CRREL

Special Report 69

OCTOBER, 1964

Performance of Subsurface Drains at Selected Airfields during the 1960 Frost Melting Period

CONDUCTED FOR

CORPS OF ENGINEERS, U.S. ARMY

BY

U.S. ARMY MATERIEL COMMAND

COLD REGIONS RESEARCH & ENGINEERING LABORATORY

HANOVER, NEW HAMPSHIRE

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PERFORMANCE OF SUBSURFACE DRAINS AT SELECTED AIRFIELDS DURING THE 1960 FROST MELTING PERIOD

by

William C. Sayman and George D. Gilman

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PREFACE

The study reported herin was conducted for, and at the request of, the Office, Chief of Engineers, Directorate of Military Construction, by the former Arctic Construction and Frost Effects Laboratory (ACFEL)*.

The observational program was formulated by Mr. K. S. Eff, OCE, and Mr. W. C. Sayman, ACFEL, and was accomplished in conjunction with concurrent field studies authorized in FY 1960 Instructions and Outline, Military Construction Investigations, Engineering Criteria and Investigations and Studies, Studies of Construction in Areas of Seasonal Frost; Frost Instrumentation. Mr. Sayman prepared the draft report.

The final report was prepared by Mr. G. D. Gilman, USA CRREL, under the general direction of Mr. K. A. Linell, Chief, Experimental Engineering Division, USA CRREL (former Chief, ACFEL), and the immediate direction of Mr. E. F. Lobacz, Chief, Construction Engineering Branch, Experimental Engineering Division, USA CRREL (former Coordinator, ACFEL).

Colonel W. L. Nungesser was Commanding Officer of the Cold Regions Research and Engineering Laboratory during the preparation of this report and Mr. W. K. Boyd was Technical Director.

*ACFEL was integrated with the U. S. Army Cold Regions Research and Engineering Laboratory (USA CRREL), Hanover, New Hampshire, in 1961.

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SUMMARY

During the 1960 frost melting period, the performance of subsurface drainage systems was investigated at selected airfields in the northern continental United States by periodic observations at manholes and/or risers. Records of air temperature, subsurface temperature, and precipitation were also maintained.

The observations were one-time "spot" notations, intended to determine the feasibility of performing more comprehensive studies and no quantitative measurements were undertaken; nor do the data obtained permit evaluation as to the overall effectiveness of the inspected systems or the validity of the criteria used in their design.

However, the study showed that the observed subdrain systems were generally performing their function of removing subsurface water. The study also confirms the need for periodic inspection and maintenance of all subsurface systems.

PERFORMANCE OF SUBSURFACE DRAINS AT SELECTED AIRFIELDS DURING THE 1960 FROST MELTING PERIOD

INTRODUCTION

During the 1960 frost melting period, the performance of subsurface drainage systems was investigated at four airfields in the northern continental United States by periodic observations at manholes and/or risers. Data were obtained from Fairchild Air Force Base, Spokane, Washington; Glasgow Air Force Base, Glasgow, Montana; Selfridge Air Force Base, Mt. Clemens, Michigan; and Dow Air Force Base, Bangor, Maine. Observations were performed by Corps of Engineers personnel assigned to frost instrumentation investigational studies concurrently being conducted at these bases.

PAVEMENT AND SUBSURFACE DRAINAGE DETAILS

The pavements and subsurface drainage systems inspected are described briefly below and pertinent details are presented in Table I.

Fairchild AFB

Drainage systems were observed on a portion of ladder taxiway no. 1, the south end of the alert taxiway, and the NE overrun of the NE-SW runway. Table I also includes pavement and subsurface drainage details for the NE end of the runway and the NE blast pad since these facilities are contiguous with both the alert taxiway and the NE overrun. The above areas include PCC pavement, AC pavement, bituminous surface treatment, and turf or AC shoulders. Subsurface drains are 6-in. perforated concrete pipe, generally located 3 ft outside of the pavement or bituminous-treated edge. Drainage lines and observational locations are shown on Figure 1, and typical pavement sections are shown on Figure 2.

Glasgow AFB

Observations were made of subsurface drains between stations 90+00 and 139+75 along the NW-SE runway, including the NW blast pad and overrun, and on the adjoining west warm-up pad. Observed areas include PCC pavement, AC pavement, bituminous surface treatment, and turf or AC shoulders. Longitudinal and perimeter subsurface drains are 6-in. perforated concrete pipe and are located $3\frac{1}{4}$ ft outside of the pavement edge except for the section of runway having 75-ft wide AC shoulders. In the latter case, the subsurface drains are $3\frac{1}{4}$ ft outside of the shoulder edge, or $78\frac{1}{4}$ ft outside of the PCC pavement edge. Subsurface drains under the warm-up pad pavement consist of two lines of 6-in. perforated bituminous-coated corrugated metal pipe, spaced 100 ft apart. Drainage lines and observational locations are shown on Figure 3 and typical runway and warm-up pad pavement sections are shown on Figure 4.

Selfridge AFB

All observations were taken along the N-S runway between stations 57+00 and 82+75. The runway pavement is PCC with turf shoulders. Subsurface drains are 6-in. perforated vitrified tile pipe located $4\frac{1}{4}$ ft outside of the pavement edge. Drainage lines, observational locations and typical pavement sections are shown on Figures 5 and 6.

Dow AFB

Subsurface drains were observed at two separate sections of the NW-SE runway and at the heavy-load apron extension. The runway has a 300-ft wide PCC pavement with turf shoulders and the PCC apron extension has 50-ft wide AC shoulders. Subsurface drains are 6-in. perforated bituminized fibre pipe located 3 ft outside of the pavement edge. Drainage lines and observational locations are shown on Figures 7 and 8 and typical pavement sections are shown on Figure 9.

SUMMARY OF OBSERVATIONS AND SUPPLEMENTARY STUDIES

Records of air temperature, precipitation, and subsurface freezing temperature penetration were accumulated in conjunction with frost instrumentation studies being conducted at the various sites. Observational location designations cited in this report were established for this study except for the locations at the heavy load apron extension at Dow AFB which are in accordance with designations shown on contract drawings. Observational results and pertinent information obtained from air and subsurface temperature records are discussed below. Daily precipitation records for the observational periods, and for approximately one prior month, are shown on Figure 10.

Fairchild AFB

The 1959-1960 freezing season was colder than normal with a freezing index of 620 degree-days as compared to a mean index of 363. The design freezing index is 989 degree-days. Subsurface temperature measurements at the alert taxiway indicate a freezing temperature penetration of approximately 4 ft, or about 15 in. into the subgrade. The frost melting period started on 5 March and thawing was completed about 20 March. Periodic subsurface drainage observations were initiated on 7 April and were continued until the end of May. All observations are summarized on Table II together with flow diagrams; and observational locations are shown on Figure 1.

Ladder taxiway no. 1. Continuous flow, up to 1-in. in depth, was noted throughout the observational period at manholes L2 and L7, located at the right and left of station 24+75, respectively. During the period 17-25 April, flow was observed at all five locations on the right side (L1 through L5); however, during this period, flow was continuous at only L7 and L10 on the left side. Unreported depths of standing water, presumably very shallow, were generally noted at L5 and L10 during the period 28 April to 24 May. All locations except L2 and L7 were dry after 24 May.

Alert taxiway. Flow was observed at both A1 and A2, on the left and right sides respectively, with considerably greater flow noted on the right or lower side.

NE overrun, NE-SW runway. No measurable flow was observed at any of the four locations. Two locations, R1 and R3, were dry throughout the period. Standing water was noted at R2 on several occasions.

Glasgow AFB

The 1959-1960 freezing index was 2169 degree-days. The mean and design freezing indexes are 1845 and 3045 degree-days, respectively. A freezing temperature penetration of 9.3 ft was measured under the west warm-up pad in mid-March, indicating a subgrade penetration of about 5 ft. The frost melting period started on 17 March and subsurface thawing was completed about 15 April. Drainage observations were made on 27 April and 6 May, and are summarized on Table III.

NW-SE runway. Clear flowing water was observed in at least one manhole on each side of the runway in both sets of observations; however, standing clear water was also reported in several instances. Muddy standing water 3 in. in depth was observed at one location (R1). Five of the twelve locations were inaccessible during one set of observations and one location was inaccessible during both sets.

West warm-up pad. Clear flowing water was reported at location P4 during both observations. Clear or muddy standing water was observed at all of the four other locations.

Selfridge AFB

The 1959-1960 freezing index was 633 degree-days. The mean freezing index is 459 degree-days and the design freezing index is 842 degree-days. The maximum freezing temperature penetration was slightly more than 4 ft, with less than 6 in. of subgrade penetration, and occurred in mid-March. The frost melting period started on 26 March with subsurface thawing completed about 5 April. Drainage observations were made on 4 and 25 April, and are summarized on Table IV.

