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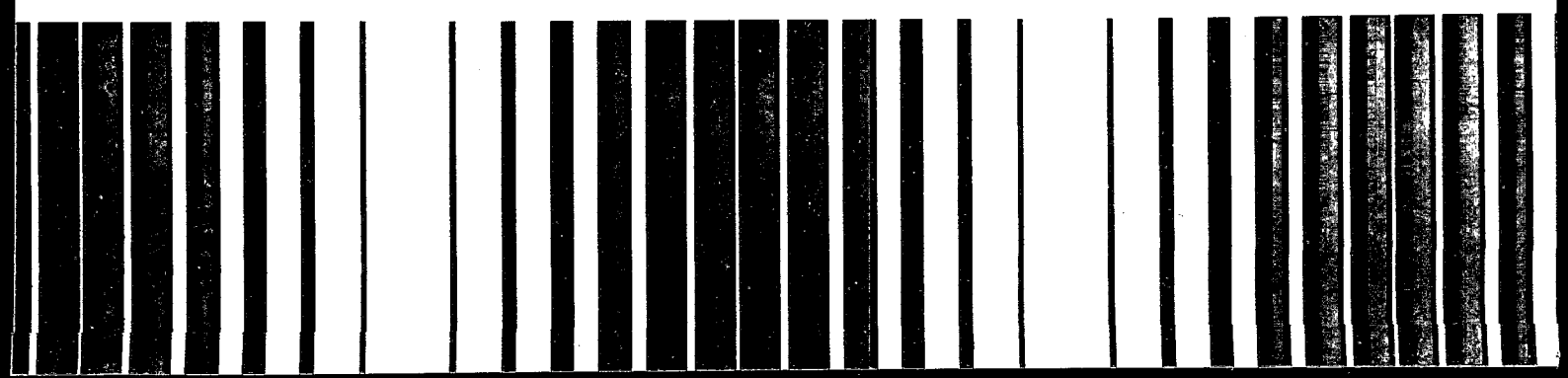
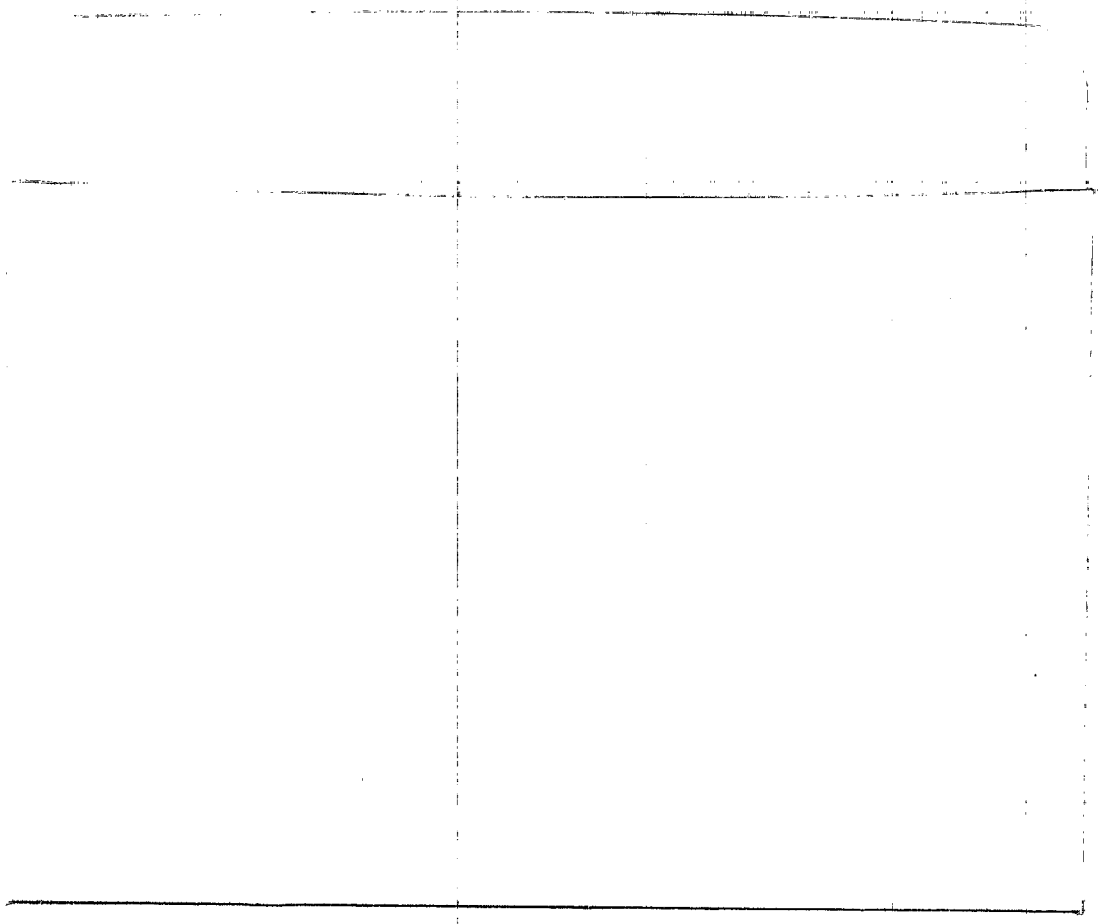
USER'S GUIDE: Strategic WAste Minimization Initiative (SWAMI) Version 2.0

A Software Tool to Aid in Process Analysis for Pollution Prevention





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USER'S GUIDE FOR

SWAMI

Strategic WAste Minimization Initiative

Version 2.0

Prepared for:

U.S. Environmental Protection Agency
Center for Environmental Research Information
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NOTICE

This user's guide describes software which was developed as a tool for demonstrating concepts of process analysis following a waste minimization audit. The software and this guide have been field tested, peer reviewed, and approved for publication by the U.S. EPA. Information obtained through the use of this software system should not be presumed to represent U.S. EPA policy and official endorsement should not be inferred. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

FOREWORD

The Strategic WAste Minimization Initiative (SWAMI) Software, Version 2.0 is a tool for using process analysis for identifying waste minimization opportunities within an industrial setting. The software requires user-supplied information for process definition, as well as material inputs and products for each unit operation and outputs associated with waste streams. SWAMI provides a scheme for identifying and prioritizing (on a cost or volume basis) waste reduction opportunities in process units and treatment operations, performs mass balance calculations, draws process flow diagrams, and directs the selection of candidate waste minimization strategies. This software system was developed in conjunction with the U.S. EPA publication "Waste Minimization Opportunity Assessment Manual" (EPA/625/7-88/003). The use of that manual can provide the information necessary for input to this software.

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ACKNOWLEDGMENTS

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USER'S GUIDE FOR SWAMI

SECTION 1.0

INTRODUCTION

The purpose of the SWAMI software is to help the user identify waste minimization opportunities, set up a procedure to prioritize those opportunities, and devise a strategy to take advantage of those opportunities that have the highest priority.

The Strategic WAste Minimization Initiative software package known as SWAMI (including program, source code, and documentation) was developed by PEER Consultants, P.C., and the University of Dayton Research Institute (UDRI).

This version of SWAMI has been developed to supply the capability of performing mass balance calculations and of generating graphic process flow diagrams. These capabilities were added to SWAMI as a result of suggestions and requests from users of earlier versions of the software.

SECTION 2.0

CONCEPTS ON WHICH SWAMI IS BASED

Before describing the mechanics of SWAMI, it is necessary to explain the conceptual basis from which SWAMI was developed. This section explains four such topics: process analysis, opportunity prioritization, preliminary strategy identification, and mass balance considerations.

2.1 PROCESS ANALYSIS

The software is based on standard systems analysis concepts in which the entire process is looked upon as a system of interacting unit operations (unit ops) or components. Commonly a process flow diagram is used to show the relation of unit operations, (their functions, and their inputs, outputs and wastes) to the overall functioning of the process. In fact, an entire production line can be considered an integrated process or system and this can include such operations as material purchase, inventory control, production, maintenance, waste collection and mixing, waste treatment, and storage. If you use the process flow diagram approach for an entire production line, the software can lead you to specific opportunity points within the plant. The software can help you generate a complete and realistic process flow diagram for your plant (if one does not already exist). The software will produce and print a process flow diagram based upon the information you enter. Thus, it is imperative that you enter realistic data into the system or the output may be meaningless to you.

Once the process flow diagram is completed, the opportunity points can be readily identified. For example, every waste stream emanating from a unit op defines a point where opportunities exist to affect <u>that</u> waste stream. Pollution Prevention Strategies include process modifications at that and preceding unit ops to change the quantity or characteristics of that stream. Other examples include:

(1) every material input stream identifies opportunities for material substitution (and for possible changes in inventory control methodologies);

(2) every connection point between unit ops (in fact, every flow line) is an occasion for spillage to occur (and thus, an opportunity to control spillage); and

(3) every point at which waste streams are joined is an opportunity for waste segregation in order to enhance recyclability of waste streams.

2.2 PRIORITIZATION

It is not reasonable to assume that a plant can immediately deal with every pollution prevention opportunity point. Therefore, once the realistic opportunity points are identified, the next step is to prioritize the opportunity points—i.e., identifying the unit op from which the highest priority waste emanated. Criteria to be used in setting up a priority rating scheme can be chosen from any combination of four criteria: volume of waste, hazardous nature of the waste, cost to manage the waste, and the percentage of wastes being recycled within the process. Further, you can evaluate each unit operation directly from its inputs and outputs if you have the information needed for prioritization. SWAMI allows you to start at the final waste streams leaving the plant, and work backward (keeping track of which waste streams cause certain costs and volume changes through any treatment steps, blend points, etc.) until you arrive at the unit op at which the waste originates. Then you can properly assess the "contribution" of that unit op to the final volume of waste streams leaving the plant as well as the "contribution" of that unit op to the cost of treating, storing, and disposing of the final waste streams leaving the plant.

Two similar algorithms are used to compute the volume and cost contributions of waste emanating from a unit op. The "volume" of waste is traced from a final waste back to its primary waste (a waste emanating from a unit op) keeping a running product of responsibilities (as decimal fractions) times the volume of the final waste. When all such paths in the process have been traced, the computed products of like primary wastes are combined (summed). The result is the total amount of waste

attributed to a particular unit op. The mathematical formulation for the volume contribution is:

$$V\ (unit\ op) = \sum_{j=1}^{n} \left[\prod_{i=1}^{k_j} r(i,j) \right] V(j)$$

where:

i = an index for the number of blend points or treatments passed when tracking a final waste back to a unit op.

j = an index for the number of paths between a final waste and a unit op.

k_j = the number of blend points or treatments on the j^{th} path.

n = the total number of final wastes that the unit op of interest contributes to.

r(i,j) = the responsibility value (assigned by you) at the i^{th} blend (or treatment) along the j^{th} pathway.

V(j) = the volume of the final waste on the j^{th} pathway to the unit op of interest.

Similarly, one can estimate a total "cost" of managing the wastes emanating from the unit op.

At any treatment or blend point, each incoming waste stream will be "responsible" for some share of the cost of operating that treatment or blend point and also responsible for a share of the subsequent costs of managing and disposing of the waste stream leaving that point. If we track backward from final disposal, then the steps in the logic process for this accumulation of costs and responsibilities can be envisioned using the following logic:

(1) Set C_j equal to final cost of j^{th} output waste.

(2) Let the index i be a counter for the number of treatment or blend points encountered in following a waste flow path back to the original unit op and k be an index which keeps track of the pathway being followed.

(3) Let $C_j = RD_i(k)C_j + RT_i(k)F_i$

where:

$RD_i(k)$ is the share of the output waste cost borne by the k^{th} input waste at the j^{th} treatment or blend point,

$RT_i(k)$ is the share of the operating cost borne by the k^{th} input waste at the j^{th} treatment,

and F_i is the operating cost of the i^{th} treatment or blend point.

(4) Repeat step 3 for each treatment or blend point encountered.

Note that for any treatment operation, there may be more than one output waste stream and so the subsequent costs of managing and disposing of those wastes must be included in the volume responsibility assignments and cost tracking.

Once these values have been calculated for each of the individual streams emanating from process unit ops, it is a simple matter to list the results on a basis of decreasing volume "responsibility" and by decreasing cost responsibility.

