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Time and Motion Study for Alternative Mixed Low-Level Waste Treatment Systems

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ACRONYMS AND ABBREVIATIONS

APC	air pollution control
$CaSO_4$	calcium sulfate
CWO	catalytic wet oxidation
DOE	U.S. Department of Energy
FTE	full-time equivalent
GAC	granular activated carbon
GPCR	gas phase corona reactor
HEPA	high efficiency particulate air filter
gpm	gallons per minute
INEL	Idaho National Engineering Laboratory
INTS	integrated nonthermal treatment system
ITTS	integrated thermal treatment system
LMITCO	Lockheed Martin Idaho Technologies Company
MEO	mediated electrochemical oxidation
MLLW	mixed low-level (radioactive) waste
OSORT	open, dump and sort activities
psi	pounds per inch
PAN	passive/active neutron scanning
R&D	research and development
RCPRP	receiving and preparation activities
RTR	real-time radiography
SCC	secondary combustion chamber
SCM	system cost model
SGS	segmented gamma scanning
TDS	total dissolved solids
TOC	total organic carbon
TRU	transuranic
UV	ultraviolet light
WBS	work breakdown structure
WRAP	Waste Receiving and Processing

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EXECUTIVE SUMMARY

The time and motion study was developed to look at time-related aspects of the technologies and systems studied in the Integrated Thermal Treatment Systems (ITTS) and Integrated Nonthermal Treatment Systems (INTS) studies. The INTS and ITTS studies combined technologies into systems and subsystems for evaluation. The system approach provides DOE a method of measuring advantages and disadvantages of the many technologies currently being researched.For example, technologies which are more likely to create secondary waste or require extensive pretreatment handling may be less desirable than technologies which require less support from other processes.

The time and motion study was designed to address the time element in the INTS and ITTS systems studies. Previous studies have focused on material balance, cost, technical effectiveness, regulatory issues, community acceptance, and operability. This study looks at system dynamics by estimating the treatment time required for a unit of waste, from receipt to certification for shipping. Labor estimates are also developed, based on the time required to do each task for each process. This focus on time highlights critical path processes and potential bottlenecks in the INTS and ITTS systems.

Gant charts were selected to model functions in this study. Although Gant charts do show a critical path, this type of analysis is not sufficiently accurate to pinpoint the exact bottlenecks in a continuously operating facility. Other commercially available scheduling software might be used to provide a more accurate work schedule and a critical path analysis model.

The purpose of this time and motion study is to provide data for research prioritization and allocation of research resources. The study is based on a review of the technologies involved, discussions with vendors, and the authors' industrial chemical processing and material handling experience.

The time focus also allows quantification of task requirements, such as sorting and characterization. One of the more interesting results of this study is that radioactive characterization labor requirements are greater than those for shredding or sorting.

The key results of the study are the following:

- Characterization is a critical path process and very labor intensive
- The differences in receiving and preparation between thermal and nonthermal systems are less dramatic than estimated in the INTS and ITTS studies
- Material handling is more significant than processing in terms of labor and time
- One-step thermal treatment processes require significantly less labor than incineration combined with vitrification of ash
- Special waste treatment is on the critical path for thermal systems
- Treatment of special wastes will require significant allocation of resources
- Storage requirements for special waste will be extensive if processes are not available for treatment
- Debris treatment is on the critical path for nonthermal systems
- Labor FTEs may be about 20% higher than estimated in the INTS and ITTS reports

1. INTRODUCTION

The purpose of this time and motion study is to provide data for further research prioritization. The time and motion study was performed on five systems developed in the Integrated Thermal and Nonthermal Treatment System studies. Systems were selected to study the impacts of various treatment technologies on the flow of materials through an integrated mixed low level waste treatment facility. The time and motion study estimated the labor to operate each system, and the time required for treatment of a drum of waste for each system. The time to process a unit of waste highlights critical path issues and potential bottlenecks in each system. Research efforts to reduce such bottlenecks may provide significant dividends to the DOE in the form of reduced labor and cost. Time-efficient operation should reduce chemical and radioactivity exposure to workers. Also, systems and technologies with fewer bottlenecks are more attractive for development demonstrations and future implementation.

2. SYSTEM DESCRIPTIONS

Three systems from the Integrated Nonthermal Treatment Study (INTS) and two systems from the Integrated Thermal Treatment Study (ITTS) were studied. These systems were chosen as representative of the INTS and ITTS systems. The five systems are included in the report *Comparison of Alternative Treatment Systems for DOE Mixed Low-Level Waste* (Schwinkendorf, 1996).

2.1 Systems Processes

This section provides only a brief introduction to these systems. They are already thoroughly described in the INTS (Biagi, 1997) and ITTS reports (Feizollahi, 1995). This brief description references the key processes.

THERMAL SYSTEMS

System A-1

This system includes the following major subsystems:

- rotary kiln with air for combustion for organic destruction
- vitrification of ash
- polymer stabilization of secondary wastes
- decontamination of surface contaminated metals
- melting of metals with entrained contamination
- retorting of mercury contaminated waste, with amalgamation of mercury

System C-1

Major subsystems include:

- plasma furnace with air for combustion for organic destruction
- polymer stabilization of secondary wastes
- decontamination of surface contaminated metals
- melting of metals with entrained contamination
- retorting of mercury contaminated waste, with amalgamation of mercury

NONTHERMAL SYSTEMS:

System NT-2

This system includes the following major subsystems:

- catalytic wet oxidation for organic destruction
- thermal desorption of soil, process residue and debris
- decontamination of surface contaminated metals
- primary stabilization of treated sludge and secondary waste in polymer
- primary stabilization of treated soil and treated debris in grout
- amalgamation of mercury waste

System NT-3

Major subsystems include:

- mediated electrochemical oxidation for organic destruction
- washing of soil, process residue and debris
- decontamination of surface contaminated metals
- primary stabilization of treated sludge and secondary waste in polymer
- primary stabilization of treated soil and treated debris in grout
- amalgamation of mercury waste

System NT-5

This system includes the following major subsystems:

- catalytic wet oxidation for organic destruction of liquids and soft (combustible) debris
- thermal desorption of process residue
- washing of soil and debris
- decontamination of surface contaminated metals
- primary stabilization of treated sludge and secondary wastes in polymer
- primary stabilization of treated soil and treated debris in grout
- amalgamation of mercury waste

2.2 Subsystem Descriptions

Each system consists of several subsystems. Most of the subsystems are identical or only slightly modified for the different systems. The subsystems which are consistent for all systems in this time and motion study are the following:

- administration
- receiving and preparation
- aqueous waste treatment
- metal decontamination
- special waste treatment
- air pollution control
- polymer stabilization
- certification and shipping

The following subsystems are used in the ITTS and INTS systems as indicated:

- vitrification (ITTS: A-1)
- metal melting (ITTS: A-1)
- mercury amalgamation, with retorting of debris (ITTS: A-1, C-1)
- mercury amalgamation (INTS: NT-2, NT-3, NT-5)
- lead recovery (ITTS: A-1, C-1)
- lead decontamination and stabilization (INTS: NT-2, NT-3, NT-5)
- incineration (ITTS: A-1)
- plasma furnace thermal treatment (ITTS: C-1)
- mediated electrochemical oxidation (INTS: NT-1, NT-3)
- catalytic wet oxidation (INTS: NT-2, NT-5)
- vacuum thermal desorption (INTS: NT-2, NT-5)
- grout stabilization (INTS: NT-2, NT-3, NT-5)
- aqueous wash (INTS: NT-3, NT-5)
- high pressure wash (INTS: NT-3, NT-5)

These subsystems are described in detail in the ITTS and INTS reports (Feizollahi, 1995; Biagi, 1997).

3. STUDY METHODOLOGY

The overall approach of the time and motion study was to follow the waste received in a single shift of operation, through handling and treatment steps. This approach did not attempt to optimize the subsystems, but only to present the subsystems as currently developed. A series of interlinked spreadsheets was developed to estimate the processing time for each handling and treatment step. A series of Gant charts presents the time required for the waste to pass from receiving through primary and secondary treatment, stabilization and finally certification and shipping. The Gant charts are provided as Figures 1 through 5 to illustrate the time elapsed for treatment of waste in each subsystem and to identify critical path functions.

The labor requirements were estimated for each step, and the total labor for each subsystem was calculated. The labor estimate is provided in Table 1. This table provides the results of the time and motion study, and compares it with the full time equivalents (FTEs) presented in the ITTS and INTS studies. These results of the time and motion study were not incorporated in the ITTS and INTS reports.

The tables from the interlinked spreadsheets are provided in Appendix A. The tables are numbered by system (e.g., Table NT5-a through NT5-r). The first table for each subsystem (Table A1-a, Table C1-a, Table NT2-a, Table NT3-a and Table NT5-a) shows waste allocation (mass flow rate). The last table in each section of Appendix A provides a summary of the full time equivalent employees (FTEs) and the time required for processing.

3.1 Waste Allocation to Subsystems

Waste was allocated to the various treatment systems based on the INTS mass balance (Biagi, 1997) and the ITTS mass balance of April 23, 1996 (Brown, 1996). Secondary as well as primary flows are accounted for by using the INTS and ITTS mass balances developed by Blaine Brown of LMITCO (Brown, 1996). Because of secondary flows, more waste is treated than is received.

Waste densities are assumed for all waste entering a given subsystem. Where available, densities from the mass balance were used. Density data developed for the Systems Cost Model were used for waste streams without assigned densities (Shropshire, 1995). For each waste type, a drum density was developed (pounds /55 gallon drum). This allowed the expression of incoming waste in terms of drums of waste per shift. The drum densities are listed on Tables A1-a, C1-a, NT2-a, NT3-a and NT5-a.

3.2 System Dynamics Modeling

The time and motion study estimated the time required for various processing steps at the design throughputs of the equipment specified in the INTS and ITTS studies. Where multiple steps or steps with low throughput were necessary, the processing time required increased. For example, special waste processing through receiving and preparation includes time required for truck receiving and unloading, waste assay, container staging, container opening, dumping and sorting, size reduction, sampling, and container decontamination for each unit of waste. For convenience, a drum of waste was selected as the unit of waste used for estimating processing time. The development of system dynamics provided insights into critical path processes and potential bottlenecks in the facility.

The time and motion study was performed by breaking down each subsystem into multiple discrete tasks. The time to perform each task was evaluated. Treatment time was estimated based on the design capacity of the equipment and estimated throughput. The total of all tasks performed in a subsystem defines the treatment time for a drum of waste. The number of drums which require treatment during a shift, multiplied by the treatment time per drum, provides a total treatment time.

For batch processes utilizing more than one drum, or for continuous processes, the total treatment time must be calculated for all the drums of waste processed in an 8 hour shift. The lag time between drums was estimated, multiplied by the number of drums, and added to the time for a single drum to traverse the subsystem. Sampling and equipment monitoring times were also estimated. The total time to process the waste sent to each subsystem was then calculated. This information was used in preparation of the Gant charts (Figures 1 through 5).

The processing time was used to determine the number of FTEs. For some processes, the FTEs were based on monitoring time, rather than flow through a process. Monitoring time was estimated by considering the number of times a piece of equipment would be monitored (typically every 20 minutes or 24 times/shift) and the amount of time required for each monitoring task (usually 2-5 minutes). Monitoring tasks are assumed to include periods of perfunctory monitoring as well as analysis during mechanical or process problems. This approach accounts for parallel operations, because it assumes an operator can monitor multiple equipment items. The assessment of total monitoring time for all operations in a subsystem provides an estimate of the number of FTEs required for monitoring. Start-up time is included for batch processes.

The FTEs are based on the total personnel required per day to run a subsystem. Supervisory personnel are included at a ratio of one supervisor to ten workers. Also, an FTE absentee value of 6 weeks per year was assigned to account for employee vacations, holiday, sick leave, jury duty, etc. Finally, an efficiency of 70 percent was assigned to all FTEs. This 70 percent factor includes time off for lunch, breaks and meetings as well as process downtime occurring during their shift.

Tables A1-b through A1-o, C1-b through C1-l, NT2-b through NT2-n, NT3-b through NT3-o, and NT5-b through NT5-q present the time and motion analysis for the subsystems associated with each system. In most subsystems, all the waste entering requires the same treatment, but in some cases waste is divided by subtypes for distinct treatment trains. For example, the receiving and preparation subsystem discussed in Section 4.2 allocates waste by waste type to certain separation processes. Another example is the aqueous waste treatment subsystem, where aqueous waste is divided into high and low total dissolved solids and organics.

Sampling frequency is generally estimated at one sample per ten drums. In-process sampling is assumed for most processes, although the type of analysis is not specified.

Table 1 and Tables A1-p, C1-m, NT2-o, NT3-p and NT5-r provide a summary of the results of the analysis. The total FTEs shown in the time and motion analysis are about 20% higher than the FTEs estimated in the ITTS and INTS study reports. The reasons for this difference are discussed in Section 5.2.

The Gant charts (Figures 1 through 5), developed with SureTrak software, are based on the summary tables A1-p, C1-m, NT2-o, NT3-p and NT5-r. The assumptions used in the modeling are presented in Appendix B.

4. TASKS EVALUATED FOR EACH SUBSYSTEM

This section discusses the tasks evaluated and the results for each subsystem. Results are discussed for the five systems in this study. Some subsystems, such as administration, will be the same for all systems. Others, such as incineration, are only appropriate for a single system. Subsystems such as certification and shipping have the same tasks for all systems, but the FTEs will be different depending on the volume of waste shipped.

4.1 Administration Subsystem

The administration subsystem analysis estimates the FTEs required to operate the facility. Tables A1-b, C1-b, NT2-b, NT3-b and NT5-b show the estimated FTEs for the Administration subsystem. The facility staff was estimated, assuming an operation similar to an industrial facility with a total of 300 FTEs. Additional supervisory staff is included for each subsystem. Laboratory staff is estimated based on:

- The estimated number of samples received per shift (totaled from other subsystems)
- Four FTEs are needed to fill all shifts in a 5 day week for a given shift assignment; this accounts for vacation, sick and holiday relief
- Analysis time for in-process samples (10 minutes)
- Analysis for characterization (30 minutes)
- Analysis for raw materials (20 minutes)

The non-laboratory staff is estimated to be the same for all thermal and nonthermal systems. A staff of 35 is estimated for the following functions:

- Facility management
- Operations Management
- Personnel/ Security
- Environmental
- Shipping/Receiving
- Purchasing
- Accounting
- Health Physics

The laboratory technician staff required is based on the expected sampling required for waste characterization, in-process testing, raw materials testing, and final waste form analysis. The laboratory staff ranges from 12 for System C-1 to 23 for System NT-3.

The total administration subsystem FTEs for each of the systems are presented below and in Table 1:

- 48 for System A-1
- 47 for System C-1
- 52 for System NT-2
- 57 for System NT-3
- 58 for System NT-5

4.2 Receiving and Preparation Subsystem

The operations in the receiving and preparation subsystem was divided into specific detailed tasks. In addition to the ITTS and INTS reports, the design document for Hanford Site's WRAP 2A (Shaw, 1995) was used as a basis for developing these tasks. Tables A1-c, C1-c, NT2-c, NT3-c and NT5-c present the Receiving and Preparation Subsystem time and motion study. Eighteen tasks are identified, but not all tasks are required for all waste types. Several assumptions are made regarding how much waste will be treated by various unit operations, such as sorting, shredding, size reduction, glove box sorting, etc. These assumptions are presented in Tables A1-c, C1-c, NT2-c, NT3-c and NT5-c.

The tasks are listed below:

- Receiving trucks containing waste
- Receiving trucks with empty containers
- Receiving trucks containing supplies
- Transfer of waste from truck to interim storage or staging areas
- Assay waste by real time radiography, gamma spectroscopy, passive/active neutron (PAN) assay
- Transfer and staging of waste for sorting
- Opening drums
- Dumping drums
- Sorting waste robotically at tables
- Glove box sorting
- Assessing debris for compliance with debris rule
- Gross size reduction (cutting)
- Shredding
- Characterization sampling
- Transferring waste to bins
- Transfer of waste between subsystem
- Box breakdown
- Container decontamination.

For each system, the mix of tasks varies. All waste must be received, staged, and assayed. For thermal systems, 50 percent of the waste is assumed to require sorting; for nonthermal systems 75 percent of the waste is assumed to require sorting. In this study, the type of waste determines the number of tasks required. For example, special waste is sorted within glove boxes. Lead waste is sent to gross size reduction, but not shredding. Many planning level assumptions were made to establish how much of each waste type would require processing through the various steps. Tables in Appendix A list the assumptions used.

The number of employees required was estimated as follows (Table 1):

- 170 for System A-1
- 168 for System C-1
- 198 for System NT-2
- 195 for System NT-3
- 192 for System NT-5

As expected, the additional sorting requirements translate into a greater number of FTEs for the nonthermal systems. However, the difference is less marked than expected.

Much of the FTE requirements are due to the initial assaying requirements. Vendor estimates show that more that two hours is typically needed to perform the three analyses (PAN, SGS and RTR) which translates to a requirement of over 60 FTEs to assay the waste (Mettler, 1996). With over nine drums of waste assayed per hour, nine of each type of instrument would be needed to avoid a bottleneck. Thus, significant savings in capital and labor could be made if assaying time was reliably reduced. Further savings would be experienced if the instrumentation did not require the constant attention of an operator.

4.3 Aqueous Waste Treatment Subsystem

This subsystem is very similar for thermal and nonthermal systems. Both require sampling and monitoring and both use UV oxidation for organic destruction. In the nonthermal systems, all aqueous waste is sent to UV oxidation, whereas in thermal systems scrubber liquor does not require further treatment for organics. Thermal systems process more aqueous waste (primarily scrubber liquor), but through fewer operations. Tables A1-e, C1-e, NT2-f, NT3-e and NT5-g present the time and motion analysis for the aqueous waste treatment subsystem. The tasks in this subsystem are divided as follows:

- Waste receiving
- Preliminary treatment (sampling, filtration, oil/water separation, precipitation)
- UV oxidation.

The number of employees required for each system was estimated to be (Table 1):

- 6 for System A-1
- 5 for System C-1
- 14 for System NT-2
- 5 for System NT-3
- 23 for System NT-5

The differences in nonthermal systems relate to the mass of waste transferred to this subsystem. System NT-5 has the highest labor requirement because of aqueous waste generated from soft debris treatment. Also, much of the wash water in System NT-3 is treated and recycled within the washing process and is not sent to the aqueous waste treatment subsystem.

4.4 Nonthermal Organic Destruction Subsystem

Two types of nonthermal organic destruction were analyzed: Mediated Electrochemical Oxidation (MEO) and Catalytic Wet Oxidation (CWO). For both subsystems, the following tasks are appropriate:

- Receiving waste through an air lock; transferring liquids into a tank, and sampling
- Feeding waste to the reactor
- Operating the reactor

For MEO, several additional tasks are specified:

- Silver recovery
- Acid recovery
- Offgas treatment.

For CWO, additional tasks include:

- Waste transfer/recycle of acids
- Treatment of inorganics.

Tables NT2-d, NT3-d and NT5-d present the time and motion analysis for the organic destruction subsystem. For MEO, 26 FTEs are needed; for CWO 11 FTEs are estimated. MEO requires more FTEs because of the complex recycling processes. For the treatment of soft debris by CWO, 21 FTEs are needed (Table NT-5e).

4.5 Vacuum Thermal Desorption

The tasks involved in this subsystem are as follows:

- Waste receiving
- Transfer of the waste into the batch vacuum thermal desorber
- Vacuum thermal desorber operation
- Monitoring offgas
- Unloading of desorbed waste and transfer of waste to mercury treatment or stabilization
- Mercury contaminated solids leaching
- Leachate /filtrate treatment.

To estimate FTEs, it was assumed that 30 percent of the desorbed solids would require leaching to remove the mercury contamination. Tables NT2-e and NT5-f present the time and motion analysis for the vacuum thermal desorption subsystem. System NT-2 was estimated to require 23 FTEs due to the large volume of waste treated in this subsystem. System NT-5, in which only sludges and process residue is desorbed, required 10 FTEs.

4.6 Aqueous Washing Subsystem

This subsystem was used to treat process residue and sludge in System NT-3, and soil in both NT-3 and NT-5. Tables NT3-f and NT5-h present the time and motion analysis for the aqueous washing subsystem. The steps required are:

- Waste receiving
- Wash water preparation
- Washing process
- Pre-rinse and rinse
- Recycle processes (solubility reduction, ultrafiltration, dissolved air flotation, surfactant separation, steam stripping).

Employee requirements were estimated at 7 FTEs for System NT-3 and 4 FTEs for System NT-5. Many operations require monitoring, but the simple nature of the equipment and operations requires less overall attention than more sophisticated and complex processes such as vacuum thermal desorption combined with mercury leaching. The monitoring requirements were more labor intensive than estimated in the INTS report, as shown on Table 5-1.

4.7 High Pressure Wash Subsystem

This subsystem uses a batch washing and rinsing process. The process was estimated to be 3000 lbs/batch, and 90 minutes for each of three stages of washing/rinsing. The tasks identified were:

- Debris waste receiving
- Waste transfer to wash/rinse vessel
- Wash water solution preparation
- Washing/rinsing process

Tables NT3-g and NT5-i present the time and motion analysis for the high pressure wash subsystem. System NT-3 processes much more waste by pressure washing than System NT-5. System NT-5 is estimated to require 5 FTEs, and NT-3 needs 37 FTEs.

4.8 Main Thermal Treatment Subsystem

Five tasks define the incineration subsystem:

- Waste receiving
- Shredding
- Characterization sampling
- Incineration (feed, incinerate, discharge)
- Monitoring instrumentation

In addition to the first three tasks listed for incineration, the plasma subsystem tasks are:

- Plasma treatment operation (feeding, reactor operation, discharge)
- Plasma treatment monitoring instrumentation
- Cooling
- Final waste container decontamination

Table A1- d presents the time and motion analysis for the incineration subsystem and Table C1-d presents the plasma treatment subsystem. Employee requirements were estimated at 20 FTEs for incineration and 23 FTEs for plasma treatment. These values are similar to those in the ITTS report. Notably, for the plasma system (C-1), the estimates are less than those reported in ITTS (Table 5-1).

4.9 Vitrification Subsystem

This subsystem provides capability to vitrify ash following thermal treatment. The tasks required are:

- Ash receiving through airlock
- Waste transfer to feed bin
- Vitrification
- Monitoring vitrification instrumentation and equipment
- Cooling
- Monitoring the APC
- Decontamination of the final waste container

This subsystem requires 14 FTEs. Only System A-1 requires this subsystem (Table A1-g). The additional labor needs showcase the advantage of the one-step thermal processes which do not require vitrification.

4.10 Metal Melting Subsystem

System A-1 uses metal melting to process metal with entrained contamination (Table A1-f). The identified tasks are:

- Metal receiving (from receiving and preparation)
- Metal melting
- Metal cooling
- Instrumentation and monitoring of the APC.

This subsystem labor requirement is estimated at 6 FTEs.

4.11 Metal Decontamination Subsystem

This relatively simple subsystem requires two tasks:

- Metals receiving/feed preparation
- Waste decontamination

Tables A1-h, C1-f, NT2-g, NT3-h and NT5-j present the time and motion analysis for the metal decontamination subsystem. The number of FTEs for each system is similar for all systems because the volumes are similar. Sixteen FTEs are estimated for both nonthermal and thermal systems. This estimate is significantly higher than the ITTS and INTS estimates (Table 5-1). Assay and decontamination time estimates increased the labor needed.

4.12 Lead Recovery Subsystem

Lead recovery for nonthermal systems includes the following tasks:

- Lead receiving and feed preparation
- Decontamination

For thermal treatment, lead melting and metal cooling tasks are added. Because waste is treated by either decontamination or metal melting, both thermal and nonthermal systems have the same number of FTEs. The time and motion study analysis is based on volume of waste (Tables A1-i. C1-g, NT2-h, NT3-i and NT5-k). Lead has a high density and, therefore, the studied volume of waste is low. Only 2 FTEs are needed to treat this waste by decontamination or melting.

4.13 Mercury Amalgamation Subsystem

Like lead, the mercury waste has a high density and a low volume of waste requiring treatment. This subsystem has the following tasks for both thermal and nonthermal systems (Tables A1-j. C1-h, NT2-i, NT3-j and NT5-l):

- Waste receiving and feed preparation
- Mercury amalgamation.

Thermal systems also treat mercury contaminated debris, using the following tasks:

- Shredding debris
- Retorting debris for mercury removal.

The mercury recovered is amalgamated as in the nonthermal systems. The thermal systems require 2 FTEs, while the nonthermal systems, which process much less waste, need less than 1 FTE.

4.14 Special Waste Treatment Subsystem

The ITTS and INTS concept for special waste treatment was that certain wastes could not be treated in the other subsystems in the facility. Therefore, a space was allotted for treatment processes that were either mobile or under development to treat the variety of waste that could not be treated by other subsystems. To estimate FTEs, it was assumed that the waste required preparation, such as size reduction, for an average of one hour per drum of waste. The waste would be treated in an unspecified batch process for two hours, sampled, and repackaged. As shown in Tables A1-k. C1-i, NT2-j, NT3-k and NT5-m, the tasks defined are defined as follows:

- Waste receiving and feed preparation
- Waste treatment.

Because the amount of special waste is significant (5 percent of the total), 11 FTEs are needed. The labor estimates for this subsystem were significantly different from the ITTS and INTS estimates.

This analysis shows that the treatment of special waste will require significant allocation of resources. Storage of waste to be treated by mobile or temporary processes in campaigns will require extensive space because special waste volume is estimated at 5 drums per shift. Therefore, treatment processes must be available before the waste can be received at the facility. This finding shows the importance of developing treatment processes to treat the less common waste streams.

4.15 Grout Stabilization Subsystem

This subsystem provides encapsulation of waste in grout. As shown in Tables NT2-k, NT3-l and NT5-n, the tasks are:

- Waste receiving and preparation
- Waste micro- or macroencapsulation
- Curing
- Decontamination of containers

Curing is estimated only in terms of the time required to move the waste in and out of a curing area, and to monitor the curing process. The actual time required for curing is not estimated. The analysis indicates that storage requirements for curing will be needed for 60 to 80 drums per shift for each shift of curing required.

The labor requirements for this subsystem are highly dependent on the waste volume which varies by system. The number of employees required was estimated as follows (Table 1):

- 21 for System NT-2
- 16 for System NT-3
- 11 for System NT-5

4.16 Polymer Stabilization Subsystem

Polymer stabilization has the same basic tasks as grout, although the specific processing steps are different. As in the grout subsystem, the actual time required for curing is not estimated. As shown in Tables A1-m, C1-j, NT2-l, NT3-m and NT5-o, the tasks are:

- Waste receiving and preparation, including drying waste
- Waste microencapsulation
- Curing
- Decontamination of containers

Labor needs reflect volume throughput. The number of employees required was estimated as follows:

- 13 for System A-1
- 13 for System C-1
- 36 for System NT-2
- 41 for System NT-3
- 36 for System NT-5

4.17 Air Pollution Control Subsystem

Equipment monitoring is the only task identified for the air pollution control subsystem. The details are shown on Tables A1-n, C1-k, NT2-m, NT3-n and NT5-p. This subsystem is much less volume dependent than other subsystems because of the absence of waste handling. Labor is based on time required to monitor equipment. The nonthermal systems require 4 FTEs. The more complex APC subsystems for thermal systems require 10 FTEs.

4.18 Certification and Shipping Subsystem

As shown in Tables A1-o, C1-l, NT2-n, NT3-o and NT5-q, the certification and shipping subsystems include the following tasks:

- Waste receiving from processing subsystems
- Waste assay
- Staging of certified waste
- Shipping (loading trucks)

The differences in labor requirements are due to the volume of waste shipped. The number of employees required was estimated as follows (Table 1):

- 24 for System A-1
- 24 for System C-1
- 101 for System NT-2
- 110 for System NT-3
- 89 for System NT-5

5. MODELING RESULTS

The simple Gant charts developed for this study provide early indication of time consumed by major functions of the facilities, and identify activities which fall on the critical path. Figures 1 though 5 present Gant charts for the systems analyzed. Table 1 summarizes the labor resource needs for all major activities for each system. For comparison, the ITTS and INTS FTEs are also listed.

Key results of this modeling are:

- Characterization is a critical path process and very labor intensive
- The differences in receiving and preparation between thermal and nonthermal systems are less dramatic than estimated in the INTS and ITTS studies
- Material handling is more significant than processing in terms of labor and time
- One-step thermal treatment processes require significantly less labor than incineration combined with vitrification of ash
- Special waste treatment is on the critical path for thermal systems
- Treatment of special wastes will require significant allocation of resources
- Storage requirements for special waste will be extensive if processes are not available for treatment
- Debris treatment is on the critical path for nonthermal systems
- Labor FTEs may be about 20 percent higher than estimated in the INTS and ITTS reports

5.1 System Dynamics Results

The time and motion study estimates the time required for various processing steps at the throughputs provided for the equipment specified. This development of system dynamics provides insights into potential bottlenecks in the facility. The results are summarized below.

- The assay function stands out as the most limiting process in the facility. Following a discussion with the assay equipment vendor, the time assigned for assay by passive/active neutron and gamma scanning was determined to be one hour per container for each scanning process.

- Other time consuming processes include material handling, shredding, and sampling. The receiving and preparation subsystem, the polymer stabilization subsystem and the certification and shipping subsystem require the longest processing time.

- Soft debris, process residue and special waste treatment require the most preparation and processing time.

- Polymer stabilization requires more treatment time than grout stabilization. Curing time is not included in the analysis, although time for moving waste into and out of the curing area is included.

5.2 Labor Requirement Results

For most subsystems, the time and motion study indicates more full time equivalent employees will be needed than were estimated in the INTS and ITTS studies. Factors that are responsible for the differences include the following:

- The time and motion study included supervisory personnel, time lost due to vacation and sick leave, and a worker efficiency of 70 percent.
- Previous analysis focused on processing requirements. In this area, the ITTS and INTS numbers were closest to the time and motion study.
- The assay function requires nearly three hours per drum with constant supervision by an operator. This function requires 63 FTEs per shift for all systems. Time for individually supervised assays was not included in earlier analyses.
- Material handling was not the focus of the INTS and ITTS studies. In a typical chemical plant, feed to a process and equipment designed to handle that specific material will be consistent. For a radioactive waste processing facility, movement of a variety of waste streams contributes to considerable time per drum. This analysis assumes each INTS drum and most ITTS drums must be opened and emptied. For several processes, the rate limiting step is getting the waste from drums to the process.
- Previous analyses characterized sorting as time consuming. The time and motion study quantifies sorting requirements. For example, glove box sorting requires five employees per shift to sort slightly less than one drum per hour.

