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BACKGROUND INFORMATION

The Leech Lake Reservation is located in Beltrami, Cass, Hubbard and Itasca counties in north-central Minnesota. The Bureau of Indian Affairs, the Minnesota Chippewa Tribe, and the Leech Lake Reservation Tribal offices are all located in Cass Lake. The Native Americans of Michigan, Minnesota, Wisconsin, the Dakotas to the south and Ontario to the north are generally designated as Chippewa in the United States and Ojibway in Canada. The tribe will be referred to as Ojibwe throughout this report.

The average annual precipitation is 25.85 inches. The average annual snowfall in nearby Bemidji is 41.1 inches. The average annual maximum temperature is 50.4°F and the average annual minimum temperature is 29.2°F. Approximately 5,147 Native Americans reside on the Leech Lake Reservation. The housing department maintains 313 Low Rent and 157 Mutual Help units of Tribal housing.

The assessment team responded to a request from the Eastern/Woodlands Office of Native American Programs to assess site and housing conditions contributing to mold and moisture problems at the Leech Lake Reservation. Marlene Mitchell, Housing Director, requested technical assistance to address mold and moisture conditions. Ms. Mitchell introduced the assessment team to housing department staff Bob Johnson and Sam Johnson. During the meeting, Paul Francisco explained the purpose of the visit and the methods that the team would be using to conduct the study. Amy Crowther distributed copies of the study's informational debriefing form, the mold survey conducted with occupants, and the site and building checklist that forms Appendix B of this document.

The assessment team visited eleven homes, two of which were unoccupied for extensive renovation. Seven homes were split level, three were ranch style and one was unrecorded because the team was unable to get into the unit. Every visited unit had a basement and propane central heating. All the homes were built in the early to mid-1980s.
PART I

LEECH LAKE HOUSING AUTHORITY TRIP REPORT

INTRODUCTION

Paul Francisco and Amy Crowther from the Building Research Council (BRC) at the University of Illinois Urbana-Champaign conducted a site visit at the Leech Lake Housing Authority (LLHA) on July 6 to 8, 2004. The LLHA administers the housing program for the Leech Lake Ojibwe Indian Tribe of Minnesota. The site visit provided technical assistance to the housing department in assessing mold and moisture conditions in housing units. This report summarizes activities and issues addressed while on site. A detailed analysis of findings and recommendations is found in PART II: Leech Lake Housing Authority Technical Housing Assessment Report: Examining Mold and Moisture Conditions of Homes on the Leech Lake Reservation.

BACKGROUND INFORMATION

The Leech Lake Reservation is located in Beltrami, Cass, Hubbard and Itasca counties in north-central Minnesota. The Bureau of Indian Affairs, the Minnesota Chippewa Tribe, and the Leech Lake Reservation Tribal offices are all located in Cass Lake. The Native Americans of Michigan, Minnesota, Wisconsin, the Dakotas to the south and Ontario to the north are generally designated as Chippewa in the United States and Ojibway in Canada. The tribe will be referred to as Ojibwe throughout this report.

The average annual precipitation is 25.85 inches. The average annual snowfall in nearby Bemidji is 41.1 inches. The average annual maximum temperature is 50.4°F and the average annual minimum temperature is 29.2°F. Approximately 5,147 Native Americans reside on the Leech Lake Reservation. The housing department maintains 313 Low Rent and 157 Mutual Help units of Tribal housing.

The assessment team responded to a request from the Eastern/Woodlands Office of Native American Programs to assess site and housing conditions contributing to mold and moisture problems at the Leech Lake Reservation. Marlene Mitchell, Housing Director, requested technical assistance to address mold and moisture conditions. Ms. Mitchell introduced the assessment team to housing department staff Bob Johnson and Sam Johnson. During the meeting, Paul Francisco explained the purpose of the visit and the methods that the team would be using to conduct the study. Amy Crowther distributed copies of the study’s informational debriefing form, the mold survey conducted with occupants, and the site and building checklist that informs Appendix B of this document.

The assessment team visited eleven homes, two of which were unoccupied for extensive renovation. Seven homes were split level, three were ranch style and one was unrecorded because the team was unable to get into the unit. Every visited unit had a basement and propane central heating. All the homes were built in the early to mid 1980s.
Day 1: Monday: July 5, 2004

Monday was a travel day.

Day 2: Tuesday: July 6, 2004

The assessment team arrived at the Leech Lake Housing Authority in Leech Lake, Minnesota on Tuesday morning to meet with Marlene Mitchell, Bob Johnson, and Sam Johnson to discuss the day’s activities, outline the team’s role while on the Reservation, and to address the housing authority’s concerns regarding the site visit. The housing staff selected units of two types: homes currently known to have significant mold problems and homes that previously had mold problems that were either repaired or were currently undergoing remediation. The residents of two investigated units were currently relocated while renovation occurred. Bob Johnson coordinated the logistics for the site visit. Nine visited homes were in the Low Rent program and the remaining two were Mutual Help units. Following the meeting, the assessment team, guided by Bob Johnson and Sam Johnson, inspected five homes on the Leech Lake Ojibwe Indian Reservation.

Day 3: Wednesday: July 7, 2004

On Wednesday morning, the assessment team, accompanied by Bob Johnson and Sam Johnson, inspected six homes.

Digital photographs were taken to record conditions in all eleven homes. The inspection process also involved visual assessments of both interior and exterior conditions. PART II: Leech Lake Housing Authority Technical Housing Assessment Report: Examining Mold and Moisture Conditions of Homes on the Leech Lake Reservation provides a detailed analysis of findings and recommendations for the homes investigated at the Reservation.

Day 4: Thursday: July 8, 2004

On Thursday morning, the assessment team gave a presentation summarizing the visual mold investigations specific to Leech Lake and also noted other possible moisture sources as noted on other reservations. The presentation was attended by Marlene Mitchell, Bob Johnson, Samuel Johnson and approximately ten members of the Leech Lake Housing Authority’s maintenance crew. The presentation was followed by a question and answer session.

Thursday afternoon and evening were spent traveling back to Illinois.

FINDINGS

An overview of findings and recommendations from the site visit follows. PART II: Leech Lake Housing Authority Technical Housing Assessment Report: Examining Mold and Moisture Conditions of Homes on the Leech Lake Reservation provides a more detailed discussion and analysis of the findings.
Leech Lake Ojibwe Indian Reservation

All inspected homes had full basements and either currently have visible mold or had undergone renovations to remove mold. Principal findings include:

1. Reduced levels of insulation and exterior air leakage over the top plates caused mold growth at the juncture of the exterior walls and ceilings, a common problem in northern climates in homes with low pitch roofs and high interior moisture loads.

2. Poorly operating bathroom fans contributed to excessive moisture in the homes.

3. Gutter systems were frequently nonexistent or incomplete. Some gutter systems were missing gutter sections, downspouts, or leaders that help draw water away from the foundation.

4. Site drainage tended to be poor, with holes and depressions found adjacent to the foundations at all homes. These depressions were typically created by animal activity or from the drip line, which originates from precipitation dropping from unguttered roof eaves. Site drainage is critical in maintaining a dry foundation and home.

5. An attic bypass in one home caused mold growth on the roof sheathing.

6. A prior or existing leak through the ridge vent of the gabled portion of one home caused mold growth on the roof sheathing for the main portion of the home.

7. All homes had one or more rim joist bays, the spaces between the floor joists, in the basement that were missing insulation.

8. Furnace filters should be capped and changed regularly to ensure proper furnace function.

9. Condensation on plumbing pipes and toilet tanks was common.

MOLD TESTING

The assessment team agrees that if mold is inside a building, it needs to be cleaned. Generally, identifying the species of mold growing in a residence is unnecessary. No baseline exists for acceptable or unacceptable mold concentrations in a home. This message concurs with other federal agencies and experts as documented below. *Attachment 1* is a copy of *The Measurement Problem Regarding Mold*.

*Guidelines on Assessment and Remediation of Fungi in Indoor Environments*, he Bemidji Area Indian Health Service Office of Environmental Health and Engineering, Environmental Health Services Section (BAIHS EHSS), takes this position on testing:
Consistent with Center for Disease Control (CDC) and Environmental Protection Agency, BAIHS EHSS does not recommend testing as the first response to an indoor air quality concern. Instead, careful detailed visual inspection and recognition of moldy odors should be used to find problems needing correction. Efforts should focus on areas where there are signs of moisture or high humidity or where moisture problems are suspected. The investigation goals should be to locate indoor mold growth to determine how to correct the moisture problem and remove contamination safely and effectively.

The Adverse Human Health Effects Associated with Molds in the Indoor Environment by the American College of Occupational and Environmental Medicine, states that to successfully remediate mold and moisture conditions, the water and moisture sources must be identified and corrected.

Mold spores are present in all indoor environments and cannot be eliminated from them. Normal building materials and furnishing provide ample nutrition for many species of molds, but they can grow and amplify indoors only when there is an adequate supply of moisture. Where mold grows indoors, there is an inappropriate source of water and moisture that must be identified and corrected before remediation of the mold colonization can succeed. Mold growth in the home, school, or office environment should not be tolerated because mold physically destroys the building materials on which it grows, mold growth is unsightly and may produce offensive odors and mold is likely to sensitize and produce allergic responses in allergic individuals. Except for persons with severely impaired immune systems, indoor mold is not a source of fungal infections. Current scientific evidence does not support the proposition that human health has been adversely affected by inhaled mycotoxins in home, school, or office environment.

BAIHS EHSS Guidelines on Assessment and Remediation of Fungi in Indoor Environments discusses the limitations of testing as follows:

Mold testing only provides a snap-shot estimate for a single point in time and a single location. How well the test represents other locations and times is uncertain since the amounts and types of mold in the environment are always changing. Furthermore, there is no basis for setting a baseline of acceptable or unacceptable mold concentrations. The variability can be especially large for airborne molds, with significant changes occurring over the course of hours or less. Caution must also be used in interpreting surface testing results, since mold growth or deposition may not be uniform over an area and may increase or decrease as time passes. Unless many samples are taken over a period of time and the investigator has been mindful of building operations and activities during the testing, the results might not be very representative of typical conditions; in addition,
tests reflecting typical conditions may also miss evidence of problems that only occur infrequently (water leaks during rain storms).

Mold testing is often expensive. Dollars spent on unnecessary or poorly done testing, reduces the amount of money available for remediation and repairs. The following web sites and references provide further information on mold remediation and testing:

**Indoor Air Quality**

**Ball State University Indoor Environment Notebook** - General resource on a number of topics related to indoor air quality.
http://publish.bsu.edu/ien/archives/archive_list.htm (will open a new browser window)

**Mold**

**EPA** - Mold Remediation in Schools and Commercial Buildings
http://www.epa.gov/iaq/molds/index.html (will open a new browser window)

**New York City Department of Health Bureau of Environmental & Occupational Disease Epidemiology** - Guidelines on Assessment and Remediation of Fungi in Indoor Environments http://www.ci.nyc.ny.us/html/doh/html/epi/moldrpt1.html (will open a new browser window)

**References**

*Guidelines on Assessment and Remediation of Fungi in Indoor Environments*, a Bemidji Area Indian Health Service Office of Environmental Health and Engineering, Environmental Health Services Section.


