TECH/NORTHWEST, INC.

ROOF CONSULTING, MOISTURE TESTING & ANALYSIS

ROOF MOISTURE STUDY

Technical Data Package

Study Conducted For:

Beaverton School District

Facilities Development
Beaverton, Oregon

Facility Tested:

FIVE OAKS MIDDLE SCHOOL

Beaverton, Oregon

Project Number: 21042

June 26, 2021

A-TECH/NORTHWEST, INC.
503-628-2882

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ROOF MOISTURE STUDY

Conducted For:

Beaverton School District
Facilities Development
16550 SW Merlo Road
Beaverton, Oregon

Facility Tested

FIVE OAKS MIDDLE SCHOOL

1600 NW 173rd Avenue
Beaverton, Oregon

ROOF CONSTRUCTION DATA

ROOF – A, B, C, E, F, G, H, I, J & K:

ROOF TYPE:	Built-up - *(BUR)* -- *Roof over Roof assembly*
SURFACE:	Gravel *(pea gravel – 4 to 6 lb psf)*
MEMBRANE:	7 plies total *(4-ply top system & 3 ply bottom system)*
BITUMEN TYPE:	Asphalt
INSULATION:	½" Fiberglass - *(top system-layer)* 1" Fiberglass - *(bottom system-layer)*
VAPOR RETARDER	None reported
DECK:	Metal
AGE REPORTED:	Unknown – Estimated 25+ years - *(1995-96 as reported)*
VISUAL APPEARANCE:	Fair to Poor *(Roof system)*
OPTIONS:	Roof system is considered to be at the end of manageable life cycle. - Short-term: Limited maintenance to maintain watertightness - Long-term: Salvage & Recover *(Recommended)* or complete removal & replacement
NOTE:	Roofs I, H & J have had an HVAC unit installed and the roofing system at those areas changes to gravel, SBS modified 2-ply with mineral cap, ½" polyiso-coverboard and 2" polyisocyanurate insulation, red rosin paper and metal deck.

ROOF MOISTURE & ROOF AREA DATA

TOTAL ROOF AREA INCLUDED WITHIN THIS STUDY		**133,963 sq. ft.**
ROOF A -- *(Insulated)*:		60,176 *sq. ft.*
Least Moisture Penetration	27.67 %	16,648 *sq. ft.*
Moderate Moisture Penetration	16.05 %	9,656 *sq. ft.*
Greater Moisture Penetration	5.26 %	3,163 *sq. ft.*
Greatest Moisture Content	.43 %	260 *sq. ft.*
Total Wet Area	49.40 %	29,727 *sq. ft.*
ROOF B -- *(Insulated)*:		25,249 *sq. ft.*
Least Moisture Penetration	19.40 %	4,899 *sq. ft.*
Moderate Moisture Penetration	8.99 %	2,270 *sq. ft.*
Greater Moisture Penetration	6.89 %	1,740 *sq. ft.*
Greatest Moisture Content	.06 %	15 *sq. ft.*
Total Wet Area	35.34 %	8,924 *sq. ft.*
ROOF C -- *(Insulated)*:		860 *sq. ft.*
Least Moisture Penetration	27.91 %	240 *sq. ft.*
Moderate Moisture Penetration	5.70 %	49 *sq. ft.*
Greater Moisture Penetration	1.86 %	16 *sq. ft.*
Greatest Moisture Content	0.00 %	0 *sq. ft.*
Total Wet Area	35.47 %	305 *sq. ft.*
ROOF E -- *(Insulated)*:		18,784 *sq. ft.*
Least Moisture Penetration	18.56 %	3,487 *sq. ft.*
Moderate Moisture Penetration	5.16 %	970 *sq. ft.*
Greater Moisture Penetration	3.20 %	602 *sq. ft.*
Greatest Moisture Content	0.00 %	0 *sq. ft.*
Total Wet Area	26.93 %	5,059 *sq. ft.*
ROOF F -- *(Insulated)*:		19,063 *sq. ft.*
Least Moisture Penetration	20.37 %	3,883 *sq. ft.*
Moderate Moisture Penetration	5.12 %	976 *sq. ft.*
Greater Moisture Penetration	.81 %	155 *sq. ft.*
Greatest Moisture Content	0.00 %	0 *sq. ft.*
Total Wet Area	26.30 %	5,014 *sq. ft.*

ROOF G -- *(Insulated)*:		5,350 *sq. ft.*
Least Moisture Penetration	10.75 %	575 *sq. ft.*
Moderate Moisture Penetration	.73 %	39 *sq. ft.*
Greater Moisture Penetration	1.79 %	96 *sq. ft.*
Greatest Moisture Content	2.04 %	109 *sq. ft.*
Total Wet Area	15.31 %	819 *sq. ft.*
ROOF H -- *(Insulated)*:		1,252 *sq. ft.*
Least Moisture Penetration	12.46 %	156 *sq. ft.*
Moderate Moisture Penetration	2.00 %	25 *sq. ft.*
Greater Moisture Penetration	1.04 %	13 *sq. ft.*
Greatest Moisture Content	0.00 %	0 *sq. ft.*
Total Wet Area	15.50 %	194 *sq. ft.*
ROOF I -- *(Insulated)*:		1,266 *sq. ft.*
Least Moisture Penetration	16.59 %	210 *sq. ft.*
Moderate Moisture Penetration	3.71 %	47 *sq. ft.*
Greater Moisture Penetration	.71 %	92 *sq. ft.*
Greatest Moisture Content	0.00 %	0 *sq. ft.*
Total Wet Area	21.01 %	266 *sq. ft.*
ROOF J -- *(Insulated)*:		1,236 *sq. ft.*
Least Moisture Penetration	25.24 %	312 *sq. ft.*
Moderate Moisture Penetration	3.88 %	48 *sq. ft.*
Greater Moisture Penetration	.24 %	3 *sq. ft.*
Greatest Moisture Content	0.00 %	0 *sq. ft.*
Total Wet Area	29.37 %	363 *sq. ft.*
ROOF K -- *(Insulated)*:		727 *sq. ft.*
Least Moisture Penetration	33.56 %	244 *sq. ft.*
Moderate Moisture Penetration	10.59 %	77 *sq. ft.*
Greater Moisture Penetration	4.68 %	34 *sq. ft.*
Greatest Moisture Content	0.00 %	0 *sq. ft.*
Total Wet Area	48.83 %	355 *sq. ft.*

DISCUSSION

An electronic roof moisture study was conducted on the roof system/assemblies on this facility to determine the internal moisture content *(if any)* within the roof's various components. This cost-effective tool is utilized to determine the most cost-effective planning, budgeting, and repair requirements on this facility for both the current specific problem areas as a temporary stabilization guide and for the information necessary to plan for eventual major roof project. The data is also very useful in development of roof specifications for either minor limited stabilization work to full major work.

The roofs tested are all roof over roof assemblies. There is an exception with Roofs I, H & J which have had a partial removal of the existing roof and new assembly installed. This was reported to have been done during a HVAC up-grade. The new insulation has polyisocyanurate insulation with a mineral grain surfaced SBS modified 2-ply assembly.

The electronic roof moisture study *(RMS)* of the roofs included within the RMS on this facility indicates varied levels of internal moisture within the roof system assemblies. The amount of internal moisture identified varies, but overall is considered to be moderate to slightly above normal for the types and ages of roofs. There are a few areas that have significant moisture content within the assembly. Based on the review of the data, it is our opinion that the high moisture content areas are often areas associated with both moisture that was trapped within the original roof assembly during the past recover project and also due to the deterioration of the top roof membrane assembly due to age with the migration of moisture down into the original *(bottom)* roof system/assembly. It is important to note and understand that the actual moisture content varies within the different roofs on this facility, but the contours do indicate an overall deterioration of the roof membrane waterproofing system.

In general, the roofs are considered to be only marginally manageable at this time due to the internal moisture content, the reported age and visible wear/deterioration of the membrane waterproofing system; however, they are considered to have significant areas that are salvageable with only a limited number/amount of specific areas requiring removal of wet materials and rebuilding when a reroof project is scheduled/conducted. Minor maintenance may be partially successful in slowing the migration of moisture into the roof assembly, but because of the pea-gravel covering, it is very difficult to find the source of actual moisture migration thru the membrane waterproofing assembly. Because this is a roof over roof configuration, current building Code requires the removal of at least the top *(recover)* roof membrane assembly layer when reroofing of this building is conducted. The wet areas that are associated with the bottom/original roof assembly will need to be removed and rebuilt as a part of the new recover assembly; however, based on the electronic RMS results, there is a significant amount of the overall roof square footage that is viable candidate for a salvage and recover project.

As noted and discussed within this report, it is important to understand that the internal moisture within the roofs, where moisture has been identified, will range from a low of slightly above ambient to areas with moderate moisture quantities and a few areas considered to be higher moisture content areas, as identified by weight. The majority of the identified moisture within the assembly will be below levels that are visible to the human eye. This is especially true with the highest moisture contoured level areas *(Greater and Greatest)* which will generally be visible to the human eye as either discolored or moisture to wet. Visibility will range from discoloration to areas that look and feel wet. There are areas with both visible and sub-visible moisture within the roof assemblies.

Based on the results of this electronic analysis and visual inspection of the roofs on this facility, it is our opinion that the roofs are generally considered viable candidates for a salvage and recover project and that maintenance until that time will only be partially successful. In addition to removal of the top roof system, there are a few areas of wet components/materials within the assembly that require removal and rebuilding; but overall, the roof system is considered to be salvageable. A new layer of insulation and membrane system is considered a viable option rather than complete tear-off and replacement.

(Refer to additional sections of this report for further discussion)

MEMBRANE - BUR:

<u>BUILT-UP ROOF *(BUR)*</u>: The maximum equilibrium moisture content of a built-up roof membrane under conditions of high relative humidity is approximately 1% *(by weight)*. The areas shown as being dry will contain less than this amount. The moisture contours developed via this study indicate moisture quantities ranging from slightly above ambient at 8.5% *(by weight)* to areas with quantities as high as 12% *(by weight)*.

Moisture was identified within the membrane ranging from slightly ambient to a high of approximately 8.75% *(by weight)*. Moisture above the normal ambient range within the roof membrane can cause substantial strength loss, making wet areas much more susceptible to further physical damage than the dry areas. When a moisture content of 7% *(by weight)* and above is reached, approximately 81% of the tensile strength can be lost.

SPECIAL NOTE: No asbestos test was conducted as a part of this study.

(Refer to additional sections of this report for further discussion)

INSULATION:

Two *(2)* types of rigid insulation have been identified as within the insulated roof assembly*(s) (above the structural deck)* on this facility. The following is a review of how moisture relates to this material when utilized within a roof system.

<u>Fiberglass Board:</u> Fiberglass insulation is a very porous material through which moisture readily passes. This insulation material, in contact with humid air, can have a moisture content of 2.0%, by weight. The dry areas will contain less than this amount.

Saturation is generally reached at levels of 690%, by weight. Because of the porous material, moisture quantities of approximately 145% and above must be reached before the human eye can accurately detect the presence of moisture within this material. This makes low level moisture, within this material, exceedingly difficult to "see" with the eye.

Moisture has been identified within this material ranging from slightly above ambient to levels as high as 340% by weight. Much of the moisture identified within the fiberglass insulation board is in the bottom 1/3 of the assembly except where and when solar heating moves it up farther into the assembly.

<u>Polyisocyanurate Foam Board:</u> Polyisocyanurate foam is a closed-cell insulation that does not absorb moisture as readily as fibrous insulation, such as fiberboard or fiberglass. It does, however, breakdown and absorb moisture when exposed to moisture over long time periods.

The maximum equilibrium moisture content possible for Polyisocyanurate foam insulation *(board type)* in contact with high Relative Humidity air is 6% *(by weight)*. The areas indicated as dry will contain less than this amount. Saturation of this material is achieved at approximately 1000% *(by weight)*. Varied but limited amounts/quantities of moisture have been identified within this material at this time. The majority of the identified moisture will be below levels that the human eye can see. This insulation material is considered to be salvageable.

Moisture in Polyisocyanurate foam board insulation is generally not visible to the human eye until a 45% *(by weight)* and above level is reached. Much of the moisture identified within this study is not visible to the human eye at this time.

(Refer to additional sections of this report for further discussion)

DECK:

The roofs tested within the scope of this study are reported to have one *(1)* type of structural deck system. The following is a discussion of moisture as it affects the material when installed in a built-up roof system assembly.

Metal: Metal decks are subject to deterioration when moisture is trapped within the roof assembly or is present in the flutes, etc. The typical deterioration is rust and corrosion. No damage was noted during the coring process during this study; however, the inspection of the metal deck was limited to the few core/probe locations conducted during the RMS to verify the electronic data.

There is always a slight potential for some minor damage to the deck, but there is no indication of problems at this time. At this time, the deck system is only visible from the building interior. The deck should be visually inspected, at suspect areas, and repaired when the eventual major roof project is conducted.

(Refer to additional sections of this report for further discussion)

INTERIOR LEAKAGE

Over the last few years, there has been periodic reports of interior leakage problems reported at this facility. The review of the interior leakage reports/repairs have indicated that the interior leakage has been relatively widespread and is associated with downslope areas, as well as with roof-mounted equipment and penetrations, perimeters and/or membrane splits and other damage/defects.

Because of the type and degree of deterioration of this roof membrane system, there is a high potential for the development of additional internal leakage problems until the recommended major roof work is completed. In addition, it is important to understand that based on the current condition of this roof system, that when moisture enters the assembly it generally does not immediately reach the building interior as an interior leak issue. There is a high probability that the current migration into the roof system components will continue and increase moisture content and square footage of the currently salvageable materials, resulting in additional removal and rebuilding of currently salvageable materials. Minor localized maintenance can help to control the moisture migration but will not stop it based on the roof system's current condition.

(Refer to additional sections of this report for further discussion)

CONTOUR INTERPRETATIONS:

The technical data developed, based on the electronic roof moisture study on this facility, has identified varied degrees of moisture within the various roof system components, based on both square footage and moisture by weight. The moisture identified within the roof system is considered to be generally at and slightly above normal life cycle expectations for this type and age roof system.

The roof membrane waterproofing system*(s)* on this facility are rapidly nearing, and by original published expectations, have reached the end of their expected and manageable life cycle. The majority of the moisture ranges from slightly above ambient to moderate level of internal moisture. There are a few areas of elevated moisture content, also. The type and degree of contours developed via this electronic Roof Moisture Study *(RMS)* indicates specific and/or multiple problems, as well as the overall age-related deterioration of the roof system membrane and flashing waterproofing assembly.

In addition to the specific problems noted, it is safe to say as a general statement that as these roofs continue to age, based on the current internal moisture content, age and type, there is an increased potential for further membrane waterproofing deterioration. This will result in an increase in not only the rate of overall deterioration but the number and degree of interior leakage problems.

The moisture identified within the roof system is a result of any one or a combination of the following:

1. General deterioration and loss of waterproofing ability due to age and drying of the waterproofing bitumen within the assembly.
2. Deterioration of the perimeter flashing details.
3. Deterioration of penetration and roof-mounted equipment flashings.
4. Membrane damage.
5. Moisture trapped in the original roof system during the recover project.
6. Low areas to which moisture migrates and collects.
7. Lateral transmission or movement of moisture.
8. Vapor drive and other physical laws of nature.

The low level moisture *(as well as the higher quantities)* identified via this study is important in the overall review of the roof and the maintenance options. When reviewing the moisture contour map, it is very important to understand that much of the moisture contoured is below levels that are visible to the human eye. The moisture contours are very important and representative of the internal condition of the roof system. Moisture is an indicator of various conditions and subsequent problems and is utilized as data towards the final maintenance recommendations and decisions. Moisture within a roof affects the short and long-term performance of all components within a roof assembly.

Moisture migration into a roof system generally starts quite slow. As it increases in quantity, the ratio of problems to the initial moisture results in ever increasing migration rates. The deterioration process is varied, but when unchecked with appropriate maintenance, can often result in pre-mature failure of a roof system. A common scenario is that a small membrane breach allows moisture into the assembly, which will adversely affect additional membrane and flashing details and allow additional problems and moisture migration, etc.

(Refer to additional sections of this report for further discussion)

MAINTENANCE SUGGESTIONS

Based on the results of this study, it is our opinion that the roofs tested as a part of this electronic roof moisture study on this facility are near the end of their manageable life. However, as discussed within this report, Code requires the removal of the top membrane system in order to be able to do a salvage and recover project. There is a significant amount of the original roof that is currently considered salvageable after the top roof *(recover)* is removed. This option should be reviewed when reviewing the various options for the reroof of this facility.

Minor localized maintenance is a temporary option to control interior leakage and further deterioration and to protect the currently salvageable materials and attempt to control the interior leakage issues until the recommended major work is conducted. The follow up inspection and limited localized maintenance should be defined/conducted based on a close follow-up inspection of the roofs in order to conduct localized stabilization repairs, as well as any localized as-required repairs when an interior leakage issue shows up. The moisture contour maps should be utilized as a guide *(map)* to review the roof membrane waterproofing system *(roof assembly)* as it applies to the internal condition of the roof assembly*(s)* in order to determine the most cost-effective way to define the localized maintenance. The application of a coating system is NOT considered a cost-effective maintenance tool on these roofs.

The areas identified within this report that should be removed and replaced *(bottom roof system)* are the moisture contoured areas indicated as having "Greater and/or Greatest Moisture Content". There is a possibility that some of the higher moisture content areas are associated with the top system, but as a way to budget and specify the work, those contoured areas should be defined as to be removed and rebuilt.

Upon completion of the roof work, the facility should be placed back into a roof management program *(RMP)*. It is our opinion that all roofs require positive management to achieve their full life expectancy and value. The successful planned roof management program should include a regular schedule of visual inspection and timely repairs. The inspections should include a written report for the permanent roof maintenance management file. We highly recommend a quarterly inspection schedule with a minimum of twice a year. The inspections can be a combination of in-house and independent professional inspections.

The successful roof management program also should include regular electronic roof moisture studies. We recommend a four *(4)* to six *(6)* year cycle for this maintenance management and internal roof condition data-gathering tool. The next scheduled date for an electronic inspection of this roof should be on the five *(5)* or six *(6)* year anniversary of the recommended salvage and recover project.

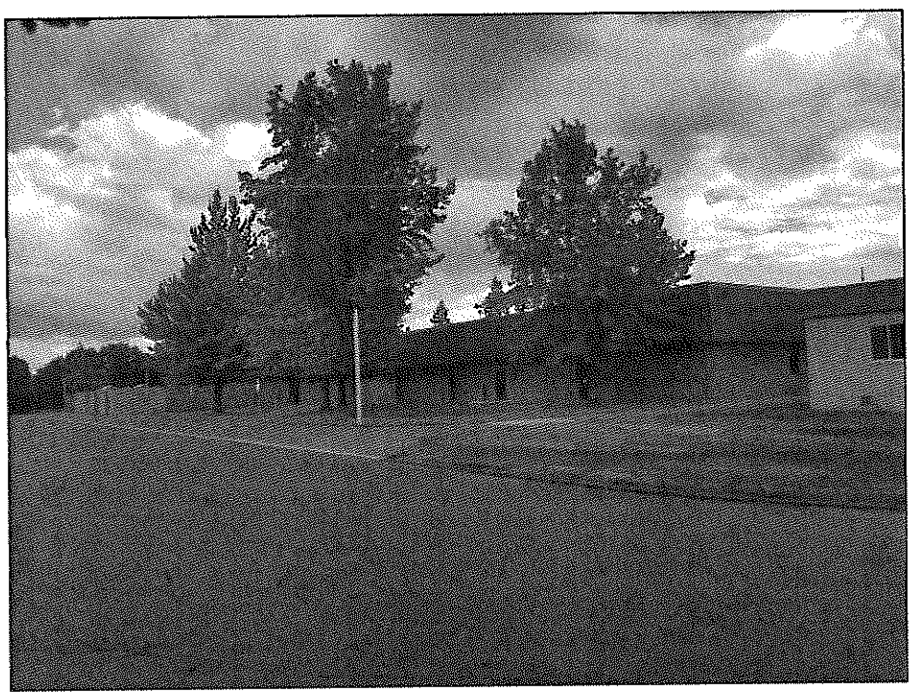
It is our experience that this type of roof management program can extend the useful life of a roof assembly by identifying potential and beginning problems before they become expensive. Positive roof management is cost-effective; crisis management is always expensive.

NOTE: *This report is written based on pertinent information received from the visual inspection and leak history provided by in-plant personnel, as well as the in-depth electronic roof moisture study. The directives are opinions based on the supplied information and should not be considered roof specifications, or final or absolute alternatives. The purpose of this report is to offer correct recommendations and guidelines to follow to avoid unnecessary repairs and/or costs.*

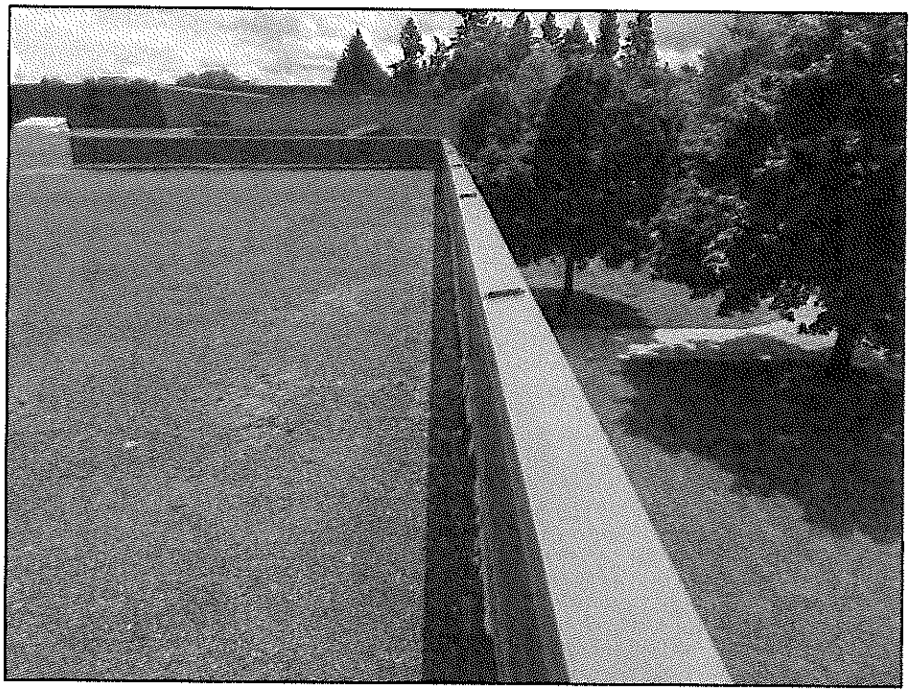
It must be cautioned that interior leakage can develop at almost any time with any roof system. This does not necessarily mean that the roof has failed, but rather, is one indication of a problem.

- *End of Report* -

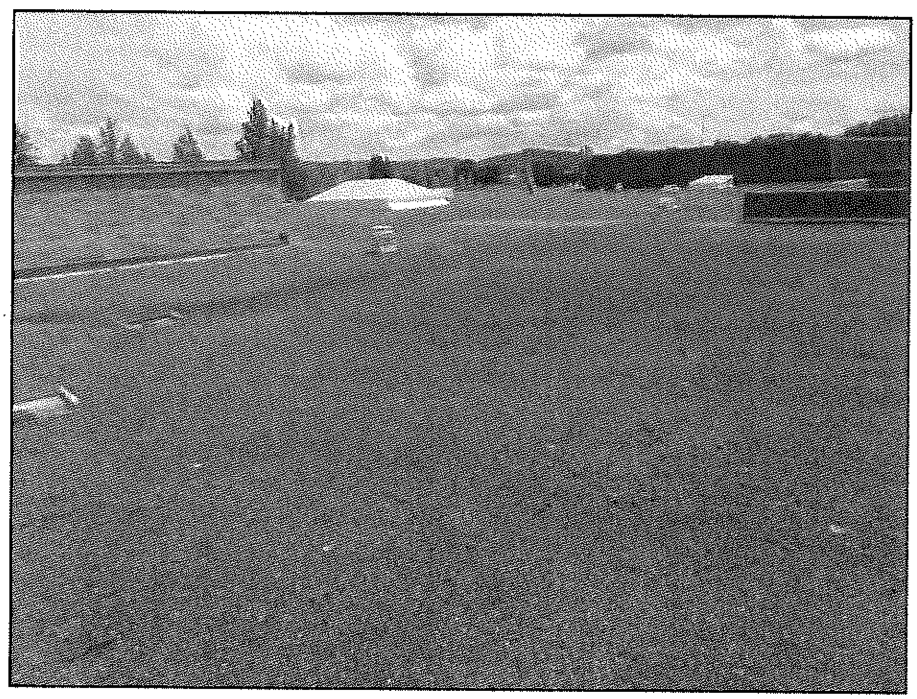
Sec. 1.01 – View to northwest of south elevation.