5.3 Conclusions

The following conclusions can be derived from the time and motion study analysis:

- Front-end and back-end handling are the areas requiring the most FTEs and processing time. These functions are most closely related to the volume of waste handled.
- After front and back-end handling and administration, stabilization processes for nonthermal systems, especially polymer, require the most time and FTEs.
- Metal decontamination and special waste treatment are labor-intensive and time consuming.
- Treatment of major waste streams, such as incinerable waste in ITTS systems and process residue in INTS systems, require significant labor and processing time. Although the processing time per unit is small, the volume of waste treated increases labor and processing time.
- Higher capacity equipment can lead to more efficient processing and reduced labor time. However, this efficiency would not be significant unless material handling and material transfer time can be reduced.
- Feed operations and transfer of material between cells require extensive effort; improvements in material transfer would have significant pay-back.
- Labor FTEs may be about 20 percent higher than estimated in the INTS and ITTS reports

6. RECOMMENDATIONS FOR FUTURE WORK

Real-time assay and characterization needs, sorting needs, size reduction needs, and material handling issues are among the major sources of design and cost uncertainties in the ITTS and INTS studies. These uncertainties indicate a need for increased R&D in this area.

The following areas are recommended for research:

- Gamma and PAN Assay:
  Develop methods with reduced assay time and reduced direct observation by an operator.

- Material handling bins:
  Develop bins or hoppers which are easily transported, filled from drums and emptied into feed systems. These bins should be dust and liquid tight.

- Sorting and segregation:
  Evaluate sorting and segregation material handling devices on the market for applicability to DOE mixed waste.

- Shredding:
  Support development of efficient, reliable shredders which need little operator support yet meet process requirements.

- Special waste:
  Develop treatment methods for special waste. Determine the effect of potential treatment processes on the size of the facility (including storage requirements) prior to facility design.

- Material handling of drums:
  Evaluate improved methods of drum transfer, drum opening, removal of drum contents, drum cleaning and drum sealing.

- Material transfer:
  Develop airlock system which allows for quick transfer of material, possibly by a closed conveyor.

- Drum decontamination:
  Develop methods that require little labor. Develop quick assay method.

- Polymer stabilization:
  Develop and optimize process to minimize labor. Automate material transfer to reduce handling.

REFERENCES

Biagi, Charles, William J. Quapp, Tom Bechtold, Daryoush Bahar, Blaine Brown, William Schwinkendorf, Ginger Swartz, Ben Teheranian, and Julia Vetromile, *Integrated Nonthermal Treatment System Study, Final Draft*, (INEL-96-0273) prepared for Idaho National Engineering Laboratory, Idaho Falls, ID, January, 1997.

Brown, Blaine, *Process Modeling for the Integrated Nonthermal Treatment System Study*, unpublished draft, prepared for Idaho National Engineering Laboratory, Idaho Falls, ID, January 1997.

Brown, Blaine, *Aspen Mass Balance for the ITTS study*, unpublished draft, prepared for Idaho National Engineering Laboratory, Idaho Falls, ID, April 23, 1996.

Feizollahi, Fred and William J. Quapp, *Integrated Thermal Treatment System Study - Phase 2 Results*, EGG-MS-11211, prepared for Idaho National Engineering Laboratory, Idaho Falls, ID, August, 1995.

Mettler, Steven, Canberra Corporation, personal communication to Julia Vetromile of Morrison Knudsen Corporation, May 6, 1996, San Francisco, CA.

Shaw, Richard, *Wrap 2A Process Control and Data Acquisition Design Basis, Waste Receiving and Processing Facility*, by Raytheon Engineers for the U.S. Department of Energy, Richland, WA, January 1995

Schwinkendorf, William E. *Comparison of Alternative Treatment Systems for DOE Mixed Low-level Waste*. (INEL-96-0247) prepared for Idaho National Engineering Laboratory, Idaho Falls, ID, 1996

Shropshire, David *System Cost Model*, Version 1.3, (INEL-95/0273, Rev 1 prepared for Idaho National Engineering Laboratory, Idaho Falls, ID, February 1996.

SureTrak Software, Project Manager for Windows, Primavera Systems, 1994

U. S. Department of Energy, *Interim Mixed Waste Inventory Report*, (DOE/NBM-1100), March 1993

Table 1. Time and Motion Study FTE Estimate Comparisonwith INTS and ITTS FTE Estimates

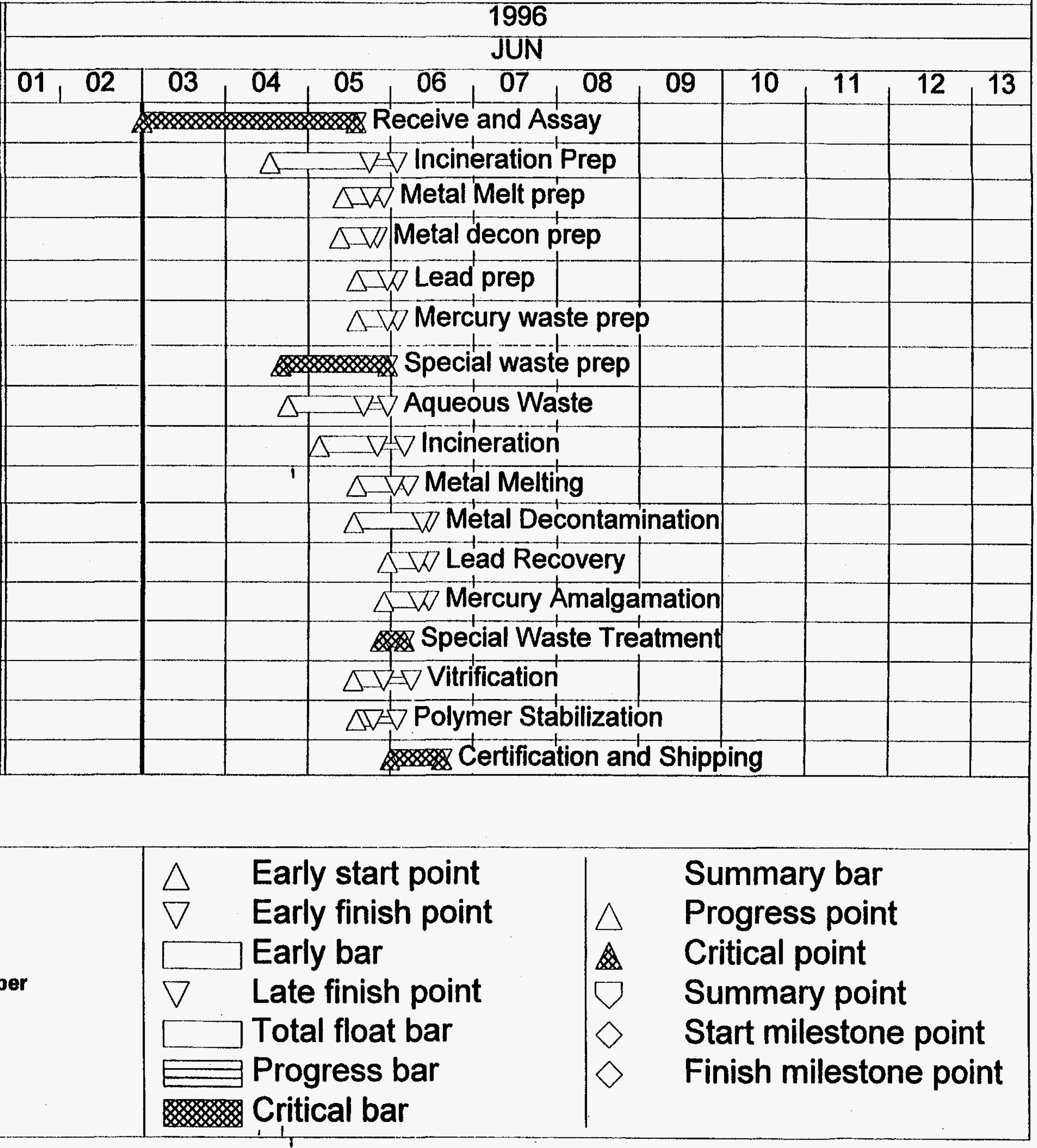
Subsystems	System A-1 Time/ motion FTEs	System A-1 INTS FTEs	System A-1 % diff.	System C-1 Time/ motion FTEs	System C-1 INTS FTEs	System C-1 % diff.	System NT-2 Time/ motion FTEs	System NT-2 INTS FTEs	System NT-2 % diff.	System NT-3 Time/ motion FTEs	System NT-3 INTS FTEs	System NT-3 % diff.	System NT-5 Time/ motion FTEs	System NT-5 INTS FTEs	System NT-5 % diff.	Average % change between Time/ Motion and INTS/ ITTS
Administraton Subsystem	48	27	44.2%	47	27	42.1%	52	32	38.6%	57	32	44.2%	58	32	44.7%	42.8%
Receiving and Preparation Subsystem	170	112	34.2%	168	112	33.1%	198	170	14.0%	195	170	13.0%	192	170	11.4%	21.2%
Aqueous Waste Treatment Subsystem	6	16	-172.5%	5	16	-202.1%	14	5	65.3%	5	5	3.5%	23	5	78.6%	-45.4%
Organic Destruction Subsystem							11	12	-12.5%	26	12	53.0%	11	12	-13.4%	9.0%
Vacuum Thermal Desorption Subsystem							23	16	30.5%				10	8	22.5%	26.5%
Aqueous Wash Subsystem										7	3	53.9%	4	2	53.7%	53.8%
Soft Debris-CWO Subsystem													21	14	31.9%	31.9%
Open Debris-High Pressure Wash Subsystem										37	16	56.6%	5	8	-67.5%	-5.4%
Main Thermal Treatment Subsystem	20	16	19.4%	23	32	-37.3%										-9.0%
Vitrification Subsystem	14	16	-16.9%													-16.9%
Metal Melting Subsystem	6	5	14.1%													14.1%
Metal Decontamination Subsystem	16	5	69.7%	16	5	69.7%	16	4	75.5%	16	4	75.5%	16	4	75.5%	73.2%
Lead Treatment Subsystem	2	8	-273.4%	2	8	-273.4%	2	3	-25.4%	2	3	-51.1%	2	3	-51.1%	-134.9%
Mercury Amalgamation Subsystem	2	4	-134.3%	2	4	-134.3%	0.31	1	-221.9%	0.09	1	-1072.6%	0.09	1	-986.2%	-509.9%
Special Waste Treatment Subsystem	11	2	81.3%	11	2	81.3%	11	3	72.3%	11	3	72.3%	11	3	72.3%	75.9%
Grout Stabilization Subsystem							21	8	61.3%	16	8	50.4%	11	8	27.4%	46.4%
Polymer Subsystem	13	8	39.5%	13	8	39.5%	36	38	-4.0%	41	40	4.6%	36	38	-2.8%	15.4%
Air Pollution Control Subsystem	10	4	59.6%	10	4	59.6%	4	4	1.8%	4	4	1.8%	4	4	1.8%	24.9%
Certification and Shipping Subsystem	24	32	-33.6%	24	32	-33.6%	101	105	-4.3%	100	110	-9.6%	89	88	1.0%	-16.0%
Total	342	255	25.4%	321	250	22.1%	489	401	18.2%	518	411	20.8%	494	400	19.0%	20.7%

Note: Minor discrepancies can be noticed between the certification and shipping numbers shown here compared to those in the INTS report.
The numbers in the INTS report and ITTS/INTS comparison report reflect an earlier draft of the time and motion study, calculated with a slightly different mass balance.

Figure 1

Time and Motion Study, System A-1

Act ID	Description	Orig Dur
1000	Receive and Assay	62
1010	Incineration Prep	29
1020	Metal Melt prep	8
1050	Metal decon prep	9
1060	Lead prep	9
1070	Mercury waste prep	9
1080	Special waste prep	31
1100	Aqueous Waste	22
1110	Incineration	17
1120	Metal Melting	11
1160	Metal Decontamination	20
1170	Lead Recovery	9
1180	Mercury Amalgamation	10
1190	Special Waste Treatment	7
1200	Vitrification	9
1210	Polymer Stabilization	5
1300	Certification and Shipping	15

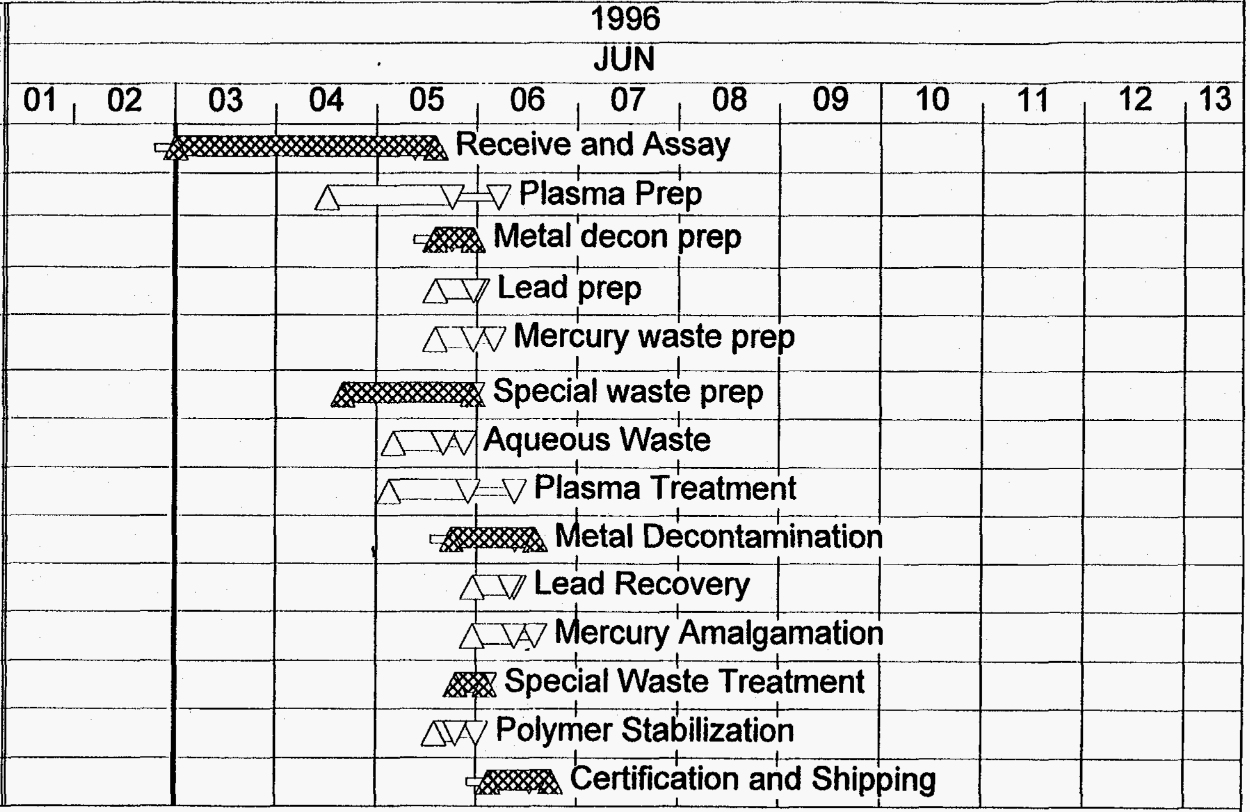


Act ID is the activity identification number

Orig Dur is the activity duration

Figure 2 Time and Motion Study, System C-1

Act ID	Description	Orig Dur
1000	Receive and Assay	62
1010	Plasma Prep	30
1050	Metal decon prep	9
1060	Lead prep	9
1070	Mercury waste prep	9
1080	Special waste prep	31
1100	Aqueous Waste	12
1110	Plasma Treatment	19
1160	Metal Decontamination	20
1170	Lead Recovery	9
1180	Mercury Amalgamation	10
1190	Special Waste Treatment	7
1210	Polymer Stabilization	5
1300	Certification and Shipping	15



Act ID is the activity identification number

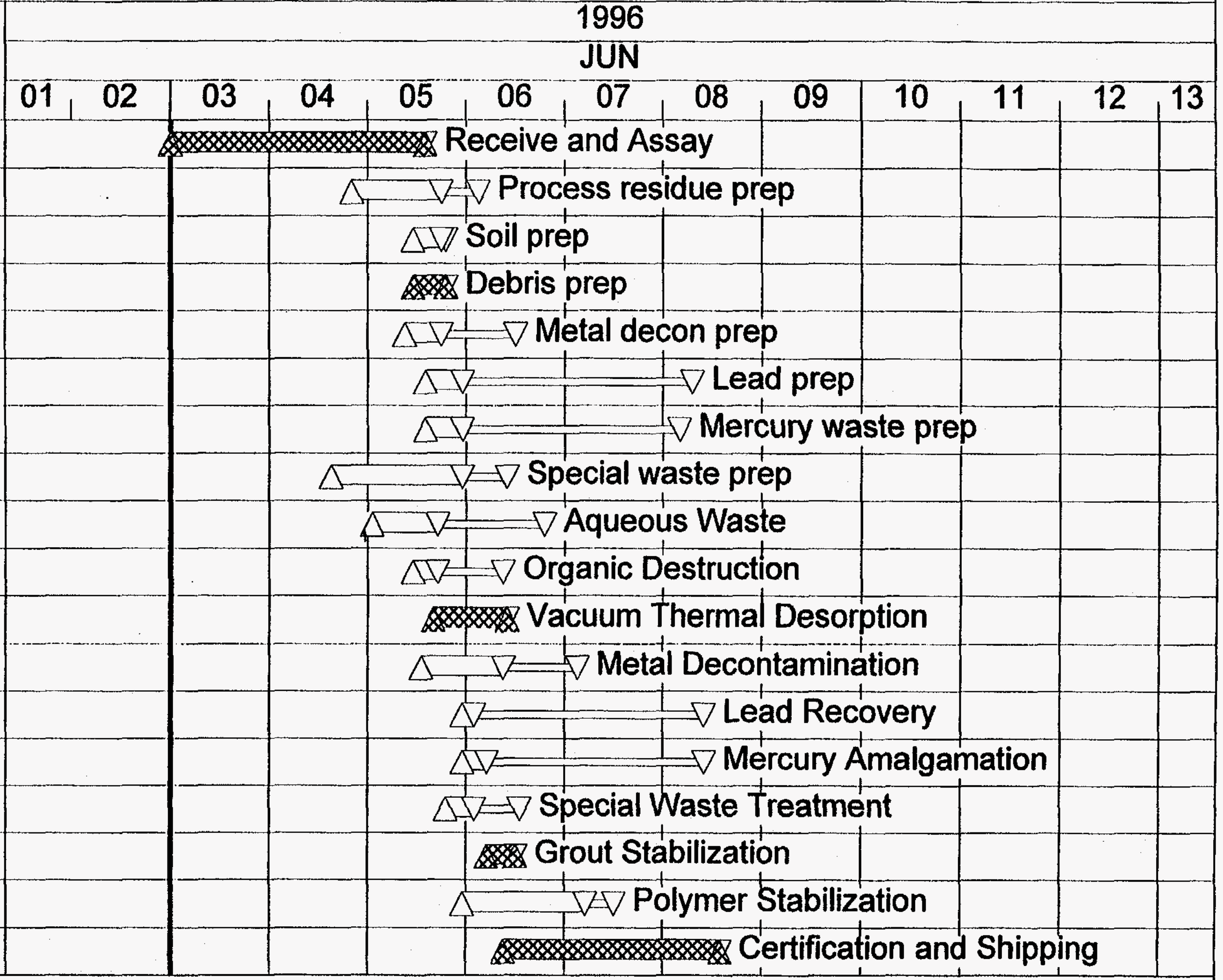
Orig Dur is the activity duration.

△ Early start point
▽ Early finish point
▭ Early bar
▽ Late finish point
▭ Total float bar
▤ Progress bar
▩ Critical bar

Summary bar
△ Progress point
▲ Critical point
⛉ Summary point
◇ Start milestone point
◇ Finish milestone point

Figure 3 Time and Motion Study, System NT-2

Act ID	Description	Orig Dur
1000	Receive and Assay	62
1010	Process residue prep	22
1020	Soil prep	7
1040	Debris prep	8
1050	Metal decon prep	9
1060	Lead prep	9
1070	Mercury waste prep	9
1080	Special waste prep	32
1100	Aqueous Waste	16
1110	Organic Destruction	6
1120	Vacuum Thermal Desorption	18
1160	Metal Decontamination	20
1170	Lead Recovery	3
1180	Mercury Amalgamation	6
1190	Special Waste Treatment	7
1200	Grout Stabilization	7
1210	Polymer Stabilization	30
1300	Certification and Shipping	53



Act ID is the activity identification number

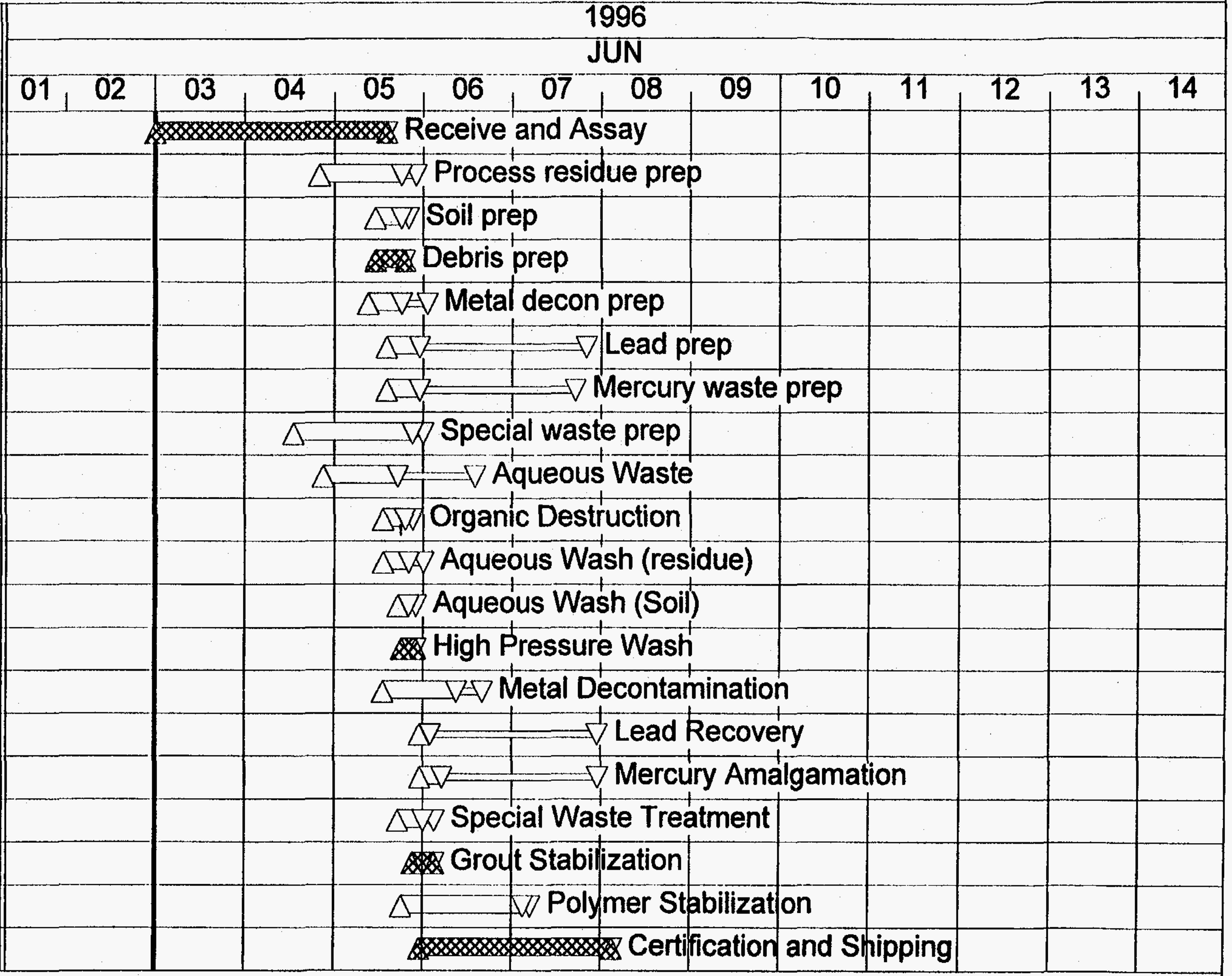
Orig Dur is the activity duration

△ Early start point
▽ Early finish point
▭ Early bar
▽ Late finish point
▭ Total float bar
☰ Progress bar
▨ Critical bar

Summary bar
△ Progress point
▲ Critical point
⛉ Summary point
◇ Start milestone point
◇ Finish milestone point

Figure 4 Time and Motion Study, System NT-3

Act ID	Description	Orig Dur
1000	Receive and Assay	62
1010	Process residue prep	22
1020	Soil prep	7
1040	Debris prep	8
1050	Metal decon prep	9
1060	Lead prep	9
1070	Mercury waste prep	9
1080	Special waste prep	32
1100	Aqueous Waste	20
1110	Organic Destruction	6
1120	Aqueous Wash (residue)	7
1130	Aqueous Wash (Soil)	3
1150	High Pressure Wash	4
1160	Metal Decontamination	20
1170	Lead Recovery	3
1180	Mercury Amalgamation	6
1190	Special Waste Treatment	7
1200	Grout Stabilization	6
1210	Polymer Stabilization	33
1300	Certification and Shipping	52



Act ID is the activity identification number

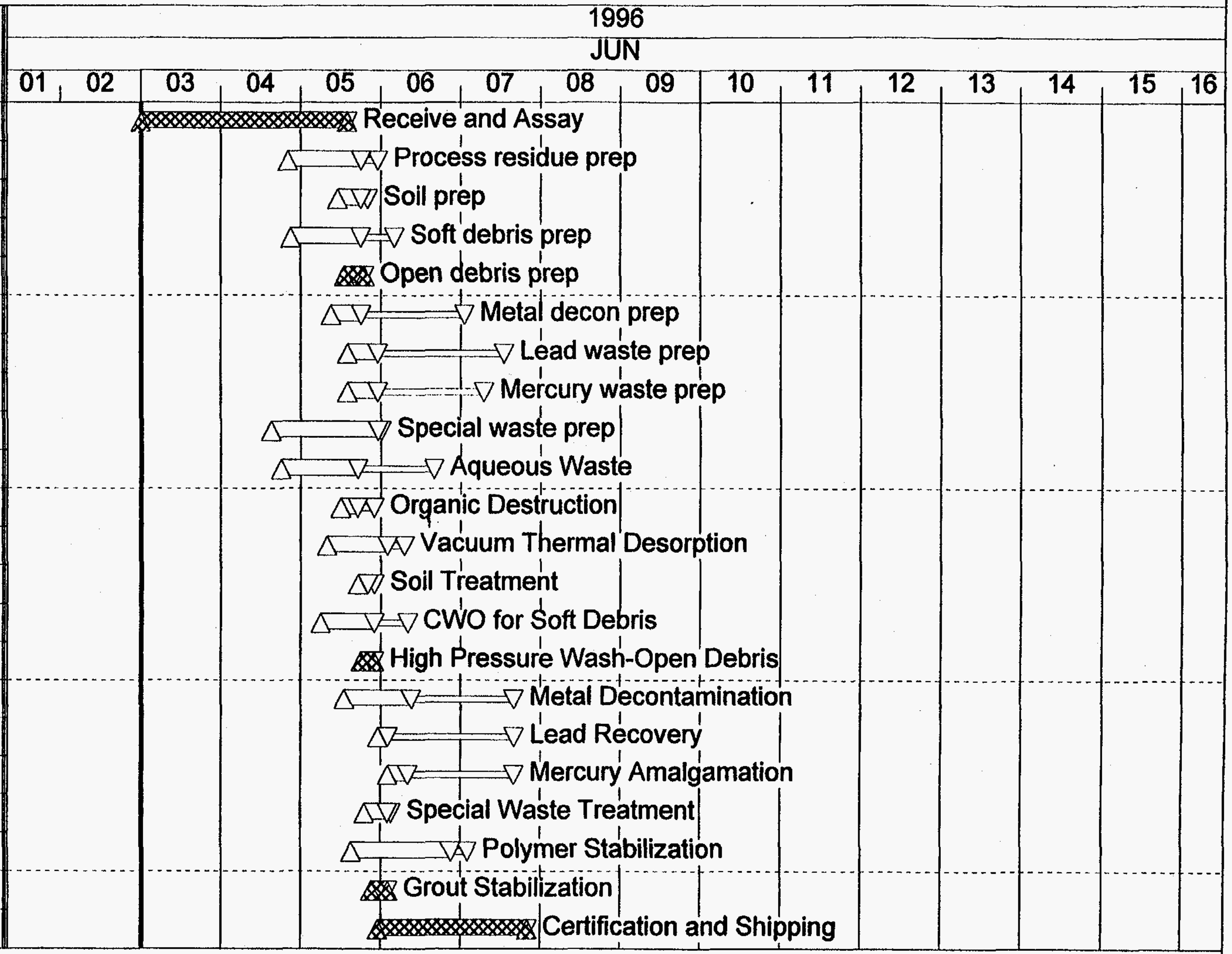
Orig Dur is the activity duration

△	Early start point		Summary bar
▽	Early finish point	△	Progress point
▭	Early bar	▲	Critical point
▽	Late finish point	⬠	Summary point
▭	Total float bar	◇	Start milestone point
▤	Progress bar	◇	Finish milestone point
▩	Critical bar		

Figure 5

Time and Motion Study, System NT-5

Act ID	Description	Orig Dur
1000	Receive and Assay	62
1010	Process residue prep	22
1020	Soil prep	7
1030	Soft debris prep	21
1040	Open debris prep	6
1050	Metal decon prep	9
1060	Lead waste prep	9
1070	Mercury waste prep	9
1080	Special waste prep	32
1100	Aqueous Waste	23
1110	Organic Destruction	5
1120	Vacuum Thermal Desorption	18
1130	Soil Treatment	3
1140	CWO for Soft Debris	16
1150	High Pressure Wash-Open	4
1160	Metal Decontamination	20
1170	Lead Recovery	3
1180	Mercury Amalgamation	6
1190	Special Waste Treatment	7
1210	Polymer Stabilization	30
1230	Grout Stabilization	5
1300	Certification and Shipping	45



Act ID is the activity identification number

Orig Dur is the activity duration

△	**Early start point**		**Summary bar**
▽	**Early finish point**	△	**Progress point**
▭	**Early bar**	▲	**Critical point**
▽	**Late finish point**	⛉	**Summary point**
▭	**Total float bar**	◇	**Start milestone point**
▤	**Progress bar**	◇	**Finish milestone point**
▨	**Critical bar**		

APPENDIX A

Time and Motion Study Calculations

Table of Contents

Introduction

The tables in this appendix are produced from five interlinked spreadsheets.

