# NATIVE VILLAGE OF KWINHAGAK
# TRIP REPORT
## Assessment of Mold and Moisture Conditions

**Final Report**

Date:
March 29-April 1, 2004

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Office of Native American Programs

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# PART I

# NATIVE VILLAGE OF KWINHAGAK TRIP REPORT

## INTRODUCTION

Jeff Gordon from the Building Research Council (BRC) at the University of Illinois Urbana-Champaign, and Robert Nemeth of Magna Systems, Inc. conducted a site visit to the Native Village of Kwinhagak on March 30, 2004. David Vought of the HUD Alaska Office of Native American Programs, Ford Kuramoto from Magna Systems, and John Davies from the Cold Climate Housing Research Center, also participated in the site visit. The purpose of the site visit was to provide technical assistance to the Native Village of Kwinhagak in assessing mold and moisture conditions in housing units and to meet with various other groups to discuss mold and moisture issues. This summarizes the site visit. A detailed analysis of the findings and recommendations is found in the attached report, entitled: *Native Village of Kwinhagak Technical Housing Assessment Report: Examining Mold and Moisture Conditions in Kwinhagak Housing.*

## BACKGROUND INFORMATION

The Native Village of Kwinhagak is located on the Kanektok River on the east shore of Kuskokwim Bay, less than a mile from the Bering Sea coast, 71 miles southwest of Bethel, Alaska. Kwinhagak is located in a cold marine climate. Precipitation averages 22 inches, with 43 inches of snowfall annually. Summer temperature medians are in the low 50° Fahrenheit and winter median temperature is slightly below 10° Fahrenheit. Extremes have been measured from 82 to -34 ° Fahrenheit. Five hundred eighty-four American Indian and Alaskan Natives reside in the Kwinhagak Formula Area.

### Day 1: Monday, March 29, 2004

Travel day to Anchorage, Alaska.

### Day 2: Tuesday, March 30, 2004

On Tuesday morning, the assessment team met with David Vought of the HUD Alaska ONAP office, Douglas MacArthur from Aleutian Housing Authority, and Ford Kuramoto from Magna Systems. Housing problems due to site drainage and modifications or replacement of foundation systems were discussed. John Davies from the Cold Climate Housing Research Center (CCHRC) in Fairbanks joined the discussion later in the morning.

In the afternoon the team met with Randy Norman, Modernization Director, and another staff member from the North Pacific Rim Housing Authority in Anchorage, Alaska. The North Pacific Rim Housing Authority is responsible for the Villages located in the Prince

William Sound Region. The team discussed general issues and mold problems that the Housing Authority had in their housing units.

**Day 3: Wednesday, March 31, 2004**

On Wednesday morning the assessment team flew from Anchorage via Bethel to Kwinhagak. Frank Fox, Housing Director, and Walter Johnson, Environmental Program Director, from the Kwinhagak Tribal Council served as guides. After completing five home inspections, the assessment team discussed the initial impressions and findings at a community meeting with approximately forty residents in attendance. In the late afternoon, the assessment team returned by plane to Bethel.

**Day 4: Thursday, April 1, 2004**

The team met on Thursday morning in Bethel with approximately fifteen persons from the Orutsararmuit Native Council (ONC) and AVCP Housing Authority to discuss common moisture problems and potential solutions. After lunch, Bob Angaiak, ONC Housing Administrator, escorted the team to inspect two homes. One house was undergoing renovation at the time of the visit. The assessment team flew back to Anchorage in the late afternoon.

**FINDINGS**

An overview of findings follows:

1. Rainwater intrusion has lead to water damage in exterior walls around the windows and in the floor structures. The two primary contributing conditions were a lack of roof overhang at the eaves and poor installation and flashing at windows.

2. Four houses had significant mold contamination on the walls and ceilings as a result of winter moisture condensation. The fifth house exhibited minor mold contamination from the same cause. Condensation problems were noted in bedroom closets, at the juncture between exterior walls and ceilings, at the floor juncture of exterior walls, on ceilings where insulation was insufficient, and in entryways.

