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Exploratory Soil and Permafrost Investigation, Norman Wells, N.W.T., 1953

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DIVISION OF BUILDING RESEARCH

No.
169

TECHNICAL NOTE

NOT FOR PUBLICATION

FOR INTERNAL USE

PREPARED BY J.A. Pihlainen
and G.H. Johnston

CHECKED BY

APPROVED BY

PREPARED FOR

DATE Dec. 7/53

SUBJECT Exploratory Soil and Permafrost Investigation,
Norman Wells, N.W.T., 1953.

During September 1953, the Permafrost Research Station of the Division of Building Research carried out a small exploratory soil and permafrost investigation at Norman Wells, N.W.T. The work was carried out at the request of Mr. K.M. Mackenzie, Superintendent, Norman Wells Refinery, Imperial Oil Ltd. to supply some general information on soil conditions at the sites of proposed housing expansion at Norman Wells. One continuous core hole was drilled at each of the three proposed housing sites as directed by Mr. Mackenzie (Fig. 1). Since only three holes were drilled, general statements of soil and permafrost conditions at Norman Wells cannot be made. The results of the exploratory program are therefore reported in logs of the holes and test results where samples were obtained (see Tables 1, 2 and 3).

DRILLING

The permafrost samples were obtained with a special drill rig, The Concore Type E5-48 manufactured by the Frank L. Howard Engineering Company. Basically it is a concrete sampler that has been modified for permafrost by drilling experience gained by the U.S. Corps of Engineers. The drill head is powered by an 8 h.p. Briggs and Stratton single-cylinder air-cooled gasoline engine. Wash water was obtained directly from the fire hydrant line at Norman Wells. A Longyear L Series, Double Tube Roller Bearing Core Barrel, size NX, was used to give a 2-inch diameter undisturbed (and frozen) sample. Core recovery ranged from 0 to 100 per cent depending on local conditions but averaged about 60 per cent.

TECHNICAL NOTE

J.A. Pihlainen
and G.H. Johnston

Dec. 1953

Exploratory Soil and Permafrost Investigation,
Norman Wells, N.W.T., 1953.

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DRILLING

The permafrost samples were obtained with a special drill rig. The Goncor Type ES-48 manufactured by the Frank L. Howard Engineering Company. Basically it is a concrete sampler that has been modified for permafrost by drilling experience gained by the U.S. Corps of Engineers. The drill head is powered by an 8 h.p. Briggs and Stratton single-cylinder air-cooled gasoline engine. Wash water was obtained directly from the fire hydrant line at Norman Wells. A Longyear L Series Double Tape Roller Bearing Core Barrel, size MX, was used to give a 2-inch diameter undisturbed (and frozen) sample. Core recovery ranged from 0 to 100 per cent depending on local conditions but averaged about 60 per cent.

SAMPLING AND TESTING

After the various soil strata in the frozen core were identified and recorded, samples sufficient to carry out pertinent classification tests were taken. Moisture content samples were placed in air-tight containers. Samples for tests in which a small loss in moisture was unimportant (grain-size distribution, Atterberg limits and specific gravity) were stored in unsealed glass jars. The soil samples were all tested in the Soil Mechanics Laboratory of the Permafrost Research Station at Norman Wells.

SUMMARY OF FINDINGS

The soils at the three borehole locations are predominantly silts with varying amounts of clay, sand, stones and organic material. The large variability in the depth to permafrost, i.e. 16 feet, 8 feet, and 2 feet, illustrates well the changes to permafrost due to construction and occupation of an area. The site of Borehole 1, where the depth to permafrost is 16 feet, is in a relatively "old" cleared and filled-in area. Borehole 2 is in a "middle-aged" cleared and filled-in area and the depth to permafrost is less, (8 feet). The depth to permafrost is even less at Borehole 3 which is also a "middle aged" fill but at this location, 2 feet of organic material shields or insulates permafrost.