**Future Housing Department Actions**

The LLHA staff was very organized and helpful during the site visit. The maintenance department addressed the mold problems with positive actions. Many units were scheduled to undergo major renovations or to have mold and moisture sources eliminated. Some of the recommendations made by the team confirmed that the steps the housing department had taken were appropriate. Applying the findings with other specific recommendations to the renovations should address the mold issues in the homes.
PROGRAMMATIC RECOMMENDATIONS

Addressing mold and moisture problems presents a two-phase challenge to housing entities to develop a prompt and effective delivery system:

- Develop a partnership between the housing entity and residents.
- Develop a two-part training program to:
  - Train maintenance staff to implement technical recommendations.
  - Train residents on their roles and responsibilities as homeowners and tenants.

The housing department has already taken excellent action steps to create a partnership between the housing entity and residents. Additional steps to strengthen their program could include formalized methods for addressing mold problems and maintenance issues as they occur. For example:

1. Require mandatory attendance at annual homeowner/tenant clinics as part of the annual recertification process. At these clinics, provide instruction on home maintenance issues, such as identifying and repairing leaks, using exhaust fans, and maintaining gutters.

2. During the annual recertification process, ask occupants to complete a survey based on Housing Quality Standards (HQS) with additional questions on mold and moisture conditions in their homes. Completing the survey further engages residents in their own home maintenance. Furthermore, the survey responses provide additional information to the housing authority on unreported problems, especially leaks and inoperable fans that might contribute to an unsafe, unhealthy home environment.
Attchment 1
APPENDIX C: LIMITATIONS OF MOLD SAMPLING

The Measurement Problem Regarding Mold
By William B. Rose, Research Architect
Building Research Council/School of Architecture
University of Illinois, Urbana-Champaign

When complaints of mold problems occur, two courses of action are appropriate: 1) visually assess the site, remove the mold, and correct the conditions that led to the mold and 2) contact health professionals for allergy or respiratory problems. The proper action is to discover sites of mold growth. Where this approach has been used, the outcome has been, in every case, improvement of indoor environment conditions (though the improvements may take time) and improvement of health conditions. This is the recommended approach for dealing with mold problems in housing in Indian areas.

Techniques for sampling biological aerosols were developed for industrial and agricultural settings. They were designed to help industrial hygienists determine the safety of workplaces and other environments. The value of their work was evident in determining the causes of the Legionella outbreak of 20 years ago, and in sampling for biological warfare agents at present. Sampling produces counts of mold material from samples taken in the air or on surfaces. It may determine the number of viable spores in a sample from the air or a surface. And it may be used to identify genus and species of mold found in the sample.

Neither of the two recognized guidelines for mold remediation, the NYC Department of Health’s Guidelines on Assessment and Remediation of Fungi in Indoor Environments and the USEPA’s Mold Remediation in Schools and Commercial Buildings, calls for environmental sampling for routine mold problems. Both guidelines discourage environmental sampling in most cases. This opinion is summarized on the CDC website:

Generally, it is not necessary to identify the species of mold growing in a residence, and CDC does not recommend routine sampling for molds. Current evidence indicates that allergies are the type of diseases most often associated with molds. Since the susceptibility of individuals can vary greatly either because of the amount or type of mold, sampling and culturing are not reliable in determining health risk . . . reliable sampling for mold can be expensive, and standards for judging what is and what is not an acceptable or tolerable quantity of mold have not been established.

In general, the use of mold sampling must be discouraged. There are several reasons for this. First, aside from allergic effects, the health outcomes of mold in homes, schools or offices have not been established. Second, given those circumstances, there is no basis for setting a baseline of acceptable or unacceptable mold concentrations. Third, the internal repeatability of mold sampling results has not been shown in the literature. Fourth, weaknesses in the visual assessment protocols have not been demonstrated.
Mold sampling has been done in residential settings, leading to conclusions about the presence of mold, about the presence of individual species of mold, and about high concentrations of mold in some locations. However, much of the information provided by sampling is already known from common sense. The following are some facts about mold in indoor environments that are known even before measurements are taken:

1. Mold is everywhere. The outdoor air contains rather high concentrations of mold spores, which are naturally occurring. By contrast, most building interiors contain lower concentrations, though the concentrations indoors and outdoors vary over time. Indoor air comes from the outdoors. If the indoor is cleaner than the outdoors, something served as a filter, accumulating mold, dust and airborne material over time. Some commercial buildings have filtration systems designed to clean air as it passes from outdoors to indoors. But in most buildings, the outdoor air infiltrates through cracks and cavities in the building envelope as it travels indoors. If the indoor air is cleaner, then the building envelope acts like a filter. Therefore, when a sample of indoor air is taken, mold spores will be found. The conclusion “This building has mold” can be made of all buildings.

2. Dust, dirt, mold spores and other particulates accumulate in building cavities over time. There is no passive cleaning process for building cavities to match this cumulative process. Because the walls and roofs filter outdoor air as it moves indoors, all building cavities must be considered as sites with high concentrations of mold spores and other airborne material.

3. Evidence indicates that where proper conditions are in place, sooner or later the species that typically inhabit such spaces will arrive. *Stachybotrys* is known to inhabit pulpy cellulose materials that are maintained at a high water activity level. With the right quantity of water, the paper facing of gypsum products generally shows the growth of *Stachybotrys*. Where the appropriate conditions are maintained for a long enough time, *Stachybotrys* and other species appear and grow. “Wet it, and they will come.”

4. It is logically impossible to prove a negative statement. There are no tests that allow one to draw the conclusion that absolutely no mold spores representing a species are to be found in a space. Even if a test should turn up no spores of a given species that does not provide conclusive evidence of the total absence of that species from the interior space. And conditions may change from one hour to another. So a finding in a room or building of any given species, including *Stachybotrys*, should not be considered exceptional. The absence of a species from a space can be determined statistically to a pre-selected degree of confidence, requiring several tests.

What, then, remains to be discovered through mold measurement? It is already determined, for all buildings, that mold is contained in the air, that any species may be found in the air or on the surface, and that high concentrations of mold are contained in the cavity. If a tenant or occupant complains about living conditions, it is clear that any unit that occupant will move to will have mold in the air, will have all common species of
mold in the air or on surfaces, and will have high concentrations of mold in the building cavities. It is wrong to presume that buildings are sterile simply by virtue of their never having been measured.

Measurements of mold are not useful if the purpose of the measurement is to determine any or all of the following:

1) if the building has mold,
2) if a certain species, say, *Stachybotrys*, is present, or
3) if the building cavities have high concentrations

For the measurement criteria above, no measurements should be made, as the results will be dismissed as being of no use.

**Possible Occasions for Mold Measurement**

After the effective implementation of visual assessment and remediation of mold as described above and conditions of mold are suspected to still exist, it is possible (though unlikely) that a visual assessment will overlook a cause of distress. If that happens, one strong possibility is that the distress is not related to mold in the first place. However, in the case where a mold problem has not been accurately identified and remediated through visual assessment, three scenarios are often suggested as possible occasions for mold measurement:

1. Active mold growth is usually accompanied by amplification, the strong increase in mold of one or two species out of proportion to the background taxa.
2. Mold may have an odd source, such as air conditioning ductwork, and may be present in the building only when that source contributes to the space, or
3. An investigator may use a fixed level as a measure of acceptability or cleanliness (though it bears repetition: there are not exposure limits set by any authorities).

In each of these cases, mold measurement may be able to provide some insight.

**The statistics of mold measurement**

For mold measurement to provide insight, or to provide material for decision-making, the results of mold testing must be statistically significant. One measurement is never statistically significant. Understanding the notion of statistical significance requires understanding error and bias.

Two samples of the same space will never provide the same results. There is always some spread (or precision error) in the data. The mold sampling industry generally fails to make public their estimates of the precision error in their sampling methods. It would be good to know, for the same equipment, same operator, same laboratory, same technician, what the estimate of the error would be. That information is not presently available. In
addition to precision error, there are many other factors that tend to bias the results one way or another. These include the following:

1. Time of the day (ascomycetes tend to release spores in the afternoon, basidiomycetes in the morning)
2. Season (lower during winter)
3. Snow cover (greatly reduces outdoor concentrations)
4. Sampling technique (lowest with culturable samples, medium with impactors, highest with PCR)
5. Variations over space (highest, usually, in basements and crawl spaces)
6. Variations by surface (highest near carpets)
7. Disturbance (greatly higher with scuffing and fluffing of carpets, etc.)
8. Variations by wetness (higher concentrations on wetter materials)
9. Laboratory
10. Technician

It is evident that achieving statistically significant results requires considerable care, in addition to thoroughly accounting for variables. All proposals for mold study that involve sampling must contain information that describes:

1. The yardstick, or baseline values, that will be used for interpretation,
2. The variables that are accounted for in the study,
3. The error estimate associated with those variables,
4. The confidence interval to be used (95% confidence in the results is recommended),
5. How the study will deliver that level of confidence.

Sampling campaigns that give numbers without giving statistical significance to those numbers are worse than worthless. They come at a financial and social cost and are very disruptive to the lives of individuals, families and tribes.

The range of concentrations often found in mold measurements is several orders of magnitude—sometimes several dozen spores or colony-forming-units (CFUs) per unit of mass or volume out to several million. Most guidance advises representing the distribution as lognormal; that is, if the data values are represented not as numbers with zeroes but as powers of ten, then the exponents occur in a normal distribution. This is quite helpful, as one of the tails of the distribution never drops below zero.

Let us presume that an environmental consultant hypothesizes that the airborne mold spore concentration in a room exceeds a certain value. Of course, the consultant would be obliged to cite the reference for the value selected. Taking a single sample gives a distinct reading for the sample but says nothing about the concentration in the room. A second sample, with a result different from the first, proves that a single sample cannot characterize the actual concentration. Also, clearly, the more samples that are taken, the more sure one can be that the mean of the measured values represents the actual value, and can be used in this comparison test.
Let us also presume that the confidence interval used is 0.05 ($\alpha = 0.05$). That means that 5% of the time the confidence in the veracity of the finding will be misguided. Nevertheless, many scientific and management findings use a 0.05 confidence interval. Tribal leaders or others who are entertaining proposals from environmental consultants might consider having a stated confidence interval at the time of the work proposal, perhaps of 5%.