3. All the houses were overcrowded, which increases the moisture levels produced from human sources, contributes to elevated interior moisture loads (interior relative humidity), and, unless controlled, ultimately leads to mold contamination from condensation problems.

4. All the inspected houses had a fuel oil-fired TOYO, a brand name, stove located in the living room at one end of the house. The homes do not have a heat distribution system. This leads to the chilling of surfaces in the rooms furthest

from the heat source, which contributes to condensation-based mold contamination.

5. Thermal bridging (cold air traversing through insufficiently insulated areas) was identified at the top and bottom plates of exterior walls and exterior corners. Air infiltrated the bottom of the exterior walls due to swollen and deteriorating siding. Localized insulation gaps were also apparent at isolated points above interior ceilings and around electrical outlets on exterior walls. All three problems lead to chilled interior surfaces, which can become sites for condensation and mold contamination.

6. The window frames were thermal bridges (insufficiently insulated areas) leading to condensation and mold contamination on windowsills and window frames.

7. The houses had insufficient ventilation to dilute the concentration of moisture and mitigate winter condensation and mold problems.

These findings are discussed in greater detail in the *Native Village of Kwinhagak Technical Housing Assessment Report: Examining Mold and Moisture Conditions in Kwinhagak Tribal Housing.*

# PART II:

# NATIVE VILLAGE OF KWINHAGAK TECHNICAL HOUSING ASSESSMENT REPORT

## EXAMINING MOLD AND MOISTURE CONDITIONS IN HOMES AT THE KWINHAGAK TRIBAL VILLAGE

## EXECUTIVE SUMMARY

The assessment team inspected five homes at the Kwinhagak Tribal Village for moisture and mold conditions. Mold and moisture problems, some severe, were identified at all the homes. The principal findings include:

1. Rainwater intrusion has lead to water damage in exterior walls around the windows and in the floor structures. The two primary contributing conditions were a lack of roof overhang at the eaves and poor installation and flashing at windows.

2. Four houses had significant mold contamination on the walls and ceilings as a result of winter moisture condensation. The fifth house exhibited minor mold contamination from the same cause. Condensation problems were noted in bedroom closets, at the juncture between exterior walls and ceilings, at the floor juncture of exterior walls, on ceilings where insulation was insufficient, and in entryways.

3. All the houses were overcrowded, which increases the moisture levels produced from human sources, contributes to elevated interior moisture loads (interior relative humidity), and, unless controlled, ultimately leads to mold contamination from condensation problems.

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6. The window frames were thermal bridges (insufficiently insulated areas) leading to condensation and mold contamination on windowsills and window frames.

7. The houses had insufficient ventilation to dilute the concentration of moisture and mitigate winter condensation and mold problems.

This report provides technical recommendations and discussion of these items. Appendix A includes a summary of findings from the inspections. Appendix B provides a detailed assessment of each home.

## INTRODUCTION

The assessment team responded to a request from the Alaskan Office of Native American Programs to assess site and housing conditions contributing to mold and moisture problems at the Native Village of Kwinhagak. Jeff Gordon from the Building Research Council (BRC) at the University of Illinois Urbana-Champaign and Robert Nemeth and Ford Kuramato from Magna Systems, Inc. visited and inspected housing units on March 31, 2004. David Vought, HUD ONAP, Alaska Office, and John Davies, Cold Climate Housing Research Center, accompanied the assessment team.

Housing in Kwinhagak consists of 137 occupied housing units and 16 unoccupied units. One hundred and twelve of the units were owner occupied and 25 were renter occupied. Approximately 93% of the housing units lacked complete plumbing systems and about 90% used fuel oil for heating.