The water, or more correctly "ice", contents are in most cases above the liquid limit of the soil, i.e., although the soil has a solid form when frozen it will be transformed into a "liquid" or "slurry" if the contained ice melts. Extremely high ice contents, four to five times the volume of soil, are most common within the first 10 feet of frozen soil.

The low values of the Atterberg Limit tests point out the predominantly silty character of the soil, known and referred to locally as "glacial till", "lean clay" or "clayey silt". At the three boreholes, the depth to bed-rock of friable greenish shale is approximately 30 feet.

Details of the three boreholes and test results are shown in Fig. 1 and Tables 1, 2, and 3.

ACKNOWLEDGEMENTS

It is a pleasure to record appreciation of the assistance rendered by Imperial Oil Ltd., personnel during the project -- in particular, Mr. R.C. Gimbel. The soil testing was performed by Mr. J.B. Bordeleau of the Permafrost Research Station.

SAMPLING AND TESTING

After the various soil strata in the frozen core were identified and recorded, samples sufficient to carry out permafrost classification tests were taken. Moisture content samples were placed in air-tight containers. Samples for tests in which a small loss in moisture was unimportant (grain-size distribution, Atterberg limits and specific gravity) were stored in unsealed glass jars. The soil samples were all tested in the Soil Mechanics Laboratory of the Permafrost Research Station at Norman Wells.

SUMMARY OF FINDINGS

The soils at the three borehole locations are predominantly silty with varying amounts of clay, sand, silt and organic material. The large variability in the depth to permafrost, i.e. 10 feet, 8 feet, and 2 feet, illustrates well the changes to permafrost due to construction and occupation of an area. The site of Borehole 1, where the depth to permafrost is 10 feet, is in a relatively "old" cleared and filled-in area. Borehole 2 is in a "middle-aged" cleared and filled-in area and the depth to permafrost is less, (8 feet). The depth to permafrost is even less at Borehole 3 which is also a "middle aged" fill but at this location, 2 feet of organic material exists or insulates permafrost.

The water, or more correctly "ice", contents are in most cases above the liquid limit of the soil, i.e., although the soil has a solid form when frozen it will be transformed into a "liquid" or "slurry" if the contained ice melts. Excessively high ice contents, four to five times the volume of soil, are most common within the first 10 feet of frozen soil.

The low values of the Atterberg Limit tests point out the predominantly silty character of the soil, known and referred to locally as "glacial till", "lean clay" or "clayey silt". At the three boreholes, the depth to bed-rock or friable granitic shale is approximately 30 feet.

Details of the three boreholes and test results are shown in Fig. 1 and Tables 1, 2, and 3.

ACKNOWLEDGMENTS

It is a pleasure to record appreciation of the assistance rendered by Imperial Oil Ltd., personnel during the project -- in particular, Mr. R.C. Gimbel. The soil testing was performed by Mr. J.B. Borden of the Permafrost Research Station.

TABLE 1

WELLS BORE HOLE No. 1 (NWB 1) POST OFFICE

Drilled 14 & 15 Sept. 1953.

Sample No.	Specific Gravity	Grain Size Distribution ⁽³⁾				Atterberg Limits ⁽⁴⁾			Sample Depth
		Clay	Silt	Sand	Gravel	Liquid	Plastic	Plasticity	
		Size %	Size %	Size %	Size %	Limit %	Limit %	Index %	
12-15'	2.69	13	50	117	20				12'
13-15'	2.73	15	52	28	5				13'
16-18'	2.74	15	75	10	-				16'
17-18'	2.73	17	76	7	-				17'
18-20'	2.73								17'

content) of a soil is equal to the weight of water contained in a unit weight of calculated as the ratio of the weight of water contained in a sample to the oven-dried weight in per cent.

the solid particles to the weight of an equal volume of pure water at 4° C.

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mm. in diameter

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STREET LIGHTING

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TABLE 2

WELL HOLE NO. 2 (NWB 2) RECREATION HALL

Drilled 16 & 17 Sept. 1953.