Then standard statistics allows us to calculate the confidence interval. The result is usually expressed as a value $y \pm z$ ($\alpha = 0.05$). The value $y$ is the mean (average) of the sample values. The value $z$ is composed of the Standard Error (SE, equal to the standard deviation divided by square root of the count-1) times a factor called “student’s-t” ($t$). This factor is commonly used in statistics when the number of samples is small; it is found in textbooks of statistics and as a common spreadsheet function. The value $z$ is equal to ($t$) * (SE).

An environmental consultant may wish to sample to determine if a certain species is present or not. Common species of mold should always be deemed to be present, but may be proved to be absent, if indeed they are absent, to any selected degree of confidence (never for certain).

Testing is expensive. So there is a strong tendency on the part of both consultants and clients to conduct testing without regard to the statistical significance. This practice should end, as the results cannot be used for decision-making. If testing is to be done at all, then the testing campaign must be designed to have the power to provide answers to the critical questions.

All mold testing must include a minimum of two samples per measurement site. Taking only one sample leaves the impression that the value is somehow elevated above error. With two samples per site, the issue of error is inescapable. In addition all mold testing should:

- State the question or hypothesis that is being answered or addressed through testing
- State the criteria (absolute or comparison) used to address the hypothesis
- State the proposed confidence level.
- List the errors and biases that are accounted for (or controlled for) in the testing.
- Calculate the margin of error.
- Report the findings with the margin of error.
- Attach statistical significance to the conclusions.

July, 2003
PART II

LEECH LAKE HOUSING AUTHORITY

TECHNICAL HOUSING ASSESSMENT REPORT

EXAMINING MOLD AND MOISTURE CONDITIONS IN HOMES ON THE LEECH LAKE RESERVATION

Executive Summary

Introduction

Section 1: Methodology

Section 2: House Descriptions

Section 3: Findings

Section 4: Technical Discussion and Recommendations

Section 5: Discussion of Common Problems

Appendix A: Housing Survey Summary Site Visit Report

Appendix B: Housing Assessment Results
EXECUTIVE SUMMARY

The assessment team inspected eleven homes for mold and moisture problems, as requested by the Leech Lake Housing Authority (LLHA) that administers the housing program for the Leech Lake Band of Ojibwe in Minnesota. The investigation was performed from July 6th - 8th by Paul Francisco and Amy Crowther of the Building Research Council. The inspection process involved visual assessment of both interior and exterior conditions, air flow measurement of bathroom exhaust fans and resident interviews where possible. Occupants were not present at three homes and the interior of one home was inaccessible.

All but one inspected home were 2 inch x 4 inch stick-built ranch homes over basements. One home was modular. Homes over crawl spaces were on the reservation, but none were selected for inspection. The homes ranged in age from 18 years old to 25 years old. The homes were heated with propane-fired forced-air furnaces.

The LLHA has been active in mold remediation at homes on the reservation. As a result, several of the inspected homes that had previously had mold and moisture problems had been repaired. In general, the repairs appear to have been successful, indicating that the LLHA has the situation largely under control.

Principal findings include:

1. Although bathroom exhaust fans were present in all the homes, many fans did not move any air due to blockage or excessive restrictions. Even fans that did move air moved much less than is desired and they were all very noisy. Ten of eleven kitchen fans were vented to the outside.

2. Only one home had a fully-functional gutter system. Many homes had no gutter system or had missing or damaged downspouts and/or leaders. As a result, several homes had water collecting at the foundation, and in some cases, had distinct drip lines or depressions that extend much of the length of the home beneath the eaves.

3. All homes had significant drainage problems in addition to gutter issues. There were depressions and/or holes around all the foundations. Site drainage is critical to maintaining a dry foundation and home.

4. Poor insulation and exterior air leakage over the eaves caused mold growth at the juncture of the exterior walls and ceilings in a few homes. This is a common problem in northern climates in homes with low pitch roofs and high interior moisture loads. There were other homes that had previously had this problem but had been addressed.
5. One home had a large attic bypass above the kitchen cabinets. This allowed warm moist air to enter the attic, which resulted in mold growth on the attic sheathing and is also a major source of heat loss.

6. All basements had some missing rim joist insulation. This is a source of heat loss and also provides a cold surface in the winter on which water can condense and create conditions amenable to mold growth.

7. Several homes had sweating pipes, meaning that condensation was on the exterior of the pipes and, in one case, on the toilet tank in the upstairs bathroom. This condition produces a high moisture load, and in the case of the sweating toilet tank, the moisture had penetrated the floor and damaged the ceiling of the room below the bathroom.

8. Five homes had wet or damp basements. In one home this was due in part to a leaky drain pipe from the washing machine. In at least two others this was due in part to drying large amounts of clothes in the basement.

9. One recently rehabilitated home had mold growing on the basement walls about two feet above the floor. It is probable that drain tile was installed only partially down the foundation, allowing the lower portion of the foundation wall to remain wet and cold.

10. One home had very moldy sheathing due to either a roof leak through the ridge of the gabled portion or the house above the sheathing.

11. One home had significant mold on the wall around the sump pump, apparently due to water seeping inside the furred-out foundation wall. The most likely pathway for this water intrusion was through a gap in the flashing located over the below-grade perimeter insulation on the exterior of the building below the sump pump discharge.

12. Several homes had mold around the windows. The LLHA had addressed this problem by enlarging the cavity around the windows and adding insulation.

13. Several homes had mold growth on the dropped ceiling of the entry area of the home. One home still had active mold growth. The LLHA was addressing this problem by lowering the ceiling in this portion of the home even further and adding more insulation in the attic above this ceiling.

14. Several homes had mold on the well around the attic hatch, indicating air flow around the hatch and into the attic. One home had a very moldy attic hatch.

15. Most homes did not have a cap on the furnace filter slot, which allowed basement air to bypass the filter. There were also other large duct leaks, both on the supply and return sides of the systems.
16. Several homes had rooms with excessive clutter.

The report provides technical recommendations and discussions focusing on these items. Appendix A includes a summary of findings at each inspected home. Appendix B provides observations and recommendations for each home.
INTRODUCTION

The Eastern/Woodlands Office of Native American Programs requested that the Building Research Council (BRC) assess site and structural conditions contributing to mold and moisture problems in the LLHA homes. Paul Francisco and Amy Crowther conducted the site visit from July 6th - 8th, 2004, with Bob Johnson and Sam Johnson of the LLHA as their escorts. LLHA selected the houses.

Two homes had mold problems at the juncture of the exterior wall and ceiling. In one home this was only at the nails for the ceiling joists, while in the other it was more extensive. Insufficient insulation over the top plates, combined with high interior moisture loads, was the primary cause of this mold. More homes had experienced mold problems of this type, but had already been repaired. Inspections of the attics indicated that, in most cases, further improvement of the insulation levels over the top plates was possible.

All homes had exhaust fans in the main bathroom. However, none provided the desired level of flow. All homes had kitchen exhaust fans venting to the outside, although one had a poor connection to the exhaust duct.

Mold was found on the roof sheathing in two attics. One of these was from a bypass above the kitchen cabinets. The other was from either a previous or current leak through the ridge vent of the gabled portion of the home.

All homes had low spots and holes adjacent to the foundation. Only one home had a good gutter system. Six homes had no gutter systems, and four had systems with missing gutter sections, downspouts, leaders and splash blocks. Five homes had wet or damp basements.

One home had a water leak through the shell of the home below the discharge of the sump pump. In addition, plumbing problems were found at five homes. Sweating pipes and/or toilet tanks were found in five homes.

SECTION 1 – METHODOLOGY

Visual inspections and limited airflow measurements were used to assess mold and mildew conditions in the homes.

The results of the mold and moisture assessments were compiled on a spreadsheet, Appendix A, with broad categories of common moisture problems noted. Findings and recommendations for individually inspected houses are presented in Appendix B.

Visual Inspection

Housing inspections consisted of visual assessment of mold and moisture conditions. Assessment forms developed for the Chicago Mold and Moisture Project (a HUD
Healthy Homes Program) were used to record information. The assessment forms are organized for a room-by-room inspection, thus all rooms were examined for water damage and evidence of mold. Assessment of kitchens, bathrooms, basements, utility rooms, and attics included additional inspection relating to plumbing, localized ventilation, water entry, and other moisture source issues. The exterior of the houses were inspected for rain water and snow melt management, including site grading, roof condition, and gutter system.

Whenever possible, residents were interviewed to gather history on moisture problems, plumbing leaks, winter condensation, health issues, number of occupants and other useful information.

Digital photographs were taken at each house to visually record notable conditions.

**Measurements**

Actual ventilation rates of bathroom fans were measured with an exhaust fan flow meter where operable fans were found. The flow meter consists of a gasketed pan that is placed tightly over an operating exhaust fan. The pan has a variable orifice and a connection for a digital manometer. The manometer measures the pressure difference between the pan and the house during fan operation. Based on the setting of the variable orifice and the measured pressure difference at the fan, the cubic feet of air per minute (CFM) exhaust by the fan is calculated.

**SECTION 2 – HOUSE DESCRIPTIONS**

The LLHA manages 470 homes for the Tribe including Low Rent and Mutual Help units. Approximately 5,147 Native Americans reside on the Leech Lake Reservation.

Eleven homes were inspected. All homes were about 18 to 25 years old.

All homes were 2 inch x 4 inch stick-built construction. One home was modular. One home was part of a duplex. Sidewall insulation was assumed to be R11 fiberglass batts. Attics were insulated from R20 to R30 with blown insulation. Soffit and ridge vents were the common attic ventilation strategy.

All homes were built over basements. All homes had one floor above the basement. Most basements were half above grade, with concrete block below grade and wood frame with drywall above grade. One basement was entirely wood frame.

All homes had propane-fired forced air heating systems. The furnaces were sealed combustion with an AFUE, or annual fuel utilization efficiency, of 90%. Fresh air intake ducts attached to the high-pressure end of the return ducts were found in two homes. All the water heaters were electric units.
SECTION 3 – FINDINGS

3.1 Exterior Wall/Ceiling Juncture

High indoor relative humidity during the winter combined with a cool interior surface could result in condensation-based mold growth on the cool surface and at the exterior wall/ceiling juncture. This is particularly common on wood frame structures with low-sloped roofs, which tend to restrict the careful placement of ceiling insulation (reducing R-value). Cold winds through the soffit vents exacerbate the problem. Two inspected homes had this condition (Figure 1). Several homes had sufficient space at the perimeter to allow for increased insulation in these locations (Figure 2).

3.2 Bathroom & Kitchen Exhaust Fans; Clothes Dryers

Properly operating and vented exhaust fans and clothes dryers remove moisture from bathrooms and homes. Exhaust fans should vent to the outside. Exhaust fans were found in the main bathrooms of all homes and were ducted to the outside. However, some fans were not moving any air or were not moving the amount desired. The primary cause of poor flow is restrictive ducting in the attic (Figure 3). Dirty fans also contribute to reduced flow (Figure 4).

