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WATER TABLE MAPS OF THE CHANNEL LANDFILL AREA, JUNEAU, ALASKA

by

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In Cooperation with
Alaska Department of Environmental Conservation

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WATER TABLE MAPS OF THE CHANNEL LANDFILL AREA, JUNEAU, ALASKA

by
R. Noll[1]

INTRODUCTION

The Alaska Department of Natural Resources, Division of Water (ADNR-DOW) was requested by the Alaska Department of Environmental Conservation (ADEC) to provide a water table map for the Channel Landfill. The landfill is a privately owned facility serving the Juneau area. A closure study, funded by the City and Borough of Juneau and Channel Inc., was completed in July 1991 by Sweet-Edwards/EMCON, Inc. The study included the installation of four monitoring wells (MW-1, 2, 3, and 4) around the landfill and the completion of two estimated water table maps. No wells off the landfill site were used by Sweet-Edwards. Water levels in the newly installed monitoring wells were measured at various times by Sweet-Edwards over four days. No synchronous water level measurements were completed. Levels in all four wells were measured on two of the days, but the measurements were split between times of high and low tide. During the other two days, only one of the four monitoring wells was measured. The Sweet-Edwards water table maps are based on the days when only one of the four monitoring wells was measured.

Channel Landfill is located on the east side of Gastineau Channel just south of the mouth of Lemon Creek (Figure 1). It is located in Holocene emergent intertidal deposits and is underlain by terrace deposits (Miller, 1975). The emergent intertidal deposits are sandy silt and silty gravelly sand composed of intertidal materials that have emerged since approximately 1900 (Miller, 1972). The emergent deposits are covered with an organic layer one to three feet thick (Bayliss, 1991). The terrace deposits are sand and pebble gravels with some cobble layers. The deposits locally extend below water level (Miller, 1972). Gravels in the Lemon Creek area have historically been mined. The landfill is unlined and in operation at this time.

The objectives of the ADNR-DOW study are to: 1) map the ground water table under and around Channel Landfill, 2) determine the need and location of additional ground water sampling sites based on mapped ground water flow directions, 3) determine tidal influence on the ground water system, 4) determine ground water flow directions, and 5) estimate ground water flow rates across the landfill.

METHODS

Initially, this investigation was limited to measuring water levels in existing wells. Two drive points wells were installed for water quality sampling by ADEC based on

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preliminary ground water flow directions determined in this study. These wells were incorporated into this study and are located up (DP-U) and down (DP-D) gradient of the east pit area (Figure 2). Surface water level control was set with staff gages for the tide flats near Lemon Creek (SG-1), the artificial pond (SG-2), and the east pit (SG-3) towards the end of the study. Water levels were measured in the four previously installed monitoring wells (wells MW-1 through 4) from the Sweet-Edwards 1991 study, and three private water wells located off the landfill site (Table 1).

Water table levels were measured with a steel tape during seven rounds of measurements between December 1991 and May 1992. Water levels were calculated from top of casing levels given in Table 4-1 of the Sweet-Edwards report. Table 1 contains all data collected in this study. Tidal influence was determined by measuring well levels on the same day during both high and low tides.

Surface water control of the water table is possible from a number of sources in the study area. A berm extends from the southern boundary of the landfill to the site boundary near MW-2 forming an artificial pond. This pond has an outlet with a tide gate to Lemon Creek. During high tide water flows from Lemon Creek into the artificial pond, and then flows back out during low tide. The depth of this pond is unknown. To the east of the artificial pond is the east pit area (Figure 2). The east pit has surface water with no outlet. During high tides, the tide flats are covered with water, and Lemon Creek water level is influenced by both its flow and the high tides. During extreme high tides (greater than 18.5 feet), tide water was observed from near DP-U to the east of the landfill, to Lemon Creek adjacent to the HD well (Figure 2).

Abandoned water wells were located in the area north and east of the landfill boundary. Well casing top elevations were surveyed in by ADEC and Alaska Department of Fish and Game personnel. MW-2 and MW-4 top of casing elevation were used as the base for the offsite well elevations, and all elevations are referenced to mean low tide level, City and Borough of Juneau datum. Well locations were plotted on location maps drawn from figures in the Sweet-Edwards report for consistency and ease of comparison.

RESULTS

A total of three existing wells were located off site. Two to the north, BF and HD (Burford and Hildre), and one to the east, LB (Liquor Barrel) (Figure 2). Of the three offsite wells, the Hildre well is currently being used, and the Burford and Liquor Barrel wells are not. The Burford and Liquor Barrel wells are not sealed. The Liquor Barrel well is located inside the store furnace room, pump removed, and has a two inch open pipe in the cap. The Burford well is capped and still has a pump installed. The Hildre well is used for cement batching operations and equipment cleanup.

The Liquor Barrel well is suspected to be plugged. Water levels did not fluctuate, and a slug test revealed very slow recovery in the well (Table 2). After increasing the water level in the well approximately three feet, the recovery was less than 0.01 ft. per hour. The Liquor Barrel well was not used in evaluation of the water table contours.

Based on preliminary water table maps from this study, two drive points were installed by ADEC for water quality sampling. One site was located near Short Street (DP-U) up-gradient of the landfill. The second well (DP-D) was located south of the east pit berm, down-gradient in the tide flats (Figure 2).

Figure 3 is a water table contour map during low tide. During low tides (or low high tides), the ground water flow system is from the northeast towards the tide flats and Lemon Creek to the west, with a component of flow to the artificial pond. The high tide on 2 January 1992 was 16.6 and contoured similar to the low tide well levels. At times of extremely high tides (greater than approximately 18.5 feet), the entire landfill and industrial area becomes surrounded by tide water. The main ground water flow direction is similar to low tides, except near Lemon Creek. Near Lemon Creek the high tide influence causes the ground water to flow from Lemon Creek to the south. Figure 4 is a contour map of the water table at high tide on 19 February 1992. Figure 5 shows the changes caused by an extreme tide in well water levels (between high and low tide on 19 February 1992).

All well water level measurements were consistent except for MW-4 on 27 December 1991 and the Liquor Barrel well. The MW-4 measurement was significantly different (greater than seven feet) from the other MW-4 measurements. This was the largest apparent change over the study period, and is probably due to a measurement error on 27 December 1991. The differences in the Liquor Barrel well measurements were due to a slug test that had very slow recovery (Table 2). This well was later abandoned as a measurement site.