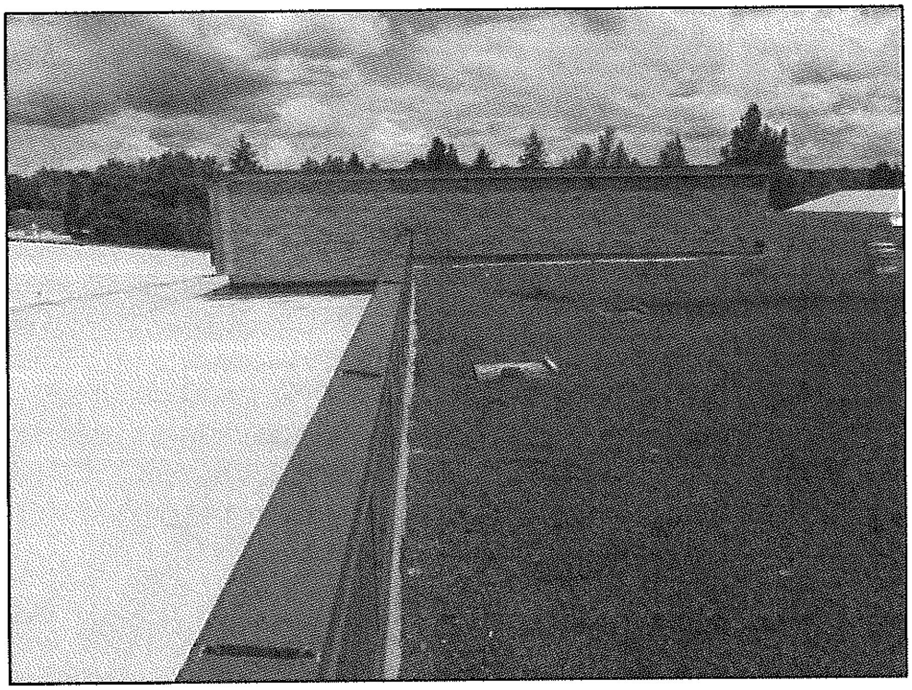
Sec. 1.02 – View to southeast of north elevation.



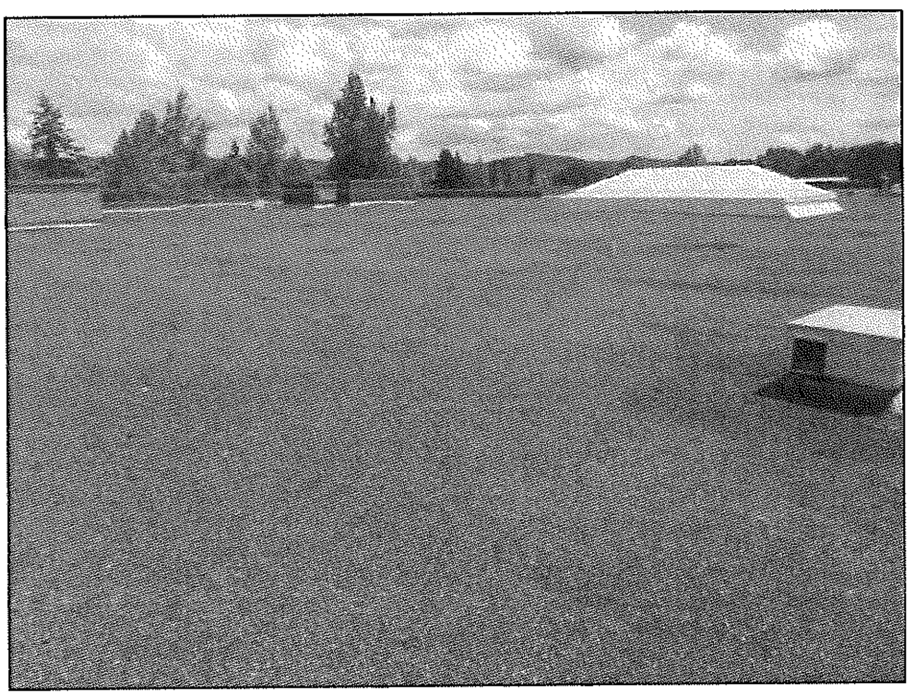
Sec. 1.03 – Roof A: View to east along south perimeter from the "A-1" reference corner.



Sec. 1.04 – Roof A: View to northeast across roof field from the "A-1" reference corner.

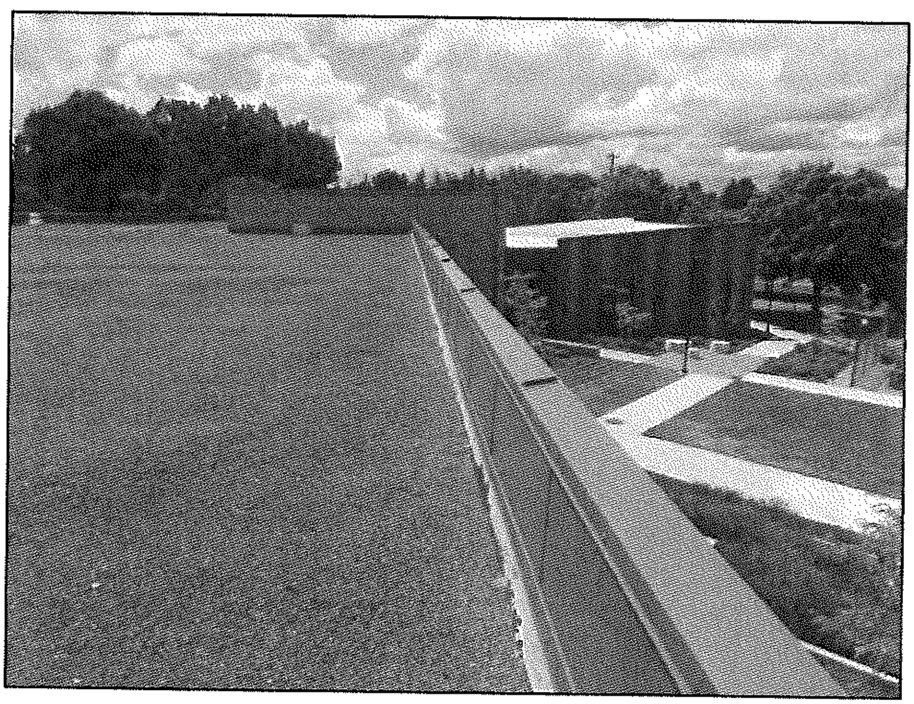


Sec. 1.05 – Roof A: View to north along west perimeter from "A-1" reference corner.



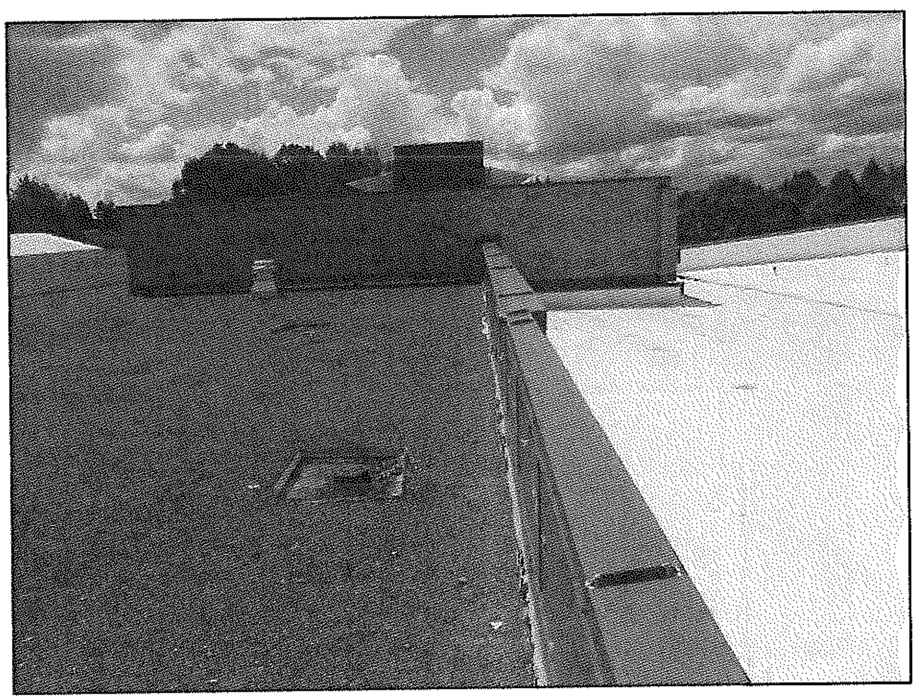
Sec. 1.06 – Roof A: View to northeast across roof field from center section of Roof A.

Sec. 1.07 – Roof A: View to north along west perimeter from center section of Roof A.

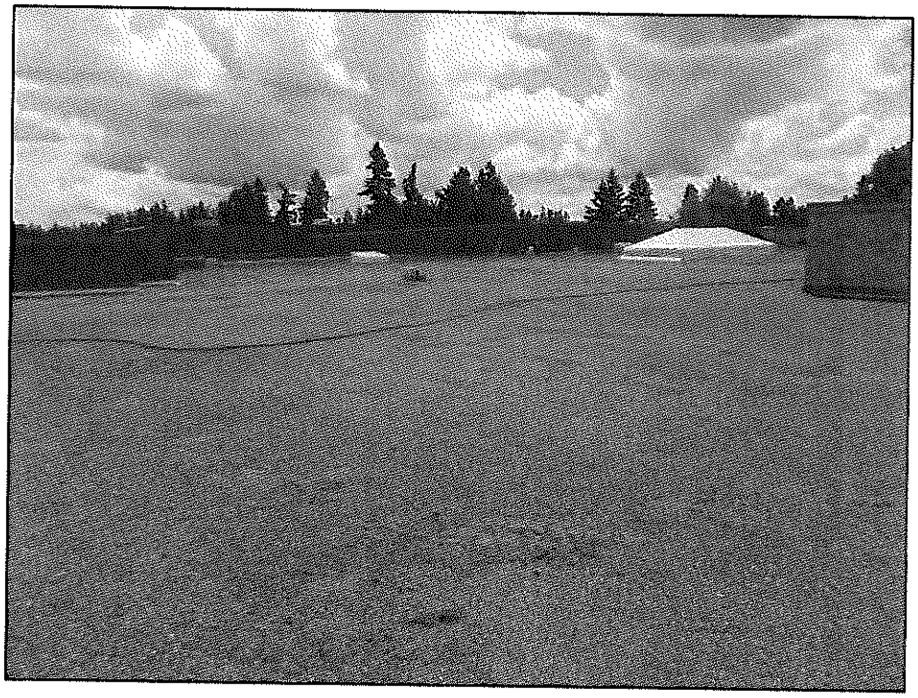


Sec. 1.08 – Roof A: View to south along west perimeter from center section of Roof A.

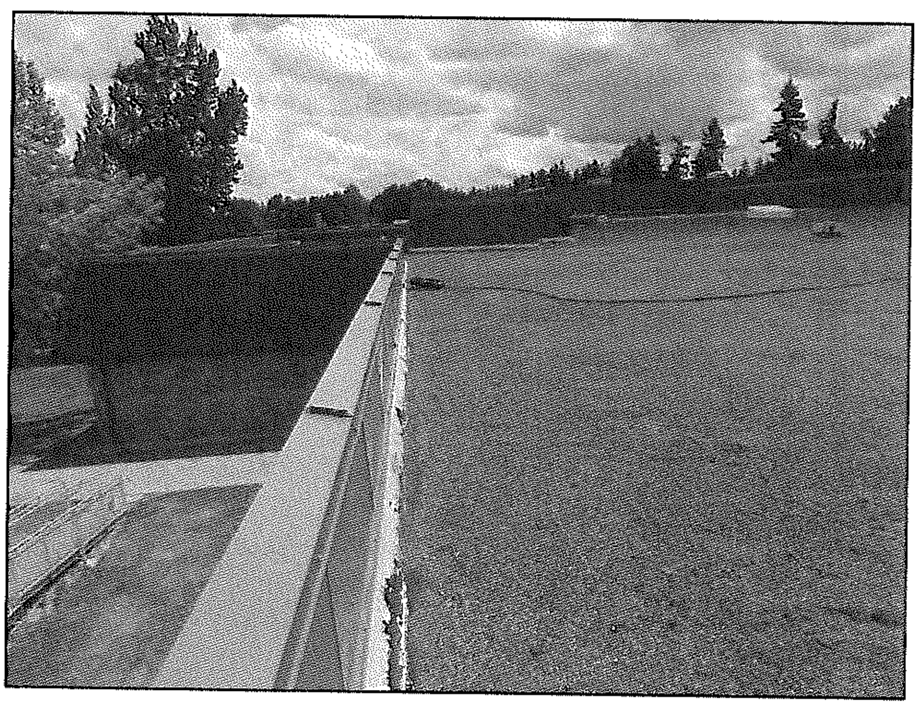
Sec. 1.09 – Roof A: View to south across roof field from southeast corner of Roof J.



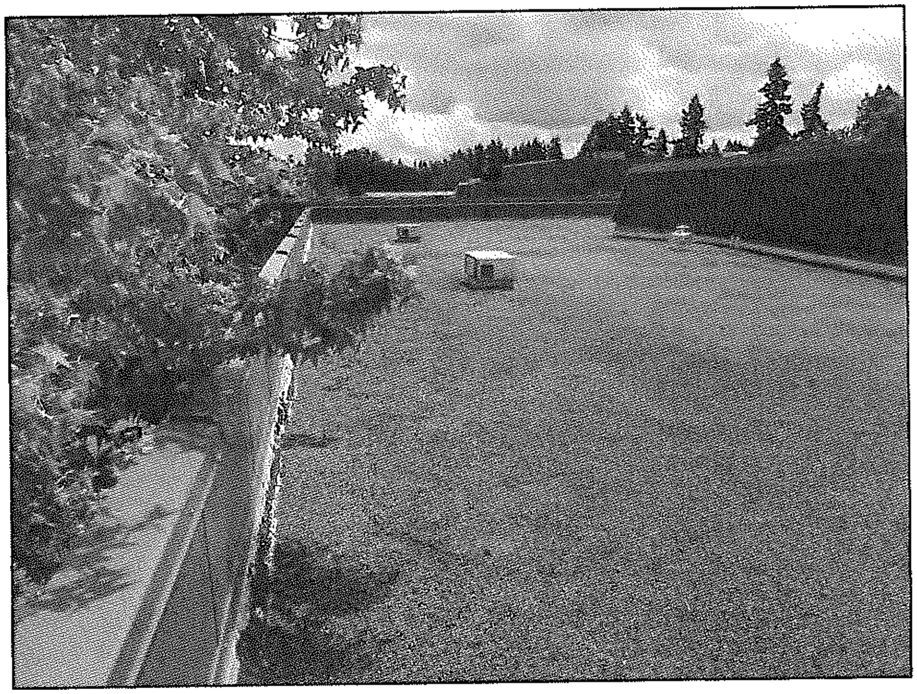
Sec. 1.10 – Roof A: View to south along west perimeter from northwest corner of roof.



Sec. 1.11 – Roof A: View to southeast across roof field from northwest corner of roof.



Sec. 1.12 – Roof A: View to east along north perimeter from northwest corner of roof.

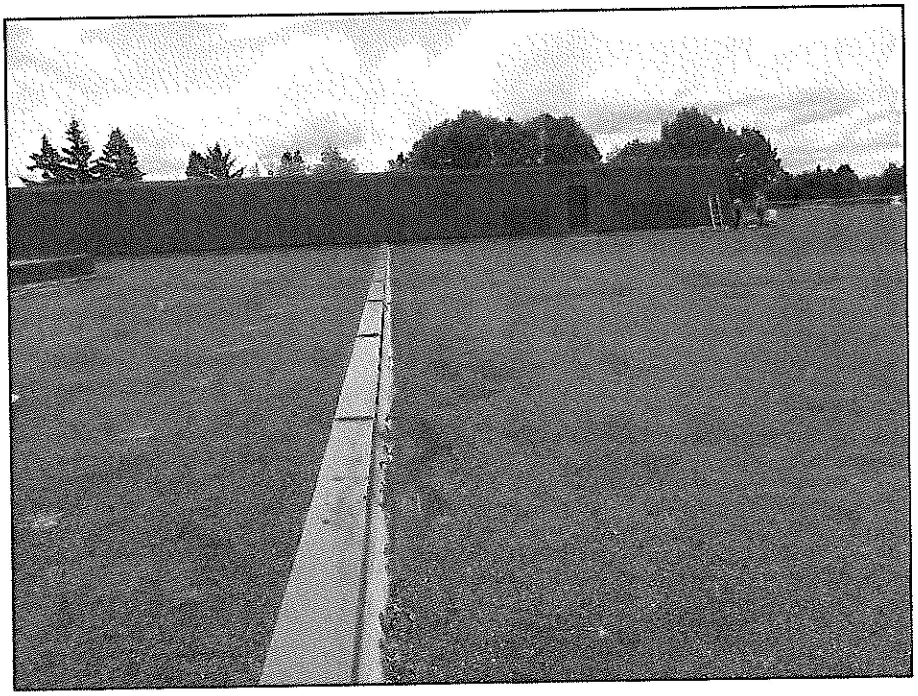


Sec. 1.13 – Roof A: View to east along north perimeter from center of north perimeter.

Sec. 1.14 – Roof A: View to west along north perimeter from northeast corner of roof.

Sec. 1.15 – Roof A: View to west across roof field from center section of east perimeter.

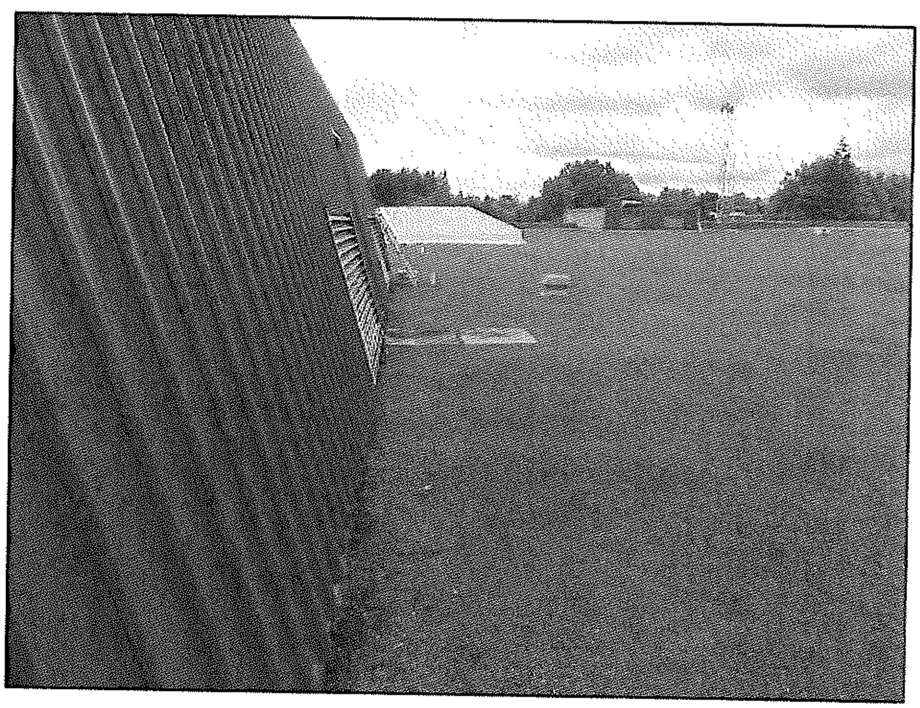
Sec. 1.16 – Roof A: View to southwest across roof field from northeast corner of roof.



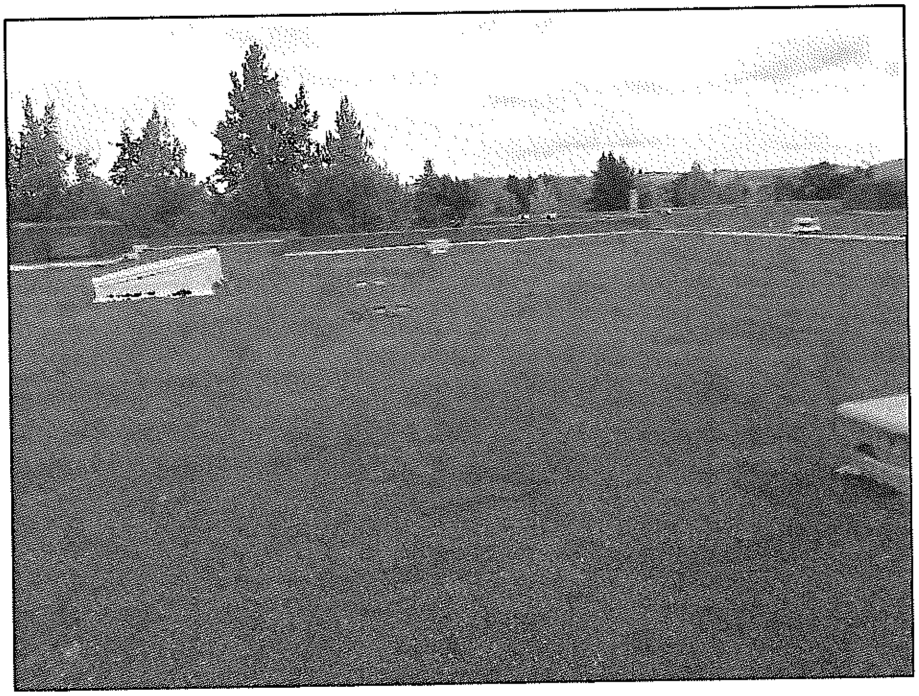
Sec. 1.17 – Roof A: View to south along east perimeter from northeast corner of roof. Roof B is at left of picture.

Sec. 1.18 – Roof A: View to north along east perimeter from southwest corner of Roof B. Roof B at is right of picture.

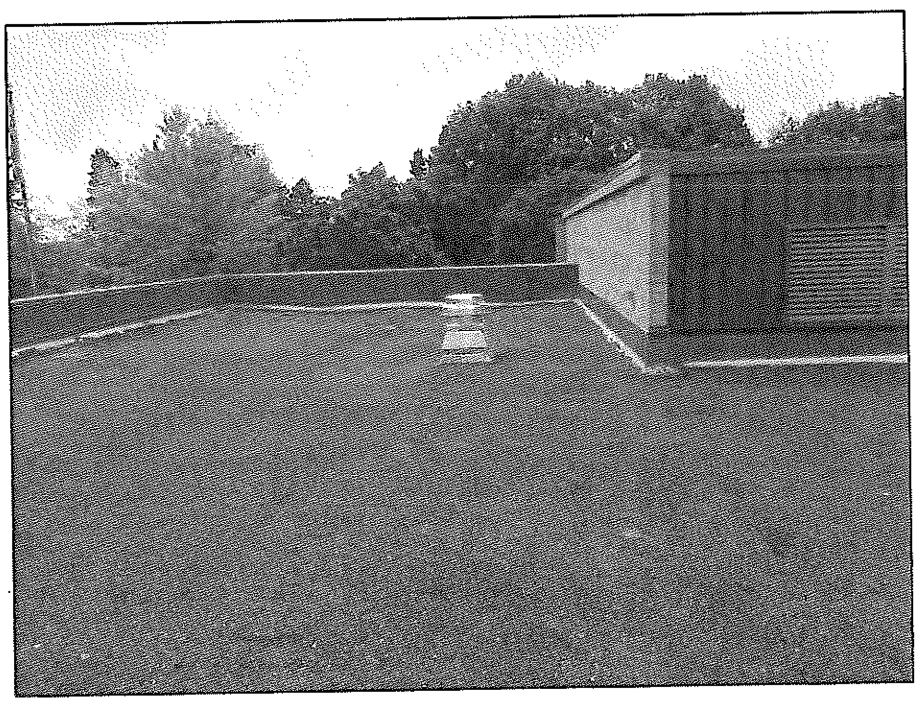
Sec. 1.19 – Roof A: View to northwest across roof field from southwest corner of Roof B.



Sec. 1.20 – Roof A: View to west across roof field from southwest corner of Roof B.

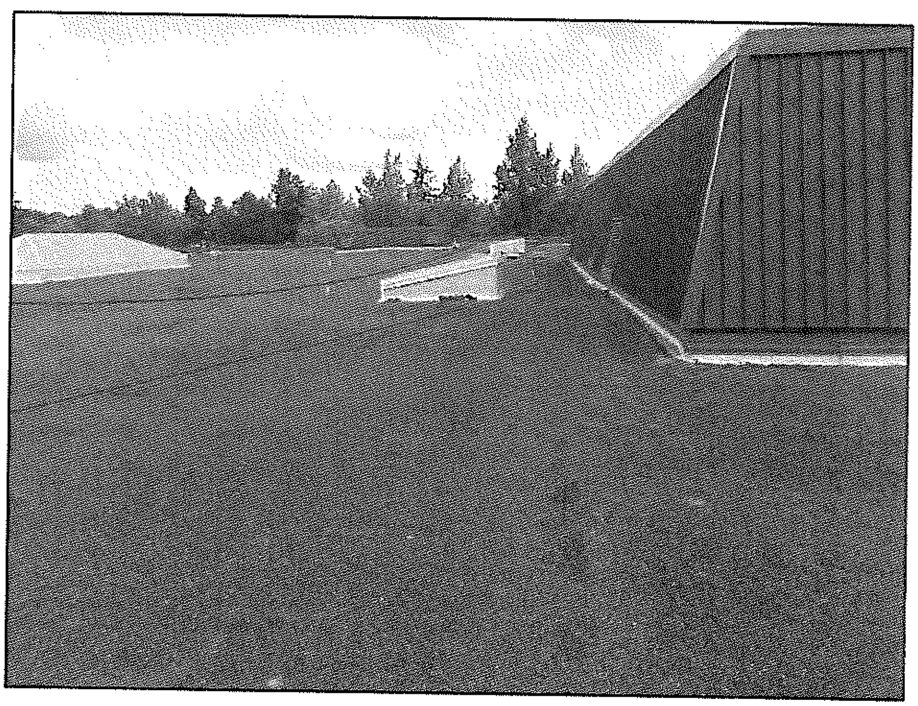


Sec. 1.21 – Roof A: View to north across roof field from northwest corner of Roof F.