## SECTION 1 – METHODOLOGY

### Visual Inspection

Housing inspections consisted primarily of visual assessments of mold and moisture conditions. The team examined all rooms for water damage and evidence of mold. Assessment of kitchens, bathrooms, and utility rooms included additional inspections relating to plumbing, localized ventilation, water entry and other moisture source issues. Housing exteriors were inspected for rainwater and snowmelt management.

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

The team used an infrared sensor to measure surface temperatures of walls and ceilings with visible mold. This measurement identifies potential insulation problems and thermal bridges that contribute to condensation and mold growth.

The spreadsheet in Appendix A compiles results of the mold and moisture assessments by broad categories of common identified moisture problems. The findings from each individual house inspection are presented in Appendix B.

## SECTION 2 – KWINHAGAK HOUSING TYPES

The five investigated houses were one-story, wood framed houses with two or three bedrooms. In most cases the houses were two-part modulars built with 2 x 6 framing in the exterior walls. All house foundations consisted of piles or piers approximately three feet

above grade. An insulated floor plane served as the thermal boundary. The primary heating source were sealed combustion TOYO stoves fired with fuel oil. The homes ranged from the remodeling stage to approximately thirty years old.

## SECTION 3 – FINDINGS

Moderate to severe visible mold contamination was often present in several locations in all the inspected houses. Because mold contamination is always associated with moisture problems, the following findings relate to the moisture problems identified during the site visit. Moisture problems contribute to and can reduce the long-term viability of housing. The team identified a need for a vigorous maintenance and rehabilitation program to secure the future of the existing housing stock. The general findings regarding mold and moisture problems identified during the inspection of the houses at the Kwinhagak Tribal Village follow.

### 1. Rainwater Intrusion/Exterior Envelope

Rainwater intrusion caused water damage in exterior walls around windows and in the floor structures. Rainwater has also degraded the original sheet cladding, particularly at the base of the exterior walls. Two primary contributing conditions are:

- Many houses with no overhang on the roof allow all roof rainwater to drain down the surfaces of the exterior walls. Any hole, void, or unsealed penetration on these walls is vulnerable to water infiltration.
- Windows had either improper or missing flashing, particularly head flashing at the top of the windows.

**Figure 1: No roof overhang, and poorly sealed and flashed windows, has led to water intrusion.**

The combination of these factors resulted in water intrusion and degradation of materials in the exterior walls (Figure 1.)

Section 4.1 discusses rainwater management in more detail.

### 2. Winter Moisture Condensation

Four houses had significant mold contamination on the walls and ceilings due to winter moisture condensation. The fifth house exhibited minor mold contamination for this same reason. Condensation problems were noted in bedroom closets, at the juncture between exterior walls and ceilings, at the floor juncture of exterior walls, on ceilings where insulation was insufficient, around windowsills and frames, and in entryways.

Condensation occurs when moisture-laden air comes in contact with a building surface that is chilled below the dew point of the air. The remaining findings relate to contributing factor of the condensation problems.

Section 4.2 discusses winter condensation issues.

### 3. Overcrowded Conditions

All the inspected houses were overcrowded, which contributed to condensation moisture problems in two ways:

- It increased the moisture loads produced by human sources (respiration, washing, cooking, etc.) and raised the interior dewpoint, thus allowing moisture problems at higher surface temperatures.
- It contributed to the placement of clothing, personal belongings, beds, and other furniture against exterior walls, chilling exterior wall surfaces and increased condensation (Figure 2).

**Figure 2: Clutter causes condensation problems on exterior walls.**

In the inspected houses, the primary moisture sources leading to the condensation problems were human sources.

### 4. Heating Method and Heat Distribution

All the inspected houses used a fuel oil-fired TOYO stove located in the living room at one end of the house (Figure 3). The TOYO stove is a point source heating device without ductwork to distribute warm air. The lack of heat distribution leads to chilling of surfaces in the rooms furthest from the heat source, contributing to condensation-based mold contamination.