Drainage observations were taken at ten locations along the N-S runway, and standing or flowing water was noted in all observations.

Dow AFB

The 1959-1960 freezing season was considerably milder than normal with a freezing index of 817 degree-days as compared to a mean index of 1125 degree-days. The design freezing index is 1875 degree-days. Maximum measured freezing temperature penetrations were 4.4 and 3.5 ft beneath the apron and runway pavements, respectively. These depths did not involve subgrade penetration. Maximum penetrations were recorded early in February, just prior to the first of three separate thaw periods of several days duration which occurred during the month and held further penetrations to shallow depths. While the maximum freezing index did not occur until 27 March, there was only a negligible freezing degree-day accumulation after 17 March, with alternate short periods of light freezing and thawing. For practical purposes, the frost melting period began on 18 March, and subsurface thawing was completed about 1 April. Drainage observations were made late in March, in mid-April, and late in April. Drainage observations are summarized on Table V.

NW-SE runway. During the initial observations, on 28 March, a trace of flow was noted at three locations on the left side (R4, R5, and R6), with the other seven locations reported as dry. All locations showed a trace of flow during the last two observations.

Heavy-load apron extension. During the initial inspection, on 29 March, the drain was found to be ice-clogged at one location (OR32) and "clogged" at OR 30, but no information was given as to the cause of the latter obstruction. Corrective action was taken and subsequent observations indicated a trace of flow at OR 30. Flow described as "fast" or "medium" was recorded at OR 1, OR 28, and OR 27.

CONCLUSIONS

The observations were all one-time "spot" notations and were not specifically scheduled with relation to temperature, precipitation, or other climatic factors. No observations were made of pavements or other structures to determine frost or other damage as related to subdrain performance. The study was intended to determine the feasibility of performing more comprehensive studies, involving instrumentation, to obtain quantitative results. However, within the limited scope, this study indicates the following conclusions:

a. Observations indicate that the subdrains were performing their function of removing subsurface water at Fairchild, Selfridge, and Dow. At Glasgow, water was present in the subdrains, but no flow was recorded. At several locations only single observations were made, and in general the observations were not of sufficient duration to establish that active flow did not occur. However, the standing water observed may have been due to inadequate slope, obstructions, or other causes.

b. The occurrence of blocked drains confirms the need for thorough periodic inspection of all subdrain facilities and the accomplishment of maintenance measures as required. As a minimum, an annual inspection should be made prior to the freezing season.

c. The data suggest a more active response to frost melting than to daily or seasonal precipitation. There was little correlation between precipitation and drainage discharge.

d. The information obtained is inadequate for detailed evaluation of either the effectiveness of the subdrainage systems or the criteria used in their design. Quantitative evaluation of the various portions of the subdrainage systems is not feasible because of factors such as position of the water table, soil permeability, infiltration from the surface, and the effect of pumping on drawdown.

RECOMMENDATIONS

a. Future studies should be more comprehensive, with frequent observations and with quantitative flow measurements, particularly at discharge points. Concurrent studies should be made to determine the reason for dry drains or standing water when other drains are flowing. Maintenance measures should be undertaken as appropriate, and observations should be continued for a sufficient period to permit evaluation of the effectiveness of these measures.

b. Based on the results of these studies, the following future frost melting period observations are recommended:

(1). Fairchild AFB: Determine if subdrains are necessary in unpaved stabilized areas.

(2). Glasgow AFB: Conduct observations before and after accomplishment of normal maintenance measures to see if muddy flow conditions are rectified; if not, determine causes and effective measures. Determine cause of standing water in subdrains.

(3). Dow AFB: Determine extent of water entrapment in base course of heavy-load apron and effectiveness of subdrain network.

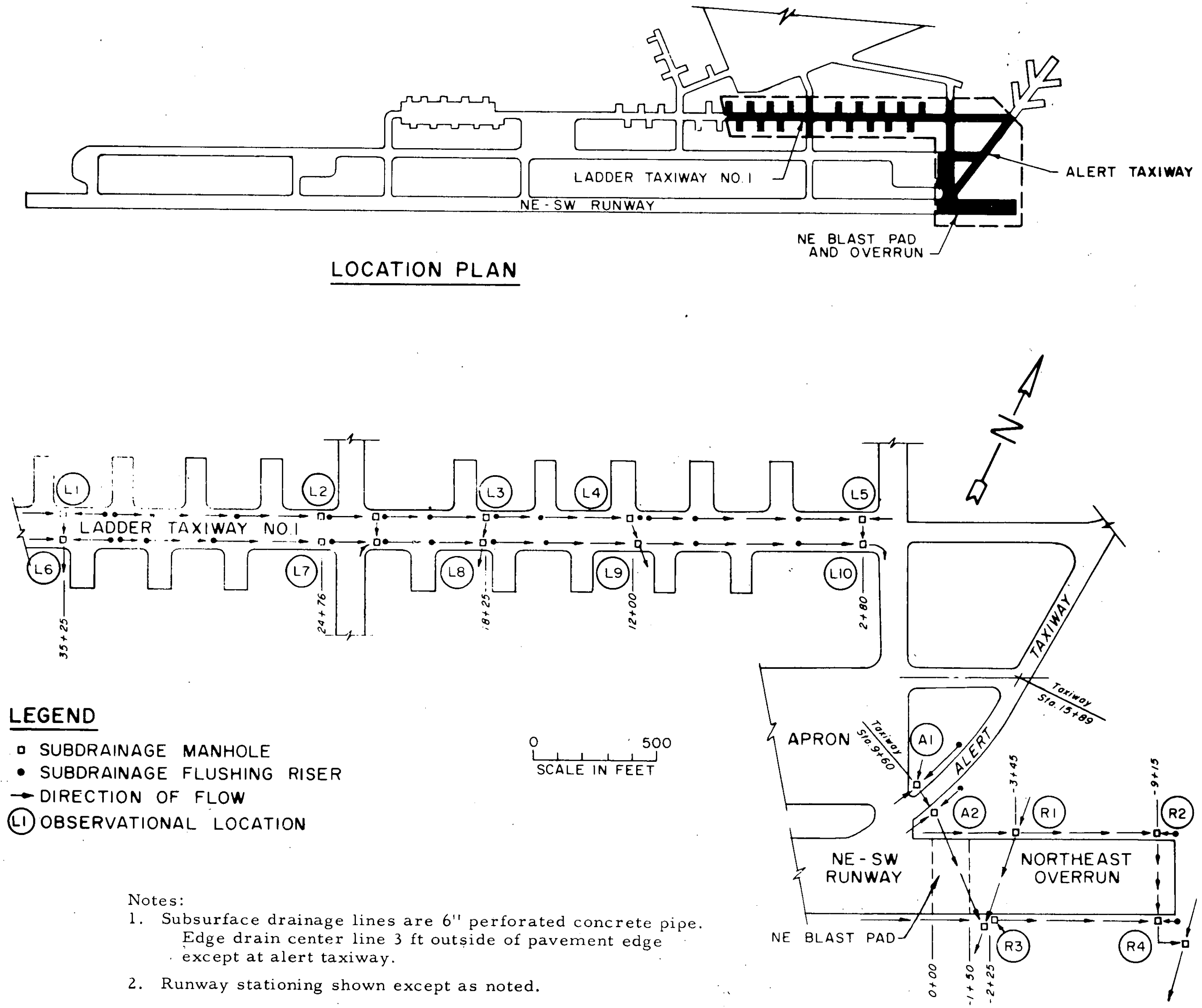


Figure 1. Subsurface drainage observational locations, Fairchild AFB.