The first table in each series (Table A1-a, C1-a, NT2-a, NT3-a and NT5-a) presents the waste feed to each subsystem, as developed in the ASPEN mass balance. For each subsystem the dominant waste types were selected, based on the MWIR waste descriptions (DOE, 1993). As shown in the third column, Waste Type, the MWIR code is shown. The fifth column shows the estimated density of the unprocessed waste in kg/cu m, as developed in the Systems Cost Model (Shropshire, 1996). The density is converted to pounds per cubic foot and to pounds/drum in the sixth and seventh columns respectively. The fourth column is the result of the second column (mass flow, lb/hr) divided by the seventh column (drum density, lb/drum).

The remaining tables estimate full time equivalent employees (FTEs) and the time required for waste treatment. The columns of these tables are described below:

- Columns one and two: Tasks and subtasks are identified.

- Column three, administration subsystem: The administration subsystem table lists FTEs without calculation in this column, because they are an estimate based on a 300 person facility.
- Column three, other subsystems (as shown in Table A1-c and others): Shows the occurrence per shift, such as drums, trucks or pallets.

- Column four: The unit for occurrence per shift is expressed, usually drums.

- Column five: "Time required" is estimated for each subtask.

- Column six: "Total Time per Shift" is the product of column three and column five. Totals for each task are provided.

- Column seven: "FTEs needed" is the total time per shift divided by the minutes in a shift.

- Column eight: "Additional Time for Next Drum" shows the estimate of the lag time between drums.

- Column nine: "Average Minutes per Shift per Drum" only appears in the receiving and preparation subsystem, is the product of the required time (column five) times the frequency of occurrence. This accounts for waste types which require different tasks; e.g. special waste requires glovebox sorting but not shredding. Column nine shows the estimated average time a drum of waste requires for processing. If only 10% of the waste is treated in a given task, then this column reflects 10% of the time required, shown in column five.

The last table in each series (Table A1-p, C1-m, NT2-o, NT3-p and NT5-r) shows the summary of the FTEs and time required for waste processing.

System A-1 Time and Motion Study Tables

Table A1-a. System A-1: Time and Motion Analysis

Subsystem	Mass Flow (lb/hr)	Waste Type	No. of Drums	SCM Unprocessed Density kg/m3	Density lb/ft3	Density lb/drum
Administration	2,927					
Receiving and preparation	2,927	all	6		64	471
Aqueous waste treatment	13,474	L1100	30		62	456
Incineration	2,000	S5300,5110	4		64	471
Vitrification	1,495	S3110	3	650	64	471
Metal Melting	149	S5110	1	509	32	234
Metal decontamination	468	S5110	2	509	32	234
Mercury amalgamation	50	X7100	0	2000	125	918
Lead recovery	26	X7200	0	2000	125	918
Polymer stabilization	113	S3120	0	700	44	321
Air pollution control	21,420		N/A			
Grout stabilization	0	soil/debris	0	750	47	344
Special treatment	153	X6000,X7500	1	500	31	229
Certification and shipping	1,958	Z000	1	2500	179	1320
Vol reduction (out/in)	1.49		0.24			

Notes:
This table provides the basis for the time and motion analysis.
Quantities of waste to a subsystem (lbs/hr) are based on LMITCO mass balance.
Densities are the same as the LMITCO mass balance except where values are shown in the SCM column.
Where values are shown in the SCM column, densities are taken from SCM and converted to lb/ft3..
Waste types are based on MWIR
The waste quantities are converted from lbs/hr to drums/hr.
Subsequent analysis is based on drums/shift of waste to a subsystem.

Table A1-b. **Administration Subsystem**

Task	Subtask	FTEs needed	Samples/ Shift	Time Required (min)	Total Time / Shift
Facility Management	Facility Manager	1			
	Secretary	1			
	Receptionist/word processor	1			
Operations Management	Department managers	2			
	Communications	1			
	Engineering Manager	1			
	Engineering staff	2			
	Maintenance Supervisor	1			
Personnel	Personnel Manager	1			
	Nurse/medical/industrial safety	1			
	Security guards at facility	4			
	Security at guard bldg	4			
Environmental	Environmental manager	1			
	Environmental clerk	1			
Shipping/Receiving/Traffic	Manager	1			
	Clerk	1			
Purchasing	Buyer	1			
Accounting	Cost Accounting	2			
	Accounting Clerk	1			
	Payroll Clerks	2			
Laboratory	Laboratory Manager	1			
	Lab Shift manager	4			
	Lab technicians for OSORT	1	4.1	30.0	123.2
	Lab technicians for internal processes	4	36.2	10.0	362.1
	Lab technicians for final waste form	3	8.4	30.0	250.9
	Lab technicians for incoming supplies	0.2	1.0	20.0	20.0
Health Physics	Shift health physics staff	4			
	Health physics manager	1			
	Total except Lab	35			
	Total Lab	13			
	Total Admin	48			

Table A1-c. Receiving and Preparation Subsystem

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Add'l/Time for Next Drum	Ave Minutes/Shift/ Drum
Receive Waste Truck	Truck docking	0.6	truck	30	17			
	Settle Paperwork	0.6	truck	120	68			
	Unload truck	0.6	truck	60	34			
	Stage pallets	0.6	truck	60	34			
	No of pallets/shift							
Total Task 1				270	153	0.3	0	153
Receive Empty container Truck	Truck docking	0.3	truck	30	8			
	Settle Paperwork	0.3	truck	30	8			
	Unload truck	0.3	truck	60	17			
	Stage pallets	0.3	truck	20	6			
Total Task 2				140	40	0.1	0	40
Receive Supplies	Truck docking	0.2	truck	30	6			
	Settle Paperwork	0.2	truck	30	6			
	Unload truck	0.2	truck	60	12			
	Stage pallets	0.2	truck	20	4			
Total Task 3				140	28	0.1	0	28
Transfer to Interim Storage	Move pallets to storage area	6.2	Pallet	5	31			
	Stack pallets/ organize storage	6.2	Pallet	10	62			
	Transfer to assay	6.2	Pallet	5	31			
Total Task 4				20	124	0.3	10	10
Assay Drums	Stage pallets	12.4	Pallet	5	62			
	Load on conveyor	49.8	drum	1	50			
	Assay RTR	49.8	drum	15	746			
	Assay gamma	49.8	drum	60	2986			
	Assay PAN	49.8	drum	60	2986			
	Remove from conveyor	49.8	drum	3	149			
	Repalletize	49.8	drum	1	50			
	Stage pallets after assaying	12.4	Pallet	5	62			
Total Task 5				150	7091	14.8	60	150
Stage and move to OSORT	Store solid waste by category	12.4	Pallet	10	124			
	Move to 50% to OSORT	6.2	Pallet	5	31			
	Stage at OSORT	6.2	Pallet	5	31			
Total Task 6			Pallet	20	187	0.4	5	20
Open Drums	Stage at drum opener	6.2	Pallet	5	31			
	Load on conveyor	24.9	Drums	5	124			
	Drum lid clamp	24.9	drum	2	50			
	Drum lid opener	24.9	drum	5	124			
	Lid staging	24.9	drum	1	25			
	Remove from conveyor	24.9	drum	1	25			
Total Task 7				19	398	0.8	5	19

Table A1-c. Receiving and Preparation Subsystem

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Add'l/Time for Next Drum	Ave Minutes/Shift/ Drum
Dump Drums	Assign drums to dump stations	24.9	drum	3	75			
	Move drums to sort table /bins	24.9	drum	5	124			
	Dump drums	24.9	drum	5	124			
Total Task 8				13	323	0.7	5	13
Sort Drums	Sort waste robotically	24.9	drum	30	746			
	Transfer waste to container	24.9	drum	15	373			
	Select destination for sorted waste	24.9	drum	3	75			
	Move container to subsystem bin or shredder	24.9	drum	3	75			
Total Task 9				51	1269	2.6	45	38
Glove Box Sort	Transfer to glove box (several trips)	6.0	drum	30	180			
	Sort waste by hand in glove box	6.0	drum	240	1440			
	Sampling (1/drum)	6.0	drum	15	90			
	Transfer waste to containers	6.0	drum	60	360			
	Select destination for sorted waste	6.0	drum	15	90			
	Move containers to subsystem bin or shredder	6.0	drum	15	90			
Total Task 10				375	2250	4.7	315	5
Gross Size Reduction	Transfer to cutting table	5.4	drum	3	16			
	Cut waste	5.4	drum	30	161			
	Return to container	5.4	drum	5	27			
	Transfer to next process	5.4	drum	3	16			
Total Task 11				41	220	0.5	35	6
Shredding	Transfer drums to shredder	3.1	drum	2	6			
	Stage drums	3.1	drum	2	6			
	Feed waste to shredder	3.1	drum	2	6.22			
	Feed bad drums to shredder	12.4	drum	2	25			
	Shred stage 1	12.4	drum	2	25			
	Shred stage 2	12.4	drum	2	25			
	Sample size of waste	1.2	drum	5	6			
	Rework 10%	0.1	drum	15	2			
	Return to container	12.4	drum	3	37			
	Transfer to next process	12.4	drum	2	25			
Total Task 12				37	164	0.3	2	30

Table A1-c. **Receiving and Preparation Subsystem**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Add'l/Time for Next Drum	Ave Minutes/Shift/ Drum
Sampling					0			
	Sample opened drums	2.5	drum	5	12			
	Sample sorted waste	1.2	drum	5	6			
	Resample (10%)	0.4	drum	5	2			
	Report/eval. results	4.1	drum	10	41			
Total Task 13				25	62	0.2	10	30
Subsystem Bin operation	Monitor bin height	24.9	drum	3	75			
	Fill containers	24.9	drum	3	75			
	Move containers	24.9	drum	2	50			
	Stage containers	24.9	drum	3	75			
	Organize campaigns	24.9	drum	15	373			
Total Task 14				26	647	1.8	0	26
Internal Transfer	Move waste from OSORT to other subsystems	24.9	drum	10	249			
	Move waste from subsystems to CSHIP	11.8	drum	10	118			
	Move treated waste to stabilization	80.0	drum	10	800			
	Move unsorted waste to incin	6.2	drum	10	62			
	Move waste to secondary treatment	20.0	drum	10	200			
	Move supplies around	20.0	drum	3	60			
	Move new drums	24.9	drum	3	75			
	Schedule movement	187.8	drum	1	188			
Total Task 15				57	1752	4.9	10	57
Box Breakdown	Stage boxes	10.0	box	2	20			
	Move to opening area	10.0	box	3	30			
	Open boxes	10.0	box	10	100			
	Transfer to dump	10.0	box	3	30			
Total Task 16				18	180	0.5	10	2
Container Decon	Stage containers	49.8	drum	5	249			
	Load conveyors	49.8	drum	5	249			
	Decon drums	49.8	drum	10	498			
	Assay drums	49.8	drum	15	746			
	Unload conveyers	49.8	drum	5	249			
	Stage drums	49.8	drum	5	249			
Total Task 17				45	2239	6.2	15	45

Table A1-c. Receiving and Preparation Subsystem

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Add'l/Time for Next Drum	Ave Minutes/Shift/ Drum
FTEs/shift					0	32.3		
Supervision	Ratio of 1:10					3.2		
Vac/sick/holiday relief	Assume 6 wks of absence					4.1		
Break relief (included in 6 hr day)	One person can relieve 3 (accounted for in efficiency)							
Total/shift						39.7		
Adj for 70% Efficiency						56.7		
Total/day						170.1		670.7

Notes:

Assume FTEs are available for 8 hrs/day; because overall 70% efficiency is taken at the end.

Trucks have 22 pallets. Waste density is 64 lb/ft3.

Pallets are assumed to hold four 55 gallon drums

As in inventory, assume 50% of drums are contaminated and can't be deconned.

Assume 50% of waste received requires interim storage; this will be dependent on assay system

Assume 10% of incoming waste is sampled

Assume opened and sorted waste is 50% of total

Assume 10% of sorted waste is sampled

Assume gross size reduction is necessary for wastes to metal decon & lead

Assume gross size reduction is 1 hr per drum.

Assume shredding is necessary for drums only

Assume 10% of shredded waste is sampled.

Box breakdown includes time beyond that required if waste was packaged in drums

Assume glove box sorting required for special, mercury and lead

Assume glove box waste requires 1 sample/drum

Assume transfer control for liquids takes the same time as for solids

Assume paperwork is accomplished within times shown

Ave. time per drum includes times for activities multiplied by the probability that the activity will occur.

Least time/drum/subsystem includes only the minimum requirements, no extra staging, sorting, or shredding

Max time/drum/subsystem includes all staging, shredding, glove box, etc

Table A1-d. Incineration Subsystem

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Time/ Add'l Drum
Receive Waste	Transfer through air lock	8.5	pallet	5	43			
	Stage drums for campaigns	8.5	pallet	15	128			
Total Task				20	170	0.35	20	15
Shredding	Transfer waste/drums to shredder	34.0	drum	2	68			
	Stage drums and waste	34.0	drum	2	68			
	Shred stage 1	34.0	drum	2	68			
	Shred stage 2	34.0	drum	2	68			
	Sample size of waste	3.4	drum	5	17			
	Rework 10%	0.3	drum	11	4			
	Return to container	34.0	drum	3	102			
	Transfer to next process	34.0	drum	2	68			
Total Task				29	463	0.96	29	15
Sampling					0			
	Sample shredded waste to characterize	3.4	drum	5	17			
	Resample (10%)	0.3	drum	5	2			
	Report/eval. results	3.7	drum	10	37			
Total Task				20	56	0.16	20	10
Incineration	Select waste for feeding	34.0	drums	5	170			
	Stage waste for feeding	34.0	drums	5	170			
	Feed incinerator (50 ft3/hr or 6.8 drums/hr)	34.0	drums	0	4			
	Incinerate waste (1 hr)	34.0		60	2040			
	Discharge waste (50 ft3/hr)	20.4		0	2			
	Sample waste in and out	16.0	times	10	160			
Total Task				80	504	1.05	80	9
Monitor incinerator	Monitor feeding							
	Monitor gas/air ratio	24.0	times	5	120			
	Monitor burner	24.0	times	5	120			
	Monitor feeding	24.0	times	5	120			
	Monitor secondary combustion	24.0	times	5	120			
	Monitor discharge	24.0	times	5	120			
Total Task				25	600	1.25	0	0
FTEs/shift					0	3.77	149.23	15
Supervision	Ratio of 1:10					0.38		
Vac/sick/holiday relief	Assume 6 wks of absence					0.48		
Total/shift						4.63	149	15
Adjustment for 70% Efficiency						6.61		
Total/day						19.84		

Notes:
Feed to incinerator requires shredding; whole drums can be shredded.
Assume 15 min/drum per stage of shredding
Assume 1 hour kiln residence time
Assume rate of feeding and discharge @ 50 ft3/hr
Waste discharge based on bottom ash @ 80% of waste to vit (mass balance shows 1196 bottom ash and 299 fly ash)
No. of samples = 20

Table A1-e. **Aqueous Waste Treatment Subsystem**

Task	Subtask	Occurrence / Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Time/ Add'l Drum
Receive Waste	Transfer through air lock	1.4	drum	5	7			
	Feed waste from drum	1.4	drum	3	4			
	Hook to transfer device	1.4	drum	3	4			
	Transfer to tank (10 gpm)	1.4	drum	6	8			
	Empty drum bottoms	1.4	drum	2	3			
	Sample feed vessel	2.0	drum	10	20			
	Detach & remove drum	1.4	drum	3	4			
	Sample waste from processes: incin,vitrification, APC	4.0	N/A					
	Arrange for transfer	12863.0	gal	0	77			
Total Task 1				32	127	0.27	32	5
Preliminary Treatment	Sample high TDS tank	0.0	drums	15	0			
	Sample low TDS tank	9.4	drums	15	14			
	Sample TOC waste	1.1	drums	15	2			
	Select treatment methods (10 drum batch)	1.1	drums	20	2			
	Transfer organic waste to oil water separator	1.1	drums	3	3			
	Filter high, low TDS and organic waste (say 50 gal/min)	10.5	drums	1	12			
	Neutralize/ppt high TDS waste	0.0	drums	11	0			
	Settle precipitated aqueous waste	0.0	drums	6	0			
	Evaporate solids(50 gpm)	10.5	drums	1	12			
	Monitor filter	24.0	times	5	120			
	Monitor evaporator	24.0	times	5	120			
Total Task 2				86	261	0.54	86	20
UV Oxidation	Adjust UV oxidation (30 min/10 drums)	1.1	drums	3	3			
	Process through UV oxidation (50 gpm)	1.1	drums	1	1			
	Carbon filtration (50 gpm)	10.5	drums	1	12			
	Ion exchange (50 gpm)	10.5	drums	1	12			
	Monitor carbon & ion exchange	12.0	times	5	60			
	Sample waste before discharge	2.0	times	30	60			1
Total Task 3				6	147	0.31	6	
Total per shift					0	1.12	124	26
Supervision	Ratio of 1:10					0.11		
Vac/sick/holiday relief	Assume 6 wks of absence					0.14		
Adjustment for 70% Efficiency						1.96		
Total per day						5.87		

Notes:

Assume waste from APC is low TDS; assume other secondary waste = 13413.70 lbs/hr 235 drums/shift
Assume waste from RCPRP is organic liq 60.30 lbs/hr 1 drums/shift
Total drums/hour = 236.4
Assume sampling of low TDS waste is one/25 drums
Assume transfer of waste requires 15 min/2500 gallons
Assume tank batches are 550 gallons (10 drums)
Assume treatment selection time is required for waste from RCPRP only;scrubber liquor has the same treatment.
Assume residence time in oil water separator is 1 hour and tank is 1000 gallons (16 gpm)
Assume filtration, centrifuge and ppt rates are 10 gpm.
Assume evaporation rate is 50 gpm
Assume UV oxidation unit is 50 gpm
Process samples = 16.5

Table A1-f. Metal Melting

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Metal Receiving	Transfer through air lock	5.1	drums	5	26			
Total Task				5	26	0.05	5	5
Feed Waste from drum	Stage at feed bin (drums)	5.1	drums	3	15			
	Hook to transfer device	5.1	drums	3	15			
	Transfer into feed bin (direct discharge)	5.1	drums	2	10			
	Empty drum bottoms	5.1	drums	2	10			
	Sample feed vessel (every 10 drums)	0.5	drums	10	5			
	Detach & remove drum	5.1	drums	3	15			
Total Task				23	72	0.15	23	10
Metal Melting	Setup/check equipment	0.5	time/ batch	30	15			
	Stage waste for feeding	0.5	batch	20	10			
	Adjust flux to melter	0.5	batch	20	10			
	Feed melter (10 min/drum)	0.5	batch	100	51			
	Melt waste	0.5	batch	60	31			
	Discharge waste	0.1	batch	60	6			
Total Task				260	124	0.26	260	260
Metal Cooling	Metal discharge into containers	0.1	drums	15	2			
	Metal cooling	0.1	drums	N/A	0			
	Staging waste into cooling	0.1		15	2			
	Slag cooling	0.0	drums	N/A	0			
	Staging waste out of cooling	0.1		15	2			
	Collect samples	0.1	drums	15	2			
Total Task				60	6	0.01	60	0
Monitor APC	Quench cooler	4.0	times	5	20			
	Baghouse/ceramic filter	4.0	times	5	20			
	Mist eliminator	4.0	times	2	8			
	GAC	4.0	times	2	8			
	HEPA filter	4.0	times	2	8			
	Offgas monitor	24.0	times	10	240			
Total Task				26	304	0.63	26	
Total FTEs/day= FTEs per shift						1.11		
Supervision	Ratio of 1:10					0.11	348	
Vac/sick/holiday relief	Assume 6 wks of absence					0.14		
Total/shift						1.36		
Adjustment for 70% Efficiency						1.94		
Total/day						5.82		

Notes:
Assume 3 hour batches at 10 drums/batch
Assume cooling time is long; staging of waste in and out is only time considered
Assume 10% slag.

Table A1-g. **Vitrification of Ash**

Task	Subtask	Occurrence / Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Ash Receiving	Transfer through air lock (100 ft3 bins); 5 min/bin	1.9	bin	5	9			
Ash Receiving	Transfer through air lock (100 ft3 bins); 5 min/bin	1.9	bin	5	9			
Total Task				5	9	0.02	0	0
Feed Waste from bin	Stage at feed bin (15 min/bin)	1.9	bin	15	28			
	Hook to transfer device	1.9	bin	3	6			
	Transfer into vitrifier (metering screw; 4000 lbs/hr)	1.9	bin	38	70			
	Sample feed vessel (once/bin; 10 min per sample)	1.9	bin	10	19			
	Detach & remove bin	1.9	bin	3	6			
Total Task				69	128	0.27	69	15
Vitrification	Adjust additives to melter	1.9	bin	15	28			
	Melt waste @ 2000 lbs/hr	1.9	bin	192	359			
	Discharge waste @ 2000 lbs/hr	1.9	bin	192	359			
Total Task				399	28	0.06	29	14
Monitor vitrifier	Monitor feeding	24.0	times	5	120			
	Monitor gas/air ratio	24.0	times	5	120			
	Monitor burner	24.0	times	5	120			
	Monitor additions	24.0	times	5	120			
Total Task				20	480	1.00		0
Cooling	Glass/slag discharge into containers (dens= 156 lb/cu ft)	10.4	drums	0	0			
	Glass cooling	10.4	drums	N/A	0			
	Staging waste into cooling	10.4	drums	5	52			
	Staging waste out of cooling	10.4	drums	5	52			
	Collect samples	1.0	drums	15	16			
Total Task				25	120	0.25	25	15
Monitor APC	Quench cooler	4.0	times	5	20			
	Baghouse/ceramic filter	4.0	times	5	20			
	Mist eliminator	4.0	times	2	8			
	GAC	4.0	times	2	8			
	HEPA filter	4.0	times	2	8			
	Offgas monitor	24.0	times	10	240			
Total Task				26	304	0.63	26	
Drum Decon	Stage containers	4.0	drum	5	20			
	Load conveyors	4.0	drum	5	20			
	Decon drums	4.0	drum	10	40			
	Assay drums	4.0	drum	15	60			
	Unload conveyers	4.0	drum	5	20			
	Stage drums	4.0	drum	5	20			
Total Task				45	180	0.38	45	45
FTEs per shift						2.60		
Supervision	Ratio of 1:10					0.26	194	
Vac/sick/holiday relief	Assume 6 wks of absence					0.33		
Total/shift						3.19		
Adjustment for 70% Efficiency						4.56		
Total/day						13.69		

Notes:

Assume bins from incin are 100 ft3 (this is our design assumption).

For time evaluation, 13.6 drums

Assume screw empties at 4000 lbs/hr = 63 ft3/hr

Assume retech vitrifier at 2000 lbs/hr;continuous operation

Assume cooling time is long; staging of waste in and out is only time considered

No of samples = 4.8

Table A1-h. **Metal Decontamination Subsystem**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Metals Receiving/ Feed Prep	Transfer through air lock	16.0	drums	5	80			
Total Task				5	80	0.17	5	0
Waste Decon	Stage containers	16.0	drum	5	80			
	Decon waste	16.0	drum	10	160			
	Assay for recycle	16.0	drum	30	480			
	Repack in drums	16.0	drum	15	240			
	Close drum lid	16.0	drum	15	240			
	Stage drums	16.0	drum	5	80			
	Monitor recirc filtration and fugitive dust system	24.0	times	6	144			
Total Task				86	1424	2.97	86	
Total FTEs/shift						3.13	91	
Supervision	Ratio of 1:10					0.31		
Vac/sick/holiday relief	Assume 6 wks of absence					0.40		
Total/shift						3.84		
Adjustment for 70% Efficiency						5.49		
Total/day						16.48		

Notes:
Assume 50% of waste must be size reduced.
Assume 60 min/drum for cutting

Table A1-i. Lead Recovery

Task	Subtask	Occurrence / Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Lead Receiving/Feed Prep	Transfer through air lock	0.2	drums	5	1			
	Glove box separation of sheet lead and gloves	0.2	drums	60	14			
	Stage at decon (80%)	0.2	drums	10	2			
	Stage at melter (20%)	0.05	drums	10	0			
Total Task				85	18	0.04	85	
Waste Decon	Stage containers	0.2	drum	5	1			
	Decon waste	0.2	drum	10	2			
	Assay for recycle	0.2	drum	30	6			
	Repack in drums	0.2	drum	15	3			
	Close drum lid	0.2	drum	15	3			
	Stage drums	0.2	drum	5	1			
	Monitor recirc filtration and fugitive dust system	24.0	times	6	144			
Total Task				86	159	0.33	86	30
Lead Melting	Setup/check equipment	0.05	time/ batch	30	1			
	Stage waste for feeding	0.05	batch	20	1			
	Adjust flux to melter	0.05	batch	20	1			
	Feed melter (10 min/drum)	0.05	batch	100	5			
	Melt waste	0.05	batch	180	9			
	Monitor APC during batch	0.05	batch	350	17			
Total Task				670	15	0.03	320	180
Metal Cooling	Metal discharge into containers	0.05	drums	15	1			
	Metal cooling (90%)	0.04	drums	N/A	0			
	Staging waste into cooling	0.05	drums	15	1			
	Slag cooling (10%)	0.00	drums	N/A	0			
	Staging waste out of cooling	0.05	drums	15	1			
	Collect samples	0.05	drums	15	1			
Total Task				60	3	0.01	60	0
Total FTEs/shift						0.41	551	
Supervision	Ratio of 1:10					0.04		
Vac/sick/holiday relief	Assume 6 wks of absence					0.05		
Total/shift						0.50		
70% efficiency						0.71		
Total/day						2.14		

Notes:
Assume assay for all drums @ 30 min/drum
20% of input is melted and 80% is deconned (ITTS ph2 assumption, fig A1-4)
Assume melter batch time is 3 hours
Assume 10 drum (9170 lb or 550 gal) batches

Table A1-j. **Mercury Amalgamation**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Mecury Receiving/ Feed Prep	Transfer through air lock	0.4	drums	5	2			
	transfer liq mercury to tank (5% of Hg waste)	0.0	drums	60	1			
	transfer Hg contaminated waste to feed bin	0.4	drums	15				
Total Task				65	3	0.01	65	15
Shredding	Transfer waste/drums to shredder	0.4	drum	2	1			
	Stage drums and waste	0.4	drum	2	1			
	Shred stage 1	0.4	drum	2	1			
	Shred stage 2	0.4	drum	2	1			
	Sample size of waste	0.4	drum	5	2			
	Rework 10%	0.0	drum	11	0			
	Return to container	0.4	drum	3	1			
	Transfer to retort staging	0.4	drum	5	2			
Total Task				32	8	0.02	32	11
Mercury Retorting	Setup/check equipment	0.4	time/ batch	30	11			
	Stage shredded waste for feeding (batch=1 drum)	0.4	drum	20	8			
	Feed retort (20 min/drum)	0.4	drum	20	8			
	Heat waste	0.4	drum	60	23			
	Condense mercury	0.0	drum	10	0			
	Separate offgas and Hg	0.0	drum	10	0			
	Discharge waste	0.4	drum	60	22			
	Monitor APC during batch	0.4	drum	160	61			
Total Task				210	132	0.28	210	60
Mercury Amalgamation	Inspect equipment	0.0	drum	30	1			
	Transfer liq mercury to amalgamater (1 gpm)	0.0	drum	55	2			
	Measure additives	0.0	drum	30	1			
	Batch amalgamation	0.0	drum	120	5			120
	Transfer out of amalgamater	0.0	drum	55	2			
	Sample waste	0.0	drum	15	1			
	Stage	0.0	drum	5	0			
	Place at assay	0.0	drum	5	0			
	Assay	0.0	drum	20	1			
	Remove from assay	0.0	drum	2	0			
Total Task				307	12	0.02	307	120
Total FTEs/shift						0.32	614	
Supervision	Ratio of 1:10					0.03		
Vac/sick/holiday relief	Assume 6 wks of absence					0.04		
Total/shift						0.40		
Adjustment for 70% Efficiency						0.57		
Total/day						1.71		

Notes:
Assume 5% of mercury waste is elemental, rest is debris
Assume 5% of debris is mercury.
Assume all debris requires 2 stage shredding
Assume retort is 1 drum batch.
Batch size for amalgamater: Assume 1 drum/batch, 2 hrs /batch

Table A1-k. **Special Waste**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Special Receiving/Feed Prep	Transfer through air lock	5.4	drums	5	27			
	Glove box preparation of wastes	5.4	drums	60	322			
	Stage waste	5.4	drums	3	16			
Total Task				68	364	0.76	68	60
Waste Treatment	Stage containers	5.4	drum	3	16			
	Treat waste as special processes TBD	5.4	drum	60	322			
	Sample treated waste	5.4	drum	15	80			
	Repack in drums	5.4	drum	30	161			
	Close drum lid	5.4	drum	3	16			
	Stage drums	5.4	drum	3	16			
Total Task				114	611	1.27	114	60
Total FTEs/shift						2.03	182	
Supervision	Ratio of 1:10					0.20		
Vac/sick/holiday relief	Assume 6 wks of absence					0.26		
Total/shift						2.49		
Adjustment for 70% Efficiency						3.56		
Total/day						10.69		

Notes:
Assume all waste is prepared in glove box
Assume waste is treated in various batch processes that average 2 hours/drum
TBD=To be determined

Table A1-I. Grout Stabilization Subsystem

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Waste Receiving/ Feed Prep	Transfer through air lock	0	drums	5	0			
	Sample waste	0	drums	15	0			
	Select process for waste	0	drums	5	0			
	Transfer to macroencapsulation		drums	2	0			
	Transfer to microencapsulation	0	drums	2	0			
	Stage at process	0	drums	2	0			
Total Task				31	0	0	31	5
Waste Encapsulation	Measure binder	0	drum	15	0			
	Mix binder	0	drum	15	0			
	Combine with waste	0	drum	30	0			
	Repack in drums	0	drum	15	0			
	Close drum lid	0	drum	15	0			
	Stage pallets	0	drum	2	0			
	Monitor activated carbon and fugitive dust system	2	times	6	12			
Total Task				98	12		98	30
Binder setup time	Move pallets to curing area	0	drum	5	0			
	Curing time	0	drum		0			
	Monitor curing process	0	drum	10	0			
	Move pallets from curing area	0	times	5	0			
Total Task				20	0	0	20	5
Drum Decon	Stage containers	0	drum	5	0			
	Load conveyors	0	drum	5	0			
	Decon drums	0	drum	10	0			
	Assay drums	0	drum	30	0			
	Unload conveyers	0	drum	5	0			
	Palletize drums	0	drum	2	0			
	Stage drums	0	drum	5	0			
Total Task				62	0	0		30
Total FTEs/shift						0		
Supervision	Ratio of 1:10					0		
Vac/sick/holiday relief	Assume 6 wks of absence					0		
Total/shift						0		
70% efficiency						0		
Total/day						0		

Notes:

Assume all complex debris (8 drums) will be sent to macroencapsulation, rest to micro.

