdown condition. Some support buildings are still used for equipment storage and repair. The wet and dry mill equipment is non-operational but both buildings contain millions of dollars worth of heavy equipment including; tanks, elevators, high tension separators, piping, and hundreds of tons of heavy equipment and structural supports. The complexity of the interior of both buildings pose a challenge to the application of a two dimensional grid system survey as proscribed in NUREG 5849.

Both the wet and dry mills have distinct process "trains" or routes the incoming material traveled. These routes were not linear, so at some points the depleted stream was diverted, while at others concentration of uranium and thorium occurred. Each mill will be divided into survey units based on the potential for concentration of uranium/thorium and common historical use with regards to material contact, as suggested in NUREG 1505. The process flow diagram (Figure 1) identifies the movement, separation, and enrichment of the various product streams through the mills. The diagram follows the raw material (ASARCO sands) to the finished product streams (zircon, leucoxene, rutile, and monazite) and mill tailings. Each process step represents a further enrichment in Thorium and Uranium since these elements follow the product stream and are removed with the monazite in the final process separation.

Each process step is represented by a physical set of equipment consisting of tanks, piping, conveyors, and/or heavy equipment. Each process step includes duplicate equipment systems. The individual systems handle the same feed material in parallel so as to increase through-put. Since each step enriches the process stream in the product, thorium and uranium are typically more

FIGURE 1


HERITAGE MINERALS INC
HEAVY MINERALS RECOVE
FLOW SHEET SCHEMATI

concentrated at the end, than at the beginning of each process step. Once the product leaves the process equipment in transit to the next step, such as in a piping or conveyor system, the concentration of these isotopes remains the same.

Individual process steps (e.g. zircon magnetic separation) and related equipment (e.g. magnetic coils and conveyors) represent logical survey units which can be examined according to the rules of NUREG 5849. This allows application of the NUREG-5849 survey recommendations (affected or unaffected, number of sampling points, and averaging rules) in a meaningful fashion to obtain a report representative of the final plant status. The process trains with the potential to be contaminated based on process knowledge are highlighted on figure 1. Outdoor areas are shown on Figure 2.These survey units are identified and located as described below:

Outdoor Properties- Unaffected

Except for the monazite pile and the area immediately surrounding the pile, all outdoor properties are unaffected. For purposes of the final status survey, the area of open space extending beyond the wet mill building to the north, south, and east by approximately 10 meters will be included in the survey. The area of open space extending approximately 10 meters around the dry mill is also included in the survey. See Figures 2, 3, 4,and 5.

Office Building - Unaffected

The Office Building was used to support administrative personnel. No process material was used in this building. See Figure 2.

Warehouse Building - Unaffected

The Warehouse Building was used for storage of new mechanical equipment and parts. No process material was used in this building. See Figure 2.

Service Building - Unaffected

The Service Building was used for repair of mechanical equipment from plant operations. No process material was used in this building. See Figure 2.

Change House - Unaffected

The Change House was used for site personnel only. It included showers and lockers for workers at the site. No process material was used in this building. See Figure 2.

FIGURE 2

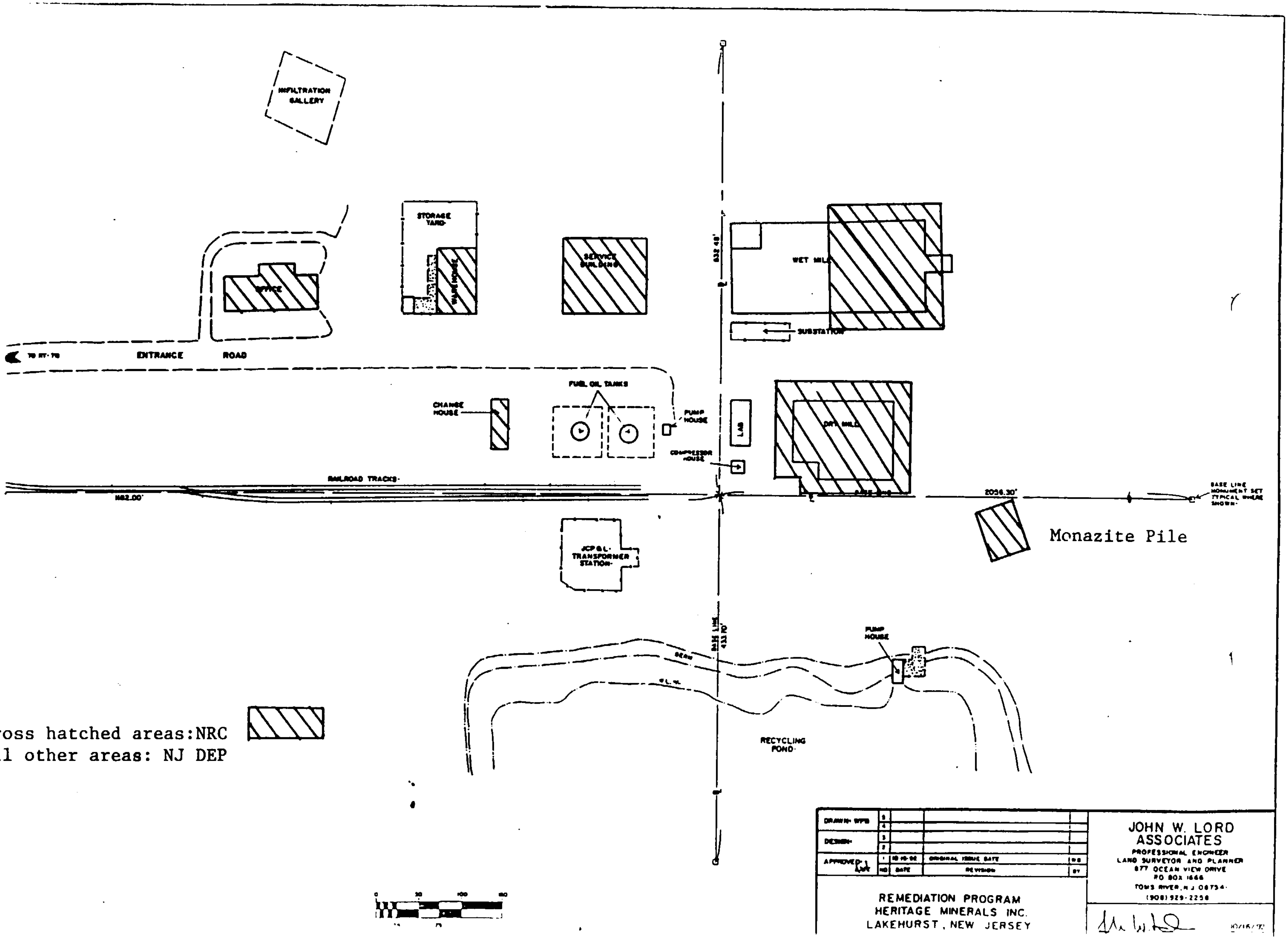
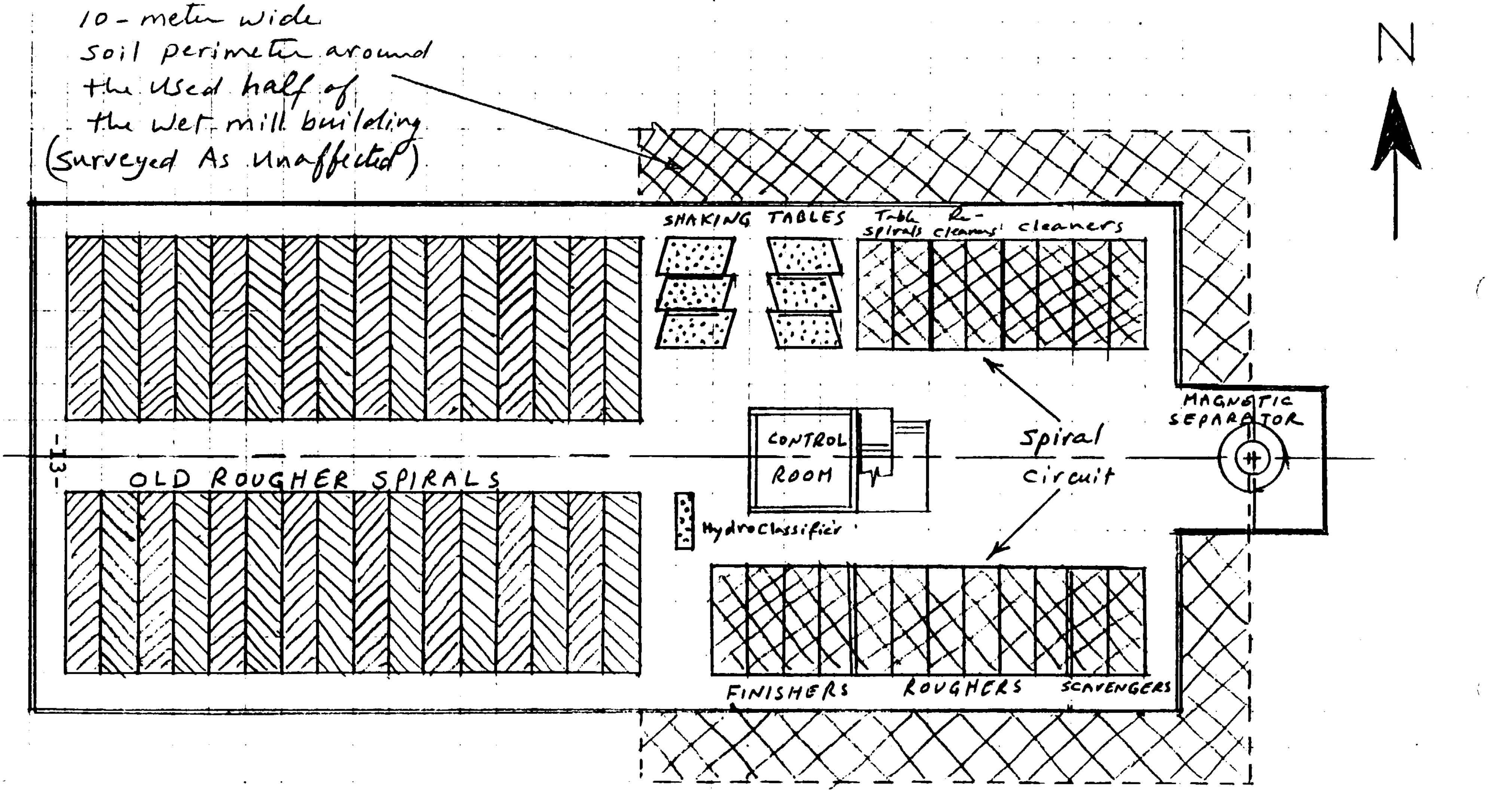

INFILTRATION GALLERY
STORAGE YARD
WAREHOUSE
OFFICE
SERVICE BUILDING
WET MILL
SUBSTATION
ENTRANCE
ROAD
FUEL OIL TANKS
CHANGE HOUSE
PUMP HOUSE
LAB
DRY MILL
COMPRESSOR HOUSE
RAILROAD TRACKS
2036.30'
Monazite Pile
JCP&L TRANSFORMER STATION
BASE LINE
PUMP HOUSE
RECYCLING POND
Cross hatched areas:NRC
All other areas: NJ DEP
DRAWN: WPB
DESIGN:
APPROVED:
ORIGINAL ISSUE DATE
NO
DATE
REVISION
BY
JOHN W. LORD ASSOCIATES
PROFESSIONAL ENGINEER
LAND SURVEYOR AND PLANNER
877 OCEAN VIEW DRIVE
PO BOX 1666
TOMS RIVER, N.J. 08754
(908) 929-2258
REMEDIATION PROGRAM
HERITAGE MINERALS INC.
LAKEHURST, NEW JERSEY

