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Evaluation of Six Options for Obtaining Red Water

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The mission of the U. S. Army Environmental Center (AEC) includes conducting research and development in support of environmental compliance at Army installations. The AEC is conducting a research and development program to select and demonstrate the best available treatment technology for red water in support of environmental compliance at Army ammunition plants (AAPs). Red water is an aqueous effluent generated during production of trinitrotoluene (TNT) and is a listed hazardous waste. TNT is a key ingredient in many of military ordnances. The AEC previously completed a comparative evaluation of thirty potential red water treatment technologies. The evaluation resulted in identification of two technologies, wet air oxidation and circulating bed combustion, that are sufficiently advanced to to warrant pilot-scale demonstration. However, the demonstrations cannot be conducted until a source of approximately 50,000 gallons of red water is secured.

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Although four Army ammunition plants (AAPs) have the production facilities necessary for the manufacture of TNT (Radford AAP; Joliet AAP; Newport AAP; and Volunteer AAP) all of these TNT production facilities are currently in mothballed status. The Army's entire TNT requirement is currently purchased from ICI Explosives Canada. Because a source of red water is a prerequisite for evaluation of treatment technologies and because the Army currently does not produce TNT or generate red water, a source of red water must be identified. The AEC identified six potential sources, or options, for obtaining red water. They were:

1. Synthesize a surrogate mixture to simulate red water.
2. Restart TNT production at an Army AAP.
3. Construct and operate a TNT production pilot plant.
4. Obtain red water from ICI Explosives Canada.
5. Obtain red water from a foreign TNT producer.
6. Conduct the demonstration test at ICI Explosives Canada's facility near McMasterville, Quebec (near Montreal)

The objective of this report is to document an evaluation that was conducted to identify the most viable red water acquisition option. A preliminary screening was the first step in the evaluation of the six options. The purpose of this screening was to identify the most viable options that warranted more in depth evaluation and consideration. This screening was accomplished through an assessment focused on identification of fatal flaws. The specific criteria used to accomplish this screening were:

Representativeness -	Red water obtained must reasonably represent AAP red water.
Capacity -	50,000 gallons of red water must be available.
Compliance -	Acquisition must be comply with applicable regulations.
Schedule -	The red water must be available by mid-1994.
Cost -	The cost of acquisition must not exceed $5 million.

Three of the six options (synthesize red water, restart an Army AAP, and construct a TNT production pilot plant) were found to have fatal flaws. Insufficient data was available to complete the screening evaluation of foreign sources. The remaining two options (obtain red water from ICI Explosives Canada and conduct the demonstration at ICI's facility in McMasterville, Quebec) were subjected to more detailed evaluation.

In a detailed evaluation each option was assessed using a set of quantitative and qualitative criteria. Weighting factors were assigned to enhance objectivity. The evaluation criteria and the weighting factors are summarized below:

<u>Primary Quantitative Criteria</u>	
Representativeness	30%
Cost	20%
Capacity Limitations	5%
Time Constraints	5%
<u>Secondary Quantitative Criteria</u>	
Transportation Constraints	8%
Regulatory Requirements	8%
Safety Considerations	8%
Environmental Impact	8%
Trade Implications	8%
<u>Qualitative Criteria</u>	
Reliability	
Acquisition Risk	
Option Specific Issues	

Based on the results of the evaluation, conducting the test at the ICI facility in McMasterville, Quebec was concluded to be the most viable option. It is recommended that the AEC pursue negotiations with ICI Explosives Canada regarding this option.

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1.0 Introduction

1.1 Background

The mission of the U.S. Army Environmental Center (AEC) includes conducting research and development in support of environmental compliance at Army installations. The AEC is conducting a research and development program to select and demonstrate the best available red water treatment technology in support of environmental compliance at Army ammunition plants (AAPs). Red water is an aqueous effluent generated during the production of trinitrotoluene (TNT). TNT is a key ingredient in many military ordnances. Because of its reactivity, red water has been listed as a hazardous waste (K047) by the U.S. Environmental Protection Agency (EPA) under Subtitle C, Part 265, of the Resource Conservation and Recovery Act (RCRA).

The AEC previously completed a comparative evaluation of 30 potential red water treatment technologies[1]. The potential of each technology to provide a technically, economically, and environmentally acceptable method of treating red water was assessed. This evaluation resulted in the identification of four technologies that warranted further consideration. Two of these technologies, wet air oxidation and circulating bed combustion, were deemed to be sufficiently advanced to be ready for pilot-scale demonstration testing. The demonstrations cannot be undertaken, however, until a source is identified that can provide the volume of red water (approximately 50,000 gallons) that is needed for the tests.

Four AAPs are equipped with the production facilities necessary for the manufacture of TNT: Radford AAP (RAAP) near Radford, Virginia; Joliet AAP (JAAP) near Joliet, Illinois; Newport AAP (NAAP) near Newport, Indiana; and Volunteer AAP (VAAP) near Chattanooga, Tennessee. The TNT production facilities at these AAPs are currently idle and held in mothballed status. The Army's entire TNT requirement is currently purchased by the government from ICI Explosives Canada. Army AAPs do not produce TNT primarily because the peacetime requirement is insufficient to justify their operation on an economical basis. An additional factor involves environmental compliance. None of the AAPs currently has the capability to treat red water. Demonstration of an acceptable waste treatment technology is an important factor involved in increasing the readiness of these facilities for mobilization of TNT production capability.

Because a source of red water is a prerequisite for the evaluation of treatment technologies and because the Army currently does not produce TNT or generate red water, a source of red water must be identified. The AEC initially identified five potential sources, or options, for obtaining red water. They are:

1) Synthesize a surrogate mixture to simulate red water
2) Restart TNT production at an Army AAP
3) Construct and operate a TNT production pilot plant
4) Obtain red water from ICI Explosives Canada
5) Obtain red water from a foreign TNT producer

The premise of each of the options identified above is that red water would be acquired from the supplier and then shipped to a test facility in the United States. A sixth option is available that would not involve shipment of red water, but instead would involve conducting the treatment tests at the point of generation. Therefore, the following option was added to the current evaluation:

6) Conduct the demonstration test at the ICI Explosives Canada facility near McMasterville, Quebec (near Montreal).

1.2 Objective
The objective of this report is to document the technical approach used as well as the results of an evaluation conducted to identify the most viable option for obtaining red water for pilot-scale demonstration testing of waste treatment technologies.

1.3 Technical Approach
The technical approach used to complete this effort was designed to allow a comparative evaluation of the six options in an objective and efficient manner. This was accomplished with the development of a set of evaluation criteria for both a preliminary screening step and the detailed evaluation. The screening criteria were designed to permit early identification of those options that exhibit major flaws with respect to preestablished requirements or constraints regarding representativeness, capacity, regulatory compliance, time, and cost. Options failing the screening criteria were eliminated from further in-depth investigation if they exhibited a fatal flaw. Options passing the screening criteria were subjected to an in-depth evaluation using both qualitative and quantitative criteria. The quantitative evaluation criteria were divided into two subsets. The first subset included representativeness, cost, capacity limitations, and time constraints; the second subset included transportation constraints, regulatory requirements, safety considerations, environmental impacts, and trade

implications. The qualitative criteria included reliability, acquisition risk, and option-specific issues.

1.4 Report Organization

In the remainder of this report, the screening and evaluation criteria are defined, the methodology used to conduct the evaluation is described, and the results obtained and recommendations made are presented. Sections 2 and 3 present a discussion of the TNT production process and red water characteristics, respectively. Section 4 provides a description of the evaluation criteria. The preliminary screening of options is discussed in Section 5. Section 6 presents the detailed evaluation of the preferred options. The report concludes with recommendations provided in Section 7.

2.0 TNT Synthesis and Production Technology

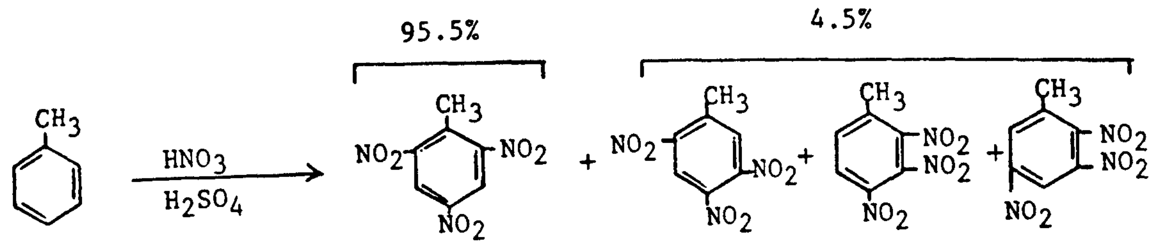
Red water is the main waste stream resulting from the manufacture of TNT. This section describes the basic synthesis and production technologies involved in the manufacture of TNT. This discussion is presented to define the generation of this waste and to provide a basis for assumptions made later in the report regarding red water characteristics.

2.1 TNT Synthesis

The synthesis of TNT involves treatment of liquid toluene with mixed nitric and sulfuric acids followed by removal of undesired isomers and residual dinitrated toluene by conversion to soluble species and extraction.

The first step, nitration, is accomplished in three successive stages whereby a nitro (-NO_2) group is attached at the 2, 4, and 6 positions of the benzene ring of toluene[2]. Substitution of the nitro group for hydrogen results in water formation requiring higher reaction temperatures for successive nitration steps. Consequently, the reaction acids are added in reverse order. An anhydrous, extremely strong 98% nitric acid and 40% oleum or fuming acid are first introduced at the third or trinitration step. In a somewhat diluted state, the waste acid leaves this nitration step stripped of most of the nitric acid and sulfuric acid. This waste acid is fortified with 60% nitric acid to accomplish the second or bionitration step. Again, the waste acid from this step is further fortified with weak nitric acid to accomplish the first or mononitration step in which the toluene is introduced to the process.

The TNT isomer sought in the nitration process is the alpha form or the symmetrical 2,4,6. The nitration process described above results in 95.5% of the desired product. The balance consists of asymmetrical TNT isomers such as the beta (2,3,4) and the gamma (3,4,6) as well as other impurities[2].



Purification of raw TNT requires treatment with a sellite solution containing sodium bisulfite and 16% sodium sulfite[2]. The sellite solution essentially dissolves the impurities, leaving the purified alpha TNT. The wash solution assumes a bright red color and is known as red water. The composition and characteristics of red water are discussed in Section 3 of this report.

2.2 TNT Production Technology

Two major variations of TNT production technology, as described below, are in current use: the conventional, three-stage, batch process; and the newer, patented, continuous, Canadian Industries Limited (CIL) process. Both variations use the same chemical synthesis described earlier. However, the physical facilities and some of the operational parameters are different and the characteristics of red water generation vary. The U.S. Army Ammunition Plants at four locations (Radford, Joliet, Newport, and Volunteer) are equipped with facilities for manufacturing TNT. The Radford and Newport AAPs can produce TNT by the continuous process, and Joliet and Volunteer can produce TNT by either the continuous process or batch process (Table 2-1).

2.2.1 Conventional Batch Process

The nitration reactions in the batch process used by AAPs are carried out in three consecutive batch units referred to as "Mono," "Bi," and "Tri" Houses[2]. A simplified flow diagram of this process is shown in Figure 2-1. The process controls at each house are exercised manually. The feed chemicals to the Mono House are toluene, and the waste acid from the Bi House is fortified with 60% HNO_3. Reaction to mononitrololuene goes smoothly and exothermically, and cooling coils are used to keep the temperature at about 40°C during mixing and then at about 60°C for approximately an hour afterward. All three isomers, ortho-, meta-, and para-, are formed; but the ortho- is predominant. The ortho- and para-isomers nitrate further to α-TNT in later stages, but the meta- isomer represents an impurity that ultimately shows up in the red water.