**Figure 3: TOYO stoves do not provide heat distribution to all the rooms.**

### 5. Thermal Bridging/Localized Air Infiltration/ Poor Insulation

Thermal bridging was identified at the top and bottom plate of exterior walls and exterior corners. Air infiltration at the bottom of the exterior walls caused swollen and deteriorating siding. Localized insulation gaps were at isolated points above interior ceilings and around electrical outlets on exterior walls. All three problems lead to chilled interior surfaces and become sites for condensation and mold.

### 6. Windows

Most windows were triple-paned, minimizing condensation problems on the glass surfaces. However, the window frames were insufficiently insulated, leading to condensation and mold contamination on the windowsills (Figure 4).


**Figure 4: Condensation and mold on window frames**

### 7. Ventilation

The house had insufficient ventilation to moderate the high moisture loads. All the residences had high interior relative humidity, a major contributing factor to condensation and mold contamination. Whole house ventilation could serve to dilute the concentration of moisture and mitigate the condensation and mold problems.

### 8. Maintenance Issues

The inspected residences suffered from insufficient interior and exterior surface maintenance, including missing drywall, deteriorated exterior cladding, deteriorated floor systems, corroded electrical outlets, and neglected exterior caulking at critical joints.

## SECTION 4 - TECHNICAL DISCUSSION

The following section discusses the two problem categories identified during the site visit to the Kwinhagak Tribal Village: rainwater management on the exterior envelope, and winter condensation problems.

### 4.1 Rainwater Management and the Exterior Envelope

Roofs, foundations and exterior walls are potential sites of bulk water entry. The first line of defense against moisture problems are water resistant and weather tight surfaces of the building envelope: the roof cladding, wall cladding, and foundation. Holes in the exterior envelope allow moisture problems to develop in the building cavities (Figure 5). Because they contain insulation and are sheltered from the drying effects of the sun and wind, building cavities can require a long time to dry. When full drying cannot be achieved between rainfall events, rot and mold may develop, leading to the degradation of building materials and ultimately structural failure. This was noted at several sites.


**Figure 5: Hole in exterior cladding.**

Holes in the exterior cladding can also lead to unwanted air infiltration into the building cavities. In the cold arctic climate of Kwinhagak, this can chill interior surfaces and lead to condensation moisture problems. This problem occurred at the base of the exterior walls where deterioration and swelling of the siding had resulted in gaps around the bottom plate (Figure 6). Waferboard siding was used in many of the Kwinhagak houses. Unfortunately this material is not very water resistant, and swells when wet. Once swollen, the material remains swollen and becomes increasingly porous. Other holes and gaps in exterior cladding were evident in the Kwinhagak houses (Figure 7).

**Figure 6: Deteriorated siding at the base of exterior wall.**

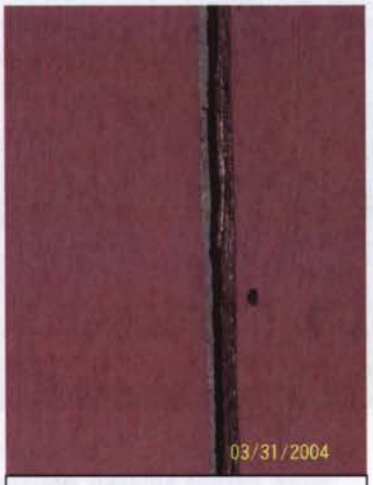


**Figure 7: Gaps in siding,**

Concentrated rainwater can also cause damage. When rainwater flow is concentrated and focused on a void in the exterior envelope, then the potential for serious water damage is magnified. Roofs, for example, concentrate and drain large amounts of rainwater. All that falls on the broad area of the roof flows downward and collects at the eave line. A house that does not shed roof drainage away from the sidewalls magnifies the potential for serious water damage. In this case, the exterior walls must shed significantly more water. Many Kwinhagak houses had no overhang at the eave (Figure 8), thus all the concentrated water from roof drainage flowed down the exterior walls. Any holes or voids in the exterior walls were subject to significant rainwater. Often, these weak points allowed water intrusion to occur at intentional openings such as windows and doors.

