A SEISMIC ASSESSMENT OF AN EXISTING WATER TREATMENT PLANT AND AN EXISTING WASTE WATER RECLAMATION PLANT, SALT LAKE CITY, UTAH

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Salt Lake City, Utah, is located in the intermountain seismic belt and has known faults running through the city. The most notable of these faults is the Wasatch Fault. This normal fault has created the Wasatch Mountain range which runs along the eastern edge of the Salt Lake valley. The fault is segmented and runs in a north-south direction for two thirds of the length of the state. Figure 1 shows the identified faults in the Salt Lake area. Geologic trenching studies have revealed that periodically the Salt Lake segment will move up to 15 feet of vertical displacement per event. The recurrence interval for the Salt Lake City segment is in the range of 1,000 to 3,000 years, whereas the recurrence interval for the fault as a whole is in the range of 400 years. The Wasatch Fault and other known faults represent a significant seismic hazard that Salt Lake City has recognized. Figure 2 contains a descriptive summary of the soils in the general location of the site.

As part of a study to assess the seismic vulnerability of the city facilities that have been determined to be essential, the main culinary water treatment plan and the main waste water treatment plant have been evaluated. "Essential" facilities are "those structures or buildings which must be safe and usable for emergency purposes after an earthquake in order to preserve the health and safety of the general public" (International Conference of Building Officials, 1985). This paper is a summary of the findings of a portion of the overall study.

WATER RECLAMATION PLANT

The water reclamation plant for Salt Lake City was designed in 1960 and various small structures have been incorporated into the plant during the intervening years. The plant treats approximately 40 million gallons of waste water on an average day and produces over 4,000 dry tons of solids for disposal each year. The plant was evaluated for its existing seismic vulnerability. There are 35 various types of structures at the plant that were evaluated. These have been numbered as shown in Figures 3 and 4. Each of these 35 structures is a distinct structure or of a distinct structure type. The structures are listed in Table 1, which contains a summary of the structural system of each facility.

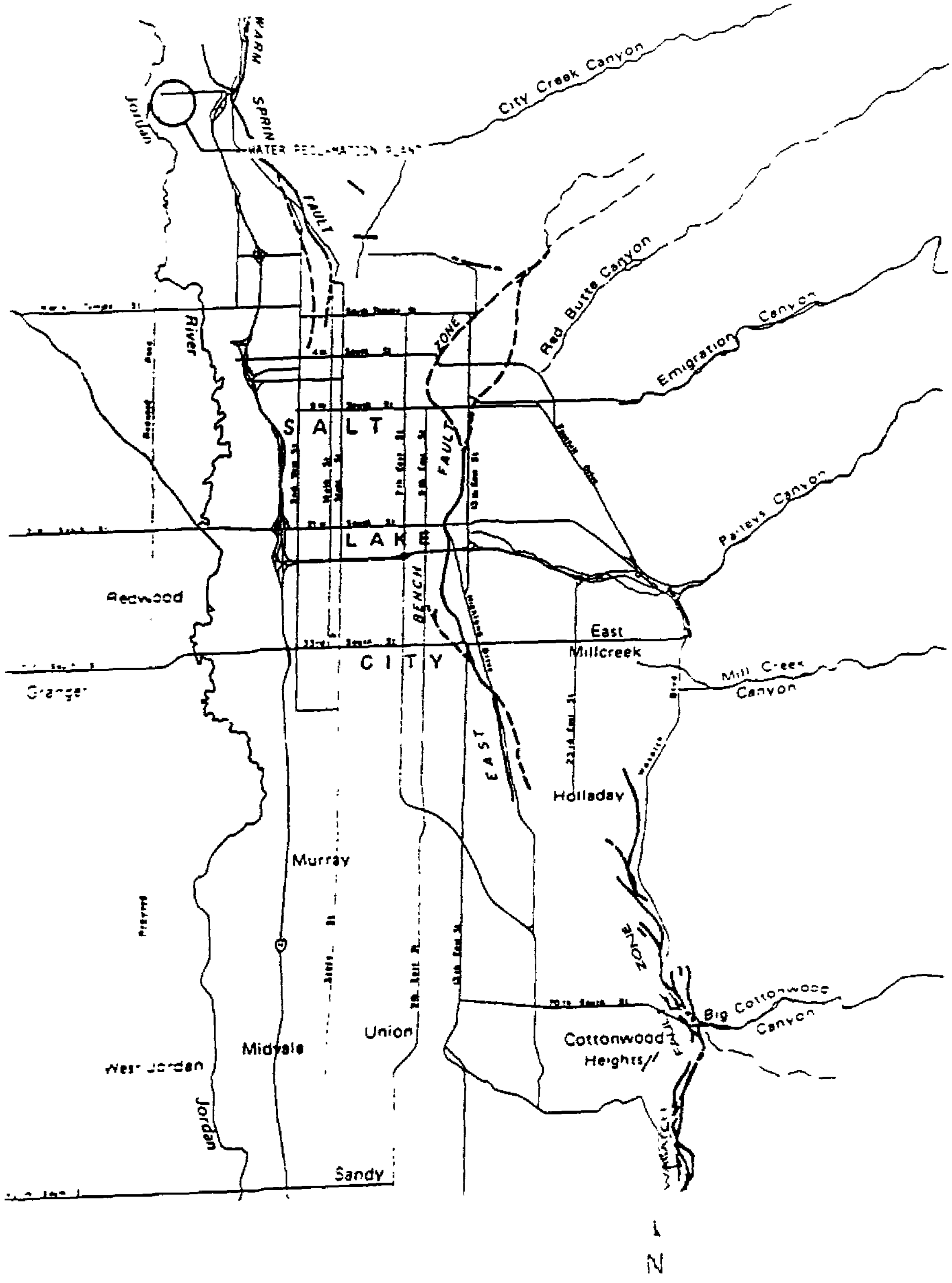
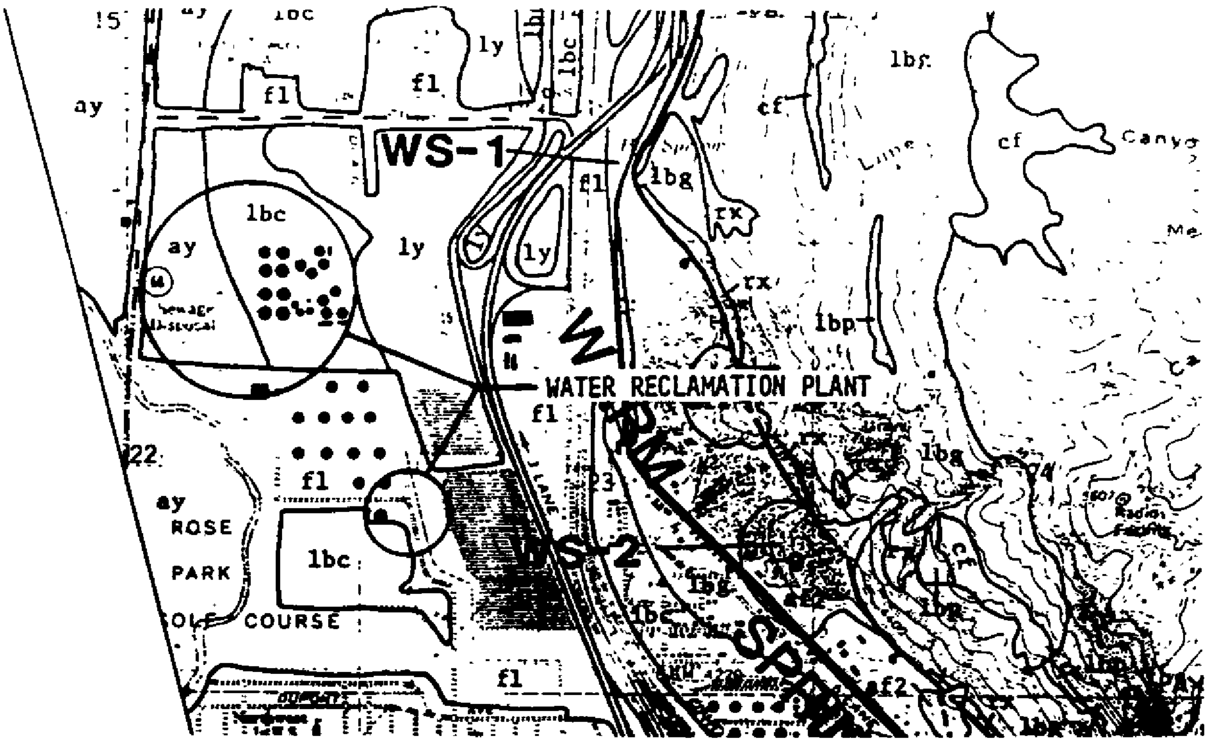


FIGURE 1 Salt Lake City essential facilities fault line map.



LAKE AND MARSH DEPOSITS

ly LAKE AND MARSH DEPOSITS OF HOT SPRING LAKE (HOLOCENE)—Silt and clay. Deposited in former lake and marshes, now drained, that existed in low-lying area west of Warm Springs fault. Subject to high water tables and flooding.

lbc Clay, silt, and sand—Clay, silt, and fine sand; good sorting of individual beds; parallel bedding, minor crossbedding, very thin laminae (<l mm) to thick beds (30 - 100 cm), bedding locally disrupted. Locally contains minor medium to coarse sand and fine gravel. Deposited in deep water on lake floor ond in lagoons and other protected areas behind spits and bars; locally includes sediments deposited as topset alluvium on deltas. Thickness 1 to more than 20 m.

ALLUVIAL DEPOSITS

Alluvial deposits are divided mainly according to type and age, which is determinded by (1) their stratigraphic and geomorphic relationships to deposits of the Bonneville lake cycle and to glacial deposits of the Bells Canyon advance and (2) by their degree of soil development.

ay FLOOD—PLAIN ALLUVIUM (UPPER HOLOCENE)—Sand, silt, clay, and locally gravel along the Jordan River and lower reaches of its tributaries; mostly pebbles and cobble gravel, sand, and silt along the upper reaches of streams that head in Wasatch Range, poor to moderate sorting; parallel bedding and crossbedding Subject to flooding and high water table. Exposed thickness 1-3 m.

FILLS AND DUMPS

fl ARTIFITIAL FILL (HISTORIC)—Fills of assorted materials, includes landfills, tailings, and engineered fills for highways, railways, and buildings

FIGURE 2 Soils map.