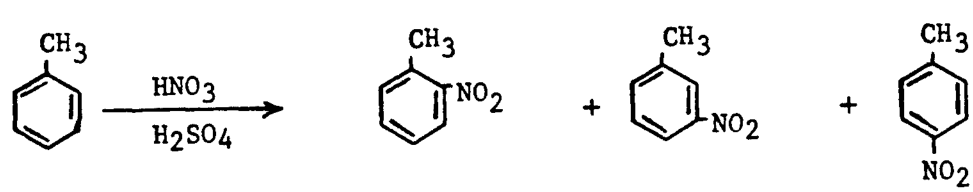


Table 2-1. North American Producers of TNT*

Producer/Process	TNT Capacity (10^6 Pounds/Month)	Red Water Generation (10^6 Gallons/Month)
RADFORD AAP		
Continuous Process	6	0.5
JOLIET AAP		
Continuous	18	1.5
Batch	30	2.5
VOLENTEER AAP		
Continuous	18	1.5
Batch	15	1.3
NEWPORT		
Continuous	15	1.3
ICI EXPLOSIVES CANADA Continuous	2	0.2

* Information supplied by AEC.

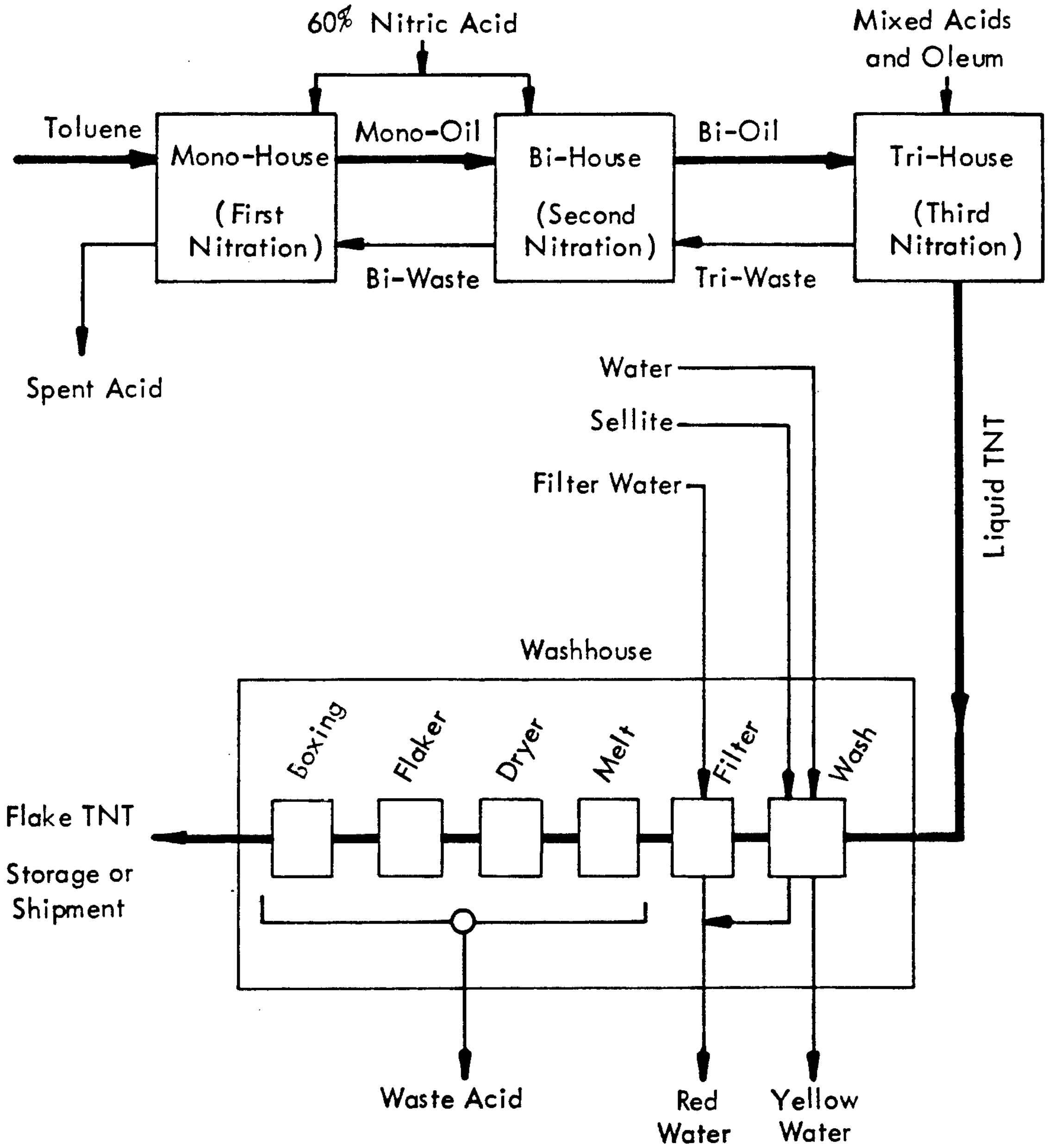


Figure 2-1.
Batch Process for TNT Manufacture.

Source: Reference No. 2

After reaction, the charge is allowed to settle. The waste acid is transferred to a storage tank for subsequent recovery, and the partially nitrated toluene ("mono oil") is pumped to the Bi House where further nitration takes place with waste acid from the Tri House fortified with 60% HNO_3. This time, the temperature is raised in steps to 90°C, and the result is a mixture of all possible dinitrated isomers - "Bi Oil."

After settling and separation, the Bi Oil is pumped to the Tri House where the feed acid is a mixture of 98% nitric acid and oleum. Temperatures are staged up to 120°C for approximately two hours. The nitrated product from this third nitration stage operation is crude TNT containing α-TNT (2,4,6 trinitrotoluene), which is the desired product, and unsymmetrical TNT isomers, which are the primary impurities. The crude TNT is then fed to the Wash House for purification.

The purification of crude TNT involves crystallization in water, neutralization of free acid with soda ash, and solubilization and removal of undesirable nitrated products by treatment with a solution of sodium sulfite (sellite). The wastewater from the sellite purification stage is the red water. In addition to red water, which is generated at a rate of approximately 1 gallon per 10 pounds of TNT produced, three other waste streams (spent acid, waste acid, and yellow water) are generated.

2.2.2 CIL Continuous Process

The Canadian Industries Limited (CIL) continuous process is the state-of-the-art TNT production technology. A simplified flow diagram of this process is shown in Figure 2-2. In this case, toluene nitration is carried out in six nitrator-separator stages with the organic phase (toluene-nitrobody mixture) flowing countercurrent to the acid phase. The first and third nitration stages have two nitration vessels per separator, whereas the remaining four stages have only one nitrator vessel per separator. The process produces a somewhat reduced waste stream as compared to the batch process because of its more efficient control of process conditions and better utilization of recycle streams[2].

The CIL purification operation (Figure 2-3) is also an incremental improvement over the conventional process. The crude molten TNT first passes through a mixer-settler-washer where five separate countercurrent water washes remove the free acids. The acid wash (yellow water) is returned to nitrator No. 2 as acid makeup. The TNT then flows through two sellite washers in series where it is neutralized with soda ash and treated with sodium sulfite. Each of the sellite washers is followed by a separator to separate the aqueous phase (red water) from the purified TNT phase. The dilute red water from the second separator is returned to the first separator, and the more concentrated red water from the first separator is sent for treatment and disposal. The sellite-treated TNT receives final countercurrent water washes and is pumped to the finishing building for drying, flaking, and packaging.

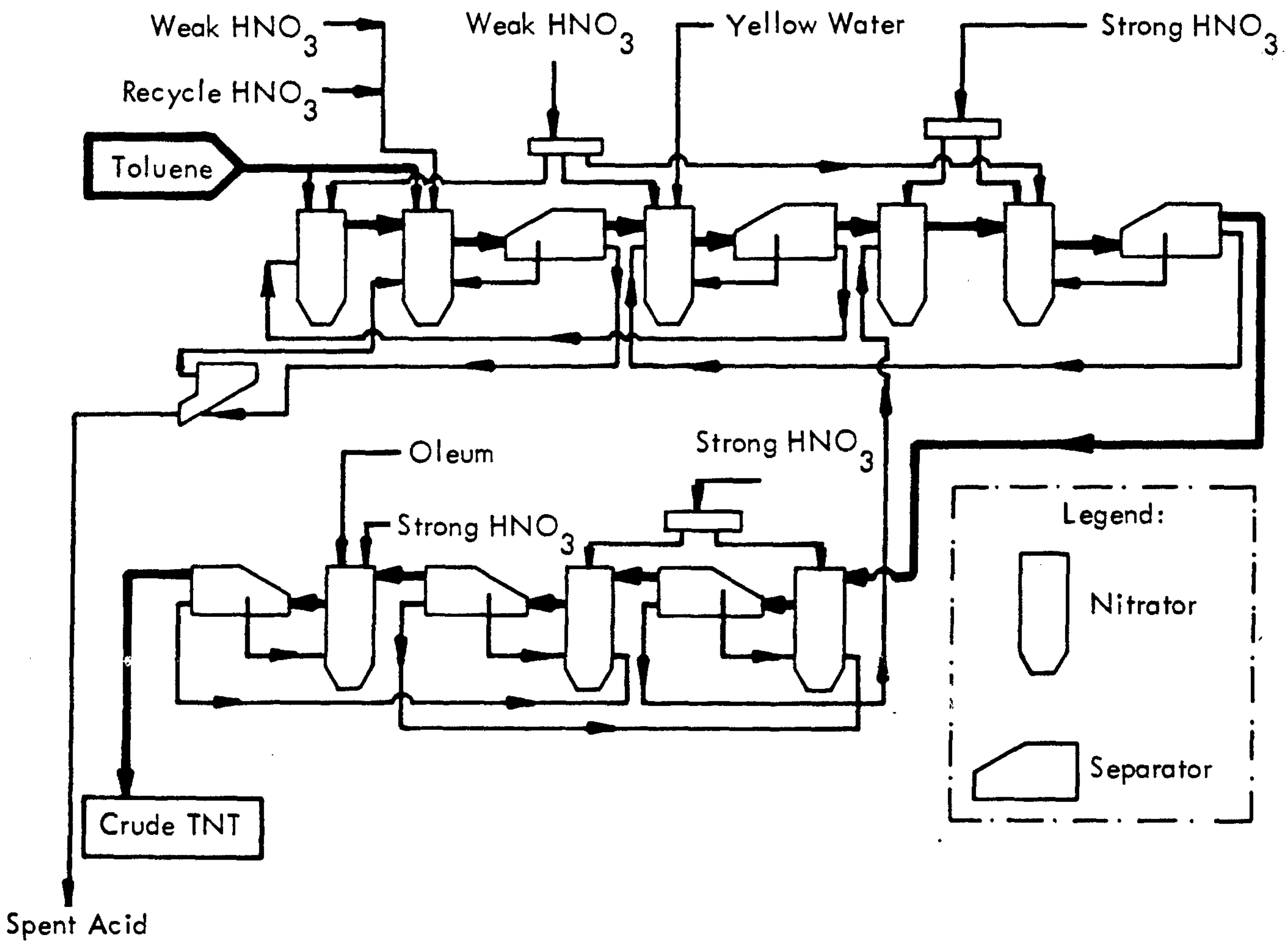


Figure 2-2.
CIL Continuous Process for TNT Manufacture.