When investigating for leaks in the exterior envelope, examine intersections first. On roofs this includes penetrations such as chimneys, vent pipes, dormers, and valleys. Install and maintain flashing to these areas to prevent water intrusion. Flashing consists of metal or waterproof membranes that are installed in the proper order to prevent water intrusion as rainwater drains off a surface. Essentially, flashing is installed shingle-style, with each lower layer tucked under the layer above. The inspections at Kwinhagak did not reveal roofing problems.

As with roofs, exterior walls tend to have water intrusion problems at the intersections: around windows, doors, and other penetrations. These components must be properly installed with flashing which follow the same rules as flashing of root penetrations on roofs.

Install metal flashing or waterproof membranes from the bottom to the top to ensure that water flows down the surfaces away from the building. The *Builder's Guide for Cold Climate*[1] is a good source for window flashing details.

Many examined windows were poorly installed. The windows were calked rather than having properly installed flashing to waterproof. Unfortunately caulking is only a temporary fix which will eventually fail and leak. This situation resulted in water intrusion and water damage around the windows. The lack of an overhang and the concentration of rainwater on the exterior walls compounded the problem. Figure 8 illustrates a poorly repaired window with even more caulking applied to stop further damage from water intrusion.

### 4.2 Winter Condensation Problems

Condensation occurs when moisture-laden air contacts a building surface that is chilled below the dew point of the air. When this happens, the moisture content of the materials at the location increases, potentially up to saturation, and mold grows on the surfaces. This problem indicates a combination of two factors:

1. A house with a high wintertime moisture load (relative humidity).

2. Cold spots - areas of the building that are near or below the dewpoint temperature.

Solving winter condensation and mold problems requires an understanding of these two factors. Relative humidity (RH) is the amount of moisture in the air relative to the temperature of the air. Cold air, especially in the winter can hold very little moisture, while warm air can hold greater amounts. Warm interior air can contain a great deal of water in any season.

**Figure 8: No overhang and poor window flashing caused water damage around several windows.**

In the winter, the amount of moisture in the interior air (RH) depends on how much moisture is being generated inside the house and how much that outside air dilutes that moisture. All buildings have air exchange with the exterior air. If a building has a tight exterior envelope, there may be relatively little air exchange with the exterior. In that case, RH can increase to levels that make condensation problems likely. All theses factors caused condensation on chilled surfaces at Kwinhagak.

The moisture sources that lead to high interior RH typically include:

- Wet foundations.

[1] Lstiburek, Joseph, Bu*ilder's Guide for Cold Climates*, Energy & Enviromental Building Association, 2001. pp. 241-252. www.eeba.org, 952-881-1098

- Human moisture sources.
- Combustion appliances.
- Moisture from bulk water leaks in roofs, cladding, and plumbing.
- Bathroom moisture sources due to high use and lack of localized ventilation.

For the houses inspected in Kwinhagak, the question of moisture source was clear. The houses did not have moisture generating sources such as enclosed foundations, the improperly vented combustion appliances, or bathrooms used for showers. In these houses, the high moisture load came from human sources. People add moisture simply by breathing. Cooking and cleaning also add moisture to the interior. More people in the house introduce more moisture into the indoor air, which makes overcrowding a critical factor in winter condensation problems. Additionally, ventilation systems, which dilute moisture levels, were either missing or not functioning in the inspected houses.

When moist interior air comes in contact with a cold surface, condensation will occur. Cold spots are usually found on the interior surfaces of exterior walls and ceilings. Several things cause a chilled surface:

- Faulty insulation or gaps in the insulation.
- Thermal bridges – areas that are poorly insulated because of structural framing (Figure 9).
- Air infiltration – where cold winter air blows into a building and chills a cavity.