Changes in well levels due to tidal influence were observed in the wells located close to Lemon Creek (HD, BF, MW-1, and MW-2). Wells MW-3 and MW-4 showed no apparent changes due to tides. The artificial pond did show small change from the tide water entering through the tide gate. Only a small change (0.04 feet) was measured in the East Pit during the 19 February 1992 tidal change (20.2 feet of tide difference during the tide cycle). This small change was probably due to measurement problems associated with ice around the staff gage. The east pit water elevation was 2.59 feet higher than the artificial pond during a low tide on 24 March 1992.

DISCUSSION

The general ground water flow direction is towards the tide flats and Lemon Creek to the west of the landfill, but anthropogenic changes in the area have influenced flow directions and rates. The anthropogenic changes in the Lemon Creek area include gravel removal at the landfill site, refilling of the site with waste that has different hydraulic properties, changes to the surface topography, and water filled pits located immediately west of the landfill site (left from gravel mining operations). The artificial pond was formed by gravel removal to the clay layer below (Bayliss, 1991).

The surface water in the pond should reflect the level of the water table around it, but the results of this study suggest that ground water flow to the artificial pond is restricted. The water elevation of the artificial pond is significantly lower than MW-3 and 4 well water levels (Table 1). The gradient of the water table surface between the wells and the artificial pond steepens, indicating a low hydraulic conductivity barrier exists between the two (Figure 3). This low hydraulic conductivity barrier is probably formed by a silt layer in combination with landfill covering material. The water in the artificial pond becomes silty as gravel is mined, and the silt forms a low permeability layer after being redeposited. MW-3 and MW-4 are located at the edge of the landfill site, and as waste in the area was covered, the covering material probably extended over the edge into the artificial pond, further restricting flow between the ground water system and the artificial pond.

Surface water enters the artificial pond from a culvert with a tide gate on the north end. The tide gate only reduces the amount of water entering the pond. The pond level change during the 19 February 1992 tidal cycle (high tide of 19.4 feet) was 0.21 feet. During the tidal cycle, the level in MW-2 (13.05 at low tide and 14.04 at high tide) changed by an amount greater than the artificial pond (0.99 feet verses 0.21 feet). This would indicate that the predominate influence on MW-2 water levels is from tidal inundation of Lemon Creek rather than changes in the artificial pond. The ground water preferentially follows the longer flow path between MW-2 and Lemon Creek, rather than the short flow path between MW-2 and the artificial pond.

The east pit water level was not influenced by tidal changes and was 2.59 feet higher in elevation than the artificial pond on 24 March 1992. The east pit water level was measured by direct survey because the staff gage was removed before its top elevation could be surveyed. The loss of the staff gage prevents determining the exact relationship between the ground water and the east pit. The berm surrounding the east pit was constructed from the organic-rich surface soils of the tide flats and is substantially impermeable (Hansen, 1985). This prevents flow from the east pit area through the berms. Because of active filling by Channel Sanitation in the east pit, flow to the ground water system is probably restricted.

Tidal influences were observed in wells MW-1, MW-2, Burford and Hildre in two sets of extreme tidal cycle measurements (21 January and 19 February 1992). The February set of data is the most complete with staff gages set to measure water levels on the tide flats (SG-1) and in the artificial pond (SG-2). The wells closest to Lemon Creek increased as a result of the high tide, with the wells closest to Lemon Creek (MW-2 and Hildre) increasing the most (Figure 5). The wells located away (MW-3 and MW-4) showed little increase. This increase indicates that the ground water system is probably connected to Lemon Creek. Lemon Creek flow apparently keeps fine silts and clays out of the creek bed allowing an easy flow path for water between the ground and surface water systems. As the tide increases, water inundates the tide flats around Lemon Creek, and the water's surface elevation increases. This increase in tide flat water elevation is transmitted to the aquifer via Lemon Creek alluvial deposits and observed in wells near the creek. At times of high tides the landfill and industrial area are surrounded by tide water.

During high tides, mixing of marine water with the ground water system is possible two ways; recharge from Lemon Creek, and recharge through the silty organic-rich sediments of the tide flats. The amount of marine water that can be recharged from Lemon Creek depends on the recharge location along Lemon Creek. Lower Lemon Creek (near SG-1 and the tide flats) will be influenced by high tides before, and more often than the upstream reaches. Repeated high tides could allow marine water to recharge and migrate south of Lemon Creek towards MW-2. Ground water under the tide flats at the landfill boundary will be influenced by periodic high tide inundation. This inundation of the tide flats percolates marine water through the silty organic-rich sediments. The effect of multiple tidal cycles is to provide an intermittent recharge source of marine water to the ground water system down gradient of the landfill.

The estimated rate of ground water movement across the landfill (based on the average linear velocity) for water moving between MW-1 and MW-2 could be up to two feet per day. This is calculated using the following simplifying assumptions: 1) the aquifer is homogenous and isotopic; 2) a hydraulic conductivity of 3.28×10^{-3} ft/sec (10^{-1} cm/sec); 3) a porosity of 35 percent; and 4) a gradient of 2.22×10^{-3}. This upper estimation is probably conservative because a value at the high end of the hydraulic conductivity range for silty sandy gravels is used, and the landfill has been refilled with material that has differing (and probably lower) hydraulic conductivities. Estimation of ground water flow rates across the landfill are dependent on the location of the flow path because of possible anthropogenic changes. A reasonable range for flow rates under the landfill is between 0.2 and two feet per day.

The Sweet-Edwards estimated water table maps (Figure 4-3 and 4-4 of the Sweet-Edwards report, Appendix A) differ from Figure 3 of this report. The Sweet-Edwards figures show a bow in the water surface contour lines that directs flow towards the artificial pond area (Sweet-Edwards, 1991). One Sweet-Edwards figure represents the ground water table during a low tide, and the other during a *low* high tide (+12.0). The Sweet-Edwards figures indicate that Lemon Creek is a possible source of ground water recharge across the site. From the Sweet-Edwards figures, MW-2 may not provide representative down-gradient ground water samples from the landfill. Figure 3 of this report suggests that MW-2 will intercept leachate from the northern area of the landfill. The hydraulic gradient at the landfill boundary indicates that flow is directly to the artificial pond. Other evidence, such as the larger change in MW-2 water levels during high tides compared with the change in the artificial pond level, suggests that a higher hydraulic conductivity flow path exists between MW-2 and Lemon Creek. This higher hydraulic conductivity flow system should allow MW-2 to intercept leachate from the northern area of the landfill. Ground water from under the center of the landfill should be intercepted by MW-3 and 4. This water may be a mix of leachate and ground water. Any sampling plan designed for determination of leachate contamination to the ground water system under the landfill should designate sampling during low tides, or during a series of *low* high tides (less than 16.0 feet).