Source: Reference No. 2

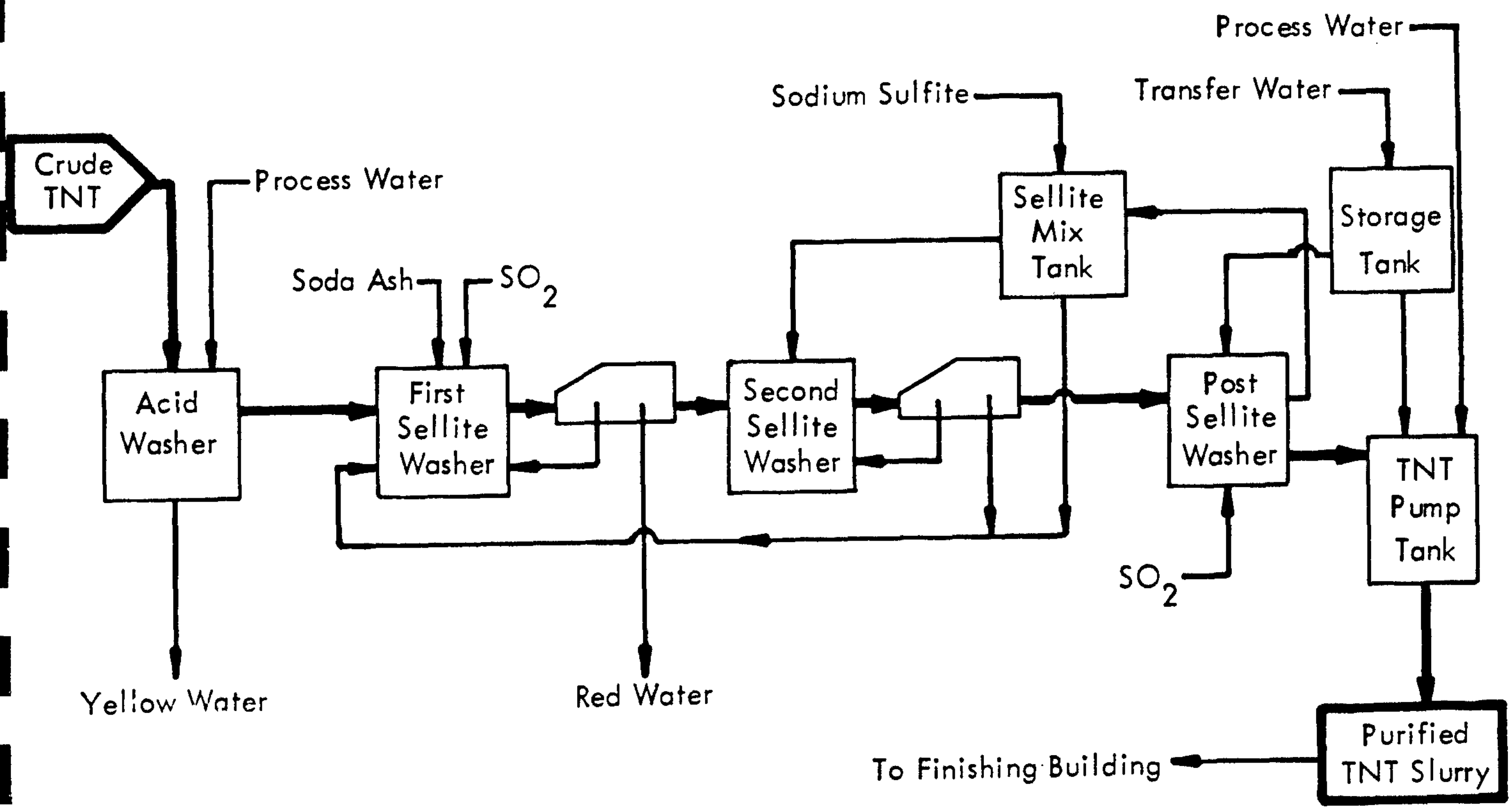


Figure 2-3.
TNT Purification, CIL Continuous Process.

Source: Reference No. 2

3.0 Characteristics of Red Water

The characteristics of red water and the extent of available characterization data are discussed in this section. The purpose of this discussion is to provide an understanding of the chemical and physical nature of this waste in order to support discussions presented later in the report, especially those discussions related to interpretations of how representative one red water might be of another.

Red water is the aqueous effluent generated during sellite purification of crude TNT. Red water has a deep red, or sometimes black color, and is a complex and somewhat variable mixture. Depending upon the TNT production process and the degree of water recycle used, red water generally contains from 15 to over 30 percents solids, has a pH in the range of 7.0 to 9.7, and a specific gravity of approximately 1.1. Roughly half of the solids are inorganic salts (sodium sulfate, sodium sulfite, sodium nitrate, and sodium nitrite); the remainder are nitrobodies including mainly sodium sulfonates of trinitrotoluene and an alpha - TNT - sellite complex. TNT is present in only trace amounts. Other organic constituents include complex, unidentified dye bodies formed from the photolysis of alpha - TNT by sunlight. The heavy metals present in the red water are thought to be a result of acid leaching from the stainless steel reaction vessels and holding tanks[3]. A summary of the characteristics of red water generated by the continuous TNT production process at RAAP is presented in Table 3-1. Information on the composition of the solids contained in red water is presented in Table 3-2. These data are not traceable to a single analysis but are a summation of available information compiled by RAAP. The data are based on actual analyses and on engineering judgement. Results of a Toxicity Characteristic Leaching Procedure (TCLP) test performed on a RAAP red water sample are given in Table 3-3. The data presented in these three tables was supplied by AEC; its exact origin is not known.

Based on the discussion held during the preparation of this report with representatives of RAAP and the McMasterville TNT plant of ICI Explosives Canada, it is believed that the composition of red water can vary significantly[4,5]. This is apparently due to the fact that MIL SPEC grade TNT can be produced by a wide range of process and operating parameters. However, data on the variability of red water was not available for review during preparation of this evaluation.

The database documenting the chemical and physical characteristics of red water is extremely limited. This is primarily due to the fact that red water has not been generated at Army facilities for a number of years. During the time of generation, the need for detailed characterization did not exist; therefore, an analytical database was not compiled. Additionally, during this time analytical methodology associated with quantitation of the unique compounds present was not well advanced. For example, the determination of meta-TNT sulfonates (2, 4, 5- and 2, 3, 4-TNT) presented considerable problems to researchers at RAAP[3]. This was primarily due to the fact that pure unsymmetrical isomers could not be reacted with sodium sulfite to prepare standards. These factors result in the limited database that exists today.

Table 3-1.
Characteristics of RAAP Red Water[a]

Water content:	84.6%
Mixed Organics:	8.7%
Mixed Inorganics:	6.7%
pH:	7.0 - .7
Color:	Dark red
Sp. G:	1.1 nominal
Dry solids:	Will burn
Solids heat value:	Variable (3200 BTU/lb nominal)

[a] Data supplied by AEC; red water was generated by RAAP's continuous TNT process lines.

Table 3-2. Composition of Solids Contained in RAAP Red Water[a]

Inorganic Salts	Percent by Weight
Sodium sulfite (Na_2SO_3)	21.5
Sodium sulfate (Na_2SO_4)	10.8
Sodium nitrate ($NaNO_2$)	11.2
Sodium nitrate ($NaNO_3$)	1.5
Sodium sulfide (NaHS-Na_2S)	May be present
Sodium carbonate/bicarbonate	May be present
Organic Nitrobodies	
Sodium sulfonate of 2, 4, 5-TNT	22.7
Sodium sulfonate of 2, 3, 4-TNT	9.6
Sodium sulfonate of 2, 3, 6-TNT	2.0
Sodium sulfonate of 2, 3, 5-TNT	Trace
2, 4, 6-TNT (trinitrobenzoic acid) sodium salt	1.0
Alpha-TNT-Sellite complex	16.2
White compound sodium salt[b]	1.0
TNBAL-bisulfite addition compound (trinitrobenzaldehyde)	1.0
TNBOH (trinitrobenzyl alcohol)	1.0
Sodium nitroformate	0.5
3, 4-DNBA (dinitrobenzoic acid) sodium salt	Trace
2, 3-DNBA (dinitrobenzoic acid) sodium salt	Trace
TNB (trinitrobenzene)-Sellite complex	Trace
Dissolved 2, 4-DNT (dinitrotoluene)	Trace
Dissolved α-TNT (trinitrotoluene)	Trace

[a] Data supplied by AEC; red water was generated by RAAPs continuous process lines.

[b] "White compound" is believed to be 2,2-dicarboxy-3,3,"5,5"-tetranitroazoxybenzene.

Table 3-3. Results of a Toxicity Characteristic Leaching Procedure Test On RAAP Red Water[a]

Contaminant	Concentration (mg/l)	Regulatory Level (mg/l)
Arsenic	0.882 mg/km	5.0
Barium	<15 mg/kg	100
Benzene	<0.010	0.5
Cadmium	<0.250 mg/kg	1.0
Carbon Tetrachloride	<0.010	0.5
Chlordane	<2.00	0.03
Chlorobenzene	<0.010	100.0
Chloroform	<0.010	6.0
Chromium	<2.50 mg/kg	5.0
o-Cresol	<100	200.0
m-Cresol	<100	200.0
p-Cresol	<100	200.0
Cresol	<100	200.0
2,4-D	<5.0	10.0
1,4-Dichlorobenzene	<0.010	7.5
1,2-Dichloroethane	<0.010	0.5
1,1-Dichloroethylene	0.094	0.7
2,4-Dinitrotoluene	36.6	0.13
Endrin	<2.00	0.02
Heptachlor (& OH)	<2.00	0.008
Hexachlorobenzene	<2.00	0.13
Hexachlorobutadiene	<2.00	0.5
Hexachloroethane	<2.00	3.0
Lead	<5 mg/kg	5.0
Lindane	<2.00	0.4
Mercury	<0.100 mg/kg	0.2
Methoxychlor	<5.0	10.0
Methyl Ethyl Ketone	<0.100	200.0
Nitrobenzene	<2.00	2.0
Pentachlorophenol	<50.0	100.0
Pyridine	<10	5.0

[a] Data supplied be AEC

4.0 Development of Evaluation Criteria

A defined set of evaluation criteria was developed to ensure that a logical, consistent, and predetermined framework was used in the evaluation process. The criteria were based on AEC program requirements, technical aspects related to red water and treatability testing, and applicable regulations. The specific evaluation process that was used to rank the six red water acquisition options is described in this section.

4.1 Rationale for Preliminary Screening

A two-stage approach was used in the application of the evaluation criteria. First, each of the six red water acquisition options was evaluated against a set of screening criteria. These screening criteria were defined by AEC programmatic prerequisites. In order for an option to be viable and receive further consideration and evaluation, it must first meet the requirements stipulated by the screening criteria. Failure to meet one or more of the screening criteria was considered to be a fatal flaw. The screening criteria addressed source capacity, regulatory compliance, time, and cost. These criteria are described in the following paragraphs.

<u>Representativeness</u> In order for the AEC's demonstration of red water treatment technologies to be valid, the red water used must either be actual AAP red water or must reasonably approximate AAP red water. Because sufficient analytical data is not available to make this determination on a statistical basis, it can only be made by comparison of the origin of the red waters. For purposes of preliminary screening, red water must be generated by the same type of production process used at AAP's (i.e., CIL continuous process).

<u>Source Capacity</u> The AEC red water treatment demonstration program requires an estimated 50,000 gallons of red water. The estimated volume was based on the following assumed specifics of the planned research and development effort. A minimum treatability evaluation would involve demonstrating both technologies under at least three sets of operating conditions. A minimum of three runs at each condition and a minimum of 16 hours per run have been assumed. The flow rate would likely be in the range of three gallons per minute. The red water volume requirement of approximately 50,000 gallons was estimated on this basis (i.e., 2 technologies x 3 tests/technology x 3 runs/test x 16 hr/run x 60 min/hr x 3 gal/min). The actual test program ultimately may require significantly more red water, especially if the number of tests or test durations

are increased. The volume estimate of 50,000 gallons was considered to be a minimum requirement for the purpose of screening potential options. The ability of a TNT producer to provide this volume is determined by the rate of TNT production and water use and recycle practices, which dictate the rate of red water generation.

Regulatory Compliance An inviolate prerequisite of all AEC programs is that they be conducted in strict compliance with all applicable regulations. In the current evaluation and for purposes of screening potential options, the following conditions would have to exist before an option could be considered viable: 1) the generating facility must be operating in full regulatory compliance; 2) transfer of ownership of the red water from the generator to the Army or to the test facility must not violate any domestic regulations or international laws or treaties; and 3) reasonable means must exist to allow the legal, permitted transport of red water.

Time The AEC must proceed with the red water treatment demonstrations in compliance with the Army's red water program schedule and as directed by the U.S. Congress. Based on previous attempts to acquire red water (e.g., the efforts conducted by CERL to acquire 5,000 gallons of red water), a significant amount of time will likely be required to initiate and bring to closure the necessary negotiations with the ultimate supplier. Although it is not possible to accurately predict this time frame, reasonable estimates can be made based on the complexities involved and on past experience. For the purpose of initial screening, the AEC determined that the contractual mechanism for obtaining the red water must be finalized by mid-1993. The targeted test date for delivery of red water is mid-1994.

Cost All research and development efforts are limited by available resources. Cost of red water acquisition was included in the options screening process in order to rule out any option that is so inherently expensive that it cannot reasonably be considered. The AEC determined that $5 million should be considered as the upper limit for this purpose. Options requiring government expenditures in excess of this amount for acquisition transport and storage were not considered to be viable. Additionally, a cost in the range of $1 to $5 million was determined to be highly questionable.

