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An Introduction to Post-Treatment and Waste Disposal for Water Desalination

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An Introduction to Post-Treatment and Waste Disposal for Water Desalination

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<u>CONTENTS</u>

1. **GENERAL PROCESS SELECTION**
2. **POST-TREATMENT**
3. **WASTE DISPOSAL**

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1. GENERAL PROCESS SELECTION

In selecting a potable water production system, it is important to estimate costs of various options. The conventional unit of comparison is cost in dollars per 1,000 gallons of product water. Water quality and energy sources will be estimated from simple site reconnaissance. For example, a sea coast site where the water source temperature exceeds 95 degrees Fahrenheit indicates a high-salinity high-temperature combination favoring distillation/ condensation processes. Reverse osmosis requires a feed water temperature below 95 degrees Fahrenheit. If local well testing indicates salinity between 500 and 3,000 milligrams per liter and electricity is inexpensive, electrodialysis reversal or highflux reverse osmosis is indicated.
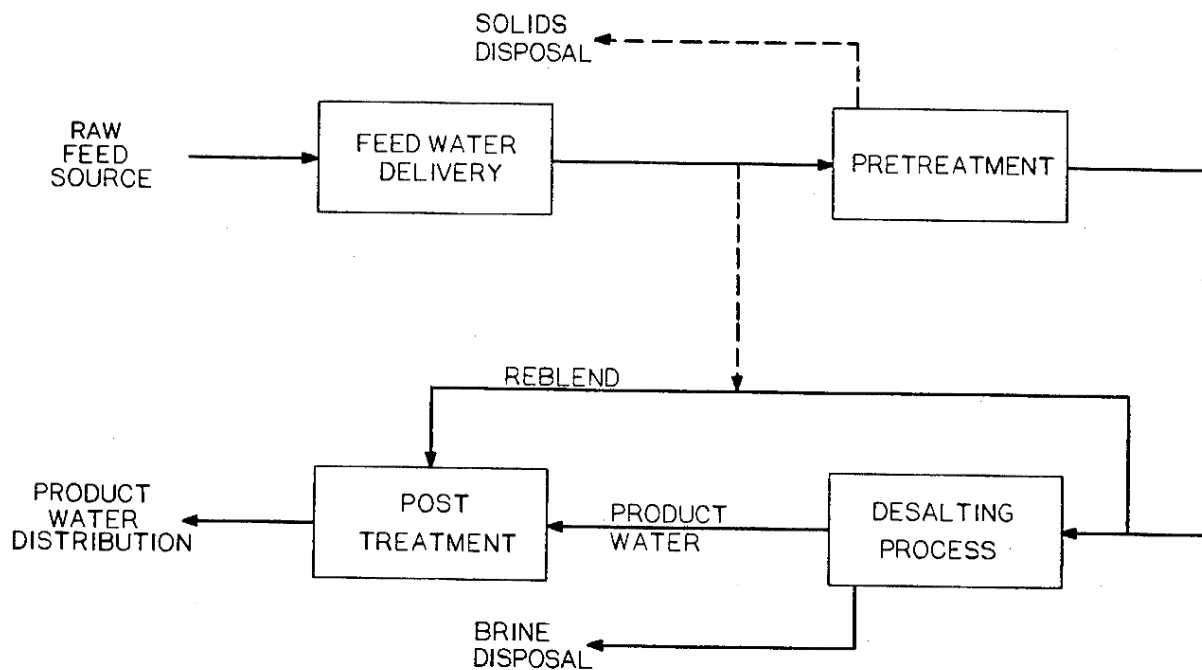
Figure 1-1

Typical desalination flowsheet

1.1 DESALINATION REQUIREMENTS. The design of a desalination system requires a clear understanding of the following: the quantity of product water desired; the quality of the desired product; and the quality of the feed water source. This course addresses the production of potable water containing less than 500 milligrams per liter of total dissolved solids. Laundries, boilers, mess halls, and hospitals may require water purer than 500 milligrams per liter of total dissolved solids. Potable water from the desalination system may be further treated to meet these requirements.

1.2 SALINE FEED WATER QUANTITY. The production of potable water from saline water usually requires a significantly larger quantity of saline feed water than the quantity of potable water produced. When desalination is necessary to produce potable water, the process splits
the feed water into two streams. One stream is the product water; the other stream is the brine that contains most of the salts originally in the feed water. In waters that need very little desalination, high-rate reverse osmosis may only reject 5 percent of the feed stream as brine. In reverse osmosis of sea water, more than 70 percent of the intake water may be rejected as brine. Multiply the required product quantity by the reciprocal of the product water recovery fraction to find the quantity of saline water that must be processed to yield the desired quantity of product water. In equation form it can be expressed as:

100% recovery of product water x water demand = saline feed water flow

In some cases, the limited quantity of available saline water may require a decision to adopt a more expensive desalination process with a higher water recovery rate. However, it may require choosing a different and more saline feed water with a greater availability.

1.3 BLENDING OF WATERS. Blending a high concentration stream with a low concentration stream wastes the osmotic pressure energy between the two streams. Therefore, it is best to match the design of the desalination system to the product quality

desired. When a desalination process cannot be economically matched to the desired product quality, then a process that yields water with a very low dissolved material content must be used. To conserve capital and equipment costs and meet the desired water demand, the high purity product water can be blended with the pretreated saline feed water to produce the required product quantity and quality. The following equation can be used to calculate the concentration of a blended water stream:

$$\left(\sum_{i=1}^{i=n} \text{concentration i} \times \text{flow i} \right) / \text{total flow} = \text{blended concentration}$$

When only two streams are blended, the equation can be rearranged to show the flow of concentrated water that when blended with a dilute flow will result in the desired product concentration. This rearranged equation is as follows:

$$[(P - H)(D)]/(C-P) = F$$

Where:

P = Desired product water concentration

H = High purity water concentration

D = Flow of the high purity water

C = Concentration in the impure concentrated stream

F = Flow rate of the concentrated stream

The same blend equations will apply to blending for remineralization, which is a more common procedure.

1.4 PROCESS LIMITATIONS. The various desalination processes presently available have limitations that must be considered prior to selecting a desalination process for a particular site. These limitations apply only to the desalination processes themselves; pretreatment can be and is often used to bring a saline feed water within limits so that a desalination process can be used. The raw feed water chemistry for all desalination

systems must be evaluated thoroughly for constituents that may precipitate in the desalination system.