Assume 10% of drums are deconned.

Assume 10% of drums are assayed

Assume mixing requires 30 min/drum

Table A1-m. **Polymer Stabilization Subsystem**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Waste Receiving/Feed Prep	Transfer through air lock	2.8	drums	5	14			
	Sample waste	0.3	drums	15	4			
	Evaluate dryness	0.3	drums	5	1			
	Dry waste	2.8	drums	30	N/A			
	Monitor drying	24.0	times	10	240			
	Stage at process	2.8	drums	2	6			
Total Task				57	265	0.55	57	30
Encapsulation	Measure polymer	2.8	drum	5	14			
	Mix polymer	2.8	drum	10	28			
	Combine with waste in extruder	2.8	drum	10	28			
	Repack in drums	24.0	drum	5	120			
	Close drum lid	2.8	drum	3	8			
	Palletize drums	2.8	drum	2	6			
	Stage drums	24.0	drum	2	48			
	Monitor activated carbon and fugitive dust system	8.0	times	6	48			
Total Task				43	300	0.63	43	60
Binder setup time	Move pallets to curing area	24.0	drum	5	120			
	Curing time	24.0	drum		0			
	Sample every 10 drums	2.4	drum	15	36			
	Monitor curing	24.0	drum	10	240			
	Move pallets from curing area	24.0	times	5	120			
Total Task				35	516	1.08	35	5
Drum Decon	Stage containers	2.8	drum	5	14			
	Load conveyors	2.8	drum	5	14			
	Decon drums	2.8	drum	10	28			
	Assay drums	2.8	drum	15	42			
	Unload conveyers	2.8	drum	5	14			
	Stage drums	2.8	drum	5	14			
Total Task				45	126	0.26	45	60
Total FTEs/shift						2.52	180	
Supervision	Ratio of 1:10					0.25		
Vac/sick/holiday relief	Assume 6 wks of absence					0.32		
Total/shift						3.09		
Adjustment for 70% Efficiency						4.41		
Total/day						13.22		

Notes:
Assume 30% of process residue waste and 100% of other waste requires drying
Assume dryer can accept waste at the rate of 2 drums/hour
No. of samples = 2.4

Table A1-n. **Air Pollution Control Subsystem**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ lb
Monitor Equipment	Dry filtration	8.0	times	10	80		
	Quencher	24.0	times	5	120		
	Prefilter/hepa filter	4.0	times	5	20		
	Acid gas scrubber	24.0	times	5	120		
	GAC	4.0	times	2	8		
	Mersorb	4.0	times	2	8		
	Evaporator System	24.0	times	5	120		
	Dioxin/ Denox Filter	8.0	times	5	40		
	Hydrosonic Scrubber	24.0	times	5	120		
	Liquid/ Solid Separator	24.0	times	5	120		
	Mist Eliminator	4.0	times	2	8		
	Heat Exchanger	4.0	times	5	20		
	Offgas monitor	24.0	times	5	120		
Total Task				61	904	1.88	0
Supervision	Ratio of 1:10					0.19	
Vac/sick/holiday relief	Assume 6 wks of absence					0.24	
Total/shift						2.31	
Adjustment for 70% Efficiency						3.30	
Total/day						9.90	

Table A1-o. **Certification and Shipping**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Waste Receiving	Transfer through air lock	11.8	drums	5	59			
	Sample waste	1.2	drums	15	18			
	Resample waste	0.1	drums	15	2			
	Stage waste	11.8	drums	5	59			
Total Task				40	138	0.29	40	15
Waste Assay	Stage pallets	11.8	drum	3	36			
	Load on conveyor	11.8	drum	1	12			
	Assay RTR	11.8	drum	15	178			
	Assay gamma	11.8	drum	60	710			
	Assay PAN	11.8	drum	60	710			
	Remove from conveyor	11.8	drum	1	12			
	Repalletize	11.8	drum	3	36			
	Stage pallets after assaying	11.8	drum	15	178			
Total Task				158	1871	3.90	158	60
Stage waste	Stage uncertified waste	11.8	drum	3	36			
	Transfer waste	11.8	drum	3	36			
	Stage certified waste	11.8	drum	3	36			
	Transfer waste	11.8	drum	3	36			
Total Task				12	142	0.30	12	
Ship Waste Truck	Truck docking	0.1	truck	30	4			
	Settle Paperwork	0.1	truck	120	16			
	Load truck	0.1	truck	60	8			
	Truck leaving	0.1	truck	60	8			
Total Task				270	36	0.08	12	
Total FTEs/shift						4.56	222	
Supervision	Ratio of 1:10					0.46		
Vac/sick/holiday relief	Assume 6 wks of absence					0.58		
Total/shift						5.59		
Adjustment for 70% Efficiency						7.99		
Total/day						23.96		

Notes:
Assume 10% of waste requires sampling
Samples collected = 1.2

Table A1-p. **Summary of FTEs and time for a single drum to work through a system**

	Daily FTEs	Time (min)/ Single Drum	Time (hrs)	Add'l Time for Next Drum	Time/Drums Received in a Shift (min)	Time (hrs)
Administration	48.4	N/A				
Receiving /Inspection Tasks common for all waste		802	13	60	3728	62
Receiving and Prep-incin		229	4	45	1714	29
Receiving and Prep-metal melt		267	4	45	452	8
Receiving and Prep-lead		557	9	315	557	9
Receiving and Prep-mercury		516	9	315	516	9
Receiving and Prep-special		516	9	315	1889	31
Receiving and Prep-metal decon		229	4	35	560	9
Receiving and Prep	170.1	670.7	11			0
Aqueous Waste	5.9	124	2	5	1301	22
Incineration	19.8	149	2	26	1007	17
Vitrification	13.7	194	3	15	561	9
Metal Decon	16.5	91	2	75	1216	20
Metal Melting	5.8	348	6	75	657	11
Lead	2	551	9	N/A	551	9
Mercury	1.7	614.0	10	N/A	614	10
Special	10.7	182.0	3	60.0	444	7
Grout	0.0	0	0		0	0
Polymer	13.2	180	3	60	288	5
APC	9.9	904	15		904	15
Certification and Shipping	24.0	222	4	60	872	15
Total	**341.8**					

Notes:
Allocation of receiving and preparation time was done as follows: Average time per drum was estimated, multiplied by the number of drums per shift. The time for each waste type was allocated according its percentage of total waste.

System C-1 Time and Motion Study Tables

Table C1-a System C-1: Time and Motion Analysis

Subsystem	Mass Flow (lb/hr)	Waste Type	No. of Drums	SCM Unprocessed Density kg/m3	Density lb/ft3	Density lb/drum
Administration	2,927					
Receiving and preparation	2,927	all	6.2		64	471
Aqueous waste treatment	6,645	L1100	14.6		62	456
Plasma Treatment	2,149	S5300,5110	4.6		64	471
Thermal treated waste	1,451	S3110	1.1		187	1375
Metal Melting	0	S5110	0.0	509	32	234
Metal decontamination	468	S5110	2.0	509	32	234
Mercury amalgamation	50	X7100	0.1	2000	125	918
Lead recovery	26	X7200	0.0	2000	125	918
Polymer stabilization	113	S3120	0.4	700	44	321
Air pollution control	6,762		N/A			
Special treatment	153	X6000,X7500	0.7	500	31	229
Certification and shipping	1,958	Z000	1.5	2500	180	1326
vol reduction (out/in)	1.49		0.2			

Notes:
This table provides the basis for the time and motion analysis.
Quantities of waste to a subsystem (lbs/hr) are based on LMITCO mass balance.
Densities are the same as the LMITCO mass balance except where values are shown in the SCM column.
Where values are shown in the SCM column, densities are taken from SCM and converted to lb/ft3.
Density for thermal treatment is based on 33% combustible (5300) and 67% noncombustible (5110).
The waste quantities are converted from lbs/hr to drums/hr.
Subsequent analysis is based on drums/shift of waste to a subsystem.
Thermal treated waste refers to waste processed through the plasma reactor.

Table C1-b. **Administration Subsystem**

Task	Subtask	FTEs Needed	Samples/ Shift	Time Required (min)	Total Time/ Shift
Facility Management	Facility Manager	1			
	Secretary	1			
	Receptionist/word processor	1			
Operations Management	Department managers	2			
	Communications	1			
	Engineering Manager	1			
	Engineering staff	2			
	Maintenance Supervisor	1			
Personnel	Personnel Manager	1			
	Nurse/medical/industrial safety	1			
	Security guards at facility	4			
	Security at guard bldg	4			
Environmental	Environmental manager	1			
	Environmental clerk	1			
Shipping/receiving/Traffic					
	Manager	1			
	Clerk	1			
Purchasing	Buyer	1			
Accounting	Cost Accounting	2			
	Accounting Clerk	1			
	Payroll Clerks	2			
Laboratory	Laboratory Manager	1			
	Lab Shift manager	4			
	Lab technicians for OSORT	1	4.1	30.0	123.2
	Lab technicians for internal processes	4	32.0	10.0	320.3
	Lab technicians for final waste form	1	4.4	30.0	132.8
	Lab technicians for incoming supplies	0.2	1.0	20.0	20.0
Health Physics	Shift health physics staff	4			
	Health physics manager	1			
	Total except Lab	35			
	Total Lab	12			
	Total Admin	47			

Table C1-c. **Receiving and Preparation Subsystem**

Task	Subtask	Occurrence / Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Add"l Time for Next Drum	Ave Minutes/Shift/ Drum
Receive Waste Truck	Truck docking	0.6	truck	30	17			
	Settle Paperwork	0.6	truck	120	68			
	Unload truck	0.6	truck	60	34			
	Stage pallets	0.6	truck	60	34			
	No of pallets/shift							
Total Task 1				270	153	0.3	0	153
Receive Empty container Truck	Truck docking	0.3	truck	30	8			
	Settle Paperwork	0.3	truck	30	8			
	Unload truck	0.3	truck	60	17			
	Stage pallets	0.3	truck	20	6			
Total Task 2				140	40	0.1	0	40
Receive Supplies	Truck docking	0.2	truck	30	6			
	Settle Paperwork	0.2	truck	30	6			
	Unload truck	0.2	truck	60	12			
	Stage pallets	0.2	truck	20	4			
Total Task 3				140	28	0.1	0	28
Transfer to Interim Storage	Move pallets to storage area	6.2	Pallet	5	31			
	Stack pallets/ organize storage	6.2	Pallet	10	62			
	Transfer to assay	6.2	Pallet	5	31			
Total Task 4				20	124	0.3	10	10
Assay Drums	Stage pallets	12.4	Pallet	5	62			
	Load on conveyor	49.8	drum	1	50			
	Assay RTR	49.8	drum	15	746			
	Assay gamma	49.8	drum	60	2986			
	Assay PAN	49.8	drum	60	2986			
	Remove from conveyor	49.8	drum	1	50			
	Repalletize	49.8	drum	3	149			
	Stage pallets after assaying	12.4	Pallet	5	62			
Total Task 5				150	7091	14.8	60	150
Stage and move to OSORT	Store solid waste by category	12.4	Pallet	10	124			
	Move to 50% to OSORT	6.2	Pallet	5	31			
	Stage at OSORT	6.2	Pallet	5	31			
Total Task 6			Pallet	20	187	0.4	5	20
Open Drums	Stage at drum opener	6.2	Pallet	5	31			
	Load on conveyor	24.9	Drums	5	124			
	Drum lid clamp	24.9	drum	2	50			
	Drum lid opener	24.9	drum	5	124			
	Lid staging	24.9	drum	1	25			
	Remove from conveyor	24.9	drum	1	25			
Total Task 7				19	398	0.8	5	19
Dump Drums	Assign drums to dump stations	24.9	drum	3	75			
	Move drums to sort table /bins	24.9	drum	5	124			
	Dump drums	24.9	drum	5	124			
Total Task 8				13	323	0.7	5	13

Table C1-c. **Receiving and Preparation Subsystem**

Task	Subtask	Occurrence / Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Add"l Time for Next Drum	Ave Minutes/Shift/ Drum
Sort Drums	Sort waste robotically	24.9	drum	30	746			
	Transfer waste to container	24.9	drum	15	373			
	Select destination for sorted waste	24.9	drum	3	75			
	Move container to subsystem bin or shredder	24.9	drum	3	75			
Total Task 9				51	1269	2.6	45	38
Glove Box Sort	Transfer to glove box (several trips)	6.0	drum	30	180			
	Sort waste by hand in glove box	6.0	drum	240	1440			
	Sampling (1/drum)	6.0	drum	15	90			
	Transfer waste to containers	6.0	drum	60	360			
	Select destination for sorted waste	6.0	drum	15	90			
	Move containers to subsystem bin or shredder	6.0	drum	15	90			
Total Task 10				375	2250	4.7	315	5
Gross Size Reduction	Transfer to cutting table	0.2	drum	3	1			
	Cut waste	0.2	drum	30	7			
	Return to container	0.2	drum	5	1			
	Transfer to next process	0.2	drum	3	1			
Total Task 11				41	10	0.0	35	6
Shredding	Transfer drums to shredder	3.1	drum	2	6			
	Stage drums	3.1	drum	2	6			
	Feed waste to shredder	3.1	drum	2	6.22			
	Feed bad drums to shredder	12.4	drum	2				
	Shred stage 1	12.4	drum	2	25			
	Shred stage 2	12.4	drum	2	25			
	Sample size of waste	1.2	drum	5	6			
	Rework 10%	0.1	drum	15	2			
	Return to container	12.4	drum	3	37			
	Transfer to next process	12.4	drum	2	25			
Total Task 12				37	139	0.3	2	30
Sampling					0			
	Sample opened drums	2.5	drum	5	12			
	Sample sorted waste	1.2	drum	5	6			
	Resample (10%)	0.4	drum	5	2			
	Report/eval. results	4.1	drum	10	41			
Total Task 13				25	62	0.2	10	30

Table C1-c. **Receiving and Preparation Subsystem**

Task	Subtask	Occurrence / Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Add"l Time for Next Drum	Ave Minutes/Shift/ Drum
Subsystem Bin operation	Monitor bin height	24.9	drum	3	75			
	Fill containers	24.9	drum	3	75			
	Move containers	24.9	drum	2	50			
	Stage containers	24.9	drum	3	75			
	Organize campaigns	24.9	drum	15	373			
Total Task 14				26	647	1.8	0	26
Internal Transfer	Move waste from OSORT to other subsystems	24.9	drum	10	249			
	Move waste from subsystems to CSHIP	11.8	drum	10	118			
	Move treated waste to stabilization	80.0	drum	10	800			
	Move unsorted waste to incin	6.2	drum	10	62			
	Move waste to secondary treatment	20.0	drum	10	200			
	Move supplies around	20.0	drum	3	60			
	Move new drums	24.9	drum	3	75			
	Schedule movement	187.8	drum	1	188			
Total Task 15				57	1752	4.9	10	57
Box Breakdown	Stage boxes	10.0	box	2	20			
	Move to opening area	10.0	box	3	30			
	Open boxes	10.0	box	10	100			
	Transfer to dump	10.0	box	3	30			
Total Task 16				18	180	0.5	10	2
Container Decon	Stage containers	49.8	drum	5	249			
	Load conveyors	49.8	drum	5	249			
	Decon drums	49.8	drum	10	498			
	Assay drums	49.8	drum	15	746			
	Unload conveyers	49.8	drum	5	249			
	Stage drums	49.8	drum	5	249			
Total Task 17				45	2239	6.2	15	45
FTEs/shift					0	31.9		
Supervision	Ratio of 1:10					3.2		
Vac/sick/holiday relief	Assume 6 wks of absence					4.0		
Break relief (included in 6 hr day)	One person can relieve 3 (accounted for in efficiency)							
Total/shift						39.1		
Adj for 70% Efficiency						55.8		
Total/day						167.5		671

Notes:

Assume FTEs are available for 8 hrs/day; because overall 70% efficiency is taken at the end.

Trucks have 22 pallets. Waste density is 64 lb/cu ft.

Pallets are assumed to hold 4 55 gallon drums

As in inventory, assume 50% of drums are contaminated and can't be deconned.

Assume 50% of waste received requires interim storage; this will be dependent on assay system

Assume 10% of incoming waste is sampled

Assume opened and sorted waste is 50% of total

Table C1-c. **Receiving and Preparation Subsystem**

Task	Subtask	Occurrence / Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Add"l Time for Next Drum	Ave Minutes/Shift/ Drum

Notes (cont.):
Assume 10% of sorted waste is sampled
Assume gross size reduction is necessary for wastes to metal decon & lead
Assume gross size reduction is 1 hr per drum.
Assume shredding is necessary for drums only
Assume 10% of shredded waste is sampled.
Box breakdown includes time beyond that required if waste was packaged in drums
Assume glove box sorting required for special, mercury and lead
Assume glove box waste requires 1 sample/drum
Assume transfer control for liquids takes the same time as for solids
Assume paperwork is accomplished within times shown
Average time per drum includes times for activities multiplied by the probability that the activity will occur.
Least time/drum/subsystem includes only the minimum requirements, no extra staging, sorting, or shredding
Max time/drum/subsystem includes all staging, shredding, glove box, etc

Table C1-d. Plasma Reactor

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l drum
Receive Waste	Transfer through air lock	9.1	pallet	5	46			
	Stage drums for campaigns	9.1	pallet	15	137			
Total Task				20	183	0.38	20	15
Shredding	Transfer waste/drums to shredder	36.6	drum	2	73			
	Stage drums and waste	36.6	drum	2	73			
	Shred stage 1	36.6	drum	2	73			
	Shred stage 2	36.6	drum	2	73			
	Sample size of waste	3.7	drum	5	18			
	Rework 10%	0.4	drum	11	4			
	Return to container	36.6	drum	3	110			
	Transfer to next process	36.6	drum	2	73			
Total Task				29	498	1.04	29	15
Sampling	Sample shredded waste to characterize	3.7	drum	5	18			
	Resample (10%)	0.4	drum	5	2			
	Report/eval. results	4.0	drum	10	40			
Total Task				20	60	0.17	20	10
Feeding	Select waste for feeding	36.6	drums	5	183			
	Stage waste for feeding	36.6	drums	5	183			
	Feed plasma reactor (50 ft3/hr or 6.8 drums/hr)	36.6	drums	0	4			
	Incinerate waste (1 hr)	36.6		60	2194			
	Discharge waste (50 ft3/hr)	6.8		0	1			
	Sample waste in and out	16.0	times	10	160			
Total Task				80	530	1.10	80	9
Plasma treatment	Monitor feeding							
	Monitor gas/air ratio	24.0	times	5	120			
	Monitor burner	24.0	times	5	120			
	Monitor feeding	24.0	times	5	120			
	Monitor secondary combustion	24.0	times	5	120			
	Monitor discharge	24.0	times	5	120			
Total Task				25	360	0.75	25	9
Cooling	Glass/slag discharge into containers (dens= 156 lb/ft3)	8.4	drums	0	0			
	Glass cooling	8.4	drums	N/A	0			
	Staging waste into cooling	8.4	drums	5	42			
	Staging waste out of cooling	8.4	drums	5	42			
	Collect samples	0.8	drums	15	13			
Total Task				25	97	0.20	15	0
Drum Decon	Stage containers	8.4	drum	5	42			
	Load conveyors	8.4	drum	5	42			
	Decon drums	8.4	drum	10	84			
	Assay drums	8.4	drum	15	127			
	Unload conveyers	8.4	drum	5	42			
	Stage drums	8.4	drum	5	42			
Total Task				45	380	0.79	45	
FTEs/shift						4.43	234	15
Supervision	Ratio of 1:10					0.44		
Vac/sick/holiday relief	Assume 6 wks of absence					0.56		
Total/shift						5.44	234	15
Adjustment for 70% Efficiency						7.77		
Total/day						23.31		

Notes:

Feed to incinerator requires shredding; whole drums can be shredded.

Assume 15 min/drum per stage of shredding

Assume 1 hour reactor residence time

Assume rate of feeding and discharge @ 50 cu ft/hr

Treated waste mass amount from LITCO mass balance of 4/23/96

Assume cooling time is long; staging of waste in and out is only time considered

No. of process samples = 20.0

Table C1-e. Aqueous Waste Treatment Subsystem

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l drum
Receive Waste	Transfer through air lock	1.4	drum	5	7			
	Feed waste from drum	1.4	drum	3	4			
	Hook to transfer device	1.4	drum	3	4			
	Transfer to tank (10 gpm)	1.4	drum	6	8			
	Empty drum bottoms	1.4		2	3			
	Sample feed vessel	2.0		10	20			
	Detach & remove drum	1.4		3	4			
	Sample waste from processes: incin, aqueous, Decon,APC	4.0	N/A					
	Arrange for transfer	6304.5	gal	0	38			
Total Task				32	88	0.18	32	5
Preliminary Treatment	Sample high TDS tank	0.0	drums	15	0			
	Sample low TDS tank	4.6	drums	15	7			
	Sample TOC waste	1.4	drums	15	2			
	Select treatment methods (10 drum batch)	1.4	drums	20	3			
	Transfer organic waste to oil water separator	1.4	drums	3	5			
	Filter high, low TDS and organic waste (say 50 gal/min)	6.0	drums	1	7			
	Neutralize/ppt high TDS waste	0.0	drums	11	0			
	Settle precipitated aqueous waste	0.0	drums	6	0			
	Evaporate solids(50 gpm)	6.0	drums	1	7			
	Monitor filter	24.0	times	5	120			
	Monitor evaporator	24.0	times	5	120			
Total Task				86	256	0.53	86	20
UV Oxidation	Adjust UV oxidation (30 min/10 drums)	1.4	drums	3	4			
	Process through UV oxidation (50 gpm)	1.4	drums	1	2			
	Carbon filtration (50 gpm)	6.0	drums	1	7			
	Ion exchange (50 gpm)	6.0	drums	1	7			
	Monitor carbon & ion exchange	12.0	times	5	60			
	Sample waste before discharge	2.0	times	30	60			1
Total Task 3				6	139	0.29	6	
Total per shift					0	1.01	124	26
Supervision	Ratio of 1:10					0.10		
Vac/sick/holiday relief	Assume 6 wks of absence					0.13		
Efficiency						1.77		
Total per day						5.30		

Notes:

Assume waste from APC and other secondary waste is low TDS   6565.00   lbs/hr   115   drums/shift

Assume waste from RCPRP is organic liq   80.00   lbs/hr   1   drums/shift

Total drums per hour=   116.6

Assume sampling of low TDS waste is one/25 drums

Assume transfer of waste requires 15 min/2500 gallons

Assume tank batches are 550 gallons (10 drums)

Assume treatment selection time is required for waste from RCPRP only;scrubber liquor has the same treatement.

Assume residence time in oil water separator is 1 hour and tank is 1000 gallons (16 gpm)

Assume filtration, centrifuge and ppt rates are 10 gpm.

Assume evaporation rate is 50 gpm

Assume UV oxidation unit is 50 gpm

Number of process sampl 12.0

Table C1-f. **Metal Decontamination Subsystem**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes / Drum	Minutes/ Add'l Drum
Metals Receiving/ Feed Prep	Transfer through air lock	16.0	drums	5	80			
Total Task				5	80	0.17	5	0
Waste Decon	Stage containers	16.0	drum	5	80			
	Decon waste	16.0	drum	10	160			
	Assay for recycle	16.0	drum	30	480			
	Repack in drums	16.0	drum	15	240			
	Close drum lid	16.0	drum	15	240			
	Stage drums	16.0	drum	5	80			
	Monitor recirc filtration and fugitive dust system	24.0	times	6	144			
Total Task				86	1424	2.97	86	
Total FTEs/shift						3.13	91	
Supervision	Ratio of 1:10					0.31		
Vac/sick/holiday relief	Assume 6 wks of absence					0.40		
Total/shift						3.84		
Adjustment for 70% Efficiency						5.49		
Total/day						16.48		

Notes:
Assume 50% of waste must be size reduced.
Assume 60 min/drum for cutting

Table C1-g Lead Recovery

Task	Subtask	Occurrence / Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Lead Receiving/Feed Prep	Transfer through air lock	0.2	drums	5	1			
	Glove box separation of sheet lead and gloves	0.2	drums	60	14			
	Stage at decon (80%)	0.2	drums	10	2			
	Stage at melter (20%)	0.0	drums	10	0			
Total Task				85	18	0.04	85	
Waste Decon	Stage containers	0.2	drum	5	1			
	Decon waste	0.2	drum	10	2			
	Assay for recycle	0.2	drum	30	6			
	Repack in drums	0.2	drum	15	3			
	Close drum lid	0.2	drum	15	3			
	Stage drums	0.2	drum	5	1			
	Monitor recirc filtration and fugitive dust system	24.0	times	6	144			
Total Task				86	159	0.33	86	30
Lead Melting	Setup/check equipment	0.05	time/ batch	30	1			
	Stage waste for feeding	0.05	batch	20	1			
	Fdjust flux to melter	0.05	batch	20	1			
	Feed melter (10 min/drum)	0.05	batch	100	5			
	Melt waste	0.05	batch	180	9			
	Monitor APC during batch	0.05	batch	350	17			
Total Task				670	15	0.03	320	180
Metal Cooling	Metal discharge into containers	0.05	drums	15	1			
	Metal cooling (90%)	0.04	drums	N/A	0			
	Staging waste into cooling	0.05	drums	15	1			
	Slag cooling (10%)	0.00	drums	N/A	0			
	Staging waste out of cooling	0.05	drums	15	1			
	Collect samples	0.05	drums	15	1			
Total Task				60	3	0.01	60	0
Total FTEs/shift						0.41	551	
Supervision	Ratio of 1:10					0.04		
Vac/sick/holiday relief	Assume 6 wks of absence					0.05		
Total/shift						0.50		
Adjustment for 70% Efficiency						0.71		
Total/day						2.14		

Notes:
Assume assay for all drums @ 30 min/drum
20% of input is melted and 80% is deconned (ITTS ph2 assumption, fig A1-4)
Assume melter batch time is 3 hours
Assume 10 drum (9170 lb or 550 gal) batches

Table C1-h. Mercury Amalgamation

Task	Subtask	Occurrence / Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Mecury Receiving/ Feed Prep	Transfer through air lock	0.4	drums	5	2			
	Transfer liq mercury to tank (5% of Hg waste)	0.0	drums	60	1			
	Transfer Hg contaminated waste to feed bin	0.4	drums	15				
Total Task				65	3	0.01	65	15
Shredding	Transfer waste/drums to shredder	0.4	drum	2	1			
	Stage drums and waste	0.4	drum	2	1			
	Shred stage 1	0.4	drum	2	1			
	Shred stage 2	0.4	drum	2	1			
	Sample size of waste	0.4	drum	5	2			
	Rework 10%	0.0	drum	11	0			
	Return to container	0.4	drum	3	1			
	Transfer to retort staging	0.4	drum	5	2			
Total Task				32	8	0.02	32	11
Mercury Retorting	Setup/check equipment	0.4	time/ batch	30	11			
	Stage shredded waste for feeding (batch = 1 drum)	0.4	drum	20	8			
	Feed retort (20 min/drum)	0.4	drum	20	8			
	Heat waste	0.4	drum	60	23			
	Condense mercury	0.0	drum	10	0			
	Separate offgas and Hg	0.0	drum	10	0			
	Discharge waste	0.4	drum	60	22			
	Monitor APC during batch	0.4	drum	160	61			
Total Task				210	132	0.28	210	60
Mercury Amalgamation	Inspect equipment	0.0	drum	30	1			
	Transfer liq mercury to amalgamater (1 gpm)	0.0	drum	55	2			
	Measure additives	0.0	drum	30	1			
	Batch amalgamation	0.0	drum	120	5			120
	Transfer out of amalgamater	0.0	drum	55	2			
	Sample waste	0.0	drum	15	1			
	Stage	0.0	drum	5	0			
	Place at assay	0.0	drum	5	0			
	Assay	0.0	drum	20	1			
	Remove from assay	0.0	drum	2	0			
Total Task				307	12	0.02	307	120
Total FTEs/shift						0.32	614	
Supervision	Ratio of 1:10					0.03		
Vac/sick/holiday relief	Assume 6 wks of absence					0.04		
Total/shift						0.40		
Adjustment for 70% Efficiency						0.57		
Total/day						1.71		

Notes:
Assume 5% of mercury waste is elemental, rest is debris
Assume 5% of debris is mercury.
Assume all debris requires 2 stage shredding
Assume retort is 1 drum batch.
Batch size for amalgamater: Assume 1 drum/batch, 2 hrs /batch

Table C1-i. **Special Waste**

Task	Subtask	Occurrence / Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Special Receiving/Feed Prep	Transfer through air lock	5.4	drums	5	27			
	Glove box preparation of wastes	5.4	drums	60	322			
	Stage waste	5.4	drums	3	16			
Total Task				68	364	0.76	68	60
Waste Treatment	Stage containers	5.4	drum	3	16			
	Treat waste as special processes TBD	5.4	drum	60	322			
	Sample treated waste	5.4	drum	15	80			
	Repack in drums	5.4	drum	30	161			
	Close drum lid	5.4	drum	3	16			
	Stage drums	5.4	drum	3	16			
Total Task				114	611	1.27	114	60
Total FTEs/shift						2.03	182	
Supervision	Ratio of 1:10					0.20		
Vac/sick/holiday relief	Assume 6 wks of absence					0.26		
Total/shift						2.49		
Adjustment for 70% Efficiency						3.56		
Total/day						10.69		

Notes:
Assume all waste is prepared in glove box
Assume waste is treated in various batch processes that average 2 hours/drum
TBD=To be determined

Table C1-j. Polymer Stabilization Subsystem

Task	Subtask	Occurrence / Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Waste Receiving/Feed Prep	Transfer through air lock	2.8	drums	5	14			
	Sample waste	0.3	drums	15	4			
	Evaluate dryness	0.3	drums	5	1			
	Dry waste	2.8	drums	30	N/A			
	Monitor drying	24.0	times	10	240			
	Stage at process	2.8	drums	2	6			
Total Task				57	265	0.55	57	30
Encapsulation	Measure polymer	2.8	drum	5	14			
	Mix polymer	2.8	drum	10	28			
	Combine with waste in extruder	2.8	drum	10	28			
	Repack in drums	24.0	drum	5	120			
	Close drum lid	2.8	drum	3	8			
	Palletize drums	2.8	drum	2	6			
	Stage drums	24.0	drum	2	48			
	Monitor activated carbon and fugitive dust system	8.0	times	6	48			
Total Task				43	300	0.63	43	60
Binder setup time	Move pallets to curing area	24.0	drum	5	120			
	Curing time	24.0	drum		0			
	Sample every 10 drums	2.4	drum	15	36			
	Monitor curing	24.0	drum	10	240			
	Move pallets from curing area	24.0	times	5	120			
Total Task				35	516	1.08	35	5
Drum Decon	Stage containers	2.8	drum	5	14			
	Load conveyors	2.8	drum	5	14			
	Decon drums	2.8	drum	10	28			
	Assay drums	2.8	drum	15	42			
	Unload conveyers	2.8	drum	5	14			
	Stage drums	2.8	drum	5	14			
Total Task				45	126	0.26	45	60
Total FTEs/shift						2.52	180	
Supervision	Ratio of 1:10					0.25		
Vac/sick/holiday relief	Assume 6 wks of absence					0.32		
Total/shift						3.09		
Adjustment for 70% Efficiency						4.41		
Total/day						13.22		