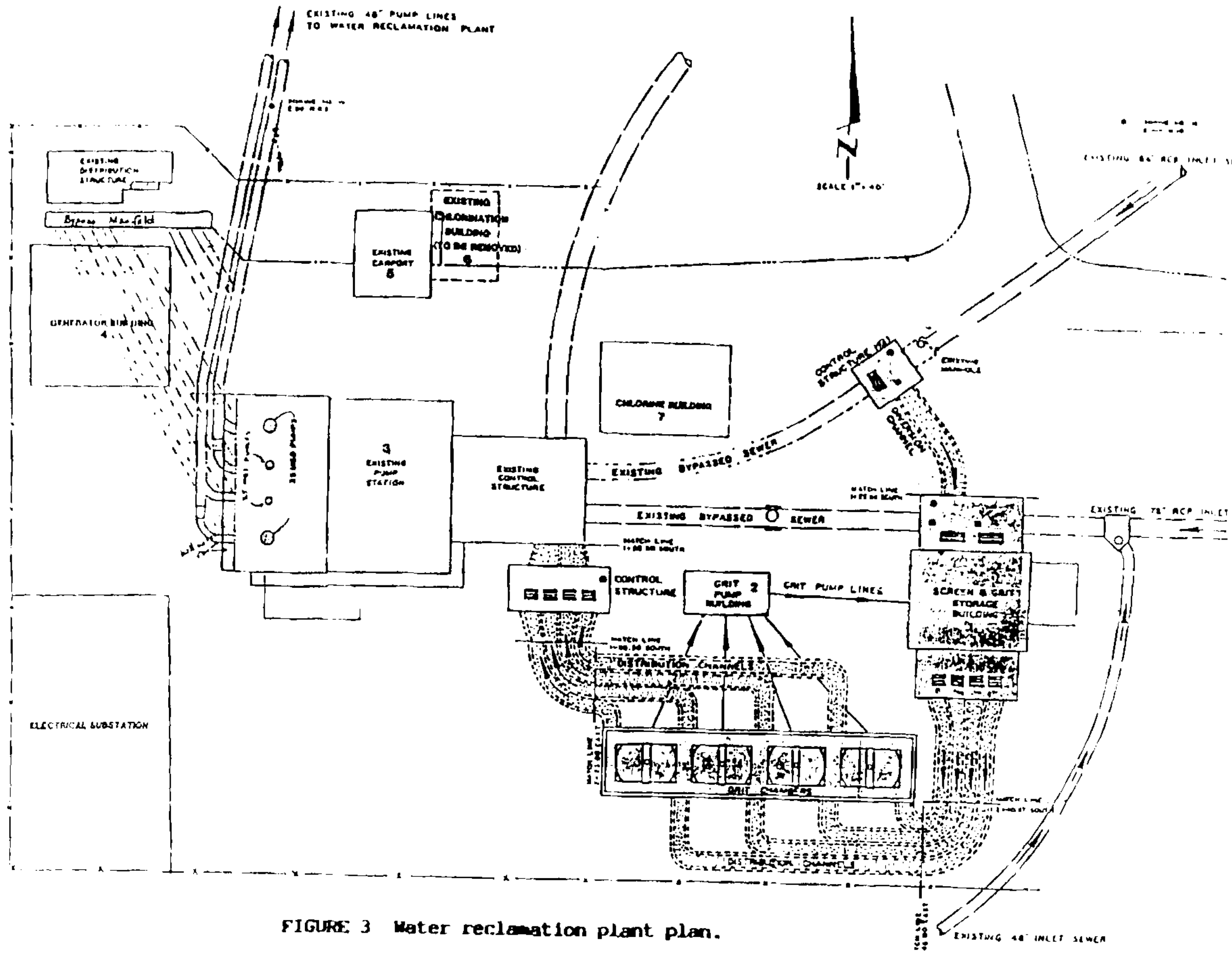


FIGURE 3 Water reclamation plant plan.

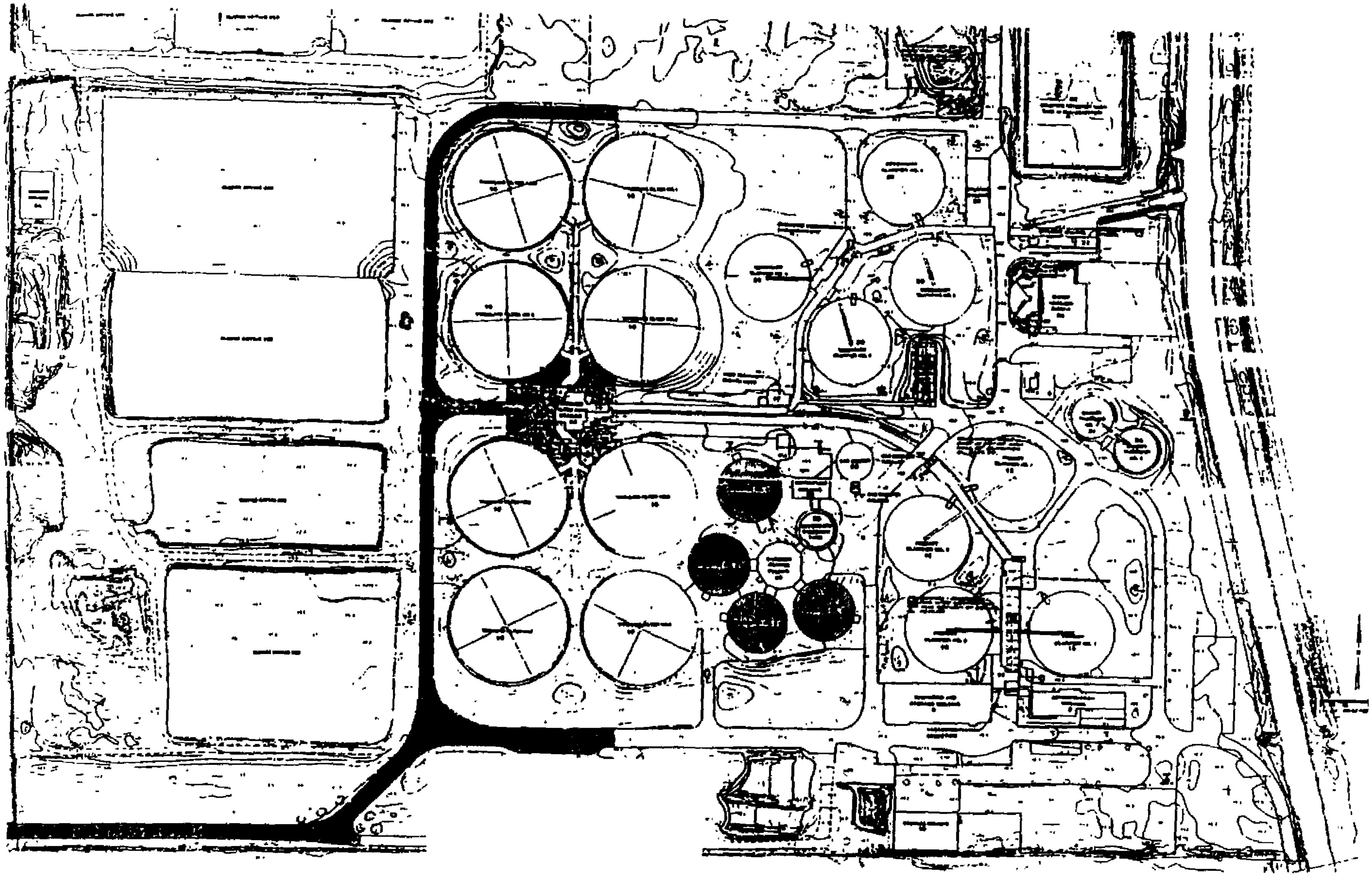


FIGURE 4 Main treatment facility site plan.

TABLE 1 Water Reclamation Plant, 1850 North Redwood Road, Salt Lake City, Utah

NO.	STRUCTURE NAME	YEAR CONST.	NUMBER OF STORIES	POURED IN PLACE CONC.			PRE-CAST CONCRETE			CONC. BLOCK	WOOD CONST	STEEL CONST.		PRE-ENGRD.
				ROOF	WALLS	FLOOR*	ROOF	WALLS	FLOOR*	WALLS	ROOF	ROOF	WALLS	METAL BUILD.
1.	Screen and Grit Storage Bldg.	1976	2			X*	X			X				
2.	Grit Pump Building	1963	1	X		X				X				
3.	Sewage Pump Building	1963	1	X	X	X*								
4.	Generator Building	1978	1			X	X	X						
5.	Storage Building (Carport)	1955	1	X	X	X								
6.	Existing Chlorine Bldg. (To be removed)		1			X								X
7.	New Chlorine Building	1986	1			X	X			X				
8.	Administration Building	1960	1	X	X	X								
9.	Operations and Storage Bldg.	1960	1	X	X	X				X (Addition)	X (Addition)			
10.	Storage Building		1			X								X
11.	Pre Sedimentation Bldg.	1960	1	X	X	X				X (Addition	X (Addition)			
12.	Pre Sedimentation Unit	1960	1	X	X	X								
13.	Primary Clarifier Tanks	1960	1		X	X								
14.	Trickling Filter Pump Station	1960	1	X	X	X								
15.	Switchgear Room	1960	1	X	X	X*								
16.	Trickling Filter Tanks	1960	1		X	X								
17.	Post Treatment Blower Room	1960	1	X	X	X (Fan)*	X(Addition)			X (Fan & Add)				
18.	Post Treatment Unit	1960	1	X	X	X								
19.	Secondary Sediment.Dist.Unit	1960	1	X	X	X								
20.	Secondary Clarifier Tanks	1960	1		X	X								
21.	Effluent Control Unit	1960	1	X	X	X*								
22.	Chlorine Retension Basin		1		X	X								
23.	Chlorine Building	1960	1	X	X(Control)	X				X (Infill-Storage)				
24.	Gravity Thick.Tanks & Pump Rm	1982	1	X(PumpRm)	X	X								
25.	Digestion Control Building	1960	1	X	X	X*								
26.	Anerobic Digesters #1,#2,& #3	1960	1		X	X						X	X(Siding)	
27.	Anerobic Digesters #4	1982	1	X	X	X							X(Siding)	
28.	Secondary Digestion Tank	1960	1 (Tower)		X	X						X(Tank)	X(Tank)	
29.	Gas Booster Building	1960	1	X	X	X*								
30.	Gas Storage Tank	1960	1		X	X						X(Tank)	X(Tank)	
31.	Gas Burn-Off Building	1960	1	X	X	X*								
32.	Centrifuge Building	1968	2			X*	X			X (Infill)				
33.	Energy Recovery Building	1986	1			X				X		X		
34.	Storage Building	Unknown	1			X				X	X			

(*) Suspended Floor

The overall facility is located on two parcels of land as shown in Figures 3 and 4 and is divided into a pretreatment facility and the main treatment facility. Various typical steps used in waste water treatment facilities are shown in Figure 5. All of the various systems in the facility have been considered except buried pipelines and conduits which were not in the scope of the project. A preliminary geotechnical evaluation was undertaken.