Depth feet	Moisture ⁽¹⁾ %	Specific Gravity ⁽²⁾ %	SOIL TESTING RESULTS GRAIN SIZE DISTRIBUTION ⁽³⁾				ATTERBERG LIMITS ⁽⁴⁾			Sample Depth
			Clay Size %	Silt Size %	Sand Size %	Gravel Size %	Liquid Limit %	Plastic Limit %	Plasticity Index %	
0-10										
10-12	2.4	2.68	15	52	14	19				6'
12-14										
14-16										
16-18										
18-20	0.8		24	72	4	--	45.0	31.3	13.7	8'
20-22	2.6		29	67	4	--				8'
22-24	8.8	2.72	29	66	5	--	44.9	27.5	17.4	9'
24-26	6.6		29	65	6	--	38.8	25.1	13.7	10'
26-28										
28-30	9.0									11'
30-32	8.5		33	63	4	--	44.3	27.6	16.7	12'
32-34	70.7									13'
34-36	70.9		21	70	9	--				14'
36-38										
38-40			22	65	13	--	34.8	22.2	12.6	19'
40-42	42.5		19	63	18	--	29.8	20.2	9.6	20'
42-44	32.9	2.74	25	60	15	--	31.0	21.1	9.9	22'
44-46	35.3	2.74	22	61	17	--	28.6	20.6	8.6	24'
46-48										
48-50		2.75	23	69	8	--	32.3	23.1	9.2	30'

- 4 -

(1) (2) (3)