1.4.1 HIGH-TEMPERATURE DISTILLATION. High-temperature distillation is limited by the saturation of alkaline earth metal salts, such as $CaSO_4$, $BaSO_4$, $SrSO_4$, $CaCO_3$, $BaCO_3$, and $SrCO_3$. Carbonate salt scaling can be controlled by acid addition. The recovery of water from a high-temperature distillation plant is usually limited by calcium sulfate solubility. When the concentration of the sulfate and the limiting alkaline earth metal is one-third of the saturated condition at ambient temperature, distillation design must include pretreatment to reduce or inhibit the scaling ions. High-temperature distillation is also limited to oil and grease levels below 1 milligram per liter. All other limitations on the high-temperature distillation process are equipment specific and require individual evaluation.

1.4.2 LOW-TEMPERATURE AND MECHANICAL DISTILLATION. Low-temperature and mechanical distillation systems are limited to operation below saturation of alkaline earth sulfates and carbonates. The lower operating temperature permits economical operation on waters that are at or below half saturation at ambient temperature. Oil and grease are limited to less than 1 milligram per liter. Any other limitations are equipment specific.

1.4.3 REVERSE OSMOSIS. The most severe limitation on reverse osmosis is the maximum limit of 50,000 milligrams per liter of total dissolved solids in the feed water. Another limitation is that there must be no iron in the feed water. This limitation is so rigid that only stainless steel and non-ferric materials will be used downstream of the iron removal. The solubility of alkaline earth sulfates and carbonates limits reverse osmosis treatment. Any water containing less than 4,000 milligrams per liter of total dissolved solids that would be saturated with an alkaline earth sulfate when the concentration is multiplied by 1.5 should not be considered for reverse osmosis desalination. Reverse osmosis is limited to waters that do not have silica saturation in the reject brine. Silica chemistry is extremely complex. When the molybdenum reactive

silica concentration exceeds 30 milligrams per liter as SiO_2 or the pH exceeds 8.3 in the brine stream, an environmental chemist or engineer should be consulted. Reverse osmosis is also limited to the treatment of waters with less than 1 milligram per liter of oil and grease.

1.4.3.1 CELLULOSE ACETATE MEMBRANES. Cellulose acetate membranes are usually limited to pH levels between 4.0 and 7.5. Cellulose acetate membranes require some form of continuous disinfection with the feed water to prevent microbial degradation of the membranes and can tolerate up to 1 milligram per liter of free chlorine. Therefore, cellulose acetate membranes are usually disinfected by maintaining 0.2 to 0.9 milligrams per liter of free chlorine in the feed water. Cellulose acetate membranes cannot be used on waters where the temperature exceeds 88 degrees Fahrenheit. Cellulose acetate membranes should not be used at pressures greater than the manufacturer's recommended pressure, since they are prone to membrane degradation by pressure compaction.

1.4.3.2 POLYAROMATIC AMIDE MEMBRANES. Brackish water polyaromatic amide membranes are generally limited to operation in feed waters between pH 4 and pH 11. Polyaromatic amide membranes are less pH tolerant and should not be used outside of the range pH 5 to pH 9. All polyaromatic amide membranes are limited to use on feed streams that are free of residual chlorine. If chlorination is necessary or desirable as a pretreatment option, complete dechlorination must be effected. Polyaromatic amide membranes are tolerant of water temperatures up to 95 degrees Fahrenheit. While polyaromatic amide membranes are not as quickly or completely compacted as are cellulose acetate membranes, manufacturer's recommended pressures must be followed to prevent mechanical damage to membrane modules.

1.4.4 ELECTRODIALYSIS REVERSAL.   While electrodialysis reversal has been used to treat water as saline as sea water, 4,000 milligrams per liter of total dissolved solids is considered to be an upper limit for economical operation. Some electrodialysis membranes can tolerate strong oxidants, like chlorine, but most cannot. The reversal of polarity used in electrodialysis reversal for removal of scale allows operation on water

that is saturated with alkaline earth carbonates. Saturation with an alkaline sulfate with low carbonate alkalinity should be avoided.

1.4.5 DISTILLATION/CONDENSATION ENERGY. In distillation/condensation plants, energy is used in the form of steam and electricity. Steam is used to heat the saline water to increase its vapor pressure. Normally, electricity is used to run the compressor in vapor compression distillation. If excess steam is available, its use as a power source should be investigated. The amount of electricity or mechanical work that steam will yield depends on its temperature as well as the temperature to which it can be condensed. The energy consumption of both vapor compression and thermal distillation, as related to the total dissolved solids of feed water, is shown in figure 1-3.
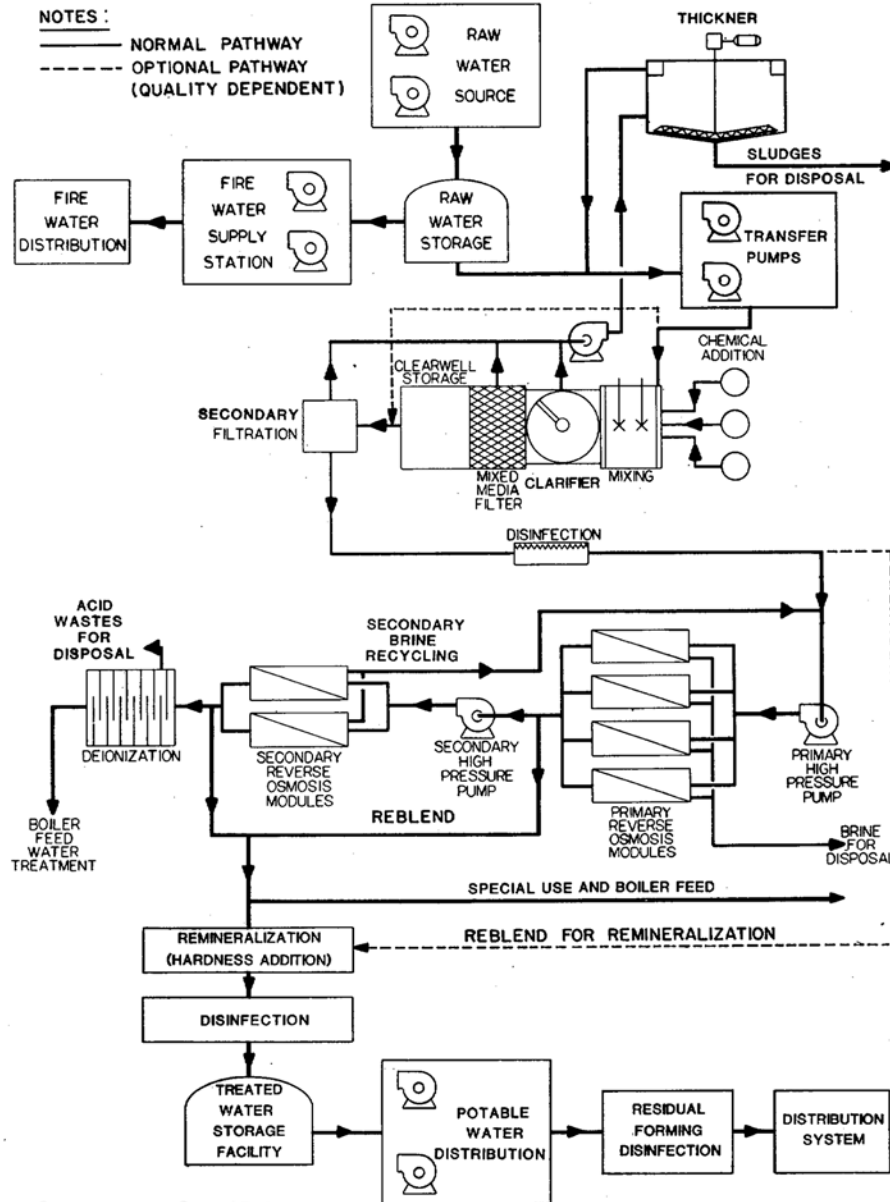
Figure 1-2