Notes:

Assume 30% of process residue waste and 100% of other waste requires drying

Assume dryer can accept waste at the rate of 2 drums/hour

No. of samples = 2.4

Table C1-k. **Air Pollution Control Subsystem**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ lb
Monitor Equipment	Dry filtration	8.0	times	10	80		
	Quencher	24.0	times	5	120		
	Prefilter/hepa filter	4.0	times	5	20		
	Acid gas scrubber	24.0	times	5	120		
	GAC	4.0	times	2	8		
	Mersorb	4.0	times	2	8		
	Evaporator System	24.0	times	5	120		
	Dioxin/ Denox Filter	8.0	times	5	40		
	Hydrosonic Scrubber	24.0	times	5	120		
	Liquid/ Solid Separator	24.0	times	5	120		
	Mist Eliminator	4.0	times	2	8		
	Heat Exchanger	4.0	times	5	20		
	Offgas monitor	24.0	times	5	120		
Total Task				61	904	1.88	0
Supervision	Ratio of 1:10					0.19	
Vac/sick/holiday relief	Assume 6 wks of absence					0.24	
Total/shift						2.31	
Adjustment for 70% Efficiency						3.30	
Total/day						9.90	

Table C1-I. **Certification and Shipping**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Waste Receiving	Transfer through air lock	11.8	drums	5	59			
	Sample waste	1.2	drums	15	18			
	Resample waste	0.1	drums	15	2			
	Stage waste	11.8	drums	5	59			
Total Task				40	138	0.29	40	15
Waste Assay	Stage pallets	11.8	drum	3	36			
	Load on conveyor	11.8	drum	1	12			
	Assay RTR	11.8	drum	15	178			
	Assay gamma	11.8	drum	60	710			
	Assay PAN	11.8	drum	60	710			
	Remove from conveyor	11.8	drum	1	12			
	Repalletize	11.8	drum	3	36			
	Stage pallets after assaying	11.8	drum	15	178			
Total Task				158	1871	3.90	158	60
Stage waste	Stage uncertified waste	11.8	drum	3	36			
	Transfer waste	11.8	drum	3	36			
	Stage certified waste	11.8	drum	3	36			
	Transfer waste	11.8	drum	3	36			
Total Task				12	142	0.30	12	
Ship Waste Truck	Truck docking	0.1	truck	30	4			
	Settle Paperwork	0.1	truck	120	16			
	Load truck	0.1	truck	60	8			
	Truck leaving	0.1	truck	60	8			
Total Task				270	36	0.08	12	
Total FTEs/shift						4.56	222	
Supervision	Ratio of 1:10					0.46		
Vac/sick/holiday relief	Assume 6 wks of absence					0.58		
Total/shift						5.59		
Adjustment for 70% Efficiency						7.99		
Total/day						23.96		

Notes:

Assume 10% of waste require sampling

Samples collected = 1.2

Table C1-m. **Summary of FTEs and time for a single drum to work through a system**

	Daily FTEs	Time (min)/ Single Drum	Time (hrs)	Add'l Time for Next Drum	Time/Drums Received in a Shift (minutes)	Time (hrs)
Administration	46.6	N/A				
Receiving /Inspection Tasks common for all waste		802	13	60	3728	62
Receiving and Prep-plasma		229	4	45	1829	30
Receiving and Prep-lead		557	9	315	557	9
Receiving and Prep-mercury		516	9	315	516	9
Receiving and Prep-special		516	9	315	1889	31
Receiving and Prep-metal decon		229	4	35	560	9
Receiving and Prep	167.5	670.7	11			0
Aqueous Waste	5.3	124	2	5	702	12
Plasma Treatment	23.3	234	4	26	1159	19
Metal Decon	16.5	91	2	75	1216	20
Lead	2	551	9	N/A	551	9
Mercury	1.7	614.0	10	N/A	614	10
Special	10.7	182.0	3	60.0	444	7
Polymer	13.2	180	3	60	288	5
APC	9.9	904	15		904	15
Certification and Shipping	24.0	222	4	60	872	15
Total	**320.8**					

Notes:
Allocation of receiving and preparation time was done as follows: Average time per drum was estimated, multiplied by the number of drums per shift. The time for each waste type was allocated according its percentage of total waste.

System NT-2 Time and Motion Study Tables

Table NT2-a. **System NT-2: Time and Motion Analysis**

Subsystem	Mass Flow (lb/hr)	Waste Type	No. of Drums	SCM Unprocessed Density kg/cu m	Density lb/cu ft	Density lb/drum
Administration	2,927					
Receiving and preparation	2,927	all	6.2		64	471
Aqueous waste treatment (total)	1,258	L1100	2.8		62	456
High TDS aqueous waste	641	L1100	1.4		62	456
Low TDS Aqueous waste	268	L1100	0.6		62	456
Organic aqueous waste	350	L1200	0.8		62	456
Organic destruction	268	L2110	0.6		62	456
Process residue and inorganic sludge treatment	1,020	S3120	3.2	700	44	321
Bulk soil treatment	329	S4100	0.7		67	493
Soft Debris treatment	435	S5300	3.0	320	20	147
Open Debris treatment	80	S5110	0.4	400	25	184
Complex Debris treatment	177	S5110	1.0	400	25	184
Metal decontamination	462	S5110	2.0	509	32	234
Mercury amalgamation	5	X7100	0.0	2000	125	918
Lead recovery	56	X7200	0.1	2000	125	918
Polymer stabilization	1,110	S3120	3.5	700	44	321
Pre-polymer drying	438	S3120	1.4	700	44	321
Air pollution control	823		N/A			
Grout stabilization	1,228	soil/debris	3.6	750	47	344
Special treatment	155	X6000,X7500	0.7	500	31	229
Certification and shipping	5,067	Z0000	6.2	N/A	111	815
Vol reduction (out/in)	0.58		1.0			

Notes:
This table provides the basis for the time and motion analysis.
Quantities of waste to a subsystem (lbs/hr) are based on LMITCO mass balance for system NT2
Densities are the same as the LMITCO mass balance except where values are shown in the SCM column.
Where values are shown in the SCM column, densities are taken from SCM and converted to lb/ft3..
The waste quantities are converted from lbs/hr to drums/hr.
Subsequent analysis is based on drums/shift of waste to a subsystem.
Pre-polymer drying assumes desorbed wastes that do not go through the leaching process (70% of output) will not need drying.

Table NT2-b. **Administration Subsystem**

Task	Subtask	FTEs needed	Samples/ Shift	Time Required (min)	Total Time/ Shift
Facility Management					
	Facility Manager	1			
	Secretary	1			
	Receptionist/word processor	1			
Operations Management					
	Department managers	2			
	Communications	1			
	Engineering Manager	1			
	Engineering staff	2			
	Maintenance Supervisor	1			
Personnel	Personnel Manager	1			
	Nurse/medical/industrial safety	1			
	Security guards at facility	4			
	Security at guard bldg	4			
Environmental	Environmental manager	1			
	Environmental clerk	1			
Shipping/Receiving/Traffic					
	Manager	1			
	Clerk	1			
Purchasing	Buyer	1			
Accounting	Cost Accounting	2			
	Accounting Clerk	1			
	Payroll Clerks	2			
Laboratory	Laboratory Manager	1			
	Lab Shift manager	4			
	Lab technicians for OSORT	4	11.3	30.0	339.2
	Lab technicians for internal processes	5	42.7	10.0	426.7
	Lab technicians for final waste form	3	10.2	30.0	307.0
	Lab technicians for incoming supplies	0.2	1.0	20.0	20.0
Health Physics					
	Shift health physics staff	4			
	Health physics manager	1			
	Total except Lab	35			
	Total Lab	17			
	Total Admin	52			

Table NT2-c. **Receiving and Preparation Subsystem**

Task	Subtask	Occurrence /Shift	Units for Occurrence	Time Required (min)	Total Time/ Shift	FTEs Needed	Add'l Time for Next Drum	Average Minutes/Shift /Drum
Receive Waste Truck	Truck docking	0.6	truck	30	17			
	Settle Paperwork	0.6	truck	120	68			
	Unload truck	0.6	truck	60	34			
	Stage pallets	0.6	truck	60	34			
	No of pallets/shift							
Total Task 1				270	153	0.3	0	153
Receive Empty Container Truck	Truck docking	0.3	truck	30	8			
	Settle Paperwork	0.3	truck	30	8			
	Unload truck	0.3	truck	60	17			
	Stage pallets	0.3	truck	20	6			
Total Task 2				140	40	0.1	0	40
Receive Supplies	Truck docking	0.2	truck	30	6			
	Settle Paperwork	0.2	truck	30	6			
	Unload truck	0.2	truck	60	12			
	Stage pallets	0.2	truck	20	4			
Total Task 3				140	28	0.1	0	28
Transfer to Interim Storage	Move pallets to storage area	6.2	Pallet	5	31			
	Stack pallets/ organize storage	6.2	Pallet	10	62			
	Transfer to assay	6.2	Pallet	5	31			
Total Task 4				20	124	0.3	10	10
Assay Drums	Stage pallets	12.4	Pallet	5	62			
	Load on conveyor	49.8	drum	1	50			
	Assay RTR	49.8	drum	15	746			
	Assay gamma	49.8	drum	60	2986			
	Assay PAN	49.8	drum	60	2986			
	Remove from conveyor	49.8	drum	1	50			
	Repalletize	49.8	drum	3	149			
	Stage pallets after assaying	12.4	Pallet	5	62			
Total Task 5				150	7091	14.8	60	150
Stage and Move to OSORT	Store solid waste by category	10.9	Pallet	10	109			
	Move to OSORT	10.9	Pallet	5	55			
	Stage at OSORT	10.9	Pallet	5	55			
Total Task 6			Pallet	20	218	0.5	5	20
Open Drums	Stage at drum opener	10.9	Pallet	5	55			
	Load on conveyor	43.6	Drums	5	218			
	Drum lid clamp	43.6	drum	2	87			
	Drum lid opener	43.6	drum	5	218			
	Lid staging	43.6	drum	1	44			
	Remove from conveyor	43.6	drum	1	44			
Total Task 7				19	589	1.2	5	19

Table NT2-c. **Receiving and Preparation Subsystem**

Task	Subtask	Occurrence /Shift	Units for Occurrence	Time Required (min)	Total Time/ Shift	FTEs Needed	Add'l Time for Next Drum	Average Minutes/Shift /Drum
Dump Drums	Assign drums to dump stations	43.6	drum	3	131			
	Move drums to sort table /bins	43.6	drum	5	218			
	Dump drums	43.6	drum	5	218			
Total Task 8				13	567	1.2	5	13
Sort Drums	Sort waste robotically	32.7	drum	30	982			
	Transfer waste to container	32.7	drum	15	491			
	Select destination for sorted waste	32.7	drum	3	98			
	Move container to subsystem bin or shredder	32.7	drum	3	98			
Total Task 9				51	1669	3.5	45	38
Glove Box Sort	Transfer to glove box (several trips)	7.1	drum	30	214			
	Sort waste by hand in glove box	7.1	drum	240	1711			
	sampling (1/drum)	7.1	drum	15	107			
	Transfer waste to containers	7.1	drum	60	428			
	Select destination for sorted waste	7.1	drum	15	107			
	Move containers to subsystem bin or shredder	7.1	drum	15	107			
Total Task 10				375	2673	5.6	315	5
Assess Debris for Debris Rule Compliance	Transfer soft, open and complex debris	35.0	drum	3	105			
	Screen debris	35.0	drum	4	140			
	Additional sampling (25%)	8.7	drum	10	87			
	Inspection	35.0	drum	5	175			
Total Task 11				22	507	1.1	5	6
Gross Size Reduction	Transfer to cutting table	14.3	drum	3	43			
	Cut waste	14.3	drum	30	429			
	Return to container	14.3	drum	5	72			
	Transfer to next process	14.3	drum	3	43			
Total Task 12				41	587	1.2	35	6
Shredding	Transfer to shredder	37.3	drum	2	75			
	Stage waste	37.3	drum	2	75			
	Feed waste to shredder	37.3	drum	2	75			
	Feed bad drums to shredder	21.8	drum	2	44			
	Shred stage 1	59.1	drum	2	118			
	Shred stage 2	59.1	drum	2	118			
	Sample size of waste	5.9	drum	5	30			
	Rework 10%	0.6	drum	15	9			
	Return to container	59.1	drum	3	177			

Table NT2-c. **Receiving and Preparation Subsystem**

Task	Subtask	Occurrence /Shift	Units for Occurrence	Time Required (min)	Total Time/ Shift	FTEs Needed	Add'l Time for Next Drum	Average Minutes/Shift /Drum
	Transfer to next process	59.1	drum	2	118			
Total Task 13				37	838	1.7	2	30
Sampling	Sample opened drums	4.4	drum	5	22			
	Sample sorted waste	5.9	drum	5	30			
	Resample (10%)	1.0	drum	5	5			
	Report/eval. results	11.3	drum	10	113			
Total Task 14				25	170	0.5	10	30
Subsystem Bin operation	Monitor bin height	4.4	drum	3	13			
	Fill containers	4.4	drum	3	13			
	Move containers	4.4	drum	2	9			
	Stage containers	4.4	drum	3	13			
	Organize campaigns	4.4	drum	15	65			
Total Task 15				26	113	0.3	0	26
Internal Transfer	Move waste from OSORT to other subsystems	4.4	drum	10	44			
	Move waste from subsystems to CSHIP	49.8	drum	10	498			
	Move treated waste to stabilization	80.0	drum	10	800			
	Move liquid waste to AQWTR and OrgDes	6.1	drum	10	61			
	Move waste to secondary treatment	20.0	drum	10	200			
	Move supplies around	20.0	drum	3	60			
	Move new drums	24.9	drum	3	75			
	Schedule movement	205.1	drum	1	205			
Total Task 16				57	1942	5.4	10	57
Box Breakdown	Stage boxes	10.0	box	2	20			
	Move to opening area	10.0	box	3	30			
	Open boxes	10.0	box	10	100			
	Transfer to dump	10.0	box	3	30			
Total Task 17				18	180	0.5	10	2
Container Decon	Stage containers	49.8	drum	5	249			
	Load conveyors	49.8	drum	5	249			
	Decon drums	49.8	drum	10	498			
	Assay drums	49.8	drum	15	746			
	Unload conveyers	49.8	drum	5	249			
	Stage drums	49.8	drum	5	249			
Total Task 18				45	2239	6.2	15	45

Table NT2-c. **Receiving and Preparation Subsystem**

Task	Subtask	Occurrence /Shift	Units for Occurrence	Time Required (min)	Total Time/ Shift	FTEs Needed	Add'l Time for Next Drum	Average Minutes/Shift /Drum
FTEs/shift					0	37.6		
Supervision	Ratio of 1:10					3.8		
Vac/sick/holiday relief	Assume 6 wks of absence					4.8		
Total/shift						46.1		
Adj for 70% Efficiency						65.9		
Total/day						197.7		676

Notes:

Assume FTEs are available for 8 hrs/day; because overall 70% efficiency is taken at the end.

Trucks carry 22 pallets. Truckloads received based on total inventory to shipping at 300 lb/drum (see separate truck calc sheet)

Pallets are assumed to hold 4-55 gallon drums

Assume 50% of drums are contaminated and can't be deconned.

Assume 50% of waste received requires interim storage (this will be dependent on assay system)

Assume 10% of incoming waste is sampled

Assume sorted waste is 75% of total; all of debris, no liq, no lead/merc/spec, 70% of residue and soil

Assume 10% of sorted waste is sampled

Assume gross size reduction is necessary for wastes to metal decon & lead

Assume gross size reduction is 1 hr per drum.

Assume shredding is necessary for waste to proc res, soil, soft debris(sorted or not)

0.75 =fraction of feed to RCPRP requiring shredding

Assume 10% of shredded waste is sampled.

Box breakdown includes time beyond that required if waste was packaged in drums

Assume glove box sorting required for 10% of open and complex debris, + all of special, mercury and lead

0.14 =fraction of feed to RCPRP requiring sorting

Assume glove box waste requires 1 sample/drum

Assume all debris must be assessed as none will be destroyed.

Assume liquids will arrive in drums and be transferred from receiving, and not go to the sorting cell

Assume transfer control for liquids takes the same time as for drums

Assume paperwork is accomplished within times shown

Average time per drum includes times for activities multiplied by the probability that the activity will occur.

Least time/drum/subsystem includes only the minimum requirements, no extra staging, sorting, or shredding

Max time/drum/subsystem includes all staging, shredding, glove box, etc

Table NT2-d CWO Organic Destruction Subsystem

Task	Subtask	Occurrence/ shift	Units	Time Required (min)	Total Time / Shift	FTEs Needed	Minutes/ First Drum	Minutes/ Add'l Drum
Receive Waste	Transfer through air lock	3.3	drum	5	16			
	Feed waste from drum	3.3	drum	3	10			
	Hook to transfer device	3.3	drum	3	10			
	Transfer to tank (10 gpm)	3.3	drum	6	18			
	Empty drum bottoms	3.3	drum	2	7			
	Detach & remove drum	3.3	drum	3	10			
	Sample feed vessel	3.3	drum	5	16			
	Arrange for transfer of secondary waste from other subsystems	1.5	drum	2	2			
Total Task				28	88	0.2	28	17
Feed waste to reactor	Startup Instrumentation and valve check	1.0		30	30			
	Meter waste to reactor (monitoring time)	24.0		10	240			
	Meter waste to reactor (300 lbs/hr)	4.7	drums	6	26			
Total Task				36	270	0.6	36	6
Operate Reactor	Instrumentation/Equip check	1.0	time	30	30			
	Time to react organics (min/drum) reaction rate: 797 lbs/hr	4.7	drums	34	162			
	Flow velocity (gpm)= drums/shift*55gal/drum /(480 min/shift)	0.5						
	Residence time (min)=Reactor volume/flow velocity: Reactor volume is 5% of 500 gal	46.2	minutes					
Total Task				64	192	0.4	64	34
Waste Transfer/ Recycle	Waste removed from tank (pump 500 gal @10 gpm)	9.1	drum	6	50			
	Filter solution	24.0	times	2	48			
	Sample filtrate	2.0	times	15	30			
	Recycle acids	24.0	times	2	48			
	Operate condenser	1.0	times	16	16			
	Wash solution	24.0	times	2	48			
	Sample	2.0	times	15	30			
	Transfer @ 10 gpm to filter	47.2	drums	6	260			
	Transfer @ 10 gpm from filter	47.2	drums	6	260			
Total Task				63	270	0.6	63	6
Treat inorganics	Transfer to neutralizer	24.0		2	48			
	Precipitate filtered solids	24.0		2	48			
	Filter precipitate	24.0		2	48			
	Transfer filtrate to Aq. Waste	24.0		2	48			
	Transfer precipitated solids to polymer	24.0		2	48			
	Collect sample	2.0		5	10			
Total Task				15	250	0.5	15	34

Table NT2-d **CWO Organic Destruction Subsystem**

Task	Subtask	Occurrence/ shift	Units	Time Required (min)	Total Time / Shift	FTEs Needed	Minutes/ First Drum	Minutes/ Add'l Drum
Receive Waste	Transfer through air lock	3.3	drum	5	16			
FTEs/shift						2.2	206	
Supervision	Ratio of 1:10					0.2		
Vac/sick/ holiday relief	Assume 6 wks of absence					0.3		
Adjustment for 70% Efficiency						0.8		
Total/shift						3.6		
Total/day						10.7		

Notes:

Total samples/shift 4.3
Assume sampling frequency = 10% of drums
From Blaine's mass balance, the feed to subsystem = 241 lbs/hr
Total feed is (drums/hr) = 0.6 (See Overall Table)
Assume continuous CWO process
Assume solids removal once/day
Waste transfer/recycle processes are continuous. Time is expected labor monitoring time

Table NT2-e. **Vacuum Thermal Desorption for Process Residue**

Task	Subtask	Occurrence /shift	Units	Time Required (min)	Total Time / Shift	FTEs Needed	Min/ Drum	Time/Add'l drum	Minimum (minutes/ shift)	Maximum (minutes/ shift)
Receive Waste	Transfer through air lock	65.8		5	329					
Receive Waste	Transfer through air lock	65.8		5	329					
	Stage drums for campaigns	65.8		2	132					
Total Task				7	460	0.96	7	2	7	7
Feed Waste from drum	Stage at feed bin (drums)	65.8		3	197					
	Hook to transfer device	65.8		3	197					
	Transfer into feed bin	65.8		5	329					
	Empty drum bottoms	65.8		2	132					
	Sample feed vessel	2.0		5	10					
	Detach & remove drum	65.8		3	197					
Total Task				16	733	1.53	16	5	16	16
Vacuum Thermal Desorption	Unit is number of batchs Batch is 15,000 lbs or	46.7		drums/ batch						
	Check equipment, instruments before startup	1.1		30	33					
	Charge desorber (15000 lbs/hr)	1.1		60	65					
	Heat desorber	1.1		60	65					
	Desorber batch	1.1		60	65					
	Cool desorber	1.1		30	33					
	Discharge desorbed waste	1.1		15	16					
Total Task				225	245	0.51	225	0	225	225
Monitor Offgas	Monitor cooler 1	24.0		1	24					
	Monitor condenser 1	24.0		1	24					
	Monitor condenser 2	24.0		1	24					
	Monitor transfer lines to APC	24.0		1	24					
Total Task				4	96	0.20	0	0	0	0
Condensate handling	Sample holding vessel from cond. 1	1.0	time	15	15					
	Sample holding vessel from condenser 2	1.0	time	15	15					
	Transfer to aqueous waste treatment	1.0	time	20	20					
	Transfer to mercury amalgamation	1.0	time	20	20					
Total Task				70	70	0.15			0	70
Separate desorbed waste	Sample waste	1.1	batch	5	5					
	Select destination	41.8	drums	1	42					
	Transfer waste to Hg leaching pr	12.5	drums	2	25					
	Transfer waste to polymer stabili	29.2	drums	2	58					
Total Task				10	131	0.27	10	8	10	10
Mercury cont. solids leaching	Process is sized for 1000 lbs/hr of waste or 25 drums/shift									
	Measure leaching agent	0.5	drums	20	9					
	Leach waste	0.5		90	41					
	Transfer to wash 1	0.5		20	9					
	Wash	0.5		60	28					
	Sample	0.5		15	7					
	Transfer to wash 2	0.5		20	9					
	Wash	0.5		60	28					
	Sample	0.5		15	7					
	Transfer to filter	0.5		20	9					
	Filter solids	0.5		30	14					
	Sample/evaluate	0.5		30	14					
	Transfer liquid to aqueous waste	0.5		10	5					
	Transfer solid to polymer	0.5		10	5					
Total Task				400	184	0.38	84	0		400

Table NT2-e. Vacuum Thermal Desorption for Process Residue

Task	Subtask	Occurrence /shift	Units	Time Required (min)	Total Time / Shift	FTEs Needed	Min/ Drum	Time/Add'l drum	Minimum (minutes/ shift)	Maximum (minutes/ shift)
Receive Waste	Transfer through air lock	65.8		5	329					
Leachate/ filtrate treatment										
	Transfer leachate to mercury reduction	0.5		20	9					
	Transfer rinse waste water to mercury reduction	0.5		20	9					
	Mercury reduction over steel wool	0.5		60	28					
	Sample	0.5		15	7					
	Transfer to mercury ppt	0.5		20	9					
	Sample	0.5		15	7					
	Add precipitation agents	0.5		15	7					
	Settle tank	0.5		60	28					
	Sample solids	0.5		15	7					
	Transfer solids to polymer	0.5		10	5					
	Transfer liquid to iodine recovery	0.5		10	5					
	Add chemicals (H2SO4, H2O2)	0.5		15	7					
	Reaction	0.5		30	14					
	Recover iodine	0.5		60	28					
	Transfer solids	0.5		20	9					
	Transfer liquid to wash 2	0.5		10	5					
Total Task				395	182	0.38	83	0		395
FTEs/shift					0	4.38	425	15	258	1123
Supervision	Ratio of 1:10					0.44				
Vac/sick/holiday relief	Assume 6 wks of absence					0.56				
Total/shift						5.37	425	15	258	1123
70% efficiency						7.68				
Total/day						23.03				

Notes:
Thermal Desorption Batch size of 15,000 lbs
Assume drum transfer of 15 min/drum or .5cu ft/min
Only 1.14 batches are required per shift based on feed to subsystem
The condenser/aqueous transfer monitoring functions will occur when the desorber is running
Number of drums following treatment is based on the 5/30 mass balance: 1020 lbs/hr in and 648 lbs/hr out
Assume 30% of the waste goes to mercury leaching process
Mercury leaching process was sized for 1000 lbs/hr of waste (@ 297 lbs/drum thisconverts to 25 drums/shift)
The weighted average of drum density was calculated to be 297 lbs/drum for this system.

Table NT2-f **Aqueous Waste Treatment Subsystem**

Task	Subtask	Occurrence / Shift		Time Required (min)	Total Time / Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Receive Waste	Transfer through air lock	1.4	drum	5	7			
	Feed waste from drum	1.4	drum	3	4			
	Hook to transfer device	1.4	drum	3	4			
	Transfer to tank (10 gpm)	1.4	drum	6	8			
	Empty drum bottoms	1.4		2	3			
	Sample feed vessel	2.0		10	20			
	Detach & remove drum	1.4		3	4			
	Sample waste from processes: CWO,Desorb, Decon,APC	4.0	N/A					
	Arrange for transfer	20.7	drum	2	31			
Total Task 1				33	81	0.17	33	5
Preliminary Treatment	Sample high TDS tank	11.2	drums	15	17			
	Sample low TDS tank	4.7	drums	15	7			
	Sample TOC waste	6.1	drums	15	9			
	Select treatment methods (10 drum batch)	10.8	drums	20	22			
	Transfer organic waste to oil water separator	6.2	drums	3	20			
	Filter high, low TDS and organic waste (say 10 gal/min)	22.1	drums	6	122			
	Neutralize/ppt high TDS waste	11.2	drums	11	124			
	Settle precipitated aqueous waste	11.2	drums	6	62			
	Evaporate solids	0.6	drums	6	3			
Total Task 2				90	382	0.80	90	20
UV oxidation	CaSO4 ppt (10 gpm)	22.1	drums	11	243			
	Centrifuge (10 gpm)	22.1	drums	11	243			
	sample waste	2.2	drums	15	33			
	Adjust UV oxidation (30 min/10 drums)	22.1	drums	3	66			
	Process through UV oxidation (50 gpm)	22.1	drums	1	24			
	Carbon filtration (10 gpm)	22.1	drums	6	122			
	Ion exchange (10 gpm)	22.1	drums	6	122			
	Sample waste before discharge	2.2		30				1
Total Task 3				52	853	1.78	52	
Total per shift						2.74	175	26
Supervision	Ratio of 1:10					0.27		
Vac/sick/ holiday relief	Assume 6 wks of absence					0.35		
70% efficiency						4.81		
Total per day						14.42		

Notes:

Assume high TDS waste comes from RCPRP, org destruction, soil treatment, debris treatment and metal decon.	640.50	lbs/hr	11	drums/shift
Assume waste from polymer, APC is low TDS	267.70	lbs/hr	5	drums/shift
Assume waste from process residue is organic liq	349.60	lbs/hr	6	drums/shift
Total drums per hour	22.1	drums/hr		

Assume tank batches are 550 gallons (10 drums)

Assume treatment selection time is required for 10 drum batches.

Assume residence time in oil water separator is 1 hour and tank is 1000 gallons (16 gpm)

Assume filtration, centrifuge and ppt rates are 10 gpm.

Assume solids to evaporator are 5% of incoming waste; assume drying rate is 10 gpm

Assume UV oxidation unit is 50 gpm

Table NT2-g Metal Decontamination Subsystem

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time / Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Metals Receiving/ Feed Prep	Transfer through air lock	15.8	drums	5	79			
Total Task				5	79	0.17	5	0
Waste Decon								
	Stage containers	15.8	drum	5	79			
	Decon waste	15.8	drum	10	158			
	Sssay for recycle	15.8	drum	30	475			
	Repack in drums	15.8	drum	15	238			
	Close drum lid	15.8	drum	15	238			
	Stage drums	15.8	drum	5	79			
	Monitor recirc filtration and fugitive dust system	24.0	times	6	144			
Total Task				86	1411	2.94	86	
Total FTEs/shift						3.11	91	
Supervision	Ratio of 1:10					0.31		
Vac/sick/ holiday relief	Assume 6 wks of absence					0.39		
Total/shift						3.81		
70% efficiency						5.44		
Total/day						16.33		

Notes:
Assume 50% of waste must be size reduced.
Assume 60 min/drum for cutting

Table NT2-h. Lead Recovery

Task	Subtask	Occurrence / Shift	Units	Time Required (min)	Total Time / Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Lead Receiving/ Feed Prep	Transfer through air lock	0.48	drums	5	2			
	Glove box separation of sheet lead and gloves	0.48	drums	60	29			
	Stage at decon	0.48	drums	10	5			
Total Task				75	36	0.08	75	
Waste Decon								
	Stage containers	0.48	drum	5	2			
	Decon waste	0.48	drum	10	5			
	Assay for recycle	0.48	drum	30	14			
	Repack in drums	0.48	drum	15	7			
	Close drum lid	0.48	drum	15	7			
	Stage drums	0.48	drum	5	2			
	Monitor recirc filtration and fugitive dust system	24.00	times	6	144			
Total Task				86	182	0.38	86	30
Total FTEs/shift						0.46	161	
Supervision	Ratio of 1:10					0.05		
Vac/sick/holiday relief	Assume 6 wks of absence					0.06		
Total/shift						0.56		
70% efficiency						0.80		
Total/day						2.39		

Notes:
Assume assay for all drums @ 30 min/drum

Table NT2-i. Mercury Amalgamation

Task	Subtask	Occurrence / Shift	Units	Time Required (min)	Total Time / Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Metals Receiving/ Feed Prep	Transfer through air lock	0.08	drums	5	0			
Metals Receiving/ Feed Prep	Transfer through air lock	0.08	drums	5	0			
	Transfer liq mercury to tank	0.06	drums	60	4			
	Transfer steel wool w/ Hg to holding bin	0.02	drums	10	0			
Total task				75	4	0.01	75	60
Mercury Amalgamation	Inspect equipment	1.00	time	30				
	Transfer liq mercury to amalgamater (1 gpm)	0.06	drum	55	3			
	Measure additives	0.08	drum	30	2			
	Transfer steel wool to amalgamater	0.08	drum	20	2			
	Batch amalgamation	0.08	drum	120	10			120
	Transfer out of amalgamater	0.08	drum	55	4			
	Stage	0.08	drum	5	0			
	Place at assay	0.08	drum	5	0			
	Assay	0.08	drum	20	2			
	Remove from assay	0.08	drum	2	0			
Total Task				312	24	0.05	312	120
Total FTEs/shift						0.06	387	
Supervision	Ratio of 1:10					0.01		
Vac/sick/holiday relief	Assume 6 wks of absence					0.01		
Total/shift						0.07		
70% efficiency						0.10		
Total/day						0.31		

Notes:

Volume of steel wool: assume 3x vol of steel to mercury

Assume 5% of mercury is in residue (this should be conservative; 5% of mercury is assumed to be in debris, not process residue)

Total volume of mercury in study is 82 lbs/hr.