Figure 3



UNUSED

USED-UNAFFECTED

AFFECTED

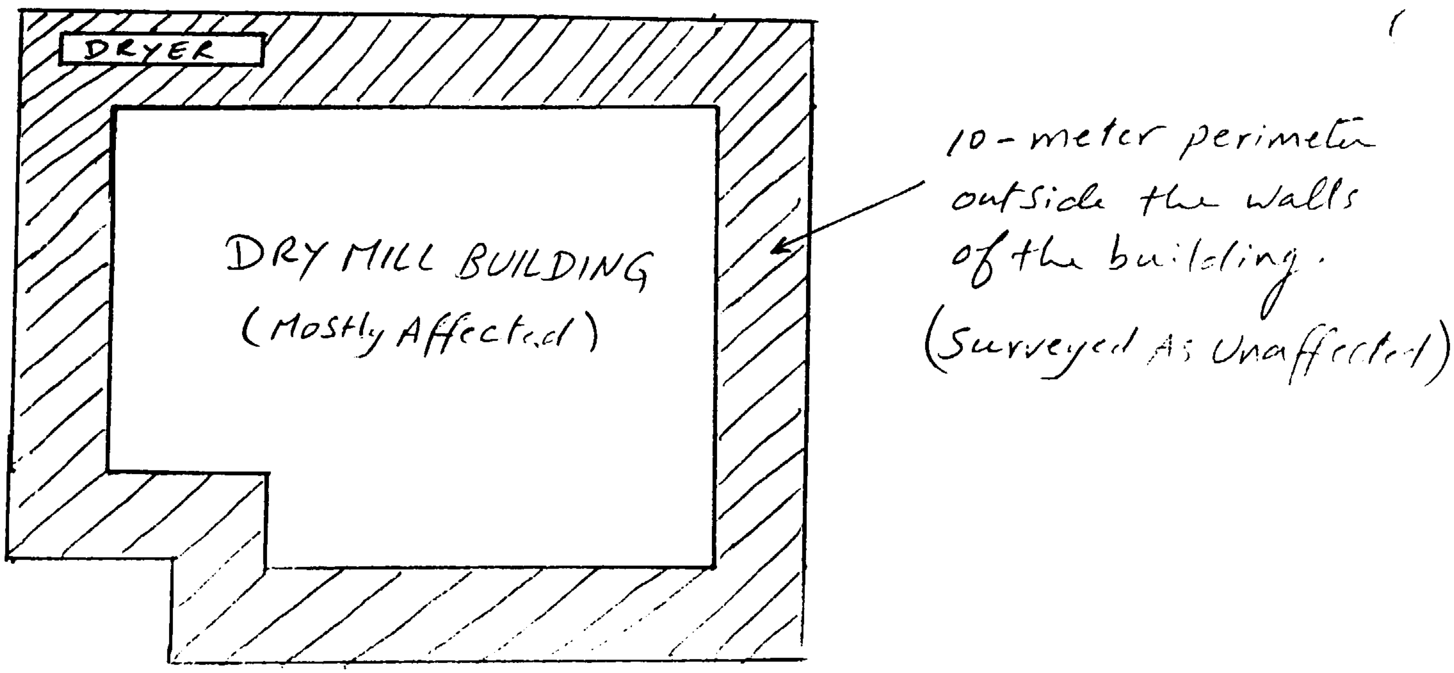
FLOOR PLAN OF THE WET MILL

SHOWING UNUSED, USED BUT UNAFFECTED

AND AFFECTED EQUIPMENT

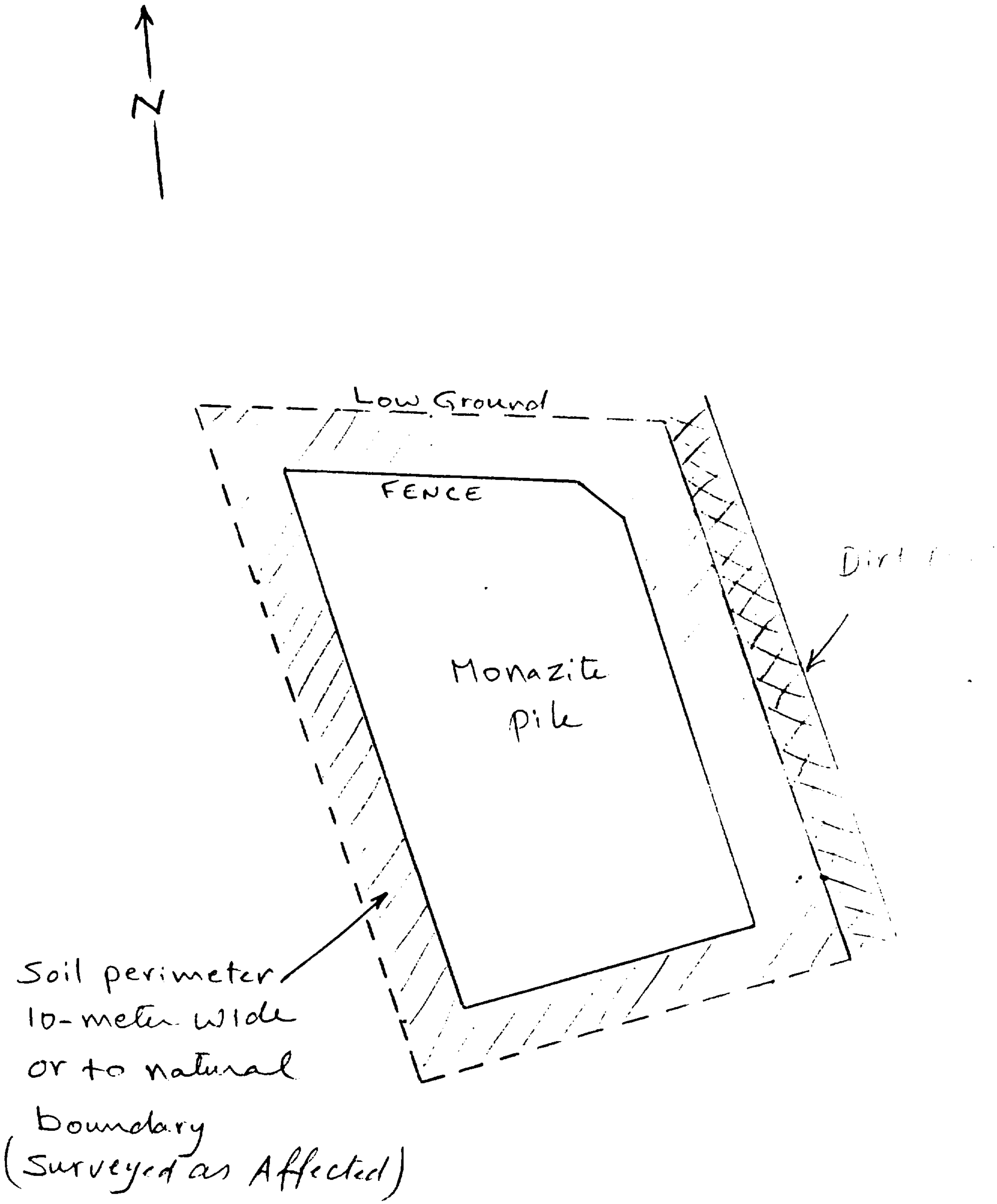
6/4/97

Figure 4



Dry Mill Building and Surrounding Soil

Figure 5



Affected Area At Monazite Pile

Laboratory - Unaffected

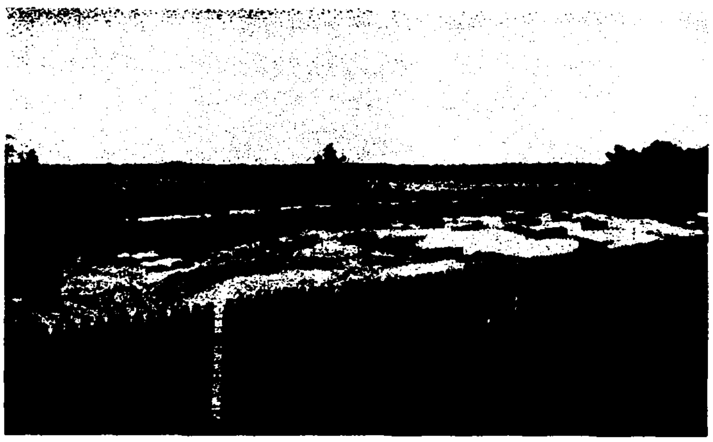
The Laboratory was used to analyze product samples from both mills. No process material was used in this building except as analytical samples. See Figure 2.

Wet Mill - see Appendix B

The Wet Mill Building contains process equipment used to extract the product materials from the raw feed. The equipment contained in the Wet Mill is divided into survey units as described in Appendix B. Some of these units are affected while the majority are unaffected. The floor and lower walls of the Wet Mill will be surveyed as an unaffected areas.

Dry Mill - see Appendix B

The Dry Mill Building contains process equipment used to extract the product materials from the process feed from the Wet Mill. The equipment contained in the Dry Mill is divided into survey units as described in appendix B. Some of these units are unaffected. The floor, ceiling and lower walls of the Dry Mill will be surveyed as affected areas.



Monazite Pile - Affected

Ten meter square grids will be established around the existing Monazite Pile, including the Monazite Pile and extending 10 meters beyond its current boundaries or to the first natural barrier where monazite would likely accumulate in higher concentrations as a result of wind or rain wash-out since the pile was not always covered. (e.g. the natural sand berms to the east and west and the low ground spot to the north of the pile). The area encompassed by the grids will be considered as an affected outdoor area.

6.0 Survey protocol

6.1 Affected Survey Units

Indoor

Affected equipment will be surveyed by dismantling as necessary and scanning with an appropriate survey meter 100% of the surface area of a single equipment train within a multiple unit system. Thirty, fixed location, one to two minute integrated measurements will be obtained in each survey unit. A wipe sample will be obtained at the location of each fixed measurement.

Outdoor

Following the packaging of the monazite for shipment, outdoor affected survey units will be scanned over 100% of the surface area with a 2"x2" sodium iodide crystal. Soil samples will be collected at a rate of one per 100 square meter grid.

6.2 Unaffected Survey Units

Indoor

Unaffected units will be surveyed by scanning 10% of the surface area with an appropriate survey meter. As with the affected survey units, thirty fixed location measurements will be obtained in each survey unit, with corresponding wipe samples. If any measurement within a particular survey unit is greater than 25%of the value for unrestricted release provided in section 4.0, then the entire survey unit will be deemed to be affected and resurveyed according to the protocol for survey of affected units as provided in section 6.1.

Outdoor

Outdoor unaffected areas will be scanned over 10% of their surface area, in the same manner as the affected areas. Thirty soil samples will be collected from the unaffected area surrounding both mills. If any soil sample measurement within a particular survey unit is greater than 75%of the value for unrestricted release provided in section 4.0, then the entire survey unit will be deemed to be affected and resurveyed according to the more stringent protocol for survey of affected units as provided in section 6.1. While there is no reason to expect any of the unaffected areas to contain concentrations of monazite ore, the requirement to upgrade the survey on the basis of a conservative guideline approach offers assurance that the survey unit will be adequately characterized.

7.0 Decontamination plan

7.1 Buildings and equipment

Building surfaces or equipment which may have been impacted by operations consists primarily of metal. No chemicals were used in the process, so it is likely monazite residue will be confined to the surface layer in the form of dust. Since decontamination was performed by Heritge Minerals in 1990 and it is unlikely that any recontamination has occurred, additional decontamination efforts may not be necessary. However, if decontamination becomes necessary, these surfaces would be brushed and vacuumed, using appropriate engineering controls and personnel protective equipment.

7.2 Monazite pile

The monazite pile (approximately 530 m^3) will be packaged in DOT approved containers and prepared for shipment. This will be accomplished using a small front end loader to transfer the material. A staging area will be set up immediately outside the existing fence to serve as a buffer zone between the controlled area and the clean area. Dust control measures may include a temporary enclosure for transfer of material, or a water spray system in the area surrounding operations. Any residual monazite sands on surface soils in the affected areas will be removed in a similar manner.

8.0 Data Reduction

Raw data collected during the final site survey will be validated, and reported in units identical to those of the release limits. For surface activity measurements, the average background from the reference area will be subtracted from the raw counts, and the results adjusted for the meters (4 pi) efficiency and probe area. Results will be reported in dpm/100 cm^2.

Soil samples will be analyzed by gamma spectroscopy. The U-238 activity will be inferred from the 609 kev photopeak of its daughter Bi-214. The Th-232 activity will be estimated from the 238 kev photopeak of its daughter Pb-212. All samples will be dried, sieved, and sealed for twenty eight days prior to counting to remove any concerns about secular equilibrium with the parent nuclides. Results will be reported in picocuries per gram (pCi/g) and adjusted for background. The U-238 results will be doubled to account for the U-234 activity, and reported as total uranium. The Th-238 results will be doubled to account for the Th-228 activity and reported as total thorium.

Exposure rate measurements will be reported in microRem per hour above background.

9.0 Statistical treatment

Guidance on the data reduction, statistical treatment and comparison with release limits was obtained from NUREG-1505 "A Nonparametric Statistical Methodolgy for the Design and Analysis of Final Status Decommissioning Surveys" (NRC 1995). This guidance is appropriate because data sets with most values reported as "less than" the instrument detection limits, or near background do not produce a normal distribution of values. When the data is plotted as a histogram, for example, the curve stops abruptly at the "less than" value or background, not smoothly approaching zero, i.e. the curve is not parametric. It is expected that after proper decontamination, residual radioactivity on most equipment and building surfaces at this facility will be less than the detection limit of the equipment. The only requirements on the data for nonparametric analysis is that the measured values are independent of one another. Because of the short range of alpha particles, any given surface activity measurements will not affect measurements at adjacent locations. Proper collection techniques for soil samples will prevent cross contamination, and thereby insure independent results.

There are three "tests" of the data from each survey unit. First. the highest single value in each survey unit must be less then three times the average release limit. The second step is to compare the median value, determined by the Wilcoxin Signed Ranks (WSR) test to the single, fixed value of the release limit. The final step is to use a Quantile test to check for small areas of elevated activity. The specifics of calculating these parameters are found in NUREG-1505.

10.0 Quality Assurance

Providing quality data for a decommissioning project is based on certain key elements as discussed in EPA guidance documents (EPA 504/G-93/071). These are known as PARCC (Precision, Accuracy, Representativeness, Completeness, and Comparability) parameters. In addition, the sensitivity of measurements, expressed as the Minimum Detectable Activity (MDA) must be sufficiently low to detect contamination $\leq$ 25% of the release criteria (NRC, 1992). The process for assessing these parameters is discussed below.

Precision

Precision is a test of how closely one can replicate a measurement. Replicate measurements for total alpha contamination will be made by obtaining two one minute counts in sequence at the same location for approximately 5% of the total number of samples. For soil samples, 5% will be blended and split in the field, then sent to the laboratory for individual analysis. The formula below will be used to determine the relative percent difference (RPD). One could expect measurements at this site to be reproduced within plus or minus ($\pm$) the RPD for a given type of measurement with similar instrumentation and count times.

$$\text{RPD} = \frac{\text{Measurement - Replicate Meas.}}{(\text{Measurement} + \text{Replicate Meas.})/2} \times 100\%$$

The RPD is often high for measurements near background, or low count rate alpha measurements. Also, "less then" values cannot be used to calculate a RPD. Therefore, the RPD will be calculated for positive values at least 50% of the release limits.

Accuracy

Accuracy is a test of how close the meter's response is to a known value. The "known value" will be a NIST traceable Thorium-230 source. Immediately after calibration and efficiency determination, a control chart will be established for each meter. The chart will be based on repetitive counts of a check source, and calculation of the average, 2 and 3 sigma values. A source check "jig" will be used to ensure the source and meter are always in the same position relative to one another. To ensure continued accuracy in the field a log will be established at the beginning of the project. Operational and source checks for field instruments will be performed each day of use, and recorded on the logsheet. All recorded measurements in the final report will be obtained with meters which pass the operational check and source check within the $\pm$ 3 sigma range.

Contamination in a geometry different from the calibration standards may be detected with a different efficiency. However, the difference between the meter's efficiency for a point source and large areas of contamination is estimated to be less than 6% (NRC, 1995a).

Representivity

Representative data would be that data which accurately reflects the environment where the measurement was obtained. One measurement of this parameter is to simply compare the number of times the premise the data is intended to show fails, compared to the number of times the premise is tested. For this project, one premise which may be tested is "the survey technique of Tech. A is capable of correctly detecting residual thorium". The QA manager will re -survey selected areas of elevated activity, counting any area determined not to be elevated as non representative data. The equation to measure this is:

$$\text{Representivity} = (1-F/N) \times 100\%$$

The goal for this project is to have all data 95% representative, or greater.