4.2 Quantitative Evaluation Criteria

In order to more fully assess the viability of potential red water acquisition options which met the screening criteria, nine quantitative evaluation criteria were defined that can be applied objectively. They are grouped into two categories: primary and secondary. The primary quantitative criteria are representativeness, cost, capacity limitations, and time constraints. Five additional quantitative criteria were classified as secondary: transportation constraints, regulatory requirements, safety considerations, environmental impact, and trade implications. These are classified as secondary criteria because they can be controlled or managed by the AEC to a greater extent than the primary criteria which cannot.

A weighting system was used to evaluate the options in terms of these criteria. The primary quantitative criteria were weighted more heavily than the secondary criteria because they reflect issues beyond the control of the program. The four primary criteria received 60 percent of the total weighting while the five secondary criteria received 40 percent. A summary of the weighting factors associated with each criterion is presented at the end of this section. The following summaries are presented to provide an understanding of these quantitative criteria.

<u>Representativeness</u> A critical scientific and engineering requirement associated with any waste treatment technology demonstration is that the sample of waste used in the demonstration must adequately represent the waste stream of concern. If it does not, the reliability and usefulness of the technology demonstration may be seriously compromised. The most advantageous situation is to conduct waste treatment testing on the actual waste at the point of generation. Only one of the potential options would provide this: restarting one of the CIL continuous process TNT production lines at an AAP. All other options involve use of non-AAP red water. For these options, the question of representativeness is critical.

A significant complication in assessing representativeness of non-AAP red water is the lack of characterization data. AAPs have not generated red water for several years and did not fully characterize it during the time of generation. Therefore, the basis for applying the criterion of representativeness must be something other than comparisons of analytical data sets. The basis selected for assessing representativeness is production process and feed stocks. AAP TNT production lines use the CIL sellite purification process in continuous mode, as discussed in Section 2. It is assumed that the characterization of red water generated at a non-AAP facility using the same production process and the same feed stocks would approximate the characteristics of AAP red water. The validity of this assumption, however, can only be assessed if and when an AAP TNT line is restarted.

<u>Cost</u> It was anticipated that the cost associated with the red water acquisition options would vary significantly, perhaps by orders of magnitude. The application of this criterion is much more straightforward than that associated with representativeness. Once the costs associated with each option are estimated, a relative ranking can be simply made with lower cost options ranking higher than higher cost options. However, the least costly option may not necessarily be the preferred option if the option does not provide red water that is representative of AAP red water. Costs include purchase cost, if any, for red water, transportation, and storage.

<u>Capacity Limitations</u> Once an option was determined to be capable of providing 50,000 gallons of red water, capacity limitations were assessed in terms of average waste generation rate and production schedules (e.g., scheduled shut downs, etc.). As with cost application, this criterion is a simple ranking once the required information is available.

<u>Time Constraints</u> The time required for acquisition and shipment of red water can only be estimated. The sooner a red water acquisition option can be implemented, the more advantageous it is to the AEC program. Similar to the criteria of costs and capacity, the application of this criterion involves a ranking of options with those requiring less time being more favorable than those requiring more.

The five secondary quantitative criteria are summarized below.

<u>Transportation Constraints</u> Transportation of any hazardous material presents a series of legal and logistical hurdles. Shipment of hazardous waste is complicated further if it involves crossing state or national boundaries. The impact of international transportation regulations and treaties must be assessed if red water is to be acquired from a foreign country. In addition, limitations may be placed on the import and export of hazardous waste. Similarly, limitations may be found on acceptable shipping vessels or containers and modes of transport. This evaluation criterion is intended to assess the relative degree of complexity related to the transportation of red water under each option.

Regulatory Requirements The acquisition, transportation, storage, and handling of hazardous waste are stringently regulated. Federal, state, and local regulations may apply. At a minimum, the Resource Conservation and Recovery Act (RCRA) and Department of Transportation (DOT) regulations must be followed. Under these regulations, permit requirements have been established for handling, transporting, storing, treating, and disposing of hazardous waste. Substantial legal liabilities are associated with these requirements. The intent of this criterion is to assess the relative degree of regulatory complexity associated with each option. Increased regulatory complexity leads to greater uncertainty and potentially more cost and longer schedules.

Safety Considerations The acquisition and transport of hazardous waste present an inherent set of safety concerns. Both worker and public safety must be considered. These concerns are magnified by longer transport distances and the frequency of waste handling. Although red water is not believed to be reactive or explosive, there is valid concern over red water residues. For example, if the solids contained in red water are permitted to accumulate and dry, a significant fire and explosion hazard may be created. A relative ranking of safety considerations is included in the evaluation to address these types of concerns.

Environmental Impact All options present some form of potential environmental impact. Red water is a hazardous waste because of its potential reactivity. Several red water components are toxic. Any release would present concerns over environmental impact. As with transportation and safety concerns, the longer transport distance and more handling result in a greater potential for accidental releases and environmental impact.

Trade Implications Production of TNT is an international business. As indicated earlier, the U.S. military does not currently produce TNT but purchases 100 percent of its requirements from a Canadian firm. The conduct of this program may lead to real or inferred concerns over international trade in the commodity. Previously, ICI had expressed concern over a potential loss of TNT sales if this effort leads to restarting an AAP[6]. Additionally, the acquisition and transportation of hazardous waste across international boundaries may present concerns related to international trade. For example, the Basel Convention is aimed at controlling international trade in hazardous waste involving less developed countries. The objective of this criterion is to provide an assessment in relative terms of trade implications associated with the options considered.

4.3 Qualitative Evaluation Criteria

The evaluation criteria discussed in Section 4.2 can be quantified in terms of cost, time, or other specific measurements. The criteria addressed in this section cannot be as readily quantified and therefore their application is subjective. These subjective, or qualitative, criteria include: reliability, acquisition risk, and option-specific issues. The reliability criterion is a subjective measure of how dependable the source of red water is believed to be. This assessment is based on past experience, if any, with the source and on communications during the course of the evaluation with the source or with others who have dealt with the source. Acquisition risk is a qualitative measure of the probability for unanticipated problems to arise during the acquisition process. This is an assessment of the complexity involved and the degree of control that can be exercised. Finally, option- specific issues are subjective assessments of issues unique to a given option. These may include political considerations or policy determinations made by the potential supplier.

4.4 Weighting Factors

As a means of increasing the objectivity of the evaluation, a weighting factor was assigned to each criterion. These factors are expressed in percentage and are listed below:

Table 4-1. Weighting Factors Assigned to Quantitative Evaluation Criteria

Primary Quantitative Criteria	
Representativeness	Total Max Points = 30
AAP red water	30
CIL process, AAP feedstocks, no storage	25
CIL process, no storage	20
CIL process, storage/transport	15
Batch process	10
Cost ($)	Total Max Points = 20
1 to 5 million	5
0.25 to 1 million	10
0 to 0.25 million	20

Table 4.1 (Continued)

Capacity	Total Max Points = 5
Capacity to generate 50,000 gallons in:	
over 3 months	1
1 to 3 months	3
less than 1 month	5
Time (to finalize agreements)	Total Max Points = 5
By September 1993	5
After September 1993	2
TOTAL MAXIMUM POINTS FOR PRIMARY CRITERIA	60
Secondary Quantitative Criteria	
Transportation	Total Max Points = 8
Primary Quantitative Criteria	
Transoceanic shipments	2
International transport	5
No transport	8
Regulatory Requirements	Total Max Points = 8
Transoceanic/Multiple international borders	2
International shipment/single border	5
No shipment	8
Safety	Total Max Points = 8
Multiple carriers/multiple modes	2
Single carrier/single mode	5
No shipment	8
Environmental	Total Max Points = 8
Transoceanic and land transport	2
Land transport	5
No shipment	8
Trade Implications	Total Max Points = 8
Current supplier	2
No trade relationships	5
None identified	8
TOTAL MAXIMUM POINTS FOR SECONDARY CRITERIA	40
TOTAL MAXIMUM WEIGHTING POINTS AWARDED	100

5.0 Preliminary Screening of Options

As discussed in Section 4, a preliminary screening was the first step in the evaluation of the six options considered for obtaining red water. The objective of this screening was to identify the most viable options that warrant more in-depth evaluation and consideration. This screening was accomplished through an initial assessment focused on identification of fatal flaws. The following specific criteria were used to accomplish this screening:

Representativeness -	The red water obtained must reasonably represent AAP red water.
Capacity -	At least 50,000 gallons of red water must be available.
Compliance -	Acquisition must be in compliance with applicable regulations.
Schedule -	The red water must be available by mid-1994.
Cost -	The cost of acquisition must not exceed $5 million.

Discussions of each option in terms of these screening criteria are presented in the remainder of this section. The results of the screening process are then presented along with a discussion of those options selected for more detailed evaluation.

5.1 Synthesize Red Water

Background One method that has been used for conducting evaluations of waste treatment technologies is the preparation of synthetic or surrogate mixtures with an essentially identical chemical composition or that mimic the characteristics of the actual waste. The use of synthetic wastes presents several advantages over testing conducted with actual waste. The main advantages are: 1) the synthetic waste can be prepared in essentially any required volume; 2) tests can be conducted at non-RCRA permitted facilities because the synthetic waste is not a RCRA hazardous waste and therefore not a RCRA-regulated material; and 3) the characteristics of the synthetic waste are predetermined and can be controlled. Additionally, because the components of the synthetic waste are known, health and safety concerns can be more readily addressed than is the case with a waste of unknown or variable composition. These advantages associated with synthetic waste testing led to the inclusion of this option in the current evaluation.

For the synthesis of a surrogate waste to present an acceptable option, the composition of the actual waste must be known in sufficient detail and the components must be available. This would include, for example, not only knowledge of which metals are present but also their speciation. Ideally, the waste being simulated would have a consistent composition (i.e., small variability in characteristics). This would simplify the preparation of the surrogate and would reduce the uncertainty in evaluating the test results. At a minimum, sufficient characterization data should be available to allow a determination of the extremes in waste characteristics so that they can be considered in the formulation of the surrogate. For complex wastes, the chemistry and interaction of the components must be fully understood so that unknown or unanticipated by-products are not inadvertently formed during preparation of the surrogate. Finally, unless the surrogate and the actual waste can be tested side-by-side in a confirmation test, a significant assumption is required in the extrapolation of the results.

The U.S. EPA, for example, developed a synthetic analytical reference matrix (SARM) for use in comparative evaluations of treatment technologies[7]. The SARM was designed as a reference matrix to represent contaminated soil found at Superfund sites. (In this case, the EPA was using the SARM to mimic a class of waste, not a site-specific waste.) The SARM contained a wide range of chemical and metal contaminants, including organics and various metal species. During the studies conduced with the SARM, differences were noted between tests conducted with SARM and tests conducted with actual contaminated soil.

Representativeness As indicated above, a detailed knowledge of the composition and characteristics of the waste is a prerequisite to the use of a synthetic surrogate. In the case of red water, a complete data-base of waste composition is not available. This lack of information is due to several issues. First, until the advent of the RCRA regulations and the evolution of pollution prevention and waste minimization initiatives, there was no need to characterize production waste streams. The primary concern of any manufacturing facility was focused primarily on the composition and characteristics of the product. Unless information relative to the production process or product quality could be derived from an analysis of the waste generated, the characteristics of the waste typically were not a major concern.

The dearth of characterization data associated with red water is quickly evident upon review of the data set presented earlier in this report for RAAP red water (Section 3). Although the available data (presented in Table 3-1 and 3-2) identify a number of specific compounds, the data set also includes components described in generic terms such as "white compound sodium salt." The validity and usefulness of this data set is compromised further because it reportedly is a combination of analytical measurements and engineering estimates. During the course of this evaluation, efforts were made to identify and obtain additional red water characterization data. Discussions were held with representative of RAAP and the Army's current TNT supplier, ICI Explosives Canada, and the ICI facility was toured including observation of the red water generated[4,5]. However, characterization data were not available for many of the same reasons discussed above. Efforts to obtain additional red water characterization data were unsuccessful.