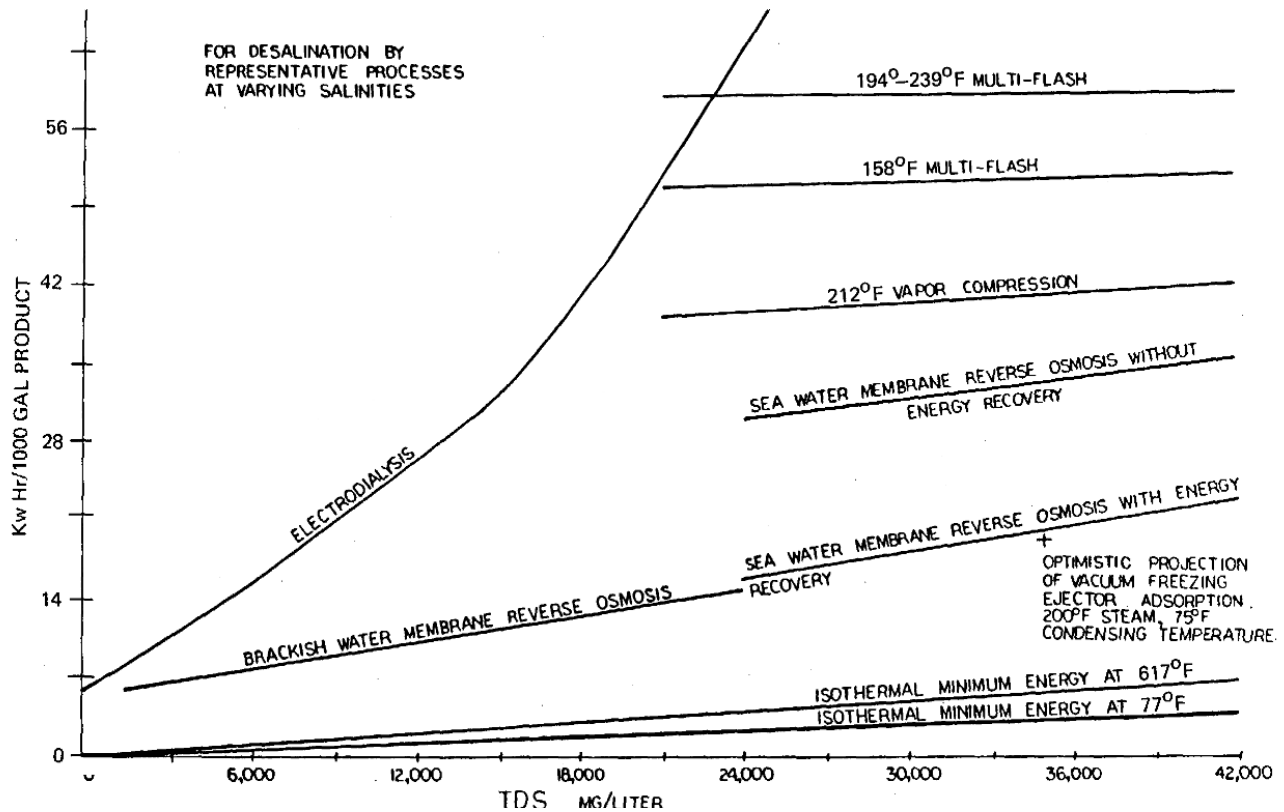Typical reverse osmosis desalination system

Figure 1-3

Energy Consumption

1.4.6 MEMBRANE ENERGY. Historically, membrane desalination systems use less energy than other systems. Brackish water desalination should be accomplished by membrane separation processes because of the reduced energy requirement. The energy consumption of electrodialysis reversal can be made to follow reduced or variable salinity, while the energy consumption of reverse osmosis is set principally by membrane water flux. Again, the energy consumption of electrodialysis reversal and reverse osmosis as a function of the total dissolved solids content of the feed water is shown in figure 1-3. As membrane materials are developed, energy consumption may be reduced.

1.4.7 WASTE DISPOSAL. Waste disposal may influence process selection. Since brine disposal costs can be an important part of process economics, brine disposal alternatives must be explored while water quality analyses are being performed.

1.4.8 PRELIMINARY PROCESS SELECTION. Use preliminary site information to eliminate certain desalination processes. A decision logic table for use with preliminary information is shown in table 1-1. Decisions based upon table 1-1 are to be considered preliminary only. Necessary water quality tests to further support the recommendations made in Column E of table 1-1 are in Column F.

1.4.9 PROCESS SELECTION. When initial site and raw water source selections have been made, use preliminary water quality information with table 1-1 to assist in a preliminary process selection. As more specific information is obtained from laboratory analyses of water quality, make an initial process selection using the second decision logic table, table 1-2. After a treatability investigation has been completed, select the final desalination process. The use of the decision logic table sequence will only provide generalized assistance in process selection; additional economic, engineering, and environmental studies may indicate that methods or combinations of methods must be used.