Completeness

Completeness is a measure of the amount of valid data obtained compared to the amount that was specified. For the purposes of evaluation, data defined as invalid through a QA review is subtracted from the complete data set to determine the number of valid data points. Generally, completeness greater than 95% is desirable.

Comparability

Comparability is a non quantitative evaluation of the agreement between different types of data sets which should be, intuitively, related to each other. For example, on this project, all locations exhibiting elevated dose rates, should also exhibit elevated gamma count rates, illustrating total comparability of these two data sets. The alpha results are not similarly comparable because the physical range of the alpha particle is measured in centimeters, insufficient to affect local dose rates.

Sensitivity

To determine a meter's suitability for a measurement, the minimum detectable activity (MDA) is compared with the project specific release limits. The minimum detectable activity will be calculated using an equation from NUREG-5849, and the average of the daily background and source checks. Count times and instrumentation will be selected such that the MDA is at least 25% or less of the established release limits. MDA calculations will be presented in the final status report, as well as calibration certificates for field instrumentation.

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Disposal or Onsite Storage of Thorium or Uranium Wastes from Past Operations 46 Federal Register 52061 (October 23, 1981)

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U.S. Nuclear Regulatory Commission (NRC,1993), NUREG-1444, *Site Decommissioning Management Plan* October 1993

U.S. Nuclear Regulatory Commission (NRC,1995), NUREG-1505, *A Nonparametric Statistical methodology for the Design and Analysis of Final Status decommissioning Surveys* . Draft Report for Comment, August 1995

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Appendix A

Background Soil Activity Determination

Report of Site Background
for
Heritage Minerals
Manchester, New Jersey

by

Radiation Science, Inc.
10 South River Road - Suite 1005
Cranbury, NJ 08512
July, 1996

Report of Naturally Occurring Radioactivity (Site Background) Surface Soil Conditions for Heritage Minerals
Manchester New Jersey

Introduction

The purpose of the sampling work and analyses described in this report is to establish the mean background soil concentration for uranium and thorium at the Heritage Minerals property in Manchester, NJ in accordance with the Manual for Conducting Radiological Surveys in Support of License Termination (NUREG-5849).

Radiation Science, Inc. (RSI) collected ten soil samples representative of background conditions from the property during May, 1995. These samples were chosen from areas of undisturbed environment, representative of natural conditions at the site. Sample locations near areas of previous mining or process activity were avoided. Sampling was conducted according to procedure to a depth of 6 inches. The results of analysis of these samples were used to calculate the total number of samples required to establish site background according to NUREG 5849. The additional samples were collected in a like manner during October, 1995. This report presents the results of these analyses and the determination of site background for the Heritage Minerals Property.

Initial Background Sampling and Determination of Further Sampling Requirements

Initial sampling was performed as described above. The final number of samples needed to characterize background levels is calculated from this data according to the prescription in the "Manual for Conducting Radiological Surveys in Support of License Termination", NUREG-5849 as follows:

$$n_B = \left| \frac{t_{97.5\%\ df} \times S_x}{0.2 \times X_B} \right|^2$$

where:

n_B,	number of background measurements required
x_B,	mean of initial background measurements
s_x,	standard deviation of initial measurements
$t_{97.5\%,df}$,	t statistic for 97.5% confidence at df = n-1 degrees of freedom, where n is the initial background data points

The t statistic for the stated confidence level with 9 degrees of freedom is 2.26. The average and standard deviation for each isotope are calculated using statistical methods.

Uranium Sample Required

Based on the results of the ten (10) background samples the total number of samples necessary to establish the background for U^{238} is;

$x_B = 0.36 \qquad sx = 0.18$

$$n_{samples} = \left| \frac{2.26 \times 0.18}{0.2 \times 0.36} \right|^2 = 32$$

Thirty two samples (32) are necessary to characterize background, minus the original ten, is twenty-two (22) additional samples.

Thorium Samples Required

Based on the results of the ten (10) background samples the total number of samples necessary to establish the background for Th^{232} is;

$x_B = 0.24 \qquad sx = 0.10$

$$n_{samples} = \left| \frac{2.26 \times 0.10}{0.2 \times 0.24} \right|^2 = 22$$

Twenty two samples (22) are necessary to characterize background, minus the original ten, is twelve (12) additional samples.

Since both Th^{232} and U^{238} are determined by the gamma spectral analysis of each sample, the final background determination for U^{238} and Th^{232} will require thirty two (32) samples to be consistent the NRC's recommended method for establishing background. These additional samples were collected and analyzed. The approximate locations from which these samples were taken are identified on the attached site map.

Laboratory Analytical Results

U^{238} and Th^{232} are at the top of their respective decay chains, each nuclide decaying to its daughter by emission of an alpha particle. Some of the daughter isotopes along the decay chains emit gamma rays with sufficient energy and intensity to be identified by gamma spectroscopy. Equilibrium is assumed between the U^{238} isotope and its daughters and between the Th^{232} isotope and its daughters. Therefore the gamma emitting daughter isotopes can be used as surrogates for the parent activity. The 609 KeV photo peak of the U^{238} daugther, Bi^{214}, was used to determine the U^{238} activity while the 238 KeV photo peak of the Th^{232} daughter, Pb^{212}, was used to infer the Th^{232} activity. A different photo peak, that of the uranium daughter Ra^{226}, was used as the surrogate for U^{238} in the initial determination of the sampling requirements. However, this has no impact on the final background calculation since Bi^{214} was used as the surrogate for U^{238} for all 32 samples in the final background calculation.

The laboratory reports of analysis for the above samples are attached with this report.

Quality Assurance

Blank, spike, and replicate samples are analyzed by the laboratory totaling at least 5% of the analytical sample load. Quality control samples prepared by other laboratory clients may be considered in computing this percentage. Spike samples are prepared from NIST traceable standards or the equivalent. The results of quality assurance samples are maintained on file by the laboratory.

Calculation of the Site Background

Soil Concentration

The mean value of the U^{238} concentration in the background samples is 0.31 pCi/gm and that for Th^{232} is 0.25 pCi/gm. The 95% confidence range about this mean has been determined according to equation (8-13) in NUREG 5849. These values are reported in the table below. Note that while this report follows the prescriptive determination of site background in the NUREG document, it is possible that naturally occurring heavy mineral deposits near the surface of this large, approximately 4,000 acre site, will display concentrations of radioactive material outside the confidence range of the expected site average.

Isotope	Average Concentration (pCi/gm)	95% Confidence Range (pCi/gm)
Uranium (U^{238})	0.31	0.27 to 0.35
Thorium (Th^{232})	0.25	0.21 to 0.28

The objective of the background determination, as stated in NUREG 5849, is to analyze a sufficient number of samples so as to determine a confidence range that is within 20% of the mean of the sample population. Since the confidence range as determined here for both U^{238} and Th^{232} is within 20% of the mean, we conclude that the background concentrations have been adequately characterized at this site for purposes of decommissioning in accordance with US NRC guidance.

Dose Rate

Calculation of the average background dose rate was accomplished by standard statistical analysis of the measurements taken at each sample location. The average dose rate (or site background), based on the above measurements is:

3 micro Rem per hour

Statistical Analysis

Uranium and Thorium Background Determination for Heritage Minerals

Sample ID	U-238 (pCi/gm)	Th-232 (pCi/gm)	Dose Rate (micro Rem/hr)
HMBKSW01S	0.15	0.14	3
HMBKSE02S	0.38	0.34	4.5
HMBKSE03S	0.25	0.26	3.5
HMBKE04S*	0.17	0.07	3
HMBKE05S	0.26	0.31	4
HMBKNEO6S	0.67	0.48	3.5
HMBKNEO7S	0.41	0.21	4
HMBKNEO8S	0.37	0.3	3.5
HMBKW09S	0.2	0.21	2.5
HMBKS10S	0.21	0.12	3
11	0.19	0.2	4
12	0.29	0.16	2
13	0.32	0.31	3
14	0.43	0.32	3
15	0.28	0.23	2
16	0.16	0.17	2
17	0.37	0.31	2
18	0.28	0.23	2
19	0.33	0.19	2
20	0.27	0.19	2
21	0.27	0.2	2
22	0.34	0.31	2
23	0.2	0.15	3
24	0.24	0.28	2
25	0.36	0.36	2
26	0.32	0.24	3
27	0.23	0.28	3
28	0.24	0.19	2
29	0.2	0.15	3
H	0.47	0.28	4.5
N	0.47	0.37	2.5
Q	0.47	0.27	3.5

* reported as "less than" value for Th232 surrogate

U-238	
Mean	0.31
Median	0.28
Mode	0.20
Standard Deviation	0.11
Sample Variance	0.01
Range	0.52
Minimum	0.15
Maximum	0.67
Count	32
97.5% t statistic (df-1)	2.04
Upper Confidence Range	0.35
Lower Confidence Range	0.27

Th-232	
Mean	0.24
Median	0.24
Mode	0.31
Standard Deviation	0.09
Sample Variance	0.01
Range	0.41
Minimum	0.07
Maximum	0.48
Count	32
97.5% t statistic (df-1)	2.04
Upper Confidence Range	0.28
Lower Confidence Range	0.21

Dose rate	
Mean	2.84
Median	3.00
Mode	2.00
Standard Deviation	0.81
Sample Variance	0.65
Range	2.50
Minimum	2.00
Maximum	4.50
Count	32

Analytical Data

TELEDYNE BROWN ENGINEERING ENVIRONMENTAL SERVICES

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TELEDYNE SAMPLE NUMBER	CUSTOMER'S IDENTIFICATION		STA NUM	COLLECTION-DATE START DATE	TIME	STOP DATE	TIME	NUCLIDE	ACTIVITY (PCI/GM DRY)	NUCL-UNIT-% U/M *	MID-COUNT TIME DATE	TIME	VOLUME - UNITS ASH-WGHT-% *	LAB.
82759	HMBKSW01S	SURFACE		04/27				RA-226	L.T. 5. E-01		05/01			4
								PB-214	2.1 +-0.5 E-01		05/01			4
								BI-214	1.5 +-0.4 E-01		05/01			4
								AC-228	L.T. 1. E-01		05/01			4
								PB-212	1.4 +-0.4 E-01		05/01			4
								TL-208	4.4 +-1.9 E-02		05/01			4
82760	HMBKSE02S	SURFACE		04/27				RA-226	L.T. 7. E-01		05/01			4
								PB-214	4.2 +-0.7 E-01		05/01			4
								BI-214	3.8 +-0.6 E-01		05/01			4
								AC-228	2.4 +-1.1 E-01		05/01			4
								PB-212	3.4 +-0.6 E-01		05/01			4
								TL-208	8.8 +-3.6 E-02		05/01			4
82761	HMBKSE03S	SURFACE		04/27				RA-226	L.T. 5. E-01		05/01			4
								PB-214	2.4 +-0.6 E-01		05/01			4
								BI-214	2.5 +-0.5 E-01		05/01			4
								AC-228	1.7 +-0.8 E-01		05/01			4
								PB-212	2.6 +-0.5 E-01		05/01			4
								TL-208	7.1 +-2.2 E-02		05/01			4
82762	HMBK E04S	SURFACE		04/27				RA-226	L.T. 6. E-01		05/01			4
								PB-214	2.1 +-0.6 E-01		05/01			4
								BI-214	1.7 +-0.6 E-01		05/01			4
								AC-228	1.8 +-1.0 E-01		05/01			4
								PB-212	L.T. 7. E-02		05/01			4
								TL-208	7.8 +-3.1 E-02		05/01			4
82763	HMBK E05S	SURFACE		04/28				RA-226	L.T. 8. E-01		05/01			4
								PB-214	3.6 +-0.8 E-01		05/01			4
								BI-214	2.6 +-0.9 E-01		05/01			4
								AC-228	2.4 +-1.0 E-01		05/01			4
								PB-212	3.1 +-0.7 E-01		05/01			4

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82763	HMBK E05S SURFACE		04/28				TL-208	9.1 +-3.6 E-02		05/01			4
82764	HMBKNE06S SURFACE		04/28				RA-226	1.5 +-0.4 E 00		05/01			4
							PB-214	8.2 +-0.6 E-01		05/01			4
							BI-214	6.7 +-0.6 E-01		05/01			4
							AC-228	4.4 +-0.8 E-01		05/01			4
							PB-212	4.8 +-0.4 E-01		05/01			4
							TL-208	1.9 +-0.3 E-01		05/01			4
82765	HMBKNE07S SURFACE		04/28				RA-226	L.T. 7. E-01		05/01			4
							PB-214	4.0 +-0.7 E-01		05/01			4
							BI-214	4.1 +-0.7 E-01		05/01			4
							AC-228	2.1 +-0.9 E-01		05/01			4
							PB-212	2.1 +-0.4 E-01		05/01			4
							TL-208	6.6 +-2.9 E-02		05/01			4
82766	HMBKNW08S SURFACE		04/28				RA-226	7.1 +-3.8 E-01		05/01			4
							PB-214	3.9 +-0.5 E-01		05/01			4
							BI-214	3.7 +-0.5 E-01		05/01			4
							AC-228	3.6 +-0.7 E-01		05/01			4
							PB-212	3.0 +-0.3 E-01		05/01			4
							TL-208	8.9 +-2.2 E-02		05/01			4
82767	HMBKW 09S SURFACE		04/28				RA-226	1.5 +-0.7 E 00		05/01			4
							PB-214	3.1 +-0.8 E-01		05/01			4
							BI-214	2.0 +-0.6 E-01		05/01			4
							AC-228	2.9 +-0.9 E-01		05/01			4
							PB-212	2.1 +-0.5 E-01		05/01			4
							TL-208	7.7 +-2.6 E-02		05/01			4

TELEDYNE BROWN ENGINEERING ENVIRONMENTAL SERVICES

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82768	HMBKS 10S	SURFACE	04/28				RA-226	L.T. 5. E-01		05/01			4
							PB-214✓	1.8 +-0.5 E-01		05/01			4
							BI-214	2.1 +-0.5 E-01		05/01			4
							AC-228	1.2 +-0.6 E-01		05/01			4
							PB-212✓	1.2 +-0.2 E-01		05/01			4
							TL-208	L.T. 3. E-02		05/01			4