Structural Elements

The structural elements can be grouped into the following classifications:

1. Buildings,
2. Concrete channels,
3. Pipe tunnels, and
4. Tanks.

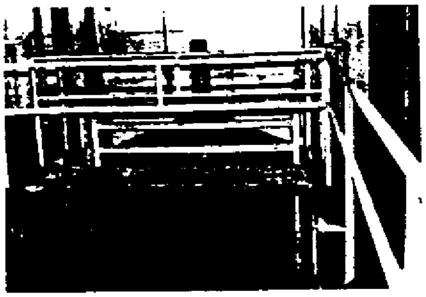
Each building houses equipment and systems that are used in different functions of the plant. Each structure contains a wide range of architectural, structural, mechanical, electrical, and piping systems. Appendix A of this paper focuses on a few of the structures considered and presents examples of the tables used to identify the structural deficiencies of each structure and suggested methods of correcting the deficiencies as well as the approximate costs. The structural facilities are, in general, reinforced for the effects of seismic forces. Although there are exceptions, many specific cost-effective measures could be implemented to increase the seismic resistance of the various structures and thereby minimize the effects of ground motion and make the facility more resistant to earthquake forces.

The first exception to the generalization is the No. 26 structures, which are three anaerobic digesters. The monetary cost of upgrading the three digesters to resist large seismic forces is very high. These digester tanks have reinforced concrete walls with a floating steel roof. They are covered with insulation, gunite, and metal siding. The deficiency stems from the fact that the walls of the structures were designed only for hydrostatic pressures and not for the increased hydrodynamic pressures that would be induced by strong ground motion.

Structure 1, the screen and grit storage building, also has a high dollar per square foot cost associated with the seismic upgrade. This structure, however, has a high vulnerability to seismic forces and should be given a priority position in any budget allocations.

Structure 3, the sewage pump building, has an above grade portion that is not entirely seismic resistant. The nature of the window openings and lack of symmetry have led to the suggestion of filling in certain window bays with reinforced concrete. The structure is critical to the overall operation of the entire plant.

PRELIMINARY TREATMENT

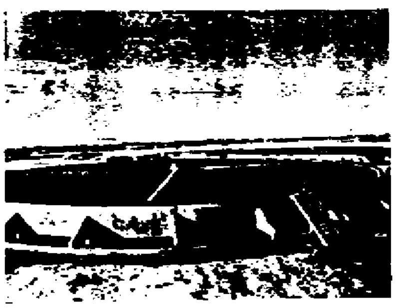


Preliminary treatment consists of screening (shown above) and grit removal so that large debris and abrasive materials do not damage plant equipment.

PRIMARY TREATMENT

Primary treatment physically removes settleable and floatable solids from the wastewater by passing it through large sedimentation tanks.

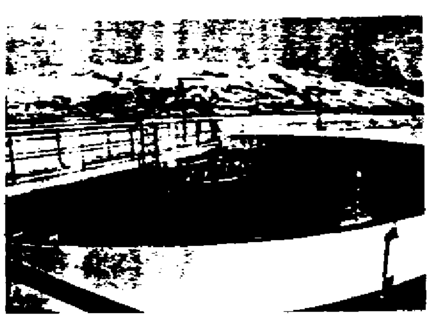
SECONDARY TREATMENT



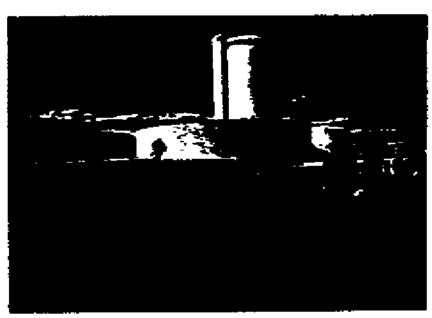
After primary treatment the wastewater passes over rock media that has attached a film of microorganisms which feed on soluble pollutants. (Trickling Filter)

Treated water from the trickling filter passes through a secondary sedimentation tank for final clarification, is disinfected by chlorination, and released to the Great Salt Lake.

WASTEWATER SOLIDS PROCESSING



Wastewater solids (sludge) that settle out in primary and secondary sedimentation are pumped to a common thickening tank before digestion.



Thickened sludge is pumped to anaerobic digesters which are closed, heated vessels that biologically reduce the sludge mass and kill pathogens.

Digested sludge is dewatered by air drying and applying it to agricultural land as a soil conditioner and nutrient supplement.

FIGURE 5 Steps in wastewater treatment.

Structure 23 is the chlorine building. This structure utilizes reinforced concrete frames with concrete masonry infill walls. The concrete frames were designed and built in an era when the current requirements for ductility had not been developed. The combination of the nonductile frames and the unreinforced concrete infill walls leaves this structure vulnerable to seismic forces. There is a definite lack of symmetry in this structure. Due to the deadly nature of chlorine, it is recommended that this structure be given a high priority.

The concrete channel structures convey the wastewater from one location to another within the complex. The bottoms of these channels have varying depths below grade. The deepest is at the pre-treatment site. It has a base that is sunk 35 feet below the ground surface. Most of the channels have been built in integrally with the pipe tunnels that are located below them. The channel and pipe tunnel structures must resist hydrodynamic pressures against the wall surface and uplift buoyant pressures since the water table is near the surface of the ground. During a seismic event the lateral pressures against the walls would be greatly increased and the potential for liquefaction of the surrounding and underlying soils is great (see geotechnical section). If there was a disruption of the water flow in these channel structures, the waste water would have to be diverted around the treatment facility and discharged into the lake without treatment.

The tank structures are constructed primarily of reinforced concrete. The walls are supported on thick mats and spread footing foundations. The tanks are circular in plan and have an inherent strength due to their form. These elements have heights in the range of 10 to 15 feet and are partially below grade. Increased pressures due to earthquake effects on the walls (external forces due to earth and groundwater and internal forces due to hydrodynamic effects) could create a condition where the steel reinforcing in the walls is greatly overstressed in radial tension. Overturning of the elements is a potential problem due to possible liquefaction from ground shaking, which would create instability in the foundation systems.

Structure 28 is a tall digester tank that was built to hold a large volume of sludge. This structure is not in use at this time because of the excessive energy costs associated with lifting the solids to the top of this facility. If this structure were full during severe ground shaking, the resulting overturning moments would create large foundation pressures and the potential for liquefaction of the soils would exist. Specific analysis of the structure was not done, but the hydrodynamic pressures created by the contents would probably damage the tank. Damage to any of the primary digestion tanks would create a condition where volatile gases would be vented to the atmosphere. This could result in fires and, possibly, explosions.

The pipe tunnels connect various structures within the complex and provide access ways for personnel and utilities. The tunnels are buried and are constructed of reinforced concrete. Earthquake forces generally would not affect the structure of these tunnels but could cause cracking of the walls due to dislocation at the point where they join at major structures. The tunnels also might tend to become buoyant due to liquefaction. Certain long tunnels could crack due to the wave shape resulting from surface ground motion and this could disrupt the flow of water in the channels above.

Nonstructural Elements

Appendix A of this paper also presents an inventory of the nonstructural features of a few of the facilities and an approximate cost to brace the items against seismic forces (see Rietherman, 1985). There are many different types of nonstructural elements to consider. The summary of these costs is given in Table 2. The nonstructural components are very vulnerable to the effects of seismic ground motion. These elements (piping and pumps especially) are essential to the operation of the plant. Backup power systems also need to be securely anchored and braced in order to be operational following an earthquake. The individual work sheets (see Appendix A for samples) for each of these structures has an itemized listing of the quantity of each type of nonstructural elements. Special attention should be given to toxic and flammable substances that are stored in a few of the facilities. It should be noted that it is very difficult in many cases to determine the exact quantity of each item listed in the table. The associated costs are therefore approximate. Many of the tasks are simple to accomplish and could be done by plant personnel.

Liquefaction Study

The liquefaction potential at the Water Reclamation Plant has been evaluated by Dames and Moore at the request of Reaveley Engineers and Associates. The basic conclusion of the report that was written is that the saturated granular site soils have a high liquefaction potential. Many of the structural facilities could experience damage in the form of excessive settlements, overturning due to bearing failure, and buoyancy uplift due to earthquake ground shaking. Connecting tunnels and pipes could sustain extensive damage.

Liquefaction, when referring to cohesionless soils, is the process that transforms the soil from a solid state to a liquefied state. This happens when earthquake ground motion causes increased porewater pressure and a resultant decrease in effective intergranular pressure.

Factors that affect liquefaction include: ground acceleration, duration of shaking, soil type, particle size and gradation, water level, relative density, and confining pressure. Liquefaction potential is the greatest where the ground water level is shallow and loose find sands occur within a depth of about 50 feet.

The following is a list of liquefaction mitigation techniques presented by Lew (1984):

1. Soil Improvement Methods
   - Dewatering
   - Relief wells (to reduce porewater pressures)

TABLE 2 Costs of Recommended Rehabilitation Steps for the Water Reclamation Plant

Structure Number	Structural Elements	Nonstructural Elements	Combined Cost
1*	$ 55,700.00	$ 12,173.00	$ 67,873.00
2	4,000.00	4,130.00	8,130.00
3	34,000.00	21,680.00	55,680.00
4*	10,020.00	8,490.00	18,510.00
5	NR†	1,430.00	1,430.00
6	NR	NR	NR
7	11,200.00	5,890.00	17,090.00
8	1,500.00	11,615.00	13,115.00
9	6,600.00	17,500.00	24,100.00
10	NR	11,200.00	11,200.00
11	1,500.00	1,830.00	3,330.00
12	NR	4,730.00	4,730.00
13	NR	NR	NR
14	NR	NR	NR
15	NR	1,930.00	1,930.00
16	NR	NR	NR
17	7,100.00	3,130.00	10,230.00
18	NR	NR	NR
19	NR	NR	NR
20	NR	NR	NR
21	2,500.00	830.00	3,330.00
22	NR	NR	NR
23	50,000.00	4,540.00	54,540.00
24	NR	NR	NR
25	NR	66,040.00	66,040.00
26*	300,000.00	NR	300,000.00
27	NR	NR	NR
28	NR	NR	NR
29	NR	575.00	575.00
30	NR	NR	NR
31	NR	962.50	962.50
32*	89,000.00	29,070.00	118,070.00
33	NR	36,870.00	36,870.00
34	5,600.00	NR	5,600.00
35	NR	44,100.00	44,100.00
Total	$578,720.00	$288,715.50	$867,435.50

*See example description of deficiencies and corrective actions in Appendix A.
†NR = none required.

- Stone columns (vibro-replacement)
- Excavation of poor soils and replacement with compacted fill
- Grout injection (compaction grouting)
- In situ densification (e.g., vibroflotation, terraprobe, impact densification, dynamic compaction, compaction piles, etc.)
- Placement of additional fill (to increase overburden pressures and soil strength)

2. Structural Fortification
   - Strengthen structural connections
   - Add graded beams and tie beams
   - Extend pile support into deeper stable soils

Of the suggested possibilities, the use of relief wells in conjunction with compaction grouting and the placement of additional fill materials appears to offer the most practical and cost-effective approach to mitigation of the liquefaction hazard at this facility.

Detailed suggestions for corrective actions to alleviate the liquefaction potential are beyond the scope of this paper but should be considered in a future study.

The consequence of liquefaction at this site would be disastrous and could destroy the facility.