RULE	A	B	C	D	D	E
	If the freshest source of water is:	And if the desired output water will be:	And if electricity is to be generated:	And if the projected cost ratio of 264 deg F steam/electricity:	Then investigate the cost of:	And have the following tests performed:
1	More salty than sea water	Potable water			Transportation of fresher water; distillation can be used but at great expense	Total Dissolved Solids (TDS)
2	Sea water	High-pressure boiler feed water	By steam turbine		Distillation followed by ion exchange	TDS, Ca, SO_4, CO_3, pH
3	Sea water	Potable water	By steam turbine	Greater than 10^7 BTU/kwh	Thermal distillation either with or without vapor compression	TDS, Ca, SO_4, CO_3, pH
4	Sea water	Potable water	By internal combustion engine		Vapor compression distillation and waste heat	TDS, bacterial count, turbidity
5	Sea water	Potable water	no	Less than 10^7 BTU/kwh	Reverse osmosis	TDS, Ca, SO_4, CO_3, pH, bacterial count, silt density index, turbidity, oil & grease
6	Brackish water	Potable water			Reverse osmosis	TDS, Ca, SO_4, CO_3, pH, bacterial count, silt density index, turbidity, oil & grease
7	Slightly saline brackish water	Potable water			Electrodialysis reversal	TDS, full ionic breakdown, bacterial count, turbidity

Table 1-1

Preliminary desalination process selection

Rule	A	B	C	D	E	F
	If the feedwater TDS is (mg/liter):	And if the raw feed water suspended solids are:	And if the product of $(Ca)(SO_4)$ moles^2/liter^2 in the reject brine is:	And if the oil and grease in the raw feedwater is:	Then investigate the cost of:	And have the following pretreatment processes investigated for effectiveness:
1	Greater than 50,000				Transportation of fresher water. Distillation of this water is extremely expensive.	Precipitation of less soluble salts
2	Between 20,000 and 50,000	Over 20 NTU	Considerably less than 2×10^{-4}	Greater than 10 mg/liter	Reverse osmosis or distillation and steam and electricity	Alum jar tests, pH adjustment, 10 micron or smaller filter plugging
3	Between 20,000 and 50,000	Over 1 NTU		Less than 10 mg/liter	Reverse osmosis	Alum jar tests, 10 micron or smaller filter plugging, UV sterilization
4	Between 20,000 and 50,000	Less than 1 NTU; SDI greater than 3		Less than 10 mg/liter	Spiral-wound membrane reverse osmosis	pH adjustment, UV sterilization, chlorine disinfection, chlorine residual
5	Between 20,000 and 50,000	SDI under 3		Less than 10 mg/liter	Hollow fine-fiber membrane reverse osmosis	10 micron or smaller filter test; UV sterilization
6	Between 3,000 and 20,000	Over 1,000 mg/liter	Considerably less than 2×10^{-4}	Greater than 10 mg/liter	Distillation	pH adjustment, alum jar test
7	Between 3,000 and 20,000			Less than 10 mg/liter	Reverse osmosis	pH adjustment, alum jar test, silt density index, UV sterilization
8	Between 500 and 4,000				Electrodialysis reversal	pH adjustment, alum jar test, 10 micron filter plugging, chlorine disinfection

Table 1-2

Selecting desalination processes after water quality data are obtained

2. POST-TREATMENT

2.1   GENERAL. Desalination can and most often does produce water so free of dissolved material that corrosion and potential health problems are possible. Electrodialysis reversal is an exception to this general rule. Electrodialysis reversal does not remove microorganisms.

2.2   REMINERALIZATION AND AERATION. Pure water is a relatively reactive chemical. When air is dissolved in extremely pure water, the resulting solution is extremely corrosive. Water without dissolved air tastes flat and objectionable. Water that contains very little hardness appears to be unhealthy for drinking purposes. Therefore, the designer of a desalination system must consider some post-treatment options, such as remineralization and aeration, in order to produce healthful, noncorrosive, pleasant-tasting water.

2.3 POST-TREATMENT OF DISTILLED WATER. The mineral content of distilled water is much lower than is considered healthy for drinking purposes. Distilled potable water should be aerated and remineralized for health, taste, and to prevent corrosion. Some radionuclides may not be removed by distillation/condensation, which may require post-treatment by ion exchange, prior to all other post-treatment methods.

2.3.1 REAERATION. Distilled potable waters will be reaerated before use. Cascade, eductor, or sprayed aeration are acceptable but must be followed by disinfection to prevent bacterial contamination.

2.3.2 MINERALIZATION. Recent studies have indicated that the hardness of drinking water is important for human health. The Langelier Corrosion Index was developed to predict the tendency of water to deposit or dissolve calcium carbonate. Recalcification of distilled water will be performed in order to reach a positive Langelier Corrosion Index by adding lime.

2.3.3 CORROSION CONTROL. Distilled water has a greater corrosion potential once it is aerated. Any boiler feed water should bypass reaeration where possible. Corrosion should be controlled by the addition of sodium hexametaphosphate or sodium silicate, in conjunction with remineralization, prior to entry into the distribution system. The Langelier Corrosion Index can be adjusted to a slightly positive value by pH adjustment. The adjustment of the distilled water pH should occur immediately after reaeration, prior to distribution, as airborne carbon dioxide may influence the pH.

2.3.4 RESIDUAL DISINFECTION. Residual disinfection should be present in the active parts of the distribution system. A break-point chlorination curve is shown in figure 2-1. Chlorine disinfection of very pure water leads to a chlorine residual that is free of combined chlorine or chloramines. Chlorination of distilled water systems should occur immediately prior to the distribution system. Where it is convenient or economical, calcium hypochlorite should be used to control pH to aid in recalcification and to disinfect the distribution system.

2.3.5 REBLENDING FOR REMINERALIZATION. One of the most cost-effective ways to remineralize distilled water is to blend a small stream of pretreated saline feed water back into the distilled product water. When bacterial contamination is sufficiently low and hardness is sufficiently high, then reblending is an acceptable means of distilled water remineralization. When reblending is practiced, boiler feed water should be removed from the system upstream of the reblend point. Saline water used for reblending must have a 30-minute chlorine contact time. This chlorinated reblend stream is an excellent method of providing the total chlorination for the distribution system. Brine can be used to electrolytically produce hypochlorite ion for disinfection.