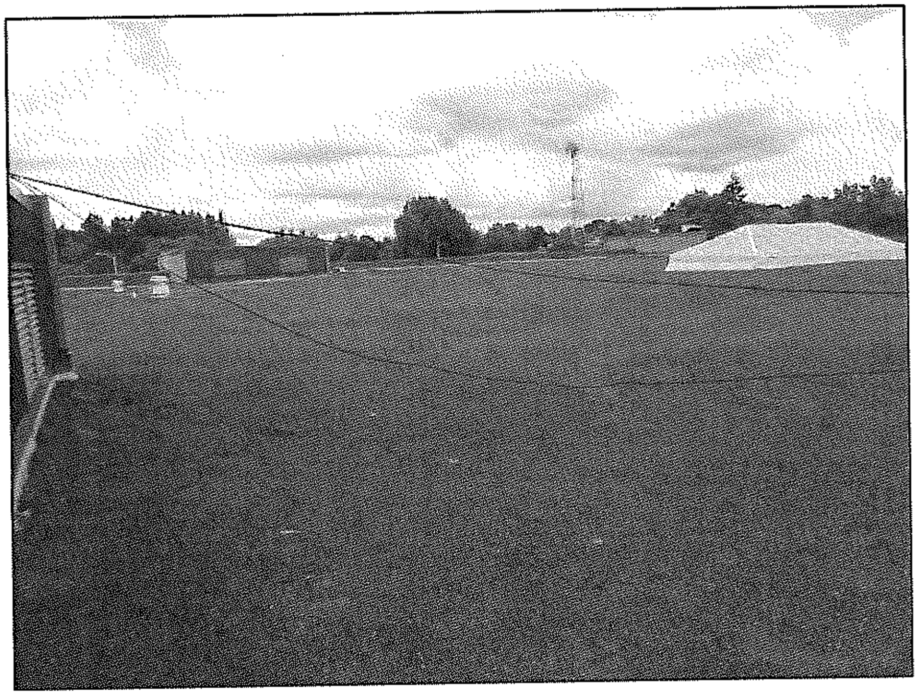


Sec. 1.22 – Roof A: View to south across roof field from southwest corner of Roof F.

Sec. 1.23 – Roof A: View to northwest across roof field from southeast corner of roof.

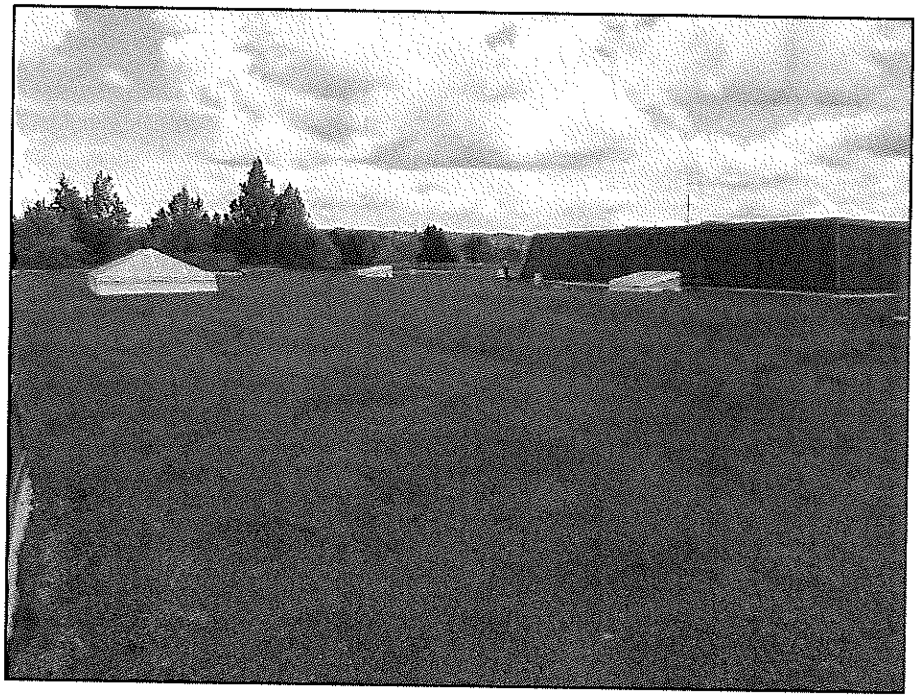


Sec. 1.24 – Roof A: View to north across roof field from northeast corner of Roof H.



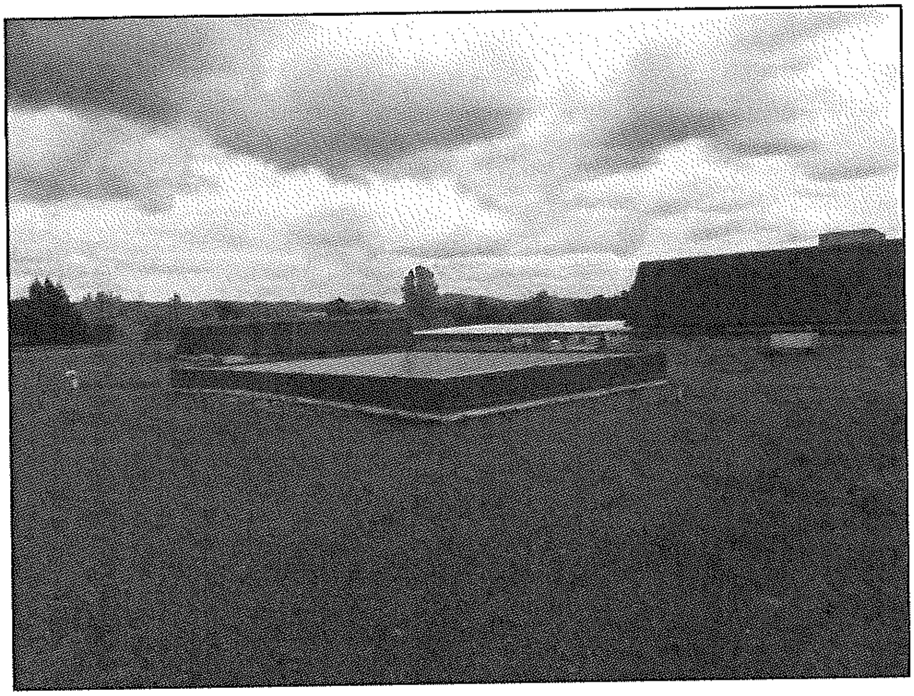
Sec. 1.25 – Roof A: View to west across roof field from northeast corner of Roof H.

Sec. 1.26 – Roof A: View to west along south perimeter from southwest corner of Roof H.



Sec. 1.27 – Roof A: View to northeast across roof field from center section of south perimeter.

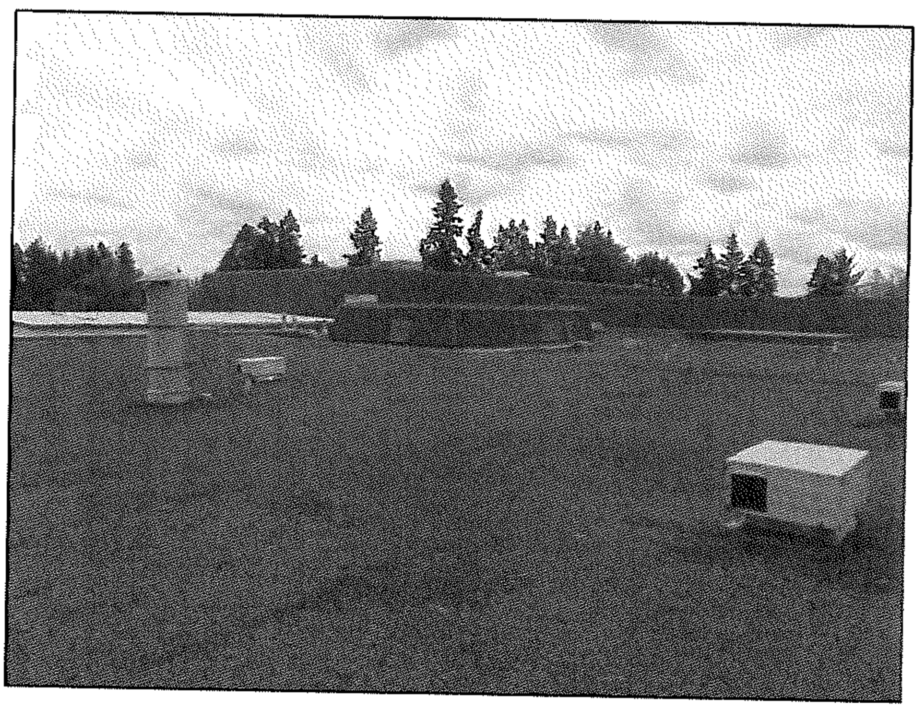
Sec. 1.28 – Roof B: View to east along south perimeter from the "A-1" reference corner.



Sec. 1.29 – Roof B: View to northeast across roof field from the "A-1" reference corner.

Sec. 1.30 – Roof B: View to north along west perimeter from the "A-1" reference corner. Roof A is at left of picture.

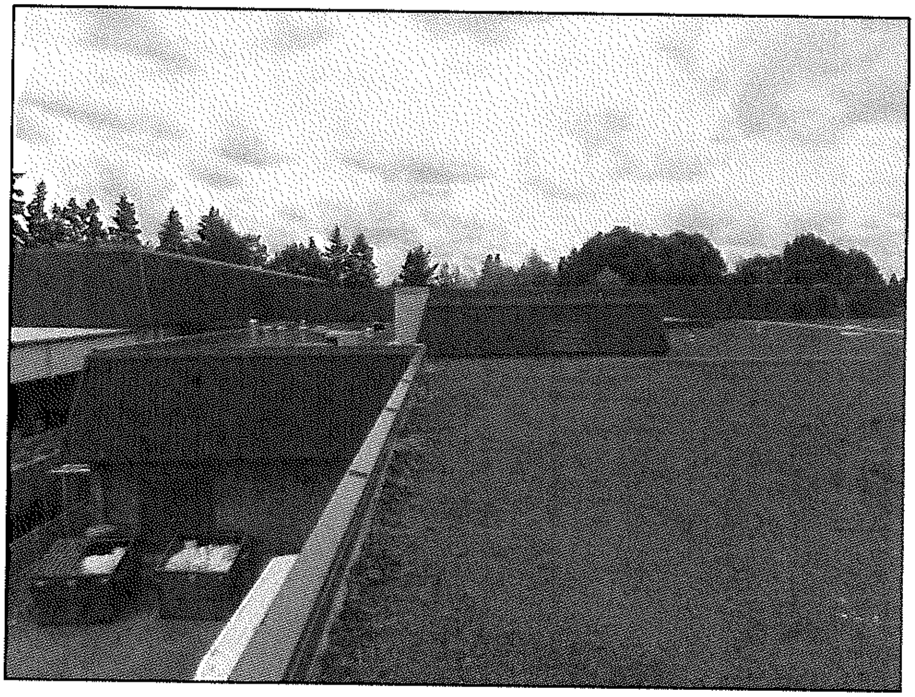
Sec. 1.31 – Roof B: View to south along west perimeter from northwest corner of roof.



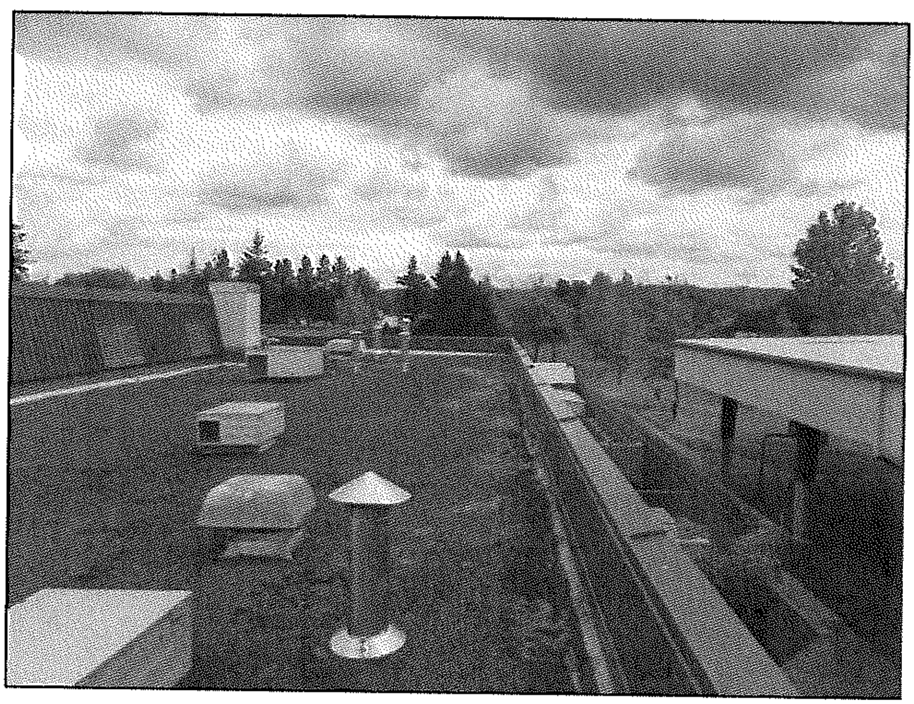
Sec. 1.32 – Roof B: View to southeast across roof field from northwest corner of roof.

Sec. 1.33 – Roof B: View to east along north perimeter from northwest corner of roof.

Sec. 1.34 – Roof B: View to west along north perimeter from northeast corner of roof.

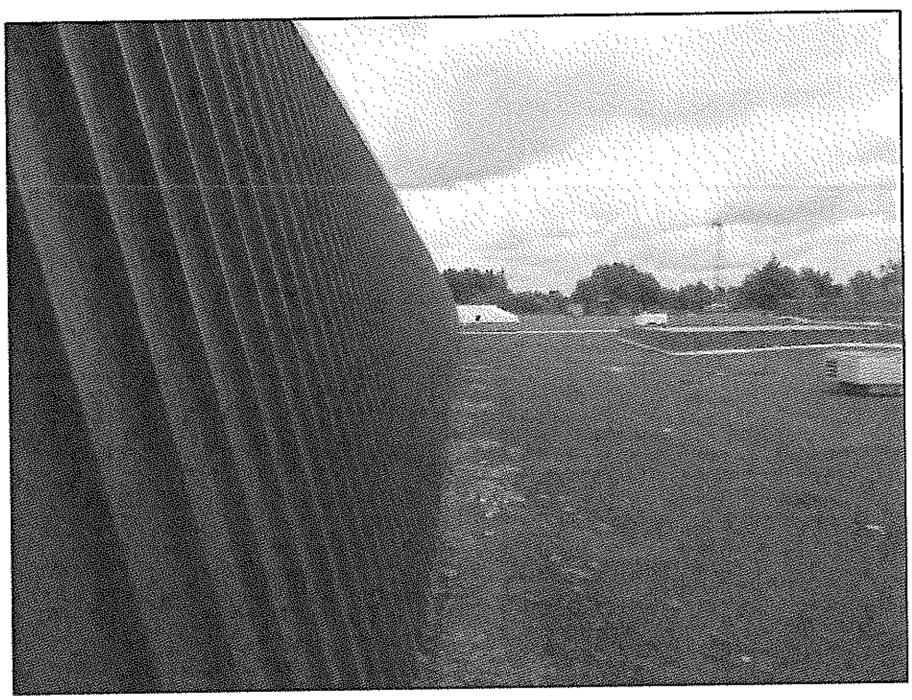


Sec. 1.35 – Roof B: View to south along east perimeter from northeast corner of roof.



Sec. 1.36 – Roof B: View to north along east perimeter from southeast corner of roof.

Sec. 1.37 – Roof B: View to northwest across roof field from southeast corner of roof.

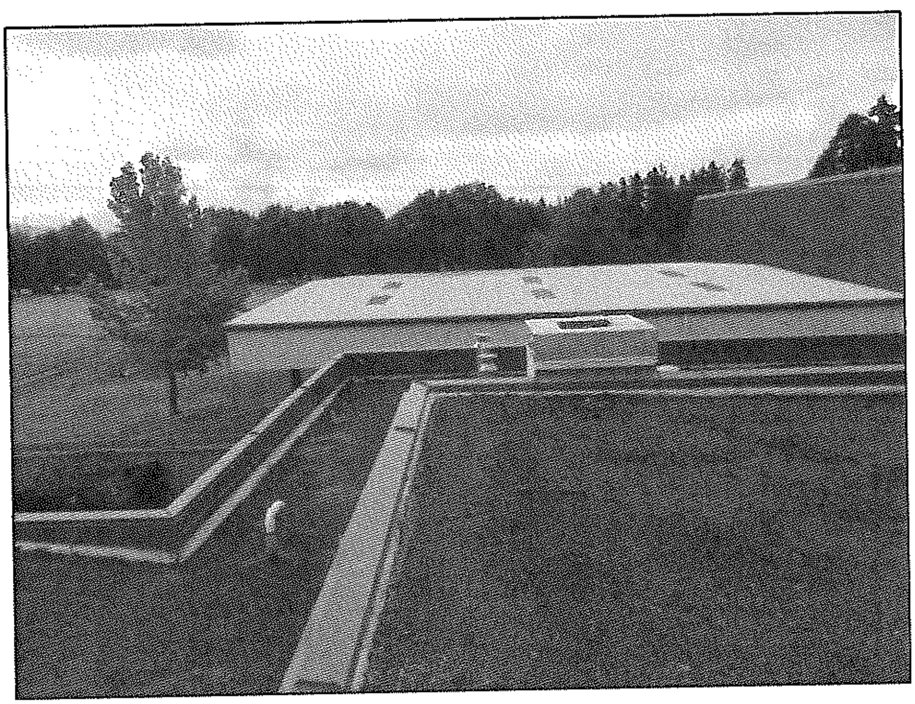


Sec. 1.38 – Roof B: View to west along south perimeter from southeast corner of roof.

Sec. 1.39 – Roof C: View to east along south perimeter from the "A-1" reference corner.

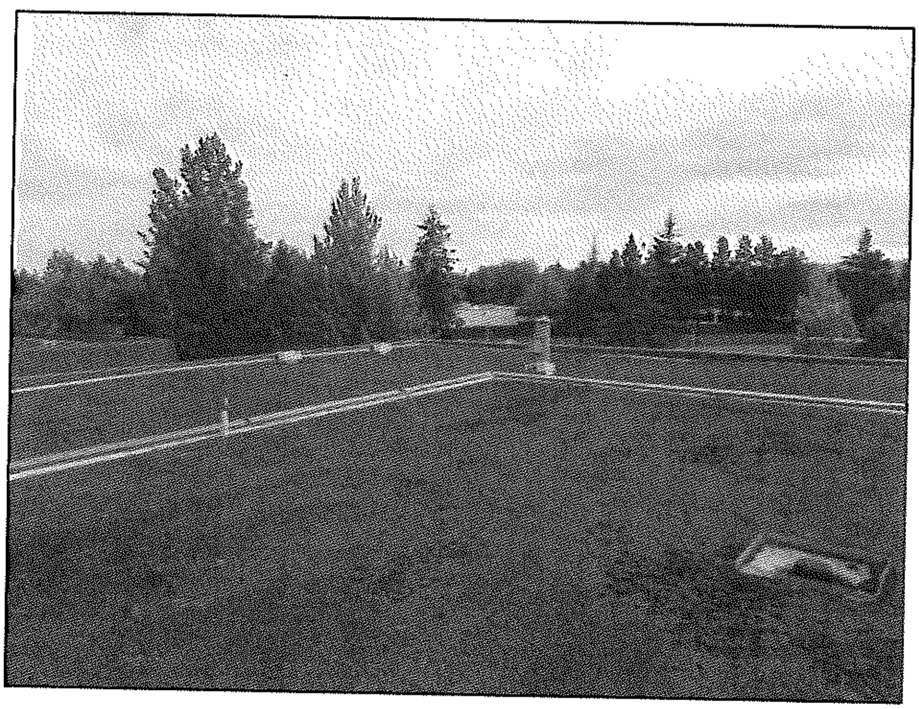
Sec. 1.40 – Roof C: View to north along west perimeter from the "A-1" reference corner.

Sec. 1.41 – Roof C: View to south along west perimeter from northwest corner of roof.



Sec. 1.42 – Roof C: View to east along north perimeter from northwest corner of roof.

Sec. 1.43 – Roof C: View to southwest across roof field from northeast corner of roof.

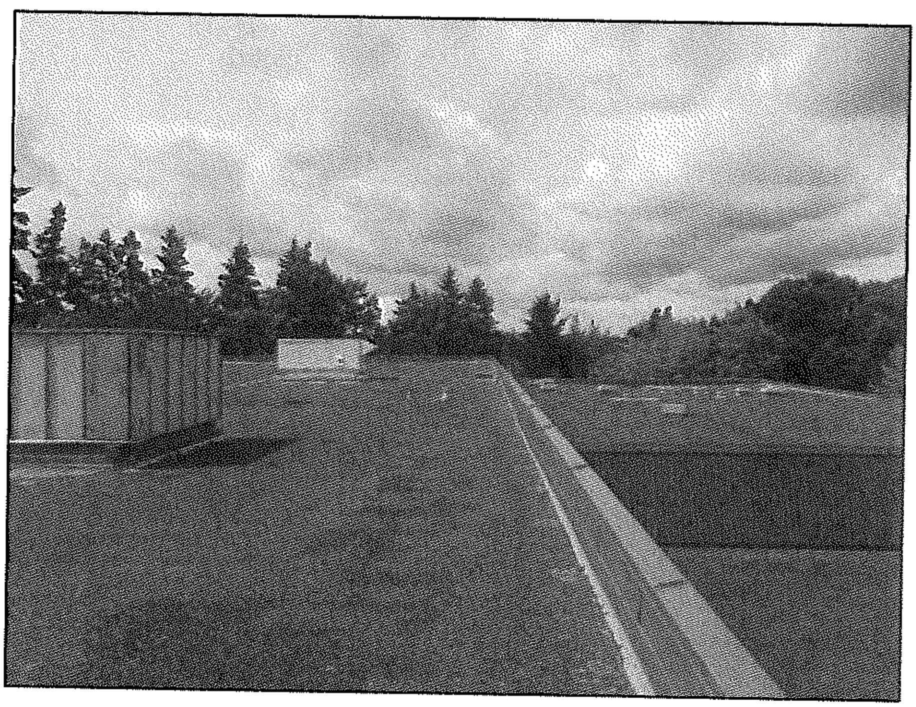


Sec. 1.44 – Roof C: View to northwest across roof field from southeast corner of roof.

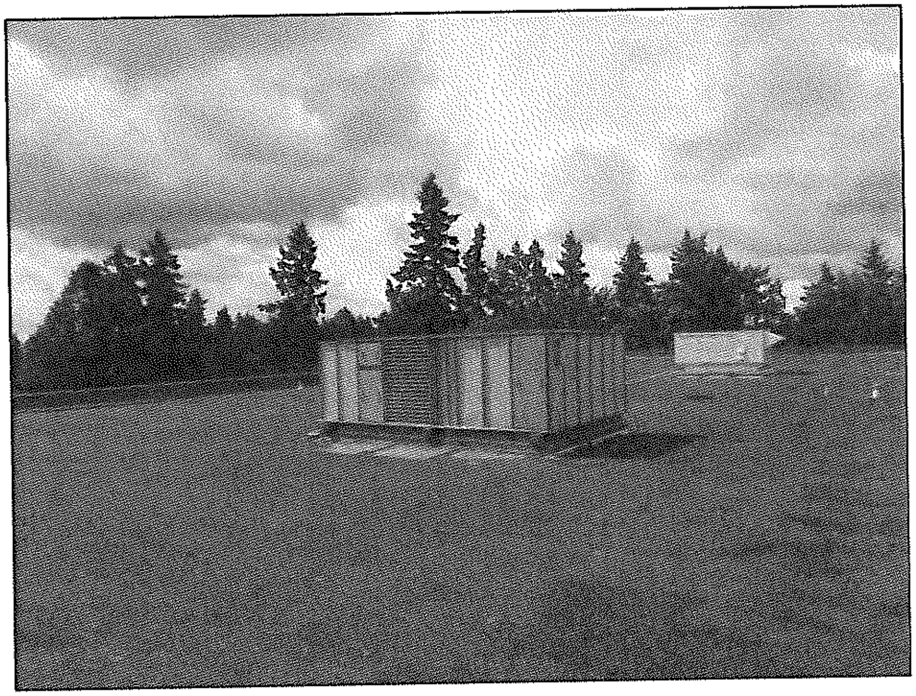
Sec. 1.45 – Roof E: View to east along south perimeter from the "A-1" reference corner.