Water level measurements in this study were consistently higher than levels measured by Sweet-Edwards. This difference may be a result of seasonal variations. The rainfall between May 91 and May 92 was above average.

CONCLUSIONS

Ground water flow and water table elevations around the Channel Landfill area have been impacted by anthropogenic changes. These impacts allow for only a generalized determination of ground water flow directions and interactions. Areas of specific interest will require a detailed study of the specific area and interactions involved. This study provides a guideline for ground and surface water interactions in the landfill area as they apply to the geologic conditions found during this study.

The ground water flow across the landfill site north of the artificial pond during low tides and *low* high tides is from the northeast towards the west to the tide flats and Lemon Creek. A component of ground water flow in this area is to the artificial pond to the south of the main landfill area. Ground water in the southern portion of the landfill around the east pit area is towards the tide flats with limited flow into or out of the surface water in the east pit.

The water table in the landfill area is influenced by extreme high tides (greater than 18.5 feet). During these extreme tides, it appears that some water is recharged from Lemon Creek to the ground water system, and may result in mixing of water from Lemon Creek with leachate, if leachate is present. Extreme tides do inundate the area to the south and east of the landfill, but silty organic-rich sediments on the tide flats and in the surrounding berms prevent significant influence on the water table under the landfill.

Water levels measured in this study were consistently higher than the previous Sweet-Edwards study. These differences in ground water flow patterns may be due to the large amount of rain during the past 12 months.

ACKNOWLEDGMENTS

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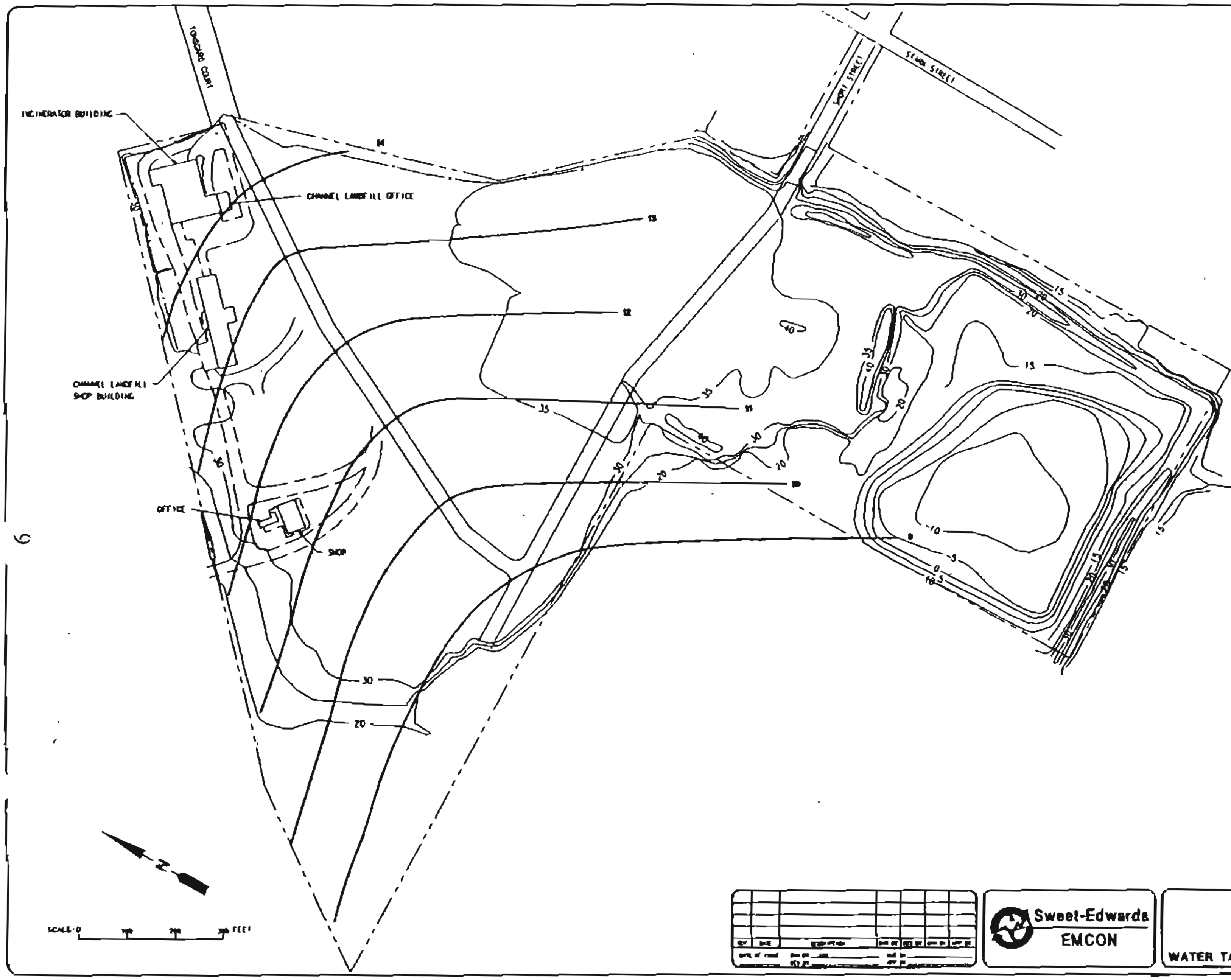
APPENDIX A