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TELEDYNE SAMPLE NUMBER	CUSTOMER'S IDENTIFICATION	STA NUM	COLLECTION-DATE START DATE	START TIME	STOP DATE	STOP TIME	NUCLIDE	ACTIVITY (PCI/GM DRY)	NUCL-UNIT-% U/M *	MID-COUNT TIME DATE	MID-COUNT TIME TIME	VOLUME - UNITS ASH-WGHT-% *	LAB.
98268	AREA ONE BACKGRND B		09/26				RA-226	9.1 +-4.5 E-01		09/29			4
							PB-214	6.4 +-0.6 E-01		09/29			4
							BI-214	5.9 +-0.6 E-01		09/29			4
							AC-228	6.0 +-1.0 E-01		09/29			4
							PB-212	6.7 +-0.7 E-01		09/29			4
							TL-208	2.2 +-0.3 E-01		09/29			4
98269	AREA ONE BACKGRND D		09/26				RA-226	6.6 +-3.9 E-01		09/29			4
							PB-214	3.2 +-0.5 E-01		09/29			4
							BI-214	2.9 +-0.6 E-01		09/29			4
							AC-228	1.9 +-0.8 E-01		09/29			4
							PB-212	1.9 +-0.3 E-01		09/29			4
							TL-208	8.6 +-2.5 E-02		09/29			4
98270	AREA ONE BACKGRND F		09/26				RA-226	L.T. 4. E-01		09/29			4
							PB-214	2.9 +-0.4 E-01		09/29			4
							BI-214	2.7 +-0.4 E-01		09/29			4
							AC-228	1.6 +-0.6 E-01		09/29			4
							PB-212	1.9 +-0.2 E-01		09/29			4
							TL-208	6.2 +-1.7 E-02		09/29			4
98271	AREA ONE BACKGRND H		09/26				RA-226	7.2 +-4.0 E-01		09/29			4
							PB-214	4.5 +-0.5 E-01		09/29			4
							BI-214	4.7 +-0.5 E-01		09/29			4
							AC-228	2.4 +-0.9 E-01		09/29			4
							PB-212	2.8 +-0.3 E-01		09/29			4
							TL-208	1.3 +-0.3 E-01		09/29			4
98272	AREA ONE BACKGRND J		09/26				RA-226	6.7 +-3.2 E-01		09/29			4
							PB-214	3.3 +-0.5 E-01		09/29			4
							BI-214	3.6 +-0.5 E-01		09/29			4
							AC-228	1.9 +-0.6 E-01		09/29			4
							PB-212	2.4 +-0.3 E-01		09/29			4

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98272	AREA ONE BACKGRND J		09/26				TL-208	7.6 +-2.0 E-02		09/29			4
98273	AREA ONE BACKGRND N		09/26				RA-226	1.1 +-0.3 E 00		09/29			4
							PB-214	5.1 +-0.5 E-01		09/29			4
							BI-214	4.7 +-0.5 E-01		09/29			4
							AC-228	4.0 +-0.6 E-01		09/29			4
							PB-212	3.7 +-0.4 E-01		09/29			4
							TL-208	1.4 +-0.2 E-01		09/29			4
98274	AREA ONE BACKGRND P		09/26				RA-226	5.7 +-3.8 E-01		09/29			4
							PB-214	4.1 +-0.6 E-01		09/29			4
							BI-214	4.4 +-0.5 E-01		09/29			4
							AC-228	3.3 +-0.8 E-01		09/29			4
							PB-212	3.4 +-0.3 E-01		09/29			4
							TL-208	1.5 +-0.3 E-01		09/29			4
98275	AREA ONE BACKGRND Q		09/26				RA-226	9.0 +-3.4 E-01		09/29			4
							PB-214	4.9 +-0.5 E-01		09/29			4
							BI-214	4.7 +-0.5 E-01		09/29			4
							AC-228	3.0 +-0.9 E-01		09/29			4
							PB-212	2.7 +-0.3 E-01		09/29			4
							TL-208	7.9 +-2.0 E-02		09/29			4

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01561	HERITAGE MINERALS 11		09/27				RA-226	L.T. 5. E-01		11/03			4
							PB-214	2.3 +-0.4 E-01		11/03			4
							BI-214	1.9 +-0.4 E-01		11/03			4
							AC-228	1.7 +-0.6 E-01		11/03			4
							PB-212	2.0 +-0.3 E-01		11/03			4
							TL-208	L.T. 3. E-02		11/03			4
							K-40	4.3 +-1.6 E-01		11/03			4
01562	HERITAGE MINERALS 12		09/27				RA-226	L.T. 4. E-01		11/03			4
							PB-214	2.9 +-0.4 E-01		11/03			4
							BI-214	2.9 +-0.5 E-01		11/03			4
							AC-228	2.5 +-0.6 E-01		11/03			4
							PB-212	1.6 +-0.3 E-01		11/03			4
							TL-208	6.8 +-2.2 E-02		11/03			4
							K-40	1.8 +-0.2 E 00		11/03			4
01563	HERITAGE MINERALS 13		09/27				RA-226	L.T. 5. E-01		11/03			4
							PB-214	3.4 +-0.5 E-01		11/03			4
							BI-214	3.2 +-0.5 E-01		11/03			4
							AC-228	2.1 +-0.6 E-01		11/03			4
							PB-212	3.1 +-0.4 E-01		11/03			4
							TL-208	6.2 +-1.9 E-02		11/03			4
							K-40	L.T. 3. E-01		11/03			4
01564	HERITAGE MINERALS 14		09/27				RA-226	L.T. 6. E-01		11/03			4
							PB-214	3.8 +-0.6 E-01		11/03			4
							BI-214	4.3 +-0.6 E-01		11/03			4
							AC-228	3.7 +-0.8 E-01		11/03			4
							PB-212	3.2 +-0.4 E-01		11/03			4
							TL-208	8.7 +-2.8 E-02		11/03			4
							K-40	L.T. 4. E-01		11/03			4

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01565	HERITAGE MINERALS	15	09/27				RA-226	4.4 +-2.5 E-01		11/03			4
							PB-214	3.0 +-0.4 E-01		11/03			4
							BI-214	2.8 +-0.4 E-01		11/03			4
							AC-228	1.4 +-0.5 E-01		11/03			4
							PB-212	2.3 +-0.3 E-01		11/03			4
							TL-208	7.8 +-1.9 E-02		11/03			4
							K-40	2.8 +-1.4 E-01		11/03			4
01566	HERITAGE MINERALS	16	09/27				RA-226	L.T. 4. E-01		11/03			4
							PB-214	2.1 +-0.3 E-01		11/03			4
							BI-214	1.6 +-0.3 E-01		11/03			4
							AC-228	1.4 +-0.4 E-01		11/03			4
							PB-212	1.7 +-0.3 E-01		11/03			4
							TL-208	3.8 +-1.3 E-02		11/03			4
							K-40	2.3 +-1.0 E-01		11/03			4
01567	HERITAGE MINERALS	17	09/27				RA-226	1.0 +-0.4 E 00		11/06			4
							PB-214	4.1 +-0.6 E-01		11/06			4
							BI-214	3.7 +-0.5 E-01		11/06			4
							AC-228	1.7 +-0.7 E-01		11/06			4
							PB-212	3.1 +-0.3 E-01		11/06			4
							TL-208	1.1 +-0.3 E-01		11/06			4
							K-40	L.T. 4. E-01		11/06			4
01568	HERITAGE MINERALS	18	09/27				RA-226	1.2 +-0.5 E 00		11/06			4
							PB-214	2.6 +-0.7 E-01		11/06			4
							BI-214	2.8 +-0.6 E-01		11/06			4
							AC-228	1.3 +-0.7 E-01		11/06			4
							PB-212	2.3 +-0.4 E-01		11/06			4
							TL-208	9.8 +-2.8 E-02		11/06			4
							K-40	L.T. 5. E-01		11/06			4

TELEDYNE BROWN ENGINEERING ENVIRONMENTAL SERVICES

REPORT OF ANALYSIS

RUN DATE 11/07/95

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3-3153		10/31/95	11/10/95	

TOM BRACKE
RADIATION SCIENCE INC
PO BOX 3299
PRINCETON NJ 08543

S O I L

TELEDYNE SAMPLE NUMBER	CUSTOMER'S IDENTIFICATION	STA NUM	COLLECTION-DATE START DATE	TIME	STOP DATE	TIME	NUCLIDE	ACTIVITY (PCI/GM DRY)	NUCL-UNIT-% U/M *	MID-COUNT TIME DATE	TIME	VOLUME - UNITS ASH-WGHT-% *	LAB.
01569	HERITAGE MINERALS 19		09/27				RA-226	5.6 +-2.8 E-01		11/06			4
							PB-214	3.2 +-0.4 E-01		11/06			4
							BI-214	3.3 +-0.4 E-01		11/06			4
							AC-228	2.9 +-0.6 E-01		11/06			4
							PB-212	1.9 +-0.2 E-01		11/06			4
							TL-208	7.4 +-1.8 E-02		11/06			4
							K-40	L.T. 4. E-01		11/06			4
01570	HERITAGE MINERALS 20		09/27				RA-226	L.T. 4. E-01		11/06			4
							PB-214	2.9 +-0.5 E-01		11/06			4
							BI-214	2.7 +-0.5 E-01		11/06			4
							AC-228	1.3 +-0.7 E-01		11/06			4
							PB-212	1.9 +-0.3 E-01		11/06			4
							TL-208	8.6 +-2.2 E-02		11/06			4
							K-40	L.T. 7. E-01		11/06			4
01571	HERITAGE MINERALS 21		09/27				RA-226	6.8 +-3.7 E-01		11/06			4
							PB-214	2.7 +-0.5 E-01		11/06			4
							BI-214	2.7 +-0.5 E-01		11/06			4
							AC-228	2.1 +-0.6 E-01		11/06			4
							PB-212	2.0 +-0.3 E-01		11/06			4
							TL-208	9.6 +-2.2 E-02		11/06			4
							K-40	3.5 +-1.6 E-01		11/06			4
01572	HERITAGE MINERALS 22		09/27				RA-226	8.0 +-3.0 E-01		11/06			4
							PB-214	4.0 +-0.4 E-01		11/06			4
							BI-214	3.4 +-0.4 E-01		11/06			4
							AC-228	2.1 +-0.5 E-01		11/06			4
							PB-212	3.1 +-0.3 E-01		11/06			4
							TL-208	9.0 +-1.6 E-02		11/06			4
							K-40	4.2 +-1.3 E-01		11/06			4

TELEDYNE BROWN ENGINEERING ENVIRONMENTAL SERVICES

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TOM BRACKE
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S O I L

TELEDYNE SAMPLE NUMBER	CUSTOMER'S IDENTIFICATION	STA NUM	COLLECTION-DATE START DATE	START TIME	STOP DATE	STOP TIME	NUCLIDE	ACTIVITY (PCI/GM DRY)	NUCL-UNIT-% U/M *	MID-COUNT TIME DATE	MID-COUNT TIME	VOLUME - UNITS ASH-WGHT-% *	LAB.
01573	HERITAGE MINERALS	23	09/27				RA-226	L.T. 5. E-01		11/06			4
							PB-214	2.3 +-0.4 E-01		11/06			4
							BI-214	2.0 +-0.4 E-01		11/06			4
							AC-228	1.8 +-0.6 E-01		11/06			4
							PB-212	1.5 +-0.3 E-01		11/06			4
							TL-208	7.7 +-1.8 E-02		11/06			4
							K-40	L.T. 3. E-01		11/06			4
01574	HERITAGE MINERALS	24	09/27				RA-226	5.3 +-3.1 E-01		11/06			4
							PB-214	2.0 +-0.4 E-01		11/06			4
							BI-214	2.4 +-0.4 E-01		11/06			4
							AC-228	1.8 +-0.6 E-01		11/06			4
							PB-212	2.8 +-0.4 E-01		11/06			4
							TL-208	6.5 +-1.7 E-02		11/06			4
							K-40	7.0 +-1.8 E-01		11/06			4
01575	HERITAGE MINERALS	25	09/27				RA-226	L.T. 1. E 00		11/06			4
							PB-214	4.4 +-0.8 E-01		11/06			4
							BI-214	3.6 +-0.7 E-01		11/06			4
							AC-228	3.9 +-1.0 E-01		11/06			4
							PB-212	3.6 +-0.5 E-01		11/06			4
							TL-208	1.2 +-0.3 E-01		11/06			4
							K-40	7.3 +-2.3 E-01		11/06			4
01576	HERITAGE MINERALS	26	09/27				RA-226	6.5 +-2.6 E-01		11/06			4
							PB-214	3.7 +-0.4 E-01		11/06			4
							BI-214	3.2 +-0.4 E-01		11/06			4
							AC-228	2.5 +-0.7 E-01		11/06			4
							PB-212	2.4 +-0.2 E-01		11/06			4
							TL-208	7.7 +-1.8 E-02		11/06			4
							K-40	3.9 +-1.5 E-01		11/06			4

TELEDYNE BROWN ENGINEERING ENVIRONMENTAL SERVICES

REPORT OF ANALYSIS

RUN DATE 11/07/95

WORK ORDER NUMBER 3-3153 | CUSTOMER P.O. NUMBER | DATE RECEIVED 10/31/95 | DELIVERY DATE 11/10/95

TOM BRACKE
RADIATION SCIENCE INC
PO BOX 3299
PRINCETON NJ 08543

S O I L

TELEDYNE SAMPLE NUMBER	CUSTOMER'S IDENTIFICATION	STA NUM	COLLECTION-DATE START DATE	START TIME	STOP DATE	STOP TIME	NUCLIDE	ACTIVITY (PCI/GM DRY)	NUCL-UNIT-% U/M *	MID-COUNT TIME DATE	MID-COUNT TIME	VOLUME - UNITS ASH-WGHT-% *	LAB.
01577	HERITAGE MINERALS	27	09/27				RA-226	L.T. 4. E-01		11/06			4
							PB-214	2.5 +-0.4 E-01		11/06			4
							BI-214	2.3 +-0.4 E-01		11/06			4
							AC-228	1.4 +-0.6 E-01		11/06			4
							PB-212	2.8 +-0.3 E-01		11/06			4
							TL-208	8.1 +-2.0 E-02		11/06			4
							K-40	4.5 +-1.6 E-01		11/06			4
01578	HERITAGE MINERALS	28	09/27				RA-226	L.T. 5. E-01		11/06			4
							PB-214	1.7 +-0.5 E-01		11/06			4
							BI-214	2.4 +-0.5 E-01		11/06			4
							AC-228	1.3 +-0.6 E-01		11/06			4
							PB-212	1.9 +-0.3 E-01		11/06			4
							TL-208	5.6 +-2.0 E-02		11/06			4
							K-40	4.7 +-1.8 E-01		11/06			4
01579	HERITAGE MINERALS	29	09/27				RA-226	L.T. 6. E-01		11/06			4
							PB-214	2.9 +-0.5 E-01		11/06			4
							BI-214	2.0 +-0.5 E-01		11/06			4
							AC-228	1.5 +-0.7 E-01		11/06			4
							PB-212	1.5 +-0.3 E-01		11/06			4
							TL-208	7.3 +-2.4 E-02		11/06			4
							K-40	4.0 +-2.0 E-01		11/06			4

LAST PAGE OF REPORT

APPROVED BY J. GUENTHER 11/07/95

SEND 1 COPIES TO RA180S TOM BRACKE

2 - GAS LAB.   3 - RADIO CHEMISTRY LAB.   4 - GE(LI) GAMMA SPEC LAB.   5 - TRITIUM GAS/L.S. LAB.   6 - ALPHA SPEC LAB.