An exhaust fan flow meter was used to measure actual CFM exhausted by the operable bathroom fans (the fan flow meter does not fit over kitchen exhaust fans). The measured exhaust ranged between 0 CFM and 38 CFM. In addition, the bathroom fans were quite...
noisy. Occupants tend not to use loud fans. Measured CFM flows of the bathroom fans are shown in Table 1.

Table 1: Bathroom Fan CFM

<table>
<thead>
<tr>
<th>Inspection number</th>
<th>Bath Fan CFM Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1</td>
<td>0</td>
</tr>
<tr>
<td>1-2</td>
<td>0</td>
</tr>
<tr>
<td>1-4</td>
<td>26</td>
</tr>
<tr>
<td>1-5</td>
<td>0 (upstairs), 20 (downstairs)</td>
</tr>
<tr>
<td>2-1</td>
<td>35</td>
</tr>
<tr>
<td>2-2</td>
<td>38</td>
</tr>
<tr>
<td>2-3</td>
<td>23</td>
</tr>
<tr>
<td>2-6</td>
<td>0</td>
</tr>
</tbody>
</table>

At a minimum, bathroom exhaust fans should provide a ventilation rate of 70 CFM. None of the bathroom exhaust fans operated at this rate, a problem not unique to the housing stock at Leech Lake but seen in all housing types, regardless of economic strata.

All the kitchen fans vented to the outside, except for one which vented into the kitchen cabinet because of a poor connection to the duct (Figure 5).

The dryer vent in one home was partially disconnected at the termination through the rim joist.

3.3 Attics

Mold was found on the roof sheathing in two homes. One was due to a large bypass above the kitchen cabinets (Figures 6 and 7). The other was due to a prior or existing leak at the ridge vent of the roof over the gabled portion of the home (Figure 8). In Figure 8, note that the bay of sheathing to the left looks fine.
Mold was found on one uninsulated attic hatch (Figure 9). Mold was also found in several homes on the wood in the well around the attic hatch (Figure 10). This indicates that air is bypassing the attic hatch.

3.4 Gutter Systems

Many homes did not have gutter systems (Figure 11). Those that did typically had only partial systems with missing or damaged downspouts and leaders (Figures 12 and 13). Some homes had only a gutter above the front door, acting as a diverter for people at the door. The lack of gutters caused extensive drip lines in the ground beneath the eaves (Figure 14) and contributed to other site drainage problems.
3.5 Site Drainage

Site drainage is critical to maintaining a dry foundation that in turn helps maintain a dry home. Holes and depressions were found adjacent to all the foundations (Figures 15 and 16). Rainwater and snow melt collecting in these depressions contributed to wet foundations. Basement window wells were open, allowing water to collect in them (Figure 17).

At one home the sump pump was discharging above flashing placed over the perimeter insulation on the exterior of the basement, apparently by penetrating through a seam in the flashing (Figure 18) and seeping into the wall, causing mold around the sump pump (Figure 19). At another home the sump pump discharged near the foundation, creating a hole in the soil (Figure 20).

At one recently repaired home mold grew in the basement at several locations about two feet above the floor (Figure 21). The assessment team was informed that drain tile had been installed outside of this home, but not all the way to the bottom of the foundation. Infrared temperature measurements showed that the wall above the mold was at a fairly uniform temperature, but that the temperature dropped off quickly from the mold line to the floor. It is probable that the ground beneath the drain tile was remaining cold and
Figure 18 - Uninsulated rim joist bay.

Figure 16 - Mold on uninsulated rim joist.

Figure 17 - Uncapped filter slot.

Figure 21 - Leaky supply trunk at plenum.

Figure 20 - Partially disconnected supply duct

Figure 19 - Leak in return duct.

wet. The drain tile needs to be re-installed at the base of the foundation.

3.6 Rim Joist Insulation

All homes had one or more uninsulated rim joist bays (Figure 22). These surfaces are cold in the winter and provide an opportunity for enough moisture to enter the wood to cause mold growth (Figure 23). These need to be insulated and sealed such that moist air can not bypass the insulation and reach the rim joist.

3.7 Heating Systems

These homes had propane fired, forced air heating systems. Two problems found with these systems were:

1. Furnace filters located in the return duct were not always properly sized, nor were the filter slots capped (Figure 24). These uncapped filter slots were a hole in the return system drawing air from the basement into the distribution system.

2. There were often other leaks in the return ducts (Figure 25) or the supply ducts (Figures 26 and 27). Return leaks draw basement air into the ducts. Supply leaks can cause comfort problems in other parts of the house due to poor distribution of conditioned air.
3.8 Plumbing

There were a variety of plumbing-related problems noted at the homes. Several homes had sweating pipes (Figure 28) and toilet tanks, which might be caused by a constant flow of water to a toilet or other device that is running continuously, or due to a plumbing leak. Sweating pipes and toilet tanks allow water to drip onto the floor beneath them. In addition to leaving significant quantities of water in the home, this water can penetrate into walls and floors and cause additional damage. At one home the sweating toilet tank in the first floor bathroom had caused damage to the ceiling of the bathroom in the basement (Figure 29) as well as mold around the first floor toilet (Figure 30).

At this same home the sewer stack was not sealed at the roof, allowing water to enter into the wall in the kitchen in which the sewer stack was located. This resulted in deterioration of the kitchen wall.

At one home the drain hose to the washing machine was not well-sealed, allowing water from the washer to leak out onto the basement floor (Figure 31).

SECTION 4 – TECHNICAL RECOMMENDATIONS

The following recommendations are based on the site visit findings.

4.1 Exterior Wall/Ceiling Juncture

Increase the insulation levels at the eaves as much as possible.

4.2. Bathroom & Kitchen Exhaust Fans; Clothes Dryers

Bathrooms and kitchens generate large amounts of moisture. Properly operating exhaust fans help remove moisture from these spaces.

- Correct all ducting problems. Replace plastic ribbed vents with recommended smooth, round sheet metal vents. Minimize long duct length, turns and bends in the ductwork. Smooth ducts

Figure 28 - Condensation on plumbing pipes.

Figure 22 - Mold behind sweating toilet.

Figure 23 - Bathroom ceiling damage due to leak from above.

Figure 31 - Leaky washer drain.
provide less resistance and improve flow over ribbed ductwork. Recommend that occupants regularly clean intake grilles of dust and lint.

- Replace inoperable exhaust fans immediately with fans rated for a minimum 70 CFM at 0.25" of static pressure (the rating provided on the box is generally at 0.10" of static pressure).

- New bathroom fans should have sone ratings no higher than 1.5. Sone is a rating for sound - the lower the sone rating, the quieter the fan. Occupants tend not to use loud fans because of the noise. Low-sone fans include Broan Solitaire and Panasonic WhisperCeiling and WhisperLite series. Low-sone fans generally cost between $75 and $100.

- Replace existing bathroom light/fan switches with fan delay timers. A fan delay timer is a two function switch that is typically wired to a fan and a light. When switched on, both the light and exhaust fan turn on. When switched off, the light turns off but the fan operates for an extended period of time. The extended period of time can be adjusted from 1 to 60 minutes. Fan delay timers cost about $35.

- A 60 minute timer switch may be used when the bathroom fan has a separate on/off switch. Timer switches cost between $15 and $50.

- Periodically inspect all bathroom and kitchen exhaust fan ducts. Ensure that exhaust ducts are vented outside, properly attached and sealed to the exhaust fan housing and to roof vent caps. Repair disconnected ducts.

- Periodically inspect dryer vents. Correct the following conditions:
  - Install a new dryer vent when missing or damaged.
  - Replace crimped or cracked dryer vents.
  - Reconnect disconnected dryer vents.
  - Re-install vents to vent only to the outside of the building.
  - Replace plastic ribbed dryer vents with smooth metal vents.

4.3 Attics

In addition to increasing the insulation levels at the eaves, the following work should be done in the attics.

4.3.1 Air Seal Attic Bypasses
Bypasses are holes and gaps in the ceiling that should be sealed prior to installing attic insulation. Pull the existing attic insulation away from bypasses, seal the bypasses with strong air-barrier materials like plywood, gypsum board or foam sheathing, and put back the insulation. Seal smaller bypasses with expanding foam or caulk. The one significant bypass noted in the Leech Lake homes was the hole over the kitchen cabinets in one home.

Additional information regarding attic bypass sealing may be found in Section 5.3.1; Air Seal Attic Bypasses.

4.3.2 Insulate and Air Seal Attic Hatches

Blocking was found around all the attic hatches. However, one hatch was not insulated and several were not air sealed. Additional information may be found in Section 5.3.2; Insulate and Air Seal Attic Hatches.

- Insulate hatches to R38 but no less than R19.
- Air seal hatches with weatherstripping or gaskets. Provide positive closure with gate hooks or sash locks.

4.4 Gutters

Good gutter systems provide one of the most important methods to control rainwater and move it away from the house. Repair and replace missing gutters, downspouts, leaders, and splash blocks. If there is a concern of vandalism, consider making one connection in the downspouts weaker than others. This will keep repairs to a minimum level of effort.

Given the snow/ice conditions in this region of Minnesota, the following recommendations for a gutter system are provided:

- Do not use plastic gutters. Use minimum 0.027 gauge aluminum gutters. The heavier gauge 0.032 is preferred because of the ice and snow conditions.
- Half-round gutters are least affected by snow and ice (Figure 32). If unavailable or too costly, the K-style gutters may be used (Figure 33).
- Use the heavier versions of the hidden hangers and secure every 18 inches. At a minimum, use the heavier hangers at stress points, such as corners and at downspouts.
- Secure downspouts with 3 fasteners, rather than 2.
• Use 1 downspout for every 40 feet of gutter.

• Use a leaf guard system (See Figure 42 on page 29) to help keep gutters free of debris.

• Use leaders and splash blocks at the base of downspouts to direct water away from the home. Water from downspouts should come out at least 3 feet away from a house that has a crawl space and 5 feet away from homes with basements.

• Use flip-up leaders that may be raised to cut grass (Figures 34 & 35).

4.5 Site Drainage

All eleven homes had site drainage problems. Five basements were damp or wet. Efforts to improve site drainage should include:

• Overall site grading to prevent water from flowing toward the houses.
• Grading directly at the foundation to ensure a soil pitch away from the foundations.
• Fill the holes and dips found adjacent to foundations, even if site drainage work cannot be done or is not planned for the immediate future.
• Make sure that sump pumps discharge well away from the foundation.

4.6 Rim Joist Insulation

Insulate and air seal each rim joist bay to prevent moist basement air from coming into contact with the cold rim joist. Insulate with foam or fiberglass batt insulation and spray foam around the perimeter to provide air-sealing (Figure 36).