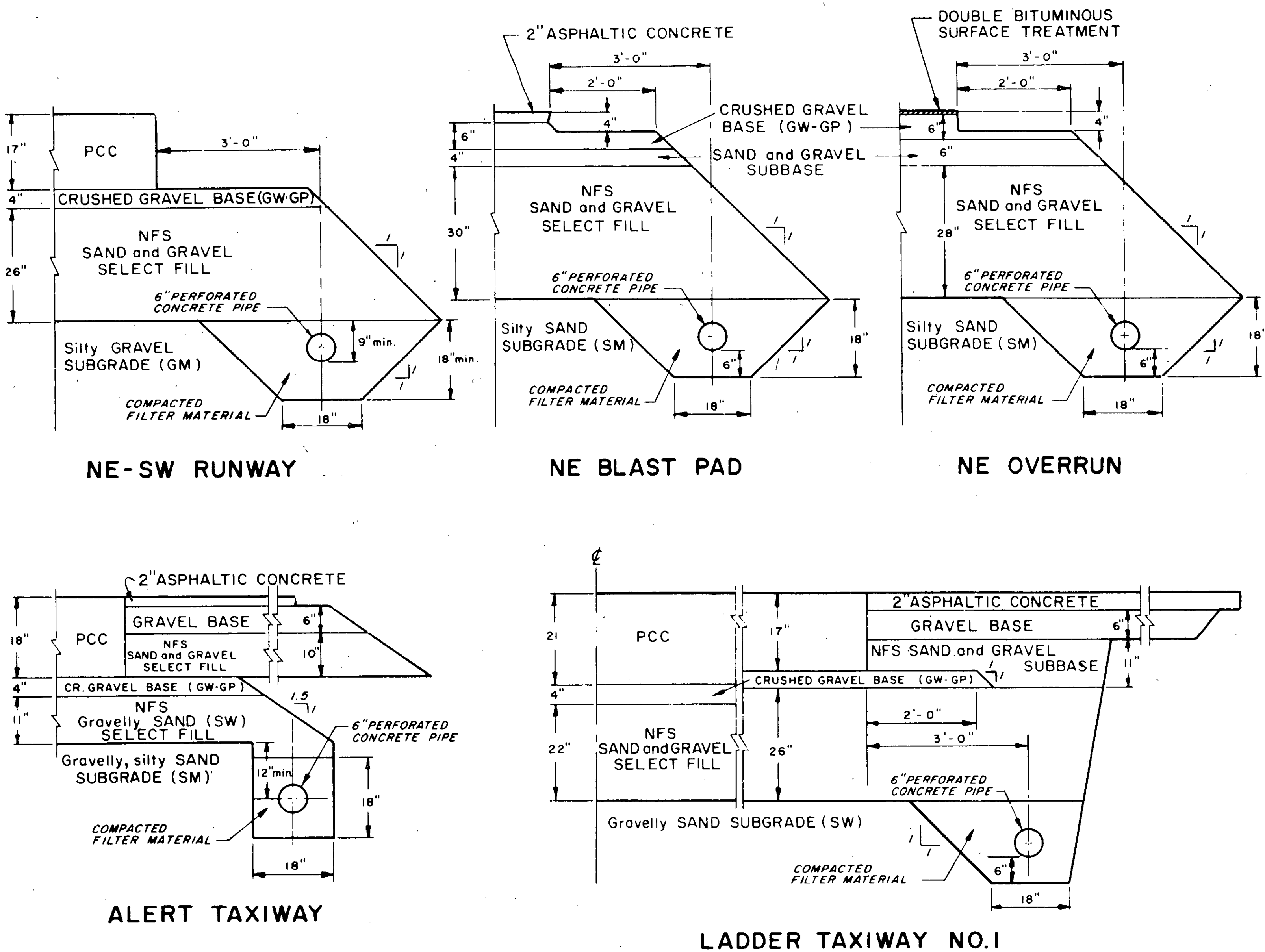
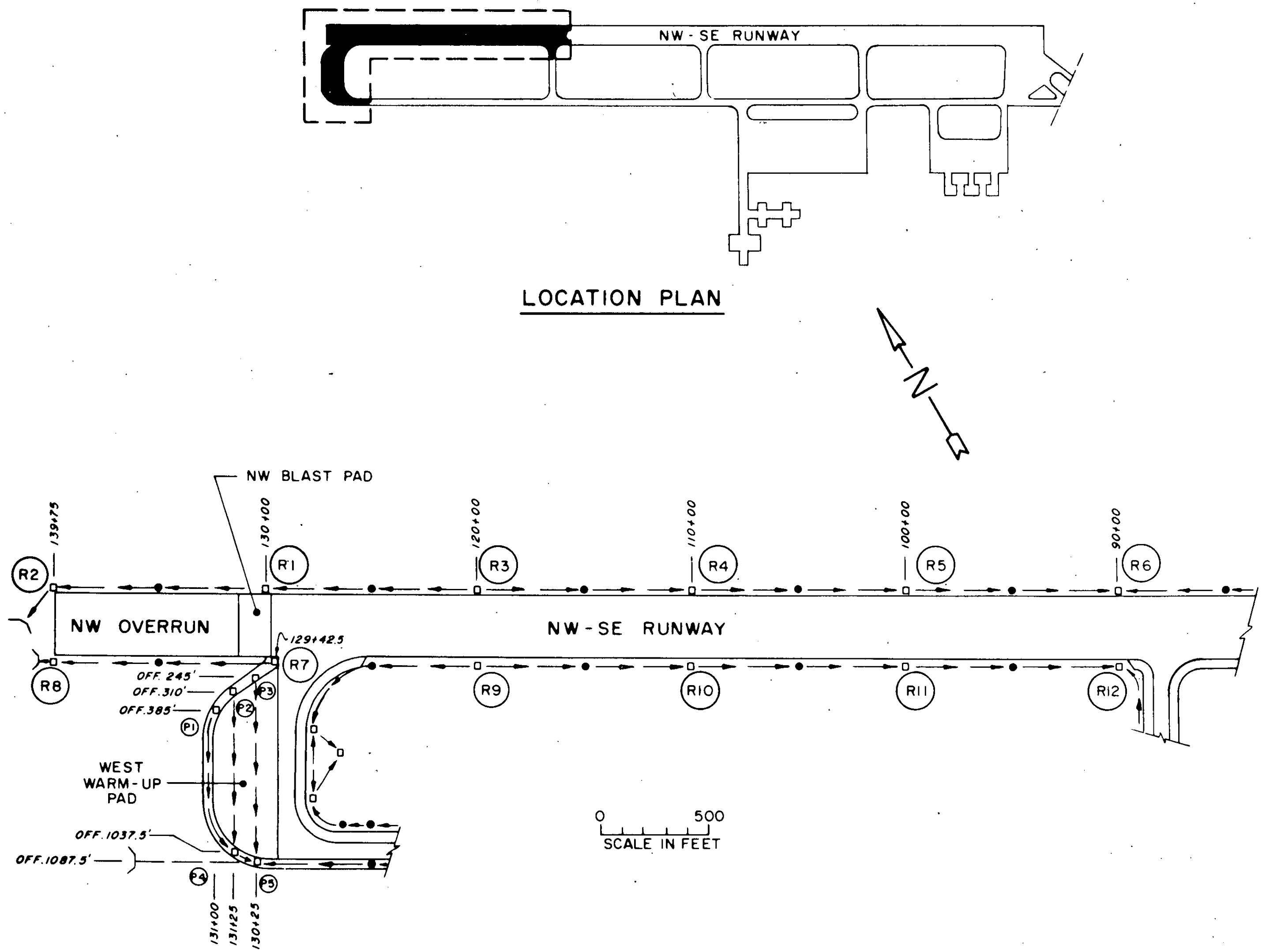


Figure 2. Typical pavement and subsurface drainage sections, Fairchild AFB.



LEGEND

- ▫ SUBDRAINAGE MANHOLE
- ● SUBDRAINAGE FLUSHING RISER
- ← DIRECTION OF FLOW
- (R1) OBSERVATIONAL LOCATION

Notes:

1. Subsurface drainage lines at pavement edges are 6" perforated concrete pipe. Edge drain center line 3'-3" outside of pavement edge.
2. Subsurface drainage lines under pavements are 6" perforated bituminous coated corrugated metal pipe.
3. Manholes at R6 and R12 discharge to storm drains.

Figure 3. Subsurface drainage observational locations, Glasgow AFB.