Sweet-Edwards EMCON

CHANNEL LANDFILL, INC
CHANNEL LANDFILL
JUNEAU, ALASKA

WATER TABLE MAP (ESTIMATED) 6-8-91

FIGURE 4-3

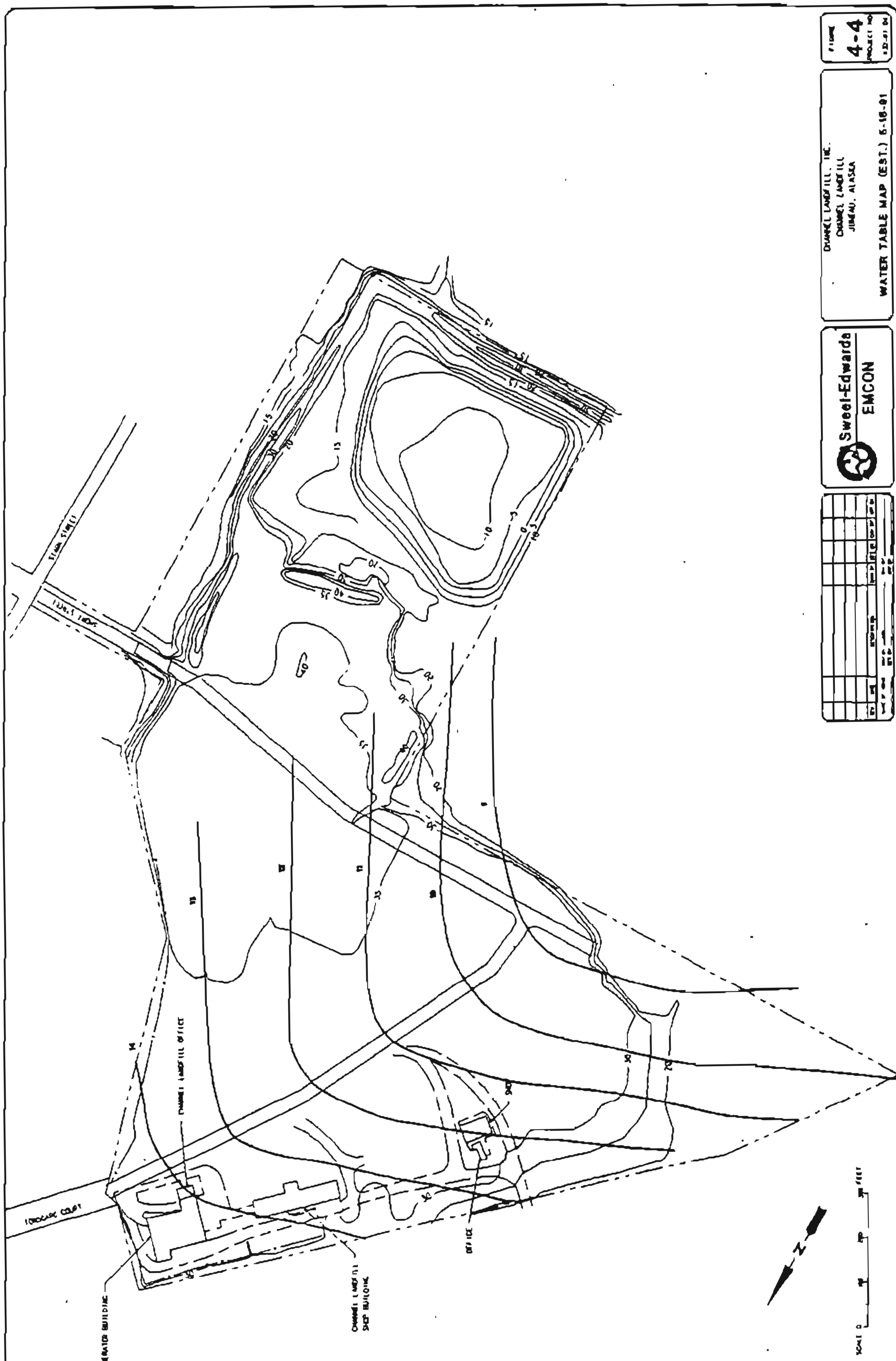


FIGURE
4-4
CHANNEL LANDFILL, INC.
CHANNEL LANDFILL
JUNEAU, ALASKA
WATER TABLE MAP (EST.) 5-18-91
Sweet-Edwards
EMCON
INCINERATOR BUILDING
CHANNEL LANDFILL SHOP BUILDING
OFFICE
SHOP
CHANNEL LANDFILL OFFICE
N
SCALE
FEET

TABLE 1

DATE	WELL OR STAFF	TIME	HOLD	CUT	DTW	TOC* ELEVATION	WATER** ELEVATION	TIDE	WATER LEVEL CHANGE
27-Dec-91	MW-1	1100	15.00	0.25	14.75	31.70	16.95	LOW	
	MW-2	1150	8.00	1.34	6.66	19.94	13.28	LOW	
	MW-3	1135	20.00	3.13	16.87	32.32	15.45	LOW	
	MW-4	1120	15.00	0.43	14.57	36.76	22.19	LOW	
	BURFORD	1155	15.00	1.71	13.29	29.83	16.54	LOW	
	LIQ BARL	1225	7.00	1.65	5.35	24.97	19.62	LOW	
2-Jan-92	MW-1	1238	18.00	2.53	15.47	31.70	16.23	HIGH	
	MW-2	1130	10.00	3.65	6.35	19.94	13.59	HIGH	
	MW-3	1231	18.00	0.32	17.68	32.32	14.64	HIGH	
	MW-4	1225	23.00	0.57	22.43	36.76	14.33	HIGH	
	BURFORD	1044	15.00	1.31	13.69	29.83	16.14	HIGH	
	LIQ BARL	1050	7.00	1.65	5.35	24.97	19.62	HIGH	
	HILDRE	1000	15.00	0.62	14.38	29.85	15.47	HIGH	
21-Jan-91	MW-1	822	15.00	0.13	14.87	31.70	16.83	LOW	
	MW-2	840	7.00	0.25	6.75	19.94	13.19	LOW	
	MW-3	905	18.00	0.51	17.49	32.32	14.83	LOW	
	MW-3	906	19.00	1.53	17.47	32.32	14.85	LOW	
	MW-4	852	23.00	0.78	22.22	36.76	14.54	LOW	
	MW-4	853	24.00	1.79	22.21	36.76	14.55	LOW	
	BURFORD	832	15.00	2.07	12.93	29.83	16.90	LOW	
	LIQ BARL	922	7.00	1.64	5.36	24.97	19.61	LOW	
21-Jan-91	MW-1	1446	15.00	0.40	14.60	31.70	17.10	HIGH	0.27
	MW-2	1421	7.00	1.67	5.33	19.94	14.61	HIGH	1.42
	MW-3	1438	19.00	1.53	17.47	32.32	14.85	HIGH	0.01
	MW-4	1439	24.00	1.83	22.17	36.76	14.59	HIGH	0.05
	BURFORD	1415	15.00	2.60	12.40	29.83	17.43	HIGH	0.53
	LIQ BARL	1412	7.00	1.65	5.35	24.97	19.62	HIGH	0.01
19-Feb-92	MW-1	802	18.00	1.98	16.02	31.70	15.68	LOW	
	MW-2	833	7.00	0.11	6.89	19.94	13.05	LOW	
	MW-3	822	21.00	3.12	17.88	32.32	14.44	LOW	
	MW-4	812	25.00	2.27	22.73	36.76	14.03	LOW	
	BURFORD	844	15.00	0.94	14.06	29.83	15.77	LOW	
	LIQ BARL	750	3.00	1.38	1.62	24.97	23.35	LOW	
	HILDRE	849	15.00	0.27	14.73	29.85	15.12	LOW	
	SG-3	740	2.00	0.10	1.90			LOW	
	SG-2	837	3.00	0.38	2.62	15.40	12.78	LOW	
19-Feb-92	MW-1	1410	17.00	1.00	16.00	31.70	15.70	HIGH	0.02
	MW-2	1350	6.00	0.10	5.90	19.94	14.04	HIGH	0.99
	MW-3	1427	20.00	2.12	17.88	32.32	14.44	HIGH	0.00
	MW-4	1420	25.00	2.28	22.72	36.76	14.04	HIGH	0.01
	BURFORD	1345	15.00	1.32	13.68	29.83	16.15	HIGH	0.38
	HILDRE	1340	15.00	1.96	13.04	29.85	16.81	HIGH	1.69
	SG-3	1452	4.00	2.14	1.86			HIGH	0.04
	SG-2	1553	3.00	0.57	2.43	15.40	12.97	HIGH	0.21
	SG-1	1359	2.00	0.33	1.67	20.50	18.83	HIGH	