Sec. 1.46 – Roof E: View to northeast across roof field from the "A-1" reference corner.

Sec. 1.47 – Roof E: View to north along west perimeter from the "A-1" reference corner.

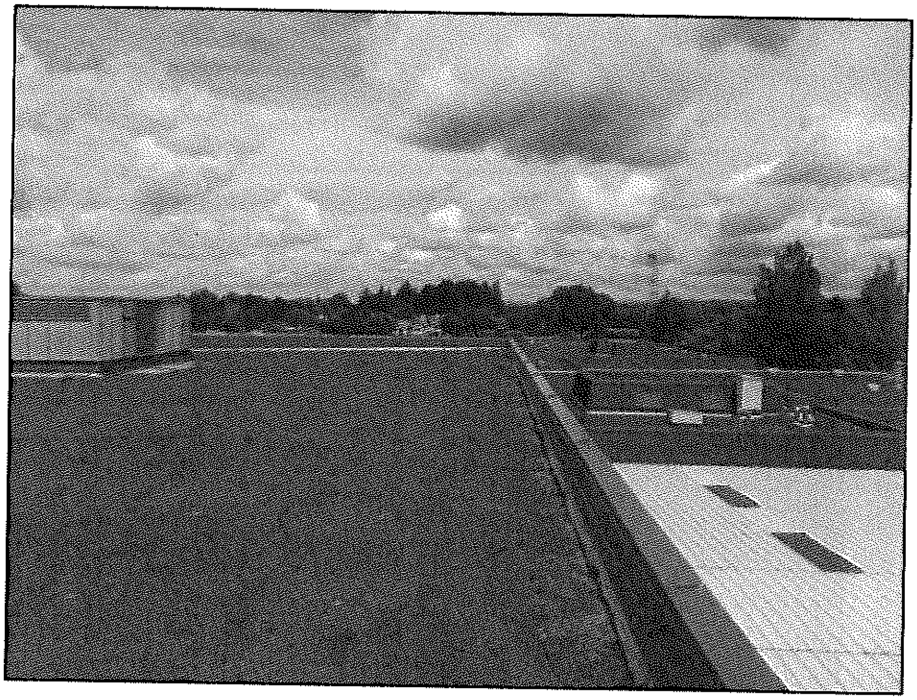


Sec. 1.48 – Roof E: View to south along west perimeter from northwest corner of roof.

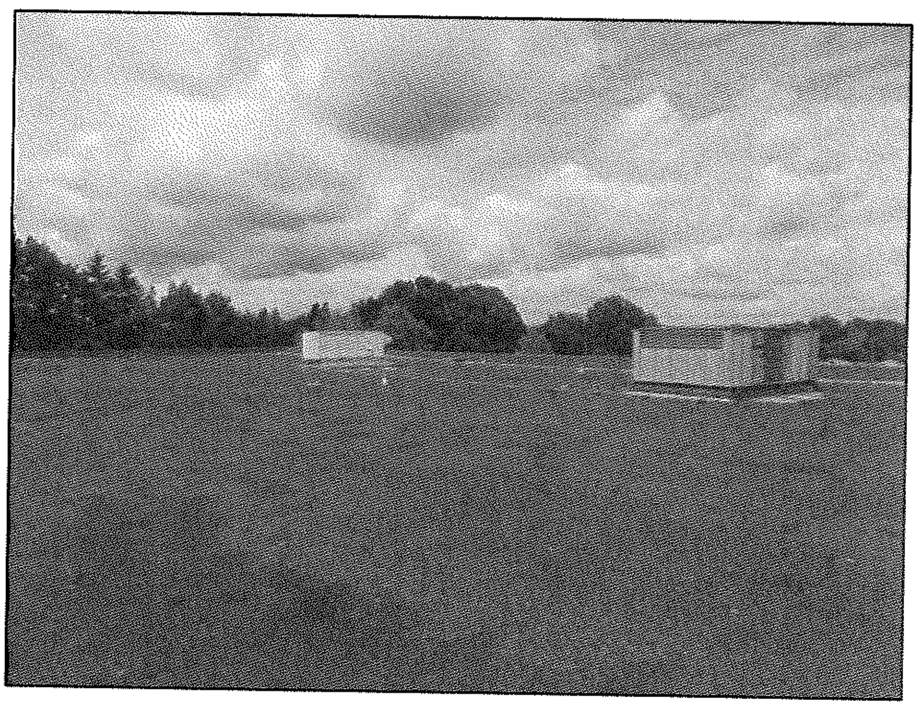


Sec. 1.49 – Roof E: View to southeast across roof field from northwest corner of roof.

Sec. 1.50 – Roof E: View to east along north perimeter from northwest corner of roof.

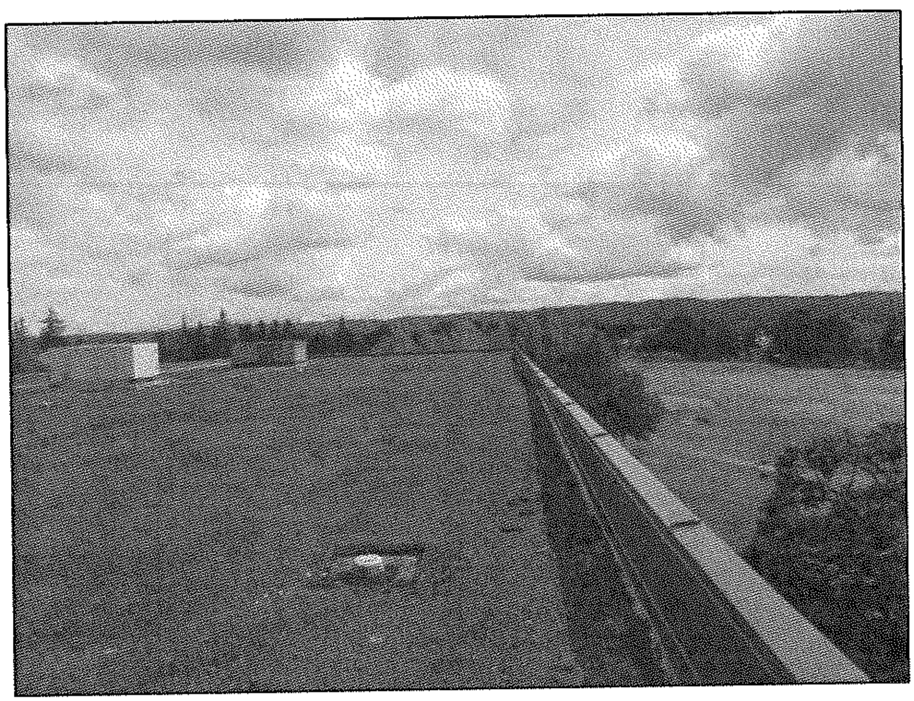


Sec. 1.51 – Roof E: View to west along north perimeter from northeast corner of roof.



Sec. 1.52 – Roof E: View to southwest across roof field from northeast corner of roof.

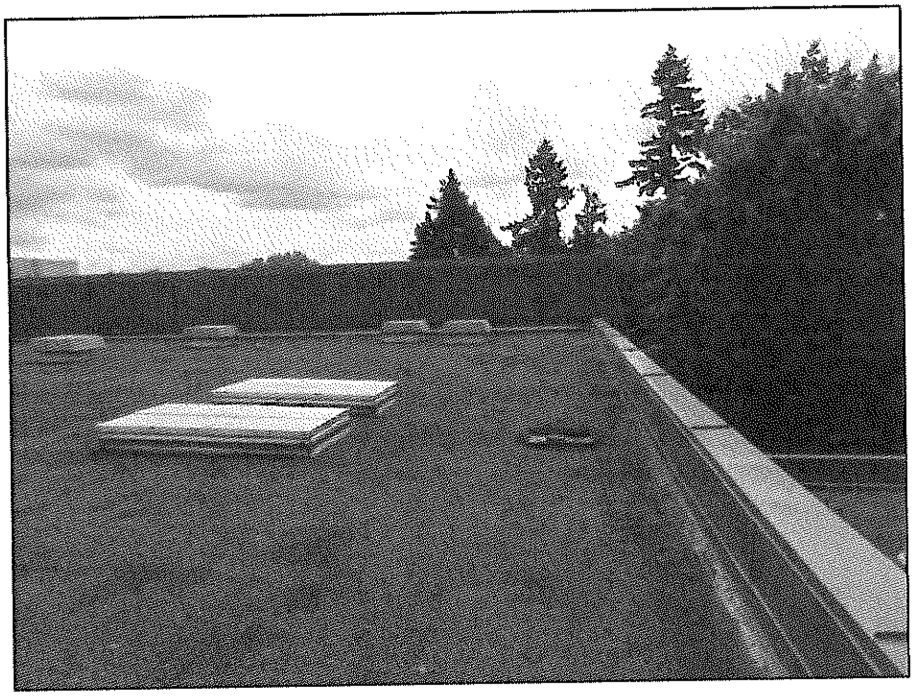
Sec. 1.53 – Roof E: View to south along east perimeter from northeast corner of roof.



Sec. 1.54 – Roof E: View to north along east perimeter from southeast corner of roof.

Sec. 1.55 – Roof E: View to northwest across roof field from southeast corner of roof.

Sec. 1.56 – Roof E: View to west along south perimeter from southeast corner of roof.



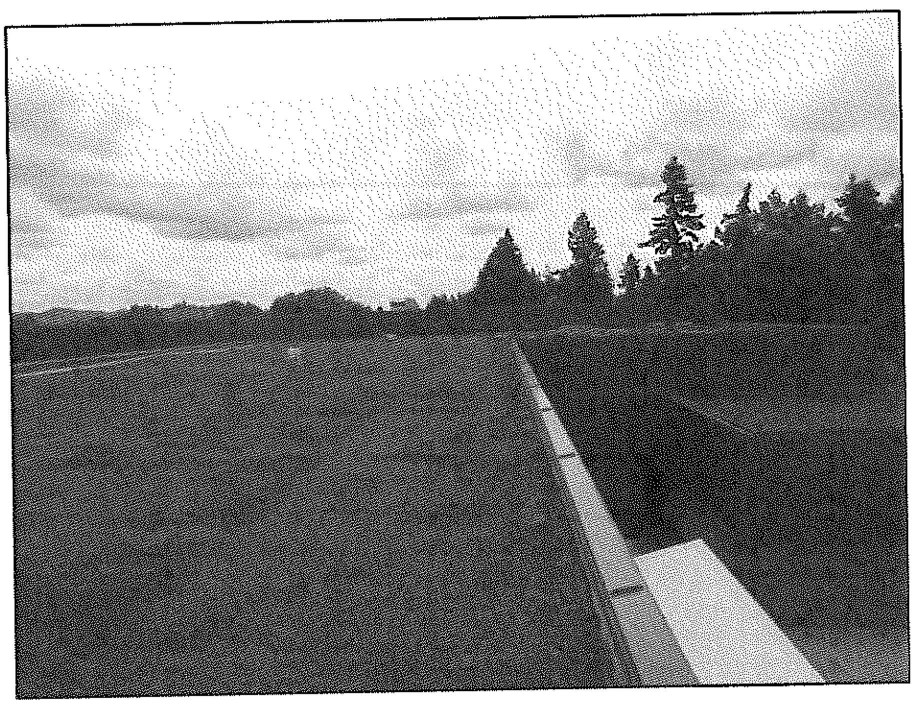
Sec. 1.57 – Roof F: View to east along south perimeter from the "A-1" reference corner.

Sec. 1.58 – Roof F: View to northeast across roof field from the "A-1" reference corner.

Sec. 1.59 – Roof F: View to north along west perimeter from the "A-1" reference corner.

Sec. 1.60 – Roof F: View to southeast across roof field from center section of roof.

Sec. 1.61 – Roof F: View to west along south perimeter from center section of roof.



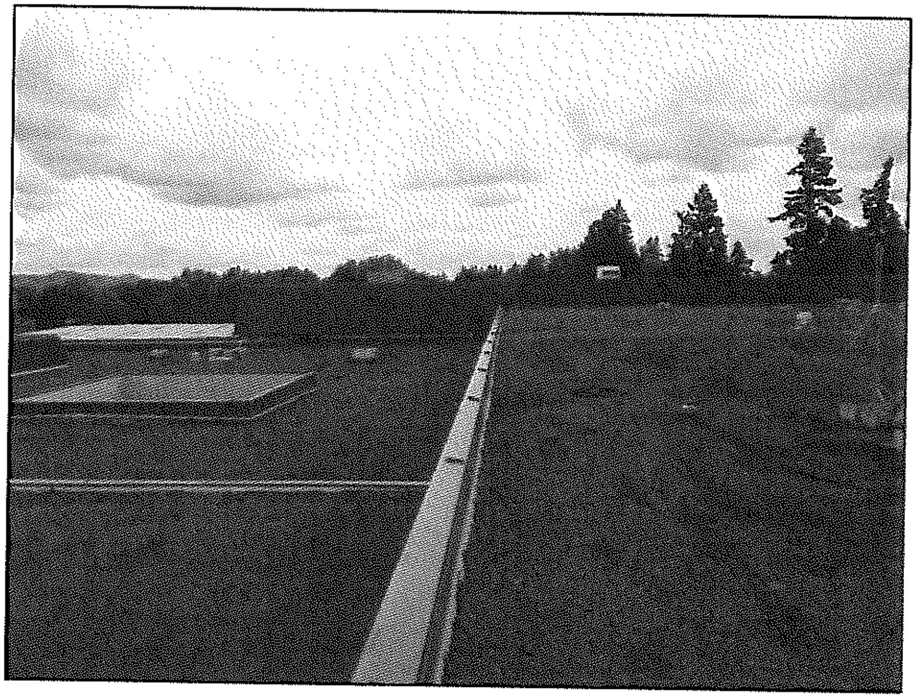
Sec. 1.62 – Roof F: View to east along south perimeter from southwest corner of roof.

Sec. 1.63 – Roof F: View to northeast across roof field from southwest corner of roof.

Sec. 1.64 – Roof F: View to north along west perimeter from southwest corner of roof.

Sec. 1.65 – Roof F: View to south along west perimeter from northwest corner of roof.

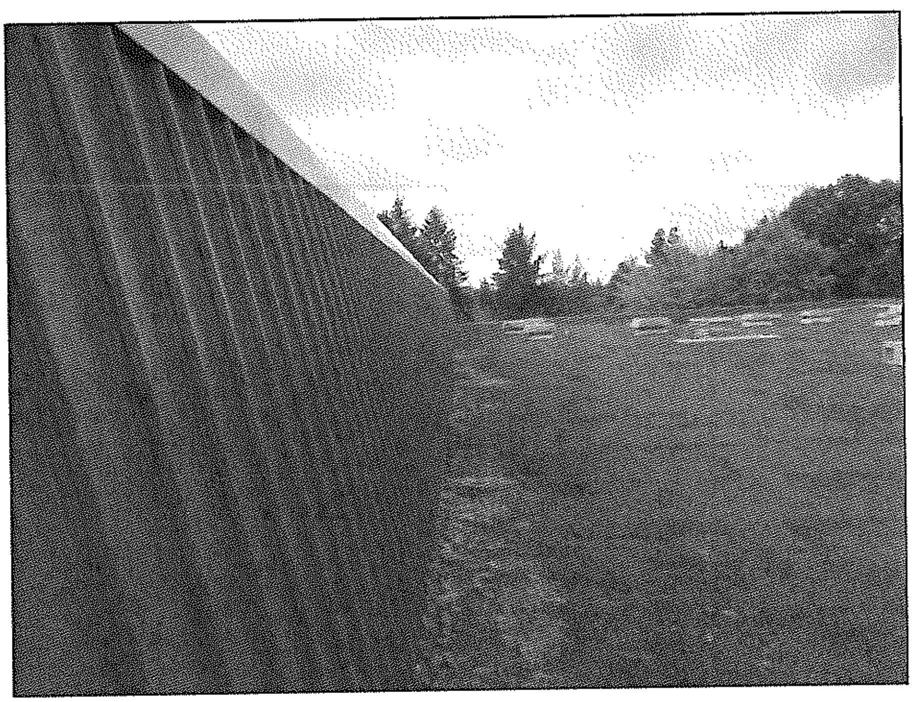
Sec. 1.66 – Roof F: View to southeast across roof field from northwest corner of roof.



Sec. 1.67 – Roof F: View to east along north perimeter from northwest corner of roof. Roof A and Roof B are at left of picture.

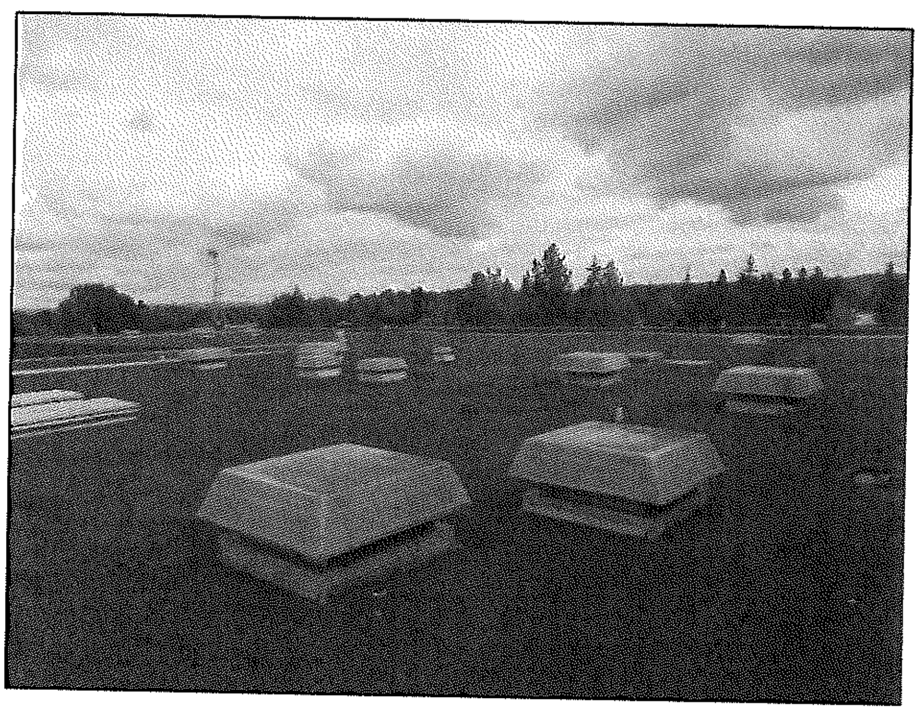
Sec. 1.68 – Roof F: View to west along north perimeter from northeast corner of roof. Roof B is at right of picture.

Sec. 1.69 – Roof F: View to southwest across roof field from northeast corner of roof.



Sec. 1.70 – Roof F: View to south along east perimeter from northeast corner of roof.

Sec. 1.71 – Roof F: View to north along east perimeter from southeast corner of roof.

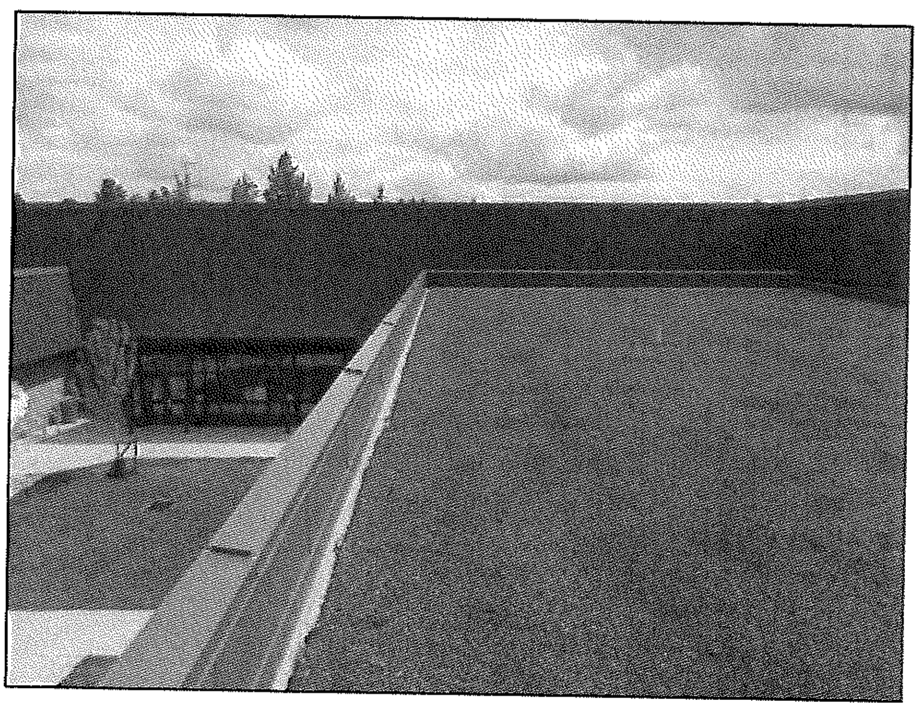


Sec. 1.72 – Roof F: View to northwest across roof field from southeast corner of roof.

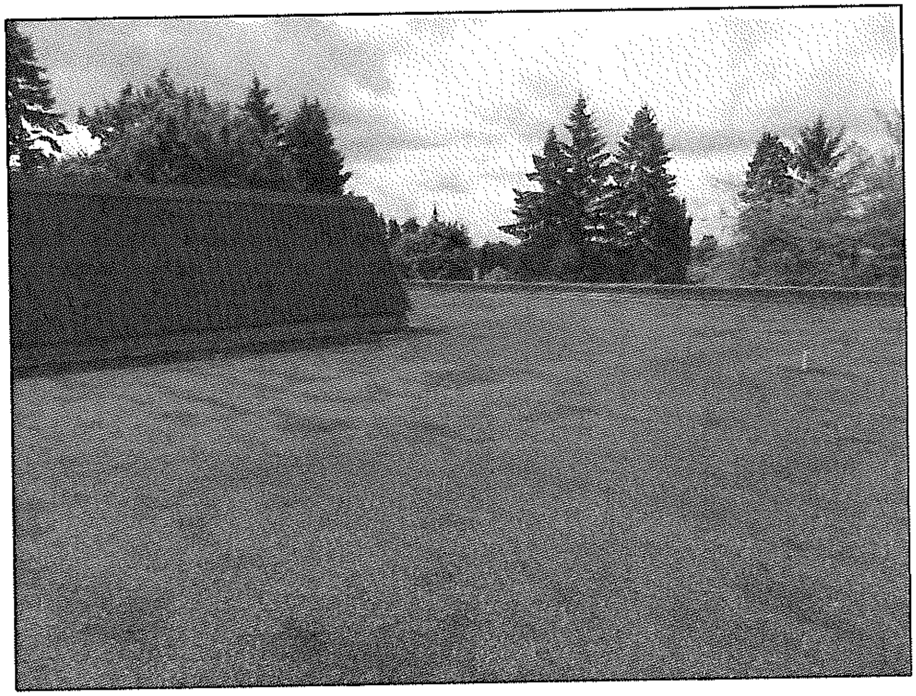
Sec. 1.73 – Roof F: View to west along south perimeter from southeast corner of roof.

Sec. 1.74 – Roof F: View of smoke hatches in southeast section of roof.

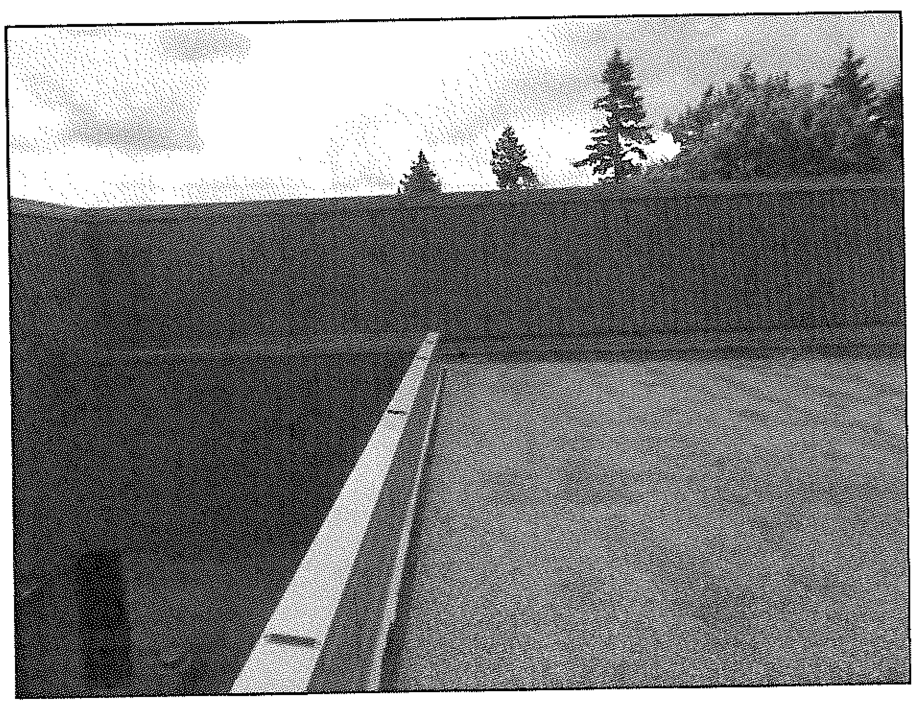
Sec. 1.75 – Roof G: View to east along south perimeter from the "A-1" reference corner.