4.7 Heating Systems

Four recommendations are made with respect to the heating systems:

1. Use properly fitted filters and change the filters at least once a year.
2. Cap filter slots with metal.

3. Seal holes in the return and supply ducts with either mastic or a high quality metal tape, not duct tape.

4. Reconnect supply boots that have come loose by nailing them to the subfloor through the side of the boot.

4.8 Plumbing

Address the problem of sweating pipes and toilet tanks through three methods: 1) repair leaks or continuously running toilets to stop the constant flow of water, 2) insulate the pipes, and 3) install mixing valves, which add some hot water, warm enough to prevent condensation on the pipes, to the cold water.

At the home with the problem around the sewer stack at the roof, install a roof jack and seal the stack.

At the home with the leaky washing machine drain, the cause of the poor connection of the drain pipe to the washer should be determined and rectified.

SECTION 5 – DISCUSSION OF COMMON PROBLEMS

5.1 Exterior Wall/Ceiling Juncture

High relative humidity and cold surfaces can lead to mold growth. When a surface approaches the dew point temperature, water will condense, be quickly absorbed by the material, and raise the moisture content of the surface. At some point, the moisture content can be sufficient to promote mold growth. This process often occurs at the wall/ceiling junction on exterior walls.

Three reasons for cold exterior wall/ceiling junctures include:

1. The insulation may have been poorly installed resulting in reduced amounts of insulation over the plate.

2. Cold wind may enter through soffit vents and pass through the porous insulation material, degrading its thermal performance.

3. The geometry of the corner usually means that slow-moving currents of warm air may not reach into the corners (Figure 37 on page 24).
Figure 37: Wall-ceiling corners are cold because of 1. Wind movement through soffit vents, 2. Smaller amounts of insulation at the corner and 3. Corner is outside the movement of warm air currents indoors.

The dark spots occur where the interior surfaces are the coldest, because that is the hardest place to insulate effectively, especially in homes with low-pitch roofs. With batt insulation, special pusher sticks may be used to get the insulation out to the edge. With loose fill insulation, the outside edge should be prepared correctly so that it is packed with insulation.

Many individuals and organizations (including model codes) stress the importance of attic ventilation. While it has some benefits, it also has some drawbacks. Wind washing of insulation at the edge is one of the major drawbacks. Designs without attic ventilation may improve the performance of the eave area, and most designs without ventilation relies on verified airtightness of the ceiling plane for good moisture performance. For more information about the benefits and drawbacks of attic ventilation see "Venting of Attics and Cathedral Ceilings". (http://brc.arch.uiuc.edu/billrose/Issues.pdf). Attic vents are, however, recommended for cold climates such as northern Wisconsin to help minimize ice dams. Attic ventilation appeared to be sufficient in these attics.
5.2 Bathroom & Kitchen Exhaust Fans; Clothes Dryers

Bathrooms, kitchens, and laundry rooms are natural moisture sources simply by the nature of their function. Showers result in 100% humidity in bathrooms. Kitchens are used for cooking and cleaning. In laundry rooms, clothes dryers must remove large quantities of water from wet clothes. By removing moisture at the source in these areas, exhaust ventilation serves as a source control strategy. Exhaust ventilation dilutes the moisture and places the room in a negative pressure, thus limiting the spread of moisture to the rest of the house until most of the moisture has been removed to the outside.

Bathroom exhaust fans, kitchen exhaust fans and clothes dryers should always vent to the outside rather than into the living space. Venting to the basement, crawl space and attic can lead to moisture problems occurring in these areas. For this reason, localized exhaust ventilation requires ductwork.

The effectiveness of exhaust fans is based on the power of the exhaust fan, length and type of exhaust duct and cleanliness of the fan grille. When there is excessive resistance in the ductwork, the exhaust fan motor may not be powerful enough to vent sufficient airflow through the duct. The longer the duct length, the greater the static pressure in the duct and the less air flow through the duct. Turns and bends in the ductwork also increase the static pressure and reduce flow. Smooth duct is preferred because it provides less resistance and improved flow over ribbed ductwork. For all types of exhaust ventilation, using round, smooth sheet metal ductwork is recommended. A dirty intake grille will also greatly increase resistance and reduce airflow.

Fan capacity is typically listed at 0.10" and 0.25" of static pressure. Bathroom exhaust fans should provide a minimum ventilation rate of 70 CFM at 0.25" of static pressure. Selecting a fan capacity at 0.10" static pressure is appropriate only if the exhaust duct is smooth, straight (no more than one elbow) and less than 15 feet in length. For example, a bathroom fan with an exhaust ventilation rate of 90 CFM or 100 CFM (at 0.10 inch) may have to be selected to obtain 70 CFM at 0.25 inch of static pressure if there are numerous elbows, the exhaust duct is ribbed and the length is over 15 feet. Fan performance curves should be reviewed to determine ventilation rates at 0.25 inch.

Replace inoperable kitchen exhaust fans whenever possible with venting to the outside. The fans should have a minimum exhaust capacity of 150 CFM. Under no circumstances should recirculating fans be installed in place of the kitchen exhaust fans.

Dryer vents should be smooth-surfaced rigid duct. Non-combustible flexible metal duct approved for dryer venting may also be used. Duct joints should be in the direction of air flow. Ducts should not be fastened with screws or fasteners that extend into the duct. Length of the duct run should be minimized, especially with flexible metal duct. Flexible metal duct should be installed without dips or sags. Dryer vents extending through non-conditioned spaces should be insulated.
Minimum duct diameter should be four inches and length should not exceed 25 feet from the dryer outlet to the termination point. If duct length is greater than 25 feet, use five-inch diameter duct.

Dryer vent caps should have a backdraft damper that closes when the dryer is not being used. Insect screens or small wire cages should not be installed over the vent cap.

5.3 Attics

5.3.1 Air Seal Attic Bypasses

Attic bypasses are holes or gaps in the top floor ceiling that allow warm moist air to move around and through insulation into the attic cavity. Batt or blown insulation will not stop air flow. Energy is lost and ice dams can result. In addition, moisture can condense on the underside of the roof sheathing.

Strong air-barrier materials like plywood, gypsum board or foam insulation board can be used to seal attic bypasses. These materials should be attached with mechanical and/or adhesive bonds.

Some examples of attic bypasses and how to seal them follow:

- **Chimney**: Seal chimney bypass with sheet metal (minimum 28 gauge thickness) and seal to chimney or flue and ceiling structure with high temperature sealant or chimney cement.

- **Soil stacks, plumbing vents, open plumbing walls**: Seal joints with expanding foam or caulk. If joint is too large, stuff with fiberglass insulation and foam over the top. Large openings may also be sealed with insulated foam board or scrap gypsum board (Figure 38).

- **Housing of exhaust fans and recessed lights**: Caulk joints where housing comes in contact with ceiling. Using gypsum board, construct a box around recessed light fixtures to prevent overheating and/or fire. Provide a minimum 3-inch clearance between the box and the sides of the fixture. Construct it to extend four inches above the installed insulation. Cover the box with gypsum board and seal to the sides of the box, but do not cover with insulation. If there is insufficient clearance to install a box 4 inches higher than the insulation, do not cover the box and use an appropriate barrier to keep the insulation 3 inches away from the fixture.

- **Wiring and conduit penetrations**: Seal joint with caulk or low expanding foam.

5.3.2 Insulate and Air Seal Attic Hatches
A non-air sealed attic hatch is another type of bypass. Mold can condense on access hatch blocking if not air sealed (Figure 39).

The hatches should be air sealed with weatherstripping or gasket as shown in Figure 40. Install latches to lock the hatches in place and provide positive closure.

Insulate attic hatches to a minimum of R38 but no less than R19. A lightweight attic hatch may be cut from damaged insulated foam core doors (Figure 41). The door has an R-value about 7. Batt insulation may be attached to the back of the door panel to achieve the desired R-value. The door panel is pre-finished, light-weight and requires no additional painting.

5.4 Gutters

Rainwater and snow melt from the roof should be collected and distributed away from the foundation with a gutter system. Make flashings around chimneys and vents watertight in the following ways:

- Include waterproofing underlayment at the eaves as part of re-roofing to prevent water damage caused by ice dams.

- Gutters can effectively manage rainwater/snow. Pitch the gutters to the downspout. Short gutters may be hung level. In hip roof houses, consider using downspouts only on the downhill side not on the uphill side. In areas with a moderate amount of trees, consider large gutters and downspouts where leaves and debris can be flushed more easily. Make sure the gutters hangers are solid so that they keep the gutter from sagging.

- Secure downspouts to the house, never undersized, but some oversizing is acceptable. Fasten elbows and straight sections together with pop rivets—screws that project into the downspout can lead to clogging.
- At the base of the downspout, the water has to be directed away from the foundation of the building. It should be directed out past the backfill onto the undisturbed soil, which may be 3 feet to 5 feet out from the edge of the house. If it is allowed to dump water close to the foundation, into the backfill, it will concentrate the water next to the foundation. The traditional way to discharge the water away from the house involves using downspout extenders (sections of straight downspout) or splash blocks. Both of these are often disturbed when lawns get mowed. A notched section of downspout that is hinged to the elbow at the base of the downspout can solve this problem. The soil at the base of the downspout should be sloped away from the house at a minimum of 5% slope. Six inches of fall in the first 10' away from the house gives a 5% slope.

- Keeping gutters clean in wooded areas can be a maintenance issue. A gutter guard system can help keep debris out of the gutter, thus minimizing maintenance, while allowing water to drain into the gutter.

Two such gutter guard systems are the PermaFlow Gutter Guard System and the WaterFall Gutter Guard System (Figure 42). These systems cost about $4.50 per 3' section and are designed for a 5" K style gutter (8' sections are sold to contractors).

![Figure 42: PermaFlow Guard System and the WaterFall Gutter Guard System](image)

5.5 Site Drainage

Good site drainage includes managing water that lands on the roof as well as water that lands on the ground. Design and build the roof so water that lands there is moved out to the edge of the roof. When rain falls on a soil surface, some of it will percolate downward through the soil—more in sandy soils and less in clayey soils. The water that does not percolate downward will move along the soil surface following the slope, out to the downhill edge of the site. The best way to prevent mold and moisture problems in houses is to make sure that rainwater moves off the roof, across the site, and off the property. Houses that allow water to accumulate in the soil in contact with the foundation have problems. The soil in contact with the foundation should be the driest soil on the site following a rainstorm. Houses with dry foundations (basements, crawl spaces and slabs)
are usually dry houses. Keeping the foundation dry is the key to a good indoor environment in most houses. To keep the foundation dry, keep the soil dry that is next to the foundation.

Keeping the soil that touches the foundation dry involves a few general rules, together with some specific guidelines:

1. The first general rule is the rule of concentration - damage is worse where greater quantities of water are concentrated. A valley on a roof acts like a funnel, with the greatest concentration of water at the base of the valley. Gutters act like funnels that collect water from the edge of the roof and concentrate it in the downspout. On the land, valleys and swales act like collectors or funnels that concentrate the water on the site. If the water management design makes use of funnels (such as valleys, gutters or swales) then they require maintenance to make sure they work as they are intended. Damage is worst where a valley, gutter or swale is blocked.