This lack of data could potentially be overcome through completion of a thorough characterization of a red water waste stream that is currently being generated. For example, a research program could be implemented (assuming the generator would agree to cooperate) to sample and analyze red water generated by ICI Explosives Canada or another TNT producer. Such a program would be a complex undertaking. Discussions conducted with representatives of the ICI facility indicated that there are significant and unpredictable variations in the characteristics of the red water generated. To capture this variability, the characterization program must include the development of a long-term monitoring effort that would generate statistically valid data. Because the waste composition is largely unknown and because standard analytical methods may not be available for all of the compounds present, the research program would also have to include the development of analytical methodology. Such a program would be a significant undertaking. The major concern over implementing such an effort would be that at the completion of the program, one would still not know the composition or characteristics of AAP wastewater. Use of a surrogate waste developed to mimic a non-AAP red water would multiply the degree of uncertainty associated with the representativeness of such a material.

Based on the lack of characterization data alone, it can be reasonably concluded that the preparation of a surrogate is not a viable option. This option, however, is further confounded by the fact that at least some of the known components are not commercially available. During recent research conducted by CERL, for example, it was reported that no commercial source could be found for the unsymmetrical isomers of TNT and DNT sulfonates, which are believed to be a significant component[8]. This lack of availability would necessitate the chemical synthesis of these compounds prior to their use to synthesize a surrogate waste. Again the concern over representativeness would be magnified.

Assessment This option was found to contain a fatal flaw: a synthetic waste cannot be prepared because the characteristics and composition of AAP red water are not known completely and because some important components are not available for use. Because of the overwhelming limitations presented above, this assessment has not included a further discussion of this option in terms of the remaining screening evaluation criteria (capacity, compliance, schedule, and cost).

5.2 Restart TNT Production at an Army Ammunition Plant

Background Upon initial review of the problem associated with the current unavailability of red water, the most obvious solution would appear to be restarting an AAP and generating the red water needed. This option appears, at face value, to be the most direct and avoids the question of representativeness. For these reasons, this option was included in the evaluation.

The TNT production equipment and support facilities required are believed to be available at four AAPs. The Radford AAP is designated as the "warm" facility and, as such, is maintained in a higher state of readiness relative to the others. For purposes of this evaluation, the discussion is therefore limited to the Radford plant. This facility was the only AAP visited during the course of this evaluation. The majority of the information used in the evaluation of this option was obtained during the on-site meeting at RAAP[4].

Representativeness As mentioned previously, representativeness would seem to be of minor concern with this option. However, several issues complicate this initial assessment. First, as pointed out earlier (see Section 3), it is believed that red water characteristics vary significantly during production. The degree of this variability is unknown. Based on general engineering experience with the start-up of complex production systems, variations are known to occur during the early stages of operation. These variations occur in both the product and waste streams. It can be concluded, therefore, that the process would have to be brought on line and reach steady-state operating conditions before the waste stream could be assumed to be representative to any degree. In spite of these concerns, however, this would be the most favored option in terms of this criterion.

Capacity The screening criterion for capacity requires that the source of red water possess the capacity to generate and provide for testing a minimum of 50,000 gallons of red water. The TNT production lines at RAAP, when operating at full capacity, would generate an estimated 10,000 gallons of red water per day. At this rate, 50,000 gallons would be generated in only 5 days. This option therefore meets the capacity criterion.

Although this option meets the minimum volume requirement, a significant problem arises in the volume of red water that would be generated during the operation of the facility. Based on information provided by representatives of RAAP, the minimum production run is 9 million pounds of TNT. (This minimum run is apparently either a minimum in terms of economic assessment or in terms of the requirements of the prime contract with the government, or both.) RAAP representatives estimate that approximately 1 million gallons of red water would be generated during the minimum run. Once the 50,000 gallons for testing is removed, RAAP would have an excess of about 950,000 gallons of red water that would require disposal.

<u>Compliance</u> This screening criterion stipulates that red water must be acquired in strict compliance with applicable regulations. Although RAAP's permit to operate the TNT process line, as issued by the Commonwealth of Virginia, extended beyond the last production run, it expired subsequent to activities conducted in support of Desert Shield/Desert Storm. The Commonwealth of Virginia has indicated to RAAP representatives that it would not extend the past permit but would require a totally new submittal prior to a restart. Therefore, the necessary permits would have to be prepared, filed, reviewed by the state, revised and resubmitted by RAAP, and finally approved by the commonwealth prior to starting production.

Because red water is a listed hazardous waste (K047), it is subject to the EPA's land disposal restrictions. To be in compliance with these RCRA regulations, RAAP would have to transport and dispose of the excess red water at a RCRA-permitted treatment, storage, and disposal (TSD) facility. RAAP formerly had an agreement with a permitted TSD facility to dispose of red water. This agreement, however, does not include a guarantee that the TSD would accept red water in the future. RAAP currently cannot be restarted to generate red water in compliance with applicable regulations. A significant effort and commitment of resources would be necessary to meet these requirements.

<u>Schedule</u> The screening criterion for schedule stipulates that red water must be available for testing in mid-1994. Two major problems are related to restarting RAAP production lines in this time frame. First, RAAP does not hold the necessary RCRA permit to generate, store, or treat red water. The RCRA permitting process has historically been a time-consuming

process, often requiring several years of effort. It does not appear reasonable to assume that the required permits could be obtained in the required time frame. Secondly, the time required to mobilize the facility itself is considerable. For example, during the Desert Shield/Desert Storm activity, RAAP initiated the mobilization of the TNT production lines. Approximately three months were spent in this effort and RAAP personnel estimate that at least one additional month would have been required for completion. Although this time frame alone (i.e., four months) would not result in failure under the criterion, the time associated with allocating the necessary funding, training operators, and designing and installing new environmental controls that would likely be required to gain a RCRA permit would certainly preclude operation by mid-1994.

Cost This screening criterion limits the total cost of red water acquisition to $5 million or less. The cost of restarting RAAP was discussed with RAAP representatives during the on-site meeting conducted during this evaluation. The cost associated with this option can be grouped into at least five major categories: acquisition of required permits, system activation, system operation, layaway, and disposal of excess red water. During the recent TNT line mobilization activities, approximately $7 million was spent and an additional $5 million would have been required to achieve mobilization[4]. The costs estimated for each of the categories are presented in Table 5-1.

Table 5-1. Estimated Costs to Restart RAAP

System activation	$ 5 million[1]
Operation	$ 11.6 million[2]
Layaway	$ 1 million[3]
Red water disposal	$0.6 million[4]
Permitting	$ 1 million[3]
TOTAL	$ 19 million

[1] Assumes state of the lines does not deteriorate from current conditions.

[2] Hercules estimates that minimum economical production run is 9 million pounds of TNT at a cost of $1.29/pound.

[3] Based on best judgement.

[4] Disposal of 950,000 gallons of red at $0.65 per gallon.

The total estimated cost of approximately $19 million significantly exceeds the limit of this criterion.

Assessment The application of the screening criteria to this option revealed several fatal flaws. The RAAP facilities are not currently permitted to produce TNT or to generate red water, and a significant effort would be required to obtain these permits. The most obvious fatal flaws are apparent in terms of schedule and cost. Although the overall time required to obtain the necessary permits, install the required controls, train operators, and mobilize the system have not been defined in detail, it appears unreasonable to assume that the system could be mobilized in one year. In terms of cost, the estimated $19 million required to restart RAAP and complete a minimum production run significantly exceeds the $5 million cost criterion. Based on this assessment, this option was concluded to exhibit fatal flaws and was therefore excluded from further detailed evaluation.

5.3 Construct and Operate a TNT Production Pilot Plant

Background Under this scenario, a pilot plant sized to generate the needed volume of red water in the required time frame would be designed, constructed, and operated. This option offers some obvious advantages including the ability to select a location for the pilot plant. The plant could be located at an Army installation, ideally the same location as the treatability test location, to minimize the logistics of transporting the red water. The plant location could also be selected to take advantage of existing permits, trained operator personnel, and ancillary/support equipment and facilities such as acid production plants. The operation of a pilot plant also offers advantages over a full-scale system including lower operating cost, easier process modification, and potentially less-severe safety hazards.

Representativeness The pilot plant would be designed, constructed, and operated to mimic as closely as possible the characteristics of the full-scale RAAP system. On a relative scale, this option would rank second to operation of an AAP TNT line in terms of representativeness. The experience of RAAP personnel, however, indicated that the CIL process does not lend itself to direct scale-up; therefore, scale-down to a pilot-plant scale may introduce variations in waste characteristics that cannot adequately be assessed.

Compliance The operation of a pilot-scale TNT production plant would require the operator to apply for and obtain the necessary environmental permits including RCRA, NPDES, and air emissions. Because the permitting procedure is usually very time consuming, obtaining the necessary permits to construct a pilot-scale TNT plant could take from 3 to 5 years.

Capacity One advantage of a pilot plant is that a plant could be sized to achieve a variety of production requirements including generation of 50,000 gallons of red water in the required time frame.

Schedule Design, construction, and operation of a TNT pilot plant is not a simple process. Representatives of RAAP estimated that, based on past experience, a total of 3 to 5 years would be required to complete the process[4]. Included in this time frame is the time necessary to obtain funding and permits. Although the overall time requirement cannot be precisely defined at this time, it is likely that a pilot plant could be brought on line by mid-1994.

Cost Based on the experience of Army personnel interviewed during this evaluation, a pilot-plant using the CIL continuous process is capable of producing approximately 5 tons of TNT per day at a cost between $15 and $25 million[4]. The automatic controls alone on the pilot plant previously operated at the Picatinny Arsenal exceeded $1 million[9].

Assessment Based on the application of the preliminary screening criteria, the option of constructing and operating a TNT pilot plant exhibits at least two fatal flaws: schedule and cost. It is unlikely that a pilot plant could be designed, constructed, and made operational by mid-1994. The estimated cost of the pilot plant significantly exceeds the $5 million screening criterion. This option therefore was not subjected to a more detailed evaluation.

5.4 Obtain Red Water From ICI Explosives Canada

Background The U.S. Army currently purchases 100 percent of its TNT requirement (approximately 3 million pounds per year) from ICI Explosives Canada's (ICI) facility located near McMasterville, Quebec. This facility is currently operational and generates red water on a continuous basis. ICI has assisted the Army's red water research and development efforts by providing small samples (less than 1 gallon) of red water to Army researchers for their use in conducting laboratory and bench-scale treatment assessments. Samples have been provided to the Corps of Engineers Construction Engineering Research Laboratory (CERL), which used the material in initial assessments of wet air oxidation. Subsequent to completion of the laboratory investigations, CERL initiated discussions with ICI regarding acquisition of a larger volume (approximately 5,000 gallons) of red water for bench-/pilot-scale treatability tests.

Representativeness The ICI McMasterville facility employs the same basic TNT production technology as that used at AAPs possessing the capability for continuous TNT production. Significant variations between ICI and AAP production do exist, however, including some variation in feed-stocks, the use of dynamic separators, and water recycling practices. Although these differences would be expected to impart some differences in characteristics between ICI and AAP red water, representatives of both ICI and RAAP indicated that the ICI red water would reasonably approximate RAAP red water[4,5]. Because the same production process is used, this option does not exhibit a fatal flaw for the representativeness criterion.

Compliance No laws, treaties, or international agreements have been identified that would preclude the shipment of red water from a facility in Canada to a test facility in the United States. Regulations that would impact the shipment, include RCRA and DOT regulations controlling the storage, shipment, and handling of hazardous wastes and hazardous materials. Compliance with applicable regulations would be complex and require a significant effort; nevertheless, compliance could be achieved and the transfer could occur without infringement on the restrictions imposed.

Capacity During the course of this evaluation, the ICI McMasterville facility was visited. During a meeting at the facility, ICI representatives indicated that the facility could easily supply the volume of red water currently anticipated for pilot-scale treatability testing. Based on a TNT production rate of 35 tons per day, the McMasterville facility generates approximately 7,000 gallons of red water per day at full production.

Schedule This option contains two schedule-related aspects: the first concerns the time frame required to reach closure of the prerequisite negotiations; and the second concerns the time frame required to produce the required volume of red water, to make the necessary legal notifications, and to coordinate the logistics of a shipment.