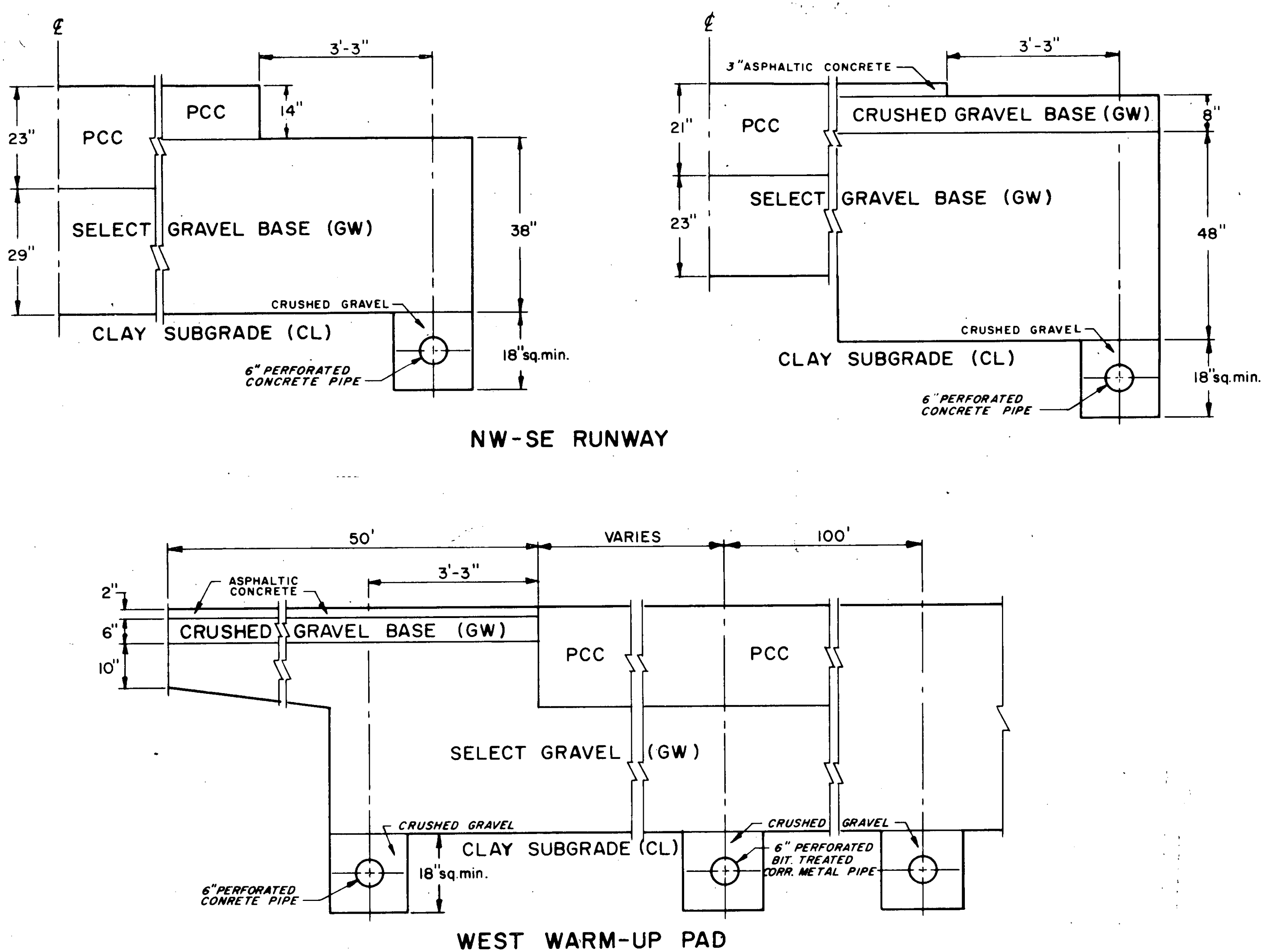
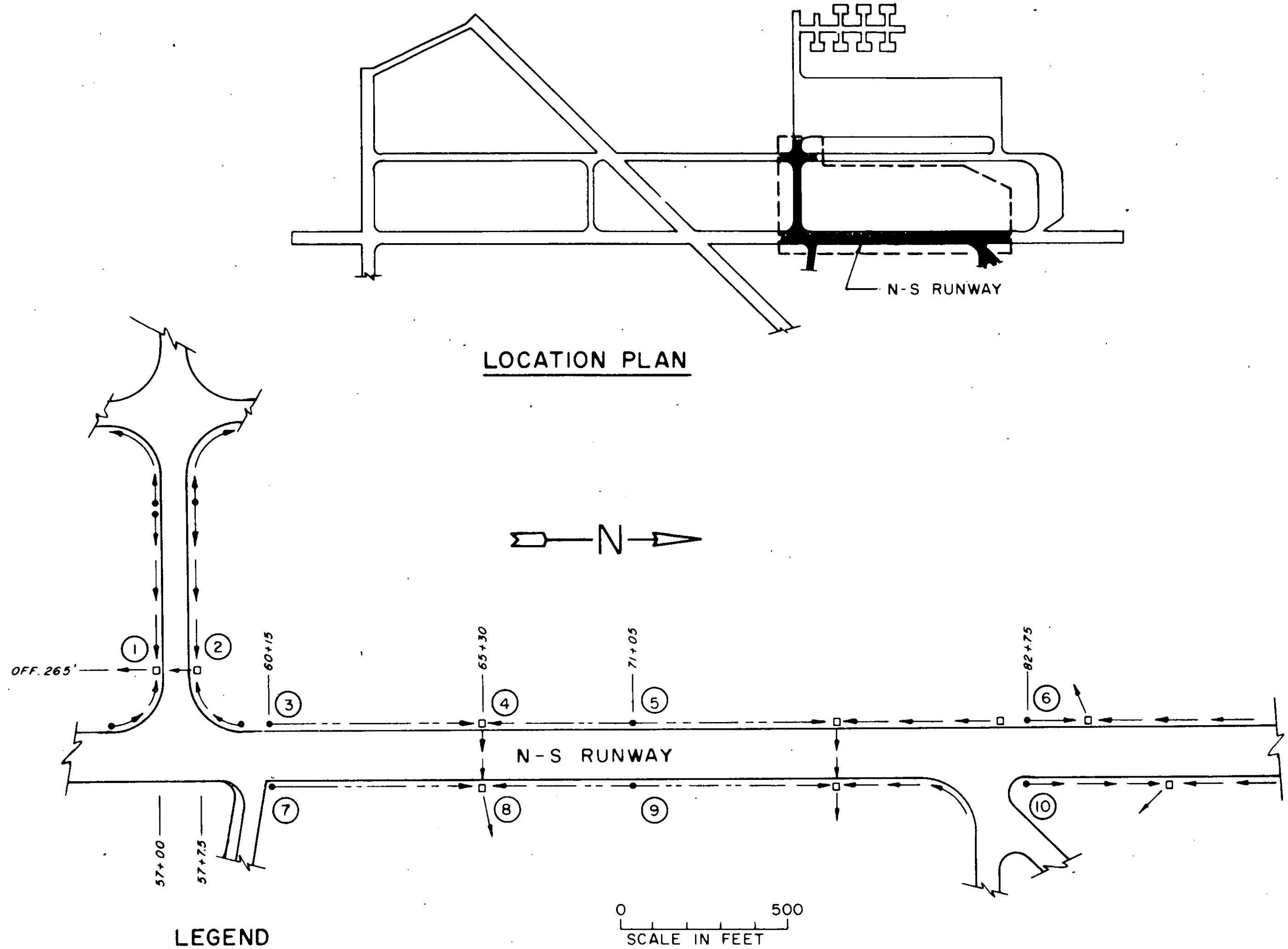


Figure 4. Typical pavement and subsurface drainage sections, Glasgow AFB.



LEGEND

- ▫ SUBDRAINAGE MANHOLE
- • SUBDRAINAGE FLUSHING RISER
- ➔ DIRECTION OF FLOW
- (1) OBSERVATIONAL LOCATION

Note:
1. Subsurface drainage lines are 6" perforated vitrified clay tile pipe.
   Edge drain center 4'-3" from pavement edge.

Figure 5. Subsurface drainage observational locations, Selfridge AFB.