TABLE 1

DATE	WELL OR STAFF	TIME	HOLD	CUT	DTW	TOC ELEVATION	WATER ELEVATION	TIDE	WATER LEVEL CHANGE
10-Mar-92	MW-1	910	17.00	1.55	15.45	31.70	16.25	LOW	
	BURFORD	1040	15.00	1.54	13.46	29.83	16.37	LOW	
	MW-2	1155	9.00	1.99	7.01	19.94	12.93	LOW	
24-Mar-92	MW-2	925	10.00	2.67	7.33	19.94	12.61	LOW	
	SG-3	1005	BY DIRECT SURVEY				14.98	LOW	
	SG-2	956	3.50	0.49	3.01	15.40	12.39	LOW	
15-May-92	MW-1	828	18.00	2.23	15.77	31.70	15.93	LOW	
	MW-2	835	8.00	0.65	7.35	19.94	12.59	LOW	
	MW-3	856	20.00	2.08	17.92	32.32	14.40	LOW	
	MW-4	951	24.00	1.20	22.80	36.76	13.96	LOW	
	BURFORD	854	20.00	6.20	13.80	29.83	16.03	LOW	
	SG-2	838	4.00	0.94	3.06	15.40	12.34	LOW	
	DP-U	759	5.00	1.96	3.04	18.64	15.60	LOW	
	DP-D	812	8.00	0.20	7.80	20.66	12.86	LOW	
15-May-92	MW-1	1352	16.00	0.24	15.76	31.70	15.94	HIGH	0.01
	MW-2	1334	8.00	0.78	7.22	19.94	12.72	HIGH	0.13
	MW-3	1402	19.00	1.08	17.92	32.32	14.40	HIGH	0.00
	MW-4	1355	23.00	0.28	22.72	36.76	14.04	HIGH	0.08
	BURFORD	1346	15.00	1.18	13.82	29.83	16.01	HIGH	-0.02
	SG-2	1336	3.00	0.04	2.96	15.40	12.44	HIGH	0.10
	SG1	1340	ESTIMATED BY EYE				12.50	HIGH	
	DP-U	1311	5.00	1.97	3.03	18.64	15.61	HIGH	0.01
	DP-D	1257	8.00	0.17	7.83	20.66	12.83	HIGH	-0.03
	* DEPTH TO WATER								
	** TOP OF CASING								

TABLE 2

DATE	WELL	TIME	HOLD	CUT	DTW*	TOC** ELEVATION	WATER ELEVATION
11-Feb-92	LIQ BARL	1010	7.00	1.60	5.40	24.97	19.57
		1012	ADD WATER VIA HOSE IN ROOM				
		1013	2.00	0.55	1.45	24.97	23.52
		1245	2.00	0.52	1.48	24.97	23.49
19-Feb-92	LIQ BARL	750	3.00	1.38	1.62	24.97	23.35
15-May-92	DP-D	1257	8.00	0.17	7.83	20.66	12.83
		1259	ADD 2 LITERS OF DI WATER				
		1259	8.00	2.12	5.88	20.66	14.78
		1304	8.00	0.20	7.80	20.66	12.86
		1307	8.00	0.17	7.83	20.66	12.83
	DP-U	1311	5.00	1.97	3.03	18.64	15.61
		1312	ADD 2 LITERS OF DI WATER				
		1314	0.17	0.00	0.17	18.64	18.47
		1315	0.24	0.00	0.24	18.64	18.40
		1320	2.00	1.18	0.82	18.64	17.82
		1326	3.00	1.58	1.42	18.64	17.22