2.3 USING SWAMI TO DEVELOP POLLUTION PREVENTION STRATEGIES

The next step in the logic process—once a unit op has been picked as a prime candidate for waste minimization activities—is to devise a strategy for alternatives to the present operation. Such alternative strategies can be as simple as resetting one control in a process, to as complex as making major equipment modifications, or making a complete change in the type of unit op used in a process. At this stage, the software package can prove helpful in identifying strategies to be considered. The program, through a sequence of questions and answers, will aid in identifying generic waste minimization strategy concepts.

The output from this exercise is a statement of relevant facts and a list of keywords. This statement and keyword list will guide you to sources of more specific information for developing alternatives. For example, with these keywords, you can access existing literature and case study data bases to find specific information about strategies used in your (and similar) industry.

Certain types of information must be gathered in order to proceed with the evaluation and selection of these waste minimization opportunities. Most such information is specific to the strategies to be evaluated. For example, specific strategies under consideration for implementation at a particular unit operation point in a process must be sized to meet the demands of the process and unit op at your plant. Furthermore, many process modifications will require installation of several pieces of equipment. Obviously, the capital cost for implementing such a strategy will then depend upon the equipment list, and the specific size of equipment necessary (to match the existing process at that point and time), while operating costs will depend on the labor, maintenance, supplies, and utilities requirements to operate and maintain the equipment. All these are cost factors about which information must be garnered for your specific application and the specific size range necessary for the proposed strategy. No software nor any computer data base will give you specific new cost data specifically applicable to your process. It is imperative, then, that when you search any data base using the keywords that SWAMI generates, you should look for information about factors such as equipment size, capital cost factors, operating cost factors, equipment lifetime, reduced production costs, reduced waste disposal costs, and intangibles such as reduction of potential liability, ease of operation, and other factors to which it is difficult to assign a dollar value. This information will help you assess the costs and benefits of such changes, when applied in your specific situation.

Note that SWAMI's usefulness does not end here. When an alternative has been designed, you can, with the aid of the program, evaluate the effects of waste minimization in light of the proposed alternative by entering the proposed modifications to your process as a new process to be analyzed with SWAMI.

2.4 MASS BALANCE CONSIDERATIONS

In order to further enhance the identification of waste minimization opportunity points, mass balance calculations can be used to ensure that material flow rates through the process are correct. Mass balance calculations can be used to identify areas where excess materials are being consumed and also to identify unaccounted waste release points.

The standard practice for mass balance calculations is based on the law of conservation of matter, which states that the total mass of material entering a system must equal the mass of material exiting the system, plus any accumulation occurring in the system. In its simplest form mass balance calculations are defined by the formula that states:

Input = Output + Accumulation.

The software incorporates this simple check into the process based on the user input material usage rates and waste generated for each unit op. This algorithm is a simple summation of the mass of material entering a given unit op compared to the mass of material exiting the unit op. (Including the flow of materials from previous unit ops and material flowing into subsequent unit ops.)

The software also allows for calculation of mass balances for individual chemical elements or compounds over the entire process. This is accomplished by defining an active ingredient and its average concentration in all materials input to the process and in the wastes exiting the process. The software then searches for all input and output entries with identical active ingredients and compares those quantities.

SECTION 3.0

USING THE SWAMI SOFTWARE

SWAMI is an acronym for "Strategic WAste Minimization Initiative." The following paragraphs explain procedures for installing and using SWAMI on your personal computer.

3.1 INSTALLING SWAMI

SWAMI was designed to operate on IBM personal computers (or compatibles) with 640K memory (at least 580K bytes must be free), a 286 or higher processor, a hard disk, and MS-DOS Version 2.0 or higher. (If your system does not meet all these requirements, you should still try to install it; it may work.) Perform the following steps to install SWAMI.

(1) Insert your floppy diskette into drive "A:" (or "B:", as appropriate). Then, type "a:install" (or "b:install") as shown below:

C:\>a:install

or

C:\>b:install

The install procedure unpacks the SWAMI files and puts them in your new SWAMI directory.

(2) The install program creates a SWAMI directory and adds your new SWAMI directory to the PATH command in your C:\AUTOEXEC.BAT file. The following examples show how you would add SWAMI to an existing PATH instruction. (These are examples only; the exact contents of your PATH instruction will probably vary.)

Example 1:

BEFORE
PATH=C:\DOS;\BATCH

AFTER
PATH=C:\DOS;\BATCH;\SWAMI

Example 2:

BEFORE
PATH=C:\DOS;\TEXT;\BATCH

AFTER
PATH=C:\DOS;\SWAMI;\TEXT;\BATCH

(3) The install program modifies the FILES command in the C:CONFIG.SYS file to read "FILES=50".

(Note: If the existing FILES command is greater than or equal to 50, no change is made.)

(4) Run the CONFIGP program if your printer is a dot matrix printer OR if you wish to generate dot matrix print files of your process flow diagrams. To do this, first establish your new SWAMI directory as the default directory (e.g., CD C:\SWAMI and press <Enter>). Next, type CONFIGP and press <Enter>. Select a printer from the list (see: Table 3.1) by typing its number and pressing <Enter>. If yours is not compatible with one in the list, use option 99 and your printer manual to customize SWAMI for your printer.

TABLE 3.1. CONFIGP – FOR SELECTING OR CONFIGURING DOT MATRIX PRINTERS TO DISPLAY PROCESS FLOW DIAGRAMS

1 – EPSON FX series
2 – EPSON MX,LX series
3 – EPSON SQ,LQ 24-pin
4 – IBM GRAPHICS
5 – IBM PROPRINTER
6 – GEMINI 10x and 15x
7 – AT&T 475
8 – PROWRITER I & II
9 – MANNESMANN 80,85, and 86
10 – CANON PW-1156A
11 – CITIZEN MSP 20
12 – TI 850 and 855
13 – DATAPRODUCTS 8052C
14 – STAR MICRONIX DELTA
15 – DIABLO P series
16 – MT SPIRIT 80
17 – NEC P2
18 – NEC P2200 24-pin
19 – OKI Microline
20 – FACIT 4512
21 – MANNESMANN MT 180
22 – ACT WRITER

(5) Reboot your system. Do this by holding down the <Alt> and <Ctrl> keys and pressing <Delete>.

(6) Make sure the new SWAMI directory is in the PATH definition. Type "SET" and press <Enter>. If \SWAMI does not appear in the path definition, consult Appendix D and try again.

3.2 GETTING STARTED WITH SWAMI

The SWAMI program is started by typing SWAMI at the DOS prompt. Since SWAMI is intended to assist you in analyzing processes in your plant, each process is stored in its own subdirectory. Separating the process data files by directories in this way simplifies your backup procedure. For example, type:

C::>copy C:\SWAMI\1*.* a:

to copy all of your process #1 data to the floppy diskette in the A: drive.

If you are entering a process into any of these files for the first time, the first input screen to appear will be the process description form (Figure 3-1). You will be asked to name and describe the process you are interested

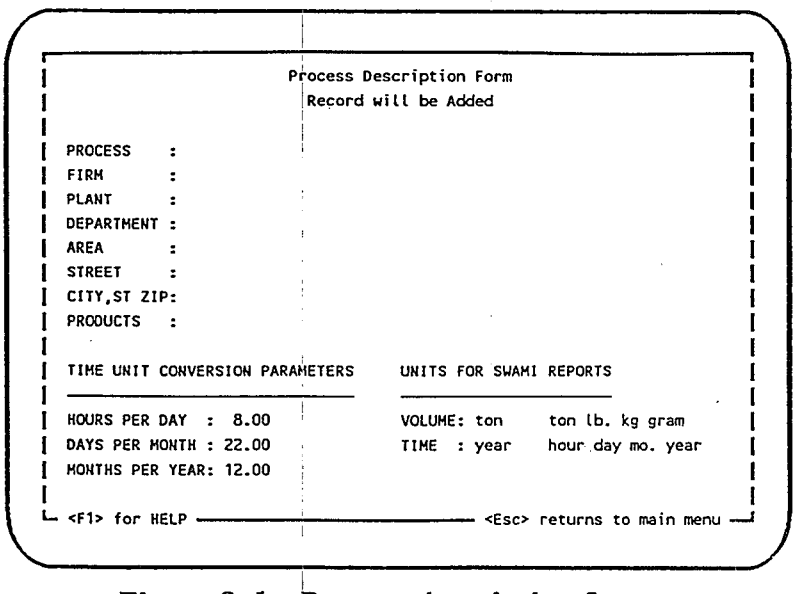


Figure 3–1. Process description form.

in analyzing. Once this form has been completed, SWAMI will thereafter begin by displaying a main menu (see Figure 3–2) consisting of eight options. If at any time thereafter you wish to change the process in this file, you must select option 1 from this main menu.

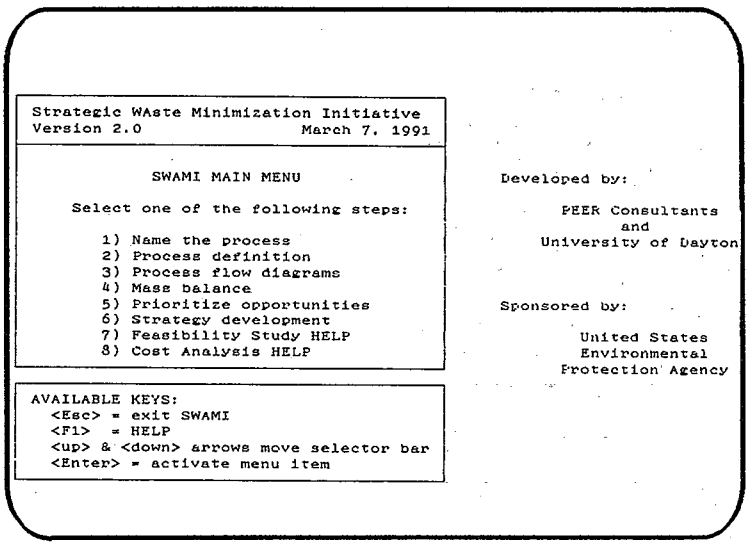


Figure 3–2. SWAMI main menu.

The arrow keys move the selector bar up and down the menu and the <Enter> key selects the highlighted option. The key labeled <F1> is the SWAMI help key. Press it any time you need additional information. Table 3.2 explains some terms which you should understand before continuing. Table 3.3 lists the SWAMI function keys and explains how they are used.

TABLE 3.2. DEFINITION OF TERMS

Cursor: a small box or line, sometimes blinking, indicating the screen position of the next typed character.

(continued)

TABLE 3.2. (continued)

Data entry form: a screen containing labels and data fields. SWAMI Data Entry Forms are analogous to traditional paper forms you are familiar with.

Data field: an area of the screen where typed values (data) appear.

Lists: data items organized in rows or columns which can be selected like menu items.

Menu: program options displayed on the screen. These options can be chosen by positioning the selector bar on the desired item and pressing the <Enter> key.

Selector bar: a highlighted rectangle on the screen for choosing items in a list or marking the maximum number of characters in a data field.

Recycle: the recovery and/or beneficial reuse of a material which otherwise would be disposed of as a waste.

Waste: material emanating from a unit op or treatment which is classified as unuseable or unsaleable and therefore must be disposed of or treated and recycled.

TABLE 3.3. SUMMARY OF IMPORTANT KEYS RECOGNIZED BY SWAMI

<up> & <down> arrows: moves the selector bar up and down

<left> & <right> arrows: moves the cursor left and right within a data field

<Enter> or <Return>: selects an item from a list or menu. Also used to complete a data field and advance to the next data field or screen.

<Esc>: a backup key. Backs up 1 field or 1 screen. Also used to exit the HELP screen.

<Ctrl–Enter>: Accepts the form as shown. Also, advances to the next strategy keyword list.

<Ctrl–Esc>: A backup key. Exits a form immediately from any field.

(continued)

TABLE 3.3. (continued)

<Backspace>: when entering data into a field, this key can be used to delete 1 character immediately to the left of the cursor.

<Insert>: used when a list appears on the screen. This key notifies SWAMI that you wish to add a data item to the list.

<Delete>: used when a list appears on the screen. This key notifies SWAMI that you wish to delete the highlighted data item from the list.