2. The second general rule is the ground-roof rule - treat the soil surface as if it were a low-slope roof surface. Pitch the surface away from the house - the steeper the pitch, the better the drainage. Imagine all the water moving to the low edge of the site, and imagine how best to get it there. Avoid areas near the building that can act as water collectors.

Specific site drainage guidelines include:

- Build the house on a crown, not a hole. With sufficient exposed foundation, the site grading at the house can be improved. If the house hugs the ground, improvements at the foundation are more difficult. A minimum of eight inches of exposed foundation should show between the ground and the beginning of the siding.

- Identify localized dips and holes immediately adjacent to the foundation and fill with dirt. Tamp the fill material to prevent future settling. Provide sufficient fill material such that water drains away from the foundation.

- If the house has no gutters or ineffective gutters, then the base of the soil around the house serves as a gutter. The surface should prevent water from splashing onto the siding of the house and should be designed with pitch to effectively move water away from the house.

- Good tamping or compaction of the backfill is very helpful because it helps keep water up on the surface where it can be managed by slope. Soil at the outside corners of the foundation, where the downspouts are usually found, can always be tamped because the corner will never collapse inward.

- Bushes and other plantings may be very helpful, especially if their root balls soak up a lot of water. Also they can be planted strategically near downspouts so that the downspout extenders are less likely to be kicked off or removed during lawn mowing.
5.6 Rim Joist Insulation

The rim joist around the perimeter of the basement can be a weak point in a home’s thermal boundary. Energy savings may be achieved by air sealing and insulating the space between joists and the longitudinal joists. The interior surface temperature of the rim joist is also elevated as a result of this action reducing the potential for condensation on the rim joist.

Two-part spray foam is the most versatile air sealing and insulation system for the rim joist as the spray foam air seals and insulates in one step. Rigid foam board insulation or vinyl faced fiberglass insulation (Figure 43) may also be used; however, the perimeter must be sealed with expanding foam to form the air barrier.

5.7 Heating System

5.7.1 Return Duct Leaks

Leaks in the return air ducts can create negative pressure in the basement. The following leaks in the return air ducts should be sealed:

- Install properly sized filters and cap slot openings.
- Seal panned returns to bottom of joists with duct mastic.
- Seal joints at branch takeoffs with mastic.
- Seal holes with mastic or a high quality metal tape, not duct tape.

5.7.2 Supply Duct Leaks

Leaks in the supply air ducts to the basement can create distribution problems, with conditioned air not getting to all of the rooms in the desired quantities. The following leaks in the supply air ducts should be sealed:

- Seal joints at branch takeoffs with mastic.
- Seal holes with mastic or a high quality metal tape, not duct tape.
- Reattach disconnected boots by nailing them to the subfloor.

Figure 43 - Vinyl faced fiberglass insulation with spray foam
### SUMMARY SITE VISIT REPORT

**DATE:** July 6-8, 2004

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<th>Gutter System Problems</th>
<th>Leaks from Exterior</th>
<th>Wet Basement or Crawl Space</th>
<th>Plumbing Problems</th>
<th>Bathroom Problems</th>
<th>Exhaust Ventilation</th>
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<tr>
<td>1-5</td>
<td>294 Sugar Point Dr NW</td>
<td>LR</td>
<td>18</td>
<td>3</td>
<td>Basement (concrete block + wood hybrid)</td>
<td>Split Level; 2x4 wood frame</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>259 Village Road</td>
<td>MH</td>
<td>20-25</td>
<td>8 or 9</td>
<td>Basement (concrete block + wood hybrid)</td>
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<td>LR</td>
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<td>Vacant</td>
<td>Basement (concrete block + wood hybrid)</td>
<td>Split Level; 2x4 wood frame</td>
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<td>No</td>
<td>No</td>
<td>No</td>
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<td>No</td>
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<td>-</td>
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<td>2-4</td>
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<td>LR</td>
<td>20-25</td>
<td>Vacant</td>
<td>Basement (concrete block + wood hybrid)</td>
<td>Split Level; 2x4 wood frame</td>
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<td>Yes</td>
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<td>13,15,17,18,19</td>
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MH = Mutual Help  TK = Turnkey/Rent to Own  LR = Low Rent
Inspection Number: 1-1
Address: 196 162nd St. NW
Age: 22 years
House Type: Low rent
Occupancy: 3
Bedrooms: 3
Foundation: Concrete block below grade/wood above grade
Heat Type: FA furnace (propane)
Construction: Stick-built, 2” x 4”

Mold and Moisture Conditions: Mold was found in the back of the kitchen cabinet under the sink and on the attic sheathing (Figure 2) above the soffit where the insulation had fallen in. There was evidence of a previous pipe leakage problem, but the pipes were not currently leaking. Cold water pipes in the basement were sweating, dripping water on the floor.

Rainwater Management: Site drainage was mixed. There were several depressions around the foundation, but otherwise the grade was away from the house. There was a gutter on the front of the house, but it had no downspout (Figure 3). This caused a small drip line depression under the end of the gutter. The back of the house had no gutter.

Basement: The basement was dry other than the water from the sweating pipes. The dryer vent was well-connected. The above-grade wood portion of the foundation wall was insulated and covered with drywall. The rim joist was insulated with fiberglass batts, with some bays missing insulation.

Bathroom/Kitchen: There were exhaust fans in both the kitchen and the bathroom. The kitchen fan vented to the outside. The bath fan was ducted to the outside but had no measurable airflow. The ducting for the bath fan was poor, with flex duct attached to PVC pipe that went through the roof. The flex duct had several bends and was attached with large amounts of duct tape (Figure 4).

Attic: The attic was insulated with approximately 10” of insulation. Insulation levels were lower over top plates, especially those sections where insulation

Figure 1 - 196 162nd St. NW
Figure 2 - Mold on roof sheathing
Figure 3 - Gutter with no downspout
Figure 4 - Problematic fan ducting
baffles were used. There was a hole through the insulation into the soffit above the kitchen cabinets (Figure 5). The roof sheathing was in very good shape with no signs of mold except for the sheathing in the bay above the hole in the insulation.

**Heating System:** The forced air system is a propane fired furnace. The propane furnace is a 90% condensing model and is sealed combustion and vented out the side of the basement. The filter slot had no cover. (Figure 6). The water heater is electric.

**Occupant Notes:** Three people had lived in the home for sixteen years. Two were smokers. No respiratory problems were reported.

**Recommendations:**

- Repair bath fan duct.
- Consider replacing bath fan with a low-sone fan with fan delay timer.
- Seal top of kitchen cabinet soffit and reinsulated.
- Clean or replace roof sheathing where moldy.
- Add insulation over top plates.
- Remove fiberglass insulation in rim joist; re-insulate and air seal with rigid foam insulation or spray foam insulation.
- Install gutters with leaders at base of downspouts.
- Fill holes and depressions around foundation.
Inspection Number: 1-2
Address: 184 162nd St. NW
Age: 22 years
House Type: Low rent
Occupancy: 9
Bedrooms: 4
Foundation: Concrete block
Heat Type: FA furnace (propane)
Construction: Stick-built, 2” x 4”

Mold and Moisture Conditions: No mold was found in the home. Remediation of mold problems had occurred previously.

Rainwater Management: Site drainage was mixed. There were several small depressions around the foundation, while the remainder of the site drainage was good. No gutters were present on the home. There were long drip lines under the eaves. There were open window wells, with deteriorating wood-frame windows (Figure 2).

Basement: The basement was dry. There was a lot of clutter on the floor. The dryer vent was partially disconnected from the termination cap. The rim joist was insulated with fiberglass batts.

Bathroom/Kitchen: There were exhaust fans in both the kitchen and the bathroom. The kitchen fan vented to the outside. The bath fan was ducted to the outside with flex duct but had no measurable airflow. The fan was very dirty (Figure 3); after cleaning there was a slight amount of flow.

Attic: The attic was insulated with approximately 10” of fiberglass insulation. Insulation levels were lower over top plates. The roof sheathing was in very good shape with no signs of mold.

Heating System: The forced air system was a propane fired furnace. The furnace was a 90% condensing model and is sealed combustion and vented out the side of the basement. The filter slot was not capped. The water heater was electric.

Occupant Notes: Nine people had lived in the home for 22 years. Two smokers were in the home. One person had a coughing problem that started prior to living in the home, but has gotten worse.
Recommendations:

- Determine cause of impaired bath fan flow and correct the problem.
- Consider replacing bath fan with a low-sone fan with a fan delay timer.
- Increase insulation over top plates.
- Cap the filter slot on the furnace.
- Remove fiberglass insulation in rim joist; re-insulate and air seal with rigid foam insulation or spray foam insulation.
- Install a gutter system with leaders at base of all downspouts.
- Fill holes and depressions around foundation.
Appendix B: Leech Lake Reservation Technical Assessment Report

Inspection Number: 1-3
Address: 254 68th Ave NW
Age: Not available
House Type: Mutual Help
Occupancy: 0
Bedrooms: Not available
Foundation: Concrete block
Heat Type: FA furnace (propane)
Construction: Stick-built, 2” x 4”

Mold and Moisture Conditions: Interior mold and moisture could not be determined because the occupant was not home.

Rainwater Management: Site drainage was mixed. Drainage was good for most of the back of the house, except at the corner where the soil was sandy. At this location the water from the gutters had made a depression in the soil. There were depressions around the foundation on the front of the house. Gutters were present, but had problems. The downspout at the front of the house was broken and caused a large depression at the foundation (Figure 2). One of the downspouts had separated from the gutter, reducing its effectiveness at moving water away from the house (Figure 3). An open window well was noted.

Basement: Basement conditions were not determined. The termination of the dryer vent on the exterior of the house was rusted.

Bathroom/Kitchen: Bathroom/kitchen conditions were not determined.

Attic: Attic conditions were not determined.

Heating System: The forced air system was a propane fired furnace.

Occupant Notes: The assessment team was unable to do an interior inspection because the homeowners were not available. The team completed an exterior assessment only.

Recommendations:

- Repair gutters so that gaps are removed and coverage is complete.
- Replace cracked downspout.
• Install leaders at base of all downspouts.

• Cap open basement window wells along the foundation.

• Install plastic dryer vent on outside, covered with a larger metal cap if necessary to prevent damage.

• Fill holes and depressions around foundation.

Mold and Moisture Conditions: The home had undergone major repairs. The windows on the ground level and the back door had been replaced or repaired. Visible mold was still present in the basement at joint points and pipe insulation.

Foundation: The foundation was dry, but visible mold was present along joints (Figure 3) and pipe insulation. The stepping stones had malfunctioned in the past but were fixed.