Appendix B

Wet Mill and Dry Mill Survey Units

In this appendix, the process equipment in the wet mill and the dry mill is divided into "Survey Units" based on the sequence in which these units were utilized in the HMI operations. The equipment in each unit and the material treated in and around the equipment are described.

Survey units are categorized as "Affected" or "Unaffected" for the purpose of determining the degree to which each of the areas is surveyed according to NUREG-5849. The decision to characterize a particular survey unit as affected or unaffected has been made on the basis of the monazite content of the process material that was in contact with, or likely to be in contact with, the equipment representing that particular survey unit. While every process stream in the plant was not analyzed for monazite content, the process history described in Appendix C makes it easy to estimate the monazite concentrations in the various process streams based on analyses of some key plant products. For example, based on the analysis of the table concentrate (740 ppm Th + U) it can be concluded that the table feed contained a maximum of 370 ppm Th + U since the tables effected a 2 to 1 concentration (see Appendix C). Since the table feed is the same as the spiral circuit concentrate, it follows that the entire spiral circuit (roughers, scavengers, cleaners, re-cleaners, and finishers) was unaffected based on the fact that all streams within the spiral circuit were at or below the 370 ppm level.

It should also be noted that the west half of the wet mill, including the spirals, launders, sumps, and pumps was never used in the HMI operations. It has remained dry and completely abandoned ever since the termination of ASARCO operations in 1982.Therefore, the west half of the wet mill, including the floor, spirals, launders, sumps, and pumps will not be included in this survey.

122539

Survey Unit #1, New Feed Hopper and Silo - Unaffected

This series of large equipment located outdoors on the Dry Mill side of the processing facility consists of: a New Feed Hopper, conveyors, and a 200 ton capacity New Feed Silo. Feed material (ASARCO tailings) was carried by front-end loader and dumped into the New Feed Hopper and conveyed to the large capacity, New Feed Silo. New feed material from the silo was metered onto a conveyor and carried to the Wet Mill Screen Feed Sump (2). The New Feed Hopper, New Feed Silo, and conveyors to the Wet Mill Screen Feed will be considered a single survey unit. This unit is considered unaffected because it was used to handle the new feed (≤ 180 ppm Th & U).

Survey Unit #2, Wet Mill Screen Feed Sump - Unaffected

The Wet Mill Screen Feed Sump (2) consists of a mechanical screen which removed debris from the feed material and a large sump tank. Feed material was washed with clean process water through the screen and into the sump. The resulting slurry was pumped across the site to the Rougher Spirals Feed Sump (3) located in the Wet Mill. The Wet Mill Screen Feed Sump (2) and piping to the Rougher Spirals Feed Sump (3) will be considered as a single survey unit. This unit was not used to effect any monazite concentration. It is therefore considered unaffected.

Wet Mill Building

Survey Unit #3, Rougher Spirals Feed Sump - Unaffected

The Rougher Spirals Feed Sump (3) located on the 0' elevation of the Wet Mill received the sand slurry from the Wet Mill Screen Feed (2). The sump served as a buffer to provide a supply of material to the Rougher Spirals (4). The Rougher Spirals Feed Sump (3), pump, and piping to the Rougher Spirals (4) will be considered as a single survey unit. The materials handled by this unit were of similar composition to the new feed (≤ 180 ppm Th & U). Therefore, unit #3 is considered unaffected.

Survey Unit #4, Rougher Spirals - Unaffected

The Rougher Spirals (4), located on the 24' elevation of the Wet Mill and consisting of four banks of twenty, five-turn spiral separators operating in parallel, represent the first step in the separation of the feed material. The centrifugal action of the water as it cascaded down the spirals caused the sand slurry to separate on the basis of particle density. Concentrate, enriched in heavy minerals including monazite, was mechanically separated from the slurry stream and passed to the Cleaner Spirals Feed Sump (5). Tailings, depleted of heavy minerals, were passed to the Scavenger Spirals Feed Sump (10). The Rougher Spirals (4) will be considered as a single survey unit. This unit is considered unaffected because it was used to remove only part of the light minerals. Therefor it only effected minor concentration of the heavy minerals. The rougher concentrate remained well below source material concentration.

Survey Unit #5, Cleaner Spirals Feed Sump - Unaffected

The Cleaner Spirals Feed Sump (5) located on the 0' elevation of the Wet Mill received the concentrate from the Rougher Spirals (4) via a series of "launders" (water troughs through which the slurry flowed by gravity to the lower elevation process equipment). The sump served as a buffer to provide a supply of material to the Cleaner Spirals (6). The launders from the Rougher Spirals (4), Cleaner Spirals Feed Sump (5), pump, and piping to the Cleaner Spirals (6) will be considered as a single survey unit. This unit was used to pump rougher spiral concentrates which were well below source material levels. Therefore, this unit is considered unaffected.

Survey Unit #6, Cleaner Spirals - Unaffected

The Cleaner Spirals (6), located on the 24' elevation of the Wet Mill, further concentrated the product stream. Heavy minerals were separated as before on the basis of particle density in two banks of twenty, five-turn spirals. Concentrate from the Cleaner Spirals (6) was passed to the Recleaner Spirals Feed Sump (7) while the depleted tailings were passed to the Thickener (40). The Cleaner Spirals will be considered as a single survey unit. The cleaner spiral concentrate remained well below source material levels. Therefore this unit is considered unaffected.

Survey Unit #7, Recleaner Spirals Feed Sump - Unaffected

The Recleaner Spirals Feed Sump (7) located on the 0' elevation of the Wet Mill received the concentrate from the Cleaner Spirals (6) via launders. The sump served as a buffer to provide material to the Recleaner Spirals (8). The launders from the Cleaner Spirals (6), Recleaner Spirals Feed Sump (7), pump, and piping to the Recleaner Spirals (8) will be considered as a single survey unit. This unit is considered unaffected for the same reason as units 5 and 6: the sand that was being pumped by this unit remained well below source material levels.

Survey Unit #8, Recleaner Spirals - Unaffected

The Recleaner Spirals (8) located on the 24' elevation of the Wet Mill further concentrated the product stream. Heavy minerals were separated as before on the basis of particle density in two banks of twenty, five-turn spirals. The concentrate was passed to the Finisher Spirals Sump (9) while the depleted tailings were passed to the Thickener (13). The Recleaner Spirals (8) will be considered as a single survey unit. This unit is considered unaffected because monazite concentration in all streams treated by the recleaner spirals were below source material levels.

Survey Unit #9, Finisher Spirals Feed Sump - Unaffected

The Finisher Spirals Feed Sump (9) located on the 0' elevation of the Wet Mill received the concentrate from the Recleaner Spirals (8) via launders. The sump served as a buffer to provide material to the Finisher Spirals (14). The launders from the Recleaner Spirals (8), Finisher Spirals Feed Sump (9), pump, and piping to the Finisher Spirals (14) will be considered as a single survey unit. This unit was handling the same material as concentrate from Unit #8 which is below source material levels. It is therefore unaffected.

Survey Unit #10, Scavenger Spirals Feed Sump - Unaffected

The Scavenger Spiral Feed Sump (10) located on the 0' elevation of the Wet Mill received the tailings from the Rougher Spirals (4) via launders. The sump served as a buffer to provide a supply of material to the Scavenger Spirals (11). The launders from the Rougher Spirals (4), Scavenger Spiral Feed Sump (10), pump, and piping to the Scavenger Spirals (11) will be considered as a single survey unit. The scavenger spiral circuit (units 10 and 11) processed rougher tailings, which is lower concentration than the new feed. Unit #10 is therefore unaffected.

Survey Unit #11, Scavenger Spirals - Unaffected

The Scavenger Spirals located on the 24' elevation of the Wet Mill reclaimed heavy minerals from the depleted tailings of the Rougher Spirals (4). Heavy minerals were separated as before on the basis of particle density in two banks of twenty, five-turn spirals. The concentrate was returned to the Rougher Spirals Feed Sump (3) while the depleted tailings were passed to the Tails Transfer Sump (12). The Scavenger Spirals (11) will be considered as a single survey unit. The scavenger spirals are unaffected because they were used to process material which contained less monazite than the new feed ($\leq$ 180 ppm Th & U).

Survey Unit #12, Tails Transfer Sump - Unaffected

The Tails Transfer Sump located on the 0' elevation of the Wet Mill received the tailings from the Scavenger Spirals (11) via launders. The sump served as a buffer to provide a supply of material to the Tails Sump (28). The launders from the Scavenger Spirals (11), Tails Transfer Sump (12), pump, and piping to the Tails Sump (28) will be considered as a single survey unit. This unit served to pump the plant tailings (the light minerals) for disposal. Analysis showed the tailings to contain ≤ 120 ppm Th & U. Therefore, this unit is unaffected.

Survey Unit #13, Thickener Sump - Unaffected

The Thickener Sump (13), located on the 0' elevation of the Wet Mill received the depleted tailings from the Cleaner Spirals (6) via launders. The Thickener process step served to de-water the tailings slurry before returning the material to the Rougher Spirals (4). The launders from the Cleaner Spirals (6), Thickener Sump (13), pump, and piping to the Rougher Spirals (4) will be considered as a single survey unit. This unit was used to process material from the spiral circuit, which was below source material levels. Therefore, this unit is considered unaffected.

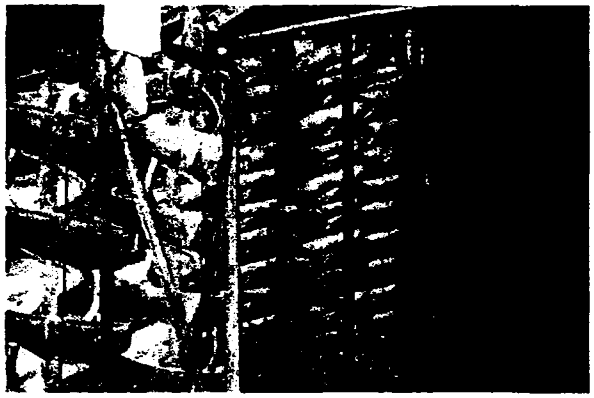
Survey Unit #14, Finisher Spirals - Unaffected

The Finisher Spirals (14) located on the 24' elevation of the Wet Mill further concentrated the product stream. Heavy minerals were separated as before on the basis of particle density in two banks of twenty, three-turn spirals. The concentrate was passed to the Table Spirals Sump (15) while the depleted tailings were returned to the Recleaner Spirals Feed Sump (7). The Finisher Spirals (14) will be considered as a single survey unit. The finisher spirals are considered unaffected because the finisher concentrate as well as all other streams remained below source material levels.

Survey Unit #15, Table Spirals Feed Sump - Unaffected

The Table Spirals Feed Sump (15) located on the 0' elevation of the Wet Mill received the concentrate from the Finisher Spirals (14) via launders. The sump served as a buffer to provide material to the Table Spirals (16). The launders from the Finisher Spirals (14), Table Spirals Feed Sump (15), pump, and piping to the Table Spirals (16) will be considered as a single survey unit. This unit is considered unaffected because the material it handled was below source material levels.

Survey Unit #16, Table Spirals - Unaffected



The Table Spirals (16) located on the 24' elevation of the Wet Mill further enriched the product stream. Heavy minerals were separated as before on the basis of particle density in two banks of eight, plastic, five-turn, double spirals. The concentrate flowed via launders to the Table Feed Sump (17) while the depleted tailings flowed via launders to the Screw Feed Sump (18). The Table Spirals (16) will be considered as a single survey unit.

Survey Unit #17, Table Feed Sump - Affected

The Table Feed Sump (17) located on the 0' elevation of the Wet Mill received the concentrate from the Table Spirals (16) via launders. The sump served as a buffer to provide material to the Main Tables (27). The launders from the Table Spirals (16), Table Feed Sump (17), pump, and piping to the Main Tables (27) will be considered as a single survey unit.

Survey Unit #18, Screw Feed Sump - Unaffected

The Screw Feed Sump (18) located on the 0' elevation of the Wet Mill received the tailings from the Table Spirals (16) via launders. The sump served as a buffer to provide material to the Screw Classifier (equipment removed). The launders from the Table Spirals (16), Screw Feed Sump (18), pump, and piping to the Screw Classifier (19) will be considered as a single survey unit.

Survey Unit #19, Screw Classifier - Unaffected

Equipment was removed early in the operation (prior to licensing) because it proved ineffective. During its use, it was part of the spiral circuit and was therefore unaffected.

Survey Unit #20, Screen Feed Sump - Unaffected

The Screen Feed Sump (20) located on the 0' elevation of the Wet Mill received the tailings from the Screw Classifier (19) via launders. The sump served as a buffer to provide material to the Magnet Feed Sump (21). The launders from the Screw Classifier (19), Screen Feed Sump (20), pump, and piping to the Magnet Feed Sump (21) will be considered as a single survey unit.

This unit is considered unaffected because it handled lower grade material from the spiral circuit.