<F1>: displays help information relevant to activity in progress.

<F2>: a process definition key which activates the treatment list.

<F3>: a process definition key which activates the materials list.

<F4>: a process definition key which activates the waste list.

<F5>: a process definition key for accessing complete lists of materials, wastes, and products without regard to their source.

<F6>: a process definition key which activates the products list.

<F10>: a process definition key, available only from the unit op list, which wipes out an entire process. However, before deleting your process, SWAMI displays a warning to avoid accidental erasure.

<PageDown>: allows forward movement through a list 1 page at a time. A page is equal to the number of items that fill the screen.

<Ctrl–PageDown>: jumps ahead to the last item in a list.

<PageUp>: allows reverse paging, 1 screen at a time, through a list.

<Ctrl–PageUp>: jumps back to the first item in a list.

<End>: moves the cursor to 1 position beyond the last character in a text field.

<Home>: moves the cursor to the first position in a text field.

SECTION 4.0

DETAILED DESCRIPTION OF SWAMI CAPABILITIES

This section describes the features of SWAMI and specific keys used to activate them. Because the informtaion is presented in a sequence consistent with anticipated usage you may wish to try using the program as you proceed though Section 4.0. The data and information that you will be called upon to enter is data about your process. Guidance for gathering such data is given in the U.S. EPA manual entitled "Waste Minimization Opportunity Assessment Manual" (EPA/625/7-88/003). To help you in matching that manual to the SWAMI data input requirements, reference is made (in this guide and in the software's HELP message screens) to specific forms in that manual, referred to as WMOAM for brevity.

4.1 USING SWAMI FOR PROCESS DEFINITION

Two menu options are used to define your process. "Initial Description" presents a Data Entry Form for defining three types of parameters that identify your process. The first type is informational only and includes: company name, plant name and location, process name, and major products. Some of these parameters appear as header information in SWAMI reports. A second group of fields contain data conversion parameters used by the mass balance and prioritization computations including: hours per day, days per month, and months per year. Finally, you can specify the units used in mass balance and prioritization reports.

The second option, "process definition" uses a series of lists and Data Entry Forms to define the components (unit operations, wastes, treatments, blends, products, and materials) of your process. Lists summarize the process components which have been defined; forms are used to define, modify, and delete components. When an empty list is activated, SWAMI automatically displays the correct form for defining the first item in that list.

4.1.1 Unit Operations

Defining the process flow begins at the unit op. The sequence of the unit ops in the unit op list should reflect

the logical order of the process. For example, the top unit op in the list represents the first unit op in the process. Similarly, the bottom unit op is the final unit op in the process.

- You can define a new unit op by pressing the <Insert> key when the unit op list is active.
- You can modify an existing unit op by moving the selector bar to highlight your choice and pressing <Enter>.
- Finally, you can delete a unit op by highlighting it, pressing the <Delete> key, and pressing <Enter>.

Once a unit op has been defined, you can activate the materials, wastes, and products lists by pressing <F3>, <F4>, and <F6> respectively. The items defined at this time will "belong" to the unit op that was highlighted when you activated one of these lists (i.e., they will be those entering or exiting the process at that unit op). Notice that SWAMI only displays the materials, wastes, or products belonging to the highlighted unit op. To define materials, wastes, or products for a different unit op, return to the unit op list and select the proper unit op (with <up> or <down>). Then, activate one of the other lists to define the materials, wastes or products as desired.

4.1.2 Waste Streams

Pressing <F4> activates a waste list showing which waste streams emanate from the highlighted unit op or treatment. Wastes can be added, modified, or deleted when this list is active (by pressing <F4> when the particular unit op is highlighted). You can return to the unit op or treatment list by pressing <Esc>. <F5> activates a waste list which shows all the wastes in your process. When the <F5> waste list is active, wastes can only be modified or deleted. Such modification and deletions are then carried throughout the process so that all unit ops and treatments effected by the change are correct.

To define a new waste, press the <Insert> key. To edit an existing waste, use the <up> and <down> arrow keys to move the selector bar, then press <Enter>. To remove a waste, move the selector bar, press the <Delete> key, press

<Enter> to acknowledge the delete, and press <Esc> to return to the unit op or treatment list. Remember, these activities are available only when one of the waste lists is active.

The "Waste Description Form" is used to add, modify, or delete a process waste. SWAMI automatically displays this "Waste Description Form" if you activate an empty waste list. After defining your first waste, you can continue adding, editing, or removing wastes by pressing <Insert>, <Enter>, or <Delete> when the waste list is active. "Record will be Added," "Record will be Changed," or "Press Enter to Delete" appears beneath the title to indicate how the entry will be processed.

The following fields appear in the Waste Definition Form:

Waste name – name which appears in the waste list to identify the waste.

Description – an optional field for expanding the waste name.

Hazardous – indicates if the waste is classified as hazardous. The choices are: "Y" = yes and "N" = no.

Media – select a media type. The choices are: "G" = gas, "L" = liquid, "D" = sludge, and "S" = solid.

Output Rate – is specified in three parts: a quantity, a mass or volume unit, and a time unit (e.g., 100 ton/hour). This rate represents the total waste stream including both active and inactive constituents. Lists (menus) of available units appear just below the density field. (see: "Annual Generation, Overall" field of WMOAM worksheet #10.)

Density – is used in the mass balance computations to convert volumetric output rates to mass units. If output rate is specified in terms of mass units, this field is not used. A list of available units appears below the density field. (see: field 2 of WMOAM worksheet #9a.)

Fate type – identifies the type of destination of the waste [e.g., a treatment operation within your plant; a blend point such as a common sump; a recycling operation in your facility; or "exit," i.e., a Treatment, Storage, or Disposal Facility (TSDF) outside of the generating plant. Note, that the term TSDF makes one think of hazardous waste, but even nonhazardous waste must be treated, stored, or disposed.]

Fate name – name of the treatment or blend point. You must either select a treatment from the treatment list appearing on the right of the screen or add a new treatment to the list and then select it from the list (e.g., your plant's industrial wastewater treatment plant; the "acid sump;" solvent still No. 3; the Harrison Landfill; etc.).

When you finish the TSDF Cost field, SWAMI begins the procedure for defining the active ingredients of the waste. Any elements or compounds you wish to track with a mass balance should be defined as active ingredients. The active ingredients are shown in a list and are defined by completing two fields in the Active Ingredient Data Entry Form. The first field is a symbolic chemical description of the stream using standard chemical notation (e.g. H_2SO_4 for sulfuric acid). The second field is used to indicate the concentration (as a percentage of the whole waste stream) of the active ingredient.

The list and form appear with the Waste Description Form as a reminder that the ingredients are defined for that waste. Like other lists, if the ingredient list is empty it automatically activates the Active Ingredient Data Entry Form to define the first ingredient. If you choose not to define active ingredients, simply press the <Esc> key. Otherwise, complete both fields. SWAMI verifies that the sum of concentrations does not exceed 100 percent, then displays the ingredients in the list. you may add new ingredients to the list by pressing <Insert>, delete an ingredient by pressing <Delete>, or modify an ingredient by moving the selector by and pressing <Enter>.

4.1.3 Input Materials

The materials list shows which materials are used by the highlighted unit op or treatment. Materials can be added, modified, or deleted when this list is active. To add a new material, press the <Insert> key. A blank Material Description Form will appear with the message "Record will be Added." To edit an existing material, use the <up> and <down> arrow keys to move the selector bar, then press <Enter>. This time the Material Description Form will contain the current data and the message "Record will be Changed." To remove a material, move the selector bar, press the <Delete> key, and press <Enter> in response to the message. Again, the Material Description Form (with current data) will be displayed. The message "Press Enter to Delete" tells you to press <Enter> to complete the deletion. Finally, when you finish editing the materials list, press <Esc> to return to the unit op or treatment list.

4.1.4 Products

The Products List shows which products are generated by the highlighted unit op or treatment. Products can be added, modified, or deleted when this list is active. To define a new product, press the <Insert> key. To edit an existing product, use the <up> and <down> arrow keys to move the selector bar, then press <Enter>.

To remove a product, move the selector bar, press the <Delete> key, and press <Enter> in response to the message. Finally, when you finish editing the products list, press <Esc> to return to the unit op or treatment list.

4.1.5 Chemical Formula Rules

There are two general principles with regard to the formula syntax rules. First, SWAMI uses a chemical formula to describe a compound strictly for the purpose of mass balance computations. Therefore, molecular properties such as ionization are irrelevant. Second, the syntax closely resembles standard notation within the limitations of a computer which does not provide a subscripting nor a superscripting capability. The rules are:

1. EXPRESS 2-CHARACTER ELEMENT SYMBOLS IN MIXED CASE. e.g., **Cl** not **CL**.

2. AN INTEGER FOLLOWING AN ELEMENT (NO INTERVENING CHARACTERS) IS A MULTIPLIER OF THAT ELEMENT. e.g., **H2O** defines water.

3. SPACE and "+" (PLUS) CHARACTERS ARE SEPARATORS. e.g., the **4** would be ignored in **H2SO 4**. Instead, use **H2SO4** for sulfuric acid.

4. RADICALS MUST BE ENCLOSED IN PARENTHESES. RADICAL MULTIPLIERS MAY OCCUR BEFORE OR AFTER THE RADICAL (exception: see rule #5). e.g., **2(OH)** and **(OH)2** are equivalent.

5. RULE 2 TAKES PRECEDENT OVER RULE 4. e.g., aluminum phosphate could be written either as **Al2(PO4)3** or as **Al2+3(PO4)**. In the latter, "+" is required or the mass would be computed as though the compound had 23 aluminum atoms.

6. SWAMI IS INCAPABLE OF INTERPRETING EXPRESSIONS WITH PARENTHESES INSIDE PARENTHESES. e.g., **2(Pb+2[NO3])** is invalid and instead should be written as **Pb2+4(NO3)**.

7. DO NOT INCLUDE IONIZATION SYMBOLS. e.g., **Ca++** is invalid.

8. MASS COMPUTATION IS THE GOAL. EXTRA SEPARATORS ARE IGNORED. e.g., **CO2**, **COO**, **C+O2**, and **C+O+O** have equivalent mass in SWAMI.

Table 4.1 lists several example formulas and why they may or may not be acceptable for use with SWAMI.

TABLE 4.1. EXAMPLE FORMULAS

Example	Explanation
H2O	Acceptable representation of water.
H+H+O	Unusual representation of water, but acceptable for computing mass.
Ni(CO)4	Acceptable formula for nickel carbonyl.
Ni+4(CO)	Alternate acceptable formula for nickel carbonyl.
BaSO4+(NaBr)2	Acceptable compound formula.
2NaBr	Incorrect, parenthesis missing. i.e., 2(NaBr).
Ag+	Plus sign"+" is ignored.
[CoCl6]–3	"–3" indicates a negatively charged ion (brackets, "–", and 3 are ignored).
4 (Ag)+(NO3) 2	Spaces cause "4" and "2" to be ignored.

4.1.6 Treatments/Blends

A treatment is similar to a unit op except it appears on your screen in an alphabetized treatment list rather than in a sequence of treatment steps. You can define a new treatment (or blend) when one of two treatment/blend lists is active. The first list is accessed by pressing <F2> when the unit op list is active. You can add a treatment by pressing <Insert>. Existing treatments can be changed by moving the selector bar to your choice and pressing <Enter>. You can remove a treatment by highlighting it and pressing the <Delete> key.

The second treatment (or blend) list appears automatically when you define a waste's fate as "treatment" or "blend." When this new treatment list is active you can press <Insert> to add a new treatment or <Enter> to select a previously defined one as the fate of the current waste.

When a treatment appears in the <F2> list, you can define its input materials, output wastes, and products by pressing <F3>, <F4>, and <F6> respectively. (The input waste list cannot be modified directly through the treatment fields. This can only be done by defining a treatment as the fate of a waste coming from a unit op in the main process. The <F2> list was generated from descriptions you made when defining the main process. That is why the <F2> list can only be modified from the process definition screens.) The items defined at this time "belong" to the treatment that was highlighted when you activated one of these lists. Notice that SWAMI only displays the materials, wastes, and products belonging to the highlighted treatment. To define materials, wastes, or products for a different treatment, return to the treatment list and select the desired treatment. Then reactivate one of the other lists.