* DEPTH TO WATER

** TOP OF CASING

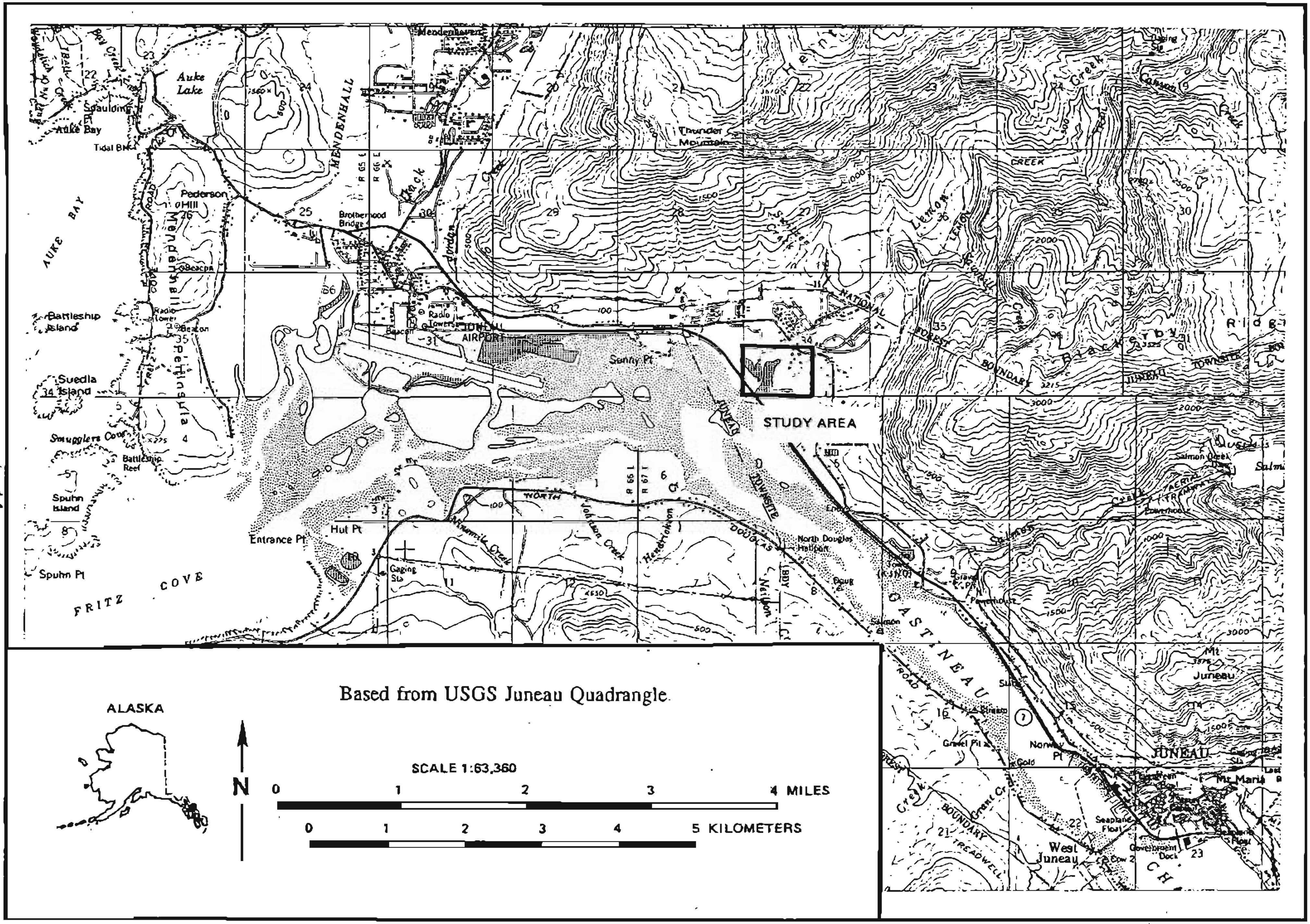


FIGURE 1: LOCATION MAP

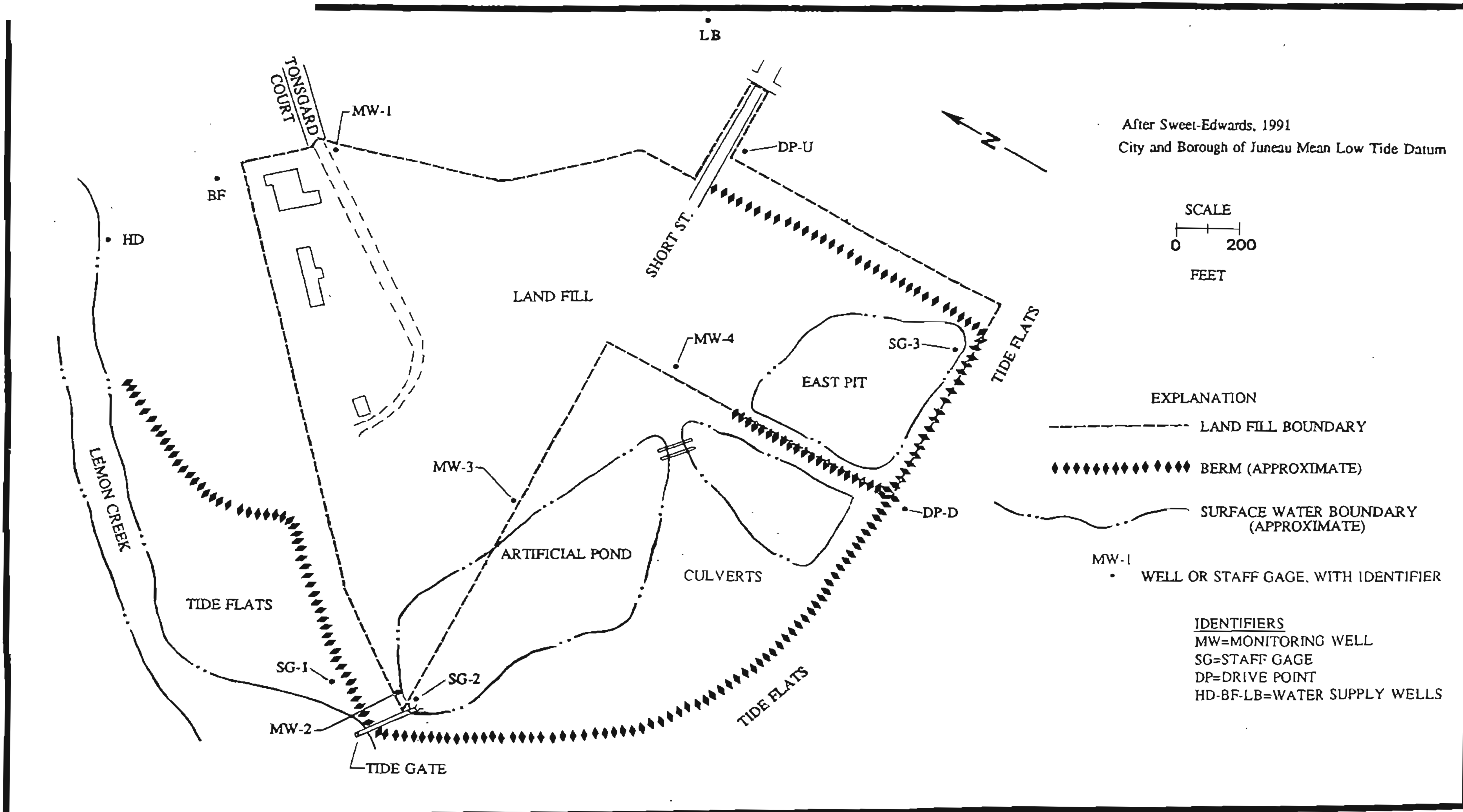


FIGURE 2: SITE MAP