2.4 POST-TREATMENT OF REVERSE OSMOSIS PRODUCT WATER. Unlike distilled water, reverse osmosis product water is not necessarily free of dissolved gases. If degasification is not used as a pretreatment step, the dissolved gas content of the reverse osmosis product stream will be roughly that of the feed stream. Since divalent and trivalent ions are better eliminated by reverse osmosis than are monovalent ions,

reverse osmosis product water is usually very soft and has a hardness level that is unhealthy when used as drinking water.

2.4.1 CORROSION CONTROL. As a consequence of the dissolved gas content of the reverse osmosis product water, corrosion control should occur as close as is convenient to the suck-back tank.
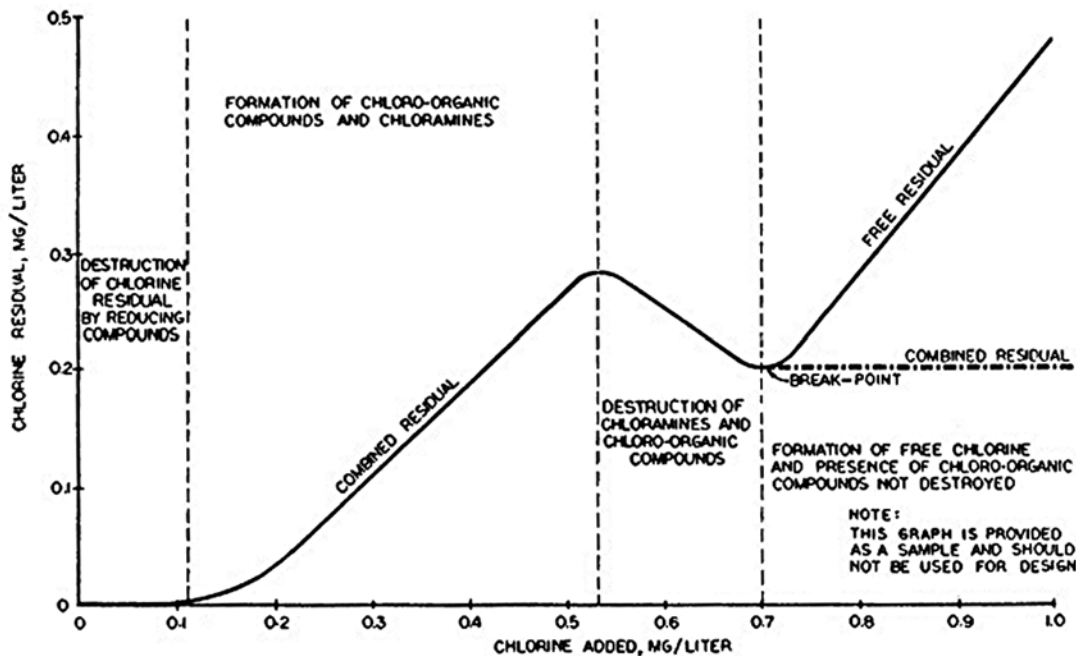

Figure 2-1

Breakpoint chlorination curve

A high carbon dioxide content in reverse osmosis product water contributes to corrosion. This is true, particularly where acid is fed for scale control. A degasification tower is used to obtain equilibrium with atmospheric carbon dioxide. Degasification should occur after remineralization. Boiler feed water or wash water should be drawn off prior to corrosion control. To control corrosion of reverse osmosis product water, add sodium silicate or sodium hexametaphosphate. Corrosion control is affected by recalcification and Langelier Corrosion Index adjustment.

2.4.2 REVERSE OSMOSIS REMINERALIZATION. Occasionally, remineralization of reverse osmosis product water is not necessary. Since reverse osmosis increases the monovalent-to-divalent ion ratio, remineralization is usually advisable. This remineralization, will contribute to the production of a pleasant tasting and healthful product water.

2.4.3 RESIDUAL DISINFECTION. The use of calcium hypochlorite for disinfection will assist in remineralization.

2.4.4 REBLENDING. Reblending of pretreated saline water is an acceptable remineralization procedure for reverse osmosis product water as long as the hardness of the reblend can be shown to be healthful. All reblended water must receive a full 30-minute chlorine contact time.

2.5 POST-TREATMENT OF ELECTRODIALYSIS-REVERSAL PRODUCT WATER. Electrodialysis reversal does not remove small suspended material. The pretreatment for electrodialysis reversal should remove any material that will plug a 10-micron filter. Loosened scale and particulate matter may require postdesalination removal. Micro-organisms are not removed by electrodialysis reversal.

2.5.1 SUSPENDED SOLIDS REMOVAL. Suspended solids removal during pretreatment is the preferred design for electrodialysis-reversal facilities. Pretreatment of suspended solids removes particulates, including microorganisms, which are prone to blind electrodialysis-reversal membranes. This removal reduces the time between cleanings. When electrodialysis-reversal product water turbidity cannot be controlled economically by pretreatment, then an attempt will be made to eliminate all pretreatment suspended solids control. If this is feasible, suspended solids control will be a post-treatment process at the electrodialysisreversal facility. When it is impossible to centralize all turbidity control, and electrodialysis reversal is still shown to be economical, both pretreatment and post-treatment suspended solids control shall be designed. At high-current densities, electrodialysis reversal will soften water by the

selective removal of multivalent ions. At low-current densities, electrodialysis reversal can be used to selectively remove monovalent ions. This selective removal of monovalent ions at low current densities can be economical for fluoride or other exotic ion removal or control where total dissolved solids and other ions are not a problem.

2.5.2 REMINERALIZATION.   Remineralization of electrodialysis-reversal product water is seldom necessary. When recalcification is deemed desirable, it is generally best to make provisions for adding calcium carbonate.

2.5.3 RESIDUAL DISINFECTION. Disinfection chlorination of electrodialysis-reversal product water should occur as soon as possible after electrodialysis-reversal desalination. Electrodialysis reversal will remove most of the free available chlorine used in any pretreatment chlorination. Electrodialysis reversal can lead to a greater concentration of bacteria in the product water than was present in the feed stream due to osmotic loss of water to the waste brine stream. Chlorination of all electrodialysis reversal waters will include a 30-minute chlorine contact time after treatment. Pretreatment chlorination will not be included as part of the 30-minute contact time. The operation and design of electrolytic hypochlorite production equipment is similar to the electrodialysis process. This can make electrolytic production an operational and strategic advantage for electrodialysis-reversal desalination facilities.