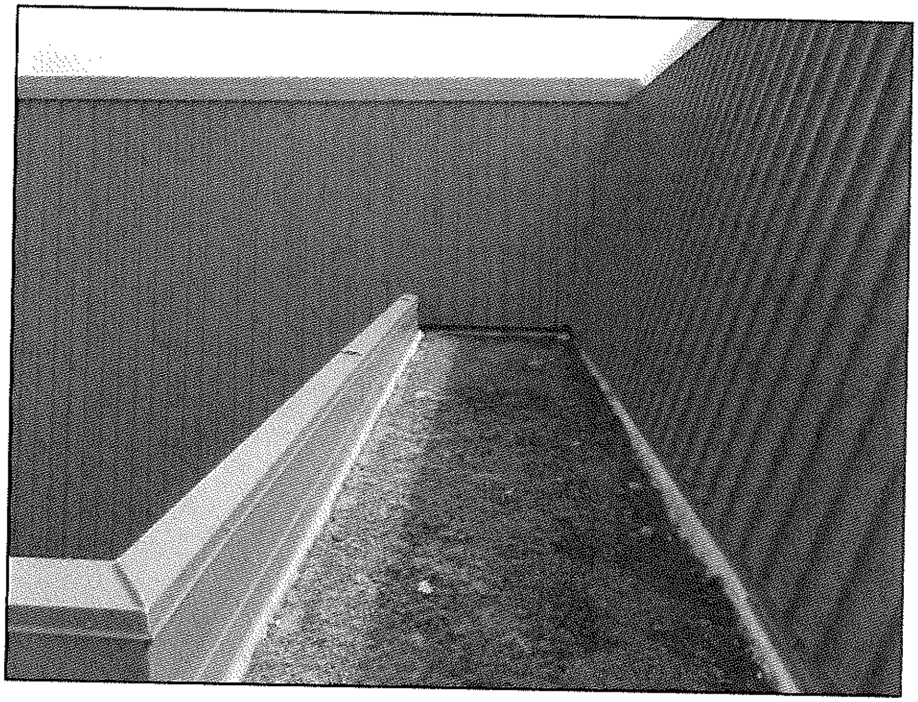
Sec. 1.76 – Roof G: View to north along west perimeter from the "A-1" reference corner.



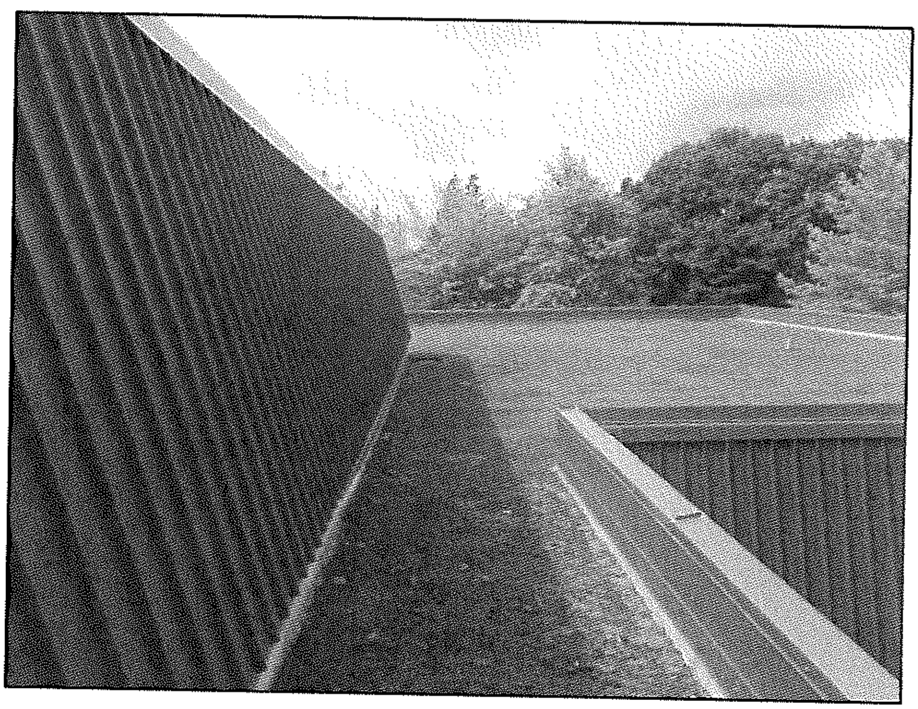
Sec. 1.77 – Roof G: View to southeast across roof field from northwest corner of roof.



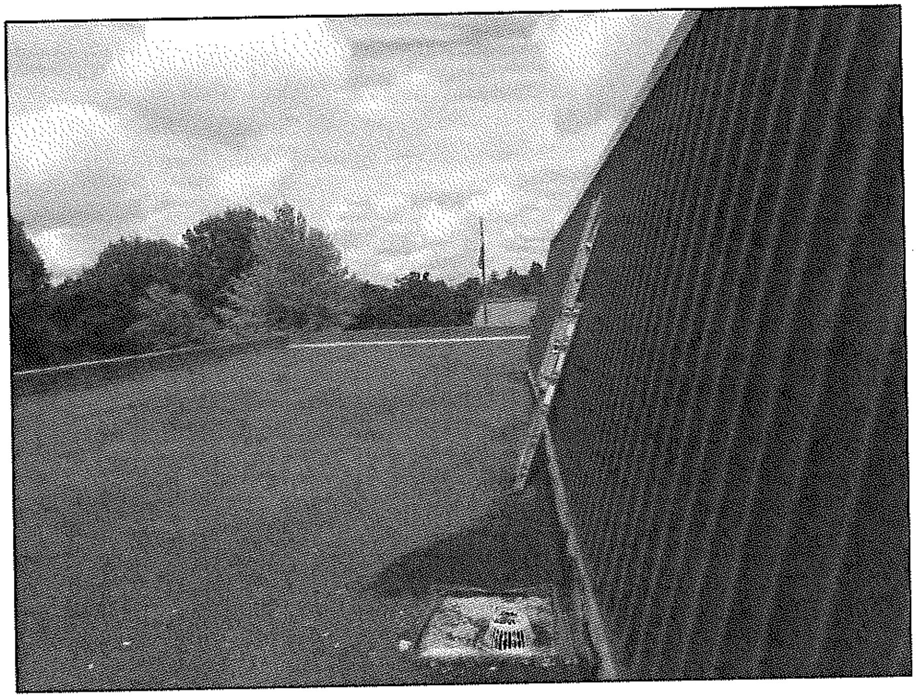
Sec. 1.78 – Roof G: View to east along north perimeter from northwest corner of roof.



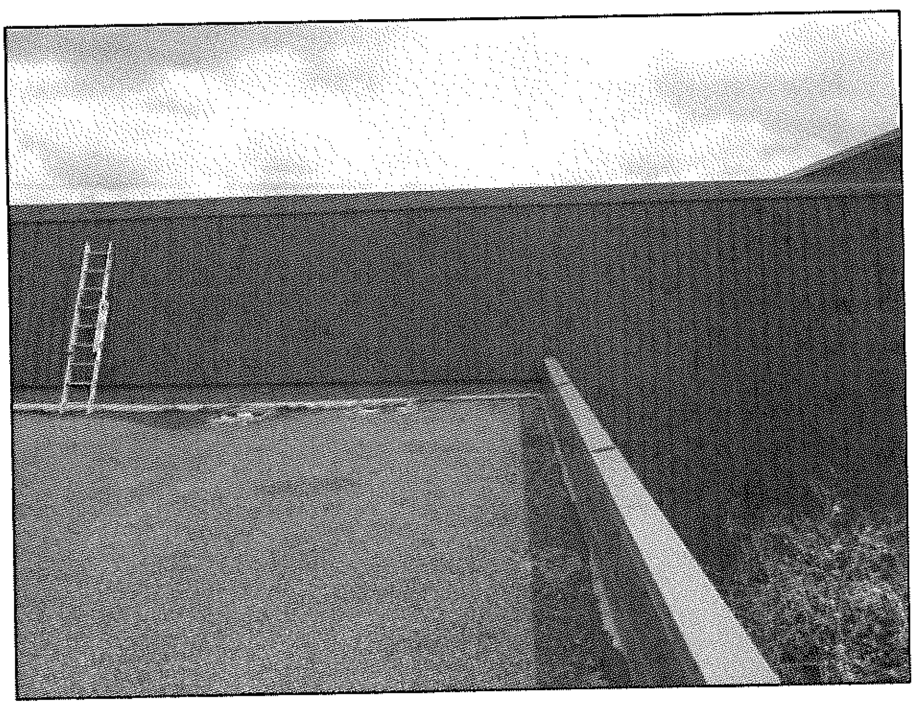
Sec. 1.79 – Roof G: View to north across roof field of small roof section on north section of roof.



Sec. 1.80 – Roof G: View to south across roof field from small roof section on north section of roof.

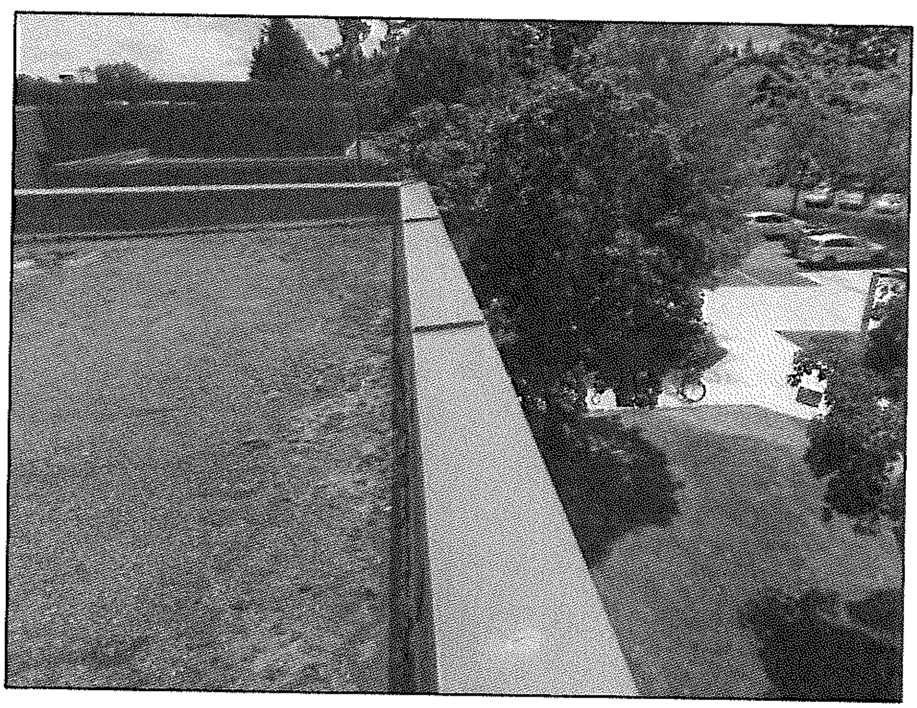


Sec. 1.81 – Roof G: View to west along north perimeter from northeast corner of roof.



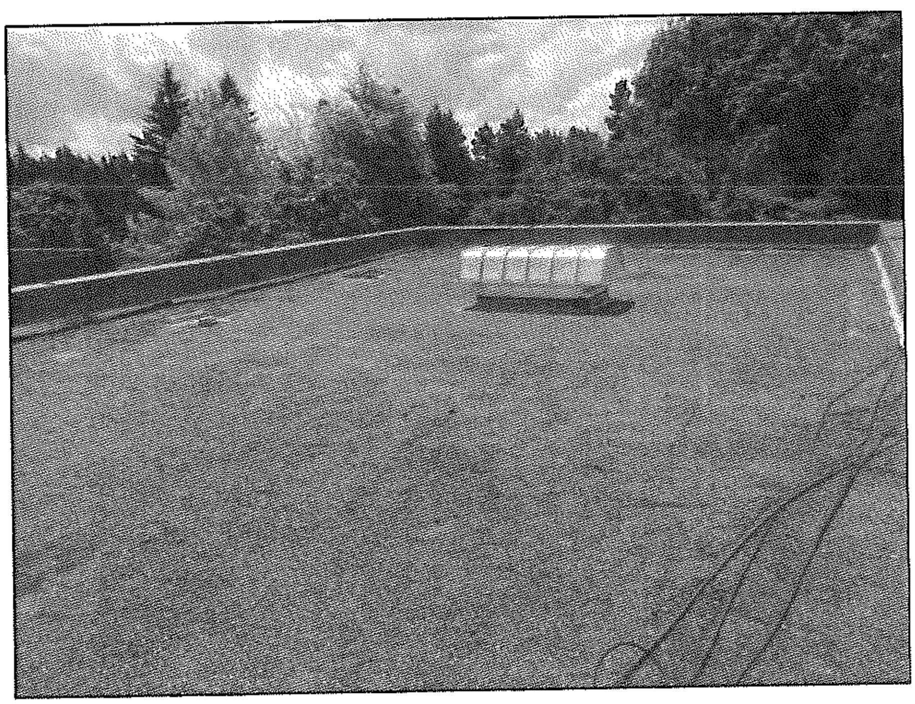
Sec. 1.82 – Roof G: View to north along east perimeter from southeast corner of roof.

Sec. 1.83 – Roof G: View to west along south perimeter from southeast corner of roof.

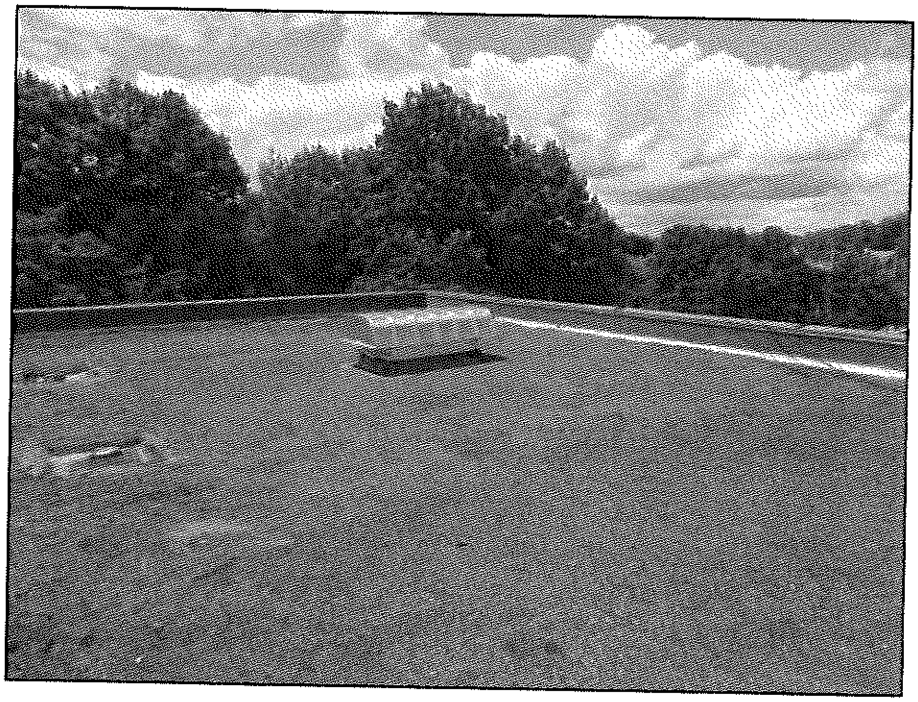


Sec. 1.84 – Roof H: View to east along south perimeter from the "A-1" reference corner.

Sec. 1.85 – Roof H: View to north along west perimeter from the "A-1" reference corner.



Sec. 1.86 – Roof H: View to southeast across roof field from northwest corner of roof.



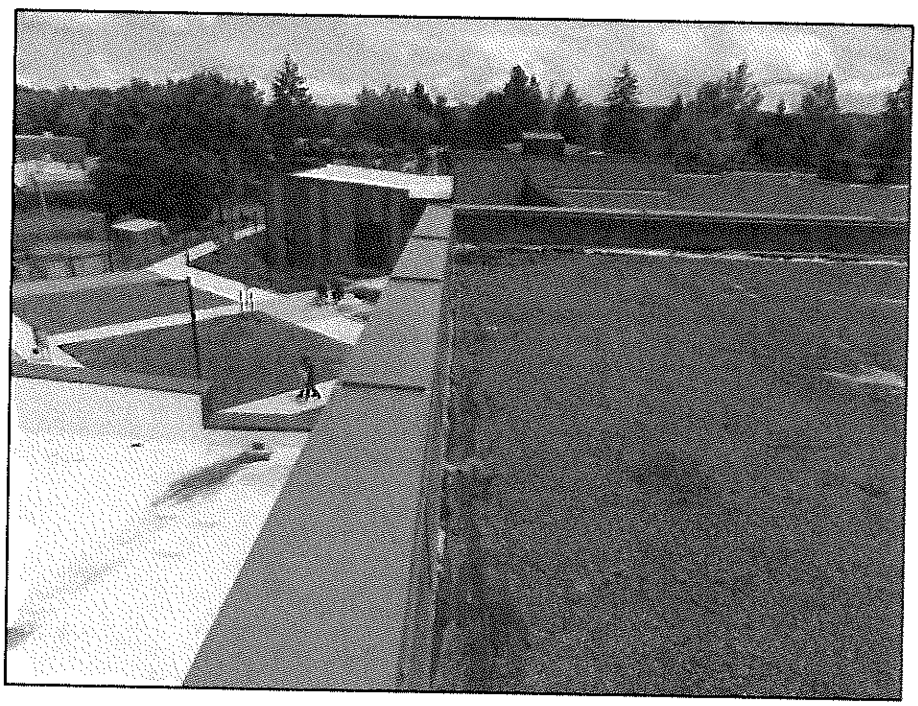
Sec. 1.87 – Roof H: View to southwest across roof field from northeast corner of roof.

Sec. 1.88 – Roof H: View to north along east perimeter from southeast corner of roof.

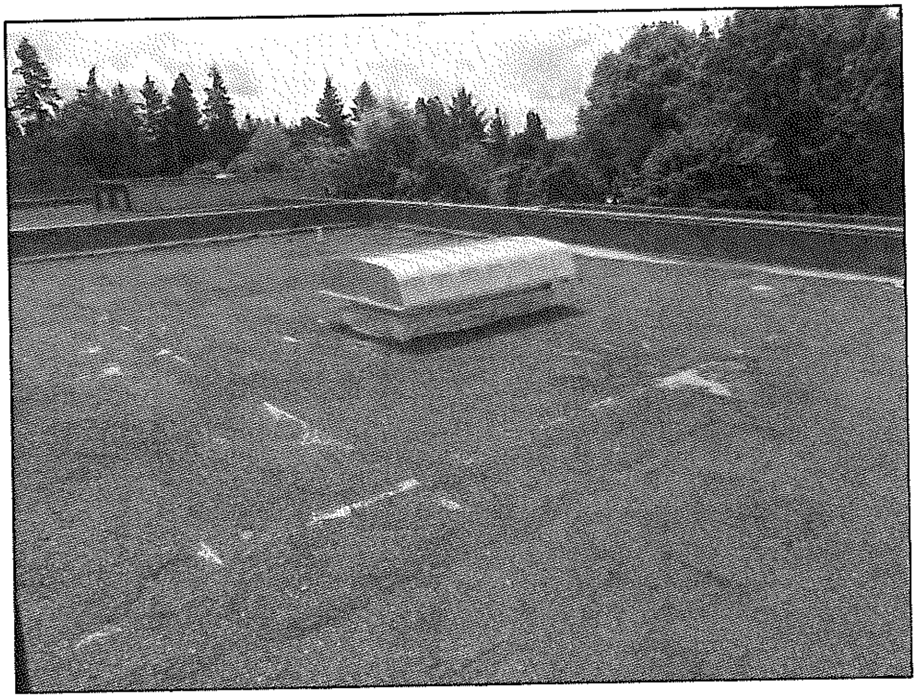
Sec. 1.89 – Roof H: View to northwest across roof field from southeast corner of roof.

Sec. 1.90 – Roof I: View to east along south perimeter from the "A-1" reference corner. Roof A is at right of picture.

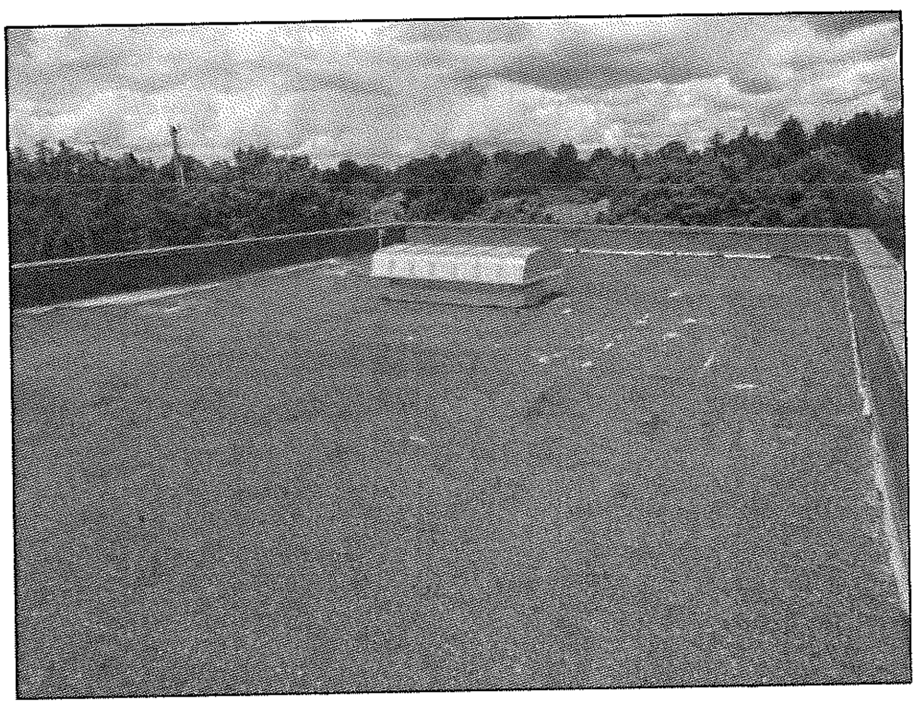
Sec. 1.91 – Roof I: View to northeast across roof field from the "A-1" reference corner.



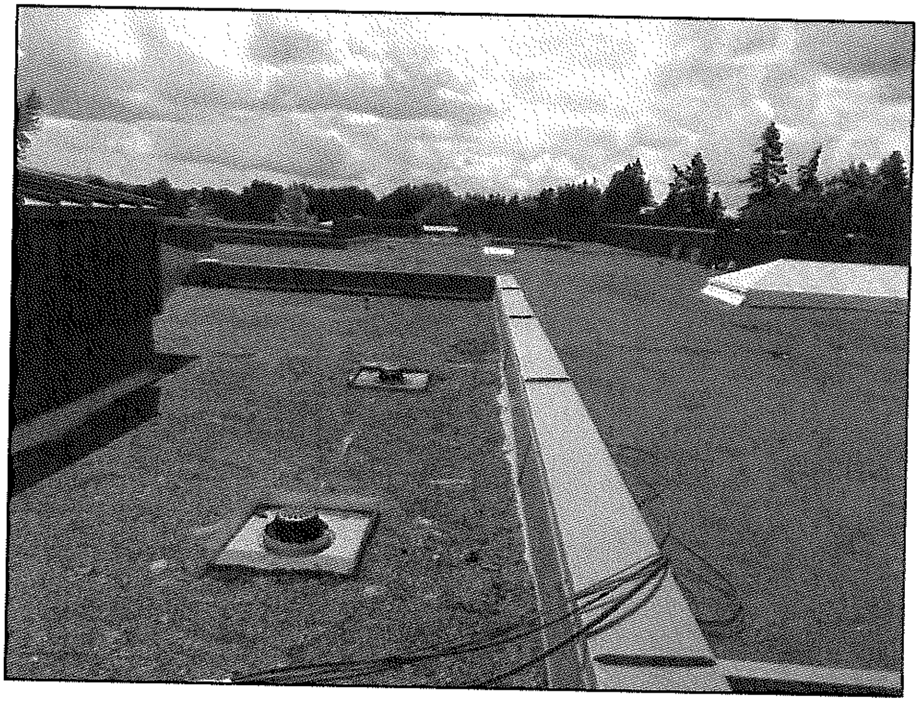
Sec. 1.92 – Roof I: View to north along west perimeter from the "A-1" reference corner. Roof M *(NIS)* is at left of picture.