Negotiations to obtain approximately 5,000 gallons of red water were initiated by the Army (CERL) in November 1991. Since that time, a series of communiques and meetings have occurred during which ICI and Army representatives identified and discussed the requirements related to this acquisition[6]. As of April 1993 (the date of initial issuance of this report), a final agreement had not been reached. The major unresolved issue preventing a final agreement is the stipulation by ICI that it be granted indemnification from all potential liabilities associated with the provision, handling, shipment, and treatment of the red water.

As summarized in a Point Paper dated September 21, 1992, the indemnification issue has not been pursued to a satisfactory conclusion[6]. Further negotiations between ICI and the Army are required. The negotiations have been time consuming and final agreement has not yet been reached; however, it appears that only one issue (indemnification) remains to be resolved. Although the time frame required to successfully resolve the issue of indemnification cannot be estimated at this time, this schedule concern is not considered a fatal flaw.

At the current rate of production, the McMasterville facility could generate the required volume of red water in less than two weeks. No anticipated changes in this production rate were identified during the meeting held at ICI in March 1992. However, the McMasterville facility is shut down for a few weeks each summer for maintenance. As with the issue of capacity, ICI representatives reported that schedule constraints (acquisition of red water by mid-1994) could be met.

For purposes of preliminary screening, a commitment from the generator must be obtained by mid-1993 and the required volume of red water must be available for shipment by mid-1994. Based on the preliminary screening effort, the option of obtaining red water from ICI Canada could be compatible with this schedule.

<u>Cost</u> The cost of exercising this option would include the cost of transportation, storage, cleaning of shipping containers, preparation of manifests, and notifications. It is assumed that the red water would be either provided by ICI either free of charge or for a nominal purchase price. Because ICI does not have the facilities to permit bulk loading or on-site storage of red water, the cost of these facilities would have to be included in the assessment. Although the costs involved were not estimated in detail for the purposes of the preliminary screening, it has been concluded that the cost would not exceed the $5 million criterion.

<u>Assessment</u> Based on the application of the preliminary screening criteria as discussed above, this option does not appear to exhibit a fatal flaw. However, a significant unknown does exist in relation to the time required for completion of negotiations regarding indemnification. This option appears viable at this level of assessment and is therefore carried forward to the detailed evaluation step.

5.5 Conduct Testing at ICI Explosives Canada

Background Five options were originally identified for obtaining red water. Four of these options involve obtaining red water from a distant facility and shipping it in bulk to a test facility. The fifth option, that of constructing a TNT pilot plant, may or may not involve shipment of red water depending upon the location of the pilot plant and the test facilities. This option, conducting the treatability demonstration at the McMasterville facility, does not involve shipment of red water. Other obvious advantages inherent in this option include: the ability to treat red water as generated without storage; the presence of trained staff and safety experts familiar with red water characteristics, handling, and disposal; and the ability to lengthen or shorten the treatment demonstration without the need to obtain more red water or to return or dispose of untreated red water. These apparent advantages led to the inclusion of this option in the current evaluation. Further, this option has been discussed with representatives of ICI Explosives Canada who indicated that in principle ICI would be willing to participate in the program.

Representativeness As discussed earlier in the preliminary evaluation of the option of obtaining red water from ICI, the ICI McMasterville facility employs the same TNT production technology as that used at AAPs possessing the capability for continuous production of TNT. Because the same production process is used, this option does not exhibit a fatal flaw for the representativeness criterion. (Additional discussion of this criterion as applicable to ICI red water was presented in the previous section, and is not repeated here.)

Compliance Conducting the demonstration test program at the McMasterville facility would significantly simplify compliance issues. It would avoid the international transport of hazardous waste and the long-distance shipping and multiple handling operations associated with the other options. The facility is currently permitted by Environment Canada to generate and treat red water; therefore, implementation of the test program is anticipated to present relatively minimal compliance issues (in comparison with other options). Residuals from the treatment demonstration could be incinerated with untreated red water, further reducing compliance concerns and complexities. Based on discussions with representatives of ICI, this option is viable and could be accomplished in full compliance with applicable regulations.

Capacity This option provides major advantages in terms of the capacity criterion. Co-locating the test facility with the point of waste generation offers significant flexibility to the test program. The test program could be expanded to include additional operating conditions, to repeat tests, or to evaluate modified test equipment without the need to obtain and ship additional quantities of red water. The costs, safety concerns, and logistical complexities associated with additional shipments would therefore be avoided. Similarly, the program could be shortened without concern over disposal of unused and untreated red water. This option therefore was determined to meet the requirements of this criterion.

Schedule As with capacity, this option offers advantages of scheduling. The schedule for the test program could be altered without the concern over the impacts on storage restrictions or the effect of aging on red water characteristics. Conducting the test demonstration at the ICI facility would avoid the issue of indemnification raised by ICI under the option in which they would supply red water. The schedule concerns over the negotiations on this issue would therefore not be of concern for this option. Negotiations would be required, however, to define contractual relationships and to resolve any issues, such as data availability, that might arise. Although the time required to complete the negotiations cannot be accurately estimated at this time, ICI representatives indicated during the meeting in March 1993 that the schedule criterion could be met.

Cost The selection of this option would present the lowest cost of acquiring red water because shipping is totally avoided. The cost of this option would be added to the treatment demonstration cost because the test facility would be located in Canada instead of the United States. Any added cost, however, cannot be assessed at this time because a location for the test, if conducted in the U.S., has not been determined. Regardless, this option would not be expected to cost more than the ceiling ($5 million) set for this preliminary screening.

Assessment No fatal flaws are associated with this option. Additionally, this option appears to offer significant advantages that should be considered in the assessment. Therefore, the option of conducting the red water treatment demonstration at the McMasterville facility is carried forward in the evaluation process for more detailed review.

5.6 Obtain Red Water from a Foreign (Other than Canadian) TNT Producer

Background In addition to the ICI Explosives facility in Canada, TNT is produced at both government and private facilities around the world; however, it is not currently produced in the U.S. For the purposes of this evaluation, the list of potential foreign red water suppliers was limited to facilities located outside of designated countries.* A list of the foreign producers of TNT was compiled based on reviews of available literature (including standard producer identification texts). This list is presented in Table 5-2.

Ongoing efforts are being made to obtain information on red water generation at these facilities. The first step taken in this effort, after identification of facilities, points of contacts, and mailing addresses, was to notify the American Embassy in each host country. The purpose of this notification was to enlist the support of the embassy staff in furthering communications with the appropriate government or corporate officials. Subsequently, a letter of introduction was sent to the facility operators. While the necessary efforts to secure the information needed for this evaluation have been initiated, they have required more time than anticipated and have not yet been concluded. For this reason, the assessment of potential foreign sources of red water cannot be completed at this time. The preliminary screening effort has been completed, however, and further evaluation of this option will be conducted by AEC if and when responses are received from the foreign TNT manufacturers.

Representativeness As stated previously, the basis for judgement of representativeness is a comparison of production processes: facilities using the same process and feedstocks as would a continuous mode TNT line at an AAP are assumed to generate representative red water. Because of the current lack of information regarding processes and TNT production facilities in foreign countries, an assessment of representativeness cannot be made at this time.

Compliance, Capacity, Schedule, and Cost Specific issues related to compliance, capacity, schedule, and cost cannot be discussed prior to identification of candidate facilities and the initiation of negotiations. It can be reasonably assumed, however, that the related concerns for obtaining red water from a foreign source would be relatively more extensive than the option of obtaining red water from ICI Canada. The validity of this assumption has not been assessed, however, nor does it indicate that a fatal flaw exists.

Assessment A lack of information precludes the assessment of this option at this time. If and when additional information is obtained regarding specific foreign TNT manufacturers,

*Afghanistan, Albania, Angola, Bulgaria, Cuba, Czechoslovakia, Ethiopia, Hungary, Iran, Iraq, Kampuchea (formerly Cambodia), Laos, Libya, Mongolian People's Republic (Outer Mongolia), Nicaragua, North Korea, People's Republic of China (including Tibet), Poland, Rumania, South Yemen, Syria, and derivatives of the former Union of Soviet Socialist Republics, Vietnam, and Yugoslavia.

Table 5-2.
List of Foreign TNT Sources

Chugoku Kayaku Co. Ltd
Tokyo, Japan

Oy Forcit AB
Hanko, Finland

Ste. Nationale des Poudres et Explosivos
Paris, France

Sociedade Partuguesa de Explosivos, S.A.
Setubal, Portugal

Union Espanola de Explosivos, S.A.
Burgos, Spain

Nobel Industries Sweden AB
Karlskoga, Sweden

IMBEL Industrial de Material Belico do
Brasil, Sao Paulo, Brasil

Fabricaciones Militares
Buenos Aires, Argentina

Nippon Oil & Fats Co. Ltd
Tokyo, Japan

Nobel Explosifs Belique S.A.
Bruxelles Belgium

Merck Limited
Dorset, Great Britain

Makina veKimya Endustrisi
Ankara, Turkey

the evaluation can be conducted. The current lack of information cannot be constructed as a fatal flaw under the bounds of the evaluation process as defined; however, further evaluation of this option remains to be conducted.

5.7 Results of Preliminary Screening

The results of the preliminary screening effort, the first step in evaluating the six potential options for obtaining red water, are summarized in this section. Because the objective of this screening was to identify the most viable options that warrant more in-depth evaluation, the screening focused on identifying fatal flaws. As shown in Table 5-3, three of the options exhibit fatal flaws. The data are currently insufficient to allow an evaluation of the foreign source option. The remaining two options (obtaining red water from ICI, conducting the tests at ICI) cannot be eliminated from consideration as a result of the application of the screening criteria and therefore are recommended for further consideration.

Table 5.3
Results of Preliminary Screening
(Page 1 of 2)

Evaluation Criteria	OPTIONS					
	Synthesize Red Water	**Restart an AAP**	**Construct a TNT Pilot Plant**	**Obtain Red Water from ICI**	**Conduct Test at ICI**	**Obtain Red Water from Foreign Source**
Representativeness	Characterization data that is necessary for synthesis does not exist.	Would allow testing on the waste of concern; most representative option.	Would allow testing on red water generated by same production process used at AAP.	ICI red water believed to reasonably represent AAP red water.	ICI red water believed to reasonably represent AAP red water.	Insufficient data available for evaluation.
Capacity	Some components not available commercially, preparation of large volume not feasible.	Screening criterion is met; however, excess red water would be generated.	Pilot plant could be sized to generate required volume.	McMasterville facility could provide required volume.	McMasterville facility could provide required volume.	Insufficient data available for evaluation.
Compliance	Synthetic red water not a hazardous waste; compliance simplified.	AAP currently not permitted; preparation of permits and receipt of State approval are a prerequisite.	Same compliance concerns exist for this option as for restarting an AAP.	Shipment of red water from ICI to test site in the U.S. can be accomplished in compliance with applicable regulations.	ICI facility currently in compliance; testing at this facility would present few compliance issues.	Insufficient data available for evaluation.
Schedule	Not assessed.	Permitting, engineering, and installation of new controls cannot be completed in required time frame.	Total time estimated to be 3-5 years.	ICI could provide the red water in the time frame required; however, concluding negotiations may be time consuming.	Testing at the McMasterville facility allows scheduling flexibility; screening criterion is met.	Insufficient data available for evaluation.

Table 5-3. (Continued)
Page 2 of 2

Evaluation Criteria	OPTIONS					
	Synthesize Red Water	Restart an AAP	Construct a TNT Pilot Plant	Obtain Red Water from ICI	Conduct Test at ICI	Obtain Red Water from Foreign Source
Cost	Not assessed.	Total estimated cost of $19 million significantly exceeds screening criterion.	Estimated cost of $15-20 million exceeds screening criterion.	Estimated cost would not exceed $5 million criterion.	Estimated cost would not exceed $5 million criterion.	Insufficient data available for evaluation.
Fatal Flaws	Yes - representativeness.	Yes - Compliance - Schedule - Cost.	Yes - Compliance - Schedule - Cost.	None identified.	None identified.	Insufficient data available for evaluation.
RECOMMENDATION	Eliminate from consideration.	Eliminate from consideration.	Eliminate from consideration	Include in evaluation of preferred options.	Include in evaluation of preferred options.	Complete screening evaluation if data become available.