Implications of the Great Salt Lake

The wastewater treatment plant is located in an area of the valley that has the lowest ground surface elevation in the city. This allows the waste water to naturally flow to this point. The rising level of Great Salt Lake presents a potential hazard to the treatment facility. If the lake continues to rise, the site could become submerged. The Utah Geologic and Mineral Survey (1986) has stated that the lake level should be anticipated to reach elevation 4217. With the lake at the present level (4211), a major displacement of the Salt Lake segment of the Wasatch Fault would have serious consequences. The various pump stations within the plant are required to lift the effluent to an elevation that allows it to flow out to the Great Salt Lake. Loss of these pumping systems would result in a massive lake of untreated waste water. There is a bypass canal that could be used to route the waste water around the plant, but it would require pumping the waste water over an earth levee. Salt Lake County currently pumps storm water tat this point. At the present time, the banks of the canal separate the lake from the treatment plant. Subsidence of the soils beneath the banks of the canals is a real possibility during ground shaking.

Another serious potential problem was discussed by Keaton (1986). This problem is associated with the likelihood that the surface of the valley floor would tilt downward towards the east. This is a result of the valley floor dropping relative to the mountain range on the east. Large areas in the vicinity of the wastewater treatment plant could become inundated by the lake water as it follows the new ground slope. This is a serious problem that has disastrous consequences. Long-range planning should be taken to deal with this possibility.

Summary and Conclusions

Sale Lake City's existing wastewater reclamation plant was evaluated for its vulnerability to seismic forces. The following is a summary of the findings and conclusion of the evaluation:

1. The facility is located in a region of potentially high ground acceleration due to seismic activity.

2. The subsoils in the vicinity of the facility have a high liquefaction potential. Many of the structural facilities could experience damage in the form of excessive settlements, overturning due to bearing failure, and buoyancy uplift. Connecting tunnels, channels, and pipes could sustain extensive damage. Costs were not estimated to correct this problem.

3. The structural facilities are, in general, reinforced for the effects of seismic forces, but there are many specific things that could be implemented to increase the seismic resistance of the various elements. These corrective actions would minimize the effects of ground motion. Many of the listed actions are very cost-effective.

4. The nonstructural components are very vulnerable to the effects of seismic ground motion. These elements (piping and pumps especially) are essential to the operational capability of the plant. Backup power systems need to be securely anchored and braced in order to be able to operate the facility following an earthquake.

5. The subsidence potential of dikes and earth levees during a seismic event is high due to the structure of the subsoils. The consequence of this happening should be evaluated.

6. The possibility of the Great Sale Lake rising to elevation 4217 should be considered. A lake surface at this elevation would be disastrous to the operation of this facility and to the ability of Salt Lake City to dispose of its waste water.

7. In conjunction with Item 6, the possible lake effects due to large scale ground tilting during earthquake action is a potential problem. Long-range planning should be implemented for this possibility.

LITTLE COTTONWOOD WATER TREATMENT PLANT

The Little Cottonwood Water Treatment Plant treats approximately 50 percent of the Salt Lake Valley's culinary water supply. Construction of the plant was completed in 1960 and is located at 9000 South Danish Road in Sandy City (Figures 6 and 7). Its water sources are the Little Cottonwood Creek and the Deer Creek reservoir aqueduct. Water from the Little Cottonwood Creek flows through the Murray City Power plant (located to the east of the plant) and then to the treatment plant. A portion of the water is then routed into the screen house of the treatment plant and then to the inlet control building. Water from the Deer Creek reservoir aqueduct first enters a diversion structure where it can be routed to either the inlet control building for further treatment or it may be routed through a bypass to the outlet building without being treated. The plant currently has a maximum capability of treating 115 million gallons of water per day. This is well below the capacity of the conduits that supply water to the treatment plant. Those conduits have a capacity of about 215 million gallons of water per day. After treatment, the water flows into the Salt Lake aqueduct which carries the water to the terminal reservoirs for storage and use.

The Little Cottonwood Water Treatment Plant consists of nine major, different structures, eight of which are interconnected. Appendix B contains a brief description of each structure. Figure 8 is a site plan of the facility. The screen house is the only structure that does not have a wall in common with another structure. Above ground, the structures are constructed primarily of concrete or masonry walls with metal panels on one or more of the exterior sides. Some of the facilities also have structural steel within the shell of the structure which supports the steel decking and built up roofs. Some of the roofs have ground parapets. All basins, the garage, and all levels that are below the ground level are constructed of reinforced concrete walls and concrete slabs on grade.

Figure 9 is a depiction of the seven major steps that all water treatment plants utilize to one degree or another. Some of the steps may differ somewhat from one plant to another. Also some of the steps may be combined into one step or use a different system for the same step. The Little Cottonwood Treatment Plant accomplishes all seven steps but in a slightly different manner from what has been depicted. This plant utilizes aerator basins which are not shown to be a part of the seven major steps. If a specific step in the process is eliminated (due to plant inoperability), the efficiency of the following steps becomes very low or the steps become impossible to perform.

The plant was previously studied by Eguchi and Taylor (1984). The following description of the plant flow process is taken largely from this reference. Figure 8 is provided to help with understanding.

Once the water enters the diversion structure from the Deer Creek reservoir aqueduct, it proceeds through the plant. Bypass capability from the diversion structure to the outlet building is available, but without chlorination capability. Water also is available from the Little Cottonwood Creek which enters the screen house where debris is

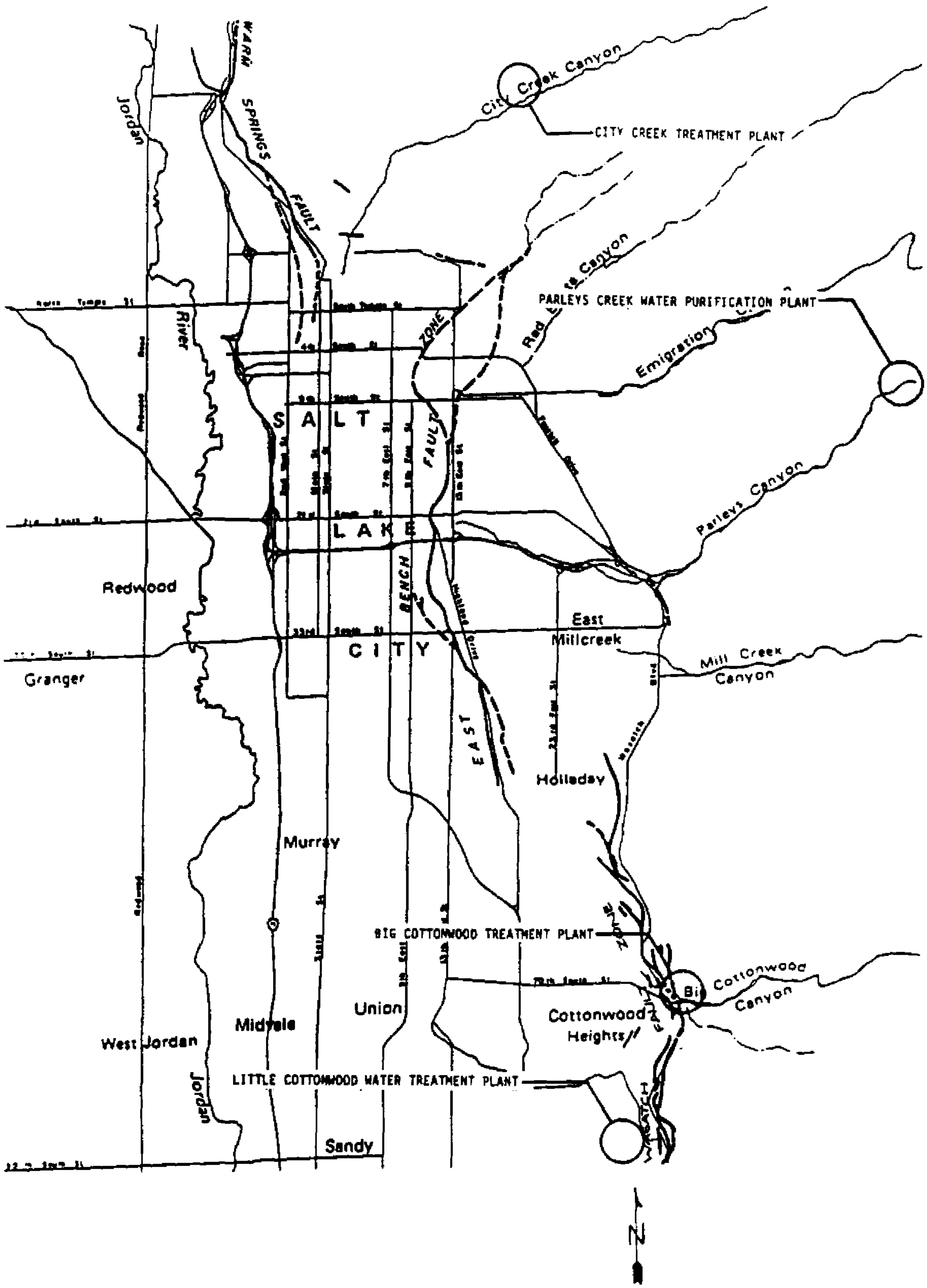


FIGURE 6 Salt Lake City essential facilities fault line map.