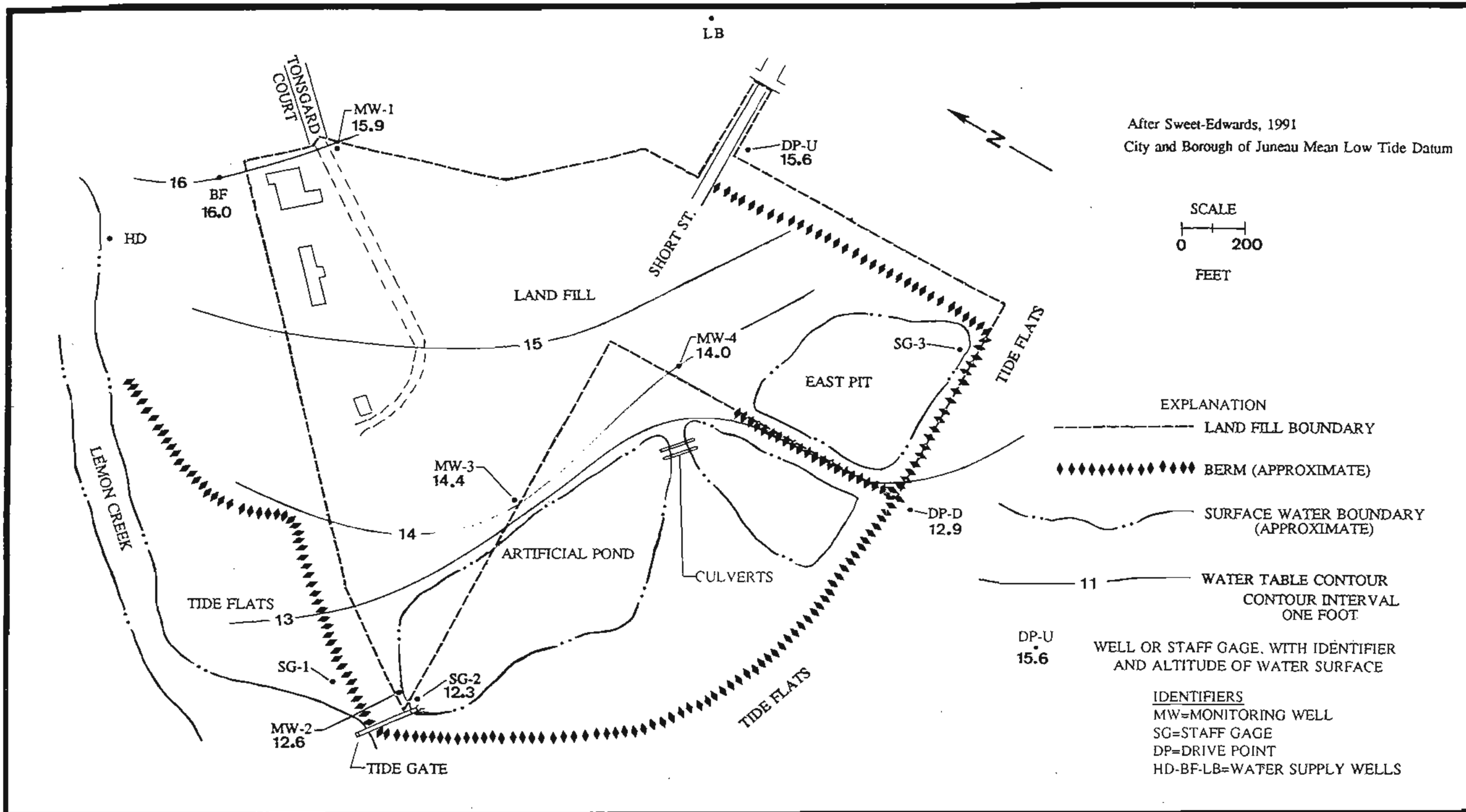


FIGURE 3: WATER TABLE SURFACE CONTOUR MAP, LOW TIDE, 15 MAY 1992

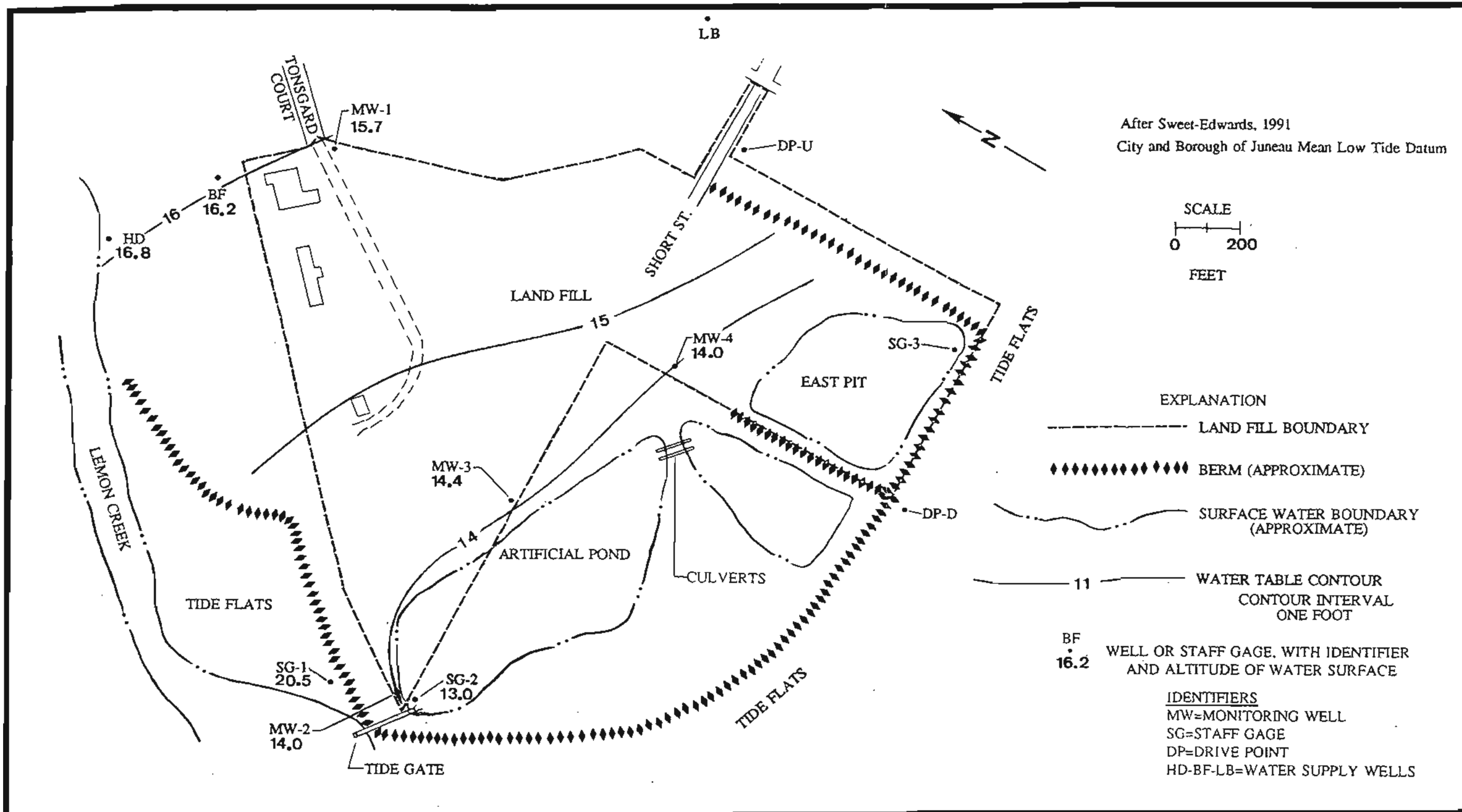