Therefore volume of steel wool w/mercury =	0.50	lbs/hr
	0.02	drums/shift

Batch size for amalgamater: Assume 1 drum/batch, 2 hrs /batch

Table NT2-j Special Waste

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Minutes Add'l Drum
Special Receiving/Feed Prep	Transfer through air lock	5.44	drums	5	27.2			
	Glove box preparation of wastes	5.44	drums	60	326.4			
	Stage waste	5.44	drums	3	16.32			
Total Task				68	369.9	0.77	68	60
Waste Treatment	Stage containers	5.44	drum	3	16.32			
	Treat waste as special processes TBD	5.44	drum	60	326.4			
	Sample treated waste	5.44	drum	15	81.6			
	repack in drums	5.44	drum	30	163.2			
	Close drum lid	5.44	drum	3	16.32			
	Stage drums	5.44	drum	3	16.32			
Total Task				114	620.16	1.29	114	60
Total FTEs/shift						2.06	182	
Supervision	Ratio of 1:10					0.21		
Vac/sick/holiday relief	Assume 6 wks of absence					0.26		
Total/shift						2.53		
70% efficiency						3.62		
Total/day						10.85		

Notes:
Assume all waste is prepared in glove box
Assume waste is treated in various batch processes that average 2 hours/drum
TBD=To be determined

Table NT2-k. **Grout Stabilization Subsystem**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Waste Receiving/ Feed Prep	Transfer through air lock	28.6	drums	5	143			
	Sample waste	2.9	drums	15	43			
	Select process for waste	28.6	drums	5	143			
	Transfer to macroencapsulation	7.8	drums	2	16			
	Transfer to microencapsulation	20.8	drums	2	42			
	Stage at process	28.6	drums	2	57			
Total task				31	443	0.92	31	5
Waste Encapsulation	Measure binder	28.6	drum	5	143			
	Mix binder	28.6	drum	5	143			
	Combine with waste	28.6	drum	10	286			
	Repack in drums	28.6	drum	5	143			
	Close drum lid	28.6	drum	3	86			
	Stage pallets	28.6	drum	2	57			
	Monitor activated carbon and fugitive dust system	2.0	times	6	12			
Total Task				36	869	1.81	36	10
Binder setup time	Move pallets to curing area	28.6	drum	2	57			
	Curing time	28.6	drum		0			
	Sample	2.9	drum	15	43			
	Monitor curing process	28.6	drum	10	286			
	Move pallets from curing area	28.6	times	2	57			
Total Task				29	443	0.92	29	5
Drum Decon	Stage containers	2.9	drum	5	14			
	Load conveyors	2.9	drum	5	14			
	Decon drums	2.9	drum	10	29			
	Assay drums	2.9	drum	15	43			
	Unload conveyers	2.9	drum	5	14			
	Palletize drums	2.9	drum	2	6			
	Stage drums	2.9	drum	5	14			
Total Task				47	134	0.28	47	15
Total FTEs/shift						3.93	143	
Supervision	Ratio of 1:10					0.39		
Vac/sick/holiday relief	Assume 6 wks of absence					0.50		
Total/shift						4.83		
70% efficiency						6.90		
Total/day						20.69		

Notes:
Assume all complex debris (8 drums) will be sent to macroencapsulation, rest to micro.
Assume 10% of drums are deconned.
Assume 10% of drums are assayed
Assume mixing requires 30 min/drum
Number of samples = 2.9

Table NT2-I Polymer Stabilization Subsystem

Task	Subtask	Occurrence/ shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Waste Receiving/Feed Prep	Transfer through air lock	27.6	drums	5	138			
	Sample waste	2.8	drums	15	41			
	Evaluate dryness	2.8	drums	5	14			
	Dry waste	10.9	drums	30	N/A			
	Monitor drying	24.0	times	10	240			
	Stage at process	27.6	drums	2	55			
Total Task				57	488	1.02	57	30
Encapsulation	Measure polymer	27.6	drum	5	138			
	Mix polymer	27.6	drum	10	276			
	Combine with waste in extruder	27.6	drum	10	276			
	Repack in drums	24.0	drum	5	120			
	Close drum lid	27.6	drum	3	83			
	Palletize drums	27.6	drum	2	55			
	Stage drums	24.0	drum	2	48			
	Monitor activated carbon and fugitive dust system	8.0	times	6	48			
Total Task				43	1044	2.18	43	60
Binder setup time	Move pallets to curing area	24.0	drum	5	120			
	Curing time	24.0	drum		0			
	Sample	2.4	drum	15	36			
	Monitor curing	24.0	drum	10	240			
	Move pallets from curing area	24.0	times	5	120			
Total Task				35	516	1.08	35	5
Drum Decon	Stage containers	27.6	drum	5	138			
	Load conveyors	27.6	drum	5	138			
	Decon drums	27.6	drum	10	276			
	Assay drums	27.6	drum	15	414			
	Unload conveyers	27.6	drum	5	138			
	Stage drums	27.6	drum	5	138			
Total Task				45	1242	2.59	45	60
Total FTEs/shift						6.86	180	
Supervision	Ratio of 1:10					0.69		
Vac/sick/holiday relief	Assume 6 wks of absence					0.87		
Total/shift						8.41		
70% efficiency						12.02		
Total/day						36.05		

Notes:
Assume 30% of process residue waste and 100% of other waste requires drying
Assume dryer can accept waste at the rate of 2 drums/hour
No. of samples = 2.4

Table NT2-m. Air Pollution Control Subsystem

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time / Shift	FTEs Needed	Minutes/lb
Monitor Equipment	Dry filtration	4	times	10	40		
	HEPA filter	4	times	5	20		
	GPCR	24	times	2	48		
	Acid gas scrubber	12	times	10	120		
	Mist eliminator	4	times	2	8		
	GAC	4	times	2	8		
	Mersorb	4	times	2	8		
	Offgas monitor	24	times	5	120		
Total Task				38	372	0.78	0
Supervision	Ratio of 1:10					0.08	
Vac/sick/holiday relief	Assume 6 wks of absence					0.10	
Total/shift						0.95	
70% efficiency						1.36	
Total/day						4.08	

Table NT2-n. **Certification and Shipping**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Minutes Add'l Drum
Waste Receiving	Transfer through air lock	49.8	drums	5	249			
	Sample waste	5.0	drums	15	75			
	Resample waste	0.5	drums	15	7			
	Stage waste	49.8	drums	5	249			
Total Task				40	580	1.21	40	15
Waste Assay	Stage pallets	49.8	drum	3	149			
	Load on conveyor	49.8	drum	1	50			
	Assay RTR	49.8	drum	15	746			
	Assay gamma	49.8	drum	60	2986			
	Assay PAN	49.8	drum	60	2986			
	Remove from conveyor	49.8	drum	1	50			
	Repalletize	49.8	drum	3	149			
	Stage pallets after assaying	49.8	drum	15	746			
Total Task				158	7862	16.38	158	60
Stage waste	Stage uncertified waste	49.8	drum	3	149			
	Transfer waste	49.8	drum	3	149			
	Stage certified waste	49.8	drum	3	149			
	Transfer waste	49.8	drum	3	149			
Total Task				12	597	1.24	12	
Ship Waste Truck	Truck docking	0.6	truck	30	17			
	Settle Paperwork	0.6	truck	120	68			
	Load truck	0.6	truck	60	34			
	Truck leaving	0.6	truck	60	34			
Total Task				270	153	0.32	12	
Total FTEs/shift						19.15	222	
Supervision	Ratio of 1:10					1.91		
Vac/sick/holiday relief	Assume 6 wks of absence					2.43		
Total/shift						23.49		
Adjustment for 70% Efficiency						33.56		
Total/day						100.69		

Notes:
Assume 10% of waste require sampling
Samples collected = 5.0

Table NT2-o. Summary of FTEs & Time for a Single Drum to Pass Through a System

	Daily FTEs	Time (min)/ Single drum	Time (hrs)	Add'l Time for Next Drum	Time/ Drums Received in a Shift (minutes)	Time (hrs)
Admininstration	52.1	N/A				
Receiving /InspectionTasks common for all waste		802	13.4	60	3727.6	62
Receiving and Prep-CWO		0	0.0		0.0	0
Receiving and Prep-residue		229	3.8	45	1328.8	22
Receiving and Prep-soil		229	3.8	45	425.2	7
Receiving and Prep-debris		288.5	4.8	5	458.3	8
Receiving and Prep-lead		557	9.3	315	557.0	9
Receiving and Prep-mercury		516	8.6	315	516.0	9
Receiving and Prep-special		516	8.6	315	1914.6	32
Receiving and Prep-metal decon		229	3.8	35	554.4	9
Receiving and Prep	197.7	676.2	11.3			0
Aqueous Waste	14.4	175	2.9	36	934.3	16
Organic Destruction	10.7	206	3.4	34	333.5	6
Vacuum Thermal Desorption	23.0	425	7.1	26	1060.4	18
Metal Decon	16.3	91	1.5	75	1204.0	20
Lead	2.4	161	2.7	N/A	161.0	3
Mercury	0.3	387.0	6.5	N/A	387.0	6
Special	10.8	182.0	3.0	60.0	448.4	7
Grout	20.7	143	2.4	10	418.6	7
Polymer	36.0	180	3.0	60	1776.0	30
APC	4.1	372	6.2		372.0	6
Certification and Shipping	100.7	222	3.7	60	3147.6	52
Total	**489.4**					

Notes:

Allocation of receiving and preparation time was done as follows:

Average time per drum was estimated, multiplied by the number of drums per shift. The time for each waste type was allocated according its percentage of total waste.

b

System NT-3 Time and Motion Study Tables

Table NT3-a. **System NT-3: Time and Motion Analysis**

Subsystem	Mass Flow (lb/hr)	Waste Type	No. of Drums	SCM Unprocessed Density kg/m3	Density lb/ft3	Density lb/drum
Administration	2,927					
Receiving and preparation	2,927	all	6.2		64.0	470.6
Aqueous waste treatment	1,632	L1100	3.6		62.0	455.9
Organic destruction	326	L2110	0.7		62.0	455.9
Process residue and inorganic sludge treatment	1,020	S3120	3.2	700	43.7	321.2
Bulk soil treatment	329	S4100	0.7		67.0	492.6
Soft Debris treatment	435	S5300	3.0	320	20.0	146.8
Open Debris treatment	80	S5110	0.4	400	25.0	183.5
Complex Debris treatment	177	S5110	1.0	400	25.0	183.5
Metal decontamination	462	S5110	2.0	509	31.8	233.5
Mercury amalgamation	3	X7100	0.003	2000	124.8	917.6
Lead recovery	26	X7200	0.0	2000	124.8	917.6
Polymer stabilization	1,246	S3120	3.9	700	43.7	321.2
Air pollution control	827		N/A			
Grout stabilization	958	soil/debris	2.8	750	46.8	344.1
Special treatment	155	X6000,X7500	0.7	500	31.2	229.4
Certification and shipping	4,919	Z000	6.2	N/A	107.9	793.4
vol reduction (out/in)	0.60		1.0			

Notes:
This table provides the basis for the time and motion analysis.
Quantities of waste to a subsystem (lbs/hr) are based on LMITCO mass balance.
Densities are the same as the LMITCO mass balance except where values are shown in the SCM column.
Where values are shown in the SCM column, densities are taken from SCM and converted to lb/cu ft
The waste quantities are converted from lbs/hr to drums/hr.
Subsequent analysis is based on drums/shift of waste to a subsystem.
Waste to CSHIP includes recyclable metals and treated solid waste ready for disposal.

Table NT3-b. **Administration Subsystem**

Task	Subtask	FTEs Needed	Samples/ Shift	Time Required (min)	Total Time / Shift
Facility Management					
	Facility Manager	1			
	Secretary	1			
	Receptionist/word processor	1			
Operations Management					
	Department managers	2			
	Communications	1			
	Engineering Manager	1			
	Engineering staff	2			
	Maintenance Supervisor	1			
Personnel	Personnel Manager	1			
	Nurse/medical/industrial safety	1			
	Security guards at facility	4			
	Security at guard bldg	4			
Environmental	Environmental manager	1			
	Environmental clerk	1			
Shipping/receiving/Traffic					
	Manager	1			
	Clerk	1			
Purchasing	Buyer	1			
Accounting	Cost Accounting	2			
	Accounting Clerk	1			
	Payroll Clerks	2			
Laboratory	Laboratory Manager	1			
	Lab Shift manager	4			
	Lab technicians for OSORT	4	11.1	30.0	334.0
	Lab technicians for internal processes	10	89.5	10.0	895.5
	Lab technicians for final waste form	3	10.3	30.0	308.6
	Lab technicians for incoming supplies	0.2	1.0	20.0	20.0
Health Physics					
	Shift health physics staff	4			
	Health physics manager	1			
	Total except Lab	35			
	Total Lab	22			
	Total Admin	57			

Table NT3-c. **Receiving and Preparation Subsystem**

Task	Subtask	Occurrence / Shift	Units for Occurrence	Time Required (min)	Total Time / Shift	FTEs Needed	Add'l Time for Next Drum	Average Minutes/ Shift/ Drum
Receive Waste Truck	Truck docking	0.6	truck	30	17			
	Settle Paperwork	0.6	truck	120	68			
	Unload truck	0.6	truck	60	34			
	Stage pallets	0.6	truck	60	34			
	No of pallets/shift							
Total Task 1				270	153	0.32	0	153
Receive Empty container Truck	Truck docking	0.3	truck	30	8			
	Settle Paperwork	0.3	truck	30	8			
	Unload truck	0.3	truck	60	17			
	Stage pallets	0.3	truck	20	6			
Total Task 2				140	40	0.08	0	40
Receive supplies	Truck docking	0.2	truck	30	6			
	Settle Paperwork	0.2	truck	30	6			
	Unload truck	0.2	truck	60	12			
	Stage pallets	0.2	truck	20	4			
Total Task 3				140	28	0.06	0	28
Transfer to Interim Storage	Move pallets to storage area	6.2	Pallet	5	31			
	Stack pallets/ organize storage	6.2	Pallet	10	62			
	Transfer to assay	6.2	Pallet	5	31			
Total Task 4				20	124	0.26	10	10
Assay Drums	Stage pallets	12.4	Pallet	5	62			
	Load on conveyor	49.8	drum	1	50			
	Assay RTR	49.8	drum	15	746			
	Assay gamma	49.8	drum	60	2986			
	Assay PAN	49.8	drum	60	2986			
	Remove from conveyor	49.8	drum	1	50			
	Repalletize	49.8	drum	3	149			
	Stage pallets after assaying	12.4	Pallet	5	62			
Total Task 5				150	7091	14.77	60	150
Stage and move to OSORT	Store solid waste by category	10.6	Pallet	10	106			
	Move to OSORT	10.6	Pallet	5	53			
	Stage at OSORT	10.6	Pallet	5	53			
Total Task 6			Pallet	20	213	0.44	5	17
Open Drums	Stage at drum opener	10.6	Pallet	5	53			
	Load on conveyor	42.6	Drums	5	213			
	Drum lid clamp	42.6	drum	2	85			
	Drum lid opener	42.6	drum	5	213			
	Lid staging	42.6	drum	1	43			
	Remove from conveyor	42.6	drum	1	43			
Total Task 7				19	575	1.20	5	16
Dump Drums	Assign drums to dump stations	42.6	drum	3	128			
	Move drums to sort table /bins	42.6	drum	5	213			
	Dump drums	42.6	drum	5	213			
Total Task 8				13	554	1.15	5	11

Table NT3-c. Receiving and Preparation Subsystem

Task	Subtask	Occurrence / Shift	Units for Occurrence	Time Required (min)	Total Time / Shift	FTEs Needed	Add'l Time for Next Drum	Average Minutes/ Shift/ Drum
Sort Drums	Sort waste robotically	31.9	drum	30	958			
	Transfer waste to container	31.9	drum	15	479			
	select destination for sorted waste	31.9	drum	3	96			
	Move container to subsystem bin or shredder	31.9	drum	3	96			
Total Task 9				51	1629	3.39	45	38
Glove Box Sort	Transfer to glove box (several trips)	6.8	drum	30	205			
	Sort waste by hand in glove box	6.8	drum	240	1639			
	Sampling (1/drum)	6.8	drum	15	102			
	Transfer waste to containers	6.8	drum	60	410			
	Select destination for sorted waste	6.8	drum	15	102			
	Move containers to subsystem bin or shredder	6.8	drum	15	102			
Total Task 10				375	2562	5.34	315	5
Assess Debris for Debris Rule Compliance	Transfer open and complex debris	35.0	drum	3	105			
	Screen debris	35.0	drum	4	140			
	Additional sampling (25%)	8.7	drum	10	87			
	Inspection	35.0	drum	5	175			
Total Task 11				22	507	1.06	5	6
Gross Size Reduction	Transfer to cutting table	13.8	drum	3	41			
	Cut waste	13.8	drum	30	413			
	Return to container	13.8	drum	5	69			
	Transfer to next process	13.8	drum	3	41			
Total Task 12				41	564	1.18	35	6
Shredding	Transfer to shredder	37.3	drum	2	75			
	Stage waste	37.3	drum	2	75			
	Feed waste to shredder	37.3	drum	2	75			
	Feed bad drums to shredder	21.3	drum	2	43			
	Shred stage 1	58.6	drum	2	117			
	Shred stage 2	58.6	drum	2	117			
	Sample size of waste	5.9	drum	5	29			
	Rework 10%	0.6	drum	15	9			
	Return to container	58.6	drum	3	176			
	Transfer to next process	58.6	drum	2	117			
Total Task 13				37	832	1.73	2	30

Table NT3-c. Receiving and Preparation Subsystem

Task	Subtask	Occurrence / Shift	Units for Occurrence	Time Required (min)	Total Time / Shift	FTEs Needed	Add'l Time for Next Drum	Average Minutes/ Shift/ Drum
Sampling	Sample opened drums	4.3	drum	5	21			
	Sample sorted waste	5.9	drum	5	29			
	Resample (10%)	1.0	drum	5	5			
	Report/eval. results	11.1	drum	10	111			
Total Task 14				25	167	0.46	10	30
Subsystem Bin operation	Monitor bin height	4.3	drum	3	13			
	Fill containers	4.3	drum	3	13			
	Move containers	4.3	drum	2	9			
	Stage containers	4.3	drum	3	13			
	Organize campaigns	4.3	drum	15	64			
Total Task 15				26	111	0.31	0	26
Internal Transfer	Move waste from OSORT to other subsystems	4.3	drum	10	43			
	Move waste from subsystems to CSHIP	49.6	drum	10	496			
	Move treated waste to stabilization	80.0	drum	10	800			
	Move liquid waste to AQWTR and OrgDes	7.2	drum	10	72			
	Move waste to secondary treatment	20.0	drum	10	200			
	Move supplies around	20.0	drum	3	60			
	Move new drums	24.9	drum	3	75			
	Schedule movement	205.9	drum	1	206			
Total Task 16				57	1951	5.42	10	57
Box Breakdown	Stage boxes	10.0	box	2	20			
	Move to opening area	10.0	box	3	30			
	Open boxes	10.0	box	10	100			
	Transfer to dump	10.0	box	3	30			
Total Task 17				18	180	0.50	10	2
Container Decon	Stage containers	49.8	drum	5	249			
	Load conveyors	49.8	drum	5	249			
	Decon drums	49.8	drum	10	498			
	Assay drums	49.8	drum	15	746			
	Unload conveyers	49.8	drum	5	249			
	Stage drums	49.8	drum	5	249			
Total Task 18				45	2239	6.22	15	45

Table NT3-c. Receiving and Preparation Subsystem

Task	Subtask	Occurrence / Shift	Units for Occurrence	Time Required (min)	Total Time / Shift	FTEs Needed	Add'l Time for Next Drum	Average Minutes/ Shift/ Drum
FTEs/shift					0	35.78		
Supervision	Ratio of 1:10					3.58		
Vac/sick/holiday relief	Assume 6 wks of absence					4.54		
Break relief (included in 6 hr day)	One person can relieve 3 (accounted for in efficiency)							
Total/shift						43.9		
Adj for 70% Efficiency						62.7		
Total/day						188.2		669

Notes:

Assume FTEs are available for 8 hrs/day; because overall 70% efficiency is taken at the end.

Trucks have 22 pallets. Truckloads received based on total inventory to shipping at 300 lb/drum (see separate truck calc sheet)

Pallets are assumed to hold 4 55 gallon drums

As in inventory, assume 50% of drums are contaminated and can't be deconned.

Assume 50% of waste received requires interim storage; this will be dependent on assay system

Assume 10% of incoming waste is sampled

Assume sorted waste is 75% of total; all of debris, no liq, no lead/merc/spec, 70% of residue and soil

Assume 10% of sorted waste is sampled

Assume gross size reduction is necessary for wastes to metal decon & lead

Assume gross size reduction is 1 hr per drum.

Assume shredding is necessary for waste to proc res, soil, soft debris(sorted or not)

0.75= fraction of feed to Receiving and Prep requiring shredding

Assume 10% of shredded waste is sampled.

Box breakdown includes time beyond that required if waste was packaged in drums

Assume glove box sorting required for 10% of open and complex debris, + all of special, mercury and lead

0.14 =fraction of feed to RCPRP requiring sorting

Assume glove box waste requires 1 sample/drum

Assume only complex and open debris require assessment, because open debris goes to CWO.

Assume liquids will arrive in drums and be transferred from receiving, and not go to the sorting cell

Assume transfer control for liquids takes the same time as for drums

Assume paperwork is accomplished within times shown

Average time per drum includes times for activities multiplied by the probability that the activity will occur.

Least time/drum/subsystem includes only the minimum requirements, no extra staging, sorting, or shredding

Max time/drum/subsystem includes all staging, shredding, glove box, etc

Table NT3-d. **MEO Organic Destruction Subsystem**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time / Shift	FTEs Needed	Minutes/ First drum	Minutes/ Add'l Drum
Receive Waste	Transfer through air lock	3	drum	5	16			
	Feed waste from drum	3	drum	3	10			
	Hook to transfer device	3	drum	3	10			
	Transfer to tank (10 gpm)	3	drum	6	18			
	Empty drum bottoms	3	drum	2	7			
	Detach & remove drum	3	drum	3	10			
	Sample feed vessel	3	drum	5	16			
	Arrange for transfer of secondary waste from other subsystems	3	drum	2	4			
Total Task				28	90	0.19	28	17
Feed Waste	Sample waste in tank	2	times	15	30			
					0			
	Screen and transfer waste (5 gpm) to primary reactor	6	drums	11	63			
	Meter waste to reactor (monitoring time)	24		3	72			
	Meter waste to reactor (300 lbs/hr)	6	drums	6	32			
Total Task				17	135	0.28	17	6
Operate MEO Reactor	Time to react organics (min/drum) reaction rate: 50kg/day/unit*42 MEO units	6	drum	142	818			
	Reaction rate 192 lbs/hr	6	drums					
	Monitor pumps and manifold	24	times/shift	5	120			
	Monitor MEO cells	24	times/shift	5	120			
	Monitor and adjust electrolyte concentration	24	times/shift	5	120			
	Monitor and adjust turbo-aerator for nitrous acid conversion	24	times/shift	5	120			
	Monitor and adjust oxygen input to aerator	24	times/shift	5	120			
	Collect samples	16	times/shift	15	240			
	Monitor primary reactor and catholyte reactor	24	times/shift	5	120			
Total Task				142	960	2.00	142	
Silver Recovery	Monitor and adjust blowdown from anolyte stream	24	times	5	120			
	Nonitor and adjust blowdown from catholyte stream	24	times	5	120			
	Sample blowdown (anolyte and catholyte	4	times	15	60			
	Monitor precipitation of silver nitrate	24	times	2	48			
	Monitor centrifuge	24	times	5	120			
	Transfer silver chloride	24	times	2	48			
	Precipitate silver	24	times	5	120			
	Separate silver	24	times	5	120			
	React silver to silver nitrate	24	times	5	120			
	Transfer AgNO3 to primary reactor	24	times	2	48			
	Transfer salts to Aq Waste	24	times	2	48			
	Sample precipator, reactor	4	times	15	60			
Total Task				68	1032	2.15	68	6

Table NT3-d. **MEO Organic Destruction Subsystem**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time / Shift	FTEs Needed	Minutes/ First drum	Minutes/ Add'l Drum
Acid Recovery	Transfer blowdown to evaporator	24	times	2	48			
	Monitor evaporator	24	times	5	120			
	Transfer to filtration or fractionater	24	times	2	48			
	Monitor fractionater	24	times	5	120			
	Monitor condenser	8	times	2	16			
	Filter solution	24	times	2	48			
	Sample filtrate	2	times	15	30			
	Sample recycle acids	8	times	15	120			
Total Task				32	198	0.41	32	6
Offgas	Monitor anolyte offgas transfer	24	times	2	48			
	Monitor catholyte offgas	24	times	2	48			
	Monitor and adjust NOx removal	24	times	2	48			
Total Task				6	144	0.30	6	0
FTEs/shift						5.33	293	17
Supervision	Ratio of 1:10					0.53		
Vac/sick/holiday relief	Assume 6 wks of absence					0.68		
	Adjust for 70% Efficiency					1.96		
Total/shift						8.50		
Total/day						25.51		

Notes:
Assume sampling frequency = 10% of drums
From Blaines mass balance, the feed to subsystem is 241 lbs/hr
Total feed = 1 Drum/hr See overall table
Assume continuous CWO process
Assume solids removal once/day
Waste transfer/recycle processes are continuous. Time is expected labor monitoring time
Assume drums of liquid transferred from Rec and Prep
Assume paperwork is accomplished within times shown
Total samples/shift = 33

Table NT3-e. **Aqueous Waste Treatment Subsystem**

Task	Subtask	Occurrence/ Shift	Unit	Time Required (min)	Total Time / Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Receive Waste	Transfer through air lock	1	drum	5	7			
	Feed waste from drum	1	drum	3	4			
	Hook to transfer device	1	drum	3	4			
	Transfer to tank (10 gpm)	1	drum	6	8			
	Empty drum bottoms	1		2	3			
	Sample feed vessel	2		10	20			
	Detach & remove drum	1		3	4			
	Sample waste from processes: CWO,Desorb, Decon,APC	4	N/A					
	Arrange for transfer	27	drum	2	41			
Total Task 1				33	91	0.19	33	5
Preliminary Treatment	Sample high TDS tank	1	drums	15	2			
	Sample low TDS tank	7	drums	15	10			
	Sample TOC waste		drums	15				
	Select treatment methods (10 drum batch)	7	drums	20	13			
	Transfer organic waste to oil water separator		drums	3				
	Filter high, low TDS and organic waste (say 10 gal/min)	8	drums	6	42			
	Neutralize/ppt high TDS waste	1	drums	11	13			
	Settle precipitated aqueous waste	1	drums	6	6			
	Evaporate solids	0	drums	6	0			
Total Task				90	86	0.18	90	20
UV oxidation	CaSO4 ppt (10 gpm)	8	drums	11	84			
	Centrifuge (10 gpm)	8	drums	11	84			
	Sample waste	1	drums	15	12			
	Adjust UV oxidation (30 min/10 drums)	8	drums	3	23			
	Process through UV oxidation (50 gpm)	8	drums	1	8			
	Carbon filtration (10 gpm)	8	drums	6	42			
	Ion exchange (10 gpm)	8	drums	6	42			
	Sample waste before discharge	1		30				1
Total Task 3				52	296	0.62	52	
Total per shift						0.99	175	
Supervision	Ratio of 1:10					0.10		
Vac/sick/holiday relief	Assume 6 wks of absence					0.13		
70% efficiency						1.73		
Total per day						5.18		1170

Notes:

Assume high TDS waste comes from RCPRP, org destruction, debris treatment, and metal decon.		lbs/hr	1	drums/shift
Assume waste from polymer, APC is low TDS	1233.10	lbs/hr	21	drums/shift
Assume waste from process residue and soil is organic liquid	371.70	lbs/hr	7	drums/shift

Total drums per hour= 29

Assume tank batches are 550 gallons (10 drums)

Assume treatment selection time is required for 10 drum batches.

Assume residence time in oil water separator is 1 hour and tank is 1000 gallons (16 gpm)

Assume filtration, centrifuge and ppt rates are 10 gpm.