Heating System: The forced air system was a propane fired furnace. The propane furnace was a high efficiency model and was sealed combustion and vented out the side of the house. The filter area was not capped. The water heater was electric. The home also had an above air heat exchanger.

Occupants: None. Prior people lived in the home. Two of the occupants were smokers. No respiratory problems were reported. Occupants had lived in the home for five months. Mold seemed more problematic during winter weather, according to one occupant.
Appendix B: Leech Lake Reservation Technical Assessment Report

Inspection Number: 1-4
Address: 166 Pleasant
Age: 20 years
House Type: Low rent
Occupancy: 3
Bedrooms: 2
Foundation: Concrete block
Heat Type: FA furnace (propane)
Construction: Stick-built, 2” x 4”

Mold and Moisture Conditions: The home had undergone major repairs. The windows on the ground level and the back door had had mold were replaced or cleaned. Visible mold was still present in the basement on rim joists and pipe insulation.

Rainwater Management: Site drainage was mixed, generally with grading applied satisfactorily. However, there were numerous holes and depressions around the foundation. A gap between the front porch and the main structure was filled with sand, leaving a pocket where water collected. Gutters were present, but were missing gutter sections, downspouts, and leaders (Figure 2). Open window wells were noted.

Basement: The basement was dry but visible mold was present at rim joists (Figure 3) and pipe insulation. The sump pump had malfunctioned in the past but was fixed.

Bathroom/Kitchen: There were exhaust fans in both the kitchen and the bathroom. The bath fan was ducted to the outside with flex duct and airflow measured at 26 cfm. The kitchen fan vented to the outside.

Attic: The attic was insulated with approximately 10” of fiberglass insulation. The roof sheathing was in good shape with no signs of mold.

Heating System: The forced air system was a propane fired furnace. The propane furnace was a 90% condensing model and was sealed combustion and vented out the side of the basement. The filter slot was not capped. The water heater was electric. The home also had an air-to-air heat exchanger.

Occupant Notes: Three people lived in the home. Two of the occupants were smokers. No respiratory problems were reported. Occupants had lived in the home for five months. Mold seemed more problematic during warmer weather, according to one occupant.
Appendix B: Leech Lake Reservation Technical Assessment Report

Recommendations:

- Install low-sone bathroom exhaust fan in the bathroom with a fan delay timer.
- Re-insulate pipes in basement to prevent condensation.
- Cap open filter slot on furnace.
- Cover open basement window wells along the foundation.
- Remove fiberglass insulation in rim joist; re-insulate and air seal with rigid foam insulation or spray foam insulation.
- Maintain air-to-air heat exchanger.
- Install missing gutter sections, downspouts, leaders, and splash blocks.
- Grade sidewalk and portion of ground next to porch to prevent water from draining towards house.
- Fill holes and depressions around foundation.

Figure A: Mold around water heater.
Figure 1: Damaged wall between toilet and tub.
Figure 2: Mildew behind upstairs toilet.
Figure 3: Damaged ceiling in downstairs bathroom.
Figure 4: Partially disconnected supply duct.
Inspection Number: 1-5  
Address: 294 Sugar Point Dr NW  
Age: 18 years  
House Type: Low rent  
Occupancy: 3  
Bedrooms: 3  
Foundation: Concrete block below grade/wood above grade  
Heat Type: FA furnace (propane)  
Construction: Stick-built, 2" x 4"

**Mold and Moisture Conditions:** Mold was found on the upstairs bathroom ceiling at the location of the joist nails at the exterior wall/ceiling juncture. Mold was also found behind the upstairs toilet (Figure 2), and along the broken towel rack in the upstairs bathroom (Figure 3). The wall between the upstairs toilet and bathtub was damaged (Figure 4). The upstairs toilet tank was sweating. The downstairs bathroom ceiling had significant water damage caused by water from the upstairs bathroom (Figure 5). The downstairs toilet was leaking. Mold was visible in the basement on the wall by the utility sink. There were leaky pipes in the basement.

**Rainwater Management:** Site drainage was poor. There were numerous holes and depressions around the foundation were water was pooling at the drip line. Metal flashing over the exterior perimeter insulation on the foundation of the house was rusty and detached. Insulation was visible below the flashing and soft to the touch. A gutter system was not present.

**Basement:** Other than the leaky pipes, the basement was dry. Mold was present along the basement perimeter, behind the utility sink, and along leaky pipes. Two supply registers were partially disconnected (Figure 6).
**Bathroom/Kitchen:** Bathroom and kitchen exhaust fans were present. The upstairs bathroom exhaust fan had no measurable airflow and the downstairs fan measured approximately 20 cfm. The duct for the upstairs bathroom was found lying in the insulation with no obvious outlet. The upstairs bathroom had mold around the toilet, which had a sweating tank, and at the nails along the exterior wall/ceiling joint above the shower. Mold was also visible along a broken towel rack. The downstairs bathroom had drywall damage around the shower from leaking behind the wall. The toilet was leaking and produced mold behind the tank. The kitchen fan vented to the outside. Bulk moisture damage was visible above the kitchen sink and was probably from a leak around the chimney stack.

**Attic:** The condition of the roof was questionable. Envelope integrity may be compromised above the kitchen around the chimney stack and from an open sewer stack. The attic was insulated with approximately 10" of fiberglass insulation. No mold was visible in the attic. The attic hatch was not insulated.

**Heating System:** The forced air system was a propane fired furnace. The propane furnace was a 90% condensing model and was sealed combustion and vented out the side of the basement. The water heater was electric.

**Occupant Notes:** Three people had lived in the home since 1986. There were no smokers in the home and no respiratory problems were reported.

**Recommendations:**

- Re-install upstairs bathroom exhaust fan duct.
- Consider replacing bath fans with low-sone fans with fan delay timers.
- Repair leaking toilet tank in downstairs bathroom.
- Insulate upstairs toilet tank.
- Repair broken towel rack in upstairs bathroom.
- Repair leaky pipes in basement.
- Insulate pipes.
- Reconnect registers in basement.
- Install gutter system with leaders at base of all downspouts.
- Fill holes and depressions around foundation.
- Repair leak around sewer stack.
- Repair leak around chimney stack.
- Insulate attic hatch.
- Repair metal flashing around exterior perimeter.
- Replace exterior perimeter foam insulation.
- Remove fiberglass insulation in rim joist; re-insulate and air seal with rigid foam insulation or spray foam insulation.

Rainwater Management: Storm drainage was poor. Water was diverting towards the house and was controlled by depressions created by the drop line. There were numerous holes and depressions around the foundation. The building had a rain diverter over the front door but lacked a complete gutter system. A deep drop line followed the perimeter of the house.

Basement: The basement was wet. The foundation was wet (Figure 3) and took moisture into entering the house through the foundation because of poor site grading and deficient sump pump drainage. The sheet metal was systematically being replaced throughout the basement because of bulk moisture damage. Mold was present on rim joists.

Bathroom/Kitchen: The kitchen and bathroom exhaust fans vented to outside. The bath fans had approximately 20 cubic air flow. There was major deterioration under the bathroom sink from a leak that had been fixed. Mold was present behind the toilet it appears that a sink or a vanity tank had been fixed as the floor under the toilet was depressed from moisture damage, but the...
Inspection Number: 2-1
Address: 259 Village Road
Age: 20-25 years
House Type: Mutual Help
Occupancy: 8 or 9
Bedrooms: 4
Foundation: Concrete block below grade/wood above grade
Heat Type: FA furnace (propane)
Construction: Stick-built, 2” x 4”

Mold and Moisture Conditions: This home was undergoing renovation at the time of the site visit. The basement, bathroom, kitchen, and bedrooms all had mold prior to renovation. The sump pump discharge pipe was cracked and was discharging next to the foundation, making a hole in the soil (Figure 2). The bathroom had leakage under the sink and around the toilet. The kitchen previously had leakage under the sink (Figure 3). The windows in the front of the house were leaking and moldy but had been fixed and sheet rock replaced. The basement was wet.

Rainwater Management: Site drainage was poor. Water was draining towards the house and was suspended by depressions created by the drip line. There were numerous holes and depressions around the foundation. The house had a rain diverter over the front door but lacked a complete gutter system. A deep drip line followed the perimeter of the house.

Basement: The basement was wet. The foundation was wet (Figure 4) and bulk moisture was entering the house though the foundation because of poor site grading and deficient sump pump drainage. The sheet rock was systematically being replaced throughout the basement because of bulk moisture damage. Mold was present on rim joists.

Bathroom/Kitchen: The kitchen and bathroom exhaust fans vented to outside. The bath fan had approximately 35 cfm airflow. There was major deterioration under the bathroom sink from a leak that had been fixed. Mold was present behind the toilet. It appears that a leak or a sweaty tank had been fixed as the floor under the toilet was depressed from moisture damage, but the...
Toilet: The kitchen fan vented to the outside. There was evidence of prior leakage in the cabinets under the kitchen sink.

Attic: The attic conditions were not assessed.

Heating System: The forced air system was a propane fired furnace. The furnace was a 90% condensing model and was sealed combustion and vented out the side of the basement. The water heater was electric.

Occupant Notes: It was estimated that eight or nine people occupied the home. The home was vacant when inspected because of the major renovation.

Recommendations:

- Install low-sone bathroom exhaust fan in the main bathroom with fan delay timer.
- Install gutter system with leaders at base of all downspouts.
- Repair cracked sump pump pipe and redirect to move water away from foundation.
- Fill holes and depressions around foundation.
- Improve grade around house to encourage proper drainage.
- Remove fiberglass insulation in rim joist; re-insulate and air seal with rigid foam insulation or spray foam insulation.
Appendix B: Leech Lake Reservation Technical Assessment Report

Inspection Number: 2-2  
Address: 201 Village Road  
Age: 20-25 years  
House Type: Low rent  
Occupancy: 5  
Bedrooms: 2  
Foundation: Concrete block  
Heat Type: FA furnace (propane)  
Construction: Stick-built, 2” x 4”

Mold and Moisture Conditions: Despite recent renovation, the basement was wet and mold was visible about two feet above the floor (Figure 2). There were two separate attics, one over the main, long-axis portion of the home and one over the front, gabled portion. The roof for the main portion of the house had several bays of moldy sheathing, including one bay immediately beneath the ridge of the gabled portion of the home that was very moldy (Figure 3). The roof had been replaced in the last two years and it was not clear whether the moldy sheathing was due to a past or present roof leak. Mold was on the blocking around the attic hatch (Figure 4).

Rainwater Management: The general site grade was acceptable; however, some large depressions were found around the foundation (Figure 5). Gutters and downspouts were present but splash-blocks were missing. The porch was not built all the way to the outside wall of the structure and the sidewalk was sinking towards this point, allowing water to pool at the foundation.