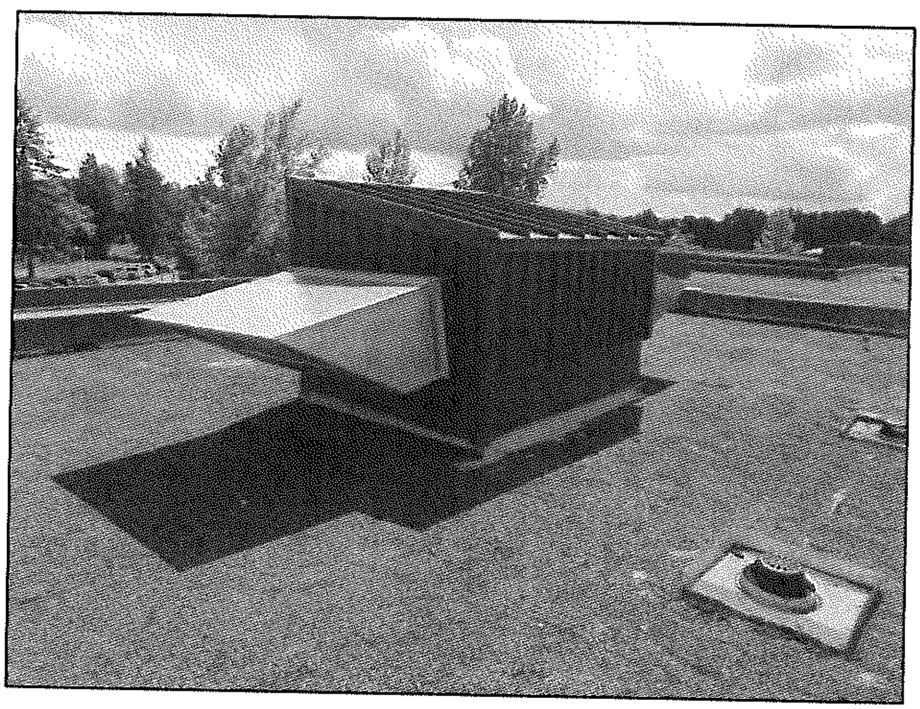
Sec. 1.93 – Roof I: View to southeast across roof field from northwest corner of roof.



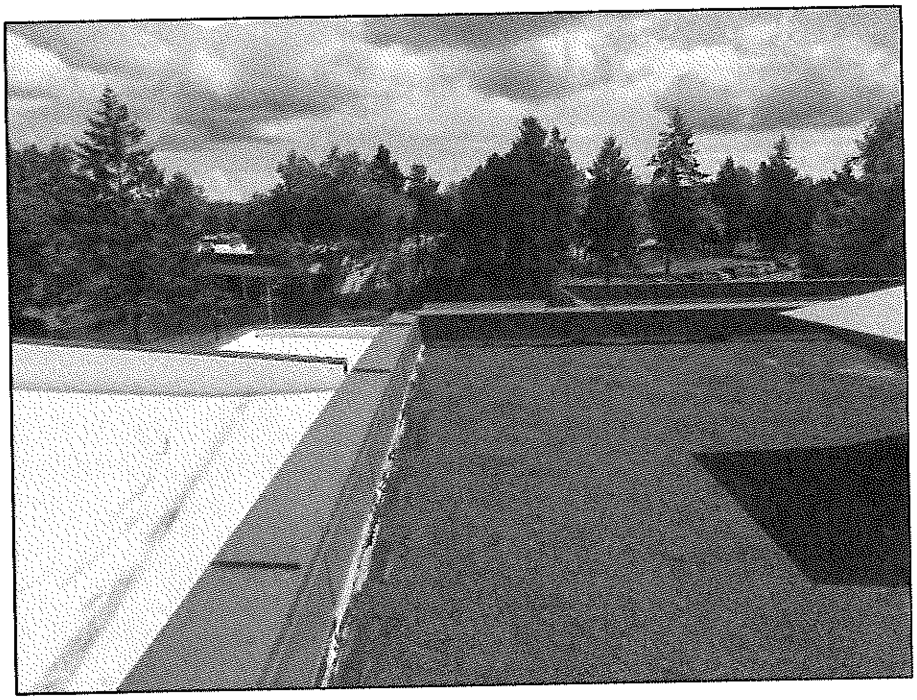
Sec. 1.94 – Roof I: View to southwest across roof field from northeast corner of roof.



Sec. 1.95 – Roof J: View to east along south perimeter from the "A-1" reference corner.



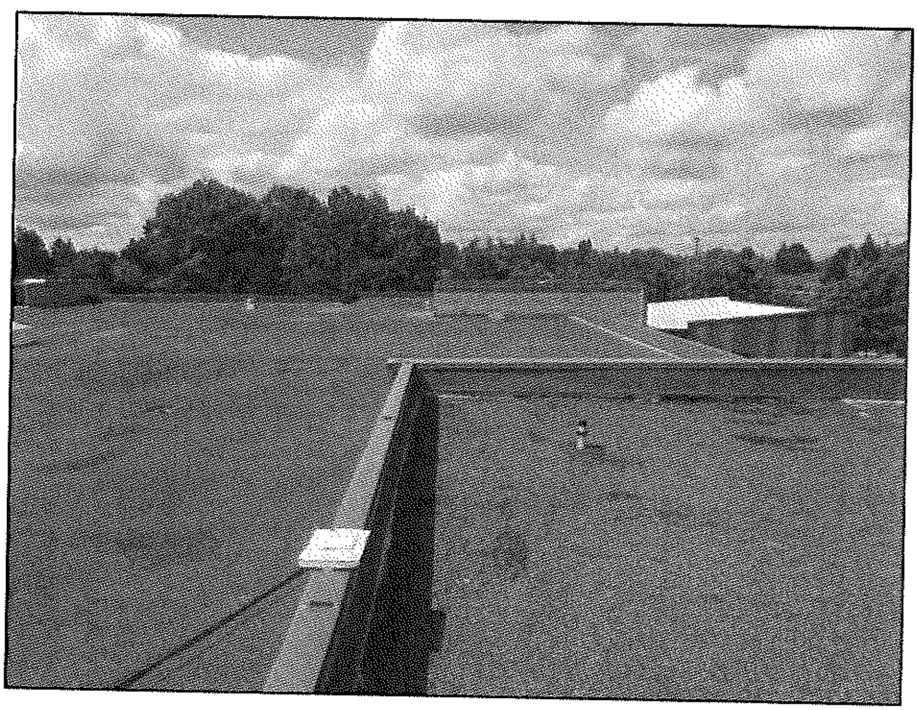
Sec. 1.96 – Roof J: View to northeast across roof field from the "A-1" reference corner.



Sec. 1.97 – Roof J: View to north along west perimeter from the "A-1" reference corner.

Sec. 1.98 – Roof J: View to east along north perimeter from northwest corner of roof.

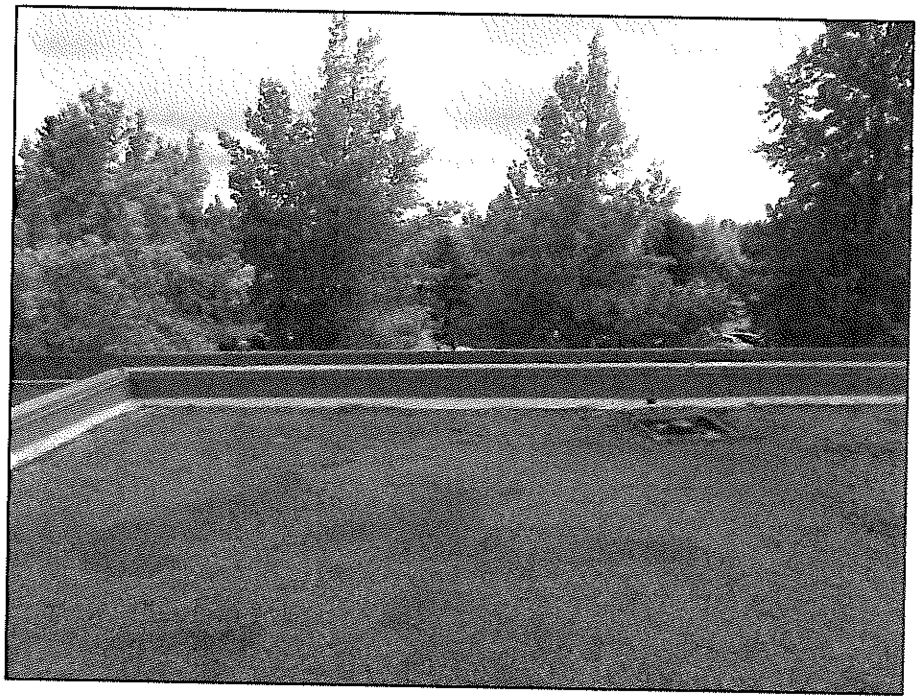
Sec. 1.99 – Roof J: View to west along north perimeter from northeast corner of roof.



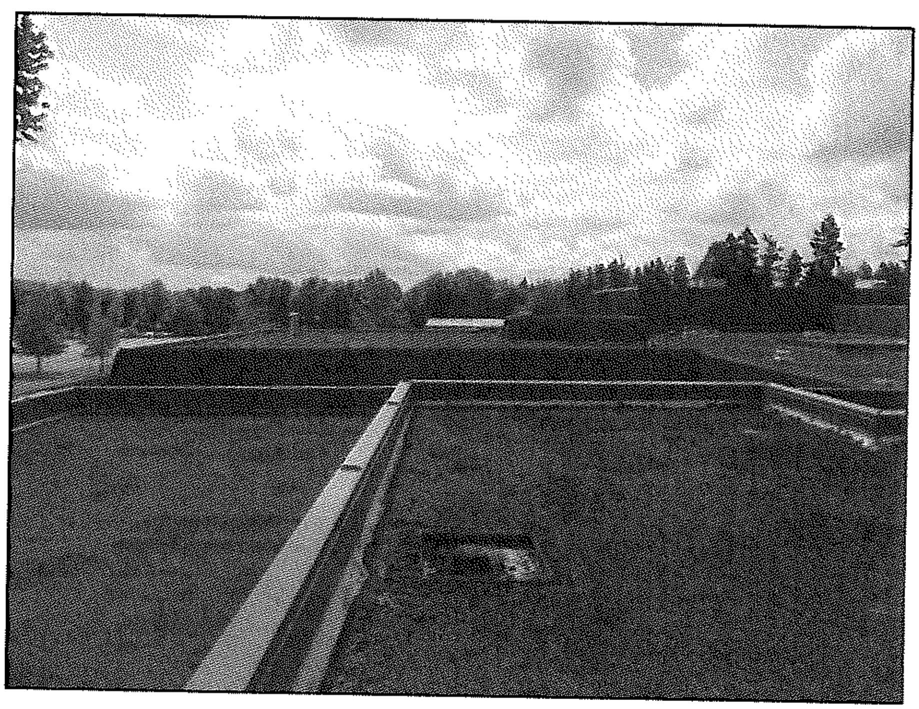
Sec. 1.100 – Roof J: View to south along east perimeter from northeast corner of roof.

Sec. 1.101 – Roof J: View to northwest across roof field from southeast corner of roof.

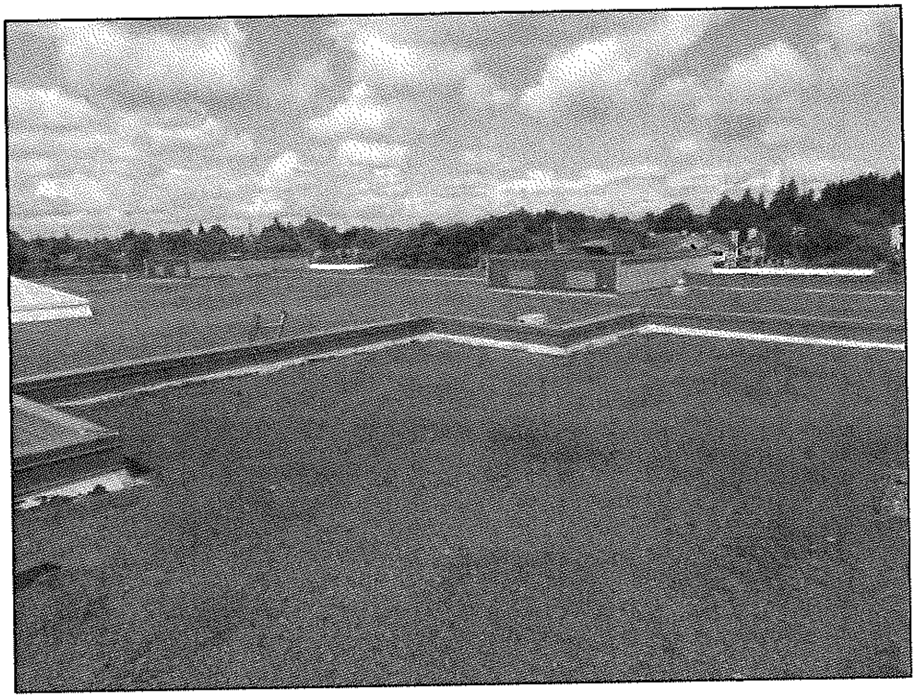
Sec. 1.102 – Roof K: View to east along south perimeter from the "A-1" reference corner.



Sec. 1.103 – Roof K: View to north across roof field from the "A-1" reference corner.



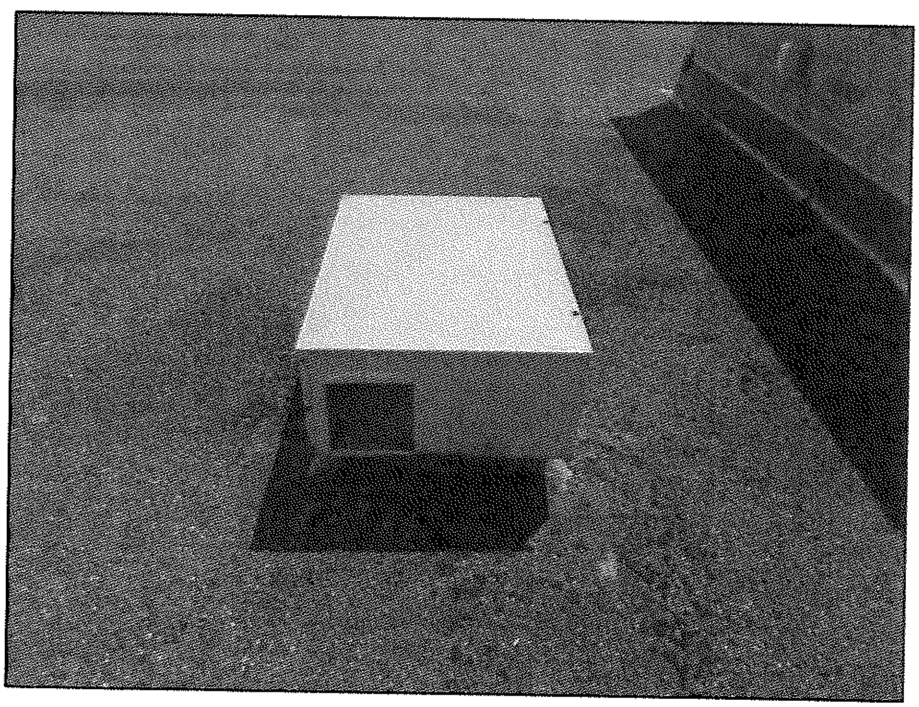
Sec. 1.104 – Roof K: View to east along north perimeter from northwest corner of roof. Roof A is at left of picture.



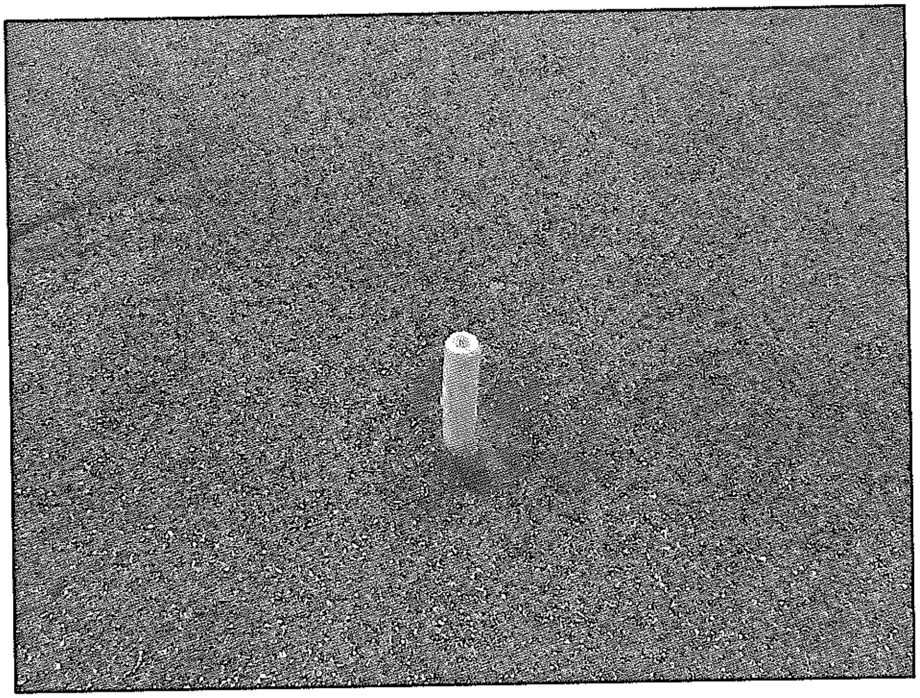
Sec. 1.105 – Roof K: View to southwest across roof field from northeast corner of roof.

Sec. 1.106 – View of typical drain with overflow scupper.

Sec. 1.107 – View of typical drain without overflow scupper.



Sec. 1.108 – View of typical vent unit.



Sec. 1.109 – View of typical plumbing vent.

Sec. 1.110 – View of capped plumbing vent.

Sec. 1.111 – View of typical large vent unit.

-End of Photo Section-

A-TECH/NORTHWEST, INC.
ROOF CONSULTING, MOISTURE TESTING & ANALYSIS

HOW TO USE

ROOF MOISTURE

CONTOUR MAPS

A-TECH/NORTHWEST, INC. • 2501 NW Gerke Rd. • Prineville, OR 97754 • www.atechnorthwest.com
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TECH/NORTHWEST, INC.
ROOF CONSULTING, MOISTURE TESTING & ANALYSIS

HOW TO USE A-TECH MOISTURE CONTOUR MAPS

The use of Roof Moisture Contour Maps is not at all complicated. Roof deterioration and moisture penetration are often closely related and the moisture contours identify and provide a reliable indicator of the degree of roof deterioration, as it relates to various degrees of moisture penetration. When this information is utilized correctly, improved maintenance management decisions result.

When the internal moisture penetration quantity and patterns of a roof structure is understood, the use of Roof Moisture Contour Maps is also understood. For ease of understanding, the contoured areas are shaded progressively darker to indicate the relative severity of moisture penetration and potential roof component damage. The darker the shading, the greater the penetration, and more severe the roof damage.

WHAT THE CONTOURS MEAN

Prior to 1974, the presence or absence of internal moisture within a roof assembly was generally determined visually and the standard recommendation of roof consultants and roofing professionals was that all wet roofing material should be removed and replaced with new dry material. The eye and touch are quite insensitive devices for determining moisture. Moisture within roofing materials is generally not apparent to sight or touch until actual moisture content exceeds 45% to 65% by weight (*varies by material*). Beginning moisture related problems cannot be detected by visual inspection and today we still hear the term saturated and/or saturation used incorrectly.

The A-TECH TESTING PROCESS, which detects minute changes in moisture content within the various roof systems' components, greatly expands the range of detectable moisture within roofing systems. Both the quality and amount of roof moisture information available as compared to the old sight and touch method has greatly expanded. Areas of hidden beginning moisture problems are located, many of which because they do not look or feel "wet", would be undiscovered by the sight and touch method. Problem areas can now be located long before they would be suspected using visual inspection techniques.

With the development of more precise electronic equipment and testing/data gathering techniques, early moisture detection and more precise and accurate information is now possible. This greatly improves the decision process concerning the type of maintenance requirements for each particular situation.

Large very wet areas of insulation and membrane in most situations should be removed and replaced, as has been the practice in the past. It is both sensible and economical in many cases to allow smaller, beginning areas of lesser moisture content to remain after repair of the moisture entrance points is accomplished. Moisture within a roof component indicates a problem that requires further action but not necessarily removal. Minor repairs prevent the spread of internal moisture and resulting damage.

The A-TECH TESTING PROCESS provides information concerning the degree of moisture content, which formerly was not available. As a result, improved judgments can be made concerning removal or non-removal of moisture containing roofing materials and the extent of repair maintenance management is achieved; thus development of true "predictive maintenance" is possible.

WHAT MOISTURE CONTOURS TELL YOU

Moisture contours call attention to hidden moisture within the roof assembly. These areas, normally detectable from visual walk through inspections, should be examined closely to determine the cause of the moisture content which is above ambient *(normal)*.

Moisture contours form distinct patterns which indicate not only the wettest areas within the roof structure but also, very often, the source area of moisture entry. Moisture entering the roof structure breaches the membrane and spreads through the insulation and over and/or into the deck. Internal moisture migrates down slope and collects at low areas. The low areas are frequently the wettest part of the roof and at or near and interior leak, but are not necessarily the source of the moisture entry into the roof assembly. The actual location of the moisture entry point may be a substantial distance from the areas of elevated of Greatest Moisture Content.

It is important to remember that moisture does not move equally through a particular component within a roof assembly. This applies to both the amount of moisture present *(quantity/volume)*, which is described as percent moisture by weight and the square footage that has been affected.

Moisture contours indicated the very wettest areas and also the less wet areas, which encompass and generally point to the true moisture entry problem areas. Cutting out and rebuilding the very wet sections of a roof without locating and repairing the true moisture entry points does not effectively repair a roof. The result often is that the repaired area will become wet and damaged again in a relatively short period of time.

Contours on the Roof Moisture Study Contour Map indicate roof areas which contain moisture at levels higher than that found in normal dry roofs *(ambient)*. Higher than ambient moisture in these areas results from one or a combination of the following causes:

1. General deterioration of the protective waterproofing membrane.
2. Physical damage to membrane *(splits/cuts, blisters, holes, etc.)*
3. Flashing imperfections *(metal, base flashing, etc.)*
4. Dew point condensation *(improper design)*.
5. Wet materials built into the roof during construction *(due to improper edge seals, rain damage, of stored materials, working in the rain, etc.)*

Flashing problems and membrane damage are by far the most common sources of internal moisture found in built-up roofing systems. However, it is not uncommon to identify moisture within the assembly due to construction problems and/or material storage related damage during construction.

Moisture contours are a tool in the process of assessing a roof's actual condition and the most cost-effective maintenance requirements and options. Moisture contoured areas should be examined closely in an effort to determine the cause of the moisture entry so repairs can be made to prevent further entry and damage. The moisture contour map*(s)* should be utilized as guide based on the roof grid coordinates to conduct the follow-up inspection. The moisture contour drawings are maps of the roof's internal condition and should be used as such.

When the visual examination of the moisture containing area, as noted via the roof moisture contour map, indicates the physical condition of the membrane to be generally sound, and the area of moisture within the membrane and/or insulation is relatively small *(quantity and size)*, localized repair and reinforcement of the moisture entry points is an acceptable and economical solution. This prevents further spread of moisture into and through the system, which can extend the useful life of the roof substantially.

When the visual examination follow-up indicates unacceptable physical deterioration of the membrane or insulation, such as delamination, rotting, etc., then tear-off and replacement of the deteriorated materials is preferred. Each roof should be examined and rated both individually and as a total system. Long and short-term considerations are critical to the economic decision process.

The basis of good maintenance is early detection and repair of moisture entry points. Small, beginning moisture entry problems are the easiest to repair and can prevent the premature need for thousands of dollars worth of roof replacement at a later date. The A-TECH TESTING PROCESS detects beginning problem areas in addition to the advanced moisture laden areas.

TERMS USED TO DEFINE MOISTURE CONTENT OF ROOF STRUCTURES

Extensive A-TECH studies during the 1970's and 1980's established limits for both the normal *(ambient)* dry range and the wet range for each individual roofing material commonly found in roof systems. A moisture content above the normal ambient range indicates a roof problem of greater or lesser degree, again depending on quantity, square footage, etc.

An individual roof can be entirely dry meaning the total roof is within normal ambient range or it can be entirely in the wet range containing moisture from ambient to saturation. Most often, they actually fall somewhere in between. A dry roof may still be rapidly approaching the point that the membrane waterproofing system will fail. The result will be internal moisture into the roof system and/or building interior *(leaks)*. A roof identified as containing moisture may have a functional waterproof membrane system with moisture entry from other sources and may or may not "leak" into the building.

DEFINITION OF DRY ROOF MATERIALS

NORMAL AMBIENT RANGE

All roofs and materials used in their construction contain moisture. The normal moisture content range of the membrane insulation and deck is governed by the moisture content of the surrounding ambient air. As the relative humidity of the ambient air increases, the moisture content of the components of the roof increases. As the relative humidity of the ambient air decreases, the moisture content of the roofing material decreases.