Assume solids to evaporator are 5% of incoming waste; assume drying rate is 10 gpm

Assume UV oxidation unit is 50 gpm

Number of samples per shift =

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Table NT3-f. **Aqueous Wash for Soil and Process Residue**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time / Shift	FTEs Needed	Minutes/ First drum	Minutes/ Add'l Drum
Soil Receiving	Transfer through air lock	31	drums	5	154			
Total Task				5	154	0.3	5	5
Feed Waste from drum	Stage at feed bin (drums)	31	drums	3	92			
	Hook to transfer device	31	drums	3	92			
	Transfer into feed bin (metering screw)	31	drums	5	154			
	Feed screw monitoring time		drums					
	Empty drum bottoms	31	drums	2	62			
	Sample feed vessel	2	drums	5	10			
	Detach & remove drum	31	drums	3	92			
Total Task				16	503	1.0	16	16
Wash Water Prep	Sample wash water	3	drums	5	15			
	Adjust Water Volume	3	drums	10	31			
	Adjust surfactant	3	drums	10	31			
Total Task				25	77	0.2	25	
Washing Process	Add waste to tank (5000 lbs/hr)	92	drums	4	356			
	Wash waste (4000 lbs/hr)	92	drums	5	N/A			
	Transfer waste and water from tank (35 gpm)	462	drums	2	726			
	Monitor tank	24	times	5	120			
Total Task				6	120	0.3	6	5
Pre-rinse and Rinse	Screening (35 gpm) (most of water leaves process here)	462	drums	2	726			
	Hydrocyclone (2@35 gpm)	185	drums	1	145			
	transfer to rinse contactor	185	drums	1	145			
	Rinse contactor (5000 gal); 6:1 water to soil/residue; 9000 lbs/hr	185	drums	2	396			
	Transfer to dryer (2x vol of soil)	185	drums	1	145			
	Drying @ 35 gpm	185	drums	2	290			
	Monitor operations	24	times	5	120			
	Collect samples	16	times	5	80			
Total Task				6	200	0.4	6	2

Table NT3-f. Aqueous Wash for Soil and Process Residue

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time / Shift	FTEs Needed	Minutes/ First drum	Minutes/ Add'l Drum
Recycle Processes	These are all monitoring times				0			
	Solubility Reduction	8.0	times	5	40			
	Additive Adjustment	8.0	times	5	40			
	Transfer to Wash Tank	16.0	times	2	32			
	Transfer to Ultrafiltration	8.0	times	2	16			
	Ultrafiltration	24.0	times	5	120			
	Dissolved Air Flotation	8.0	times	5	40			
	Surfactant Separation	24.0	times	5	120			
	Additive Adjustment	8.0	times	5	40			
	Steam stripping	8.0	times	5	40			
	Transfer recycled surfactant	8.0	times	5	40			
	Transfer waste to organic destruction	8.0	times	5	40			
	Transfer metals to polymer	8.0	times	5	40			
	Collect samples	24.0	times	5	120			
Total Task				59	728	1.5	59	
Total FTEs/day= FTEs per shift						3.7		
Supervision	Ratio of 1:10					0.4	117	2
Vac/sick/holiday relief	Assume 6 wks of absence					0.5		
Total/shift						4.6		
70% efficiency						6.5		
Total/day						6.5		

Notes:
Sample wash water every 10 drums
Assume drum transfer of 15 min/drum or .5 cu ft/min
System designed for 1 shift not 3
Residence time in wash tank based on 4x wt of water to feed
Wash tank is 3000 gal .
Assume transfer rates are 10 gpm; this includes both waste and rinse or wash water
Waste to screening includes water in tank (4x input volume)
Waste to rinse contactor and hydrocyclone assumes 1:1 soil to water (2x input volume)
Rinse tank has 5000 gallons of water and soil (size is 6000 gal)
Drying: assume 1 hr drying time,2000 lbs/hr (6 drums/hr)
For purposes of processing time, recycle is not included, as these are not soil treatment
Samples collected per shift= 45

Table NT3-g. High Pressure Wash for Open Debris

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time / Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Debris Receiving	Transfer through air lock	35	drums	5	175			
	Stage drums for campaigns	35	drums	15	524			
Total Task				20	699	1.5	20	15
Feed Waste from bin	Stage at feed bin (drums)	35	drums	3	105			
	Hook to transfer device	35	drums	3	105			
	Transfer into feed bin (metering screw)	35	drums	15	524			
	Empty drum bottoms	35	drums	2	70			
	Sample feed vessel	3	drums	10	35			
	Detach & remove drum	35	drums	3	105			
Total Task				36	944	2.0	36	23
Wash Water Prep	Sample wash water	3	drums	5	17			
	Adjust Water Volume	3	drums	10	35			
	Adjust surfactant	3	drums	10	35			
Total Task				25	87	0.2	25	
Washing Process	Check out Equipment	1	times	30	30			
	Add waste to tank	35	drums	15	524			15
See notes; based on 16 drum batch	Wash/ rinse waste	35	drums	17	N/A			
	Transfer water from tank	35	drums	28	961			
	Monitor tank	24	times	5	120			
	Collect Samples	3	times	5	15			
Total Task				94	1636	3.4	94	
Total per shift						7.0	175	
Supervision	Ratio of 1:10					0.7		
Vac/sick/holiday relief	Assume 6 wks of absence					0.9		
Total/shift						8.6		
70% efficiency						12.3		
Total/day						36.9		
Total FTEs						36.9		

Notes:

Sample wash water every 10 drums

Assume drum transfer of 15 min/drum or .5cu ft/min

Batch size is 1 to 2 tons; say 3000 lbs or 16 drums

Residence time in wash tank based on 3 stages, 90 minutes each

Assume transfer rates are 10 gpm; this includes both waste and rinse or wash water

Assume water volume is roughly 5x waste volume

Table NT3-h. Metal Decontamination Subsystem

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time / Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Metals Receiving/ Feed Prep	Transfer through air lock	16	drums	5	79			
Total Task				5	79	0	5	0
Waste Decon	Stage containers	16	drum	5	79			
	Decon waste	16	drum	10	158			
	Assay for recycle	16	drum	30	475			
	Repack in drums	16	drum	15	238			
	Close drum lid	16	drum	15	238			
	Stage drums	16	drum	5	79			
	Monitor recirc filtration and fugitive dust system	24	times	6	144			
Total Task				86	1411	3	86	
Total FTEs/shift						3	91	
Supervision	Ratio of 1:10					0		
Vac/sick/holiday relief	Assume 6 wks of absence					0		
Total/shift						4		
70% efficiency						5		
Total/day						16		

Notes: Assume 50% of waste must be size reduced. (need basis for this)
Assume 60 min/drum for cutting

Table NT3-i Lead Recovery

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Lead Receiving/Feed Prep	Transfer through air lock	0.24	drums	5	1			
	Glove box separation of sheet lead and gloves	0.24	drums	60	14			
	Stage at decon	0.24	drums	10	2			
Total Task				75	18	0	75	
Waste Decon	Stage containers	0.24	drum	5	1			
	Decon waste	0.24	drum	10	2			
	Assay for recycle	0.24	drum	30	7			
	Repack in drums	0.24	drum	15	4			
	Close drum lid	0.24	drum	15	4			
	Stage drums	0.24	drum	5	1			
	Monitor recirc filtration and fugitive dust system	24.00	times	6	144			
Total Task				86	163	0	86	30
Total FTEs/shift						0	161	
Supervision	Ratio of 1:10					0		
Vac/sick/holiday relief	Assume 6 wks of absence					0		
Total/shift						0		
70% efficiency						1		
Total/day						2		

Notes: Assume assay for all drums @ 30 min/drum

Table NT3-j. Mercury Amalgamation

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Metals Receiving/ Feed Prep	Transfer through air lock	0.02	drums	5.0	0.1			
	Transfer liq mercury to tank	0.02	drums	60.0	1.3			
Total Task				65.0	1.4	0.0	65.0	60.0
Mercury Amalgamation	Inspect equipment	1.00	time	30.0				
	Transfer liq mercury to amalgamater (1 gpm)	0.02	drum	55.0	1.2			
	Measure additives	0.02	drum	30.0	0.7			
	Batch amalgamation	0.02	drum	120.0	2.6			120.0
	Transfer out of amalgamater	0.02	drum	55.0	1.2			
	Stage	0.02	drum	5.0	0.1			
	Place at assay	0.02	drum	5.0	0.1			
	Assay	0.02	drum	20.0	0.4			
	Remove from assay	0.02	drum	2.0	0.0			
Total Task				292.0	6.4	0.0	292.0	120.0
Total FTEs/shift						0.0	357.0	
Supervision	Ratio of 1:10					0.0		
Vac/sick/holiday relief	Assume 6 wks of absence					0.0		
Total/shift						0.0		
70% efficiency						0.0		
Total/day						0.1		

Notes:
Batch size for amalgamater: Assume 1 drum/batch, 2 hrs /batch

Table NT3-k. Special Waste

Task	Subtask	Occurrence / Shift	Units	Time Required (min)	Total Time / Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Special Receiving/Feed Prep	Transfer through air lock	5.4	drums	5.0	27.2			
	Glove box preparation of wastes	5.4	drums	60.0	326.4			
	Stage waste	5.4	drums	3.0	16.3			
Total Task				68.0	369.9	0.8	68.0	60.0
Waste Treatment	Stage containers	5.4	drum	3	16.3			
	Treat waste as special processes TBD	5.4	drum	60	326.4			
	Sample treated waste	5.4	drum	15	81.6			
	Repack in drums	5.4	drum	30	163.2			
	Close drum lid	5.4	drum	3	16.3			
	Stage drums	5.4	drum	3	16.3			
Total Task				114.0	620.2	1.3	114.0	60.0
Total FTEs/shift						2.1	182.0	
Supervision	Ratio of 1:10					0.2		
Vac/sick/holiday relief	Assume 6 wks of absence					0.3		
Total/shift						2.5		
70% efficiency						3.6		
Total/day						10.8		

Notes:
Assume all waste is prepared in glove box
Assume waste is treated in various batch processes that average 2 hours/drum
TBD=To be determined

Table NT3-I. Grout Stabilization Subsystem

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time / Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Waste Receiving/ Feed Prep	Transfer through air lock	22	drums	5	111			
	Sample waste	2	drums	15	33			
	Select process for waste	22	drums	5	111			
	Transfer to macroencapsulation	8	drums	2	16			
	Transfer to microencapsulation	14	drums	2	29			
	Stage at process	22	drums	2	44			
Total Task				31	345	0.7	31	5
Waste Encapsulation	Measure binder	22	drum	5	111			
	Mix binder	22	drum	5	111			
	Combine with waste	22	drum	10	222			
	Repack in drums	22	drum	5	111			
	Close drum lid	22	drum	3	67			
	Stage pallets	22	drum	2	44			
	Monitor activated carbon and fugitive dust system	2	times	6	12			
Total Task				36	679	1.4	36	10
Binder setup time	Move pallets to curing area	22	drum	2	44			
	Curing time	22	drum		0			
	Samples	2	times	15	33			
	Monitor curing process	22	drum	10	222			
	Move pallets from curing area	22	times	2	44			
Total Task				29	345	0.7	29	5
Drum Decon	Stage containers	2	drum	5	11			
	Load conveyors	2	drum	5	11			
	Decon drums	2	drum	10	22			
	Assay drums	2	drum	15	33			
	Unload conveyers	2	drum	5	11			
	Palletize drums	2	drum	2	4			
	Stage drums	2	drum	5	11			
Total Task				47	105	0.2	47	15
Total FTEs/shift						3	143	
Supervision	Ratio of 1:10					0		
Vac/sick/holiday relief	Assume 6 wks of absence					0		
Total/shift						4		
70% efficiency						5		
Total/day						16		

Notes:

Assume all complex debris (8 drums) will be sent to macroencapsulation, rest to micro.

Assume 10% of drums are deconned.

Assume 10% of drums are assayed

Assume mixing requires 30 min/drum

No. of samples= 2

Table NT3-m. **Polymer Stabilization Subsystem**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time / Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Waste Receiving/Feed Prep	Transfer through air lock	31	drums	5	155			
	Sample waste	3	drums	15	47			
	Evaluate dryness	3	drums	5	16			
	Dry waste	31	drums	30	N/A			
	Monitor drying	24	times	10	240			
	Stage dried waste at process	31	drums	2	62			
Total Task				57	519	1	57	30
Encapsulation	Measure polymer	31	drum	5	155			
	Mix polymer	31	drum	10	310			
	Combine with waste in extruder	31	drum	10	310			
	Repack in drums	31	drum	5	155			
	Close drum lid	31	drum	3	93			
	Palletize drums	31	drum	2	62			
	Stage drums	31	drum	2	62			
	Monitor activated carbon and fugitive dust system	8	times	6	48			
Total Task				43	1196	2	43	60
Binder setup time	Move pallets to curing area	31	drum	5	155			
	Curing time	31	drum		0			
	Samples	3	times	15	47			
	Monitor curing	31	drum	10	310			
	Move pallets from curing area	31	times	5	155			
Total Task				35	667	1	35	5
Drum Decon	Stage containers	31	drum	5	155			
	Load conveyors	31	drum	5	155			
	Decon drums	31	drum	10	310			
	Assay drums	31	drum	15	466			
	Unload conveyers	31	drum	5	155			
	Stage drums	31	drum	5	155			
Total Task				45	1397	3	45	60
Total FTEs/shift						8	180	
Supervision	Ratio of 1:10					1		
Vac/sick/holiday relief	Assume 6 wks of absence					1		
Total/shift						10		
70% efficiency						14		
Total/day						41		

Notes:

Assume 30% of process residue waste and 100% of other waste requires drying

Assume 1 hr drying time, 2000 lbs/hr

No. of samples= 3

Table NT3-n. **Air Pollution Control Subsystem**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time / Shift	FTEs Needed	Minutes/ lb
Monitor Equipment	dry filtration	4	times	10	40		
	hepa filter	4	times	5	20		
	GPCR	24	times	2	48		
	Acid gas scrubber	12	times	10	120		
	mist eliminator	4	times	2	8		
	GAC	4	times	2	8		
	mersorb	4	times	2	8		
	offgas monitor	24	times	5	120		
Total Task				38	372	1	0
Supervision	Ratio of 1:10					0	
Vac/sick/holiday relief	Assume 6 wks of absence					0	
Total/shift						1	
70% efficiency						1	
Total/day						4	

Table NT3-o. **Certification and Shipping**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time / Shift	FTEs Needed	Minutes/ Drum	Minutes/ Add'l Drum
Waste Receiving	Transfer through air lock	50	drums	5	248			
	Sample waste	5	drums	15	74			
	Resample waste	0	drums	15	7			
	Stage waste	50	drums	5	248			
Total Task				40	578	1	40	15
Waste Assay	Stage pallets	50	drum	3	149			
	Load on conveyor	50	drum	1	50			
	Assay RTR	50	drum	15	744			
	Assay gamma	50	drum	60	2976			
	Assay PAN	50	drum	60	2976			
	Remove from conveyor	50	drum	1	50			
	Repalletize	50	drum	3	149			
	Stage pallets after assaying	50	drum	15	744			
Total Task				158	7837	16	158	60
Stage waste	Stage uncertified waste	50	drum	3	149			
	Transfer waste	50	drum	3	149			
	Stage certified waste	50	drum	3	149			
	Transfer waste	50	drum	3	149			
Total Task				12	595	1	12	
Ship Waste Truck	Truck docking	1	truck	30	17			
	Settle Paperwork	1	truck	120	68			
	Load truck	1	truck	60	34			
	Truck leaving	1	truck	60	34			
Total Task				270	152	0	12	
Total FTEs/shift						19	222	
Supervision	Ratio of 1:10					2		
Vac/sick/holiday relief	Assume 6 wks of absence					2		
Total/shift						23		
Adjustment for 70% Efficiency						33		
Total/day						100		

Notes:
Samples collected = 5
Assume 10% of waste require sampling

Table NT3-p. Summary of FTEs & Time for a Single Drum to Pass Through a System

	Daily FTEs	Time (min)/ Single drum	Time (hrs)	Add'l Time for Next Drum	Time/ Drums Received in a Shift (minutes)	Time (hrs)
Admin	57.3	N/A				
Receiving /Inspection Tasks common for all waste		802.0	13.4	60.0	3727.6	62.1
Receiving and Prep-liquids		0.0	0.0		0.0	0.0
Receiving and Prep-residue		229.0	3.8	45.0	1328.8	22.1
Receiving and Prep-soil		229.0	3.8	45.0	425.2	7.1
Receiving and Prep-debris		288.5	4.8	5.0	458.3	7.6
Receiving and Prep-lead		557.0	9.3	315.0	557.0	9.3
Receiving and Prep-mercury		516.0	8.6	315.0	516.0	8.6
Receiving and Prep-special		516.0	8.6	315.0	1914.6	31.9
Receiving and Prep-metal decon		229.0	3.8	35.0	554.4	9.2
Receiving and Prep	195.5	668.7	11.1			0.0
Aqueous Waste	5.2	175	2.9	36	1170.4	19.5
Organic Destruction	25.5	293	4.9	17	371.1	6.2
Residue/Soil Treatment	6.5	117	2.0	16	594.3	9.9
Open Debris	36.9	175	2.9	23	233.0	3.9
Metal Decon	16.3	91	1.5	75	1204.0	20.1
Lead	2	161	2.7	N/A	161.0	2.7
Mercury	0.1	357.0	6.0	N/A	357.0	6.0
Special	10.8	182.0	3.0	60.0	448.4	7.5
Grout	16.1	143	2.4	10	355.4	5.9
Polymer	41.4	180	3.0	60	1982.4	33.0
APC	4.1	372	6.2		372.0	6.2
Certification and Shipping	100.4	222	3.7	60	3138.0	52.3
Total	**518.1**					

Notes:
Allocation of receiving and preparation time was done as follows: Average time per drum was estimated, multiplied by the number of drums per shift. The time for each waste type was allocated according its percentage of total waste.

System NT-5 Time and Motion Study Tables

Table NT5-a. System NT-5: Time and Motion Analysis

Subsystem	Mass Flow (lb/hr)	Waste Type	No. of Drums	SCM Unprocessed Density kg/m3	Density lb/ft3	Density lb/drum
Administration	2,927					
Receiving and preparation	2,927	all	6.22		64	471
Aqueous waste treatment	1,956	L1100	4.29		62	456
Organic destruction	256	L2110	0.56		62	456
Process residue and inorganic sludge treatment	1,020	S3120	3.18	700	44	321
Bulk soil treatment	329	S4100	0.67		67	493
Soft Debris treatment	435	S5300	2.96	320	20	147
Open Debris treatment	80	S5110	0.44	400	25	184
Complex Debris treatment	177	S5110	0.97	400	25	184
Metal decontamination	462	S5110	1.98	509	32	234
Mercury amalgamation	3	X7100	0.00	2000	125	918
Lead recovery	26	X7200	0.03	2000	125	918
Polymer stabilization	1,127	S3120	3.51	700	44	321
Pre-polymer drying	459	S3120	1.43	700	44	321
Air pollution control	1,433		N/A			
Grout stabilization	651	soil/debris	1.89	750	47	344
Special treatment	155	X6000,X7500	0.68	500	31	229
Certification and shipping	4,270	Z000	5.49	N/A	106	777
vol reduction (out/in)	0.69		0.88			

Notes:
This table provides the basis for the time and motion analysis.
Quantities of waste to a subsystem (lbs/hr) are based on LMITCO mass balance of 5/30/96 except for grout and polymer, and certification and shipping (9/10/96 balance).
Densities are the same as the LMITCO mass balance except where values are shown in the SCM column.
Where values are shown in the SCM column, densities are taken from SCM and converted to lb/ft3..
The waste quantities are converted from lbs/hr to drums/hr.
Subsequent analysis is based on drums/shift of waste to a subsystem.

Table NT5-b. **Administration Subsystem**

Task	Subtask	FTEs Needed	Samples/ Shift	Time Required (min)	Total Time/ Shift
Facility Management					
	Facility Manager	1			
	Secretary	1			
	Receptionist/word processor	1			
Operations Management					
	Department managers	2			
	Communications	1			
	Engineering Manager	1			
	Engineering staff	2			
	Maintenance Supervisor	1			
Personnel	Personnel Manager	1			
	Nurse/medical/industrial safety	1			
	Security guards at facility	4			
	Security at guard bldg	4			
Environmental	Environmental manager	1			
	Environmental clerk	1			
Shipping/Receiving/Traffic					
	Manager	1			
	Clerk	1			
Purchasing	Buyer	1			
Accounting	Cost Accounting	2			
	Accounting Clerk	1			
	Payroll Clerks	2			
Laboratory	Laboratory Manager	1			
	Lab Shift manager	4			
	Lab technicians for OSORT	4	11.3	30.0	340.3
	Lab technicians for internal processe	11	100.2	10.0	1002.1
	Lab technicians for final waste form	3	8.3	30.0	249.1
	Lab technicians for incoming supplie	0.2	1.0	20.0	20.0
Health Physics					
	Shift health physics staff	4			
	Health physics manager	1			
	Total except Lab	35			
	Total Lab	23			
	Total Admin	58			

Note:

Laboratory time is estimated by calculating the samples per shift. To fill all shifts for a 7 day week, 4 FTEs @ 6 hours per day of analysis time are assumed.

Table NT5-c **Receiving and Preparation Subsystem**

Task	Subtask	Occurrence/ Shift	Units for Occurrence	Time Required (min)	Total Time / Shift	FTEs Needed	Add'l/Time for Next Drum	Ave. Minutes/Shift/Drum
Receive Waste Truck	Truck docking	0.6	truck	30	17			
	Settle Paperwork	0.6	truck	120	68			
	Unload truck	0.6	truck	60	34			
	stage pallets	0.6	truck	60	34			
	No of pallets/shift							
Total Task 1				270	153	0.3	0	153
Receive Empty container Truck	Truck docking	0.3	truck	30	8			
	Settle Paperwork	0.3	truck	30	8			
	Unload truck	0.3	truck	60	17			
	Stage pallets	0.3	truck	20	6			
Total Task 2				140	40	0.1	0	40
Receive supplies	Truck docking	0.2	truck	30	6			
	Settle Paperwork	0.2	truck	30	6			
	Unload truck	0.2	truck	60	12			
	Stage pallets	0.2	truck	20	4			
Total Task 3				140	28	0.1	0	28
Transfer to Interim Storage	Move pallets to storage area	6.2	Pallet	5	31			
	Stack pallets/ organize storage	6.2	Pallet	10	62			
	Transfer to assay	6.2	Pallet	5	31			
Total Task 4				20	124	0.3	10	10
Assay Drums	Stage pallets	12.4	Pallet	5	62			
	Load on conveyor	49.8	drum	1	50			
	Assay RTR	49.8	drum	15	746			
	Assay gamma	49.8	drum	60	2986			
	Assay PAN	49.8	drum	60	2986			
	Remove from conveyor	49.8	drum	1	50			
	Repalletize	49.8	drum	3	149			
	Stage pallets after assaying	12.4	Pallet	5	62			
Total Task 5				150	7091	14.8	60	150
Stage and move to OSORT	Store solid waste by category	11.0	Pallet	10	110			
	Move to OSORT	11.0	Pallet	5	55			
	Stage at OSORT	11.0	Pallet	5	55			
Total Task 6			Pallet	20	219	0.5	5	20
Open Drums	Stage at drum opener	11.0	Pallet	5	55			
	Load on conveyor	43.9	Drums	5	219			
	Drum lid clamp	43.9	drum	2	88			
	Drum lid opener	43.9	drum	5	219			
	Lid staging	43.9	drum	1	44			
	Remove from conveyor	43.9	drum	1	44			
Total Task 7				19	592	1.2	5	19
Dump Drums	Assign drums to dump stations	43.9	drum	3	132			
	Move drums to sort table /bins	43.9	drum	5	219			
	Dump drums	43.9	drum	5	219			
Total Task 8				13	570	1.2	5	13
Sort Drums	Sort waste robotically	32.9	drum	30	987			
	Transfer waste to container	32.9	drum	15	494			
	Select destination for sorted waste	32.9	drum	3	99			
	Move container to subsystem bin or shredder	32.9	drum	3	99			
Total Task 9				51	1678	3.5	45	38

Table NT5-c **Receiving and Preparation Subsystem**

Task	Subtask	Occurrence/ Shift	Units for Occurrence	Time Required (min)	Total Time / Shift	FTEs Needed	Add'l/Time for Next Drum	Ave. Minutes/Shift/Drum
Glove Box Sort	Transfer to glove box (several trips)	6.8	drum	30	205			
	Sort waste by hand in glove box	6.8	drum	240	1639			
	Sampling (1/drum)	6.8	drum	15	102			
	Transfer waste to containers	6.8	drum	60	410			
	Select destination for sorted waste	6.8	drum	15	102			
	Move containers to subsystem bin or shredder	6.8	drum	15	102			
Total Task 10				375	2562	5.3	315	5
Assess Debris for Debris Rule Compliance	Transfer open and complex debris	11.3	drum	3	34			
	Screen debris	11.3	drum	4	45			
	Additional sampling (25%)	2.8	drum	10	28			
	Inspection	11.3	drum	5	56			
Total Task 11				22	164	0.3	5	6
Gross Size Reduction	Transfer to cutting table	14.2	drum	3	43			
	Cut waste	14.2	drum	30	425			
	Return to container	14.2	drum	5	71			
	Transfer to next process	14.2	drum	3	43			
Total Task 12				41	581	1.2	35	6
Shredding	Transfer to shredder	37.3	drum	2	75			
	Stage waste	37.3	drum	2	75			
	Feed waste to shredder	37.3	drum	2	75			
	Feed damaged drums to shredder	21.9	drum	2	44			
	Shred stage 1	59.3	drum	2	119			
	Shred stage 2	59.3	drum	2	119			
	Sample size of waste	5.9	drum	5	30			
	Rework 10%	0.6	drum	15	9			
	Return to container	59.3	drum	3	178			
	Transfer to next process	59.3	drum	2	119			
Total Task 13				37	840	1.7	2	30
Sampling					0			
	Sample opened drums	4.4	drum	5	22			
	Sample sorted waste	5.9	drum	5	30			
	Resample (10%)	1.0	drum	5	5			
	Report/eval. results	11.3	drum	10	113			
Total Task 14				25	170	0.5	10	30
Subsystem Bin operation	Monitor bin height	4.4	drum	3	13			
	Fill containers	4.4	drum	3	13			
	Move containers	4.4	drum	2	9			
	Stage containers	4.4	drum	3	13			
	Organize campaigns	4.4	drum	15	66			
Total Task 15				26	114	0.3	0	26

Table NT5-c **Receiving and Preparation Subsystem**

Task	Subtask	Occurrence/ Shift	Units for Occurrence	Time Required (min)	Total Time / Shift	FTEs Needed	Add'l/Time for Next Drum	Ave. Minutes/Shift/Drum
Internal Transfer	Move waste from OSORT to other subsystems	4.4	drum	10	44			
	Move waste from subsystems to CSHIP	43.9	drum	10	439			
	Move treated waste to stabilization	80.0	drum	10	800			
	Move liquid waste to AQWTR and OrgDes	5.9	drum	10	59			
	Move waste to secondary treatment	20.0	drum	10	200			
	Move supplies around	20.0	drum	3	60			
	Move new drums	24.9	drum	3	75			
	Schedule movement	199.1	drum	1	199			
Total Task 16				57	1876	5.2	10	57
Box Breakdown	Stage boxes	10.0	box	2	20			
	Move to opening area	10.0	box	3	30			
	Open boxes	10.0	box	10	100			
	Transfer to dump	10.0	box	3	30			
Total Task 17				18	180	0.5	10	2
Container Decon	Stage containers	49.8	drum	5	249			
	Load conveyors	49.8	drum	5	249			
	Decon drums	49.8	drum	10	498			
	Assay drums	49.8	drum	15	746			
	Unload conveyers	49.8	drum	5	249			
	Stage drums	49.8	drum	5	249			
Total Task 18				45	2239	6.2	15	45
FTEs/shift						36.5		
Supervision	Ratio of 1:10					3.7		
Vac/sick/holiday relief	Assume 6 wks of absence					4.6		
Break relief (included in 6 hr day)	One person can relieve 3 (accounted for in efficiency)							
Total/shift						44.8		676
Adj for 70% Efficiency						64.0		
Total/day						191.9		

Notes:

Assume FTEs are available for 8 hrs/day; because overall 70% efficiency is taken at the end.

Trucks have 22 pallets. Truckloads received based on total inventory to shipping at 300 lb/drum (see separate truck calc sheet)

Pallets are assumed to hold 4 55 gallon drums

As in inventory, assume 50% of drums are contaminated and can't be deconned.

Assume 50% of waste received requires interim storage; this will be dependent on assay system

Assume 10% of incoming waste is sampled

Assume sorted waste is 75% of total; all of debris, no liq, no lead/merc/spec, 70% of residue and soil

Assume 10% of sorted waste is sampled

Assume gross size reduction is necessary for wastes to metal decon & lead 0.3

Assume gross size reduction is 1 hr per drum.

Assume shredding is necessary for waste to proc res, soil, soft debris(sorted or not)

0.75 =fraction of feed to RCPRP requiring shredding

Assume 10% of shredded waste is sampled.

Box breakdown includes time beyond that required if waste was packaged in drums

Assume glove box sorting required for 10% of open and complex debris, + all of special, mercury and lead

0.14 =fraction of feed to RCPRP requiring glove box sorting

Assume glove box waste requires 1 sample/drum

Assume only complex and open debris require assessment, because open debris goes to CWO.

Assume liquids will arrive in drums and be transferred from receiving, and not go to the sorting cell

Assume transfer control for liquids takes the same time as for drums

Assume paperwork is accomplished within times shown

Average time per drum includes times for activities multiplied by the probability that the activity will occur.

Table NT5-c **Receiving and Preparation Subsystem**

Task	Subtask	Occurrence/ Shift	Units for Occurrence	Time Required (min)	Total Time / Shift	FTEs Needed	Add'l/Time for Next Drum	Ave. Minutes/Shift/Drum

Notes (cont.)