4.2 PROCESS FLOW DIAGRAMS

This feature presents a graphic rendition of your process flow diagram on the screen and optionally to a printer or print file. After selecting "Process Flow Diagrams" from the main menu, SWAMI asks you which devices will present your flow diagram. The three choices are: screen only, printer, and print file. All three options will display a process flow diagram, one page at a time, on your screen. The latter two options will also send the flow diagram to the printer or print file, respectively.

4.2.1 Page Numbering

There is a limit to the amount of information which can be displayed on a personal computer screen. SWAMI breaks process flow diagrams into pages which must then be assembled to show the flow diagram for an entire process. The individual pages are identified using letters A–Z to represent the columns and integers 1–99 for the rows, much like popular spreadsheet software. Figure 4–1 shows how the pages fit together to complete the process flow diagram.

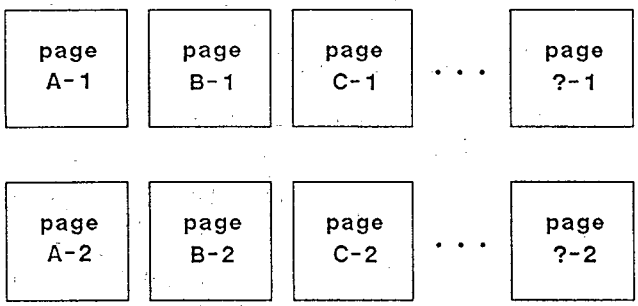


Figure 4–1. Assembling pages of process flow diagrams.

4.2.2 Screens

Each screen represents one page of the process flow diagram. SWAMI presents all of the column A pages before displaying column B pages. A short high–pitched tone is sounded when the page is complete. Simply press the <Enter> key to show the next page. Note, you cannot backup a page or skip pages. Since printing is time–consuming, you may wish to view the flow diagram in "screen only" mode before making hard copies.

4.2.3 Printers

If your printer is an HP Laserjet or one of the dot matrix printers listed in Table 3.1, or is compatible with any of these, you can get a hard copy simply by selecting "Printer" from the destination menu. Note that matrix printer selection/setup is an installation procedure and must be performed before using SWAMI (see: SWAMI installation procedures in Section 3.1). Laser printers are compatible with SWAMI if they support the Hewlett–Packard Printer Control Language (PCL).

If your printer is not supported by SWAMI, you will have to install a printer driver (also called: "print utilities" and "screen dump utilities") and use the <Print Screen> key to send the screen image to your printer. Many such drivers are available from a variety of vendors. Make sure the one you acquire works with your printer and that it can handle graphics. (Many printer drivers only work with text.) GRAFPLUS by Jewell Technologies is one such print utility that works for a wide array of printers including

laser and color printers. (NOTE: this reference is for information purposes only and does NOT constitute an endorsement of GRAFPLUS or Jewell Technologies.)

4.2.4 Print Files

Print files allow you to save your process flow diagram pages in files so that you can copy them to another system for printing. Print files are compatible with HP Laserjet, HP Paintjet, and the dot matrix printers shown in Table 3.1. Since print files are binary, you must use the /B option when copying. The following DOS command should be used to print:

COPY PAGEA-1 LPT1: /B

Furthermore, you should not use the DOS PRINT command to print. Print files have the same name as the page number except that laser printer print files will, whenever possible, put two pages in a file. This means that PAGEA-1 could also contain page A-2. (Hint: files containing two pages will be twice as large as files with one page.)

4.2.5 Symbol and Color Legend

Understanding the symbols and colors will help you interpret your process flow diagram. (Be aware that printers will produce slightly different shades of color and some will distort the shapes.) Figure 4-2 explains the colors and shapes used in a process flow diagram and Figure 4-3 shows them all in a generic configuration..

4.3 MASS BALANCE

There are three types of mass balance calculations available in SWAMI. Each can appear on the screen or be sent to your printer. The first type compares total mass inputs and outputs at the unit operation level and for the process as a whole. The results include a list of inputs and outputs and a mass balance report for each unit operation, blend, treatment, and the process as a whole. The second type generates similar input/output summaries and mass balance reports, except it is used to track a single element of the periodic table. The third type allows you to track chemical compounds. Each mass balance analysis has certain data requirements which are described in subsec-

tions 4.3.1 through 4.3.3. In all cases, you must be sure to define all process streams (i.e., wastes, products and materials).

4.3.1 Mass Balance – Total Mass

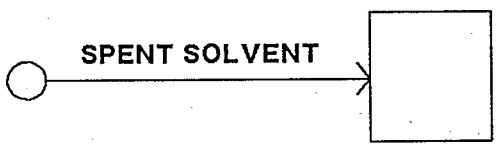
A total mass balance can be computed if each material, waste, and product definition includes an accurate flow rate description and a density specification for those flow rates defined in terms of volume. If the input and output masses balance for the individual unit ops, treatments and the entire process, you can feel confident

PRIMARY SYMBOLS:

Unit Operation	= Black box and text found only on the left side of a page
Treatment	= Blue box and text found to the right of the unit ops
Material	= Green line and text, always on the left side of a unit op or treatment
Waste	= Red lines and text
Final Product	= Black line and text ending with a small shaded box
Interim Product	= Vertical line connecting two unit op boxes. The product name does not appear

OTHER SYMBOLS:

a. A circle on the left end of a waste indicates the waste stream is a continuation from another part of the diagram. The color indicates if the source is a unit operation (black) or a treatment (blue).



b. A black shaded circle on the right end of a waste line indicates the waste is recycled back to a unit operation.

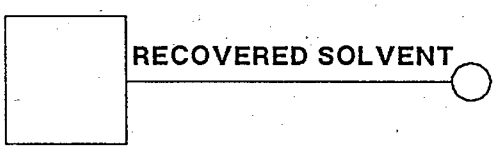
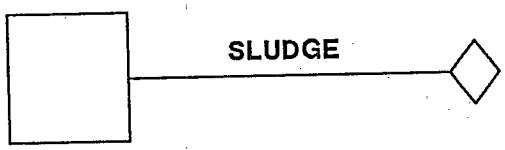


Figure 4–2. Color and symbol legend.

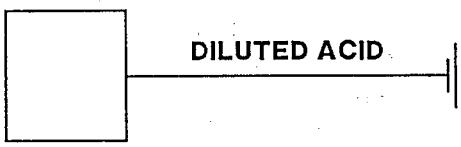
(continued)

Figure 4–2. Continued

c. A blue diamond at the right end of a waste indicates a waste which enters a treatment elsewhere in the diagram.



d. A pair of vertical lines indicates either an exit waste (red) or a waste recycled to another process (blue).



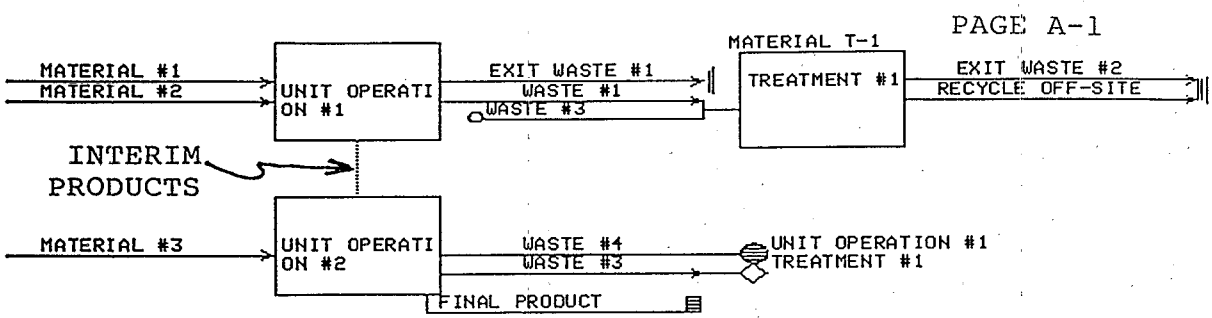


Figure 4–3. Example black and white symbols configuration.

that you have accurately defined the process. Otherwise, check to make sure all process streams have been entered and that the flow rates are correct.

4.3.2 Mass Balance – of an Element

Like total mass balances, single element mass balances require that flow rates (and densities as needed) are specified for each process stream. In addition, those streams which contain the element you wish to track must include chemical formula descriptions along with concentrations of the active ingredients. As before, make sure the masses balance for individual unit operation and treatments AND the process as a whole.

4.3.3 Mass Balance – of a Compound

Like the single element mass balance, compound mass balances require that flow rates (and densities as needed), formulas, and concentrations be specified for each process stream. Two additional conditions will cause this type of computation to not balance. First, whenever a compound being tracked is chemically altered by a unit operation or treatment, the report will show an imbalance. Second, compounds not specified in exactly the same way will not be compared. For example, when performing a mass balance on H2SO4 (sulfuric acid) SWAMI will not detect the presence of sulfuric acid in the compound H2SO4+H2O. Instead, you must enter H2SO4 and H2O as separate ingredients.

4.4 PRIORITIZATION WITH SWAMI

"Prioritization" helps you select wastes which offer the best opportunities for waste minimization. A precise process definition must be completed to ensure an accurate prioritization. Selecting "prioritization" presents the menu shown in Figure 4–4.

4.4.1 Assign Responsibility

During the "Assign Responsibility" operation you will estimate the share of responsibility an input waste has for the on–site treatment cost as well as the off–site cost and volume of the wastes emanating from that treatment. For example, if a treatment has 2 input wastes and 1 output waste, you probably want the percentages assigned to each input waste to total 100% with respect to the output waste

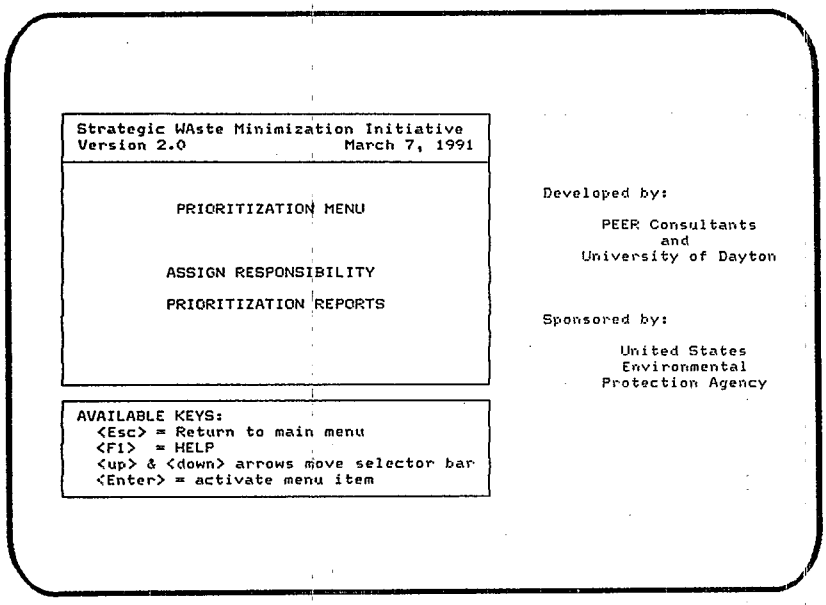


Figure 4–4. Prioritization menu.

and treatment cost (unless there are other processes in your plant which "feed" wastes to the same treatment operation).

In order to help you in assigning "responsibilities" the software presents each output waste "paired with" each contributing input waste sequentially. In Figure 4–5 there are two waste pairs: (1) input waste #1 and the output waste and; (2) input waste #2 and the output waste.

This selection of waste pairs provides the foundation for the "Assign Responsibility" operation. You will be asked to tell what share of the treatment costs, what share of the output waste's volume, and what share of the output waste's subsequent treatment and disposal costs are there because of the need to treat and dispose of each of the two incoming wastes.