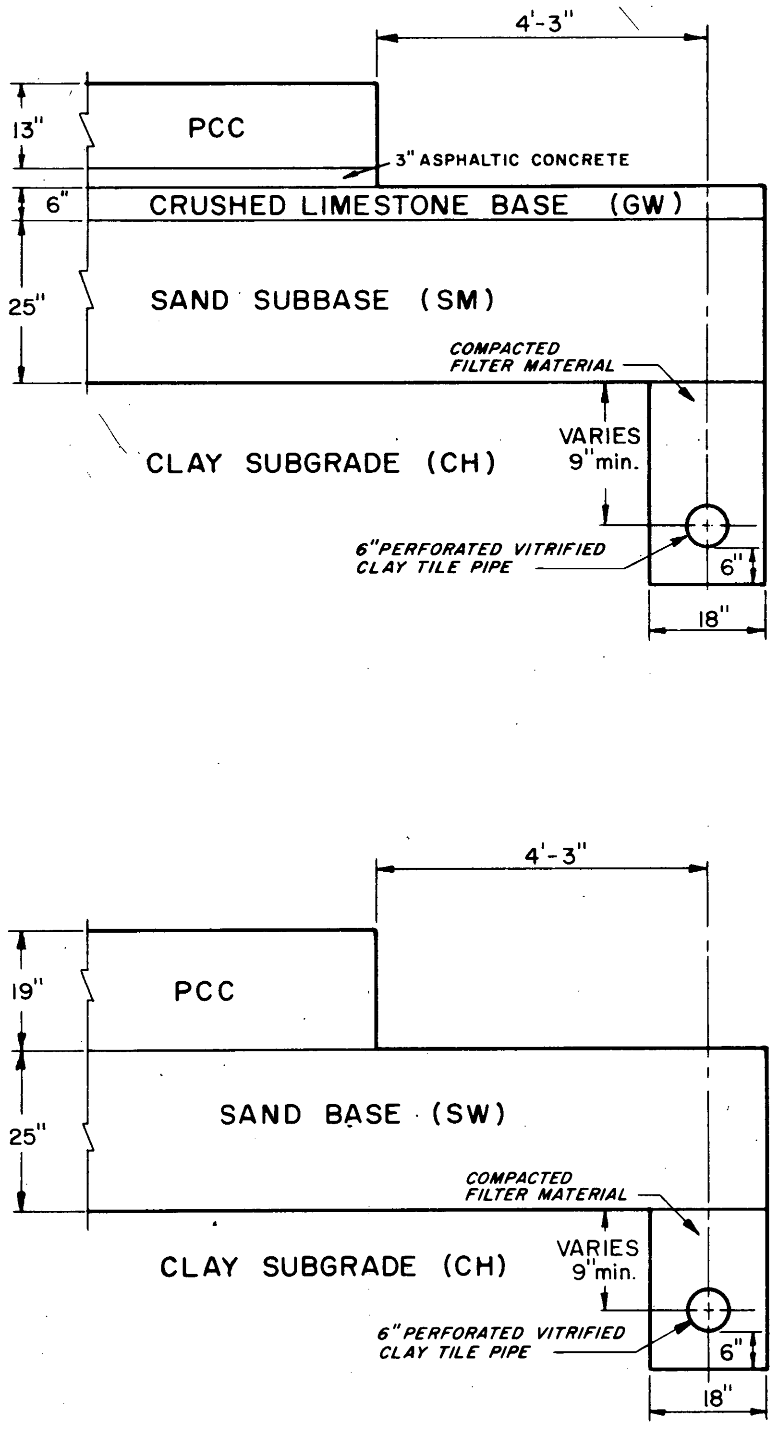
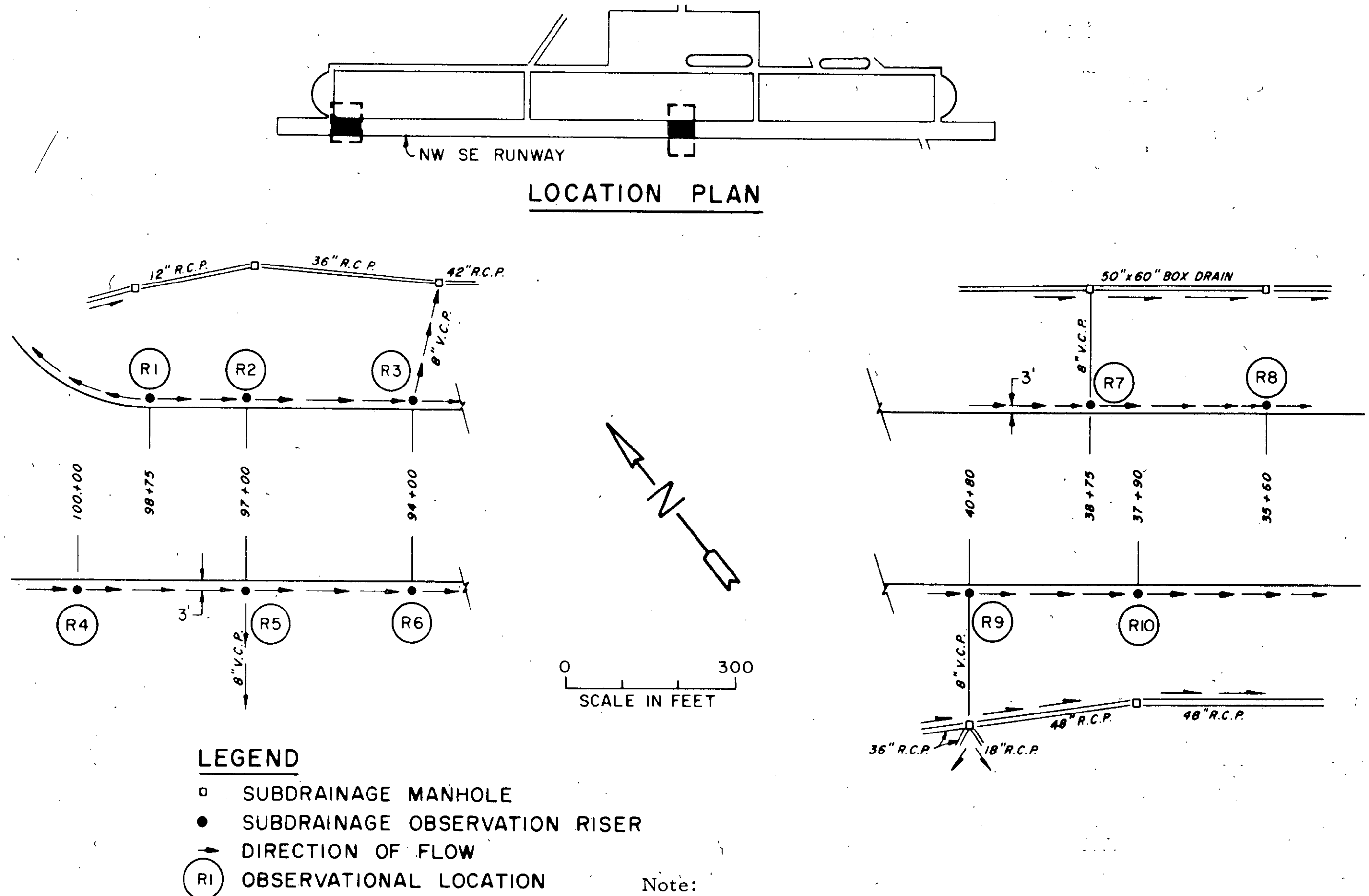
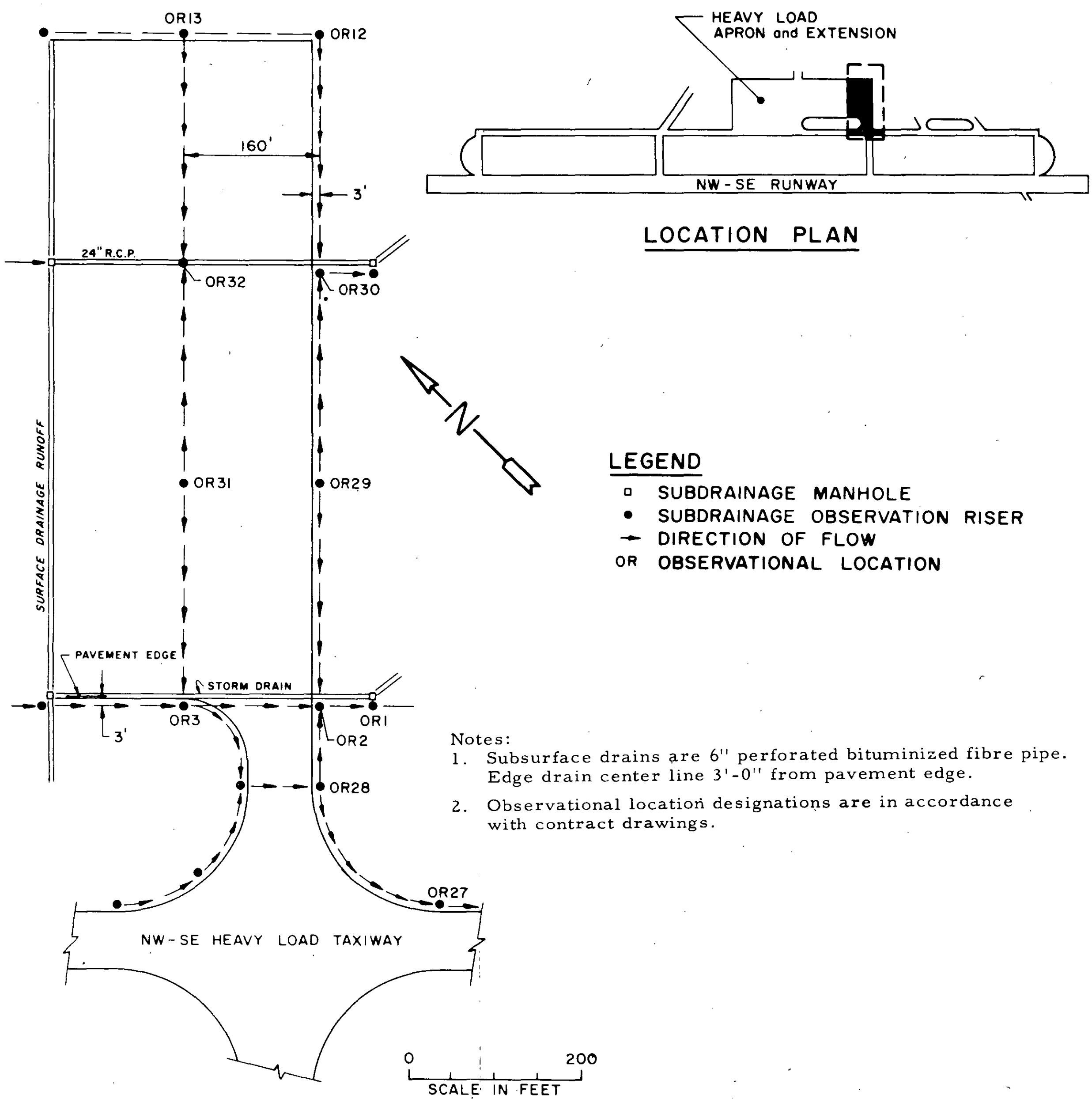


Figure 6. Typical pavement and subsurface drainage sections, N-S Runway, Selfridge AFB.