Each individual roofing material has a normal moisture content range, which is controlled by the moisture content of the surrounding ambient air. A dry range which is normal for one roofing material is not the same as the normal range of other roofing materials. They will vary based on their own particular physical properties and standard laws of physics. *(Refer to Table #1)*

DEFINITION OF WET ROOF MATERIALS

Roofing materials which contain moisture above normal ambient are defined as wet. While this does not necessarily indicate the need for replacement of all or even a portion of the particular roofing material*(s)*, it does indicate roof problem conditions and roof problem areas that warrant further examination.

The wet range moisture content varies from slightly above maximum ambient to saturation. Each roofing material has a wet moisture content range which is specific unto itself. A-TECH studies have established the limits of the wet range for each individual roofing material. *(Refer to Table #1)*

The ambient Dry Range and Wet Range of various roofing materials are shown in Table #1. Table #1 for example, indicates the normal range of Fiberboard is 0% to 12% while the wet range of Fiberglass is 0% to 2% while the wet range varies from 2% to 690%. The percentages are "by weight" calculations rather than volume.

TABLE #1

	APPROXIMATE MAXIMUM MOISTURE CONTENT	APPROXIMATE MAXIMUM CONTENT (SATURATION)
ROOFING MATERIAL		
Organic Felt Membrane	1.0%	20%
Glass Felt Membrane	NK	NK
#15 Organic Felt	4.30%	75%
#15 Asbestos Felt	2.0%	25%
Glass Felt	1.0%	19%
INSULATION		
Fiberboard	12.0%	430%
Perlite Board	3.5%	460%
Fiberglass	2.0%	690%
Lightweight Concrete	6.0%	60% - 110%
Cellular Glass	0.01%	30%
Urethane	6.0%	1000%
Expanded Polystyrene	3.0%	2000%
Extruded Polystyrene	0.5%	10% - 15%
Dry Asphaltic	0.1%	60%
DECK		
Concrete	2.0%	
Gypsum	2.5%	105%
Wood	16.0%	60% - 100%
Tectum	10.0%	97%
APPROXIMATE PERCENT MOISTURE BY WEIGHT		

APL3/144

NOTE: Discussions about roofing materials as they apply to moisture often refer to "saturated" materials. Saturation is the maximum amount of moisture a material can hold. It has very little to do with the visual reference to moisture. This is a much misused term. Saturation levels are difficult to achieve; however, depending on the material, can "look" very wet at levels well below saturation.

WHAT MOISTURE CONTOURS INDICATE

A built-up roof *(BUR)*, or single-ply *(SP)*, is a structure composed of membrane, insulation *(optional)*, and deck. When one part of the structure is defined as wet and contains moisture above ambient, it does not necessarily follow that the remaining layers and/or components are wet or equally as wet. It is important to understand that the rate of moisture absorption varies by material, gravity, water stops, etc.

Five distinct areas of moisture content can be contoured based on the A-TECH test procedures and equipment. Additional delineations are possible. However, because of the data drift and other uncontrollable field data gathering conditions, the accuracy of the results may be diminished. Therefore, those results are not included within the scope of the data presented within this electronic study.

Roof structures particularly over concrete decks frequently can contain extensive areas of moisture penetration with no indication of interior building leaks. Conversely, a roof may have numerous interior leaks and actually have very little moisture within the roof components. Interior leakage is only one of many indicators of a roof's actual condition.

HIGH AMBIENT MOISTURE CONTOURS

Since dry areas contain a moisture content which varies from near zero to maximum ambient *(for example, the range for fiberboard insulation is from 0% to 12%)* it is frequently possible to obtain contours indicating higher moisture content within the "dry" range. While the high ambient moisture contours do not indicate excessive wetness, they frequently indicate beginning problem areas. It is our experience that these areas will often continue to draw moisture and eventually become a part of a larger problem. The rate at which this problem develops depends on the roof type.

FIRST STAGE MOISTURE CONTOURS (*MEMBRANE*)

BUR: First Stage designates minor moisture penetration into the membrane system. This creates weakened areas which have increased susceptibility to further physical damage.

SP/Other: Least Moisture Content designates low levels of moisture within the assembly only slightly above ambient *(system related moisture)*.

SECOND STAGE MOISTURE CONTOURS (*MEMBRANE*)

BUR: Second Stage is similar to the First Stage Penetration except greater moisture quantities by weight is present in the membrane. At times this may be quite severe causing delamination, ridging, blistering, and extensive loss of membrane tensile strength. Second stage Moisture Penetration is frequently associated with wet insulation areas indicating moisture penetration into the membrane from the wet insulation below.

SP/Other: Moderate Moisture Content is similar to the First Stage but in higher quantities. These contours indicate and increased potential of moisture related problems *(system related moisture)*.

THIRD STAGE MOISTURE CONTOURS (*INSULATION*)

BUR: Third stage designates moisture penetration of the insulation. Extensive horizontal migration can take place within various roof insulation types. Wet insulation loses both its physical strength *(dimensional stability)* and its ability to insulate *(R-Value)*. The moisture quantity will vary considerably and close review of the written text with the Roof Moisture Study Technical Report is necessary.

SP/Other: Greater Moisture Content indicates moisture levels that are generally a concern to the overall performance of the roof system. Wet insulation loses both its physical strength *(dimensional stability)* and it ability to insulate *(R-Value)*.

AREAS OF GREATEST MOISTURE CONTENT

BUR/SP: The areas of Greatest Moisture Content are the areas of most severe penetration and indicate one or more of the following conditions:

1. Flashing and membrane problem areas where moisture entry occurs from damage such as tears, splits, punctures, and flashing imperfections;
2. Low areas of the roof to which internal moisture migrates and collects, such as around drains;
3. Major construction and/or installation problems.

Greatest Moisture Content contours are often at levels well within that which is visible to the human eye. GMC areas require immediate follow up to determine cause. They do not always require immediate major work.

GENERAL SUGGESTIONS CONCERNING REPAIR

BUR AND MODIFIED BITUMEN ROOF SYSTEMS

When damage exists in a built-up roof, corrective action calls for either:

1. Replacement and rebuilding of the area with new, dry materials, possible recover, etc., or;
2. Localized reinforcement of the damaged areas with high quality materials to restore as much of the strength loss as possible and prevent further moisture entry into the roof system and/or building interior. (*Follow-up maintenance to membrane waterproofing assembly on annual basis may be required with this option.*)

A-TECH studies indicate that when First Stage wet membrane areas are properly repaired and sealed to prevent further moisture entry, the areas will dry within approximately one year. Second Stage wet membrane areas will dry considerably in a year or two. The key is to stop the moisture migration. Tensile strength loss is not recovered during the drying process.

Third Stage wet insulation areas within roof assemblies dry much too slowly to have any practical benefit on improving insulating properties. They also remain a weak area because of strength loss and the continuing expansion and contraction of the trapped moisture. Often the trapped moisture results in membrane damage, which accelerates the deterioration process. A review of the quantity of moisture and affected area *(square footage)* allows for positive maintenance management decisions.

The early repair of beginning moisture penetration areas greatly facilitates a planned PREDICTIVE MAINTENANCE PROGRAM, which reduces the occurrence of building leaks *(interior leakage)*, expensive repairs, unnecessary replacement, and expensive heat loss due to nonfunctioning wet insulation.

HIGH AMBIENT

While high ambient moisture content is acceptably dry, the areas should be examined carefully. High ambient frequently indicates beginning problems that require minimal maintenance.

FIRST STAGE PENETRATION

Large areas of First Stage generally indicate normal deterioration resulting from age. Small areas often indicate damage to the waterproofing membrane from punctures, tears, flashing problems, and deterioration of the protective top surfacing. The actual amount of excess moisture indicated by first stage in the total roof system of the built-up roof is quite low when calculated by weight. This moisture is generally well below levels visible to the human eye.

Repair of the First Stage areas generally consists of localized reinforcement of physical damage, such as splits, punctures, or tears, and localized rejuvenation of the top coat if age or other deterioration has caused it to lose its effectiveness. Cold applied coatings can be useful in this application when of high quality and properly applied. A repair without reinforcement will not last and should be avoided. We recommend either three *(3)* or five *(5)* course repair be utilized.

SECOND STAGE PENETRATION

Second Stage is more extensive moisture penetration of the membrane *(greater quantity by weight)*. There is an increased potential for this level of moisture to be visible.

The amount of moisture in Second Stage and the amount of physical deterioration and loss of tensile strength of the affected membrane is considerably greater than that found in First Stage. As a result, the membrane in these areas should be closely examined. If it exhibits good physical integrity with no delamination, localized reinforcement and repair can be practiced, with generally acceptable results.

If the membrane is weak, delaminated, and deteriorated, it should be stripped and replaced with new, dry material whenever feasible. Follow recommended techniques depending on repair products and roof membrane type.

THIRD STAGE PENETRATION

Third Stage indicates insulation which contains moisture above normal ambient. It is possible to have Third Stage moisture penetration and still be well below levels visible to the human eye. Note Table #1 for the wide ranges possible depending on insulation type. The range of moisture will vary; therefore, it is very important to review the Roof Moisture Study Technical Report as it applies to the specific roof tested.

Very wet Third Stage *(identified as Greatest Moisture Content)* is the final stage of a roof's deterioration process. The roof no longer functions as designed. The passage of moisture into the roof assembly is no longer being stopped and the wet insulation has lost much of its insulating efficiency *(R-Value)*. When no insulation is present, the contours indicate extensive membrane and/or deck related conditions.

Reinforcement and repair of the membrane or flashing problem*(s)* at Third Stage areas, if relatively small in size *(square footage)*, can frequently stop and/or control building leaks and prevent further spread of internal moisture within the roof assembly.

Small, relatively low moisture content *(by weight)* areas may be treated as above; very wet Third Stage *(Greatest Moisture Content)* areas with any size to them should be corrected by removal and rebuilding with new dry materials (*in most instances*).

SINGLE-PLY ROOF SYSTEMS & SPECIAL REPORT SITUATIONS

NOTE: Quite often, moisture contours will be reported as "potential moisture". This situation develops when no core samples are cut through the membrane for verification. This is generally due to current warranty and guarantee considerations. Refer to technical discussion and review if moisture is identified as potential.

HIGH AMBIENT

This is moisture within the roof assembly at levels only slightly above normal.

LEAST MOISTURE CONTENT OR PENETRATION (*SP*)

This is moisture within the roof assembly at levels considered only slightly above ambient. Generally, this moisture either indicates moisture migration into the assembly in small amounts, often associated with beginning problems, or moisture trapped within assembly during construction. These contours are considered preliminary warning indicators.

Repairs are based on the result of the visual examination of the affected area. Generally, repairs will be localized. However, they must be compatible with the membrane type.

MODERATE MOISTURE CONTENT OR PENETRATION (*SP*)

Second Stage contours indicate more moisture within the roof assembly *(by weight)* than the levels indicated as First Stage. The quantities of moisture by weight will often be below levels visible to the human eye.

These contours are considered a warning signal and require further review. If no visible problem is identified, the area should be monitored for further change.

GREATER MOISTURE CONTENT OR PENETRATION (*SP*)

Third Stage penetration areas are moisture levels that have reached a quantity by weight that quite often will be visible to the human eye. This moisture is often a result of membrane or flashing damage, construction problems, or roofed over wet materials.

GREATEST MOISTURE CONTENT OR PENETRATION *(GMC)* (*SP*)

GMC contours within single-ply systems are at levels that should be considered a concern. While there may not be a need to remove and rebuild, this quantity of moisture within the system can adversely affect the deck, insulation, and/or membrane. All GMC contoured areas should be closely examined to determine if moisture is still entering the roof system.

SUGGESTIONS CONCERNING REPAIR MATERIALS

INCOMPATIBILITY OF BITUMENS

BUR: There are two distinct types of bitumens used in the construction of built-up roofs. One is asphalt and the other is coal tar pitch. They both look black, but are different chemically. Because of their chemical difference, they are incompatible with one another and care should be taken that they are not used on the same roof.

Asphalt has a straight chain molecular structure and is a residue derived from petroleum distillation. Roofing grade asphalts are a blend specifically manufactured for roofing applications. Roofing asphalt will have a grade which identifies its softening point, etc.

Coal tar pitch has composition in which six-sided benzene ring structures predominate. It is derived from the destructive distillation of coal during the manufacture of coke and gas.

MODIFIED BUTUMEN: There are two types of modified bitumen membrane assemblies currently utilized. They are APP and SBS. They should not be mixed; however, both are compatible with asphalt BUR assemblies independently.

HOT STUFF vs. COLD

There is controversy from time to time concerning the merits of HOT STUFF as compared to cold applied bitumens. All bitumens, before they can be applied as roof coatings or adhesives, must be made fluid. Hot applied bitumens are fluidized by melting at high temperature. Cold applied bitumens are fluidized by either dissolving in a solvent *(cut back)* or emulsifying *(suspension of bitumen in water)*. The bitumen materials used for both hot applied or cold applied are basically the same, but have been made fluid by different methods.

For new roof construction where new, dry materials are used, hot applied procedures work well and are generally the most economical and most common. This includes hot asphalt, coal tar, and torch applied assemblies.

In repair situations where substantial areas of damaged roof are torn off and rebuilt with new, dry materials, hot application procedures again are very good and generally the most economical. However, there is a potential to damage surrounding membrane due to thermal shock associated with applying hot material over a cured and aged membrane.

In repair situations where moisture containing areas are not replaced but are instead rejuvenated by repairing tears, splits and punctures, cold process materials have the best chance of success. The reason is that when 450 degree *(F)* hot bitumen is mopped wet roofing material, the trapped internal moisture is turned into steam. Delamination of the plies occurs and permanent damage results. Cold applied bitumens do not have this adverse temperature problem.

It is imperative to remember that renewal of protective top coats with not be successful if membrane splits and tears are not repaired prior to coating. A coating will not repair a membrane puncture, split, or blister.

A general method for repairing splits and tears is as follows: Reinforcing fabric, such as roofer's jute or plastic mesh fabric is used to entirely cover the crack of split. Make sure surface is clean and dust free a minimum of three inches *(3")* to each side of the problem. The fabric is adhered to the sound and dry membrane. The mastic selected should be permanently flexible material specifically manufactured for use in roof maintenance applications. Materials that become dry, hard and brittle lose their pliability at winter temperatures and soon crack again allowing additional moisture entry. The lower *(first layer)* of mastic should be worked up and through the reinforcing fabric before additional mastic is applied to assure a proper bond. Repairs are short lived if poor materials or techniques are utilized.

SUGGESTIONS CONCERNING APPLICATION OF REPAIRS

There is a major difference between applying a new roof system and repairing and rebuilding the same roof a few years later. New, as received, roofing materials are clean and generally dry; however, all received materials should be checked. The same materials once installed as a part of a roof system become covered with dust and grime and frequently contain varying amounts of moisture as well.

The built-up and modified roof membrane consists of layers of roofing felts *(plies)* adhered together with bitumen adhesive. One of the basic requirements to attain good adhesion is the need for clean, dry surfaces. These conditions are relatively easy to attain during new construction, but extra care and craftsmanship are needed to attain them during a repair operation.

A common reason that repairs fail is often due to poor adhesion in the overlap or tie-in areas resulting from poor adhesion of the repair adhesive. The poor adhesion is generally caused by dust and dirt on the roof's surface not completely cleaned from these areas prior to the application of the adhesive. This suggests that not only should these overlap areas be thoroughly swept and blown to remove dust, but that cut back primer be applied. This wets through the residual dust and assures a more complete bonding and a longer term success.

Lack of a good technique in the tie-in adhesion areas is a major cause of roof repair failures. Extra care in these areas can assure a sound and cost-effective repair.

RECOVER / RE-ROOFING

A repair method in which a new membrane layer *(ply)* is hot mopped directly over an existing old roof has been practiced to some extent. We do not recommend this procedure in most situations. A strict interpretation of current UBC code is that the addition of even one ply to an existing roof results in a roof structure which is defined as a "roof-over-roof". This is an important consideration when reviewing maintenance options.

Because of surface dirt, roughness and moisture content, it is very difficult to obtain uniform bonding to an old roof mat. The moisture problems are covered up and only temporarily hidden, but formation is frequent. This is not considered good roofing practice.

Addition of a recover board and a multiple-ply system is much more successful. UBC code considerations are important when considering adding a recover roof. Current Code allows two *(2)* roofs maximum. Code also requires certain procedures and analysis be conducted before proceeding. The major wet areas should be removed and rebuilt with similar compatible materials prior to installing the recover board. Small quantities of moisture can remain without damaging the new system. However, the entire assembly should be reviewed prior to proceeding.

BREATHER VENTS

Stack venting is frequently suggested as a method of drying out moisture trapped in roofing insulation. As a means of removing moisture, it is inefficient and is not of practical benefit. Effective drying is dependent upon exposing large segments of surface area to dry air flow. Recommendations for venting usually stipulate the area to dry air flow. Recommendations for venting usually stipulate the use of one vent per 1,000 square feet of roof area. Studies under controlled conditions indicate that 25 to 70 years would be required to successfully dry wet insulation. We do not recommend "venting" the roof to "dry out" existing wet areas.

Vents can equalize or reduce vapor pressure when installed correctly with selected insulation materials. The more porous the insulation, the more effective the results of pressure stabilization.

SUGGESTIONS FOR REPAIR OPERATIONS

NOTE: With all roof repairs, we highly recommend that a written repair specification be developed. The purpose is to define the scope of the work and establish quality control standards. In addition, it is important to remember that a roof system requires skill and craftsmanship to assemble correctly.

MINOR REPAIRS OF GRAVEL ROOFS

The gravel in the moisture contoured areas should be carefully swept back and the surface blown clean. Inspect the membrane surface for physical damage and reinforce and repair as required. The type of repair shall be determined based on the type and degree of problem*(s)* noted. Then recoat and re-gravel the area.

MINOR REPAIR OF SMOOTH ROOFS

The particular coating may or may not require removal. However, proper preparation of the surface prior to repair is necessary to assure correct results. Type of membrane shall be determined based on type and degree of problem noted and the type of membrane and coating currently installed.

MINOR REPAIRS ALONG THE ROOF PERIMETER

The gravel and/or other roof surfacing along the perimeter at the moisture contour areas should be swept back and/or prepared approximately four feet *(4')* from the edge and the surface blown clean. Inspect membrane surface for physical damage and reinforce and repair as needed. Recoat and resurface to complete repair. A more extensive repair would include reworking with granulated surfaced SBS membrane installation after removal of all loose and/or deteriorated membrane.

Inspect base flashing and counter-flashings in defective area to correct obvious faulty conditions. All loose metal should be refastened and sealed on an as-required basis.

REPAIR OF WRINKLES, BLISTERS, SPLITS

Cold Method

Blisters that are firm under foot and are not directly associated with a ply or cap sheet lap may not need to be disturbed. Others that are soft under foot should be repaired via one of the following two options:

1. Cross-out *(X)* incision is made, cutting only blistered plies of felt, the four segments are folded back and any water in the blister is mopped out and allowed to dry. Trowel a liberal amount of cold applied mastic into the blister and press the four segments into the mastic.

   Next, trowel another coat of mastic over the blister and embed jute membrane into the mastic to adequately cover the blister. A third coat of mastic is then spread over the jute membrane. Entire mastic replacement should extend four inches *(4")* beyond original blistered area.

2. Same as number one but replace mastic with SBS granulated membrane set in adhesive.

All splits and breaks in the membrane should be repaired and reinforced by spreading mastic to a width of four inches *(4")* beyond the ends or termination of a split, wrinkles, or felt ridge.

Hot Method / BUR

1. Remove all gravel, surfacing, dust and dirt within twelve inches *(12")* of repair area. Cu out all wrinkled, blistered or delaminated felt area. Prime areas around cut out section. Apply four plies of Type IV fiberglass felt using twenty-five pounds *(25 lbs)* of asphalt between plies. Each ply shall overlap the previous ply by six inches *(6")*. Apply a glaze coat or other surfacing to match existing system.

TORCH APPLIED: Conduct preparation as noted above under Hot Method/BUR. Once area is properly repaired, apply torch applied SBS modified membrane per membrane manufacturer's printed instructions and guidelines.

MAJOR TEAR OUT AND REPLACEMENT OF DEFECTIVE AREAS

1. If graveled, remove gravel a minimum of twenty-four inches *(24")* beyond patch boundary. Sweep and blow dust to clean. Care should be taken in the distribution of the removed gravel to prevent concentrated load damaging the existing roof membrane system.
2. If emulsion or other surfacing is present, remove and/or prepare surfacing per manufacturer's printed instructions and/or recommendations a minimum of twenty-four inches *(24")* beyond patch boundary. Sweep and blow dust to clean.
3. Cut out and remove area to be rebuilt.
4. If required, install vapor barrier in such a manner that it extends across the patch and splices into existing barrier.
5. If insulation is being replaced, install insulation 1/4" to 1/2" thicker than existing insulation to eliminate creation of a depressed area.

   If insulation is not being replaced, the cut out area should be filled in to level off existing membrane by alternate built-up layers of membrane and bitumen.

6. Prime entire repair area using a cut back primer intended for use on the particular type roof being repaired.

7. Lap base ply approximately twelve inches *(12")* over existing membrane.
8. Lap next ply four inches *(4")* further over existing membrane that the base *(bottom)* ply sheet which it covers.
9. Lap each succeeding ply four inches *(4")* further over the existing membrane than the one it covers.
10. Surface coat patched area and extend twenty-four inches *(24")* over existing membrane.
11. Re-gravel if original roof is gravel or surface coat is to meet existing coating type, surface and color.

SUGGESTIONS CONCERNING SELECTION OF A ROOFING CONTRACTOR

All roofing contractors install new roofs and all roofing contractors repair and maintain roofs. It is also a fact that some develop preference and special skills more applicable to one operation than the other.

All good roofers are craftsmen that take pride in their work. It takes a patient, skilled and a special craftsmanship to repair sections of a roof, replacing part, saving part. The roof mechanic needed for repair work is one that takes pride in a good fit and sound, water-tight repair. This is not always the same roofer as the one skilled for the mass production operation of installing a new roof. The contractor selected for repair work should be one who has developed an appreciation of roof maintenance problems and has special crews for this skilled work.

The success of a roof repair is only as good as the roofing professional that performs the repair.

ROOF MANAGEMENT

Roof management is possible and cost-effective when conducted correctly. "Crisis Management" is always expensive. A regular schedule of visual inspections *(minimum two annually)* and regular follow-up timely repairs is necessary. In addition, a regular schedule of electronic roof analysis is recommended. Depending on the roof's condition, a cycle of four *(4)* or five *(5)* year is cost-effective. Good roof management practices can extend the useful life of the roof beyond its normal life expectancy.