1. Fe^{2+} ions (1) μm

NOTES

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Lowell, John, 1811-1862, 1863, 1864, 1865, 1866, 1867, 1868, 1869, 1870, 1871, 1872, 1873, 1874, 1875, 1876, 1877, 1878, 1879, 1880, 1881, 1882, 1883, 1884, 1885, 1886, 1887, 1888, 1889, 1890, 1891, 1892, 1893, 1894, 1895, 1896, 1897, 1898, 1899, 1900, 1901, 1902, 1903, 1904, 1905, 1906, 1907, 1908, 1909, 1910, 1911, 1912, 1913, 1914, 1915, 1916, 1917, 1918, 1919, 1920, 1921, 1922, 1923, 1924, 1925, 1926, 1927, 1928, 1929, 1930, 1931, 1932, 1933, 1934, 1935, 1936, 1937, 1938, 1939, 1940, 1941, 1942, 1943, 1944, 1945, 1946, 1947, 1948, 1949, 1950, 1951, 1952, 1953, 1954, 1955, 1956, 1957, 1958, 1959, 1960, 1961, 1962, 1963, 1964, 1965, 1966, 1967, 1968, 1969, 1970, 1971, 1972, 1973, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2058, 2059, 2060, 2061, 2062, 2063, 2064, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072, 2073, 2074, 2075, 2076, 2077, 2078, 2079, 2080, 2081, 2082, 2083, 2084, 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, 2093, 2094, 2095, 2096, 2097, 2098, 2099, 2100, 2101, 2102, 2103, 2104, 2105, 2106, 2107, 2108, 2109, 2110, 2111, 2112, 2113, 2114, 2115, 2116, 2117, 2118, 2119, 2120, 2121, 2122, 2123, 2124, 2125, 2126, 2127, 2128, 2129, 2130, 2131, 2132, 2133, 2134, 2135, 2136, 2137, 2138, 2139, 2140, 2141, 2142, 2143, 2144, 2145, 2146, 2147, 2148, 2149, 2150, 2151, 2152, 2153, 2154, 2155, 2156, 2157, 2158, 2159, 2160, 2161, 2162, 2163, 2164, 2165, 2166, 2167, 2168, 2169, 2170, 2171, 2172, 2173, 2174, 2175, 2176, 2177, 2178, 2179, 2180, 2181, 2182, 2183, 2184, 2185, 2186, 2187, 2188, 2189, 2190, 2191, 2192, 2193, 2194, 2195, 2196, 2197, 2198, 2199, 2200, 2201, 2202, 2203, 2204, 2205, 2206, 2207, 2208, 2209, 2210, 2211, 2212, 2213, 2214, 2215, 2216, 2217, 2218, 2219, 2220, 2221, 2222, 2223, 2224, 2225, 2226, 2227, 2228, 2229, 2230, 2231, 2232, 2233, 2234, 2235, 2236, 2237, 2238, 2239, 2240, 2241, 2242, 2243, 2244, 2245, 2246, 2247, 2248, 2249, 2250, 2251, 2252, 2253, 2254, 2255, 2256, 2257, 2258, 2259, 2260, 2261, 2262, 2263, 2264, 2265, 2266, 2267, 2268, 2269, 2270, 2271, 2272, 2273, 2274, 2275, 2276, 2277, 2278, 2279, 2280, 2281, 2282, 2283, 2284, 2285, 2286, 2287, 2288, 2289, 2290, 2291, 2292, 2293, 2294, 2295, 2296, 2297, 2298, 2299, 2300, 2301, 2302, 2303, 2304, 2305, 2306, 2307, 2308, 2309, 2310, 2311, 2312, 2313, 2314, 2315, 2316, 2317, 2318, 2319, 2320, 2321, 2322, 2323, 2324, 2325, 2326, 2327, 2328, 2329, 2330, 2331, 2332, 2333, 2334, 2335, 2336, 2337, 2338, 2339, 2340, 2341, 2342, 2343, 2344, 2345, 2346, 2347, 2348, 2349, 2350, 2351, 2352, 2353, 2354, 2355, 2356, 2357, 2358, 2359, 2360, 2361, 2362, 2363, 2364, 2365, 2366, 2367, 2368, 2369, 2370, 2371, 2372, 2373, 2374, 2375, 2376, 2377, 2378, 2379, 2380, 2381, 2382, 2383, 2384, 2385, 2386, 2387, 2388, 2389, 2390, 2391, 2392, 2393, 2394, 2395, 2396, 2397, 2398, 2399, 2400, 2401, 2402, 2403, 2404, 2405, 2406, 2407, 2408, 2409, 2410, 2411, 2412, 2413, 2414, 2415, 2416, 2417, 2418, 2419, 2420, 2421, 2422, 2423, 2424, 2425, 2426, 2427, 2428, 2429, 2430, 2431, 2432, 2433, 2434, 2435, 2436, 2437, 2438, 2439, 2440, 2441, 2442, 2443, 2444, 2445, 2446, 2447, 2448, 2449, 2450, 2451, 2452, 2453, 2454, 2455, 2456, 2457, 2458, 2459, 2460, 2461, 2462, 2463, 2464, 2465, 2466, 2467, 2468, 2469, 2470, 2471, 2472, 2473, 2474, 2475, 2476, 2477, 2478, 2479, 2480, 2481, 2482, 2483, 2484, 2485, 2486, 2487, 2488, 2489, 2490, 2491, 2492, 2493, 2494, 2495, 2496, 2497, 2498, 2499, 2500, 2501, 2502, 2503, 2504, 2505, 2506, 2507, 2508, 2509, 2510, 2511, 2512, 2513, 2514, 2515, 2516, 2517, 2518, 2519, 2520, 2521, 2522, 2523, 2524, 2525, 2526, 2527, 2528, 2529, 2530, 2531, 2532, 2533, 2534, 2535, 2536, 2537, 2538, 2539, 2540, 2541, 254

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For more information

ON MARCH 15, 1964

These authors have shown that the magnitude of the effect of the interaction between the two variables is not significant. The effect of the interaction between the two variables is not significant.

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TABLE 3

LLS BORE HOLE NO. 3 (NWB 3) CURLING RINK

Drilled 21 Sept. 1953.