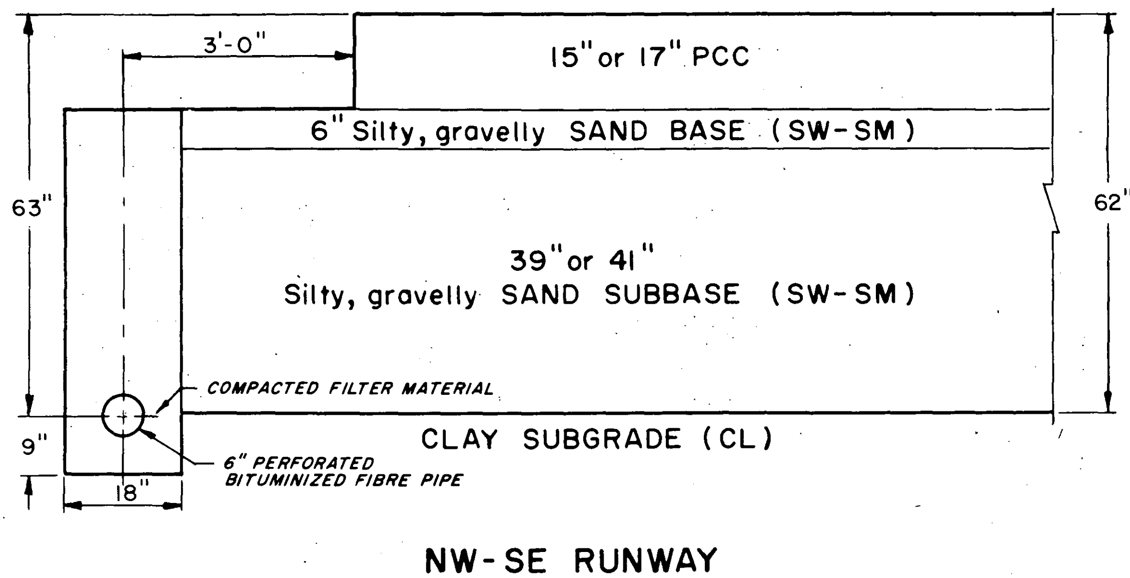
Note:
1. Subsurface drains are 6" perforated bituminized fibre pipe. Edge drain center line 3'-0" from pavement edge.

Figure 7. Subsurface drainage observational locations, NW-SE Runway, Dow AFB.



Notes:
1. Subsurface drains are 6" perforated bituminized fibre pipe. Edge drain center line 3'-0" from pavement edge.
2. Observational location designations are in accordance with contract drawings.

Figure 8. Subsurface drainage observational locations, heavy load apron extension, Dow AFB.



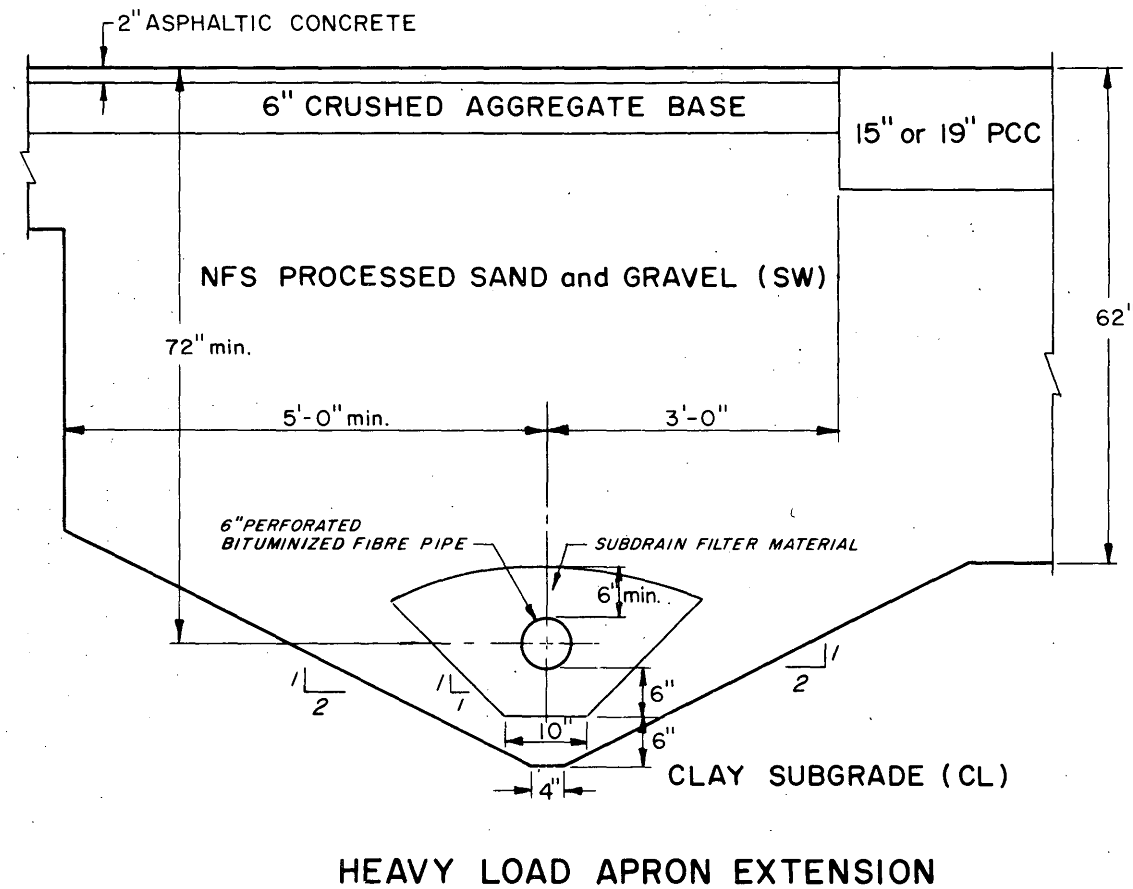


Figure 9. Typical pavement and subsurface drainage sections, Dow AFB.