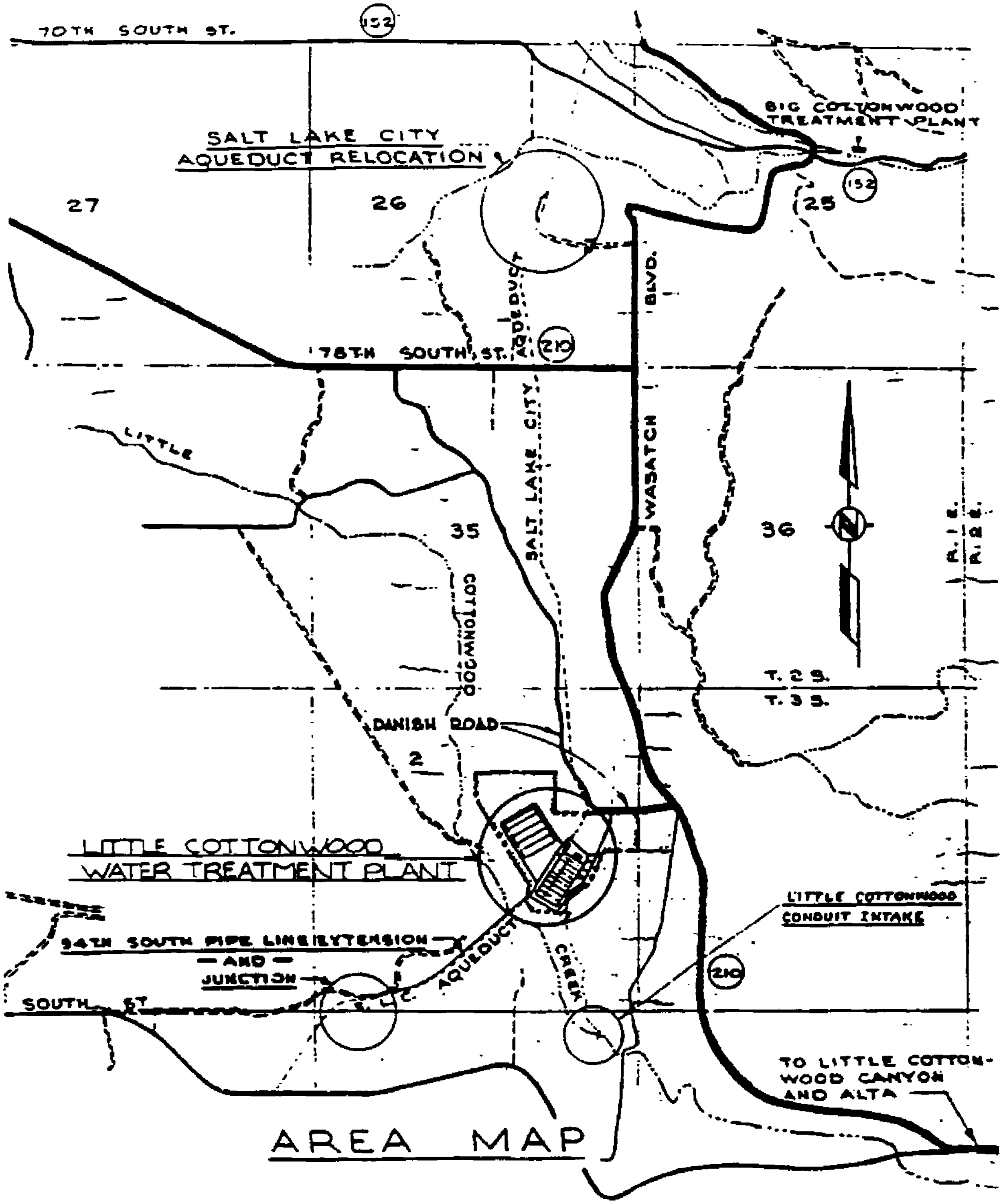


FIGURE 7 Area map.

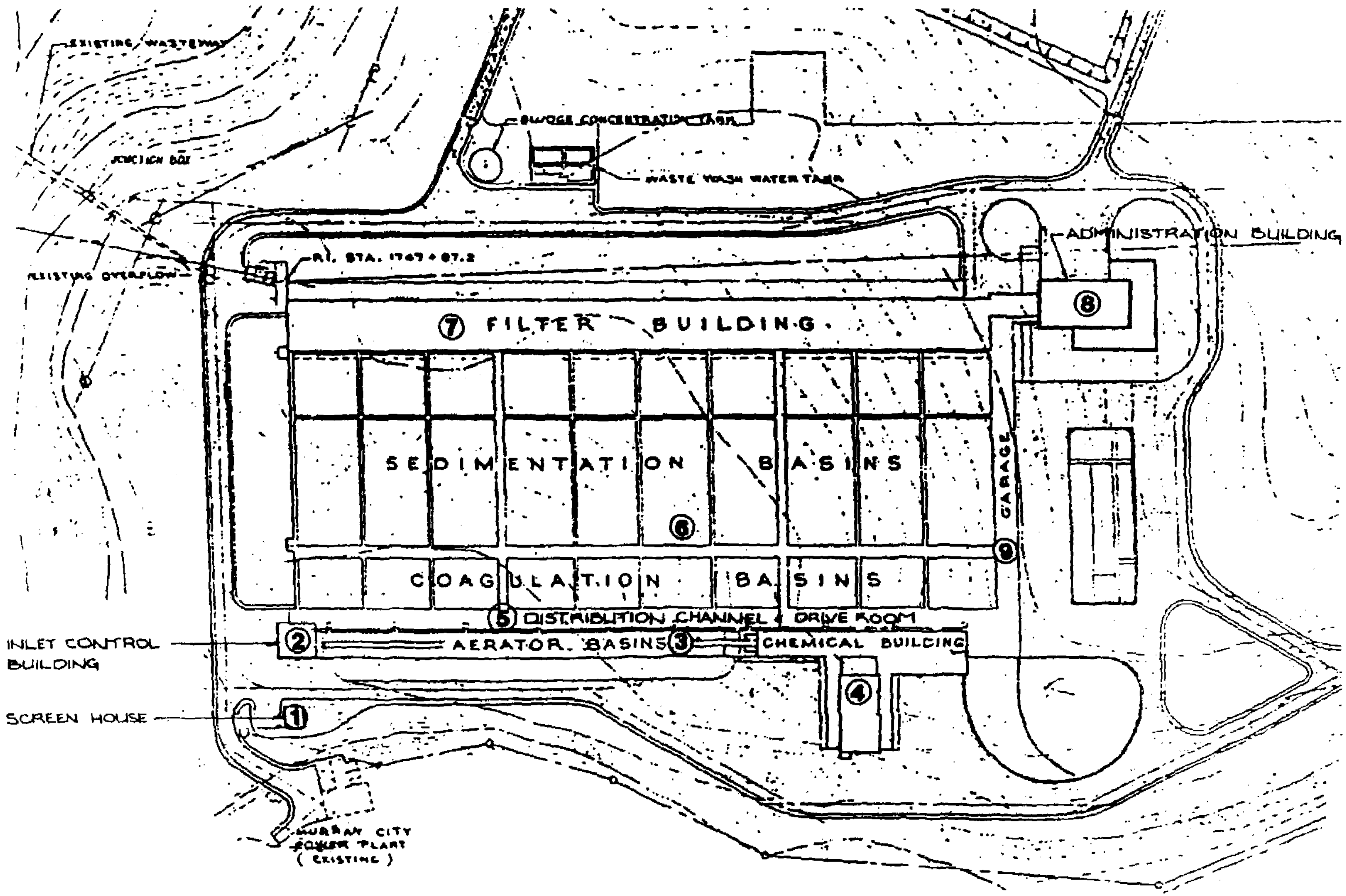
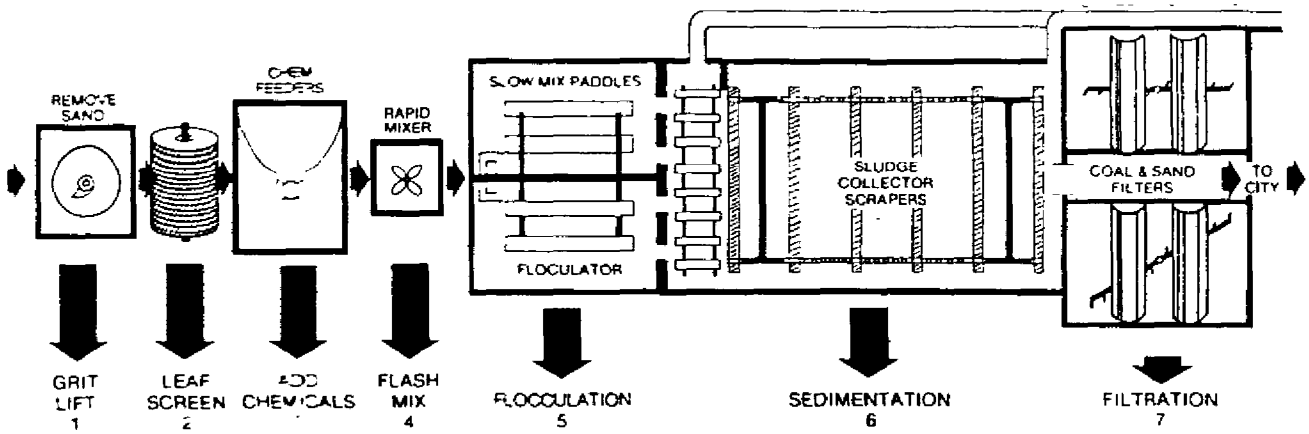
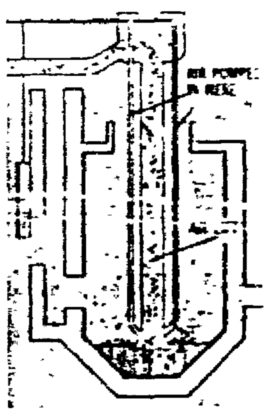


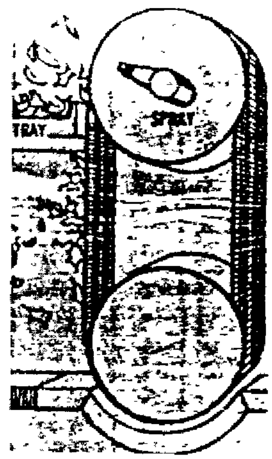
FIGURE 8 Treatment plant site plan.





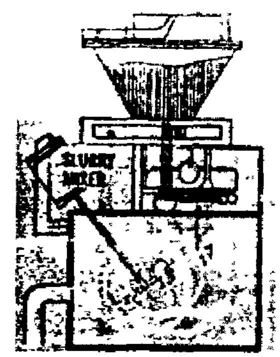
1. GRIT REMOVAL

Water from the stream is fed into basins at a high velocity. Sand settles at the bottom and is removed with an air lift pump. The clear water then flows over the top and into the plant.



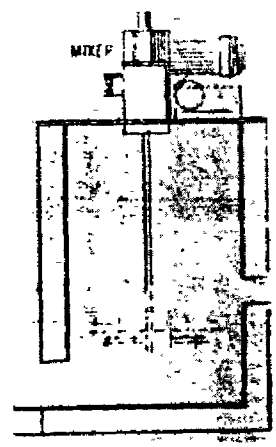
2. SCREENS

Traveling leaf screen removes leaves. High pressure water spray cleans screens, tray conveys leaves to outside for disposal



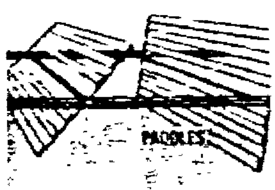
3. APPLICATION OF CHEMICALS

Aluminum sulphate, lime polymer and chlorine are applied by the chemical feeders. Slurry mixers stir the chemicals into water solutions which are fed into the water supply. The amount of chemicals used is based on the quantity of water flowing



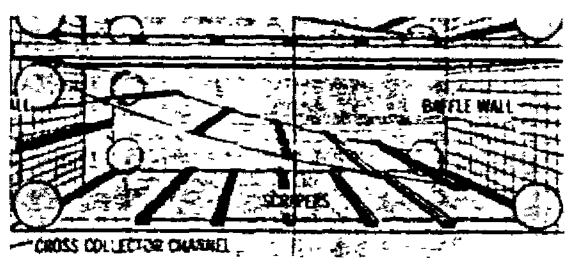
4. FLASH MIXERS

Powerful rapid mixers thoroughly mix chemicals into the water stream, which then begin to chemically react forming floc particles around the dirt, silt and bacteria. This process is called coagulation of the chemicals alum and lime. Silica or polymer are sometimes added to make tougher, hardier floc to withstand breakup.