3. WASTE DISPOSAL

3.1 GENERAL. Wastes from desalination systems include solids, liquids, and gases. Evaluate each desalination system to determine its particular waste products, and then use the appropriate systems to treat or contain these wastes. A waste disposal overview is shown in figure 3-1.
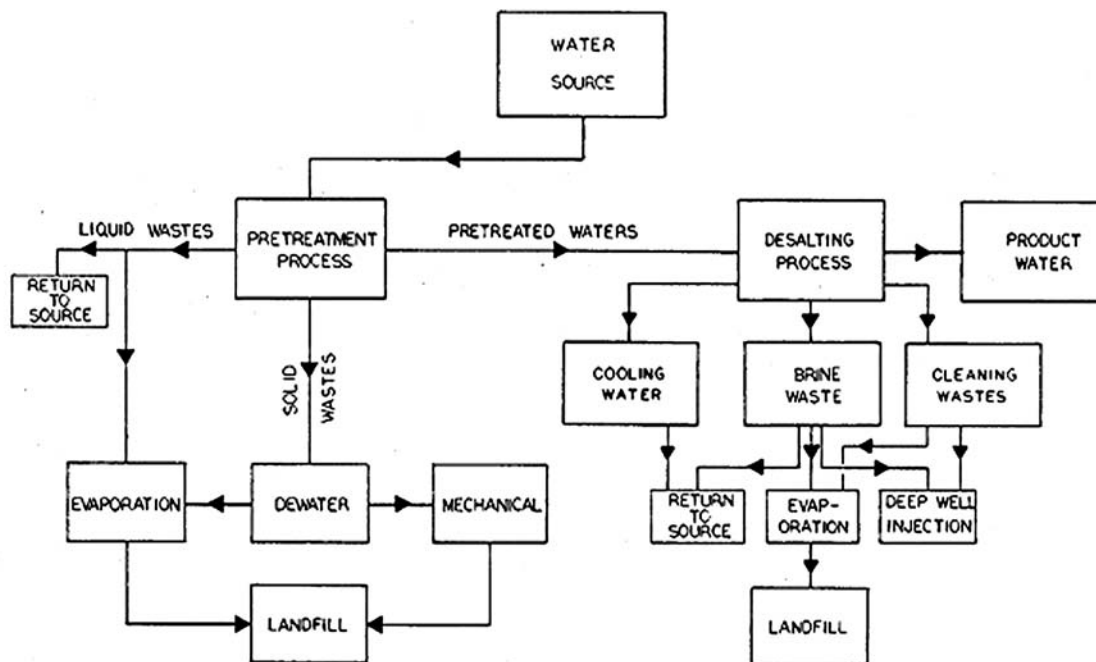

Figure 3-1

Waste disposal overview

3.2 PRETREATMENT WASTES. Systems that require pretreatment processes produce pretreatment wastes. Solid materials, and the chemicals added to precipitate them, form floc that will be removed from raw water by clarification. The sludges formed must undergo dewatering and are sent to a landfill. Dewatering processes can be mechanical, which are centrifugation or press operations, or evaporative, which are solar beds or lagoon operations. The alternatives for pretreatment sludge disposal are shown in figure 3-2. In addition to solid wastes, pretreatment processes can produce

liquid wastes from filter backwash operations. These liquid wastes often can be reclaimed or treated along with other liquid wastes from desalination process.

3.3 DISTILLATION/CONDENSATION SYSTEM WASTES. The waste stream volume produced by distillation/condensation systems is usually less than that produced by other desalination processes. The vaporization process yields concentrated brine with a reduced liquid waste loading. The use of less extensive pretreatment requirements for these systems generally results in a reduction of solid wastes. The cooling water discharge produced by many distillation processes does present a separate thermal discharge problem.

3.3.1 BRINE RETURN TO SOURCE. The brines from distillation/condensation processes are highly concentrated. For this reason, brines will be discharged where contamination of the intake water will not occur. The liquid brines will be returned to the raw water source if impact studies show there will be no significant environmental impact. Wetlands and estuarian areas that are often used for discharge are usually productive growth sites for many valuable food species. These areas are easily damaged by thermal discharges and require study to ensure that they are acceptable disposal areas for concentrated desalination waste liquids.

3.3.2 BRINE EVAPORATION. If it is not feasible to return the brines to the raw water source, then consider the use of evaporation ponds to dry the liquid wastes. The thermal nature of the brine from most distillation/condensation systems can aid evaporation of the wastes to dry salts. In areas where the net evaporation rate is low, but thermal energy sources are available, use thermal evaporation. Thermal evaporation has high energy requirements and usually is not cost-effective.
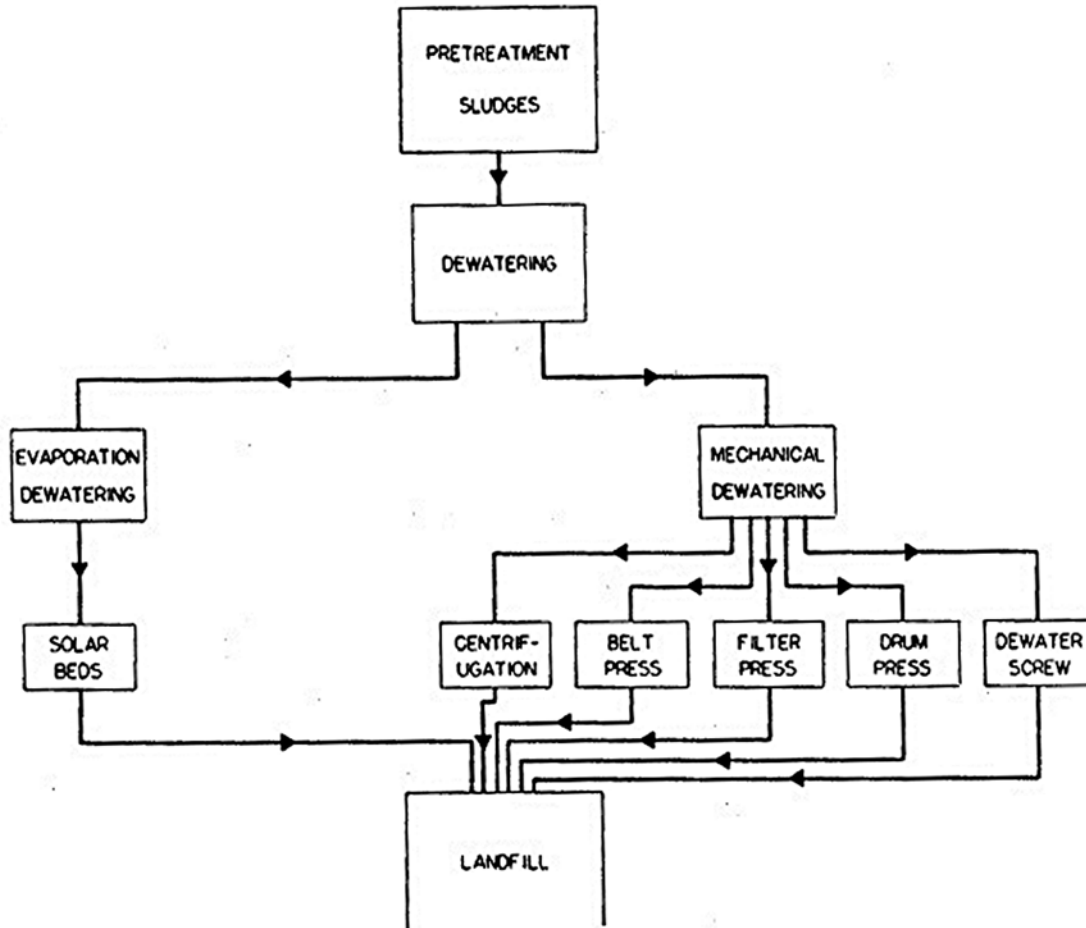
Figure 3-2