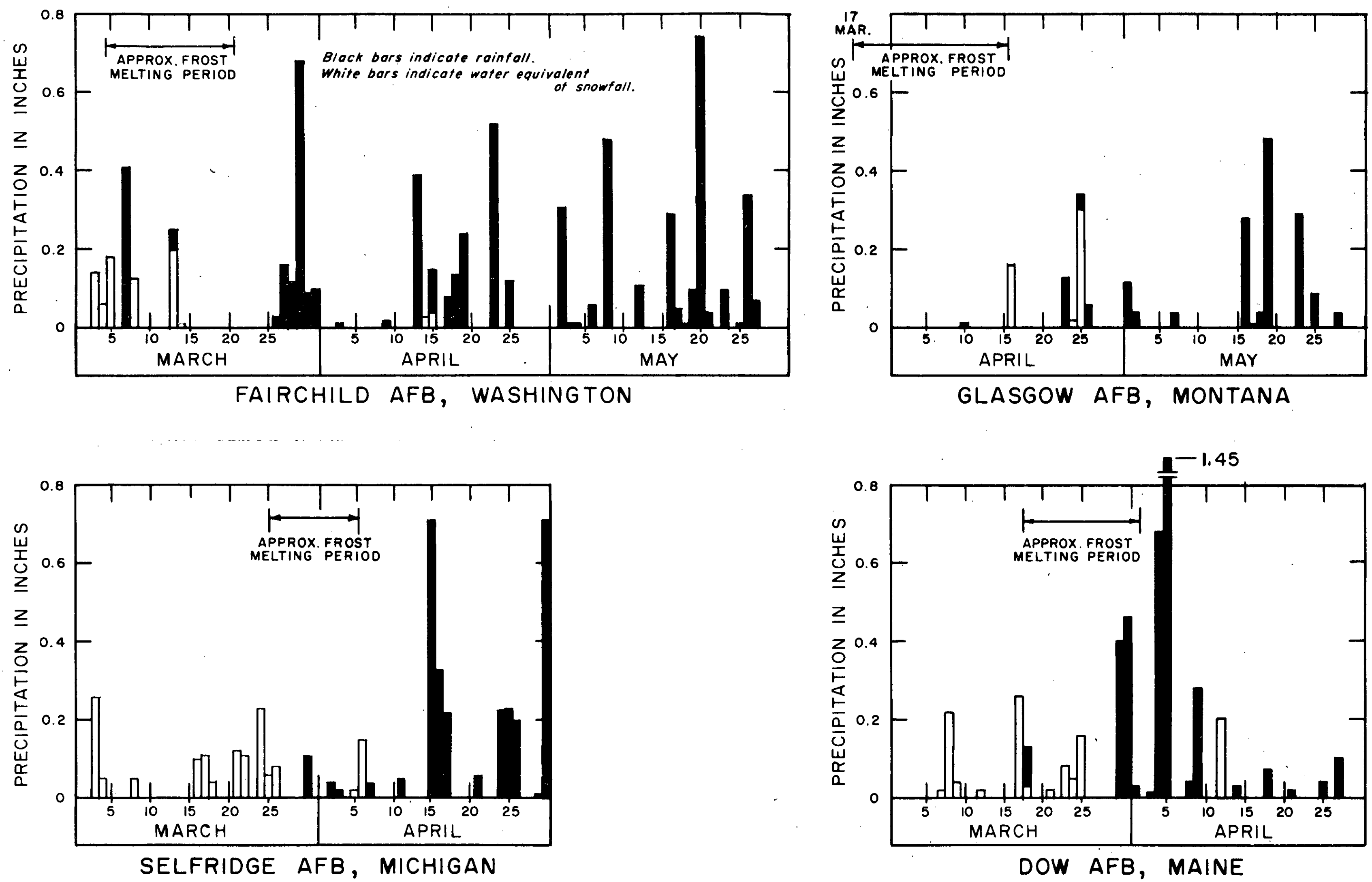


Figure 10. Daily precipitation during observational period.

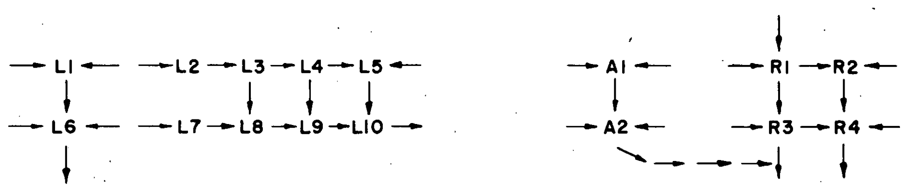
Table I. Summary of pavement and subsurface drainage details.

SITE	PERTINENT PAVEMENT DETAILS							SUBSURFACE DRAINAGE DETAILS		
	FEATURE DESIGNATION	LOCATION	PAVEMENT			SHOULDERS		TYPE OF PIPE (perforated-6" diameter)	DISTANCE FROM PAVEMENT EDGE TO ℄ PIPE (feet)	INVERT DEPTH BELOW SURFACE AT OBSERVATIONAL POINTS (feet)
			TYPE	THICKNESS (inches)	WIDTH (feet)	SURFACE	WIDTH (feet)			
Fairchild AFB Washington	NE-SW Runway	0+00 to 2+80	PCC	17	300	Turf	Variable	Concrete	3.0	4.5 to 4.7
	NE Blast Pad	0+00 to -1+50	AC	2	"	"	"	"	"	"
	NE Overrun	-1+50 to -10+00	Bit. Treat.	-	"	"	"	"	"	"
	Alert Taxiway	9+00 to 9+60	PCC	18	75	AC	50	Concrete	5.0 to 12.0	5.6 and 6.7
	Ladder Taxiway No.1	2+80 to 35+25	PCC	17, 21	50	AC	102.5 (left) 32.5 (right)	Concrete	3.0	5.3 to 11.4
Glasgow AFB Montana	NW-SE Runway	90+00 to 119+75	PCC	21	150	AC	75	Concrete	78.25	7.2 to 9.5
		119+75 to 129+75	PCC	14, 23, 26	300	Turf	Variable	"	3.0	"
	NW Blast Pad	129+75 to 131+25	AC	2	300	Turf	Variable	"	"	"
	NW Overrun	130+00 to 139+25	Bit Treat.	-	300	Turf	Variable	Concrete	3.25	8.9 to 11.4
	West Warmup Pad	130+25 to 131+90	PCC	23, 26	200	AC	50	Concrete	3.25	7.3 to 7.8
								Bit. Corrugated Metal	Under Pavement (100' on center)	-
Selfridge AFB Michigan	N-S Runway	57+00 to 80+00	PCC AC	13 3	150	Turf	Variable	Vitrified Clay Tile	4.25	5.0 (approx.)
		80+00 to 82+75	PCC	19	150	Turf	Variable	Vitrified Clay Tile	4.25	"
Dow AFB Maine	NW-SE Runway	35+60 to 40+80 and 94+00 to 100+00	PCC	15, 17	300	Turf	Variable	Bituminized Fibre	3.0	5.5 (min.)
	Heavy Load Apron Extension	22+00 to 26+00	PCC	15, 19	775	AC	50	Bituminized Fibre	3.0	6.2 (min.)

Table II. Subsurface drainage observations, Fairchild AFB
7 April - 30 May 1960.

OBSERVATION POINT	LOCATION		7 APRIL		17 APRIL		20 APRIL		25 APRIL		28 APRIL		3 MAY		6 MAY	
	Station(1)	℄ Offset	Depth of Water (Inches)	Description	Depth of Water (Inches)	Description	Depth of Water (Inches)	Description	Depth of Water (Inches)	Description	Depth of Water (Inches)	Description	Depth of Water (Inches)	Description	Depth of Water (Inches)	Description
							LADDER TAXIWAY No. 1									
L1	35+25	Right	-	No Reading	1/4	Flowing	1/4	Flowing	1/4	Flowing	-	Dry	-	Damp	-	Damp
L2	24+75	"	1/2	Flowing	1/2	Flowing	3/8	Flowing	1/2	Flowing	1	Flowing	3/8	Flowing	3/8	Flowing
L3	18+25	"	-	Dry	3/4	Flowing	3/4	Flowing	3/4	Flowing	-	Dry	-	Damp	-	Damp
L4	12+00	"	-	Damp	-	Slight Flow	1/4	Flowing	-	Slight Flow	-	Damp	-	Dry	-	Dry
L5	2+80	"	-	Trickle	3/4	Flowing	3/4	Flowing	3/4	Flowing	-	Damp	-	Damp	-	Damp
L6	35+25	Left	-	Dry	-	Damp	-	Damp	-	Damp	-	Dry	-	Dry	-	Dry
L7	24+75	"	1	Flowing	3/4	Flowing	3/4	Flowing	3/4	Flowing	1	Flowing	1/2	Flowing	3/8	Flowing
L8	18+25	"	-	Trickle	-	Damp	-	Damp	-	Damp	-	Dry	-	Dry	-	Dry
L9	12+00	"	-	Dry	-	Slight Flow	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry
L10	2+80	"	-	Trickle	3/4	Flowing	1	Flowing	1	Flowing	-	No Flow	-	No Flow	-	No Flow
							NE OVERRUN, NE-SW RUNWAY									
R1	-3+45	Left	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry
R2	-9+15	"	-	Dry	1/2	No Flow	3/8	No Flow	1/2	No Flow	-	Damp	-	Dry	-	Dry
R3	-2+25	Right	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry
R4	-9+15	"	-	Trickle	-	Damp	-	Damp	-	Damp	-	Damp	-	Damp	-	Damp
							ALERT TAXIWAY									
A1	9+60(2)	Left	-	Trickle	-	Dry	-	Dry	-	Dry	-	Dry	3/4	Flowing	3/4	Flowing
A2	9+60(2)	Right	-	Damp	1	Flowing	1	Flowing	1	Flowing	1	Flowing	2	Flowing	2	Flowing

(1) NE-SW Runway stationing except as noted.
(2) Alert Taxiway stationing.



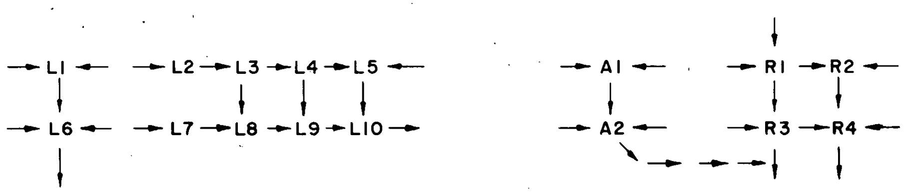
FLOW DIAGRAM

Sheet 1 of 2

Table II (Cont'd). Subsurface drainage observations, Fairchild AFB
7 April - 30 May 1960.