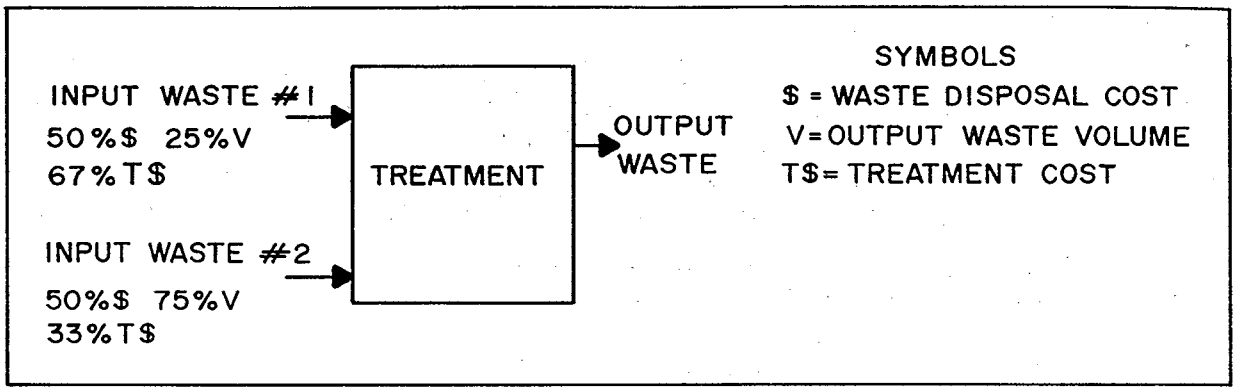


Figure 4–5. Example of responsibility assignment.

For example, suppose that input waste #1 were a high–volume, dilute waste stream, while input waste #2 has a small volume of highly hazardous material. Then you might decide that most of the cost of disposing of the output waste is because of waste #2, while most of the tankage in the treatment existed because of the need to handle waste #1. These are decisions you must make, based on your knowledge of your plant.

The treatment list displayed in "Assign Responsibility" appears to the left of the waste pair list. To proceed, select a treatment from the treatment list. (Use the arrow keys to move the selector bar, then press <Enter>.)

The waste pair list shows all combinations of input and output waste pairs for the treatment highlighted in the treatment list. (Remember that the relationship of input waste to output waste is fundamental for assigning responsibility.) To proceed, select a waste pair from the waste pair list. SWAMI will ask you the following:

(1) What percentage of the treatment cost is attributable to the input waste?

(2) What percentage of the volume of output waste is attributable to the input waste?

(3) What percentage of the final disposal costs of the output waste is attributable to the input waste?

Your responses to the responsibility questions are recorded in the waste pair list. (SWAMI assigns 100% when only 1 input waste exists for a treatment. Note that if other processes should share these costs and volumes, you must correct the numbers appropriately.) You can then check the list to ensure that the information is correct.

4.4.2 Prioritization Reports

"Prioritization Reports" presents a menu allowing you to choose the type of report: screen or print. The two options in this menu, both generate a Prioritization Report. The difference is the destination of the report. If you wish to view the report on the screen, select the first option. Option two causes a printed report. If you are not connected to a printer, this option may lock–up your computer. (Note: To recover from a computer lock–up, you must reboot. To accomplish this, hold down the <Alt> and <Ctrl> keys while pressing <Delete>.)

4.5 STRATEGIZING WITH SWAMI

Begin the strategizing process by selecting "Strategies" from the main menu. Next, select a waste from the strategy waste list. This waste list shows all wastes in the process. Presumably, you have used SWAMI's prioritization or some other methodology to identify the best pollution prevention opportunity points. To select one of these opportunities, use the <up> and <down> arrow keys to move the selector bar, then press <Enter>.

Next, SWAMI displays the strategy menu. There are two options in the strategy menu, each pertaining to the waste you just selected. The first, "Identify Strategies," presents several questions you must answer to determine the cause of the waste, and eventually leads to a set of candidate pollution prevention strategies. The "Print Report" option sends the strategy report to your printer. If no printer is connected to your computer, selecting this option may lock–up your computer. (See reboot requirements in Section 3.1.)

Answering the set of questions presented in this step will lead to a set of possible strategies for reducing or eliminating the selected waste. (To answer the question, position the selector bar to your choice using the <up> and<down> arrow keys. Then press the <Enter> or <Return> key. You can back up 1 question by pressing the <Esc> key.) This step helps you rule out any strategies which absolutely do not apply to the chosen pollution prevention opportunity point. For these, type "N"; otherwise, type "Y." The temptation might be to rule out strategies which, on the surface, seem unlikely candidates. However, if you are not sure, keep them until additional research proves them infeasible or undesirable.

SECTION 5.0

SAMPLE SESSION WITH SWAMI

SWAMI is best learned by using it. For this reason, Section 5.0 gives a detailed step–by–step account of a sample problem for you to try. The sample problem is totally artificial, intentionally brief and incomplete. Even so, every type of input screen is used so that you may practice entering information at every point the software could require. Each step in this chapter includes an action, a short explanation of the action, and a description or picture of the results. If this is not enough explanation, you can press <F1> any time during the session for additional information. When you complete the example, you will be ready to put SWAMI to use with your real problem. Figure 5–1 shows the sample process you will be using. This section assumes you are working the example for the first time (i.e., using empty data files).

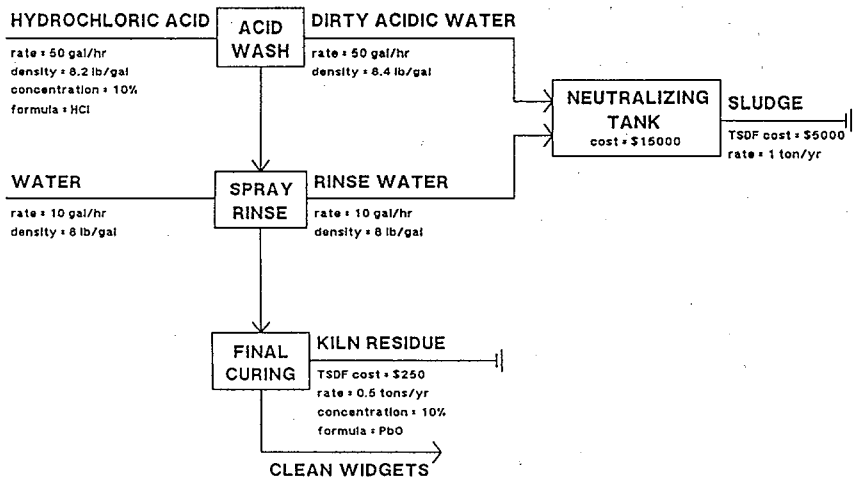


Figure 5–1. Sample process for SWAMI.

Step #1

Action:

type: SWAMI1
and press: <Enter>

Result:

The screen goes blank for a few seconds and a title screen appears.

Explanation:

You will both select a process and begin executing SWAMI with this one instruction. If you wish to access the process defined in subdirectory C:\SWAMI\1 type the instruction "SWAMI1" and press the <Enter> key. Likewise, "SWAMI2" will select the process in C:\SWAMI\2 and execute SWAMI. Altogether, there are nine SWAMI commands (SWAMI1 through SWAMI9) meaning you can have nine processes on your system at one time (or more if you create additional batch command files). For this sample we will assume you are starting a new problem.

Step #2

Action:

Read this title screen then press <Enter>.

Result:

SWAMI creates new data files or loads them if they already exist. Next SWAMI ordinarily would display the main menu (see: Figure 5–2) but, since this is a brand new process, it skips this screen and automatically selects the first option.

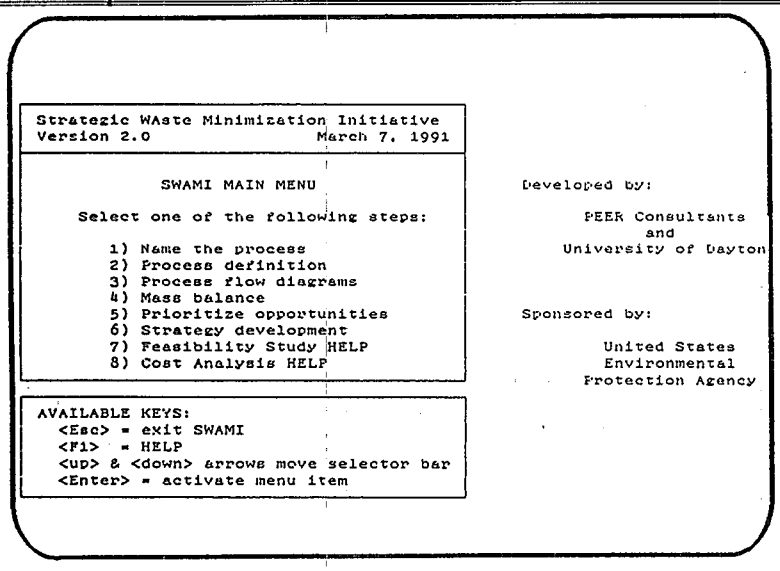


Figure 5–2. SWAMI main menu.

Step #3

Explanation:

The title screen shows that SWAMI can be used to perform three important parts of a waste minimization analysis and identifies software available for performing two additional parts.

Action:

The Process Description Form shown in Figure 5–3 appears. Complete this screen as follows:

type: **Widget finisher**
press: <Enter>
type: **XYZ Widget Manufacturing Corporation**
press: <Enter>
type: **Eastside plant**
press: <Enter>
type: **Post–production Finishing**
press: <Enter>
type: **Building 200**
press: <Enter>
type: **1424 E. Western Ave.**
press: <Enter>
type: **Smallville, Ohio 45678**
press: <Enter>
type: **Clean widgets**
press: <Enter> **six times**

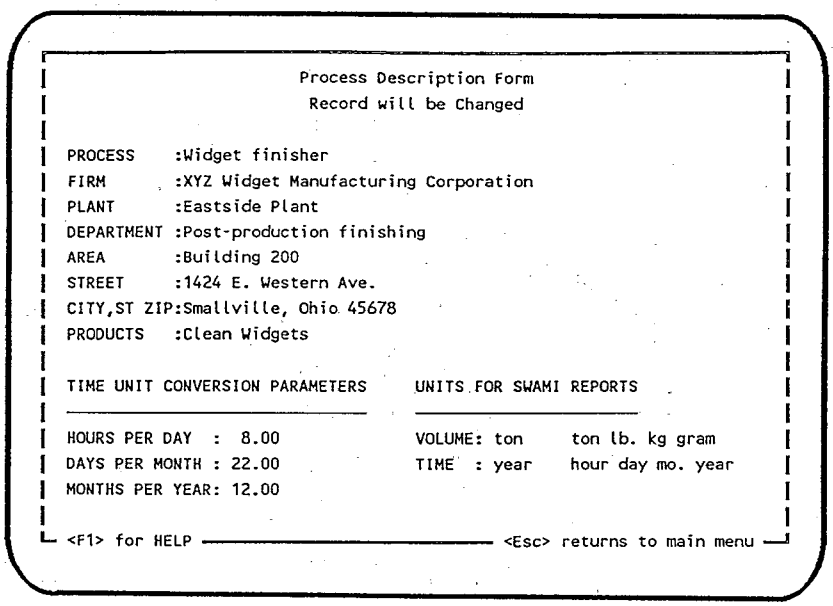


Figure 5–3. A completed Process Description Form.

Result:
The data is entered onto the form. When you press <Enter> from the last field, the process description data are saved and the main menu is redisplayed.

Explanation:
Each time you complete one of the SWAMI Data Entry Forms, the contents are saved on your disk. The top portion of this form merely serves as a reminder to you of the process that you intend to store in this data file (SWAMI1). The bottom portion of the screen allows you to define the time and mass units that SWAMI will use in your reports.

Step #4

Action:
Press 2, then press the <Enter> key.

Result:
The process definition screen appears and the "Unit Operation Description Form" (also called a worksheet or a Data Entry Form) appears superimposed on top of it.

Explanation:
The next step for a new problem is to define the entire process including all unit operations, input materials, wastes, products, treatments, and blends. Pressing 2 moves the selector bar to the second menu option, "Process Definition;" pressing <Enter> activates it. Futhermore, since no unit ops exist for the new process, SWAMI displays the "Unit Op Description Form" to define your first unit operation.

Step #5

Action:
type: ACID WASH
and press: <Enter>

Result:
Your first unit op is defined. SWAMI removes the Data Entry Form and "ACID WASH" appears as the first unit op in your process.