Pretreatment sludge disposal

3.3.3 BRINE DEEP-WELL INJECTION. If discharging the brine to a surface water or evaporation is impractical or uneconomical, deep-well injection of brines is possible. The injection of liquid wastes to deep underground formations can provide a disposal alternative where none was previously available. To properly design and install a deep-well injection facility, a complete geologic and geochemical analysis of the reservoir formation is required. Volumes of less than 53 gallons per minute can be disposed of practically in injection wells, while volumes in excess of 264 gallons per minute will be much more difficult to dispose of by use of this method. Compatibility tests must be run between the proposed waste and a sample of the formation water. This test should

ensure that the two waters do not react to form precipitates that may clog the receiving formation. The receiving formation must be separated from any fresh water or the desalination source water by an aquiclude that will ensure that the brine will not contaminate them. The area must be checked for geologic faults and any manmade penetrations of the aquiclude. The brine must contain less than 15 milligrams per liter of suspended solids, with a maximum size of 20 microns. Figure 3-3 shows a typical injection well. High construction and operating costs and the potential for serious operational problems usually cause deep-well injection to be the last process selected. If deep-well injection, evaporation, or return-to-source liquid-disposal options are not possible, review the entire facility location.

3.3.4 DRIED SALTS. When evaporation processes have reduced the brines to dry salts, make evaluations to determine a market value for these salts, as some salts have a value when dried. A landfill operation must be maintained when no market value can be assigned to the dried salts. An overview of brine wastes disposal is shown in figure 2-4.

3.3.5 USE OF BRINE. Desalination evaporation ponds make excellent solar stratification ponds. These ponds can be used to produce a stored thermal energy gradient, which can be harvested with a Rankin cycle engine. Electricity from such a system can be used to electrolytically produce chlorine. The total disposal of brine by chlorine production is not expected to ever be economical for the military. The internal production of chlorine for water disinfection is strategic. Presently, the smallest systems available produce over 22 pounds of chlorine per day. The brine concentration must be greater than above 35,000 milligrams of total dissolved solids to be practical. Any hardness in the brine limits efficiency and causes scaling.

3.3.6 CLEANING WASTES. At regular intervals, distillation systems must be cleaned. This usually involves strong acid cleaning solutions. These solutions must be neutralized and may require lime precipitation of heavy metals before they can be discharged. These wastes can be dried in evaporation ponds or disposed of in injection

wells. The volume of cleaning waste is small enough that transportation of the cleaning wastes to commercial hazardous waste disposal facilities is a third alternative. The operation of pretreatment scale control can reduce the frequency of cleaning.

3.3.7 GASES. Gas wastes from desalination processes are removed from the system during deaeration or distillation. These gases include carbon dioxide, nitrogen, and oxygen and require no special disposal or monitoring facilities. When hydrogen sulfide gas is removed from raw feed water or toxic and explosive gasses such as methane are generated in waste treatment process, special precautions must be taken for its safe discharge.

3.4 MEMBRANE SYSTEM WASTES. Membrane desalination systems are the most efficient potable water procedures. However, they produce the most pretreatment wastes, a less concentrated brine waste, and spent membrane modules.

3.4.1 BRINES. Brines produced from membrane desalination are usually less concentrated and are at a lower temperature than distillation/ condensation system brines. The concentration and temperature of these membrane brines make them ideal for disposal by return-to-source technology if it is approved by regulatory authorities. Other methods, such as evaporation or injection, can be used.

3.4.2 MEMBRANE MODULES. Membranes can become fouled, compacted, or destroyed during the normal course of membrane desalination operation. None of the membrane systems in current use present health or environmental hazards when disposed in a landfill. It is customary for the membrane manufacturers to dispose of defective membranes and their modules when replacement is necessary.

3.5 ION-EXCHANGE SYSTEM WASTES. Neutralize the acid and caustic solutions from ion exchange regeneration. Then dispose of wastes as concentrated brines. The only other major waste product from ion-exchange systems is the ion-exchange bed itself. Resins that are spent and not to be regenerated can be placed in a landfill.