OBSERVATION POINT	LOCATION		11 MAY		13 MAY		16 MAY		20 MAY		24 MAY		27 MAY		30 MAY	
	Station(1)	Offset	Depth of Water (Inches)	Description	Depth of Water (Inches)	Description	Depth of Water (Inches)	Description	Depth of Water (Inches)	Description	Depth of Water (Inches)	Description	Depth of Water (Inches)	Description	Depth of Water (Inches)	Description
							LADDER TAXIWAY No. 1									
L1	35+25	Right	-	Damp	-	Damp	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry
L2	24+75	"	3/8	Flowing	3/8	Flowing	1/4	Flowing	1/4	Flowing	1/4	Flowing	1/2	Flowing	1/2	Flowing
L3	18+25	"	-	Damp	-	Damp	-	Damp	-	Damp	-	Damp	-	Dry	-	Dry
L4	12+00	"	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry
L5	2+80	"	-	No Flow	-	No Flow	-	No Flow	-	No Flow	-	No Flow	-	Dry	-	Dry
L6	35+25	Left	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry
L7	24+75	"	1/2	Flowing	3/8	Flowing	1/4	Flowing	1/4	Flowing	1/4	Flowing	1/2	Flowing	1/2	Flowing
L8	18+25	"	-	Damp	-	Damp	-	Damp	-	Damp	-	Damp	-	Dry	-	Dry
L9	12+00	"	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry
L10	2+80	"	-	No Flow	-	No Flow	-	No Flow	-	No Flow	-	No Flow	-	Dry	-	Dry
							NE OVERRUN, NE-SW RUNWAY									
R1	-3+45	"	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry
R2	-9+15	"	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry
R3	-2+25	Right	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry
R4	-9+15	"	-	Damp	-	Damp	-	Dry	-	Dry	-	Damp	-	Dry	-	Dry
							ALERT TAXIWAY									
A1	9+60(2)	Left	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry
A2	9+60(2)	Right	1/2	Flowing	1/2	Flowing	-	Dry	-	Dry	-	Dry	-	Dry	-	Dry

(1) NE-SW Runway stationing except as noted.
(2) Alert Taxiway stationing



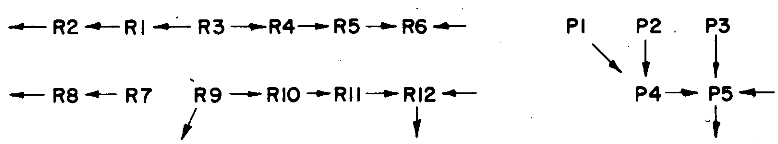
FLOW DIAGRAM

Sheet 2 of 2

Table III. Subsurface drainage observations, Glasgow AFB
27 April and 6 May 1960

OBSERVATION POINT	LOCATION		27 APRIL		6 MAY	
	Station[1]	℄ Offset	Depth of Water (Inches)	Description	Depth of Water (Inches)	Description
			NW-SE RUNWAY			
R1	130+00	Right	-	Inaccessible	3	Muddy, No Flow
R2	139+75	Right	2	Clear, No Flow	2	Clear, No Flow
R3	120+00	Right	-	Dry	-	Dry
R4	110+00	Right	1	Clear, Flowing	-	Dry
R5	100+00	Right	-	Dry	-	Dry
R6	90+00	Right	3	Clear, Flowing	2	Clear, Flowing
R7	120+42.5	Left	-	Inaccessible	-	Inaccessible
R8	139+75	Left	2	Clear, No Flow	2	Clear, Flowing
R9	120+00	Left	-	Dry	-	Inaccessible
R10	110+00	Left	-	Dry	-	Inaccessible
R11	100+00	Left	-	Dry	-	Inaccessible
R12	90+00	Left	3	Clear, Flowing	-	Inaccessible
			WEST WARM-UP PAD			
P1	131+90	385' Left	3	Clear, No Flow	2	Muddy, No Flow
P2	131+25	310' Left	3	Clear, No Flow	2	Muddy, No Flow
P3	130+25	245' Left	-	Inaccessible	$\frac{1}{2}$	Muddy, No Flow
P4	131+25	1037.5' Left	1	Clear, Flowing	$\frac{1}{2}$	Clear, Flowing
P5	130+25	1087.5' Left	2	Clear, No Flow	2	Clear, No Flow

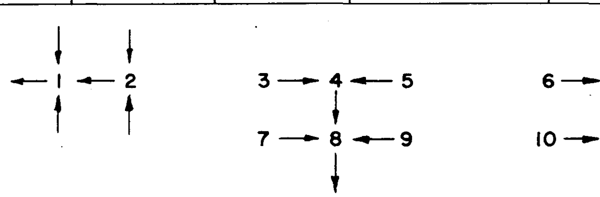
(1) NW-SE Runway stationing.



FLOW DIAGRAM

Table IV. Subsurface drainage observations, Selfridge AFB
4 and 25 April 1960.

OBSERVATION POINT	LOCATION		4 APRIL		25 APRIL	
	Station	℄ Offset	Depth of Water (Inches)	Description	Depth of Water (Inches)	Description
1	57+00	265' Left	1	Flowing	1	Slow Flow
2	57+75	265' Left	1	Flowing	1	Slow Flow
3	60+15	Left	$2\frac{3}{8}$	No Flow	$\frac{1}{2}$-1	No Flow
4	65+30	Left	-	Very Slow Flow	1	Slow Flow
5	71+05	Left	$\frac{1}{2}$-1	No Flow	$\frac{1}{2}$-1	No Flow
6	82+75	Left	$\frac{1}{2}$-1	No Flow	$\frac{1}{2}$-1	No Flow
7	60+15	Right	$\frac{5}{8}$	No Flow	$\frac{1}{2}$-1	No Flow
8	65+30	Right	-	Very Slow Flow	1	Slow Flow
9	71+05	Right	$\frac{1}{2}$-1	No Flow	$\frac{1}{2}$-1	No Flow
10	82+75	Right	$\frac{1}{2}$-1	No Flow	$\frac{1}{2}$-1	No Flow

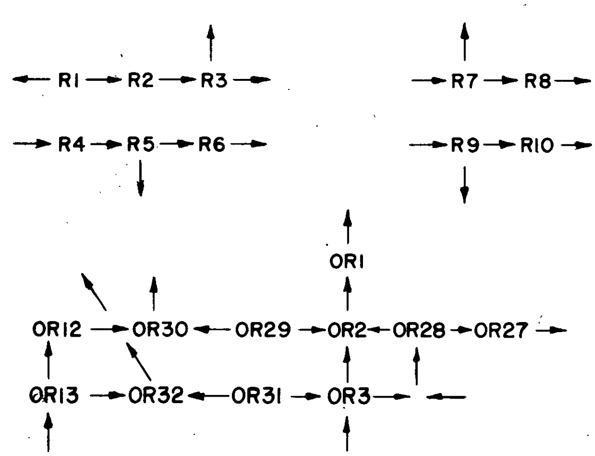


FLOW DIAGRAM

Table V. Subsurface drainage observations, Dow AFB
28 March - 28 April 1960.

OBSERVATION POINT	LOCATION		28 - 29 MARCH	14 APRIL	28 APRIL
	Station	℄ Offset			
			NW-SE RUNWAY		
R1	98+75	Right	Dry	Trace	Trace
R2	97+00	"	Dry	Trace	Trace
R3	94+00	"	Dry	Trace	Trace
R4	100+00	Left	Trace	Trace	Trace
R5	97+00	"	Trace	Trace	Trace
R6	94+00	"	Trace	Trace	Trace
R7	38+75	Right	Dry	Trace	Trace
R8	35+60	"	Dry	Trace	Trace
R9	40+80	Left	Dry	Trace	Trace
R10	37+90	"	Dry	Trace	Trace
		HEAVY LOAD APRON EXTENSION			
OR12	(1)	(1)	Trickle	Dry	Trace
OR30			Clogged (2)	Trace	Trace
OR29			Trickle	Trace	Trace
OR2			Trickle	Trickle	Trace
OR1			Fast Flow	Medium Flow	Trace
OR28			Medium Flow	Medium Flow	Medium Flow
OR27			Medium Flow	Medium Flow	Medium Flow
OR13			Trickle	Dry	Dry
OR32			Full of Ice (2)	Dry	Dry
OR31			Dry	Dry	Dry
OR3			Trickle	Trickle	Dry

(1) Locations shown on Figure 8.
(2) Corrective action taken prior to next observation.



FLOW DIAGRAM