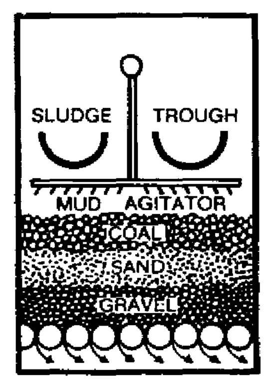
5. SLOW MIXING

Flocculation is the process of slowly mixing the tiny chemically formed floc particles until they attach to each other building a small snowflake appearing precipitate called floc. This floc is continuously agitated by huge flocculator paddles causing the floc particles to make contact and grow larger and heavier as they collect bacteria and microscopic particles. Activated carbon may also be added to absorb bad tastes, odors and color caused by gases from decomposing organics. All added chemicals are almost completely removed before the water leaves the plant. Even the chlorine used to kill bacteria dissipates, leaving only a small protective residual



6. SEDIMENTATION

Actually a dual process generally referred to as coagulation and sedimentation is accomplished by adding chemicals to produce a "floc" that collects small foreign particles and bacteria which are settled out as the floc-laden water flows slowly through the sedimentation basins where it remains nearly motionless, while the floc is allowed to settle Periodically, the sludge collection scrapers in the sedimentation basins are turned on to collect and remove the settled floc



7. FILTRATION

The four-hour water treatment is completed as water filters through 32 inches of coal sand and gravel The sand is periodically cleaned by backwashing A rotating agitator breaks up any caked floc or sludge, and grinds the sand particles clean during backwash Troughs and channels carry floc sludge to large evaporation drying beds

FIGURE 9 Major steps in the drinking water treatment plant process.

removed. The screen house is especially needed for removing debris in the spring and fall. Deer Creek Reservoir is the major source of water, with variable flows from the Little Cottonwood Creek that naturally provides more water in the spring.

The inlet control building receives water from the screen house and also from the diversion structure. The inlet control building leads to aeration channels and the mixing area, where the flows enter a distribution channel and then enter coagulation and mixing basins. It is after water has passed through the aeration channels that chemicals from the chemical building are added to the water. The chemical building does not actually make up a link in the system of water flow, although chlorination piping and other conduits connect various systems with the chemical building to other parts of the plant.

Water flows from the coagulation and sedimentation basins to filter basins located within the filter building. There are ten coagulation and sedimentation basins and ten filter basins. As a result, barring considerable permanent displacement, it is unlikely that all basins would be damaged in an earthquake. Even if several basins are damaged, those can be valved and repaired while flows continue in the other available channels.

From the filter basins, water flows into the pipes in the pipe gallery also located in the filter building to a post chlorination area, one of several points connected by piping to the chemical building so that chlorine can be added. From this area, water can flow either into the backwash system or to the outlet building.

Water for backwashing the filter beds is stored within the administration building. The plant can generally operate for one day before backwashing is indispensable. Backwash water flows to the waste washwater tank from where water can be routed back to the inlet control building.

Structural Elements

The structural elements can be grouped into the following classifications: buildings, reinforced concrete channels, reinforced concrete basins and pipe tunnels. Each structural element houses a different function of the plant or houses equipment and materials which help with a specific function being performed elsewhere within the plant. Each structural element contains a wide range of architectural, structural, mechanical, electrical and piping systems.

Appendix B of this paper contains examples of listings of structural deficiencies of structural elements and suggested methods of correcting the deficiencies. Approximate costs to implement the corrective action are included in Table 3. The structural facilities are in general not reinforced for the effects of seismic forces. There are many specific corrective measures which could be implemented to increase the seismic resistance of the various structures. These corrective actions would minimize the effects of ground motion and make the facility more resistant to earthquake forces.

TABLE 3 Cost of Recommended Rehabilitation Steps for the Little Cottonwood Treatment Plant

Structure & No.	Structural Elements	Nonstructural Elements	Combined Cost	Accum. Total
Admin., 8*	$300,000	$24,513	$324,513	$ 324,513
Dist. & Drive, 5	240,000	41,340	281,340	605,853
Chemical, 4	12,000	54,590	66,590	672,443
Coag. & Sed., 6*	900,000	NA	900,000	1,572,443
Garage, 9	532,000	12,565	544,565	2,117,008
Filter, 7	12,000	3,030	15,030	2,132,038
Inlet Con., 2	2,500	850	3,350	2,135,388
Screen Hse., 1	1,100	350	1,450	2,136,838
Aerator Bas.,3	NA	7,100	7,100	2,143,938

NOTE: Recommended rehabilitation steps are listed in order of importance, the first step being the highest priority.

*See example description, findings, evaluations, and recommendations in Appendix B.

Nonstructural Elements

Appendix B also contains sample listings of the approximate quantity of each type of nonstructural element housed within a structure and the approximate cost to brace the items against the seismic forces. A summary of these costs is included in Table 3. Much of the bracing is simple to install and could be done by plant personnel. The nonstructural components are very vulnerable to the effects of seismic ground motion. These elements (piping and pumps especially) are essential to the operation of the plant. Back up power systems also need to be securely anchored and braced in order to be able to operate the facility should they be needed. Special attention should be given to toxic substances that are stored at the plant. It should be noted that it is very difficult in many cases to determine the exact quantity of each nonstructural item and that the actual quantities will very somewhat from those reported.

Geologic Setting

The Little Cottonwood Water Treatment Plant is located along the east edge of the Salt Lake Valley at the mouth of Little Cottonwood Canyon. The main fault line lies to the east of the plant and is between the plant and the mountains. The fault trace is within one quarter of a mile of the facility. The plant is on the down thrown side of the normal fault and may be within the zone of surface deformation.

The water that is supplied to the plant crosses the fault zone. If this segment of the fault moves, the conduits that contain the water will surely be disrupted. Emergency plans should be formulated to deal with this potential. These plans should include the alignment and containment of Little Cottonwood Creek, and the containment of the water in the Deer Creek aqueduct. It might be prudent to stock extra sections of the large diameter concrete pipe of which the aqueduct is constructed. Sections that have bends in them as well as straight pieces could easily be stocked in the proximity of the fault line for emergency use. Valves that control the flow in the aqueduct should be studied for their vulnerability and location with respect to the fault.

The near proximity of the fault guarantees that elements of the plant would experience high levels of ground shaking if there were slippage at this section of the fault. High levels of vertical acceleration as well as horizontal motion should be anticipated.

Conclusions

The Little Cottonwood Water Treatment Plant was studied for the seismic vulnerability of the nine main structures which make up the facility. Construction of the facility was completed before seismic design regulations were adopted by the building community in the Utah area. Structural systems were designed for earth, wind, or water forces. Most nonstructural components were not considered for anchorage or bracing for earthquake forces. These and other observations lead to the following conclusions concerning the water treatment plant:

1. The facility is located in a region of potentially high ground acceleration due to seismic activity. Ground surface deformation may occur at this site due to its close proximity to the fault line.

2. The structures are subject to damage and collapse from expected seismic forces. However, the structures can be seismically retrofitted to increase the seismic resistance of the various structures to resist the expected seismic forces. There are many specific things that could be implemented. These corrective actions would minimize the effects of ground motion. Many of the listed actions are very cost effective and do not appear to be prohibitive considering the consequences of any of the elements becoming inoperative because of a large earthquake.

3. Probable collapse potential exists for the administration building, chemical building and garage.

4. The drive room and also the coagulation and sedimentation basins were not designed for the hydrodynamic forces generated during a major earthquake. The walls of these structures were

designed for hydrostatic forces that are many times smaller than the expected hydrodynamic forces generated by an earthquake.

5. Retrofitting the administration building was deemed to be the most important of the recommended rehabilitation steps because the filters would become inoperable after a short period of time; somewhere between 24 and 72 hours. The administration building also houses many of the instruments needed for monitoring all of the functions of the entire facility. It is the nerve center of the facility. The administration building is probably the least seismic resistant structure at the facility.

6. The distribution channel and drive room was deemed to be the next most important structure for needed rehabilitation steps because if any of its walls were to fail, it is possible that water could never reach the filters. Also, substantial quantities of electrical equipment and pathways for water to reach other areas of the plant housed in this structure.

7. The chemical building was deemed to be the next most important structure for needed rehabilitation steps because it houses all of the chemicals used in the water treatment process.

8. The nonstructural components are very vulnerable to the effects of seismic ground motion. These elements (piping and pumps especially) are essential to the operational capability of the plant. Backup power systems need to be securely anchored and braced in order to be able to operate the facility following an earthquake.

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APPENDIX A

WATER RECLAMATION PLANT

NON-STRUCTURAL ELEMENTS
Water Reclamation Plant
1850 North Redwood Rd.
Salt Lake City, UT 84116

STRUCTURE: NO.1 SCREEN AND GRIT STORAGE BUILDING

ITEM	QTY.	BRACED	UNBRACED	UNIT BRACING COST	COST	COMMENTS
Furnace/Boiler				$100		
Water Heater				$100		
Water Tanks				$100		
Hanging Unit Heater	4		x	$100	$400	2 upper - 2 lower
Roof Top HVAC Equipment				$100		
Roof Top Swamp Cooler				$150		
Pumps for HVAC Equipment						
Natural Gas Lines	180'		x	$50/12'	$750	
Gas Meter						
Water Lines				$50/12'		
Ceiling Diffuser				$50		
Duct Work for Odor Control	100'		x	$100/10'	$1,000	
Sludge Lines	240'		x	$100/12'	$2,000	
Pumps/Water	2	x				Bolted to floor
Pumps/Sludge						
Storage Hoppers	2		x	$500	$1,000	
Grit Conveyors	2		x	$750	$1,500	
Emergency Generator				$200		
Emergency Batteries				$200		
Transformers				$200		
Battery Powered Lights				$50		
Light Fixtures	36		x	$30	$1,080	
Electrical Panels/Equipment	7		x	$100	$700	Adjacent to wall
Electrical Conduit	500'		x	$50/12'	$2,083	
Parapets				$75/Ft		
Chimneys				$200		
Exterior Cladding/Ornamentation						
Interior Partitions/Built-In				$15/Ft		
Interior Partitions/Movable				$10/Ft		
Ceiling Systems				$2/Sq Ft		
Overhead Door and Supports				$400		
Tall Storage Racks/Shelves				$250		
Office Equip/Computers/Printers				$50		
Tall File Cabinets/Furnishings				$30		
Lockers				$30		
Screen Enclosure Extension	2		x	$300	$600	
Communication Equipment				$50		
Fuel Pumps				Var.		
Steel Tanks w/Compressed Gas				$200		
Chemical Storage/Cleaning Mat'l				Var.		
Fire Extinguishers & Cabinets	2		x	Var.	$60	No cabinets
Odor Control Equipment	1		x	$1000	$1,000	
					======	
				TOTAL	$12,173	

NON-STRUCTURAL ELEMENTS
Water Reclamation Plant
1850 North Redwood Rd.
Salt Lake City, UT 84116