Explanation:
A name is the only data item needed for a unit operation. If you make a mistake while entering the name, use the <Backspace> key to go back and fix it. The left and right arrow keys, <Delete>, and <Insert> also work. The <Insert> key switches between over–

strike and insert modes. Experiment with these keys while the worksheet is visible. If you decide to exit the form without saving the data, press <Esc>.

Step #6

Action:
Press the <Insert> key.

Result:
SWAMI pops up a box for choosing if you want to insert the unit op before or after "ACID WASH," the unit op which is highlighted.

Explanation:
Try using the left and right arrow keys to switch between the words "Before" and "After." If you use the <Esc> key to return to the process screen, no new unit op is added.

Step #7

Action:
Use the left or right arrow keys to move the selector bar between "After" and "Before." Select "After." Then press <Enter>.

Result:
SWAMI displays an empty unit op Data Entry Form.

Explanation:
Once again, a name is the only data item on the unit op worksheet. Pressing <Esc> at this time will return you to the process screen without adding a new unit op. However, once you press <Enter>, the unit op is saved on your disk.

Step #8

Action:
type: SPRAY RINSE
and press: <Enter>

Result:
Your second unit op is defined. SWAMI removes the Data Entry Form and "SPRAY RINSE" appears below "ACID WASH" as the second unit op in your process.

Explanation:
Remember, you can use <Backspace>, the arrow keys, <Delete>, and <Insert> when completing a Data Entry Form.

Step #9

Action:
Press the <Insert> key then,
press the <Enter> key.

Result:
Again, SWAMI pops up the box for choosing if you want to insert the unit op before or after the unit op which is highlighted. "After" is chosen and SWAMI displays the "Unit Op Description Form."

Explanation:
You are ready to enter the name of your third and final unit op. If you use the <Esc> key to return to the process screen, no new unit op is added.

Step #10

Action:
type: FINAL CURING
and press: <Enter>

Result:
Your third and final unit op is defined. SWAMI removes the Data Entry Form and "FINAL CURING" appears in the process flow list.

Explanation:
The data become permanent when you complete the name field and press <Enter>.

Step #11

Action:
Press <F4>

Result:
The waste list is activated and the "Waste Description Form" appears.

Explanation:
The only way to define a new waste is from the <F4> waste list. This list shows all wastes defined for the highlighted unit op, "FINAL CURING." Since no wastes have been defined for "FINAL CURING," SWAMI displays the "Waste Description Form."

Step #12

Action:
type: KILN RESIDUE
and press: <Enter>

Result:
The cursor advances to the field labeled "Description."

Explanation:
A waste name can be up to 25 characters in length. Because the waste name is what you use to reference a waste stream, SWAMI will not let you proceed to the next field until you type at least one character into the "Waste Name" field.

Step #13

Action:
type: ASH
and press: <Enter>

Result:
The cursor advances to the field labeled "Hazardous?"

Explanation:
The description field is optional.

Step #14

Action:
Use the left or right arrow key to highlight "Yes" then press <Enter>.

Result:
The cursor advances to the field labeled "Media."

Explanation:
The only way to proceed to the next field is by selecting "Yes" or "No" in response to the hazardous question.

Step #15

Action:
Press the left arrow key once then, press <Enter>.

Result:
The waste is defined as a solid. Then the cursor advances to the field labeled "Output Rate."

Explanation:
You could also have used the right arrow key to move the selector bar. This step demonstrates that menus are circular.

Step #16

Action:
Type: .5
and press: <Enter>.

Result:
The output rate is entered and the cursor advances, moves toward the right.

Explanation:
The flow rate of wastes (as well as materials and products) is a three–part answer: a value, a mass or volume unit, and a time unit.

Step #17

Action:
Press the right arrow key five times, then press <Enter>.

Result:
"Ton" becomes the mass unit, the density label disappears, and the cursor moves right to the time portion of the "output rate" field.

Explanation:

Density disappears because it is only used when one of the volumetric units (e.g., gallons) is selected.

Step #18

Action:
Press the left arrow key and press <Enter>.

Result:
"Year" becomes the time unit of the output rate. The cursor advances to the field labeled "Fate Type."

Explanation:
The output rate has been defined as a half ton per year.

Step #19

Action:
Press the <Enter> key.

Result:
SWAMI moves the cursor to a newly–displayed field called "Annual cost to outside TSDF."

Explanation:
Select "Exit" as the fate type when a waste "goes out the gate" or when a waste leaves the process. Presumably, it is this point when the process personnel have knowledge and records of costs to treat, store, and/or dispose of the waste stream.

Step #20

Action:
type: 250
and press: <Enter>

Result:
An extension to the Data Entry Form appears. It is a Data Entry Form for describing the active ingredients of the waste.

Explanation:
The TSDF cost represents the annual expenses for disposing of a waste leaving the plant including labor and shipping expenses and fees paid to outside agencies to store and treat the waste.

Step #21

Action:
type: PbO
and press: <Enter>

Result:
The chemical equation for lead oxide appears in the "Formula" field and the cursor drops down to the "Concentration" field.

Explanation:
Any elements or chemical compounds you wish to track with a mass balance must be part of the active ingredient list for every material, waste, and product.

Step #22

Action:
type: 10
and press: <Enter>

Result:
The ingredient Data Entry Form is complete. SWAMI displays a list of all active ingredients. Right now, the only ingredient in the list is "PbO."

Explanation:
The active ingredient list is like all other lists in SWAMI. You can add, change, or delete the items in the list. You will see how this is done shortly.

Step #23

Action:
Press the <Esc> key.

Result:
SWAMI writes the waste to your disk and returns you to the waste list.

Explanation:
<Esc> is used to exit the active ingredient list and return to the waste list. (<Enter> is used to select an ingredient from the list.) A banner at the bottom of the ingredient list reminds you of your options.

Step #24

Action:
Press the <Esc> key.

Result:
SWAMI returns to the unit op list.

Explanation:
Among other things, returning to the unit op list allows you to select another unit op to work with. The material, waste, and product lists describe components of the highlighted unit op and therefore must be activated after highlighting the desired unit op.

Step #25

Action:
Press <F6>

Result:
The product list is activated and the "Product Description Form" appears.

Explanation:
The only way to define a product is from the <F6> products list. This list shows all products defined for the highlighted unit op, "FINAL CURING." Since no products have been defined for "FINAL CURING," SWAMI displays the "Product Description Form."

Step #26

Action:
type: NEW WIDGETS
and press: <Enter>

Result:
The cursor advances to the field labeled "Product Type."

Explanation:
SWAMI will not let you proceed to the next field until you type at least one character into the product name field.

Step #27

Action:
type: F
and press: <Enter>

Result:
The cursor advances to the field labeled "Hazardous?"

Explanation:
Select "Final" when a product is ready to be shipped out for sale to a customer. "Interim" Products are the materials that pass through the process from unit–op to unit–op on their way to becoming final products. All interim products must be defined to achieve an accurate mass balance.

Step #28

Action:
Use the left or right arrow key to highlight "No" then press <Enter>.

Result:
The cursor advances to the field labeled "Media."

Explanation:
The only way to proceed to the next field is by selecting "Yes" or "No" in response to the hazardous question.

Step #29

Action:
Press the left arrow key once then, press <Enter>.

Result:
The product is defined as a solid. Then the cursor advances to the field labeled "Output Rate."

Explanation:
You could also have used the right arrow key to move the selector bar. This step demonstrates that menus are circular.

Step #30

Action:
Type: 69
and press: <Enter>.

Result:
The output rate is entered and the cursor advances, moves toward the right.

Explanation:
The flow rate of products (as well as materials and wastes) is a three–part answer: a value, a mass or volume unit, and a time unit.

Step #31

Action:
Press the right arrow key six times, then press <Enter>.

Result:
"Lb" becomes the mass unit, the density label disappears, and the cursor moves right to the time portion of the "output rate" field.

Explanation:

Density disappears because it is only used when one of the volumetric units (e.g., gallons) is selected.

Step #32

Action:
Press <Enter>.

Result:
"Hour" becomes the time unit of the output rate. The cursor advances to the field labeled "Critical Product Specification."

Explanation:
The output rate has been defined as 69 lbs per hour.

Step #33

Action:
Type: "still must pass inspection" and press <Enter> twice.

Result:
An extension to the "Project Description" Form appears. It is the Data Entry Form for describing the active ingredients of the product.

Explanation:
The critical product specification field is optional

Step #34

Action:
type: PbO
and press: <Enter>

Result:
The chemical formula for lead oxide appears in the "Formula" field and the cursor drops down to the "Concentration" field.

Explanation:
Any elements or chemical compounds you wish to track with a mass balance must be part of the active ingredient list for every material, waste, and product.

Step #35

Action:
type: 10
and press: <Enter>

Result:
The ingredient Data Entry Form is complete. SWAMI displays a list of all active ingredients. Right now, the only ingredient in the list is "PbO."

Explanation:
The active ingredient list is like all other lists in SWAMI. You can add, change, or delete the items in the list.

Step #36

Action:
Press the <Esc> key.

Result:
SWAMI writes the product to your disk and returns you to the product list.

Explanation:
<Esc> is used to exit the active ingredient list and return to the product list. (<Enter> is used to select

an ingredient from the list.) A banner at the bottom of the ingredient list reminds you of your options.

Step #37

Action:
Press the <Esc> key.

Result:
SWAMI returns to the unit op list.

Explanation:
Among other things, returning to the unit op list allows you to select another unit op to work with. The material, waste, and product lists describe components of the highlighted unit op and therefore must be activated after highlighting the desired unit op.

Step #38

Action:
Move the selector bar to "ACID WASH" by pressing the up arrow key twice. Then, press the <F4> key.

Result:
The empty waste list for "ACID WASH" is activated and the "Waste Description Form" appears.

Explanation:
The waste worksheet appears because no wastes are present in the waste list for "ACID WASH."

Step #39

Action:
type: DIRTY ACIDIC WATER
press: <Enter>
press: <Enter>

Result:
The cursor advances to the field labeled "Description," then to the "Hazardous?" field.

Explanation:
So far, completing the waste worksheet is just as you did before.

Step #40

Action:
press: <Enter>
type: L
press: <Enter>

Result:
The waste is tagged as a hazardous liquid.

Explanation:
The first <Enter> accepts "yes" as the answer to the question of whether the waste is hazardous. The L and the second <Enter> defines the waste as a liquid. Both must be completed before you can proceed.

Step #41

Action:
type: 50
press: <Enter>
press: right arrow key
press: <Enter>
press: <Enter>

Result:
The cursor advances to the "Density" field. "50 gal per hour" is the output rate.

Explanation:
50 gal/hr can be converted to mass by the mass balance algorithm only if you complete the "Density" field.

Step #42

Action:
type: 8.2
press: <Enter>
press: L
press: <Enter>
press: G
press: <Enter>

Result:
The cursor advances to the "Fate Type" field.

Explanation:
For this example, we are using 8.2 lb/gal as the density of an aqueous waste stream containing a small amount of dirt.

Step #43

Action:
press: right arrow key
press: <Enter>

Result:
The waste destination is a treatment. SWAMI displays an empty treatment list and a "Treatment Description Form."

Explanation:
When you identify a waste's fate (destination) as treatment, SWAMI displays a list of the defined treatments and waits for you to select one. Since none have been defined, SWAMI gives you the "Treatment Description Form."

Step #44

Action:
type: NEUTRALIZING TANK
and press: <Enter>

Result:
The cursor advances to the "Annual Operating Cost" field.

Explanation:
"Treatment Name" is a required field.

Step #45

Action:
type: 15000
and press: <Enter>

Result:
The treatment worksheet disappears and "NEUTRALIZING TANK" appears in the treatment list highlighted by the selector bar.

Explanation:
Be sure to include all costs associated with operating the treatment. Among other things, this includes input materials, labor, utilities, and amortized equipment and maintenance costs. Remember, defining the treatment is only an intermediate task required to complete the waste definition.

Step #46

Action:
Press the <Enter> key.

Result:
"NEUTRALIZING TANK" is selected from the treatment list and becomes the fate of "DIRTY ACIDIC WATER." The "Active Ingredient Data Entry Form" appears.