6.0 Evaluation of Preferred Options

As discussed in Section 5, two of the potential options for obtaining red water did not exhibit fatal flaws as defined by the screening criteria used. These two options, obtaining red water from ICI Explosives Canada and conducting the treatability demonstration at ICI's McMasterville facility, therefore passed the screening and were subjected to a more in-depth evaluation. (The process and the criteria used for this evaluation were described in Section 4 of this report.) In summary, each option was evaluated against a series of criteria. Weighting factors were assigned as follows based on the degree to which the option met the requirements of each criterion:

Criteria	Weighting Factor
Primary Quantitative Criteria	
Representativeness	30%
Cost	20%
Capacity Limitations	5%
Time Constraints	5%
Secondary Quantitative Criteria	
Transportation Constraints	8%
Regulatory Requirements	8%
Safety Considerations	8%
Environmental Impact	8%
Trade Implications	8%

In addition, each option was evaluated in terms of three qualitative criteria: reliability, acquisition risk, and option-specific issues. A narrative description of the evaluation of the two preferred options is presented in Sections 6.1 and 6.2. A tabular summary of the weighting points assigned to each option under each evaluation criterion is presented in Section 6.3.

6.1 Obtain Red Water From ICI Explosives Canada

As discussed previously, ICI Explosives Canada operates a TNT production facility in McMasterville, Quebec, Canada, approximately 30 miles southeast of Montreal. The TNT plant produces approximately 3 million pounds per year of MIL SPEC grade TNT for sale to the U.S. Army. This represents about 50 percent of the McMasterville plant's current annual production. To obtain current information on the plant and to solicit input regarding this option from ICI, a meeting was held with representatives of ICI at the McMasterville facility on March 23, 1993[5]. The purpose of the meeting was to discuss the AEC's red water treatment research and development program in general and this red water acquisition option in detail.

6.1.1 Background

The ICI facility uses the same CIL continuous mode sellite purification process used at AAPs. It is believed that the process used by ICI at McMasterville represents state-of-the-art in TNT production. The process has evolved over recent years to include refinements and improvements such as the addition of dynamic separators and increased water recycling. Plant operators currently maximize the recycle process water to avoid once-through usage. This practice results in generation of a red water that is probably more concentrated (perhaps as much as 10 times more concentrated) than red water generated during most recent TNT production at RAAP. If production at RAAP or another AAP were to resume, however, it is likely that similar water recycling and process enhancements would be practiced.

Red water generated at McMasterville flows by gravity from the production area to an open top storage/surge tank. The red water is then pumped to an adjacent incinerator for thermal destruction with other wastewaters from the McMasterville facility. Facilities do not currently exist for handling red water in an alternate manner.

In addition to the TNT production facilities, ICI operates a research and development (R&D) facility and laboratory at McMasterville that employs about 80 scientists and engineers. A pilot-plant area includes fabrication shops, laboratories, and high bay pilot plant facilities. This R&D facility is used by ICI to test and develop new or modified production processes prior to full-scale implementation. An analytical R&D laboratory is housed in the same location. This laboratory is used to develop the specialized analytical methods required by ICI to monitor production and develop new products.

ICI representatives expressed a willingness to cooperate in this effort and to supply red water for the Army's research needs with certain limitations. These limitations focus mainly on the issue of liability. During the March 1993 meeting, representatives of ICI stated that as a prerequisite the Army must grant ICI indemnification from liability because of the unknown and variable characteristics of red water and because of safety concerns related to the handling of red water. The indemnification required by ICI would absolve it of any liability associated with the handling, shipment, storage, treatment, and ultimate disposal of any red water supplied to the Army. The indemnification would have to be effective at the point red water is removed from the ICI facility. This issue had been identified and discussed during previous negotiations between ICI and CERL. To date the issue has not been resolved. During the meeting in March, ICI and AEC representatives agreed that their respective legal departments would determine if a resolution is possible. If this issue cannot be resolved, it will be diagnosed as a fatal flaw and the option will become moot. The following evaluation is based on the premise that this issue can be resolved in a reasonable time frame.

6.1.2 Primary Quantitative Criteria

The four primary quantitative criteria (representativeness, cost, capacity limitations, and time constraints) were assigned a weighting of 60 percent of the total. These criteria are weighted more heavily than the secondary criteria, which received the remaining 40 percent, because of their overriding importance.

Representativeness As pointed out earlier in this report, a database is not available that would allow a side-by-side comparison of the compositional characteristics of red water generated by ICI and any of the four AAPs. Therefore, an evaluation of how well ICI red water would represent AAP red water must instead be based on a comparison of the production process and feedstocks used. The inherent assumption is that similar processes using similar feedstocks would generate similar red water. The ICI McMasterville facility employs the same continuous-mode sellite purification TNT production technology as that used at AAPs. Based on this fact, it is inferred that red water generated at ICI would reasonably represent AAP red water. The ICI and AAP red water may exhibit some variations because of the use of different feedstocks [at times ICI has used ONT (orthonitrotoluene) as a feed stock whereas AAP's have used DNT (dinitrotoluene) in the past]. Additionally, a greater degree of water recycling is believed to be currently practiced at ICI-McMasterville than was the case during most recent production at the AAPs. Although these differences would be expected to impart some variation in characteristics between ICI and AAP red water, technical representatives of both ICI and RAAP agreed that the ICI red water would reasonably approximate RAAP red water.

Cost The cost of exercising this option would include transportation, storage, cleaning of shipping containers, preparation of manifests, and notifications. Although ICI has not disclosed any direct sales charge for the red water, it is assumed that the red water would be either provided free of charge or provided at a nominal price. Because ICI's current facilities do not permit bulk loading or on-site storage of red water, the cost of these facilities would have to be included in the assessment. Based on a typical cost of $3 per loaded mile for over-the-road transportation of liquid hazardous waste, a transportation cost of about $30,000 would be incurred (assumes a 1000-mile transport distance and 10 tanker-truck loads). Storage, tanker decontamination, and preparation of manifests and notifications would add to the cost; however, the total estimated cost would likely not exceed $50,000.

Capacity Limitations During the visit to the ICI McMasterville facility, it was learned that ICI currently is generating between 3,000 and 4,000 gallons of red water per day. The facility is operated 24 hours per day, 5 days per week. Thus, the requirement for 50,000 gallons of red water could be fulfilled with less than 3 weeks of production. Therefore, capacity is not considered a constraint for this option. ICI representatives agreed that the McMasterville facility could easily supply the volume of red water currently anticipated as necessary for completion of pilot-scale treatability testing.

Time Constraints This option entails two schedule-related aspects: the first involves the time frame required to reach closure of the prerequisite negotiations; and second concerns the time frame required to produce the required volume of red water, to make the necessary legal notifications, and to coordinate the logistics of a shipment.

Negotiations to obtain approximately 5,000 gallons of red water were initiated by the Army (CERL) in November 1991. Since that time, a series of communiques and meetings have occurred during which ICI and Army representatives identified and discussed the requirements related to this acquisition. As of the date of this report (April 1993), a final agreement has not been reached. The major unresolved issue preventing a final agreement is the stipulation by ICI that it be granted indemnification from all potential liabilities associated with the provision, handling, shipment, and treatment of red water. As summarized in a Point Paper, prepared by CERL, dated September 21, 1992, the indemnification issue has not been pursued to a satisfactory conclusion. Further negotiations between ICI legal staff and Army lawyers are required. The negotiations have been time consuming and final agreement has not yet been reached; however, it appears that only this one issue (indemnification) remains to be resolved. Although the time frame required to successfully resolve the issue of indemnification cannot be accurately estimated at this time, this schedule concern has not been determined to be a fatal flaw. It does, however, present a significant concern. The time required for either ICI to review and revise their position or for the Army to review, decide, and extend indemnification could be extensive.

At the current rate of production, the McMasterville facility could generate the required volume of red water in less than three weeks. No anticipated changes in this production rate were identified during the meeting held at ICI in March 1993. The McMasterville facility, however, is shut down for several weeks in July/August each year for maintenance. As with the issue of capacity, ICI representatives reported that schedule constraints (acquisition of red water by mid-1994) could be met. For purposes of this evaluation, a commitment from the generator must be obtained by mid-1993 and the required volume of red water must be available for shipment by mid-1994. Based on the discussions with ICI, the option of obtaining red water from ICI Canada may be compatible with this schedule, if the issue of indemnification can be resolved.

6.1.3 Secondary Quantitative Criteria

Transportation Constraints As a listed hazardous waste, red water transport is subject to U.S. and Canadian Department of Transportation regulations pertaining to packaging, placarding, security, prompt delivery, and unloading. Compliance with these regulations can be assured by enlisting the services of an experienced, licensed, and approved carrier.

Regulatory Requirements No laws, treaties, or international agreements have been identified that would preclude shipment of red water from a facility in Canada to a test facility in the United States. Regulations that would impact the shipment would include RCRA and DOT regulations controlling the storage, shipment, and handling of hazardous wastes and hazardous materials. Although compliance with applicable regulations would be complex and require a significant effort, it could be achieved and the transfer could occur without infringement on the restrictions imposed.

Safety Considerations Red water contains known toxic and carcinogenic compounds. It also presents a potential fire and explosion hazard if the water fraction is allowed to evaporate or if settleable solids are allowed to collect. ICI has reported fires associated with red water solids. Red water, however, is not flammable or explosive. Prior to handling, storage, or transport, a detailed Accident Prevention and Safety Plan must be prepared.

The safety considerations of handling red water are regulated by the Occupational Health and Safety Administration (OSHA). Red water is a hazardous substance and is regulated under OSHA 1910.120(a)(3). This safety regulation stipulates hazardous waste handling, decontamination, and emergency response procedures for uncontrolled release of hazardous substances.

__Environmental Impact__ The potential for environmental impact exists during the transportation, handling, and/or storage of any hazardous material. A release of red water during any phase of acquisition or transport would result in either a real or a perceived environmental threat. Transportation of red water entails the risk of accidental release to the environment. Both α-TNT and 2, 4-dinitrotoluene (2, 4-DNT) can be toxic to aquatic organisms. α-TNT is potentially toxic to fish at concentrations of less than 10 ppm, and 24- and 96-hour mediam lethal concentration (LC50) values of 2, 4-DNT for bluegill sunfish are 50 and 16 mg/liter, respectively.[10]

__Trade Implications__ No applicable trade restrictions were identified that govern the shipment of waste from Canada into the United States for the purposes of testing. Because the Army purchases about half of ICI's TNT production, however, there may be a business concern on ICI's part. This concern may involve an uncertainty related to the potential impact on the amount of TNT purchased by the Army. If ICI assists the Army in demonstrating a red water treatment technology that would enhance the Army's ability to mobilize TNT production at an AAP, ICI may perceive that their assistance could result in a significant loss of sales revenue. This concern had been expressed by ICI in the past.

6.1.4 Qualitative Criteria

Qualitative criteria are necessarily subjective assessments based on experience and best judgement. These criteria have been included to allow the identification and evaluation of issues that can have major impacts on the probability of success but that cannot be readily quantified. As discussed in Section 4.3, qualitative criteria include reliability, acquisition risk, and option-specific issues.

__Reliability__ The reliability criterion is intended as a subjective measure of how dependable the source is believed to be. In the case of ICI, a high degree of reliability is assumed, once prerequisites such as the indemnification issue are resolved. This assumption is based on the fact that the Army is a major customer of ICI and that ICI would benefit directly from testing conducted on their own red water. This benefit would include compositional analyses and treatability test results that are directly applicable to their waste stream. This information would help ICI engineers and managers to assess the viability of further or different waste treatment or disposal techniques at their facility.

__Acquisition Risk__ This criterion is a subjective measure of the probability of unanticipated problems arising during the acquisition process. Based on ICI's willingness to cooperate and their familiarity with red water, a relatively low probability for unanticipated problems is inferred.

Option-Specific Issues Issues unique to this option are limited to the issue of indemnification of liability. As discussed earlier, it is unknown at this time whether or not this issue can be resolved. This issue has precluded successful completion of red water acquisition attempts by CERL over the past year and a half. In addition, a relatively high degree of uncertainty appears to be associated with this option because of this issue. If this issue is not resolved, a fatal flaw would exist and the option would be dropped from consideration.