Survey Unit #21, Magnet Feed Sump - Unaffected

The Magnet Feed Sump (21) located on the 0' elevation of the Wet Mill received the screened feed from the Screen Feed Sump (20). Screened particles were pumped to the Tails Sump (28). The Magnet Feed Sump served as a buffer to provide material to the High Intensity Wet Magnetic Separator (22). The piping from the Screen Feed Sump (20), Magnet Feed Sump (21), pump, and piping to the High Intensity Wet Magnetic Separator (22) will be considered as a single survey unit. The wet magnetic circuit was used to process tailings for the recovery of additional titanium values. It is therefore unaffected.

Survey Unit #22, High Intensity Wet Magnetic Separator - Unaffected

Tailings entering the High Intensity Wet Magnetic Separator (22) falls by gravity through a high density magnetic field where the sand particles are separated according to their magnetic properties. The magnetic fraction, containing any recovered titanium minerals, was transferred via launders to the Magnetics Feed Sump (23). The non-magnetic fraction, still containing the monazite, was transferred via launders to the Non-Magnetic Feed Sump (24). The High Intensity Wet Magnetic Separator (22) will be considered as a single survey unit. This unit is unaffected for the same reason as unit #21.

Survey Unit #23, Magnetics Feed Sump - Unaffected

The Magnetics Feed Sump (23) located on the 0' elevation of the Wet Mill received the magnetic sand, rich in titanium from the High Intensity Wet Magnetic Separator (22) via launders. The sump served as a buffer to provide material to the Stockpile. The launders from the High Intensity Wet Magnetic Separator (22), Magnetics Feed Sump (23), pump, and piping to the Stock Pile will be considered as a single survey unit. This unit was unaffected for the same reason as unit #21.

Survey Unit #24, Non-Magnetics Feed Sump - Unaffected

The Non-Magnetics Feed Sump (24) located on the 0' elevation of the Wet Mill received the non-magnetic sand, depleted in titanum and still containing the monazite, from the High Intensity Wet Magnetic Separator (22) via launders. The sump served as a buffer to provide material to the Table Scavenger Spirals (25). The launders from the High Intensity Wet Magnetic Separator (22), Non-Magnetics Feed Sump (24), pump, and piping to the Table Scavenger Spirals (25) will be considered as a single survey unit. This unit was unaffected for the same reason as unit #21.

Survey Unit #25, Table Scavenger Spirals - Unaffected

The Table Scavenger Spirals (25) located on the 24' elevation of the Wet Mill received material from the main table tailings stream. Heavy minerals were separated as before on the basis of particle density in two banks of twenty, five-turn spirals. The concentrate was passed to the Scavenger Table Feed Sump (26) while the depleted tailings were passed to Tails Sump (28). The Table Scavenger Spirals (25) will be considered as a single survey unit. The table scavenger spirals processed the low-grade rejects from the tables. These rejects contained little or no monazite. Therefore, this unit was unaffected.

Survey Unit #26, Scavenger Table Feed Sump - Unaffected

The Scavenger Table Feed Sump (26) located on the 0' elevation of the Wet Mill received the concentrate from the Table Scavenger Spirals (25) via launders. The sump served as a buffer to provide material to the Scavenger Tables (27). The launders from the Table Scavenger Spirals (25), Scavenger Table Feed Sump (26), pump, and piping to the Scavenger Tables (27) will be considered as a single survey unit. This unit is unaffected for the same reason as unit #25.

Survey Unit #27, Scavenger Table Separators - Affected

The Scavenger Table Separators (27), consisting of two separate units of three-stacked decks, performed another mechanical separation of the process stream. The sand slurry was washed with clean water over a series of vibrating, specially grooved and inclined tables, which further separated the particles on the basis of particle density. The heavier particles, including monazite, were contained in the concentrate stream. The concentrate was returned to the product stream via launders to the Table Feed Sump (17). Tailings (depleted in thorium and uranium) were passed via launder to the Screw Feed Sump (18). Middlings were recycled in the process step. The Scavenger Table Separators (27) and middlings recycling piping will be considered as a single survey unit.

Survey Unit #28, Tails Sump - Unaffected

The Tails Sump (28) located on the 0' elevation of the Wet Mill received the tailings from the Scavenger Spirals (11) via the Tails Transfer Sump (12) and plant process water from the various de-watering stages. The Tails Sump (28) served as the exit point for depleted material leaving the plant. The piping systems from the Tails Transfer Sump (12), Tails Sump (28), pump, and exit piping will be considered as a single survey unit. This unit is considered unaffected for the same reason as unit #12. It handled the rejects of the plant which were light minerals after the removal of heavy minerals, including monazite.

Survey Unit #29, Main Table Separators - Affected

The Main Table Separators, consisting of four separate units of three stacked decks, performed another mechanical separation of the process stream. The sand slurry was washed with clean water over a series of vibrating, specially grooved and inclined tables, which further separated the particles on the basis of particle density. The heavier particles, including monazite, were contained in the concentrate stream. The concentrate flowed through a series of launders to the Classifier Cyclone Feed Sump (30). Tailings (depleted in thorium and uranium) were passed via launder to the Screw Feed Sump (18). Middlings were recycled in the process step. The Main Table Separators (29) and middlings recycling piping will be considered as a single survey unit.

Survey Unit #30, Classifier Cyclone Feed Sump - Affected

The Classifier Cyclone Feed Sump (30) located on the 0' elevation of the Wet Mill received the concentrate from the Main Table Separators (29) via launders. The sump served as a buffer to provide material to the Hydro Classifier (31). The launders from the Main Table Separators (29), sump, pump, and piping to the Hydro Classifier (31) will be considered as a single survey unit. This unit was originally used in the dry mill as the monazite transfer sump (survey unit #43). It was subsequently relocated to the wet mill for this duty when the decision was made to receive the monazite in drums.

Survey Unit #31, Hydro Classifier - Affected

The Hydro Classifier (31) separated the concentrate on the basis of particle size to improve downstream process equipment efficiency and to return large, non-heavy minerals (largely deplete in thorium and uranium) to the Rougher Spirals (4) for further separation. The Hydro Classifier (31) will be considered as a single survey unit.

Survey Unit #32, Dryer Filter Feed Sump - Affected

The Dryer Filter Feed Sump (32) located on the 0' elevation of the Wet Mill received the concentrate from the Hydro Classifier (31) via launders. The sump served as a buffer to provide feed material to the Dry Mill process. The launders from the Hydro Classifier (31), Dryer Filter Feed Sump (32), pump, and piping to the Dryer (33) will be considered as a single survey unit.

Dry Mill Building

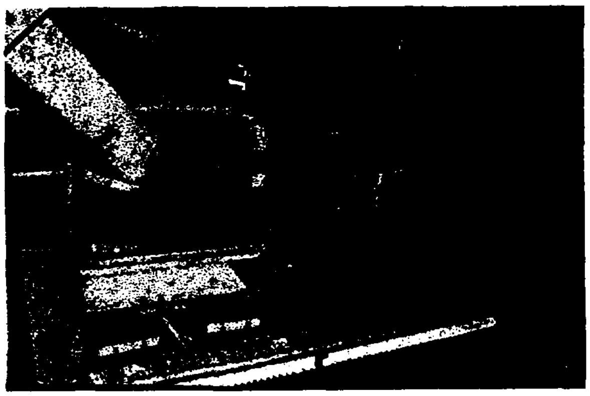
Survey Unit #33, Dryer - Affected

The concentrate from the Wet Mill enters the Dryer (33), located outside the Dry Mill, as a sand/water slurry. The slurry is separated in a Cyclone Dryer and filtered to remove the water before entering the Dryer (33). Water is recycled to the Wet Mill Screen Feed. The dry concentrate travels by gravity through a Dryer which heats the sand to 200°C before entering the Dry Mill at the 0' elevation. The hot sand was conveyed and distributed to the Rougher High Tension Separators (35) hoppers on the 28' elevation. The dryer (33), conveyor, elevator, and feed box hoppers on the Rougher High Tension Separators (35) will be considered as one survey unit.

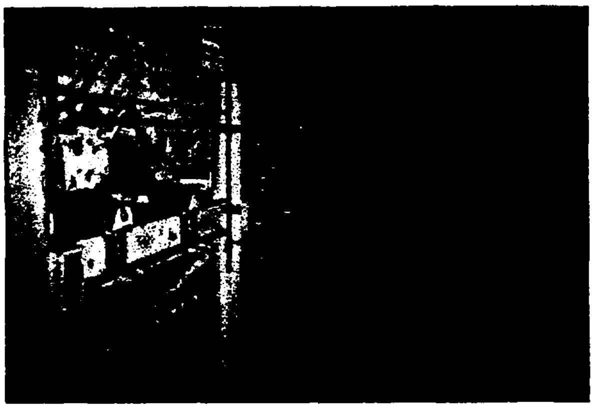
Survey Unit #34, Flue Gas Scrubber - Unaffected

Hot gases from the Dryer (33) were exhausted through the Flue Gas Scrubber (34). The gases were cooled by a water spray and exhausted through the flue. Liquid water effluent was recycled to the Wet Mill Screen Feed (2). The Flue Gas Scrubber (34) will be considered as one survey unit. This unit is unaffected because monazite, a very high density mineral was not carried by the flue gases into the scrubber.

Survey Unit #35, Rougher High Tension Separators - Affected



Material entering the hoppers of the Rougher High Tension Separators (35) falls by gravity onto the surface of rotating cylinders where the sand particles are separated according to their conductive properties in a high tension electro-



static field. The non-conductive fraction, containing the monazite and zircon, is collected and conveyed to the Cleaner High Tension Separators (36). The conductive fraction (deplete in uranium and thorium) is conveyed to the Plate Separator (38) and the Middlings recycled to the up-stream side of the Rougher High Tension Separators (35). There are sixteen identical units in the bank of Rougher High Tension Separators (35) operating in parallel. All sixteen units will be considered as a single survey unit.

Survey Unit #36, Cleaner High Tension Separators - Affected

The particle separation process in the Cleaner High Tension Separators (36) is essentially identical to the previous separation process in the Rougher High Tension Separators (35). The non-conductive fraction, containing the monazite, is conveyed to the Recleaner High Tension Separators (37). The conductive fraction (deplete in uranium and thorium) is conveyed to the Plate Separator (38) and the Middlings are recycled to the upstream side of the Cleaner High Tension Separators. There are sixteen identical units in the bank of Cleaner High Tension Separators (36) operating in parallel. All sixteen units, conveyors, and elevators from the Rougher High Tension Separators (35) will be considered as a single survey unit.

Survey Unit #37, Re-Cleaner High Tension Separators - Affected

The particle separation process in the Re-Cleaner High Tension Separators (37) is essentially identical to the previous separation in the Cleaner High Tension Separators (36). The non-conductive fraction, containing the monazite, is conveyed to the Zircon Magnetic Separators (42). The conductive fraction is conveyed to the Plate Separator (38) and the Middlings (also deplete in thorium and uranium) are recycled in the same process step. There are sixteen identical units in the bank of Re-Cleaner High Tension Separators (37) operating in parallel. All sixteen units, conveyors, and elevators from the Cleaner High Tension Separators (36) will be considered as a single survey unit.

Survey Unit #38, Plate Separator - Unaffected

The conductive fraction (deplete in monazite) entering the Plate Separators (38) cascades by gravity through a series of specially designed plates. The non-conductive fraction (containing any monazite present in the depleted fraction from the High Tension Separators) is returned to the Rougher High Tension Separator (35) Elevator. The conductive fraction (further depleted in thorium and uranium) is conveyed to the Leucoxene Magnetic Separators (39). Middlings from the process are recycled in the same process step. The Plate Separator (38), conveyors, and elevators from the Zircon Magnetic Separators (42) will be considered as a single survey unit. This unit is unaffected because it only treated the conductive minerals (Ti minerals) and no monazite could have reached the unit.

Survey Unit #39, Leucoxene Magnetic Separator - Unaffected

The conductive fraction (deplete in thorium and uranium) from the Plate Separator (38) is conveyed to the Leucoxene Magnetic Separator (39). The sand fall by gravity through a series of cascading, rotating cylinders where particles are separated according to their magnetic properties in a high intensity magnetic field. The magnetic fraction is passed to the final Leucoxene product bins and the non-magnetic fraction (containing any scavenged monazite) is conveyed to the Finisher High Tension Separators (40). There are two identical units in the bank of Leucoxene Magnetic Separators (39) operating in parallel. Both units, conveyors, and elevators from the Plate Separators (38) will be considered as a single survey unit.

Survey Unit #40, Finisher High Tension Separators - Unaffected

The non-magnetic fraction from the Leucoxene Magnetic Separators (39) is conveyed to the Finisher High Tension Separators (40). The sand cascades by gravity through a series of mechanical veins and rotating cylinders where the sand particles are separated according to their conductive properties in a high tension electro-static field. The non-conductive fraction, containing any scavenged thorium and uranium, is returned to the Plate Separator (38) and the middlings recycled in the same process step. The conductive fraction, completely depleted of uranium and thorium, is conveyed to the Rutile Plate Separator (41). There are two identical units in the bank of Finisher High Tension Separators (40) operating in parallel. Both units, conveyors, and elevators from the Leucoxene Magnetic Separators (39) will be considered as a single survey unit. This unit processed the titanium circuit products only, which involved little or no monazite. It is therefore unaffected.

Survey Unit #41, Rutile Plate Separator - Unaffected

The conductive fraction (deplete in monazite) entering the Rutile Plate Separators (41) from the Finisher High Tension Separators (40) cascades by gravity through a series of electrostatically charged plates. The non-conductive fraction (containing any monazite present in the conductor fraction from the High Tension Separators) is returned to the Rougher High Tension Separator (35) Elevator. The conductive fraction is Rutile (deplete of thorium and uranium) which is conveyed to the product bins. Middlings from the process are recycled in the same process step. The Rutile Plate Separator (41), conveyors, and elevators from the Finisher High Tension Separators (40) will be considered as a single survey unit. This unit is also unaffected because it treated only a high-titanium, low-monazite stream.

Survey Unit #42, Zircon Magnetic Separators - Affected

Material entering the hoppers of the Zircon Magnetic Separators (42) falls by gravity through a series of cascading, rotating cylinders where the sand particles are separated according to their magnetic properties in a high intensity magnetic field. The magnetic fraction of this process step is monazite, which contains the thorium and uranium. This material was conveyed to the Monazite Transfer Sump (equipment currently removed) where it was combined with water and pumped as a slurry to the Wet Mill Tails Sump (28). This material was later collected in drums and moved to the monazite pile located outside the Dry Mill. The non-magnetic fraction (deplete in uranium and thorium) is conveyed to the zircon sands storage bins. There are six identical units in the bank of Zircon Magnetic Separators (42) operating in parallel. All six units, conveyors, and elevators from the Re-Cleaner High Tension Separators (37) will be considered as a single survey unit.