Explanation:
Once again you are asked to define active ingredient(s) as a part of the waste definition procedures.

Step #47

Action:
Press the <Esc> key.

Result:
The active ingredient Data Entry Forms disappear. SWAMI returns to the waste list with the blinking message "Press Esc when finished."

Explanation:
This step demonstrates that you need not define any active ingredients for a particular waste. Remember that this may effect the results of a mass balance of elements or compounds.

Step #48

Action:
Press the <Esc> key.

Result:
The blinking message disappears. The unit op list is reactivated.

Explanation:
Remember, since the process is defined around the unit op, you will constantly return to the unit op list.

Step #49

Action:
Press the <F3> key.

Result:
The empty materials list for "ACID WASH" is activated and the "Material Description Form" pops up.

Explanation:
The material worksheet appears because no materials are present in the material list for "ACID WASH."

Step #50

Action:
type: HYDROCHLORIC ACID
and press: <Enter>

Result:
The cursor advances to the "Supplier" field.

Explanation:
"Material Name" is required. SWAMI will not proceed until the "Material Name" field is filled in. If you press <Enter> when the field is empty, you can select a material from the list of defined materials.

Step #51

Action:
type: ABC Chemical Company
and press: <Enter>

Result:
The cursor advances to the "Delivery Mode" field.

Explanation:
The "Supplier" field is optional.

Step #52

Action:
Press the <Enter> key twice.

Result:
The cursor advances to the "Hazardous?" field.

Explanation:
The "Delivery Mode" and "Shelf Life" fields are optional and may be skipped.

Step #53

Action:
type: Y
and press: <Enter>

Result:
The cursor advances to the "Media" field.

Explanation:
The "Hazardous?" field in the material worksheet is just like the one for wastes. In previous steps you used the left and/or right arrow keys to move the selector bar. This step shows that typing the first character of a menu option is another way to move the selector bar.

Step #54

Action:
press: the right arrow key
press: <Enter>

Result:
The material is in liquid form. The cursor advances to the "Usage Rate" field.

Explanation:
You may have noticed that the "Material Description Form" is similar to the form for defining wastes.

Step #55

Action:
type: 50
press: <Enter>
type: G
press: <Enter>
press: <Enter>
type: 62
press: <Enter>
type: L
press: <Enter>
type: C
press: <Enter>

Result:
The "Usage Rate" and "Density" fields are complete. They contain 50 gal/hr at a density of 62 lb/cu ft. A blank "Active Ingredient Data Entry Form" appears.

Explanation:
The "Usage Rate" field serves the same purpose as the "Output Rate" field on the "Waste Description Form."

Step #56

Action:
type: HCl
press: <Enter>
type: 10
press: <Enter>
press: <Esc>

Result:
SWAMI saves the material data (including one active ingredient) and returns to the Material List. "HYDROCHLORIC ACID" appears in the list.

Explanation:
Because it is unlikely that we will track water, the H2O portion of the hydrochloric acid solution was not included in the active ingredient list.

Step #57

Action:
Press the <Esc> key.

Result:
The unit op list is reactivated.

Explanation:
One material and one waste have been defined for "ACID WASH."

Step #58

Action:
Press the <F6> key.

Result:
The empty product list for "ACID WASH" is activated and the "Product Description Form" appears.

Explanation:
The product worksheet appears because no products are present in the product list for "ACID WASH."

Step #59

Action:
type: WASHED WIDGETS
press: <Enter>
press: I
press: <Enter>
press: N
press: <Enter>
press: S
press: <Enter>

Result:
The cursor advances through the fields labeled "Product Type, Hazardous and Media".

Explanation:
So far, completing the product worksheet is just as you did before only this time you specified the "Washed Widgets" as an interim product because they are passing from the "Acid Wash" unit-op to the "Spray Rinse" unit-op.

Step #60

Action:
type: 71
press: <Enter>
press: L

press: <Enter> twice
press: <Enter> two more times

Result:
The cursor advances to the "Active Ingredient Data Form" field.

Explanation:
71 lbs/hr of washed widgets are now defined as an input material for the spray rinse unit-op. Note: The washed widgets will not appear as an input on the process description screen but will apear on the mass balance reports. Note also that you have skipped the critical product specification field.

Step #61

Action:
type: PbO
and press: <Enter>
type: 10
and press: <Enter>

Result:
The chemical formula for lead oxide appears in the "Formula" field at a concentration of 10%. The ingredient Data Entry Form is complete. SWAMI displays a list of all active ingredients. Right now, the only ingredient in the list is "PbO."

Explanation:
Any elements or chemical compounds you wish to track with a mass balance must be part of the active ingredient list for every material, waste, and product.

Step #62

Action:
Press the <Esc> key.

Result:
SWAMI writes the product to your disk and returns you to the product list.

Explanation:
<Esc> is used to exit the active ingredient list and return to the product list.

Step #63

Action:
Press the <Esc> key.

Result:
SWAMI returns to the unit op list.

Explanation:
One material, one waste, and one product have now been defined for "ACID WASH."

Step #64

Action:
Press the down arrow key to "SPRAY RINSE" then, press <F4>.

Result:
The empty waste list for "SPRAY RINSE" and a blank waste worksheet appear.

Explanation:
Remember, each waste list pertains to a particular unit op. Even though two wastes have already been defined, these were for different unit ops. That is why this waste list is empty.

Step #65

Action:
type: RINSE WATER
press: <Enter>
press: <Enter>
press: <Enter>
type: L
press: <Enter>

Result:
The first four fields are completed and the cursor is moved to "Output Rate."

Explanation:
Remember, the "Description" field is optional.

Step #66

Action:
type: 10
press: <Enter>
type: G
press: <Enter>
press: <Enter>
type: 8
press: <Enter>
type: L
press: <Enter>
type: G
press: <Enter>

Result:
The cursor moves down to the "Fate Type" field.

Explanation:
There is nothing new here. You have done this very step (define usage rates) several times already.

Step #67

Action:
type: T
press: <Enter>

Result:
A treatment list appears.

Explanation:
SWAMI is waiting for you to select a treatment. When the waste "goes to" one of the listed treatments, use the arrow keys and press <Enter> to select the correct one. Otherwise, press <Insert> to define a new treatment.

Step #68

Action:
press: <Enter>
press: <Esc>
press: <Esc>

Result:
"NEUTRALIZING TANK" becomes the fate name of "RINSE WATER." The "Active Ingredient Data Entry Form" appears. The first <Esc> returns you to the waste list. The second returns you to the unit op list.

Explanation:
We have skipped the active ingredient step for this waste.

Step #69

Action:
Press the <F2> key.

Result:
A new screen appears with a treatment list in the center flanked by two waste lists, a material list, and a product list.

Explanation:
The treatment screen is used to define the path of wastes until they leave the plant or process as "Exit" wastes. Wastes coming into the treatment are shown

in the input waste list. You can define wastes leaving the treatment by pressing the <F4> key.

Step #70

Action:
Press the <F4> key.

Result:
The empty waste list for "NEUTRALIZING TANK" is activated and the "Waste Description Form" appears.

Explanation:
The waste worksheet appears because no wastes are present in the output waste list for "NEUTRALIZING TANK."

Step #71

Action:
type: SLUDGE
press: <Enter>
press: <Enter>
type: Y
press: <Enter>
type: D
press: <Enter>
type: 1
press: <Enter>
type: T
press: <Enter>
type: Y
press: <Enter>
type: E
press: <Enter>

Result:
After selecting "Exit" for the fate type, SWAMI adds another field, "Annual Cost to Outside TSDF" field.

Explanation:
SWAMI only asks for this value when the waste is an "Exit" waste.

Step #72

Action:
type: 5000
press: <Enter>
press: <Esc>

Result:
The waste and active ingredient worksheets disappear and "SLUDGE" appears, highlighted, in the output waste list. "Press ESC when finished" blinks at the bottom of the waste list.

Explanation:
The "Exit" waste is now part of the process.

Step #73

Action:
Press the <Esc> key three times.

Result:
SWAMI builds a prioritization file, then takes you back to the main menu.

Explanation:
You are now finished defining the sample process. If you wish to expand the process definition, you can come back to it when you finish the rest of Section 5.0.

Step #74

Action:
type: 3
press: <Enter>

Result:
SWAMI chains to the flow diagram program and a menu appears for selecting the destination of your diagram.

Explanation:
It is a good idea to verify your process definition by viewing and/or printing its symbolic flow diagram.

Step #75

Action:
type: S
press: <Enter>

Result:
SWAMI displays the flow diagram (shown in Figure 5–4) on the screen only. This example problem fits on one page. SWAMI beeps to let you know the page is complete.

Explanation:
Advancing to the next page occurs when you press any key.

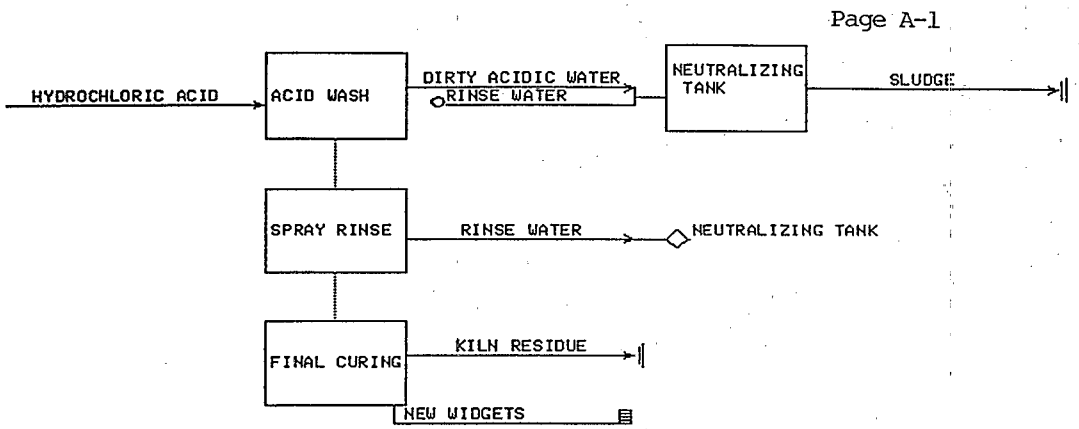


Figure 5–4. SWAMI flow diagram for sample problem.

Step #76

Action:
press: <Space Bar>

Result:
SWAMI exits the flow diagram program and returns to the main SWAMI menu.

Explanation:
You can only go forward through the pages of your flow diagram.

Step #77

Action:
type: 4
press: <Enter>

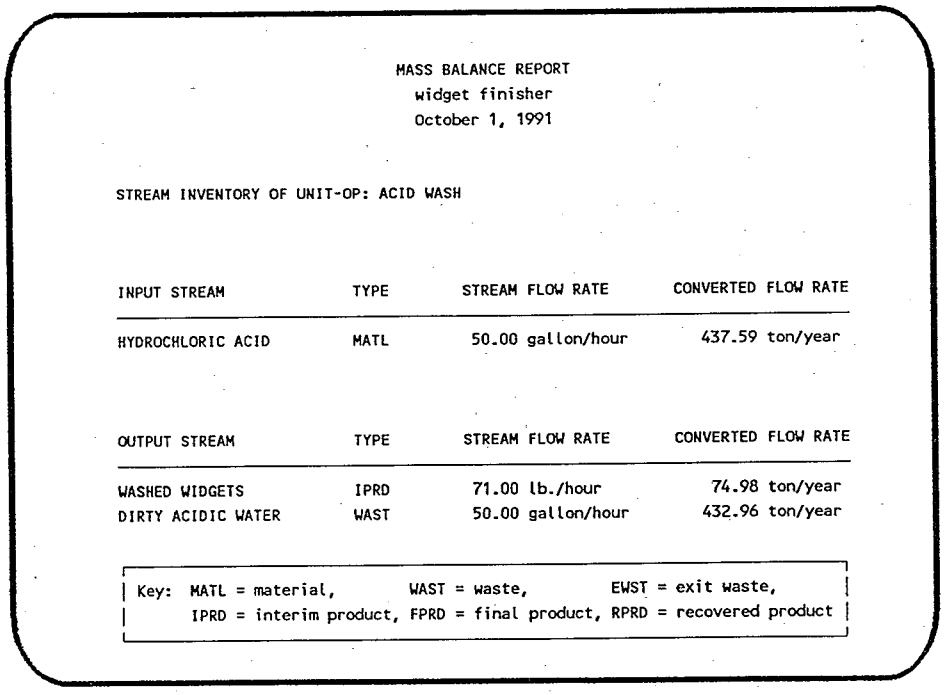
Result:
The mass balance menu appears.