SOIL TESTING RESULTS									
Moisture(1) Content	Specific(2) Gravity	Grain Size Distribution(3)				Atterberg Limits(4)			Sample Depth
		Clay Size	Silt Size	Sand Size	Gravel Size	Liquid Limit	Plastic Limit	Plasticity Index	
%	%	%	%	%	%	%	%	%	
172.7									4'
162.0									4'
133.0									5'
48.9	2.73	29	66	5	--	43.0	27.9	15.1	11'
									12'
34.3		23	68	9		42.2	30.5	11.7	13'
36.8		21	69	10		37.8	27.3	10.5	16'
		29	64	7		35.6	21.8	13.8	19'
49.0									20'
45.9		21	64	15		29.8	21.4	8.4	21'
		18	68	14		27.9	20.5	7.4	22'

- 5 -

(1), (2), (3)

... (1) ...

SS	4.7	30.2	8.78	11	68	78	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
ST	4.8	31.18	8.88	12	69	79	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	
SO	4.9	32.08	8.98	13	70	80	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100		
SI	5.0	33.08	9.08	14	71	81	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100			
SL	5.1	34.08	9.18	15	72	82	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100				
SM	5.2	35.08	9.28	16	73	83	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100					
SN	5.3	36.08	9.38	17	74	84	87	88	89	90	91	92	93	94	95	96	97	98	99	100						
SO	5.4	37.08	9.48	18	75	85	88	89	90	91	92	93	94	95	96	97	98	99	100							
SI	5.5	38.08	9.58	19	76	86	89	90	91	92	93	94	95	96	97	98	99	100								
SL	5.6	39.08	9.68	20	77	87	90	91	92	93	94	95	96	97	98	99	100									
SM	5.7	40.08	9.78	21	78	88	91	92	93	94	95	96	97	98	99	100										
SN	5.8	41.08	9.88	22	79	89	92	93	94	95	96	97	98	99	100											
SO	5.9	42.08	9.98	23	80	90	93	94	95	96	97	98	99	100												
SI	6.0	43.08	10.08	24	81	91	94	95	96	97	98	99	100													
SL	6.1	44.08	10.18	25	82	92	95	96	97	98	99	100														
SM	6.2	45.08	10.28	26	83	93	96	97	98	99	100															
SN	6.3	46.08	10.38	27	84	94	97	98	99	100																
SO	6.4	47.08	10.48	28	85	95	98	99	100																	
SI	6.5	48.08	10.58	29	86	96	99	100																		