Basement: The basement was wet with a noticeable smell of mold. Drain tile had been placed in the ground around the foundation, but was likely not installed all the way to the base. Water below the drain tile was keeping the ground wet and chilling the inside surface of the concrete block. The wall was colder near the bottom of the wall, with the temperature above the mold line at 66.5°F but dropping off quickly to a temperature at the

Figure 1 - 201 Village Road
Figure 2 - Mold on basement wall.
Figure 3 - Moldy attic sheathing.
Figure 4 - Mold on attic hatch blocking.
Figure 5 - Depression at foundation.
bottom of 62.5°F. The house had no dryer, thus clothes were hung to dry in the basement. A heat recovery ventilator, incorporated into the return side of the furnace, was present to remove moisture from the basement. There was occasional missing insulation in rim joists (Figure 6).

**Bathroom/Kitchen:** Bathroom and kitchen exhaust fans were present. The bathroom exhaust fan was measured at 38 cfm airflow and was vented straight to the outside with flex duct. The kitchen fan vented to the outside.

**Attic:** The attic was insulated with approximately 10 inches of fiberglass insulation. Insulation was unevenly distributed (Figure 7) but appeared to be generally adequate in its coverage. There was extensive mold on attic sheathing, primarily beneath the ridge for the roof over the gabled portion of the home. This location of moldy sheathing suggested a leaky roof, but it was not clear whether the leak was from the previous or current roof.

**Heating System:** The forced air system was a propane fired furnace. The propane furnace was a 90% condensing model and was sealed combustion and vented out the side of the basement. There were several holes in the ducts (Figures 8 and 9), likely from duct cleaning. The water heater was electric. An air-to-air heat exchanger was present. One occupant noted that when the propane runs out, they often opened the oven door to heat the home. This is not a major problem with an electric range, but would be a problem with a gas range.

**Occupant Notes:** Five people had lived in the home for 4-5 years with two smokers. No respiratory problems were reported.

**Recommendations:**

- Re-install drain tile at the base of the foundation.
- Clean mold in basement.
- Seal holes in ducts.
- Remove fiberglass insulation in rim joist; re-insulate and air seal with rigid foam insulation or spray foam insulation.
- Determine whether the current roof over the gabled portion of the home is leaking and repair if necessary.
- Monitor attic for increasing mold growth.
- Clean or replace roof sheathing where moldy.
- Weatherstrip around attic hatch.
- Install a low-sone bathroom exhaust fan with a fan delay timer.
- Maintain the air-to-air heat exchanger.
- Grade sidewalk and portion of ground next to porch to prevent water draining towards house.
- Fill holes and depressions around foundation.
Inspection Number: 2-3
Address: 200 Village Road
Age: 20-25 years
House Type: Low rent
Occupancy: Vacant
Bedrooms: 3
Foundation: Concrete block below grade/wood above grade
Heat Type: FA furnace (propane)
Construction: Stick-built, 2” x 4”

Mold and Moisture Conditions: This home had recently undergone extensive renovation. Some siding was loose on the front exterior of the house. No other mold or potential sources of moisture were noted at the time of inspection.

Rainwater Management: Site drainage was mixed. Some depressions were found around the foundation. The gutter system was satisfactory.

Basement: The basement was dry. The basement was reported to have previously had large amounts of garbage and clutter that were absorbing moisture. Insulation was missing from the a few bays in the rim joist. The dryer vent was open with no dryer present. The moisture load will increase significantly, if clothes are line dried indoors.

Bathroom/Kitchen: Bathroom and kitchen exhaust fans vented to the outside. The bathroom fan was in good condition, measured 23 cfm airflow, and was very dirty. The kitchen fan was not connected properly to the vent duct (Figure 2).

Attic: The attic was insulated with approximately 10” of fiberglass insulation. The insulation was well distributed, all the way to the eaves. A few rafters had old, dormant mold. It is likely that the old rafters were not replaced when the new roof was installed.

Heating System: The forced air system was a propane fired furnace. The propane furnace was a 90% condensing model and was sealed combustion and vented out the side of the basement. The furnace had return air leaks and did not have a cap on the filter slot. The water heater was electric. An air-to-air heat exchanger was present and incorporated into the return side of the furnace (Figure 3).

Occupant Notes: The house was vacant due to extensive rehabilitation.
Appendix B: Leech Lake Reservation Technical Assessment Report

Recommendations:

- Re-attach loose siding to house.
- Remove fiberglass insulation in rim joist; re-insulate and air seal with rigid foam insulation or spray foam insulation.
- Fill holes and depressions around foundation.
- Install low-sone bathroom exhaust fan with fan delay timer.
- Attach kitchen exhaust fan to duct.
- Maintain the air-to-air heat exchanger.
- Seal holes in ducts.
- Cap filter slot.
Inspection Number: 2-4
Address: 175 Bow String River Rd
Age: 20-25 years
House Type: Low rent
Occupancy: Vacant
Bedrooms: N/A
Foundation: Concrete block above grade/wood below grade
Heat Type: FA furnace (propane)
Construction: Stick-built, 2” x 4”

Mold and Moisture Conditions: Mold was found extensively in the foyer, especially along the exterior wall/ceiling junction (Figure 2). Mold was also visible in the basement. Moisture loads in the basement were high due to line drying of very large amounts of clothing (Figure 3) and leaky pipes and appliances.

Rainwater Management: Site drainage was mixed. The grade mostly sloped away from the house, but fill is needed around the foundation at various points to even out the grade. Some depressions were found around the foundation, and a deep drip line was noted in the rear. No gutter system was present.

Basement: The basement was wet. The washing machine had a leak around the drain pipe, which was wet at the time of inspection (Figure 4). Many pipes were exposed and sweating. Insulation was missing in various bays between rim joists (Figure 5). Extensive amounts of wet laundry were being line dried indoors, and the basement also had clutter.

Bathroom/Kitchen: Bathroom and kitchen conditions were not determined.

Attic: The attic conditions were not determined.

Heating System: The forced air system was a propane-fired
furnace. The propane furnace was a 90% condensing model and was sealed combustion and vented out the side of the basement. The furnace filter was completely clogged. Many of the ducts had holes. The main supply trunk was partially disconnected from the plenum (Figure 6). The water heater was electric.

**Occupant Notes:** It was not determined how many occupants lived in the house. No interview was conducted and only an exterior and basement assessment took place.

**Recommendations:**

- Drop and insulate the foyer ceiling.
- Repair leaky appliances.
- Insulate sweating pipes.
- Remove fiberglass insulation in rim joist; re-insulate and air seal with rigid foam insulation or spray foam insulation.
- Install gutter system with leaders at base of all downspouts.
- Fill holes and depressions around foundation.
- Repair holes in ducts.
- Repair connection between main supply trunk and plenum.
- Replace furnace filter.
Mold and Moisture Conditions: Mold was found at the exterior wall/wall juncture in the basement laundry room (Figure 2). It appears that water was entering at the furred-out foundation wall behind the sump pump. It is probable that water is coming in at a seam in the flashing that is located over the below-grade perimeter insulation on the exterior of the building below the sump pump discharge (Figure 3).

Rainwater Management: Site drainage was mixed. Overall, the grade sloped away from the structure. Some depressions were found around the foundation, and were exacerbated by a drip line that circled the house. No gutter system was installed. A rain diverter was mounted above the door with no downspouts or leaders. Metal flashing along base perimeter was rusting. Gaps were apparent between metal strips, exposing rigid exterior foam insulation.

Basement: The basement was mostly dry with the exception of the bulk moisture damage next to the sump pump. A washing machine was present but a dryer was not. The dryer vent was capped.

Bathroom/Kitchen: The kitchen fan vented to the outside. In the past, the kitchen sink has leaked but currently has no problems. The bathroom was not inspected.

Attic: The attic conditions were not determined.

Heating System: The forced air system was a propane fired furnace, a 90% condensing model, sealed combustion and vented out the side of the basement. An outdoor air intake into the return side of the system provided ventilation (Figure 4). This duct was fastened using duct tape and was coming loose. The water heater was electric.
Appendix B: Leech Lake Reservation Technical Assessment Report

Occupant Notes: One person reportedly lived in the home. There were frequent additional visitors.

Recommendations:

- Install a gutter system with leaders at the base of all downspouts.
- Fill holes and depressions around foundation.
- Seal seams in metal flashing.
- Re-attach flex duct outdoor air intake.
- Repair sump pump leak.
Inspector Number: 2-6
Address: 147 Sugar Point Dr
Age: 25-30 years
House Type: Low rent
Occupancy: 4
Bedrooms: 4
Foundation: Wood
Heat Type: FA furnace (propane)
Construction: Modular, 2" x 4"

Mold and Moisture Conditions: Mold was found at the wall/ceiling juncture in two bedrooms (Figure 2). Mold was found around the toilet in the bathroom and on the attic hatch (Figure 3). Mold was noted in the basement (Figure 4). The cold water pipes in the basement were sweating heavily (Figure 5). There was a leak under the utility sink.

Rainwater Management: Site drainage was mixed. The front of the house had an adequate grade to move water away from the house. The sides of the house were relatively flat, and the rear was sloped towards the house. Some depressions were found around the foundation (Figure 6), and a drip line was evident (Figure 7). No gutter system was present.
Appendix B: Leech Lake Reservation Technical Assessment Report

Basement: The basement was wet. Minor plumbing leaks were noted under the utility sink (Figure 8) and at the washing machine hookup. Sweaty pipes ran along the ceiling and dripped water onto the basement floor. The pressure tank was sweaty and parts were uninsulated.

Bathroom/Kitchen: The bathroom exhaust fan vented to the outside. It had no measurable airflow and was dirty. Mold was found behind the toilet. The toilet was sweating, leaking, and unsteady, indicating floor deterioration. The kitchen fan was a re-circulating fan that vented back into the kitchen. The kitchen also had a leak under the sink.

Attic: The attic was insulated with approximately 10" fiberglass insulation. Mold was visible on the attic hatch. Insulation should be better distributed to the corners of the attic to avoid mold in bedroom corners.

Heating System: The forced air system was a propane fired furnace, a 90% condensing model, sealed combustion and vented out the side of the basement. The filter slot was properly capped. The supply trunk line was leaking (Figure 9). The PVC pipe for the furnace combustion air was broken and the duct tape meant to hold it together was coming loose (Figure 10). The exhaust PVC pipe was loosely connected. The water heater is electric.

Occupant Notes: No occupants were available.

Recommendations:

- Insulate attic hatch.
- Distribute insulation to the corners of the attic.
- Replace non-operable bathroom exhaust fan with a low-sone fan controlled by a fan-delay timer.
- Replace kitchen re-circulating fan with a fan that vents to the outside.
• Install gutter system with leaders at base of all downspouts.

• Fill holes and depressions around foundation.

• Insulate pipes.

• Repair plumbing leaks.

• Inspect floor around toilet and replace if necessary.

• Seal supply duct leak.

• Replace cracked PVC pipe.

• Properly reattach PVC pipe.