STRUCTURE: NO.4 GENERATOR BUILDING

ITEM	QTY.	BRACED	UNBRACED	UNIT BRACING COST	COST	COMMENTS
Furnace/Boiler				$100		
Water Heater	1		x	$100	$100	24" high - no attach.
Water Tanks				$100		
Hanging Unit Heater	4		x	$100	$400	
Roof Top HVAC Equipment				$100		
Roof Top Swamp Cooler				$150		
Pumps for HVAC Equipment						
Natural Gas Lines				$50/12'		
Gas Meter						
Water Lines				$50/12'		
Ceiling Diffuser				$50		
Pumps/Water						
Pumps/Sludge						
Storage Hoppers						
Emergency Generator	2	x		$200		Exhaust unbraced
Emergency Batteries	2		x	$200	$400	Floor mounted
Transformers				$200		
Battery Powered Lights				$50		
Light Fixtures	16		x	$30	$480	Ceiling hung
Electrical Panels/Equipment				$100		
Electrical Conduit	600'		x	$50/12'	$2,500	Various sizes
Bridge crane	1		x	$1250	$1,250	5-ton capacity
Parapets				$75/Ft		
Chimneys				$200		
Exterior Cladding/Ornamentation						
Interior Partitions/Built-In	1		x	$15/Ft	$750	At control room
Interior Partitions/Movable				$10/Ft		
Ceiling Systems	1		x	$2/Sq Ft	$2,000	At control room
Overhead Door and Supports	2	x		$400		
Tall Storage Racks/Shelves				$250		
Office Equip/Computers/Printers				$50		
Tall File Cabinets/Furnishings				$30		
Lockers				$30		
Communication Equipment				$50		
Fuel Pumps				Var.		
Steel Tanks w/Compressed Gas				$200		
Chemical Storage/Cleaning Mat'l				Var.		
Fire Extinguishers & Cabinets	2		x	Var.	$60	No cabinet-wall hung
Fuel tank	1		x	150	$150	Floor mounted
Exhaust stacks	2		x	200	$400	
					======	
				TOTAL	$8,490	

NON-STRUCTURAL ELEMENTS
Water Reclamation Plant
1850 North Redwood Rd.
Salt Lake City, UT 84116

STRUCTURE: NO.32 CENTRIFUGE BUILDING

ITEM	QTY.	BRACED	UNBRACED	UNIT BRACING COST	COST	COMMENTS
Furnace/Boiler				$100		
Water Heater				$100		
Water Tanks	1		x	$100	$100	Angle stand
Hanging Unit Heater	4		x	$100	$400	
Roof Top HVAC Equipment				$100		
Roof Top Swamp Cooler				$150		
Pumps for HVAC Equipment						
Natural Gas Lines	1200'		x	$50/12'	$5,000	
Gas Meter						
Water Lines	1800'		x	$50/12'	$7,500	
Ceiling Diffuser				$50		
Vapor Lines	2400'		x	$50/12'	$10,000	
Compressor Tanks	2		x	$100	$200	
Pumps/Water						
Pumps/Sludge						
Storage Hoppers						
Storage Bins	3		x	$100	$300	
Plywood Storage Bins	1		x	$100	$100	
Emergency Generator				$200		
Emergency Batteries				$200		
Transformers	2		x	$200	$400	Adjacent to wall
Battery Powered Lights				$50		
Light Fixtures	24		x	$30	$720	Incand. hung from ceil.
Electrical Panels/Equipment	10		x	$100	$1,000	
Electrical Conduit	500'		x	$50/12'	$2,000	
Vapor Boxes	3		x	$100	$300	Vert.-Floor mounted
Parapets				$75/Ft		
Chimneys	3	x		$200		
Exterior Cladding/Ornamentation						
Interior Partitions/Built-In				$15/Ft		
Interior Partitions/Movable				$10/Ft		
Ceiling Systems				$2/Sq Ft		
Overhead Door and Supports				$400		
Tall Storage Racks/Shelves	1		x	$250	$250	
Office Equip/Computers/Printers				$50		
Tall File Cabinets/Furnishings				$30		
Lockers	1		x	$30	$30	
Saws and Woodworking Equip.	6		x	$100	$600	
Communication Equipment				$50		
Fuel Pumps				Var.		
Steel Tanks w/Compressed Gas				$200		
Chemical Storage/Cleaning Mat'l				Var.		
Fire Extinguishers & Cabinets	3		x	Var.	$90	Wall hung-no cabinet
					======	
				TOTAL	$29,070	

WATER RECLAMATION PLANT
1850 NORTH REDWOOD ROAD
SALT LAKE CITY, UT 84116

STRUCTURE: #1 SCREEN & GRIT STORAGE BUILDING

DESCRIPTION: CMU ABOVE GRADE, DOUBLE TEE ROOF, POURED IN PLACE CONCRETE FLOORS, CONCRETE BELOW GRADE.

AREA: 1300 SQ. FT. MAIN & UPPER LEVELS
2600 SQ. FT. LOWER LEVEL

ITEM NO.	STRUCTURAL DEFICIENCY	CORRECTIVE ACTION	UNIT COST	COST	ACCUM. COST	COMMENTS
1	ROOF DIAPHRAGM IS NOT CONTINUOUS	CONNECT DOUBLE TEE FLANGES WITH 7" X 3/16" PLATES AND 5/8" DIA. BOLTS @ 16" O.C.	$10/ BOLT $.25/ STEEL	$22,700	$22,700	
2	MASONRY WALLS ARE OVERSTRESSED.	4" LAYER OF GUNITE, REINFORCED W/ #5 @ 12" O.C. E.W. ON NORTH, AND EAST WALLS. ADHESIVE ANCHORS & DOWELS @ ROOF, UPPER, AND MAIN LEVELS.	$200/YD GUNITE $.38/LB STEEL $20/ANCH & DOWEL	$33,000	$55,700	

WATER RECLAMATION PLANT
1850 NORTH REDWOOD ROAD
SALT LAKE CITY, UT 84116

STRUCTURE: #4 GENERATOR BUILDING

DESCRIPTION: PRE-CAST DOUBLE TEE ROOF AND WALL PANELS, CONCRETE SLAB ON GRADE

AREA: 1630 SQ FT.

ITEM NO.	STRUCTURAL DEFICIENCY	CORRECTIVE ACTION	UNIT COST	COST	ACCUM. COST	COMMENTS
1	NO CHORD TIES AT THE ROOF	ATTACH A 3" X 1/4" CONT. PLATE TO WALLS. LOCATE BELOW BEARING HAUNCH OF WALL PANELS. CONNECT TO WALL PANEL AT EACH BEARING POINT WITH EXPANSION BOLTS.	$10/FT.	$1720	$1720	
2	CONNECTION OF THE DOBLE TEE LEG TO THE BEARING HAUNCH IS DOUBTFUL.	CONNECT DOUBLE TEE LEG TO HAUNCH OR WALL.	$100/ CONNECT	$2200	$3920	
3	DIAPHRAGM ACTION OF ROOF IS NOT ESTABLISHED.	CONNECT ROOF TO WALL WITH 5" X 5" X 1/4" BENT PLATE W/ 5/8" DIA. BOLTS @ 16" O.C. TO ROOF AND WALLS.	$35/ FT	$6100	$10,020	

WATER RECLAMATION PLANT
1850 NORTH REDWOOD ROAD
SALT LAKE CITY, UT 84116

STRUCTURE: #26 ANEROBIC DIGESTERS #1, #2, & #3

DESCRIPTION: FLOATING STEEL ROOF WITH CONCRETE WALLS AND FLAT SLAB, WALLS ARE COVERED WITH GUNITE AND METAL SIDING.

AREA: APPROXIMATELY 7100 SQ. FT.

ITEM NO.	STRUCTURAL DEFICIENCY	CORRECTIVE ACTION	UNIT COST	COST	ACCUM. COST	COMMENTS
1.	EXTERIOR TENSILE STEEL DOES NOT HAVE THE NECESSARY CAPACITY FOR SEISMIC LOADS.	REMOVE EXISTING GUNITE AND INSULATION AND WRAP POST-TENSION CABLES AROUND EXTERIOR UP TO THE HIGHEST SLUDGE LEVEL. REPLACE INSULATION AND GUNITE.	$100,000	$300,000	$300,000	

WATER RECLAMATION PLANT
1850 NORTH REDWOOD ROAD
SALT LAKE CITY, UT 84116

STRUCTURE: #32 CENTRIFUGE BUILDING

AREA: 2300 SQ. FT. - MAIN AND UPPER LEVELS

DESCRIPTION: PRE-CAST DOUBLE TEE ROOF PANELS BEARING ON CONCRETE BEAMS, SUPPORTED BY CONCRETE PILASTERS. POURED-IN-PLACE CONCRETE FLOOR BEARING ON CONCRETE BEAM. CONCRETE SLAB ON GRADE. CMU INFILL PANELS BETWEEN CONCRETE PILASTERS.

ITEM NO.	STRUCTURAL DEFICIENCY	CORRECTIVE ACTION	UNIT COST	COST	ACCUM. COST	COMMENTS
1	PLANS DO NOT AGREE WITH THE STRUCTURE AS BUILT.					
2	REINFORCED MASONRY WALLS DO NOT HAVE THE NECESSARY SHEAR CAPACITY.	REPLACE ONE BAY OF CMU ON ALL 4 SIDES AND REPLACE WITH 8" THICK CONCRETE. REINFORCE WITH # 5 @ 15" O.C. EACH WAY.	$38/ SQ. FT.	$1700	$1700	
3	ROOF DIAPHRAGM IS INCOMPLETE	CONNECT DOUBLE TEE FLANGES W/ 7" X 3/16" PLATES AND 5/8" DIA. EXP. BOLTS @ 16" O.C. GUNITE BETWEEN DOUBLE TEE LEGS. CONNECT DOUBLE TEES TO WALLS W/ 5" X 5" X 1/4" BENT PLATE AND 5/8" DIA. EXP. BOLTS @ 16" O.C.	$.35/ SQ. FT. $200/YD GROUT $35/FT. CONN.	$80,000 $1000 $6900	$89,000	

APPENDIX B

COTTONWOOD TREATMENT PLANT

Structure 6—Coagulation and Sedimentation

Description

The coagulation and sedimentation basins are located in the center of the plant and occupy the largest plant area. The function of the coagulation basins is to allow for slow mixing of the chemicals into the water. Sedimentation then takes place in the sedimentation basins. During the sedimentation process, the water flows very slowly, allowing the "floc" (produced by chemicals which attract bacteria) to settle to the bottom for periodic removal. The water then flows to the filters. The processes occurring in the coagulation and sedimentation basins correspond to Steps 5 and 6 of Figure 9.

The basins are built of reinforced concrete beams and walls. The beams, at an elevation of 5027 feet, provide additional support at the top of the walls to prevent movement of the walls below. The floor slabs of the basins are composed of reinforced concrete with varying top of slab elevations, but the top of slab elevation is generally at about 5015 feet.

Findings and Evaluations

The basins are located in seismic Zone 3 as defined in the 1985 Uniform Building Code. When the structure is analyzed using static forces generated by using the Uniform Building Code requirements in conjunction with the method of analysis recommended by AFM 88-3 Seismic Design for Buildings, all of the walls are stressed more than they are capable of withstanding. The capacity of the walls separating individual basins in about 5.2 K-ft/ft while the seismic loads are about 39.4 K-ft/ft in the worst case or 14 K-ft/ft under the most favorable assumptions. These walls are grossly inadequate for forces generated during a seismic event. The capacity of the drive room walls is about 8.09 K-ft/ft, while the seismic loads are about 31.8 K-ft/ft in the worst case or 11.3 K-ft/ft under the most favorable assumptions. These walls are also inadequate for the loads which could be generated by a seismic event.