3.6 ULTIMATE DISPOSAL. All waste streams from desalination processes must reach a point of ultimate or final disposal. Without adequate waste disposal facilities, site development cannot continue.
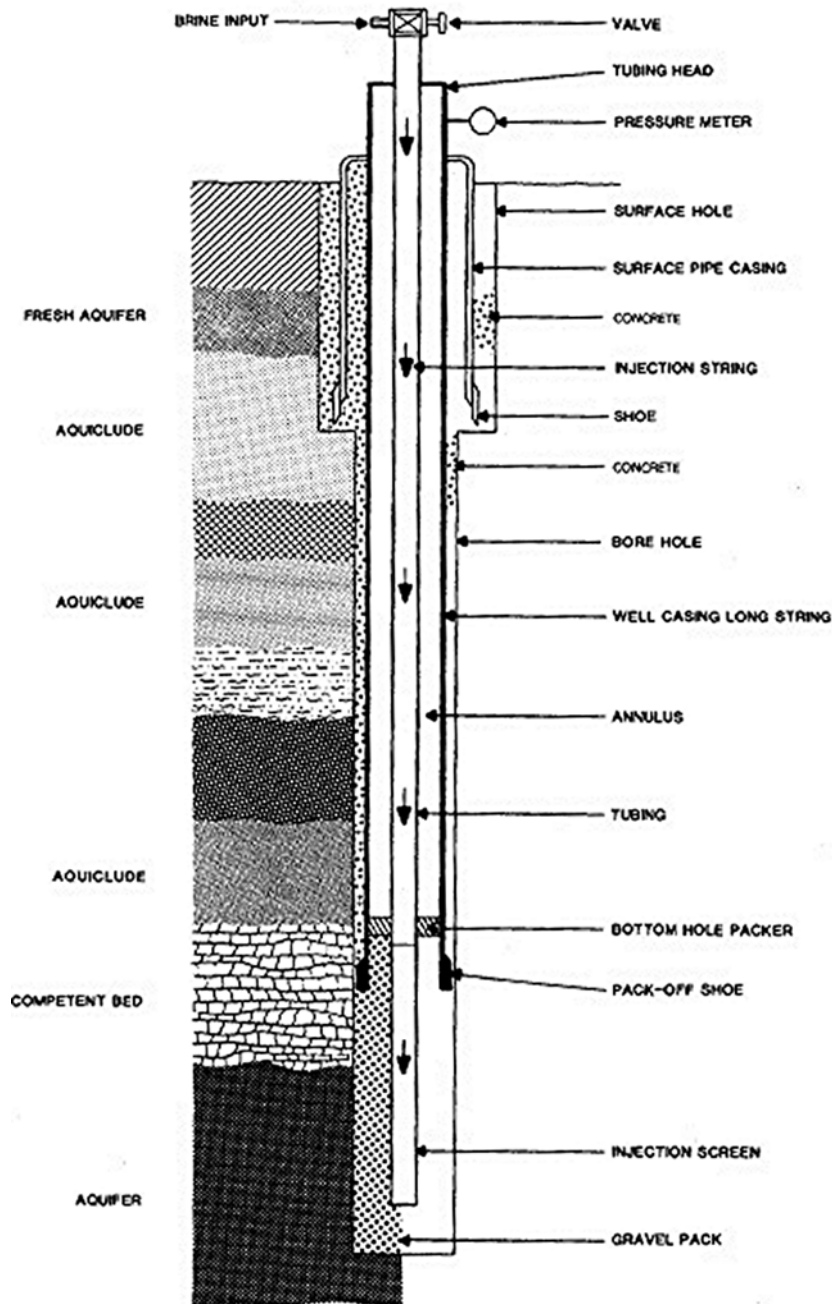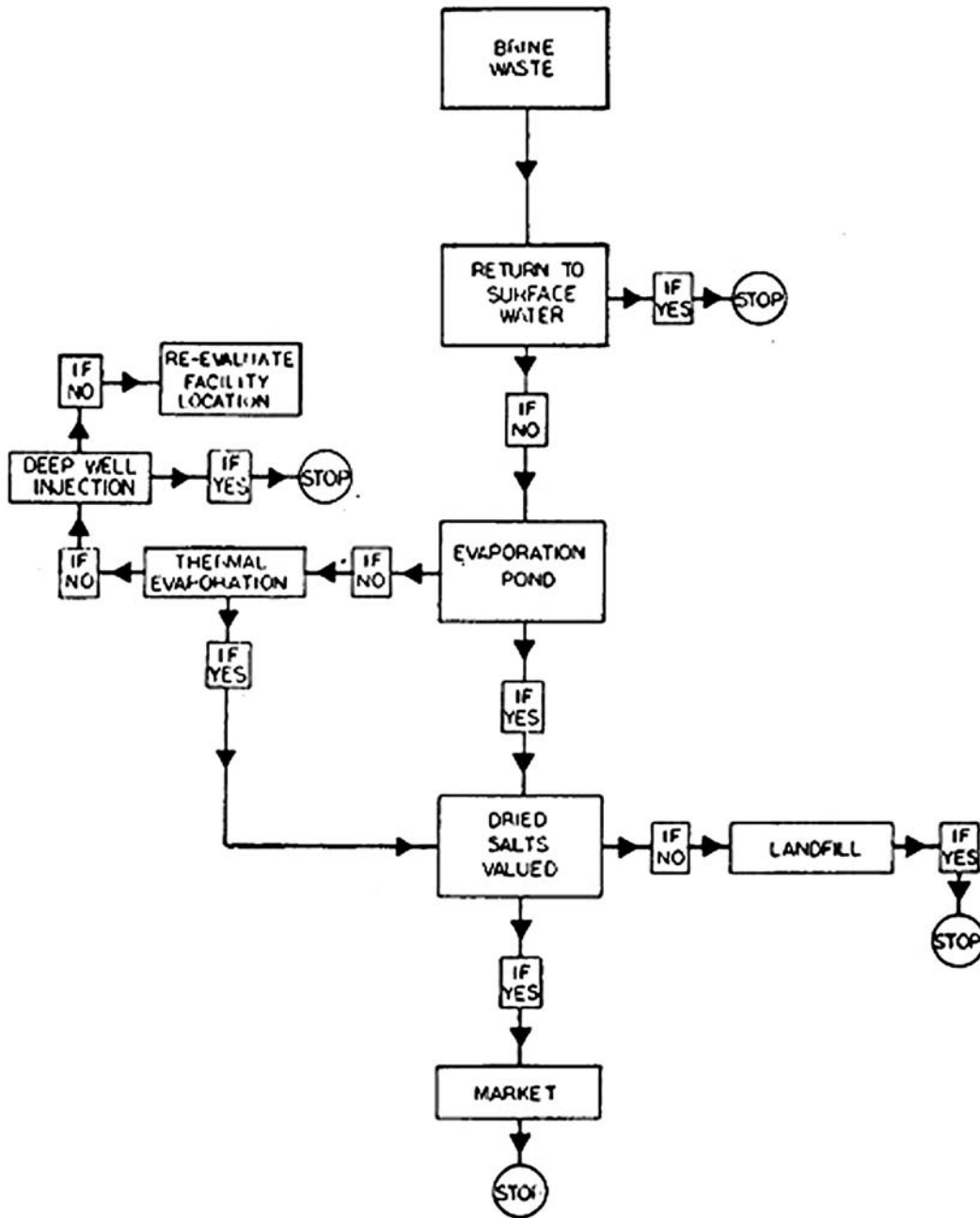

Figure 3-3

Deep-well disposal unit

Figure 3-4

Brine waste disposal