Explanation:
It is a good idea to verify that your process is correct by performing a total mass balance.

Step #78

Action:
press: <Enter> twice.

Result:
You have chosen to perform a total mass balance and directed the output to your screen. An inventory is displayed of all inputs and outputs for the unit operation "ACID WASH" as shown in Figure 5–5.



MASS BALANCE REPORT
widget finisher
October 1, 1991

STREAM INVENTORY OF UNIT-OP: ACID WASH

INPUT STREAM	TYPE	STREAM FLOW RATE	CONVERTED FLOW RATE
HYDROCHLORIC ACID	MATL	50.00 gallon/hour	437.59 ton/year

OUTPUT STREAM	TYPE	STREAM FLOW RATE	CONVERTED FLOW RATE
WASHED WIDGETS	IPRD	71.00 lb./hour	74.98 ton/year
DIRTY ACIDIC WATER	WAST	50.00 gallon/hour	432.96 ton/year

Key: MATL = material, WAST = waste, EWST = exit waste,
IPRD = interim product, FPRD = final product, RPRD = recovered product

Figure 5–5. SWAMI mass balance inventory for the "Acid Wash" unit–op.

Step #79

Explanation:

The summary you see will have only one input and two outputs so it is easy to recognize that this unit op does not balance, even before you get to the summary screen.

Action:

press: <Enter>

Result:

A mass balance summary table appears as shown in Figure 5–6.

Explanation:

Since the unit op is not in balance you must be missing one or more streams or your flow rates must be incorrect. For the purposes of this example we will not explore the discrepancy.

UNIT OPERATION MASS BALANCE SUMMARY
*** TOTAL STREAM ***

UNIT OP: ACID WASH

INPUTS	MASS RATE*	OUTPUTS	MASS RATE*
MATERIALS	437.59	EXIT WASTES	0.00
INTERIM PRODUCTS	0.00	OTHER WASTES	432.96
RECYCLED WASTES	0.00	FINAL PRODUCTS	0.00
		INTERIM PRODUCTS	74.98
TOTAL INPUT:	437.59	TOTAL OUTPUT:	507.94

* Mass rate = ton per year

Figure 5–6. Unit operation mass balance summary.

Step #80

Action:
Continue pressing <Enter> and looking at the input/output summaries and mass balance summary tables.

Result:
There will be nine screens in all including a mass blance summary report for the entire process shown in Figure 5–7. You will end up back at the "Mass Balance Options" menu.
the "Acid Wash" unit–op.

Explanation:
The last summary screen shows the mass balance report for the process as a whole. For the purposes of this example we will not explore any of the mass discrepancies.

Step #81

Action:
press: <Esc>
type: 5
and press: <Enter>

MASS BALANCE REPORT
widget finisher
October 1, 1991

TOTAL MASS BALANCE REPORT
*** TOTAL STREAM ***

INPUTS	MASS RATE*	OUTPUTS	MASS RATE*
MATERIALS	437.59	EXIT WASTES	1.50
		FINAL PRODUCTS	72.86
		RECOVERED PRODUCTS	0.00
TOTAL PROCESS MATERIAL:	437.59	TOTAL PROCESS OUTPUT:	74.36

* Mass rate = ton per year

Figure 5–7. Mass balance summary report.

Result:
SWAMI returns to the main menu then displays the "Prioritization Menu." The selector bar is positioned on the first option, "Assign Responsibility."

Explanation:
You are now ready to begin the prioritization process.

Step #82

Action:
Press the <Enter> key.

Result:
The screen for assigning responsibility appears. "NEUTRALIZING TANK" is highlighted in the treatment and blend list.

Explanation:
Responsibility assignments are simply percentage estimates of a waste's contribution to the cost of operating a treatment, cost of each of the treatment's output wastes, and volume (mass) of the treatment's output wastes. For each treatment, SWAMI displays a list of all possible pairs of waste where one waste is an input to the selected

treatment and the other is an output of the same treatment. In this sample, there is only one treatment and it has two waste pairs.

Step #83

Action:
Press the <Enter> key.

Result:
The selector bar highlights the first waste pair.

Explanation:
Remember, these waste pairs represent an input waste and an output waste of the selected treatment.

Step #84

Action:
Press the <Enter> key.

Result:
Three responsibility questions appear on the left where the treatment list was previously.

Explanation:
The first two questions pertain to the selected waste pair. The third is relevant for the input waste and the treatment.

Step #85

Action:
type: 75
press: <Enter>
type: 90
press: <Enter>

Result:
The cursor moves to the field following the third question.

Explanation:
In this sample, we have decided that "DIRTY ACIDIC WATER" is 75% responsible for the TSDF cost of "SLUDGE" and 90% responsible for the volume of "SLUDGE" emanating from the "NEUTRALIZING TANK."

Step #86

Action:
type: 100
press: <Enter>

Result:
SWAMI redraws the waste pair list with the completed waste pair highlighted.

Explanation:
In this hypothetical example, we decided that since we have another process in the plant that is able to use the "Rinse Water," the "NEUTRALIZING TANK" is necessary only as long as we have the "DIRTY ACIDIC WATER." Therefore, "DIRTY ACIDIC WATER" is 100% responsible for the treatment operating costs.

Step #87

Action:
Press the down arrow key, then press <Enter>.

Result:
Again, the responsibility questions appear. This time they refer to the other waste pair.

Explanation:
Again, the first two questions pertain to the selected waste pair. The third is relevant for the input waste and the treatment.

Step #88

Action:
type: 25
press: <Enter>
type: 10
press: <Enter>

Result:
The cursor moves to the field following the third question.

Explanation:
You will notice that the percentages add up to 100%. For example, it follows logically that if "DIRTY ACIDIC WATER" is 75% responsible for the TSDF cost of "SLUDGE," then "RINSE WATER" is responsible for the remaining 25% of the cost. Although there are cases when this is not true, it is still a good way to check your numbers. If the percentages total more than 100%, SWAMI displays an error message and will not let you exit responsibility assignment until the problem is corrected.

Step #89

Action:
Type a zero, then press the <Enter> key.

Result:
SWAMI returns to the waste pair list.

Explanation:
Because "DIRTY ACIDIC WATER" already accounts for 100% of the treatment cost, "RINSE WATER" is responsible for none of it.

Step #90

Action:
press: <Esc>
press: <Esc>

Result:
SWAMI computes the prioritization results and returns you to the "Prioritization Menu."

Explanation:
Since there is only one treatment, we are finished with the responsibility assignment.

Step #91

Action:
Press the down arrow key, then press <Enter>.

Result:
SWAMI displays a menu of two ways to receive your prioritization report: screen and printer.

Explanation:
Never select the option "Printer" when using a computer that does not have a printer. Doing so may lock–up your keyboard.

Step #92

Action:
Press the <Enter> key.

Result:
SWAMI displays the first prioritization report as shown in Figure 5–8.

Explanation:
Each waste report lists the primary wastes and source unit ops, "Y" or "N" indicating if the waste is hazardous or not, and the computed cost and volume of the waste. The first report sorts the wastes from highest to lowest cost. Notice that "DIRTY ACIDIC WATER" heads this report.

PRIMARY WASTE RESPONSIBILITY REPORT
by COST
May 8, 1991

PRIMARY WASTE	SOURCE UNIT-OP	HAZ.	ANNUAL TSDF COST	VOLUME (ton/year)	AMT. RE-USED
DIRTY ACIDIC WATER	ACID WASH	Y	$18750.00	0.90	0.0%
RINSE WATER	SPRAY RINSE	Y	$1250.00	0.10	0.0%
KILN RESIDUE	FINAL CURING	Y	$250.00	0.50	0.0%

Press <Enter> to continue.

Figure 5–8. Prioritization report sorted by cost.

Step #93

Action:
Press the <Enter> key.

Result:
SWAMI displays the second prioritization report as shown in Figure 5–9.

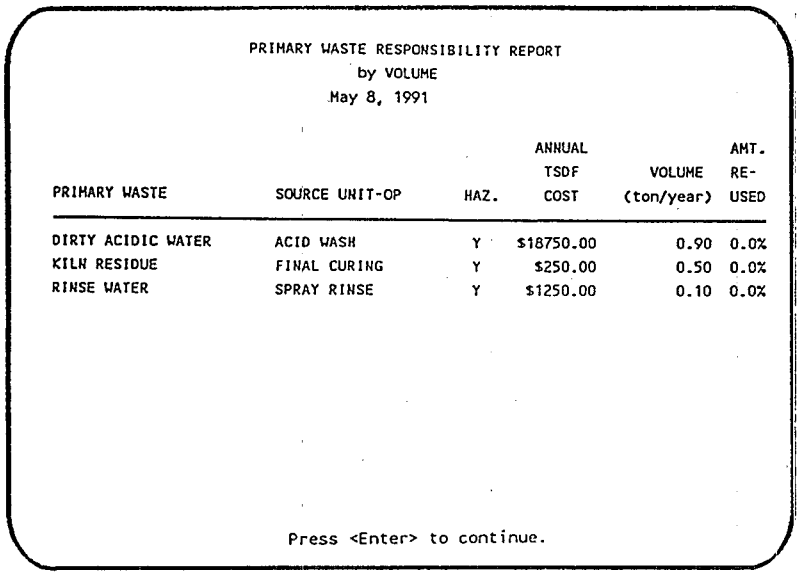
Explanation:
The second report includes the same information as the first but is sorted by volume. In this example, the only difference is in the report title.

Step #94

Action:
press: <Enter>
press: <Esc>

Result:
SWAMI returns to the main menu.

Explanation:
You are ready to begin the strategy portion of the analysis.



PRIMARY WASTE RESPONSIBILITY REPORT
by VOLUME
May 8, 1991

PRIMARY WASTE	SOURCE UNIT-OP	HAZ.	ANNUAL TSDF COST	VOLUME (ton/year)	AMT. RE-USED
DIRTY ACIDIC WATER	ACID WASH	Y	$18750.00	0.90	0.0%
KILN RESIDUE	FINAL CURING	Y	$250.00	0.50	0.0%
RINSE WATER	SPRAY RINSE	Y	$1250.00	0.10	0.0%

Press <Enter> to continue.

Figure 5–9. Prioritization report sorted by volume.

Step #95

Action:
press: 6
press: <Enter>

Result:
SWAMI shows an alphabetical list of the wastes defined in your process.

Explanation:
Remember, the prioritization reports indicated that "DIRTY ACIDIC WATER" was judged responsible for the greatest amount of waste in terms of cost and volume.

Step #96

Action:
Press the <Enter> key.

Result:
"DIRTY ACIDIC WATER" is selected and SWAMI displays the strategy menu.

Explanation:
For this sample problem we have elected to go after the biggest generator. In actual use, you may have reasons to start with a different waste.

Step #97

Action:
To begin the strategy selection process, press the <Enter> key.

Result:
SWAMI displays a question and two valid responses. The question reads "Why do we have this waste? The waste is:."

Explanation:
After choosing a waste stream, you must select "Identify Strategies." Remember that all questions, answers, and candidate strategies pertain to the waste chosen in the previous step ("DIRTY ACIDIC WATER").

Step #98

Action:
To select "process–related or a process requirement," press the <Enter> key.

Result:
SWAMI presents the next question: "What type of process waste is it?"

Explanation:
You have selected "process–related or a process requirement" as the best answer to the question. Now, study the next question and the available choices. If you decide to back up a question, press the <Esc> key. However, make sure you return to this point before continuing with the sample problem.

Step #99

Action:
To select "physical change of precursor," press the down arrow key. Then press <Enter>.

Result:
SWAMI presents the next question: "What type of physical change occurs to the precursor?"

Explanation:
You have selected "physical change of precursor" as the best answer to the question.

Step #100

Action:
To select "physically contaminated (dirty)," press the down arrow key 3 times. Then press <Enter>.

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