Recommendations for Repairs and/or Seismic Upgrade

1. It is recommended that the entire length of the wall which separates the basins from the garage be thickened with a layer of concrete 8 inches thick placed on both sides of the wall. Each layer would need to be reinforced with a No. 6 bar vertical at 12 inches o.c. and a No. 4 bar horizontal at 12 inches o.c.

2. It is recommended also that the entire length of the wall which separates the basins from the two tunnels which connect the drive room to the filter building be thickened with a layer of concrete 8 inches thick placed on both sides of the wall. Each layer would need to reinforced with a No. 6 bar vertical at 12 inches o.c. The beams at the top of the two tunnels would also need to be enlarged in order to carry the large seismic loads.

3. It is also recommended that the entire wall which separates the basins from the drive room be thickened with a 12 inch layer of concrete reinforced with a No. 8 bar vertical at 12 inches o.c. at each face and a No. 4 bar horizontal at 12 inches o.c. at each face.

Structure 8—Administration Building

Description

The administration building is a four story structure with approximately 5450 square feet at each floor. This building performs a variety of functions. Besides containing the administrative offices, it also houses a large amount of monitoring equipment, the main laboratory, and two large backwash water tanks. While none of the water treatment process is performed in this building, it is the last structure of the plant that the treated water passes through before it is released into the Salt Lake City aqueduct for use by the general public.

The floor structure is built out of steel deck, beams, and columns. The floors are constructed out of reinforced concrete slabs, beams, and columns and walls.

Findings and Evaluations

The administration building does not have any type of lateral load resisting system in the north-south direction. The loads could be resisted by frames or shear walls but neither has been incorporated into the design of the building. One item in particular adds to the severity of the problem. It is the two backwash water tanks located on the top floor. These have a tremendous effect on the static lateral loads that must be imposed upon the building. Also, the building has been constructed of a heavy building material, concrete, which also increases the lateral loads that must be imposed. Also, the concrete wall at the west side of the administration building is broken and discontinuous. Any portion of the wall which is continuous from the foundation upwards would be overstressed by seismic forces.

Recommendations for Repairs and/or Seismic Upgrade

It is recommended that shear walls be added to the structure at the east and west sides of the building. These walls would directly resist forces in the north-south direction and also resist torsional forces that arise when the forces are in an east-west direction. It would be best to center these walls in the existing metal panel walls. The walls would need to be 12 inch thick concrete reinforced with No. 5 bars horizontal at 12 inches o.c. at each face and No. 4 bars vertical at 12 inches o.c. at each face. The walls would need to 50 feet long up to elevation 40 feet (the top floor) and then could decrease to 20 feet long up to the roof. Each wall would require excavating underneath and underpinning the existing foundations an replacing them with new ones. An alternate method would be to place the backwash water tanks outside of the building. This would greatly reduce the seismic forces that the building would have to resist although the building would still require shear walls in the east and west walls. They would not need to be so large, however.

It is the author's understanding that the filter beds will operate for only about 72 hours without being backwashed. It will be difficult to achieve the correct connections between the floors and the recommended concrete walls and it will also be difficult to construct the required foundations but with the two additional walls, the building could be brought up to nearly 100 percent of the capacity that is required by the 1985 *Uniform Building Code*.

LITTLE COTTONWOOD WATER TREATMENT PLANT

9000 SOUTH DANISH ROAD
SANDY, UT 84092

STRUCTURE: #6 COAGULATION AND SEDIMENTATION BASINS

AREA: 22,300 SQ. FT. PER SET OF COAGULATION AND SEDIMENTATION BASINS

DESCRIPTION: REINFORCE CONCRETE WALLS AND SLAB ON GRADE, CONCRETE BEAMS AT THE TOP OF THE WALS FOR STABILITY

ITEM NO.	STRUCTURAL DEFICIENCY	CORRECTIVE ACTION	UNIT COST	COST	ACCUM. COST	COMMENTS
1.	REINFORCED CONCRETE WALLS SEPARATING THE TUNNELS FROM THE BASINS IS UNDERDESIGNED FOR THE HYDRO-DYNAMIC WATER PRESSURES	PLACE A LAYER OF CONCRETE 8" THICK AND REINF. WITH #6 BAR AT 12"O.C. VERT. AND #4 BAR AT 12"O.C. AT EACH SIDE OF THE WALL	$25.00 PER SQ. FT.	$450,000	$450,000	
2.	REINFORCED CONCRETE WALL SEPARATING THE GARAGE FROM THE BASINS IS UNDERDESIGNED FOR THE HYDRO-DYNAMIC WATER PRESSURES	PLACE A LAYER OF CONCRETE 8" THICK AND REINF. WITH #6 BAR AT 12"O.C. VERT. AND #4 BAR AT 12"O.C. AT EACH SIDE OF THE WALL	$25.00 PER SQ. FT.	$900,000	$1,350,000	
3.	REINFORCED CONCRETE WALL SEPARATING THE DRIVE ROOM FROM THE BASINS IS UNDERDESIGNED FOR THE HYRO-DYNAMIC WATER PRESSURES	PLACE A LAYER OF CONCRETE 12" THICK AND REINF. WITH A #8 BAR AT 12" O.C. VERT. AND EACH FACE AND A #4 BAR AT 12" O.C. HORIZ. AND AT EACH FACE ON THE BASIN SIDE OF THE WALL	$25.00 PER SQ. FT.	$240,000	$1,590,000	

LITTLE COTTONWOOD WATER TREATMENT PLANT
9000 SOUTH DANISH ROAD
SANDY, UT 84092

STRUCTURE: #8 ADMINISTRATION BUILDING

DESCRIPTION: CONCRETE FLOORS, STEEL ROOF DECK, NORTH AND SOUTH WALLS ARE OF CONCRETE WITH VENEER, EAST AND WEST WALLS ARE OF A WINDOW AND METAL PANEL SYSTEM

AREA: 5450 SQ. FT.

ITEM NO.	STRUCTURAL DEFICIENCY	CORRECTIVE ACTION	UNIT COST	COST	ACCUM. COST	COMMENTS
1.	LATERAL CAPACITY IN THE NORTH-SOUTH DIRECTION IS UNDER-DESIGNED	ADD A 50' LONG, 12" THICK SHEAR WALL TO THE EAST AND WEST SIDES OF THE BUILDING	$45.00 PER SQ. FT.	$300,000	$300,000	

NON-STRUCTURAL ELEMENTS
Little Cottonwood Water Treatment Plant
9000 South Danish Road
Sandy, UT 84092

STRUCTURE: NO.6 COAGULATION AND SEDIMENTATION BASINS

ITEM	QTY.	BRACED	UNBRACED	UNIT BRACING COST	COST	COMMENTS
Furnace/Boiler	N/A					
Water Heater	N/A					
Water Tanks	N/A					
Hanging Unit Heater	N/A					
Roof Top HVAC Equipment	N/A					
Roof Top Swamp Cooler	N/A					
Pumps for HVAC Equipment	N/A					
Natural Gas Lines	N/A					
Gas Meter	N/A					
Water Lines	N/A					
Ceiling Diffuser	N/A					
Pumps/Water	N/A					
Pumps/Sludge	N/A					
Storage Hoppers	N/A					
Drive units	20	x				
Emergency Generator	N/A					
Emergency Batteries	N/A					
Transformers	N/A					
Battery Powered Lights	N/A					
Light Fixtures	N/A					
Electrical Panels/Equipment	N/A					
Electrical Conduit	N/A					
Coagular Paddles	60	x				Bolted to slab
Retrieval system	40	x				
Parapets	N/A					
Chimneys	N/A					
Exterior Cladding/Ornamentation	N/A					
Interior Partitions/Built-in	N/A					
Interior Partitions/Movable	N/A					
Ceiling Systems	N/A					
Overhead Door and Supports	N/A					
Tall Storage Racks/Shelves	N/A					
Office Equip/Computers/Printers	N/A					
Tall File Cabinets/Furnishings	N/A					
Lockers	N/A					
Communication Equipment	N/A					
Fuel Pumps	N/A					
Steel Tanks w/Compressed Gas	N/A					
Chemical Storage/Cleaning Mat'l	N/A					
Fire Extinguishers & Cabinets	2	x				

NON-STRUCTURAL ELEMENTS
Little Cottonwood Water Treatment Plant
9000 South Danish Road
Sandy, UT 84092

STRUCTURE: NO.8 ADMINISTRATION BUILDING

ITEM	QTY.	BRACED	UNBRACED	UNIT BRACING COST	COST	COMMENTS
Furnace/Boiler	3		x	$100	$300	Small - Table units
Water Heater	N/A					
Water Tanks	7		x	$150	$1,050	3 large - 4 small
Hanging Unit Heater	5		x	$100	$500	
HVAC Equipment - Cooling Units	2	x		$100		
Roof Top Swamp Cooler	N/A					
Ducts for HVAC Equipment	60'		x	$50/12'	$250	
Natural Gas Lines	N/A					
Gas Meter	N/A					
Water Lines	2000'		x	$50/12'	$8,333	
Ceiling Diffuser	N/A					
Roof Drain Lines	100'		x	$75/10'	$750	Cast Iron
Small Motors	3	x				
Large Motors	2	x				
Storage Hoppers	N/A					
Emergency Generator	N/A					
Emergency Batteries	N/A					
Transformers	N/A					
Battery Powered Lights	N/A					
Light Fixtures	100		x	$30	$3,000	
Electrical Panels/Equipment	15	x				
Electrical Conduit	N/A					
Switch Panels	21		x	$100	$2,100	
Light Panels	15	x				
Parapets	N/A					
Chimneys	N/A					
Exterior Cladding/Ornamentation	N/A					
Interior Partitions/Built-In	N/A					
Interior Partitions/Movable	N/A					
Ceiling Systems	N/A					
Overhead Door and Supports	N/A					
Tall Storage Racks/Shelves	11		x	$250	$2,750	
Office Equip/Computers/Printers	N/A					
Tall File Cabinets/Furnishings	5		x	$30	$150	
Ladder	1	x		$100		Attached to wall
Water Softener Tank	1		x	$100	$100	
Copy Machine & Typewriter	4		x	$50	$200	
Communication Equipment	N/A					
Fuel Storage Tanks	2		x	Var.	$750	
Steel Tanks w/Compressed Gas	6	x				Chained to cabinets
Chemical Storage/Cleaning Mat'l	Var.		x	Var.	$1,500	Bottle stor. not secure
Fire Extinguishers & Cabinets	6		x	$30	$100	
Refrigerator	4		x	$100	$400	
Stove	1		x	$100	$100	
Microwave	1		x	$100	$100	
Civilian Food Storage	Var.		x	$50/cu ft	$2,000	
					======	
				TOTAL	$24,513	