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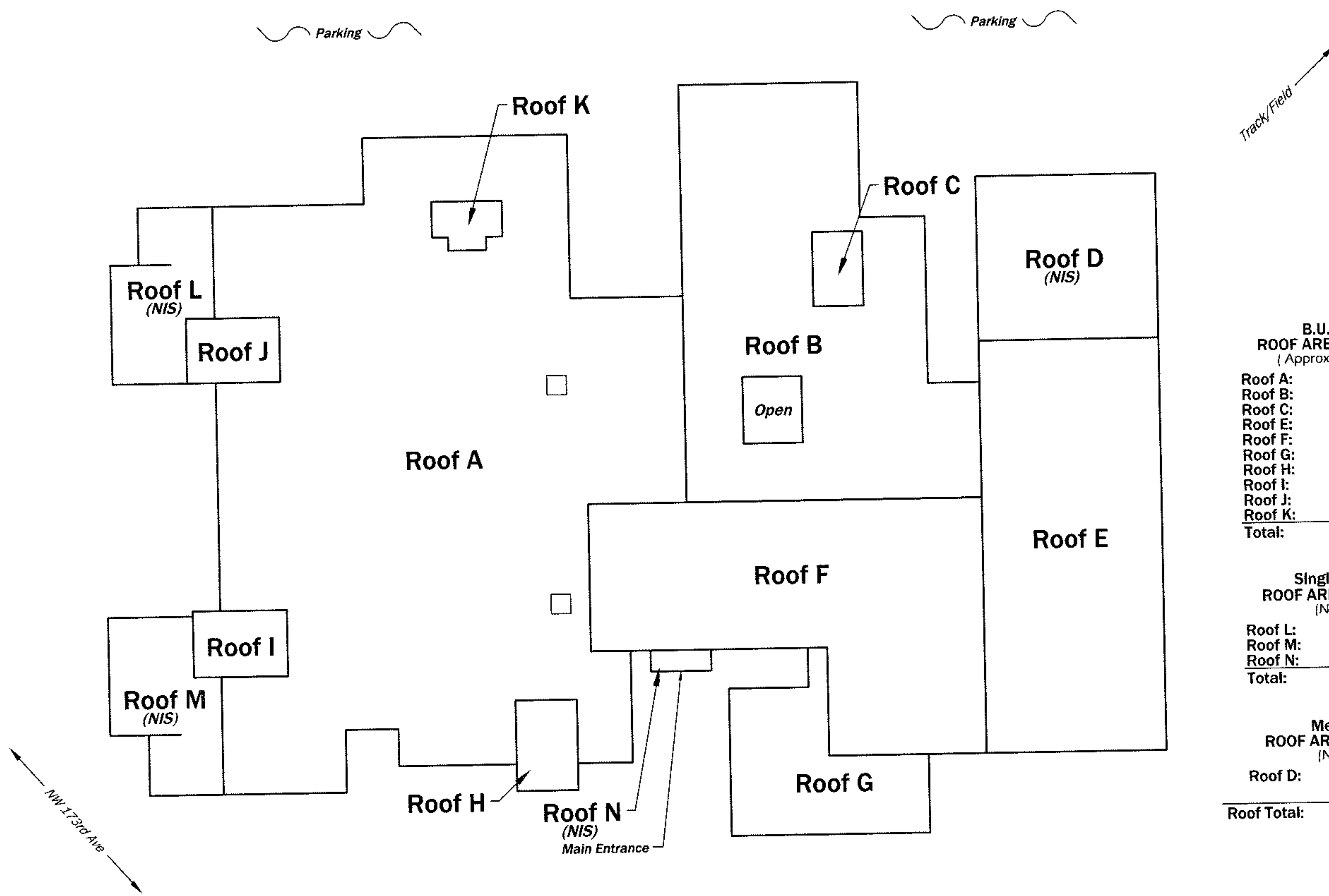


B.U.R. ROOF AREA SQ.FT. (Approximate)

Roof A:	60,176 sf
Roof B:	25,249 sf
Roof C:	860 sf
Roof E:	18,784 sf
Roof F:	19,063 sf
Roof G:	5,350 sf
Roof H:	1,252 sf
Roof I:	1,266 sf
Roof J:	1,236 sf
Roof K:	727 sf
Total:	133,963 sf

Single-ply ROOF AREA SQ.FT. (NIS)

Roof L:	3,916 sf
Roof M:	4,262 sf
Roof N:	337 sf
Total:	8,515 sf

Metal ROOF AREA SQ.FT. (NIS)

Roof D:	7,689 sf
Roof Total:	150,167 sf

Five Oaks Middle School
1600 NW 173rd Ave
Beaverton, Oregon

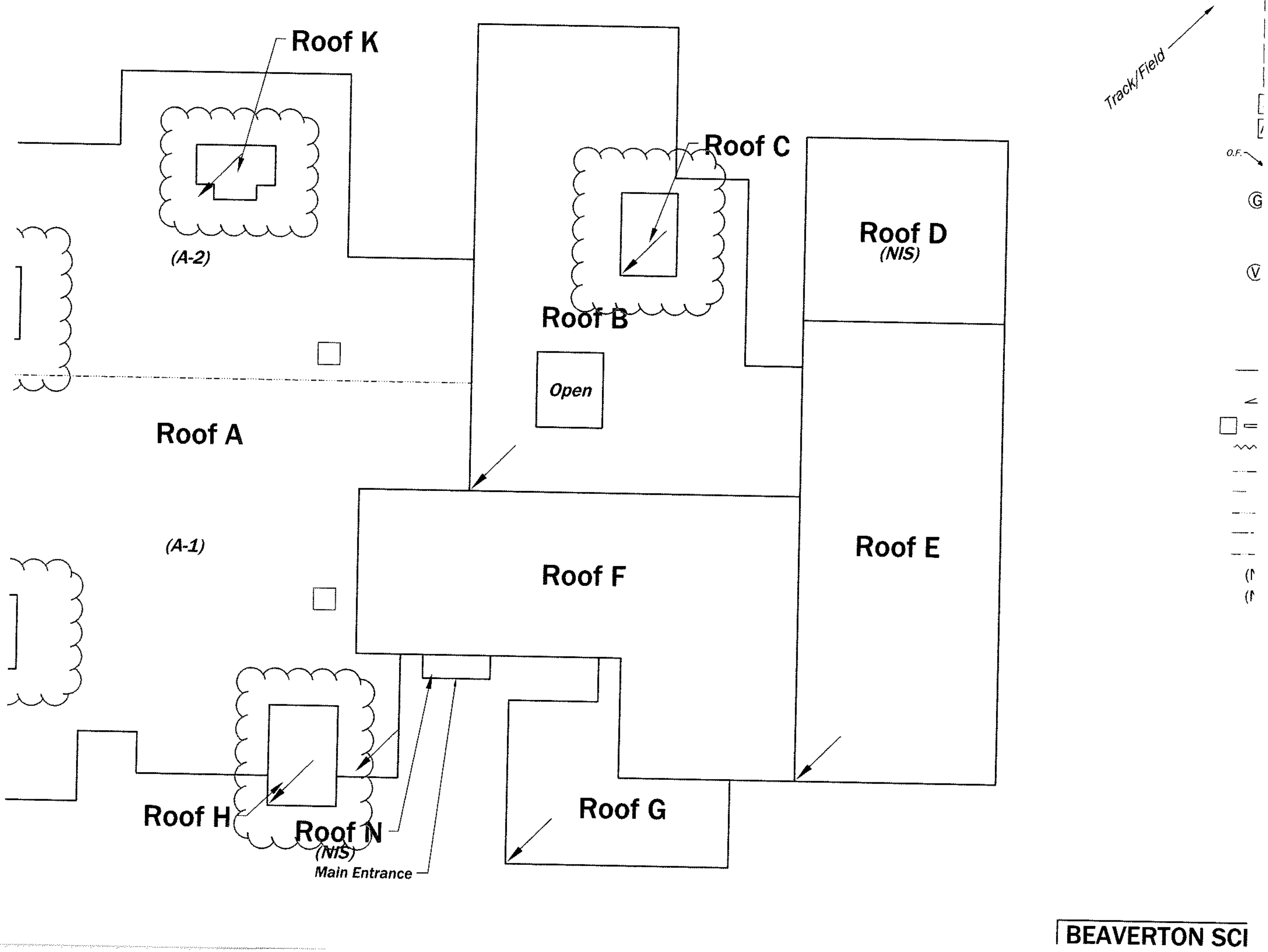
BEAVERTON SCHOOL DISTRICT
Five Oaks Middle School - Beaverton, OR

SCALE: NTS
DATE: 6/25/21
1 of 1
DRAWN BY: D.V.G.
REVISED: 07/15/21

A-TECH/NORTHWEST, INC.
Portland & Prineville, Oregon 503 - 628 - 2882

As-Built Drawing

PROJECT NUMBER: 21042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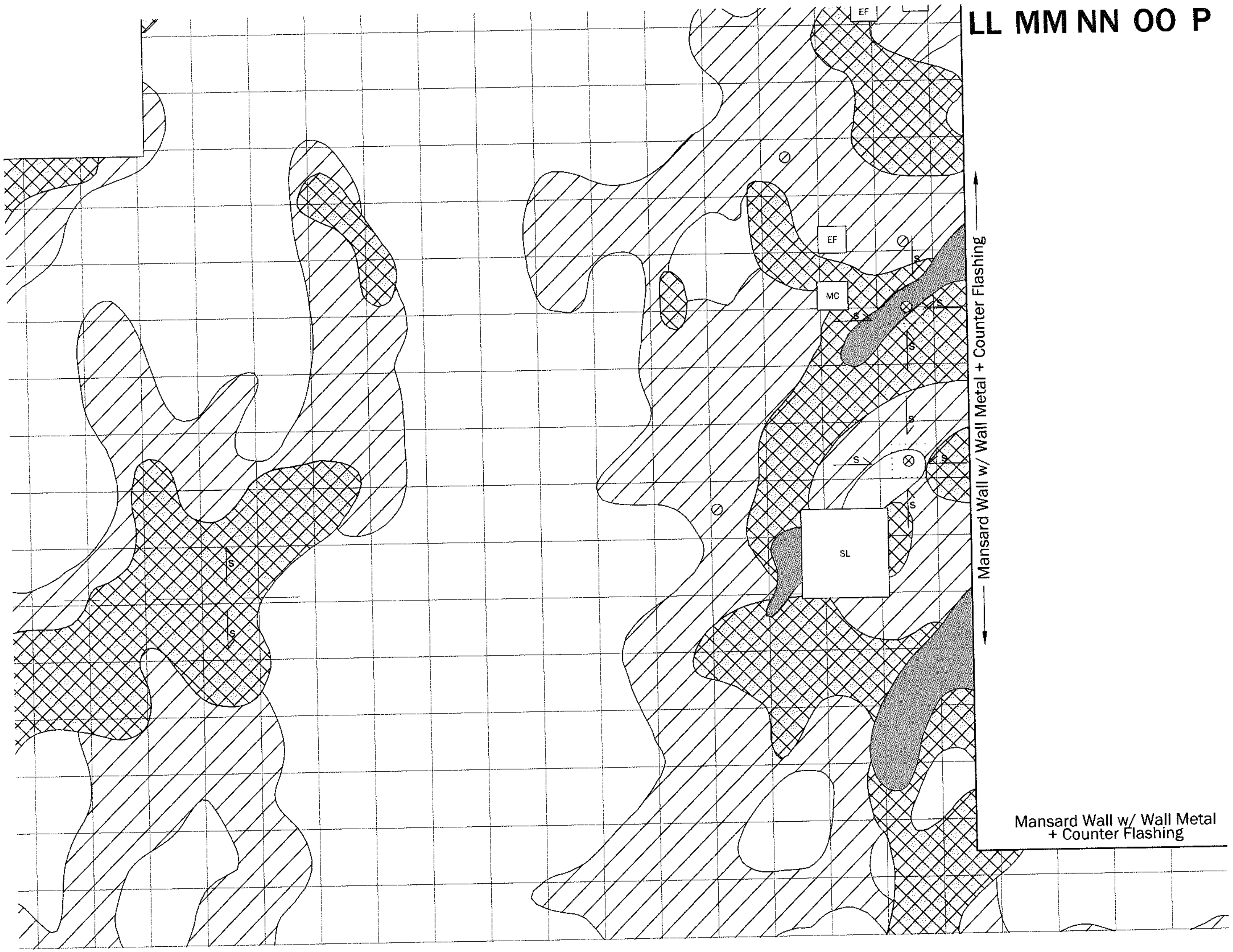
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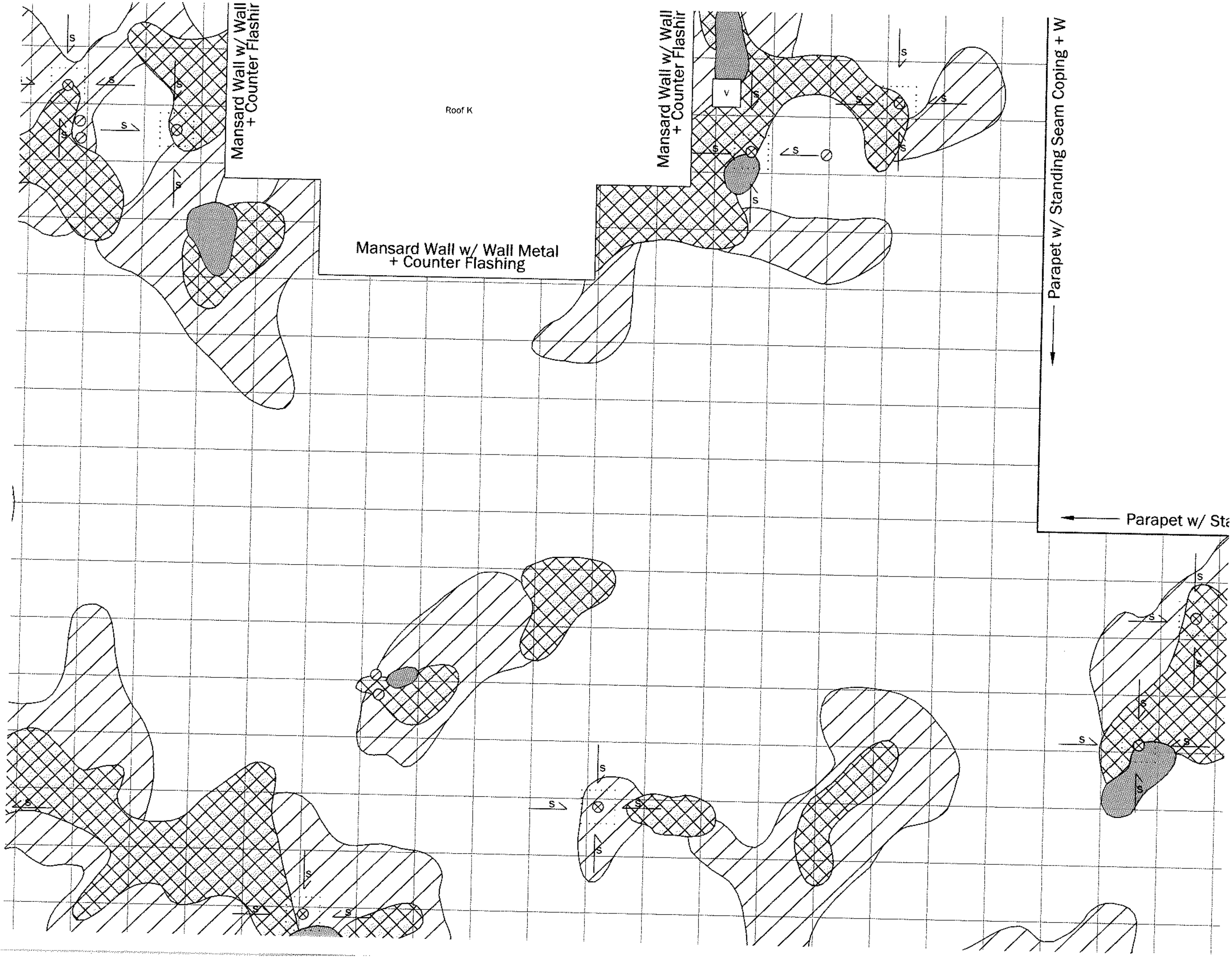

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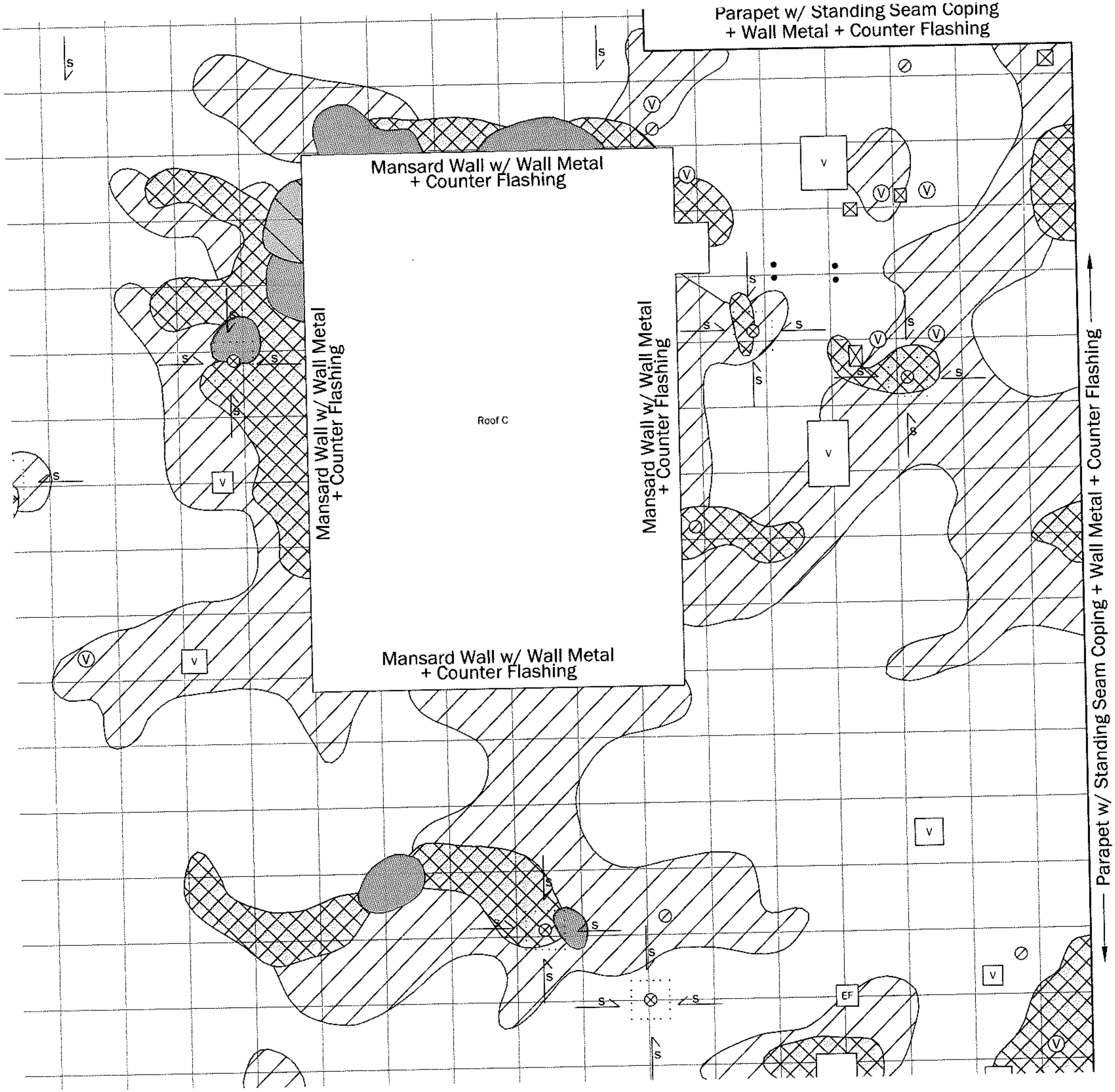
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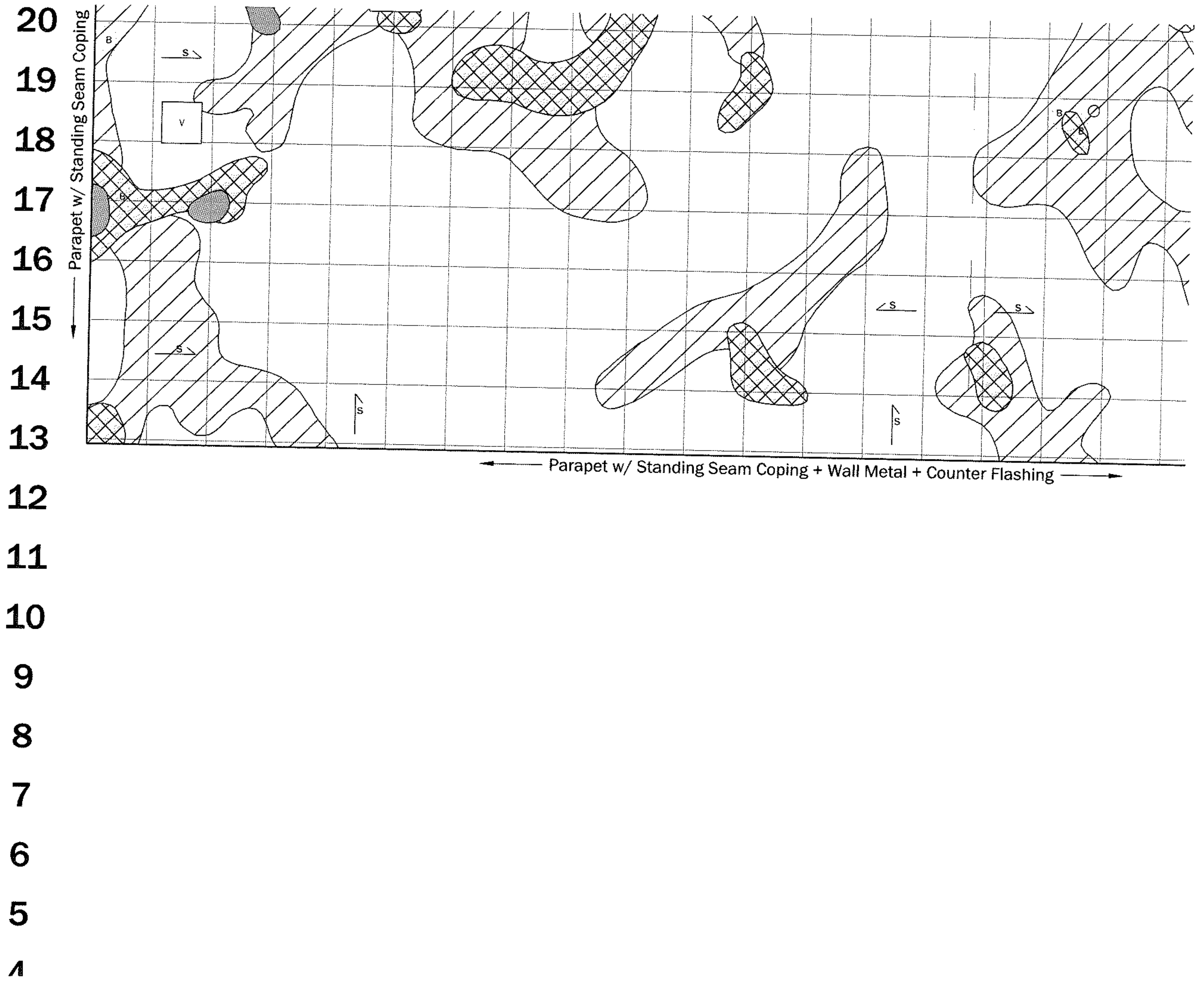

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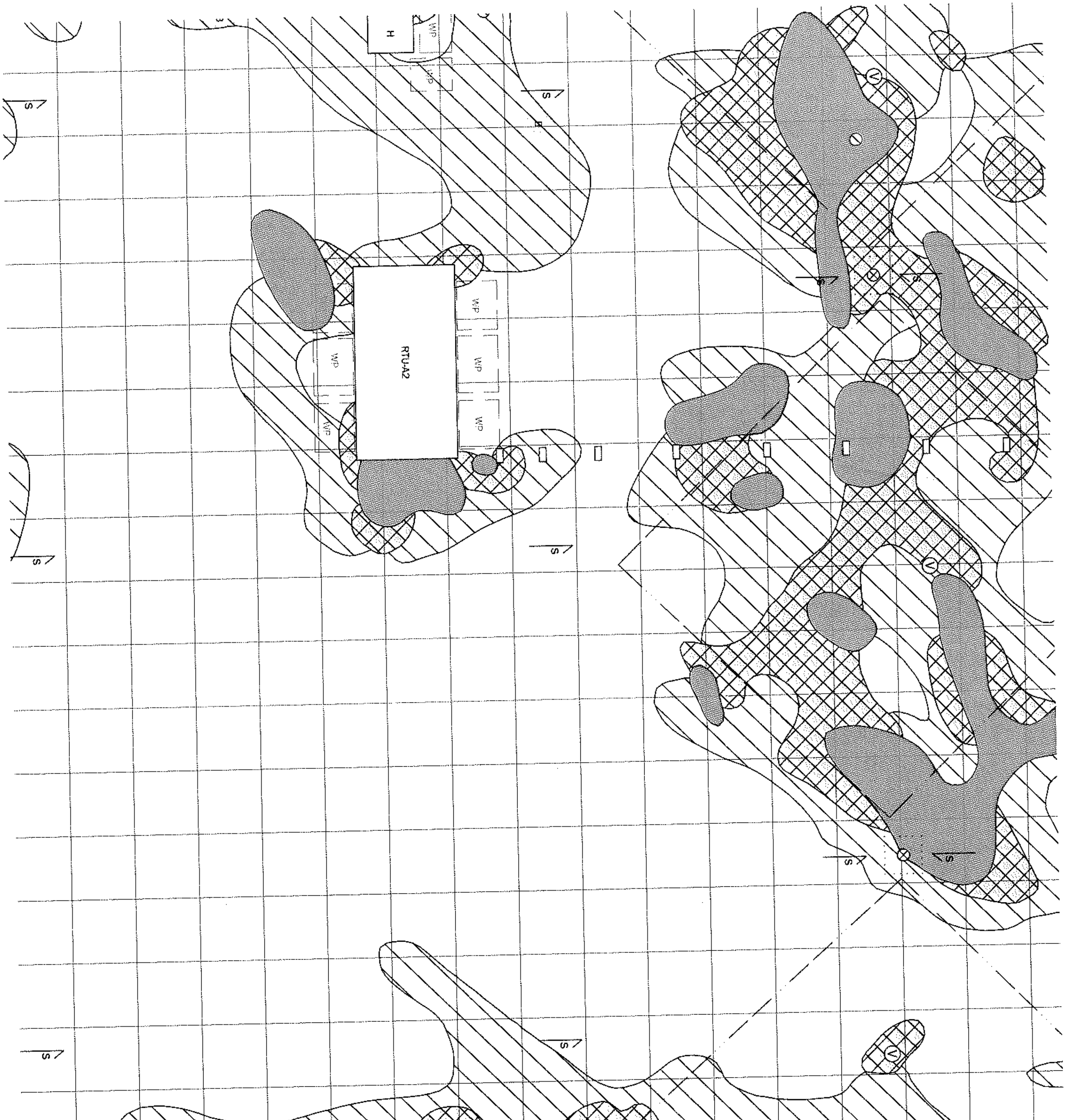
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