SL	6.6	49.08	10.68	30	87	97	100																			
SM	6.7	50.08	10.78	31	88	98	100																			
SN	6.8	51.08	10.88	32	89	99	100																			
SO	6.9	52.08	10.98	33	90	100																				
SI	7.0	53.08	11.08	34	91	100																				
SL	7.1	54.08	11.18	35	92	100																				
SM	7.2	55.08	11.28	36	93	100																				
SN	7.3	56.08	11.38	37	94	100																				
SO	7.4	57.08	11.48	38	95	100																				
SI	7.5	58.08	11.58	39	96	100																				
SL	7.6	59.08	11.68	40	97	100																				
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SI	8.0	63.08	12.08	44	100																					
SL	8.1	64.08	12.18	45	100																					
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SN	8.3	66.08	12.38	47	100																					
SO	8.4	67.08	12.48	48	100																					
SI	8.5	68.08	12.58	49	100																					
SL	8.6	69.08	12.68	50	100																					
SM	8.7	70.08	12.78	51	100																					
SN	8.8	71.08	12.88	52	100																					
SO	8.9	72.08	12.98	53	100																					
SI	9.0	73.08	13.08	54	100																					
SL	9.1	74.08	13.18	55	100																					
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SO	11.9	102.08	15.98	83	100																					
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SO	16.9	152.08	20.98	100																						
SI	17.0	153.08	21.08	100																						
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SO	18.9	172.08	22.98	100																						
SI	19.0	173.08	23.08	100																						
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SO	22.4	207.08	26.48	100																						
SI	22.5	208.08	26.58	100																						
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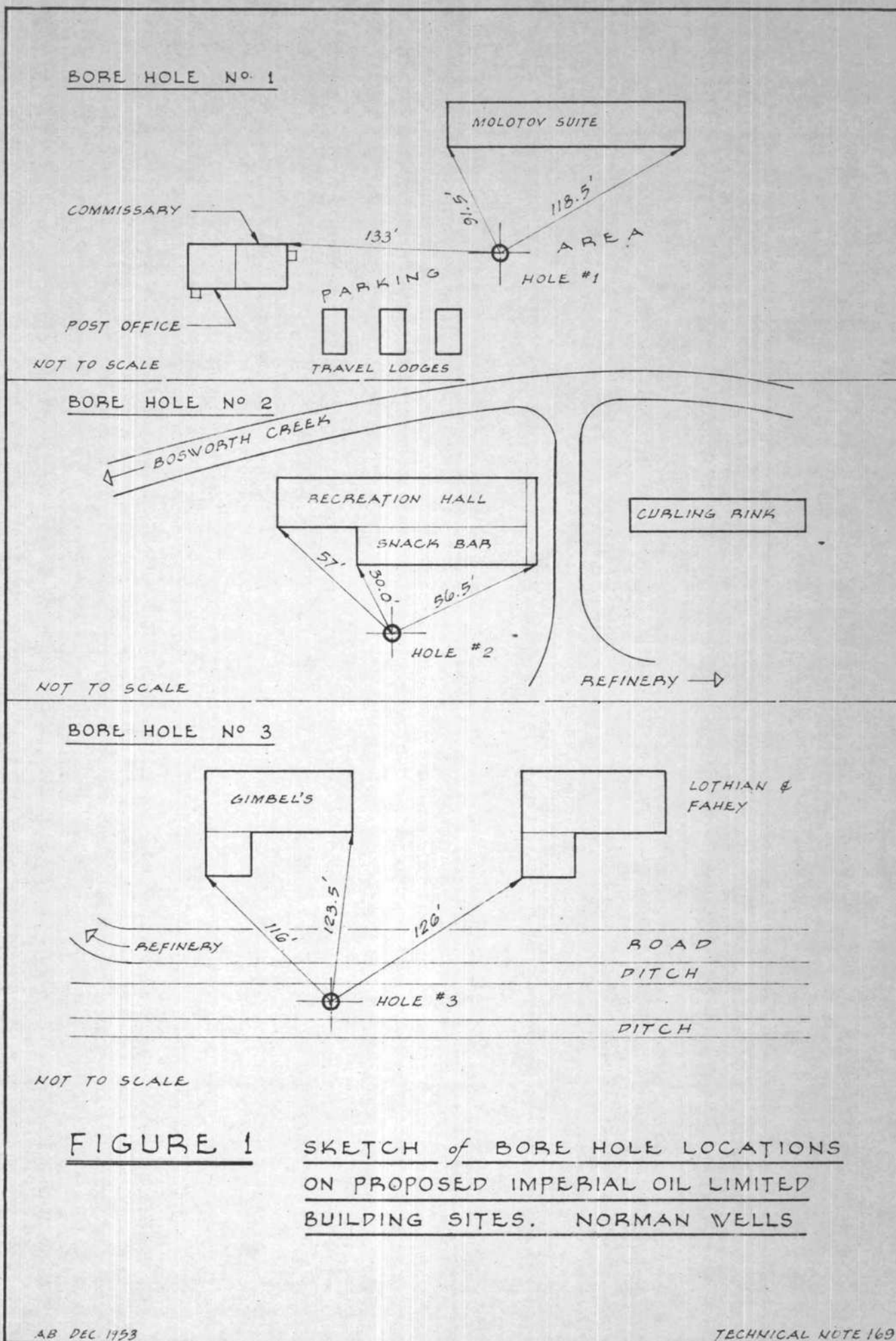


FIGURE 1 SKETCH of BORE HOLE LOCATIONS ON PROPOSED IMPERIAL OIL LIMITED BUILDING SITES. NORMAN WELLS