Survey Unit #43, Monazite Transfer Sump - Affected

Monazite from the Zircon Magnetic Separator (42) was conveyed to the Monazite Transfer Sump (equipment currently removed) where it was combined with water and pumped as a slurry to the Wet Mill Tails Sump (28). This material was later collected in drums and moved to the monazite pile located outside the Dry Mill. The Monazite Transfer Sump (43) was relocated to the wet will and used in the table circuit when it was decided to receive the monazite sands directly into steel drums. This unit is the same as unit #30.

Survey Unit #44, Dry Mill Floor and Walls up to two (2) meters - affected

The concrete floor and lower walls of the Dry Mill will be surveyed as an affected area on a one square meter grid system to determine compliance with the release criteria.

Survey Unit #45, Wet Mill Floor and Walls up to two (2) meters - Unaffected

The portion of the concrete and earthen floor and lower walls of the eastern half of the Wet Mill (excluding that portion beneath the ASARCO spirals, see discussion below) will be surveyed as an unaffected area on a 3x3 or 2x2 (wall grids only) meter grid system to determine compliance with the release criteria.

Survey Unit #46, Dry Mill Bag House - unaffected

Ventilation air was supplied to the Dry Mill by a series of open air fans. The circulating air in the Dry Mill was drawn through fiber bag filters and large particulate mater removed before exhausting to the outdoors. The bag house is located outside the Dry Mill and consists of four (4) identical filter units.

ASARCO Spirals - Unused

Approximately half of the area of the Wet Mill is occupied by about 1,500 separator spirals known as the ASARCO Spirals which were not used in the HMI separation process. These spirals were used by ASARCO to separate the raw, natural sands dredged from the original deposit. It was the tailings from these spiral separators that become the feed material for the HMI process. These spirals and the sumps servicing them remained unused since ASARCO stopped operations in 1982. They are therefore not included in this survey.

Appendix C

Process and Decommissioning History

Past Efforts:

Shortly after the final plant shutdown in August, 1990, both mills were subjected to a thorough cleaning and decommissioning as follows:

1. Wet Mill Building:

All equipment in the wet mill building which was in use in the project (whether affected or unaffected) was washed down with high-pressure water hoses and nozzles until no sand was visible on or around the equipment. The collection launders, which are the troughs underneath the spirals used to collect and convey the products were washed next using the high pressure water until all the sand was sluiced down to the sump-pumps on the ground floor. Since the shaking tables were the only "affected" equipment, i.e., they were the only processing equipment to have come in contact with source material, they were pressure washed a second time with the loose edges of the rubber lining lifted so that any sand that might have been entrapped under the lining may be washed off. The same treatment was applied to the launders attached to the table frames for product collection. The sand and water collected in the sumps and pumps were drained on the concrete floor, the sump tanks cleaned with the pressure hoses and the pump casings opened and washed with the high pressure water. The sand collected was transported to the monazite pile using shovels and wheelbarrows.

2. Dry Mill Building:

No water was used in the dryer or the dry mill building because of the electrical equipment present. Instead, high pressure air hoses were used to blow down the sand and dust from the equipment, structural steel, walls and other surfaces. Personnel involved in this activity used dust masks and film-badge monitors. The sand and dust collected on the ground floor were collected using vacuum cleaners and transported to the monazite pile.

Clean up of the mill buildings was performed by plant operators who were familiar with the equipment, the process and the buildings. The work was supervised by Tony Cuculic, then plant Chief Engineer and Radiation Safety Officer.

Following the clean up of the plant buildings, Tony Cuculic, as Radiation Safety Officer, performed a gamma survey of the plant buildings and selected pieces of equipment which were known to be "affected" due to the monazite concentration in the products which were in contact with the equipment. The gamma survey was conducted with a

Ludlum Model 19 micro R meter. In addition, "Fixed Contamination" measurements were made on representative pieces of affected equipment (wet tables, dryer and dry magnets) using an Eberline E120 c/w HP260 "Pancake probe". The same equipment was also subjected to smear testing for "Removable Contamination". Standard filter paper discs were used in the smears and were sent to Teledyne Isotopes for counting.

The above-mentioned surveys and smear tests were performed on January 28, 1991 to verify that the decommissioning work was complete and to reveal any areas that might require additional work. This phase of the work was not intended for submission to the NRC as a Final Status Survey, which was never done because, due to the presence of the monazite pile, the site was not ready for final release.

Unaffected Buildings:

In addition to the two plant buildings there are five other buildings on the site. Namely, the laboratory, the change house, the maintenance building, the warehouse and the main office. All five building are considered "unaffected" because of the fact that monazite-rich products (source material) were never handled or present in any of these buildings. Source-material grade sand was not sampled or analyzed in the laboratory. The maintenance building was not used to repair any of the affected process equipment. Such equipment was maintained and repaired on location in the plant buildings.

Process History and Origin of the Monazite Pile:

Following is a detailed historical description of the entire process, starting from the beginning of the original mining carried out by Asarco prior to the inception of HMI.

ASARCO Operation

The site was operated by ASARCO, Inc. between 1973 and 1982. The operation consisted of hydraulic mining (dredging) of the sand deposits and processing those sands to extract the titanium mineral ilmenite. The mineral composition of the sand deposits at the site were ascertained by earlier geological and mineralogical studies conducted by ASARCO. The deposits contained approximately 95% silica (common sand) and 5% heavy minerals. There are many mineral constituents in the deposits that are heavier than silica, which is why they are called heavy minerals. Ilmenite is the predominant heavy mineral, followed by zircon, kyanite, sillimanite, rutile, staurolite, tourmaline and monazite. Monazite is the mineral that contains thorium and uranium which cause the radioactivity in the deposits.

The following is a description of ASARCO's process, which is also illustrated in Figure 6:

1) At the very beginning, since there was no pond for the dredge, one was created by removing the top soil and sufficient sand using a dragline. The material so removed was stockpiled in a location west of the railroad tracks.

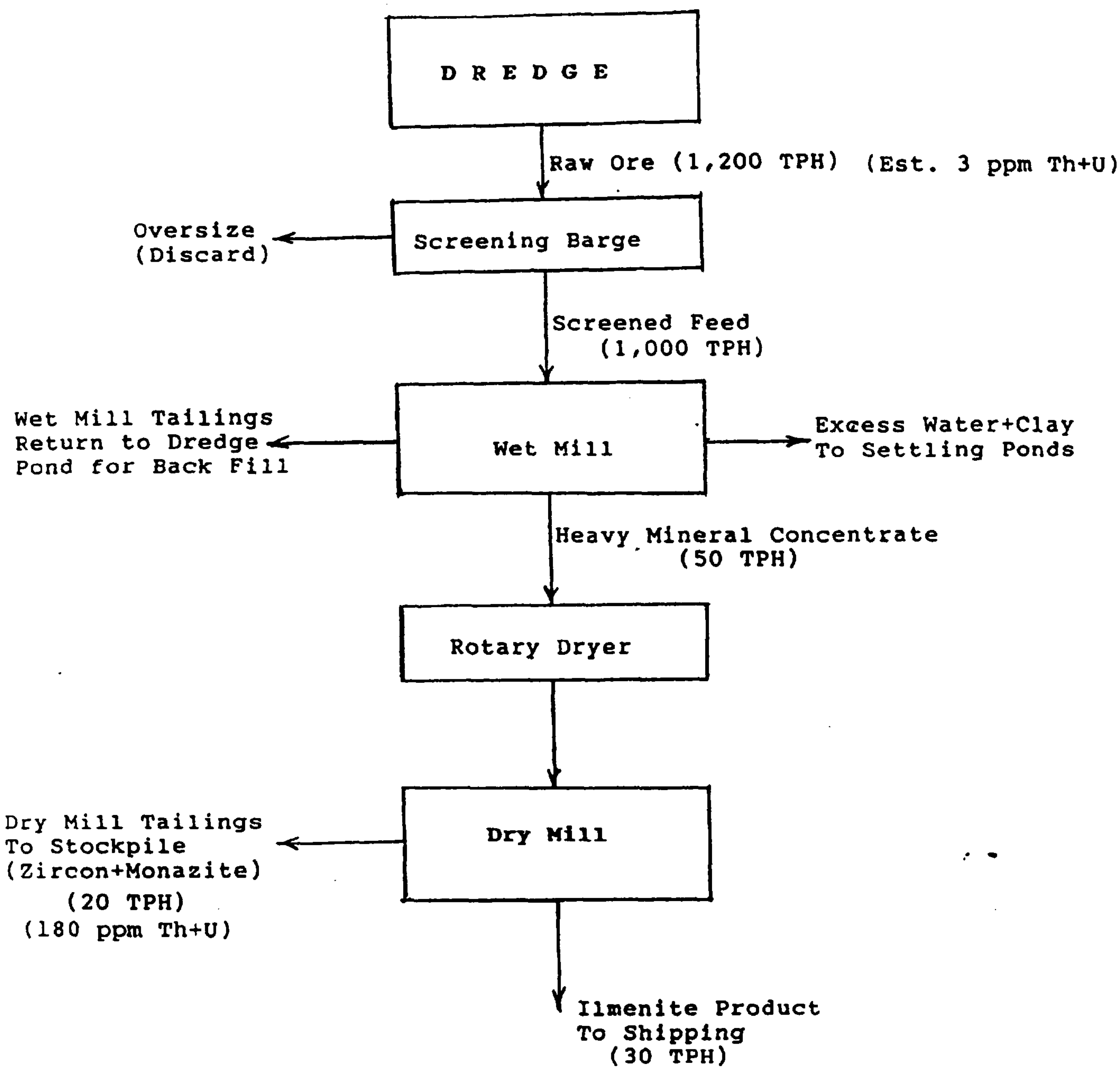


FIGURE 6

ASARCO's OPERATION SCHEMATIC

2) The dredged sand was pumped to a screening barge where large roots, clay balls and gravel were removed from the sand. The dredging rate was about 1,200 tons per hour.

3) The screened sand was pumped, still in slurry form, to a land-based concentrating plant consisting of a wet mill and a dry mill. The slurry went first to the wet mill wherein the heavy minerals were concentrated using spiral separators known as Humphreys spirals. The wet mill tailings, consisting primarily of silica sand and water were pumped back to the dredge pond as back-fill of the mined-out areas. At the start of dredging, there was no place to back fill in the newly created dredge pond. Therefore, the wet mill tailings were stored west of the railroad tracks in the same location as the top soil removed by the dragline. This practice created a pile of roughly one million tons of material consisting of top soil and wet mill tailings. This pile is being referred to as <u>Asarco wet mill tailings or old tailings</u>. Based on its history, the radionuclide concentration of this pile is below the natural background concentration of the area. The heavy minerals followed a different path down the spiral and were dewatered and stockpiled outside the wet mill. Approximately 50 tons per hour of heavy-mineral concentrate were produced.

4) A great deal of wash water was used to assist the separation on the spirals and to wash away the fine clay which coated the mineral particles. The excess wash water and suspended clay were decanted off using large holding tanks (sumps) before pumping the sand.

5) The clay-laden water was pumped to a series of large-area settling ponds (about 10 acres) on the north side of the wet mill. The clay was allowed to settle out and the clarified water was recycled to the wet mill. This is the area which is now known as the "Blue Area". The reference came from the color-coded map which was presented to the US NRC by Heritage Minerals during licensure in 1990.

6) It should be noted that the monazite concentration was increased by the ratio of 24:1 as a result of going through the wet mill and concentrating the heavy minerals from 1,200 tons to 50 tons.

7) The heavy mineral concentrate was allowed to drain for several days then transferred to a 200-ton storage silo.

8) Using a disc feeder at the bottom of the storage silo and a conveyor belt, the heavy mineral concentrate was fed to an oil-fired rotary dryer wherein the heavy mineral sands were completely dried and heated to about 300 degrees F.

9) The heated sand was conveyed to the dry mill which contained high-tension electrostatic separators and high-intensity magnetic separators.

10) The ilmenite was separated from the other heavy minerals using the high-tension separators which take advantage of the difference in electrical conductivity among minerals. Ilmenite, which was the desired titanium mineral, is electrically conductive. All the other heavy minerals in the concentrate are non-conductors.

11) The conductor product was then fed to the high-intensity magnetic separators for final cleaning of the ilmenite which was then placed in storage bins pending shipping to customers by rail or truck. About 30 tons per hour were produced.

12) The non-conductor rejects from the high tension separators were referred to as the Dry Mill Tailings. They were mixed with water and pumped to a storage area east of the mill. This is the area now referred to as the "Gray Area".

13) The Dry Mill Tailings, at about 20 tons per hour, contained virtually all the monazite that was contained in 50 tons of heavy minerals concentrate. Therefore the concentration of monazite was increased by the ratio of 2.5:1 relative to the heavy mineral concentrate. Since this is also the monazite that was contained in 1,200 tons of dredge output, it can be concluded that the monazite and its contained thorium and uranium were concentrated by a factor of 1,200:20, or 60:1 above original deposits. A sample of the Dry Mill Tailings was analyzed by the US NRC during an inspection of the Heritage operation in January, 1988. It was found that the ASARCO Dry Mill Tailings (later referred to as the New Feed by Heritage) contained <u>180</u> ppm (parts per million) thorium plus uranium (Th+U). Approximately one million tons of Dry Mill Tailings were accumulated in the Gray Area during the ASARCO operation.Based on the above, it is estimated that the unprocessed sand deposits contained about 3 ppm Th+U (180/60=3).

14) ASARCO had planned to process the Dry Mill Tailings at a later date for the extraction and sale of zircon and monazite. Extensive laboratory and pilot-plant testing was performed by ASARCO on the recovery of zircon and monazite. However, deteriorating market conditions caused ASARCO to discontinue all operations at the site in 1982 and sold the property to Heritage Minerals, Inc. in 1986.