Least time/drum/subsystem includes only the minimum requirements, no extra staging, sorting, or shredding

Max time/drum/subsystem includes all staging, shredding, glove box, etc

Table NT5-d **CWO Organic Destruction Subsystem**

Task	Subtask	Occurrence/ Shift	Units for Occurrence	Time Required (min)	Total Time / Shift	FTEs Needed	Add'l Time for Next Drum	Average Minutes/Shift /Drum
Receive Waste	Transfer through air lock	3.3	drum	5	16			
	Feed waste from drum	3.3	drum	3	10			
	Hook to transfer device	3.3	drum	3	10			
	Transfer to tank (10 gpm)	3.3	drum	6	18			
	Empty drum bottoms	3.3	drum	2	7			
	Detach & remove drum	3.3	drum	3	10			
	Sample feed vessel	3.3	drum	5	16			
	Arrange for transfer of secondary waste from other subsystems	1.2	drum	2	2			
Total Task				28	88	0.18	28	17
Feed waste to reactor	Startup Instrumentation and valve check	1.0		30	30			
	Meter waste to reactor (monitoring time)	24.0		10	240			
	Meter waste to reactor (300 lbs/hr)	4.5	drums	6	25			
Total Task				36	270	0.56	36	6
Operate Reactor	Instrumentation/Equip check	1.0	time	30	30			
	Time to react organics (min/drum) reaction rate: 797 lbs/hr	4.5	drum	34	154			
	Flow velocity (gpm)= drums/shift*55gal/drum /(480 min/shift)	0.5						
	Residence time (min)=Reactor volume/flow velocity: Reactor volume is 5% of 500 gal	48.7	minutes					
Total Task				64	184	0.38	64	34
Waste Transfer/ Recycle	Waste removed from tank (pump 500 gal @10 gpm)	9.1	drum	6	50			
	Filter solution	24.0	times	2	48			
	Sample filtrate	2.0	times	15	30			
	Recycle acids	24.0	times	2	48			
	Operate condenser	1.0	times	16	16			
	Wash solution	24.0	times	2	48			
	Sample	2.0	times	15	30			
	Transfer @ 10 gpm to filter	44.8	drums	6	246			
	Transfer @ 10 gpm from filter	44.8	drums	6	246			
Total Task				63	270	0.56	63	6
Treat inorganics	Transfer to neutralizer	24.0		2	48			
	Precipitate filtered solids	24.0		2	48			
	Filter precipitate	24.0		2	48			
	Transfer filtrate to Aq. Waste	24.0		2	48			
	Transfer precipitated solids to polymer	24.0		2	48			
	Collect sample	2.0		5	10			
Total Task				15	250	0.52	15	34
FTEs/shift						2.21	206	
Supervision	Ratio of 1:10					0.22		
Vac/sick/holiday relief	Assume 6 wks of absence					0.28		
Adjust for 70% Efficiency						0.81		
Total/shift						3.53		
Total/day						10.58		

Notes:

Total Samples/Shift = 4.3

Assume sampling frequency = 10% of drums

From Blaines mass balance, the feed to subsystem = 241.40 lbs/hr

Total feed is (drums/hr) = 0.6

Assume continuous CWO process

Assume solids removal once/day

Waste transfer/recycle processes are continuous. Time is expected labor monitoring time

Assume drums of liquid transferred from Rec and Prep

Assume paperwork is accomplished within times shown

Table NT5-e **CWO Organic Destruction Subsystem for Soft Debris**

Task	Subtask	Occurrence/ Shift	Units for Occurrence	Time Required (min)	Total Time / Shift	FTEs Needed	Add'l/Time for Next Drum	Average Minutes/Shift/ Drum
Receive Waste	Transfer through air lock	24	drum	5	118			
	Stage drums for campaigns	24	drum	5	118			
Total Task				10	237	0	10	15
Feed Waste from drum	Stage at feed bin (drums)	24	drum	3	71			
	Hook to transfer device	24	drum	3	71			
	Transfer into feed bin (2-300 lb/hr metering screws)	24	drum	15	348			
	Feed screw monitoring time	24		10	240			
	Empty drum bottoms	24		2	47			
	Sample feed vessel	2		10	20			
	Detach & remove drum	24		3	71			
Total Task				36	520	1	36	33
Feed waste to reactor	Startup Instrumentation and valve check	1		30	30			
	Meter waste to reactor (600 lbs/hr)	24		15	348			
	Feed screw monitoring time	24		10	240			
Total Task				45	270	1	45	15
Operate reactor	Instrumentation/Equip check	1		30	30			
	Reaction rate (see rxn calcs table): 1069 lb/hr in a 2500 gal vessel	24	drum	21	488			
Total Task				51	518	1	51	21
Waste Transfer/ Recycle	Waste removed from tank (pump 5 gpm)	24	times	2	48			
	Filter solution	24	times	2	48			
	Sample filtrate	2	times	15	30			
	Recycle acids	24	times	2	48			
	Operate condenser	1	times	16	16			
	Wash solution	24	times	2	48			
	Sample	2	times	15	30			
	Transfer @ 10 gpm to filter	237	drums	6	1302			
	Transfer @ 10 gpm from filter	237	drums	6	1302			
Total Task				65	268	1	65	
Treat inorganics	Transfer to neutralizer	24		2	48			
	Precipitate filtered solids	24		2	48			
	Filter precipitate	24		2	48			
	Transfer filtrate to Aq. Waste	24		2	48			
	Transfer precipitated solids to polymer	24		2	48			
	Collect sample	2		5	10			
Total Task				15	250	1	15	
FTEs/shift						4		
Supervision	Ratio of 1:10					0		
Vac/sick/holiday relief	Assume 6 wks of absence					1		
Adjustmnet for 70% Efficiency						2		
Total/shift						7	221	15
Total/day						21		

Notes:
From Blaines mass balance, the feed to subsystem is 435 lbs/hr
Total feed is (drums/hr) = 3
Assume continuous process for CWO
Assume solids removal once/day
Waste transfer/recycle processes are continuous. Time is expected labor monitoring time
Number of process samples = 8

Table NT5-f Vacuum Thermal Desorption for Process Residue

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Time/ Add'l Drum
Receive Waste	Transfer through air lock	25.4		5	127			
	Stage drums for campaigns	25.4		2	51			
Total Task				7	178	0.37	7	2
Feed Waste from drum	Stage at feed bin (drums)	25.4		3	76			
	Hook to transfer device	25.4		3	76			
	Transfer into feed bin	25.4		5	127			
	Empty drum bottoms	25.4		2	51			
	Sample feed vessel	2.0		5	10			
	Detach & remove drum	25.4		3	76			
Total Task				16	290	0.60	16	5
Vacuum Thermal Desorption	Unit is number of batches: batch is 15000 lbs or	46.7		drums/ batch				
	Check equipment, instruments before startup	0.5		30	16			
	Charge desorber (15000 lbs/hr)	0.5		60	33			
	Heat desorber	0.5		60	33			
	Desorber batch	0.5		60	33			
	Cool desorber	0.5		30	16			
	Discharge desorbed waste	0.5		15	8			
Total Task				225	122	0.26	225	0
Monitor Offgas	Monitor cooler 1	24.0		1	24			
	Monitor condenser 1	24.0		1	24			
	Monitor condenser 2	24.0		1	24			
	Monitor transfer lines to APC	24.0		1	24			
Total Task				4	96	0.20	0	0
Condensate handling	Sample holding vessel from cond. 1	1.0		15	15			
	Sample holding vessel from condenser 2	1.0		15	15			
	Transfer to aqueous waste treatment	0.5		20	10			
	Transfer to mercury amalgamation	0.5		20	10			
Total Task				70	50	0.10		
Separate desorbed waste	Sample waste	0.5	batch	5	3			
	Select destination (see note)	16.2	drums	1	16			
	Transfer waste to Hg leaching	4.8	drums	2	10			
	Transfer waste to polymer stabi	11.3	drums	2	23			
Total Task				10	51	0.11	10	8
Mercury cont. solids leaching	Process is sized for 1000 lbs/hr of waste or 25 drums/shift							
	Measure leaching agent	0.2	drums	20	4			
	Leach waste	0.2		90	18			
	Transfer to wash 1	0.2		20	4			
	Wash	0.2		60	12			
	Sample	0.2		15	3			
	Transfer to wash 2	0.2		20	4			
	Wash	0.2		60	12			
	Sample	0.2		15	3			
	Transfer to filter	0.2		20	4			
	Filter solids	0.2		30	6			
	Sample/evaluate	0.2		30	6			
	Transfer liquid to aqueous wast	0.2		10	2			
	Transfer solid to polymer	0.2		10	2			
Total Task				400	78	0.16	84	0

Table NT5-f **Vacuum Thermal Desorption for Process Residue**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Time/ Add'l Drum
Leachate/ filtrate Ttreatment	Transfer leachate to mercury re	0.2		20	4			
	Transfer rinse waste water to m	0.2		20	4			
	Mercury reduction over steel w	0.2		60	12			
	Sample	0.2		15	3			
	Transfer to mercury ppt	0.2		20	4			
	Sample	0.2		15	3			
	Add precipitation agents	0.2		15	3			
	Settle tank	0.2		60	12			
	Sample solids	0.2		15	3			
	Transfer solids to polymer	0.2		10	2			
	Transfer liquid to iodine recover	0.2		10	2			
	Add chemicals (H2SO4, H2O2	0.2		15	3			
	Reaction	0.2		30	6			
	Recover iodine	0.2		60	12			
	Transfer solids	0.2		20	4			
	Transfer liquid to wash 2	0.2		10	2			
Total Task				395	77	0.16	83	0
FTEs/shift					0	1.96	425	15
Supervision	Ratio of 1:10					0.20		
Vac/sick/holiday relief	Assume 6 wks of absence					0.25		
Total/shift						2.41	425	15
Adjustment for 70% efficiency						3.44		
Total/day						10.32		

Notes:
Thermal Desorption Batch size of 15,000 lbs
Assume drum transfer of 15 min/drum or 0.5 ft3/min
Only 0.6 batches required per shift based on feed to subsystem
The condenser/aqueous transfer monitoring functions will occur when the desorber is running
Number of drums following treatment is based on the 5/30 mass balance: 1020 lbs/hr in and 648 lbs/hr out
Assume 30% of the waste goes to mercury leaching process
Mercury leaching process was sized for 1000 lbs/hr of waste (@ 321 lbs/drum thisconverts to 25 drums/shift)
Number of process samples = 5.7

Table NT5-g **Aqueous Waste Treatment Subsystem**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Time/ Add'l Drum
Receive Waste	Transfer through air lock	1	drum	5	7			
	Feed waste from drum	1	drum	3	4			
	Hook to transfer device	1	drum	3	4			
	Transfer to tank (10 gpm)	1	drum	6	8			
	Empty drum bottoms	1		2	3			
	Sample feed vessel	2		10	20			
	Detach & remove drum	1		3	4			
	Sample waste from processes: CWO,Desorb, Decon,APC	4	N/A					
	Arrange for transfer	33	drum	2	49			
Total Task				33	100	0.21	33	5
Preliminary Treatment	Sample high TDS tank	28	drums	15	42			
	Sample low TDS tank	6	drums	15	9			
	Sample TOC waste	0	drums	15	0			
	Select treatment methods (10 drum batch)	6	drums	20	12			
	Transfer organic waste to oil water separator	0	drums	3	0			
	Filter high, low TDS and organic waste (say 10 gal/min)	34	drums	6	188			
	Neutralize/ppt high TDS waste	28	drums	11	309			
	Settle precipitated aqueous waste	28	drums	6	154			
	Evaporate solids	1	drums	6	8			
Total Task				90	715	1.49	90	20
UV Oxidation	CaSO4 ppt (10 gpm)	34	drums	11	376			
	Centrifuge (10 gpm)	34	drums	11	376			
	sample waste	3	drums	15	51			
	Adjust UV oxidation (30 min/10 drums)	34	drums	3	103			
	Process through UV oxidation (50 gpm)	34	drums	1	38			
	Carbon filtration (10 gpm)	34	drums	6	188			
	Ion exchange (10 gpm)	34	drums	6	188			
	Sample waste before discharge	3		30				1
Total Task 3				52	1321	2.75	52	
Total per shift					0	4.45	175	26
Supervision	Ratio of 1:10					0.44		
Vac/sick/holiday relief	Assume 6 wks of absence					0.56		
Adjustment for 70% efficiency						7.80		
Total per day						23.39		1170

Notes:

Assume high TDS waste comes from RCPRP, org destruction, soil treatment, debris treatment, and metal decon. 28.08 drums/shift

Assume waste from polymer, APC is low TDS 6.40 lbs/hr 0.11 drums/shift

Assume waste from process residue is organic liq 349.60 lbs/hr 6.13 drums/shift

Assume waste from RCPRP is organic liq

Total drums per hour= 34.32

Assume tank batches are 550 gallons (10 drums)

Assume treatment selection time is required for 10 drum batches.

Assume residence time in oil water separator is 1 hour and tank is 1000 gallons (16 gpm)

Assume filtration, centrifuge and ppt rates are 10 gpm.

Assume solids to evaporator are 5% of incoming waste; assume drying rate is 10 gpm

Assume UV oxidation unit is 50 gpm

Number of process sample 41.6

Table NT5-h Aqueous Wash for Soil

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Time/ Add'l Drum
Soil Receiving	Transfer through air lock	5.4	drums	5	27			
Total Task				5	27	0.06	5	5
Feed Waste from drum	Stage at feed bin (drums)	5.4	drums	3	16			
	Hook to transfer device	5.4	drums	3	16			
	Transfer into feed bin (metering screw)	5.4	drums	5	27			
	Feed screw monitoring time		drums					
	Empty drum bottoms	5.4	drums	2	11			
	Sample feed vessel	2.0	drums	5	10			
	Detach & remove drum	5.4	drums	3	16			
Total Task				16	96	0.20	16	13
Wash Water Prep	Sample wash water	0.5	drums	5	3			
	Adjust Water Volume	0.5	drums	10	5			
	Adjust surfactant	0.5	drums	10	5			
Total Task				25	13	0.03	25	
Washing Process	Add waste to tank	16.1	drums	5	80			
	Wash waste (1200 lbs/hr)	16.1	drums	25	N/A			
	Transfer waste and water from tank	80.4	drums	6	442			
	Monitor tank	24.0	times	5	120			
Total Task				30	120	0.25	30	25
Pre-Rinse and Rinse	Screening (10 gpm) (most of water leaves process here)	80.4	drums	2	126			
	Hydrocyclone (10 gpm)	32.2	drums	6	177			
	Transfer to rinse contactor	32.2	drums	6	177			
	Rinse contactor (2000 lbs/hr)	32.2	drums	15	475			
	Transfer to dryer (2x vol of soil)	32.2	drums	2	51			
	Drying @4 drums/hr	32.2	drums	15	482			
	Monitor operations	24.0	times	5	120			
	Collect samples	16.0	times	5	80			
Total Task				42	200	0.42	42	15
Recycle Processes	These are all monitoring times				0			
	Solubility Reduction	8.0	times	5	40			
	Additive Adjustment	8.0	times	5	40			
	Transfer to Wash Tank	16.0	times	2	32			
	Transfer to Ultrafiltration	8.0	times	2	16			
	Ultrafiltration	24.0	times	5	120			
	Dissolved Air Flotation	8.0	times	5	40			
	Surfactant Separation	24.0	times	5	120			
	Additive Adjustment	8.0	times	5	40			
	Steam stripping	8.0	times	5	40			
	Transfer recycled surfactant	8.0	times	5	40			
	Transfer waste to organic destruction	8.0	times	5	40			
	Transfer metals to polymer	8.0	times	5	40			
	Collect samples	24.0	times	5	120			
Total Task				59	728	1.52		

Table NT5-h **Aqueous Wash for Soil**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Time/ Add'l Drum
Total FTEs/day= FTEs per shift						2.47		
Supervision	Ratio of 1:10					0.25	118	15
Vac/sick/holiday relief	Assume 6 wks of absence					0.31		
Total/shift						3.03		
Adjustment for 70% Efficiency						4.32		
Total/day						4.32		

Notes:
Sample wash water every 10 drums
Assume drum transfer of 15 min/drum or .5 ft3/min
System designed for 1 shift not 3
Residence time in wash tank based on 4x wt of water to feed
Wash tank is 700 gal (12 drums); residence time per drum = 358.21 min
Assume transfer rates are 10 gpm; this includes both waste and rinse or wash water
Waste to screening includes water in tank (4x input volume)
Waste to rinse contactor and hydrocyclone assumes 1:1 soil to water (2x input volume)
Rinse tank has 1300 gallons of water and soil. Residence time = 705.56
Drying: assume 1 hr drying time,2000 lbs/hr (4 drums/hr)
For purposes of processing time, recycle is not included, as these are not soil treatment
No. of samples = 40.5

Table NT5-i High Pressure Wash for Open Debris

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Time/ Add'l Drum
Debris Receiving	Transfer through air lock	3.5	drums	5	18			
Debris Receiving	Transfer through air lock	3.5	drums	5	18			
	Stage drums for campaigns	3.5	drums	15	53			
Total Task				20	70	0.15	20	15
Feed Waste from drum	Stage at feed bin (drums)	3.5	drums	3	11			
	Hook to transfer device	3.5	drums	3	11			
	Transfer into feed bin (metering screw)	3.5	drums	15	53			
	Empty drum bottoms	3.5	drums	2	7			
	Sample feed vessel	0.4	drums	10	4			
	Detach & remove drum	3.5	drums	3	11			
Total Task				36	95	0.20	36	23
Wash Water Prep	Sample wash water	0.4	drums	5	2			
	Adjust Water Volume	0.4	drums	10	4			
	Adjust surfactant	0.4	drums	10	4			
Total Task				25	9	0.02	25	
Washing Process	Check out Equipment	1.0	times	30	30			
See notes; based on 16 drum batch	Wash/ rinse waste	3.5	drums	17	N/A			
	Transfer water from tank	3.5	drums	28	97			
	Monitor tank	24.0	times	5	120			
	Collect Samples	3.0	times	5	15			
	Remove waste from tank	3.5	drums	15	53			15
Total Task				84	262	0.55	84	
Total per shift						0.91	165	
Supervision	Ratio of 1:10					0.09		
Vac/sick/holiday relief	Assume 6 wks of absence					0.12		
Total/shift						1.11		
Adjustment for 70% efficiency						1.59		
Total/day						4.78		
Total FTEs						4.78		

Notes:
Sample wash water every 10 drums
Assume drum transfer of 15 min/drum or .5 cu ft/min
Batch size is 1 to 2 tons; say 3000 lbs or 16 drums
Residence time in wash tank based on 3 stages, 90 minutes each
Assume transfer rates are 10 gpm; this includes both waste and rinse or wash water
Assume water volume is roughly 5x waste volume

Table NT5-j Metal Decontamination Subsystem

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Time/ Add'l Drum
Metals Receiving/ Feed Prep	Transfer through air lock	15.8	drums	5	79			
Total Task				5	79	0.2	5	0
Waste Decon	Stage containers	15.8	drum	5	79			
	Decon waste	15.8	drum	10	158			
	Assay for recycle	15.8	drum	30	475			
	Repack in drums	15.8	drum	15	238			
	Close drum lid	15.8	drum	15	238			
	Stage drums	15.8	drum	5	79			
	Monitor recirc filtration and fugitive dust system	24.0	times	6	144			
Total Task				86	1411	2.9	86	
Total FTEs/shift						3.1	91	
Supervision	Ratio of 1:10					0.3		
Vac/sick/holiday relief	Assume 6 wks of absence					0.4		
Total/shift						3.8		
Adjustment for 70% efficiency						5.4		
Total/day						16.3		

Notes:

Assume 50% of waste must be size reduced.

Assume 60 min/drum for cutting

Table NT5-k Lead Recovery

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Time/ Add'l Drum
Lead Receiving/Feed Prep	Transfer through air lock	0.24	drums	5	1			
	Glove box separation of sheet lead and gloves	0.24	drums	60	14			
	Stage at decon	0.24	drums	10	2			
Total Task				75	18	0.04	75	
Waste Decon	Stage containers	0.24	drum	5	1			
	Decon waste	0.24	drum	10	2			
	Assay for recycle	0.24	drum	30	7			
	Repack in drums	0.24	drum	15	4			
	Close drum lid	0.24	drum	15	4			
	Stage drums	0.24	drum	5	1			
	Monitor recirc filtration and fugitive dust system	24.00	times	6	144			
Total Task				86	163	0.34	86	30
Total FTEs/shift						0.38	161	
Supervision	Ratio of 1:10					0.04		
Vac/sick/holiday relief	Assume 6 wks of absence					0.05		
Total/shift						0.46		
Adjustment for 70% efficiency						0.66		
Total/day						1.98		

Notes:
Assume assay for all drums @ 30 min/drum

Table NT5-I Mercury Amalgamation

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Time/ Add'l Drum
Metals Receiving/ Feed Prep								
	Transfer through air lock	0.02	drums	5	0			
	Transfer liq mercury to tank	0.02	drums	60	1			
	Transfer steel wool w/ Hg to holding bin	0.001	drums	10	0			
Total Task				75	1	0.00	75	60
Mercury Amalgamation								
	Inspect equipment	1.00	time	30				
	Transfer liq mercury to amalgamater (1 gpm)	0.02	drum	55	1			
	Measure additives	0.02	drum	30	1			
	Transfer steel wool to amalgamater	0.02	drum	20	0			
	Batch amalgamation	0.02	drum	120	3			120
	Transfer out of amalgamater	0.02	drum	55	1			
	Stage	0.02	drum	5	0			
	Place at assay	0.02	drum	5	0			
	Assay	0.02	drum	20	0			
	Remove from assay	0.02	drum	2	0			
Total Task				312	7	0.01	312	120
Total FTEs/shift						0.02	387	
Supervision	Ratio of 1:10					0.00		
Vac/sick/holiday relief	Assume 6 wks of absence					0.00		
Total/shift						0.02		
Adjustment for 70% efficiency						0.03		
Total/day						0.09		

Notes:
Volume of steel wool: assume 3x vol of steel to mercury
Assume 5% of mercury is in residue (this should be conservative; 5% of mercury is assumed to be in debris, not process residue)
Total volume of mercury in study is 2.5 + 0.1 lbs/hr.
Therefore volume of steel wool w/mercury = 0.020 lbs/hr
0.001 drums/shift
Batch size for amalgamater: Assume 1 drum/batch, 2 hrs /batch

Table NT5-m **Special Waste**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Time/ Add'l Drum
Special Receiving/Feed Prep	Transfer through air lock	5.4	drums	5	27			
	Glove box preparation of wastes	5.4	drums	60	326			
	Stage waste	5.4	drums	3	16			
Total Task				68	370	0.77	68	60
Waste Treatment	Stage containers	5.4	drum	3	16			
	Treat waste as special processes TBD	5.4	drum	60	326			
	Sample treated waste	5.4	drum	15	82			
	Repack in drums	5.4	drum	30	163			
	Close drum lid	5.4	drum	3	16			
	Stage drums	5.4	drum	3	16			
Total Task				114	620	1.29	114	60
Total FTEs/shift						2.06	182	
Supervision	Ratio of 1:10					0.21		
Vac/sick/holiday relief	Assume 6 wks of absence					0.26		
Total/shift						2.53		
Adjustment for 70% efficiency						3.62		
Total/day						10.85		

Notes:

Assume all waste is prepared in glove box
Assume waste is treated in various batch processes that average 2 hours/drum
TBD=To be determined

Table NT5-n Grout Stabilization Subsystem

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Time/ Add'l Drum
Waste Receiving/ Feed Prep	Transfer through air lock	15.1	drums	5	76			
	Sample waste	1.5	drums	15	23			
	Select process for waste	15.1	drums	5	76			
	Transfer to macroencapsulation	7.8	drums	2	16			
	Transfer to microencapsulation	7.4	drums	2	15			
	Stage at process	15.1	drums	2	30			
Total Task				31	234	0.49	31	5
Waste Encapsulation	Measure binder	15.1	drum	5	76			
	Mix binder	15.1	drum	5	76			
	Combine with waste	15.1	drum	10	151			
	Repack in drums	15.1	drum	5	76			
	Close drum lid	15.1	drum	3	45			
	Stage pallets	15.1	drum	2	30			
	Monitor activated carbon and fugitive dust system	2.0	times	6	12			
Total Task				36	466	0.97	36	10
Binder setup time	Move pallets to curing area	15.1	drum	2	30			
	Curing time	15.1	drum		0			
	Sample	1.5	drum	15	23			
	Monitor curing process	15.1	drum	10	151			
	Move pallets from curing area	15.1	times	2	30			
Total Task				29	234	0.49	29	5
Drum Decon	Stage containers	1.5	drum	5	8			
	Load conveyors	1.5	drum	5	8			
	Decon drums	1.5	drum	10	15			
	Assay drums	1.5	drum	15	23			
	Unload conveyers	1.5	drum	5	8			
	Palletize drums	1.5	drum	2	3			
	Stage drums	1.5	drum	5	8			
Total Task				47	71	0.15	47	15
Total FTEs/shift						2.09	143	
Supervision	Ratio of 1:10					0.21		
Vac/sick/holiday relief	Assume 6 wks of absence					0.27		
Total/shift						2.57		
Adjustment for 70% Efficiency						3.67		
Total/day						11.01		

Notes:
Assume all complex debris (8 drums) will be sent to macroencapsulation, rest to micro.
Assume 10% of drums are deconned.
Assume 10% of drums are assayed
Assume mixing requires 30 min/drum
No. of samples 1.5

Table NT5-o **Polymer Stabilization Subsystem**

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Time/ Add'l Drum
Waste Receiving/Feed Prep	Transfer through air lock	28.1	drums	5	140			
	Sample waste	2.8	drums	15	42			
	Evaluate dryness	2.8	drums	5	14			
	Dry waste	11.4	drums	30	N/A			
	Monitor drying	24.0	times	10	240			
	Stage at process	28.1	drums	2	56			
Total Task				57	493	1.03	57	30
Encapsulation	Measure polymer	28.1	drum	5	140			
	Mix polymer	28.1	drum	10	281			
	Combine with waste in extruder	28.1	drum	10	281			
	Repack in drums	24.0	drum	5	120			
	Close drum lid	28.1	drum	3	84			
	Palletize drums	28.1	drum	2	56			
	Stage drums	24.0	drum	2	48			
	Monitor activated carbon and fugitive dust system	8.0	times	6	48			
Total Task				43	1058	2.21	43	60
Binder setup time	Move pallets to curing area	24.0	drum	5	120			
	Curing time	24.0	drum		0			
	Sample	2.4		15	36			
	Monitor curing	24.0	drum	10	240			
	Move pallets from curing area	24.0	times	5	120			
Total Task				35	516	1.08	35	5
Drum Decon	Stage containers	28.1	drum	5	140			
	Load conveyors	28.1	drum	5	140			
	Decon drums	28.1	drum	10	281			
	Assay drums	28.1	drum	15	421			
	Unload conveyers	28.1	drum	5	140			
	Stage drums	28.1	drum	5	140			
Total Task				45	1264	2.63	45	60
Total FTEs/shift						6.94	180	
Supervision	Ratio of 1:10					0.69		
Vac/sick/holiday relief	Assume 6 wks of absence					0.88		
Total/shift						8.51		
Adjustment for 70% Efficiency						12.16		
Total/day						36.49		

Notes:

Assume 30% of process residue waste and 100% of other waste requires drying

Assume dryer can accept waste at the rate of 2 drums/hour

No. of samples = 2.4

Table NT5-p Air Pollution Control Subsystem

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ lb
Monitor Equipment	Dry filtration	4	times	10	40		
	HEPA filter	4	times	5	20		
	GPCR	24	times	2	48		
	Acid gas scrubber	12	times	10	120		
	Mist eliminator	4	times	2	8		
	GAC	4	times	2	8		
	Mersorb	4	times	2	8		
	Offgas monitor	24	times	5	120		
Total Task				38	372	0.8	0
Supervision	Ratio of 1:10					0.1	
Vac/sick/holiday relief	Assume 6 wks of absence					0.1	
Total/shift						1.0	
Adjustment for 70% Efficiency						1.4	
Total/day						4.1	

Table NT5-q Certification and Shipping

Task	Subtask	Occurrence/ Shift	Units	Time Required (min)	Total Time/ Shift	FTEs Needed	Minutes/ Drum	Time/ Add'l Drum
Waste Receiving	Transfer through air lock	43.9	drums	5	220			
	Sample waste	4.4	drums	15	66			
	Resample waste	0.4	drums	15	7			
	Stage waste	43.9	drums	5	220			
Total Task				40	512	1.07	40	15
Waste Assay	Stage pallets	43.9	drum	3	132			
	Load on conveyor	43.9	drum	1	44			
	Assay RTR	43.9	drum	15	659			
	Assay gamma	43.9	drum	60	2635			
	Assay PAN	43.9	drum	60	2635			
	Remove from conveyor	43.9	drum	1	44			
	Repalletize	43.9	drum	3	132			
	Stage pallets after assaying	43.9	drum	15	659			
Total Task				158	6939	14.46	158	60
Stage waste	Stage uncertified waste	43.9	drum	3	132			
	Transfer waste	43.9	drum	3	132			
	Stage certified waste	43.9	drum	3	132			
	Transfer waste	43.9	drum	3	132			
Total Task				12	527	1.10	12	
Ship Waste Truck	Truck docking	0.5	truck	30	15			
	Settle Paperwork	0.5	truck	120	60			
	Load truck	0.5	truck	60	30			
	Truck leaving	0.5	truck	60	30			
Total Task				270	135	0.28	12	
Total FTEs/shift						16.90	222	
Supervision	Ratio of 1:10					1.69		
Vac/sick/holiday relief	Assume 6 wks of absence					2.15		
Total/shift						20.74		
Adjustment for 70% Efficiency						29.62		
Total/day						88.87		

Notes:
Assume 10% of waste require sampling
Samples collected = 4.4

Table NT5-r Summary of FTEs & Time for a Single Drum to Pass Through a System

	Daily FTEs	Time (min)/ Single Drum	Time (hrs)	Add'l Time for Next Drum	Time/Drums Received in a Shift (min)	Time (hrs)
Administration	57.9	N/A				
Receiving /Inspection Tasks common for all waste		802	13	60	3728	62
Receiving and Prep-CWO		0	0		0	0
Receiving and Prep-soft		229	4	45	1250	21
Receiving and Prep-residue		229	4	45	1329	22
Receiving and Prep-soil		229	4	45	425	7
Receiving and Prep-debris		289	5	5	340	6
Receiving and Prep-lead		557	9	315	557	9
Receiving and Prep-mercury		516	9	315	516	9
Receiving and Prep-special		516	9	315	1915	32
Receiving and Prep-metal decon		229	4	35	554	9
Receiving and Prep	191.9	676.2	11			0
Aqueous Waste	23.4	175	3	36	1375	23
Organic Destruction	10.6	206	3	34	325	5
Vacuum Thermal Desorption	10.3	425	7	26	1060	18
Soil Treatment	4.3	118	2	15	183	3
Soft Debris	20.6	221	4	33	962	16
Open Debris	4.8	165	3	23	223	4
Metal Decon	16.3	91	2	75	1204	20
Lead	2.0	161	3	N/A	161	3
Mercury	0.1	387.0	6.45	N/A	387	6
Special	10.8	182.0	3	60.0	448	7
Grout	11.0	143	2	10	284	5
Polymer	36.5	180	3	60	1805	30
APC	4.1	372	6		372	6
Certification and Shipping	88.9	222	4	60	2797	47
Total	**493.5**					

Notes:
Allocation of receiving and preparation time was done as follows: Average time per drum was estimated, multiplied by the number of drums per shift. The time for each waste type was allocated according its percentage of total waste.

APPENDIX B

SureTrak Modeling Assumptions

SureTrak Modeling Assumptions

The Gant charts (Figures 1 through 5) were developed with SureTrak software and are based on the summary tables A1-p, C1-m, NT2-o, NT3-p and NT5-r. Figures A1, C1, NT2, NT3 and NT5 use the following bases:

1) Receiving and Preparation is divided into multiple steps.

2) All waste is processed through Receive and Assay.

3) Following Receive and Assay, sorting or other feed preparation is performed. Since this is different based on waste type, a preparation stage is included for all nonliquid feed.

4) Successors to Receive and Assay are on a finish-to-finish basis. Feed preparation cannot end before all waste is assayed; a lag time required to process a drum though feed preparation is inserted.

5) Successors to Receive and Assay are also on a start-to-start basis. Some waste can be treated at feed preparation before all waste is received. However, no waste can be treated before at least one drum has been processed through Receive and Assay. A start-to-start lag is required to process one drum though Receive and Assay.

6) Successors to processing systems are all modeled as both finish-to-finish and start-to-start.

7) Lead recovery and mercury amalgamation are modeled on a finish-to-finish basis only. This allows waste to be received at Certification and Shipping before these processes have treated a single drum. These small volume processes would otherwise delay the start of certification and shipping which is not representative of anticipated operations.