6.2 Conduct Testing at ICI Explosives Canada

The option of conducting the red water treatment demonstration at ICI's McMasterville facility was discussed with representatives of ICI Explosives Canada prior to and during the project meeting held at the facility in March 1993. At that time, ICI representatives expressed a willingness in cooperating and hosting the demonstration. These discussions did not comprise the negotiations necessary to identify and resolve all issues related to this option; however, they did initiate communications regarding the basic requirements of a test program.

6.2.1 Primary Quantitative Criteria

Representativeness The discussion of the representativeness of the red water generated by the ICI facility in McMasterville was presented in the previous section and is not repeated here. However, one significant difference does exist: the degree of representativeness would be enhanced by this option because any issues related to aging of red water during shipment and storage are eliminated. Tests conducted at McMasterville could be conducted on a slip stream of red water as it is generated. This situation would not only preclude concerns over aging but would also most closely mimic the actual implementation of a treatment technology. Performance of the demonstration at the point of generation and on a slip stream of red water as it is produced would allow the treatment efficiency to be assessed under actual conditions. The converse disadvantage is that the characteristics of the waste stream may vary between and among tests, thereby making direct comparison of results somewhat more difficult. This problem, however, also would exist under the previously discussed option (obtaining red water from ICI) unless a homogeneous mixture could be maintained and if red water characteristics didn't change over time.

Cost Since the red water demonstration would be conducted at the point of generation, there would be no acquisition or shipping costs. In addition to the direct shipping costs that would be avoided, this option significantly reduces the logistical complexities associated with transporting red water. A reduction in ancillary costs would be achieved with the reduction in logistical complexity. The incremental costs of implementing this option would include any incremental or additional expenses associated with conducting the test near Montreal as opposed to at a U.S. location. Depending upon the contractual arrangements finally agreed upon between the Army and ICI, some compensation may be required for the use of the facility, access to laboratory capability if needed, and safety oversight.

Capacity Limitations As discussed in the previous section, the McMasterville facility has the capacity to generate the required volume of red water. As pointed out earlier, conducting the tests at the point of generation would allow flexibility in capacity requirements.

Time Constraints The McMasterville facility is currently operational and is projected to be operational over the time required for the test program. The time constraint inherent to this option involves the length of time required to complete the negotiations of required agreements and understandings between the Army and ICI. Although the amount of time needed cannot be definitively predicted, it is anticipated that this option could be completed within the required time frame.

6.2.2 Secondary Quantitative Criteria

Transportation Constraints Under this option, the need to transport red water is avoided. Thus, all of the potential complications, complexities, and costs associated with transportation are avoided. Because residuals from the treatment testing could be returned to the existing stream and disposed of via incineration in the on-site permitted facility, there would be no need to transport residuals. Similarly, if the test program were altered and either more or less red water were required, this could be accomplished easily without the concerns or time delays associated with shipping red water to the test facility or returning unused red water.

Regulatory Requirements ICI representatives indicated that the McMasterville facility is fully permitted to generate and treat red water. Further, they indicated that a pilot-scale treatment plant could be located at the facility to treat a slip stream of red water. Because the envisioned treatment evaluation would not involve the addition of new compounds, treated effluent and other process residuals could be returned to the red water line or tank and incinerated. This minimizes or eliminates the need for additional permitting or permit modifications.

Safety Considerations The safety considerations are significantly less for this option than for the other options because of the following reasons: 1) red water would not be transported, thus avoiding potential safety concerns related to handling of red water or exposure to the public during transport over long distances; and 2) ICI operators and safety personnel are familiar with the safety aspects of red water and therefore have in place existing policies and procedures for its safe handling.

Environmental Impact This option minimizes the potential for environmental impact. The major potential for release and impact under this program is during transport of the red water to a distant test location. This option avoids transportation totally. Neither untreated or treated red water, or treatment residuals, would require transport. Sufficient space is available to locate a pilot-scale test unit at the McMasterville facility adjacent to the existing red water storage tank and incinerator. The facility could be designed so that any release of red water would be contained and routed back to the storage tank or directly to the incinerator feed line.

Trade Implications The trade implications of this option are the same as those described for the previous option (obtaining red water from ICI) and therefore are not repeated here.

6.2.3 Qualitative Criteria

The evaluation of the qualitative criteria of reliability and acquisition risk applicable to this option is the same as discussed previously for the option of obtaining red water from ICI; therefore, this evaluation is not repeated here. The option-specific issue of indemnification discussed under the previous option does not apply for this option. Because ICI would maintain direct control of the red water, since it would not leave the site, the issue of indemnification should not be a concern. Limited releases from liability would likely be addressed in the negotiations between the Army and ICI and any Army contractor involved in site work.

Additional option-specific issues for conducting the test at the point of generation include the following: the availability of trained safety personnel experienced with red water; the ability to conduct tests on waste as generated, thus removing concerns over aging or effects of transportation; and no need for additional permits as the facility is currently permitted.

6.3 Award of Weighting Factors

Based on the methodology described in Section 4 of this report, weighting factor points were assigned for each option based on each criteria. The maximum points available and the points awarded are presented in Table 6-1.

Table 6-1. Weighting Factors Assigned as a Result of the Detailed Evaluation

		Option A: Obtain Red Water from ICI	Option B: Conduct Test At ICI
Primary Quantitative Criteria			
Representativeness	Total Max Points = 30		
AAP red water	30		
CIL process, AAP feedstocks, no storage	25		
CIL process, no storage	20		20
CIL process, storage/transport	15	15	
Batch process	10		
Cost ($)	Total Max Points = 20		
1 to 5 million	5		
0.25 to 1 million	10		
0 to 0.25 million	20	20	20
Capacity	Total Max Points = 5		
Capacity to generate 50,000 gallons in:			
over 3 months	1		
1 to 3 months	3		
less than 1 month	5	5	5
Time (to finalize agreements)	Total Max Points = 5		
By September 1993	5		5
After September 1993	2	2	
TOTAL POINTS FOR PRIMARY CRITERIA		42	50
Secondary Quantitative Criteria			
Transportation			
Transoceanic shipments	2		
International transport	5	5	
No transport	8		8
Regulatory Requirements			
Transoceanic/ Multiple international borders	2		
International shipment/ single border	5	5	
No shipment	8		8

Table 6-1. (Continued)

		Option A: Obtain Red Water from ICI	Option B: Conduct Test At ICI
Safety			
Multiple carriers/multiple modes	2		
Single carrier/single mode	5	5	
No shipment	8		8
Environmental			
Transoceanic and land transport	2		
Land transport	5	5	
No shipment	8		8
Trade Implications			
Current supplier	2	2	2
No trade relationships	5		
None identified	8		
TOTAL POINTS FOR SECONDARY CRITERIA		22	34
TOTAL WEIGHTING POINTS AWARDED		64	84

7.0 Conclusions and Recommendations

7.1 Conclusions

Based on the information assessed and the criteria compiled to guide the evaluation, the following conclusions have been reached:

- Three of the six options considered exhibit fatal flaws and were eliminated from consideration: 1) restarting an AAP; 2) constructing a TNT pilot plant; and 3) synthesizing a surrogate red water.

- Sufficient information was not available during the performance of this project to allow a definitive evaluation of the option of obtaining red water from foreign sources.

- Two of the six options evaluated are viable in terms of the evaluation criteria applied: 1) obtaining red water from ICI Explosives Canada; and 2) conducting the red water treatment demonstration at ICI's facility in McMasterville, Quebec. Of these two viable options, conducting the red water demonstration at ICI's facility is the preferred option. This option offers several significant advantages over other options: it avoids transport of red water; it provides the ability to treat red water as generated and avoids the negative effects of storage on waste characteristics; the testing would benefit from the presence and participation of a trained staff and safety experts familiar with red water characteristics, handling, and disposal; and it permits flexibility in the treatment demonstration, especially in terms of changes in schedule and test duration, without the need to obtain more red water or to return or dispose of untreated red water.

7.2 Recommendations

The following recommendations have been formulated based on the evaluation documented in the preceding sections of this project report:

- The Army and ICI Explosives Canada should conduct negotiations to finalize the agreements and understandings necessary for performing the treatment demonstration at the McMasterville facility.

- The Army and ICI Explosives Canada should complete their ongoing negotiations regarding the issue of indemnification. If negotiations cannot be brought to closure by either a change in ICI's current policy or by the Army offering the indemnification, the option of obtaining red water from ICI Explosives Canada should be removed from consideration. A definite time frame (e.g., August 1993) should be set for completion of the negotiations.

- Information regarding the type of production processes used by foreign TNT producers should be evaluated as it becomes available. The time frame during which this option remains open for consideration should be defined; this time frame may be the same as the one set for negotiations with ICI.

REFERENCES

1. PEI Associates, Inc. 1990. "Technology Evaluation for Treatment/Disposal of TNT Red Water" U.S. Army Toxic Hazardous Materials Agency (USATHAMA) Contract No. DAAA15-88-D-0001 Aberdeen Proving Ground, Maryland. CETHA-TE-CR-90048

2. Tabakin, R., 1976, "State-of-the-Art Military Explosives and Propellants Production Industry." U.S. Environmental Protection Agency. EPA-600.2-76-213a.

3. Hercules, Inc. 1973. "Final Engineering Report on Production Engineering Projects PE-238 and PE-289."

4. IT Corp. 1993. "Minutes of Red Water Project Meeting at Radford Army Ammunition Plant." AEC Contract No. DACA31-91-D-0074.

5. IT Corp. 1993. "Trip Report to ICI Explosives Canada, McMasterville, Quebec.: AEC Contract No. DACA31-91-D-0074.

6. Petrone, J. 1992. "Point Paper - Provision of Red Water for Army Research Purposes." AMX1B-IA

7. U.S. EPA. 1991. "EPA's Synthetic Sal Matrix Blending Facility." Proceedings of the Seventeenth Annual RREL Hazardous Waste Research Symposium.

8. IT Corp. 1993. Conversation with Lt. Col. K.K. Phull of AEC.

9. IT Corp. 1993. Conversation with James Carrazza of U.S. Army Armament Research, Development, and Engineering Center. Picatinny Arsenal, N.J.

10. Liu, D.H., 1976, "Toxicity of TNT Wastewater (Pink Water) to Aquatic Organisms." U.S. Army Medical Research and Development Command. Washington, D.C.

APPENDIX A

List of Potentially Applicable Regulations

List of Potentially Applicable Regulations

- 33 CFR 160 Subpart C - Notification of Arrivals, Departures, Hazardous Conditions and Certain Dangerous Cargoes
- 33 CFR 126 DOT Regulation for Handling Dangerous Cargoes at Waterfront Facilities
- 33 CFR 160 Subpart C - Notification of Arrivals, Departures, Hazardous Conditions and Certain Dangerous Cargoes
- 33 CFR 126 DOT Regulation for Handling Dangerous Cargoes at Waterfront Facilities
- 40 CFR 262.20(a) - Manifesting
- 40 CFR 262.30 - Packaging
- 40 CFR 262.33 - Placarding
- 49 CFR 171 - DOT General Hazardous Materials Transport Rules
- 49 CFR 171.12(a) - Exceptions
- 49 CFR 172 - DOT Rules for use of Hazardous Materials Tables
- 49 CFR 172.101 DOT Hazardous Materials Table
- 49 CFR 172.320 - Explosive Hazardous Materials
- 49 CFR 173 Subpart B - DOT Rules on Preparation of Hazardous Materials for Transport
- 49 CFR 176 DOT Regulations for Carriage by Vessel
- 49 CFR 176 Subpart A - General
- 49 CFR 176 Subpart B - General Operating Requirements
- 49 CFR 175 Subpart C - General Handling and Storage
- 49 CFR 176 Subpart D - General Segregation Requirements
- 49 CFR 176 Subpart F - Special Requirements for Barges

- 49 CFR 176 Subpart G - Detailed Requirements for Class 1 (Explosives) Materials
- 49 CFR 177 - DOT Regulations for Carriage by Public Highway
- 49 CFR 177 - Subpart A: General Information and Regulation
- 49 CFR 177 - Subpart B: Loading and Unloading
- 49 CFR 177 - Subpart C: Segregation and Separation Chart for Hazardous Materials
- 49 CFR 178 - DOT Specifications for Packaging
- 49 CFR 179 - DOT Tank Car Specifications