<u>Heritage Minerals Operation</u>

After the property was purchased by Heritage in 1986, the plant facilities were leased to Mineral Recovery, Inc. MRI ran additional laboratory and pilot-plant tests for the recovery of zircon and additional titanium minerals left behind by ASARCO, but not monazite which was to remain a part of the Dry Mill Tailings. The test work was conducted at Hazen Research of Golden, Colorado.

Based on the results of the test work and Hazen's recommendations the plant was modified and additional equipment was purchased. The plant started operation in October, 1986. In August, 1987 MRI's lease was terminated and Heritage Minerals took over the operation until August of 1990 when all production stopped. The operating period between October, 1986 and August 1987 (MRI's operation) was mostly a plant break-in and tune-up period during which actual production was minimal. As a result, the bulk of the zircon and titanium values in the New Feed remained in the tailings during this period.

The following is a description of the Heritage plant operation, which is also illustrated in Figure 7:

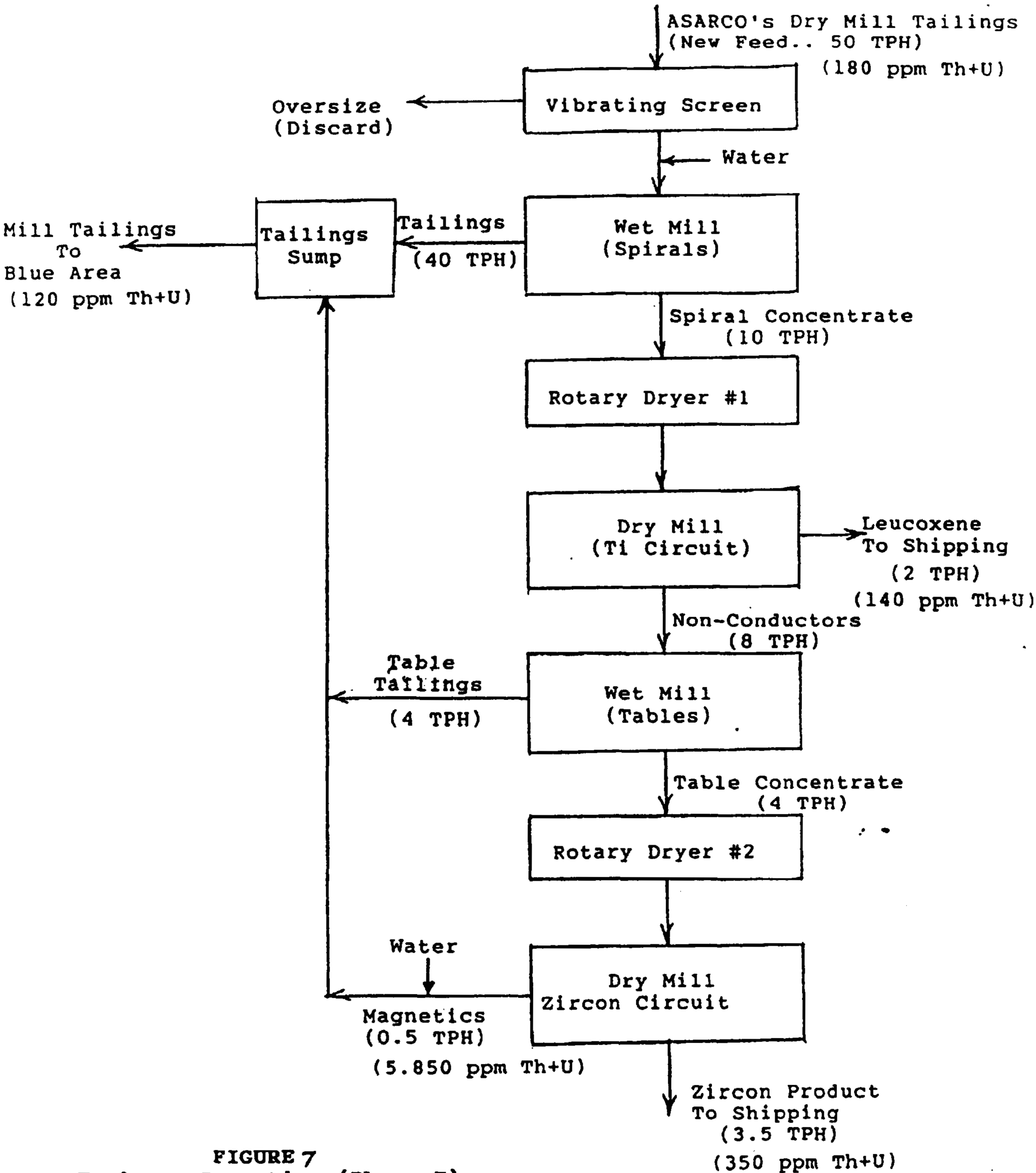


FIGURE 7
Heritage Operation (Phase I)

1) The ASARCO Dry Mill Tailings located in the Gray Area, which will now be referred to as the New Feed for the zircon plant, were mixed with water and pumped to the wet mill at the rate of 50 tons per hour.

2) The slurry was processed over Humphreys spirals to remove any remaining silica sand and some of the aluminum minerals. Although the aluminum minerals are considered heavy minerals, they are considerably lighter than zircon, monazite and titanium minerals. As such it was possible to reject some of those aluminum minerals on the Humphreys spirals. Little or no zircon or monazite were lost in the spiral tailings. Some titanium losses were incurred, however, due to the presence of low-density, weathered ilmenite. The spiral tailings were collected in a large holding tank (sump) and pumped to the area north of the wet mill which was occupied by the clay settling ponds during ASARCO's operation (the Blue Area).

3) The spiral concentrate was dewatered using a vacuum filter then dried and heated to 300 degrees F in an oil-fired rotary dryer, similar to the one used by ASARCO but much smaller.

4) The dry, heated sand was fed to the first section of the dry mill (the Ti circuit) where the titanium minerals were separated using high tension machines. The primary titanium mineral recovered was leucoxene, which is a transition mineral between ilmenite and rutile. Leucoxene is a conductor as are ilmenite and rutile, and hence could be separated using high-tension machines.

5) The conductor product from the high-tension separators was cleaned using high-intensity magnetic separators to produce market-grade leucoxene. Because there is a certain degree of imperfection in any separation process, some zircon and monazite remained with the leucoxene. As a result, the leucoxene product, when analyzed by NRC, was found to contain 140 ppm Th+U. This was well below any regulatory or safety concerns and was acceptable to the customers.

6) The non-conductor product from the high-tension separators contained the zircon, monazite and the remaining aluminum minerals. It was reslurried with water and pumped back to the wet mill.

7) In the wet mill, the non-conductors were fed to a hydraulic classifier and then shaking tables, which were used to reject the remaining aluminum minerals. The table tailings were combined with the spiral tailings in the same holding tank, and were pumped together to the Blue Area.

8) The table concentrate was dewatered on a vacuum filter then dried and heated in a second oil-fired rotary dryer.

9) The dry, heated table concentrate was conveyed to another section of the dry mill (the zircon circuit) where it was treated on high-tension machines to remove any remaining traces of titanium minerals. Those were collected as conductors and returned to the Ti circuit.

10) The non-conductor product from the high-tension machines contained the zircon and monazite plus traces of aluminum minerals. The non-conductors were then fed to

high-intensity magnets to remove magnetic minerals (monazite, staurolite and tourmaline) and thus produce market-grade zircon for sale to customers. Once again, because of the nature of the separation processes, some monazite remained in the zircon product. A sample of zircon was also taken and analyzed by NRC and found to contain 350 ppm TH+U. This was again below the regulatory threshold of 500 ppm set by NRC for "Source Material" requiring licensing. The Th+U content of the zircon was also below the specifications set by customers.

11) The magnetic product, which contained the monazite, was mixed with water and pumped back to the wet mill where it was combined with the spiral tailings and the table tailings in the holding tank to make up the plant tailings that were pumped to the blue Area. When analyzed by NRC along with the other materials, the combined plant tailings were found to contain 120 ppm Th+U, which is less than the 180 ppm that was found in ASARCO's dry mill tailings (Heritage's New Feed). The decrease in Th+U concentration is explained by the loss of monazite to both the zircon and leucoxene product. The analyses show that the Heritage operation resulted in a net improvement in the radiological condition of the site when compared with what it was at the end of ASARCO's operation and before the property was purchased by Heritage. While these numbers are one-time analyses of single samples, they represent the correlation amongst the various products, since all the samples were taken at the same time.

12) The ASARCO Dry Mill Tailings in the Gray Area (the New Feed) were exhausted at the end of February, 1990. At that time, Heritage decided that sufficient zircon and leucoxene had remained in the plant tailings in the Blue Area, especially during MRI's initial operation period, to warrant the recycle of those tailings through the plant for a second round of processing to extract additional zircon and leucoxene products. This was started in March, 1990 and became known as Phase II of the operation.

13) Some minor variations on the above-described process were tested and incorporated in the plant operations in the efforts to improve product quality and yield. For example,additional stages of spirals were added to improve silica and alumina rejection. Another variation, which was incorporated to reduce fuel consumption, was eliminating the second rotary dryer and processing the spiral concentrate directly on the shaking tables prior to processing in the dry mill. A third variation, which was dictated by NRC during the licensing process, involved isolating the monazite-rich magnetic product in a separate holding area rather than combining it with the other tailings. When that practice started, the mill tailings were no longer pumped to the Blue Area but were sent to a separate area east of the wet mill. The monazite-rich magnetics were stored separately in an area southeast of the dry mill. This is the area known as "the Monazite Pile".

14) The above-mentioned variations were incorporated at the start of reprocessing of the plant tailings (phase II) in March, 1990. In August, 1990, after about 200,000 tons of tailings were reprocessed through the plant, Heritage decided to terminate all operations due to the economic downturn which resulted in reduced demand and prices for the plant products.

15) During the final 30 days of operation, the monazite-rich sand was stored in 55-gallon steel drums instead of being pumped to the monazite pile. This was in anticipation of shipping the monazite off site to another processing facility.

The reprocessing of the 200,000 tons of Blue Area tailings during which the monazite was isolated in the Monazite Pile resulted in further improvement in the condition of the site through producing about 150,000 tons of tailings that were virtually monazite free . These tailings were stored separately in an area east of the Blue Area and north of the Gray Area. As a consequence of this practice, approximately 695 cubic yards (1,400 tons) of monazite-rich product were generated and are stored in the Monazite Pile. The Monazite Pile, as well as the plant buildings, are under the control of the NRC according to the terms of License No. SMB-1541. Figure 8 is a schematic of phase II of the plant operation.

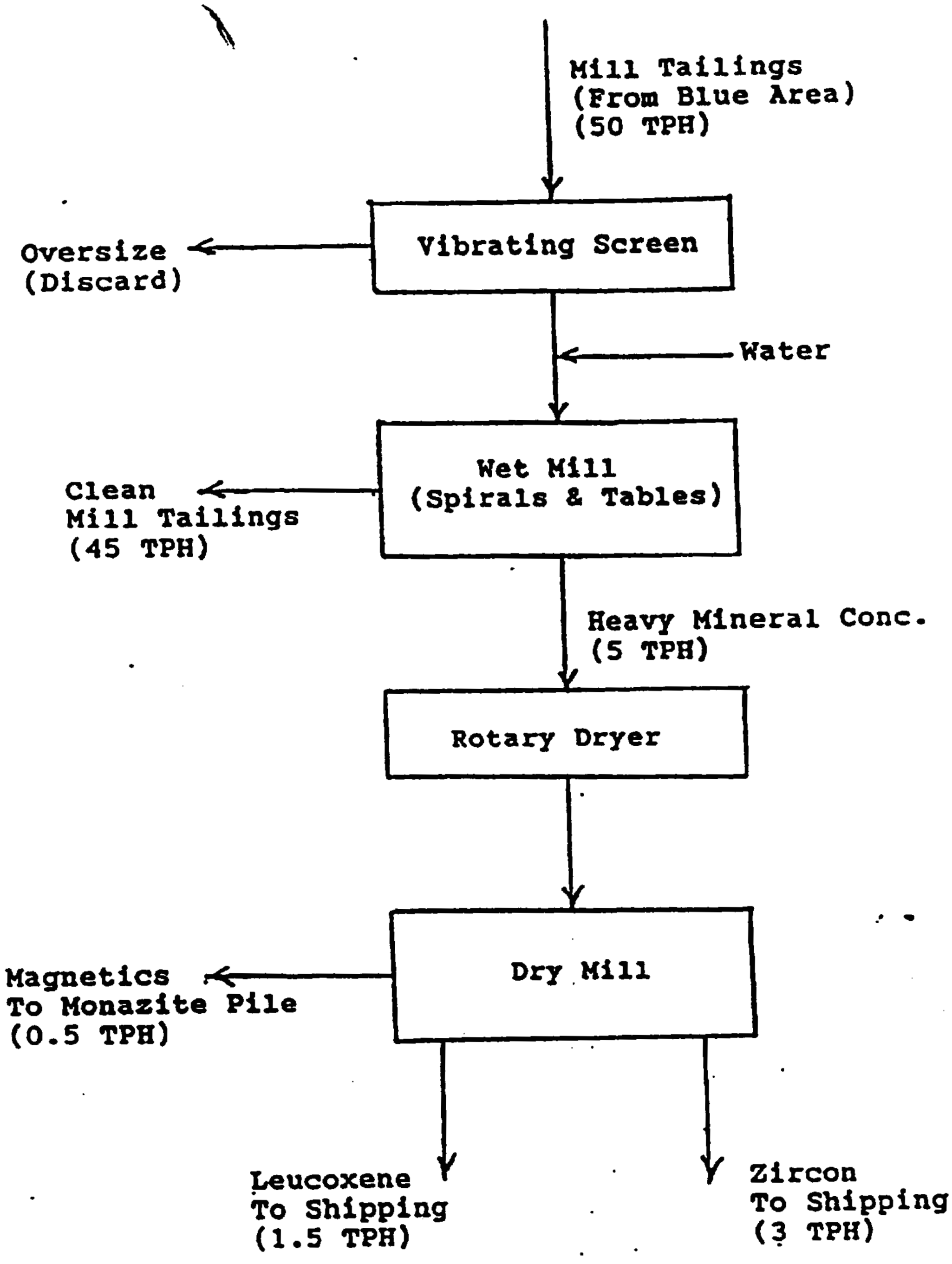


FIGURE 8

Heritage Operation (Phase II)

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