FIGURE 4: WATER TABLE SURFACE CONTOUR MAP, HIGH TIDE, 19 FEBRUARY 1992

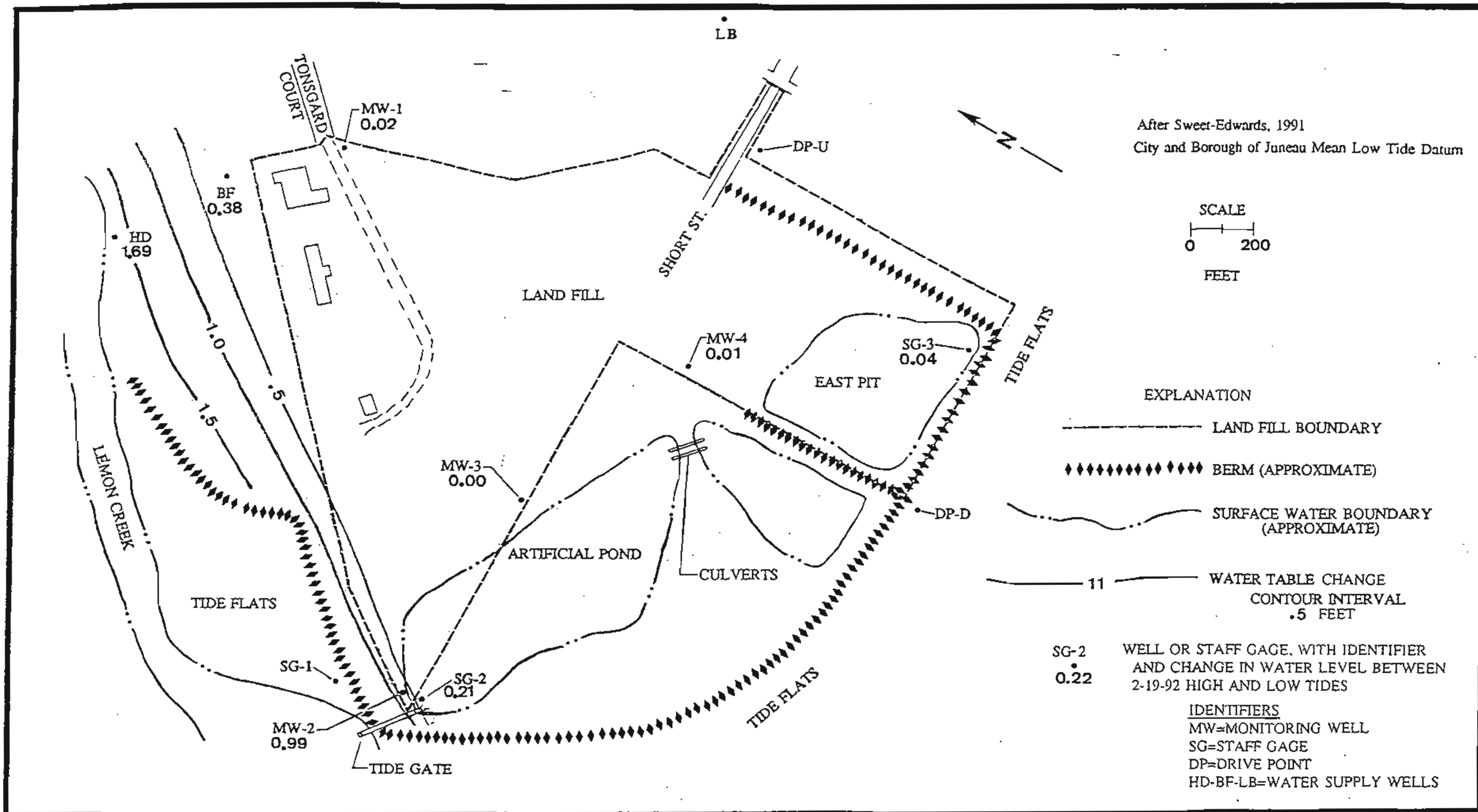


FIGURE 5: WATER TABLE SURFACE CHANGE OVER 19 FEBRUARY TIDAL CYCLE