**Figure 9: Thermal bridging at exterior wall/ceiling juncture results in condensation and mold contamination**

- Poor heat distribution – rooms that are cold because they don't receive enough heat.
- Placement of furniture and personal belongings against exterior walls, which chills the wall and prevents warm interior air from reaching the surface.

Relative humidity and surface temperature work together. The colder the surface, the less humidity it takes to cause condensation problems. The warmer the surface, the more humidity it takes to experience condensation. In solving condensation problems, both parts of the problem must be recognized. Solutions will often involve these complementary steps that address both parts:

1. Reduce interior relative humidity (RH) by either: a) identifying and reducing the moisture sources that contribute to the elevated humidity, or b) providing ventilation with drier exterior air to dilute the interior moisture, thus reducing the RH.
2. Warm up the cold spots where condensation occurs. Identify the cause of the chilled surfaces and add insulation, weather sealing, or airflow improvements to reduce or eliminate the chilling of the surfaces.

Adding whole house ventilation can also reduce the moisture load in the house. Ventilation mixes drier exterior air with the moist interior air, thus lowering the humidity level. The exceptionally cold winter climate at the Kwinhagak Tribal Village presents unique conditions for designing a ventilation system. A heat recovery ventilation system is preferred under these conditions. Install and locate fresh air supply ports on the inside of the house, so that occupants do not feel drafts from the supply. Ultimately, the success of whole house ventilation depends on educating the residents to the purpose, control, and maintenance of the system.

Maintaining surface temperatures above the dew point temperature is the second approach to solving condensation problems. As previously indicated, a variety of causes contribute to the creation of cold surfaces. A single, stationary heat source like a wood stove or propane heater dramatically affects the heat distribution in the house. The room with the heating appliance will be warm (and even hot) while the rooms furthest from the heat source will be cooler. The potential for chilled surfaces and mold problems rises dramatically in the cold rooms. If the rooms are particularly cold and the indoor relative humidity is high, condensation can occur most anywhere on exterior walls and ceilings. However, windows, exterior walls of closets, and wall/ceiling junctions on exterior walls have the greatest potential for condensation problems.

A number of steps to warm problem surfaces are outlined in the following section.

## SECTION 5: RECOMMENDATIONS

### 5.1 Exterior Recommendations

Proper exterior renovation can address some existing moisture problems. Three inter-related recommendations associated with an exterior renovation include:

5.1.1 Most of the houses require new siding. A layer of extruded polystyrene (EPS) foam insulation followed by new exterior plywood cladding is advised. This renovation will serve several purposes:

- Eliminate existing holes and water intrusion sites.
- Offer the opportunity to correctly flash around windows.
- Provide additional insulation and eliminate cold spots on the interior.

- Allow access to the sites of current deterioration (primarily around windows and at the base of walls) to perform repairs.

Figure 10 provides a section drawing of the renovation. The EPS foam should extend all the way to the bottom of the walls, covering the bottom plate. It is critical that the assembly at the bottom of wall be sealed to block the air infiltration resulting from the current state of deterioration of the siding. Correctly flashing windows and doors will be equally critical.

5.1.2 Develop and install a boxed roof extension to create an overhang for the houses without roof overhangs. These extensions can be built in 8 feet sections and installed much like casework. Once installed, foam insulation can be blown into the interior of the sections. The roof extensions will serve two purposes:

- Direct the concentrated rainwater from the roof away from the siding.
- Provide extra insulation at the top plate, where condensation and mold contamination is common.

Firmly attaching the roof extensions to the framing of the house to resist uplift pressure from the wind will be critical. Figure 10 provides an illustration of this proposed solution.

For those houses that already have modest overhangs, box the overhangs on the bottom, to create a fairly deep soffit, and use blown-in foam to provide additional insulation outside of the top plate. Both the retrofit roof extension and the foam insulation address the thermal bridge condition at the top plate.

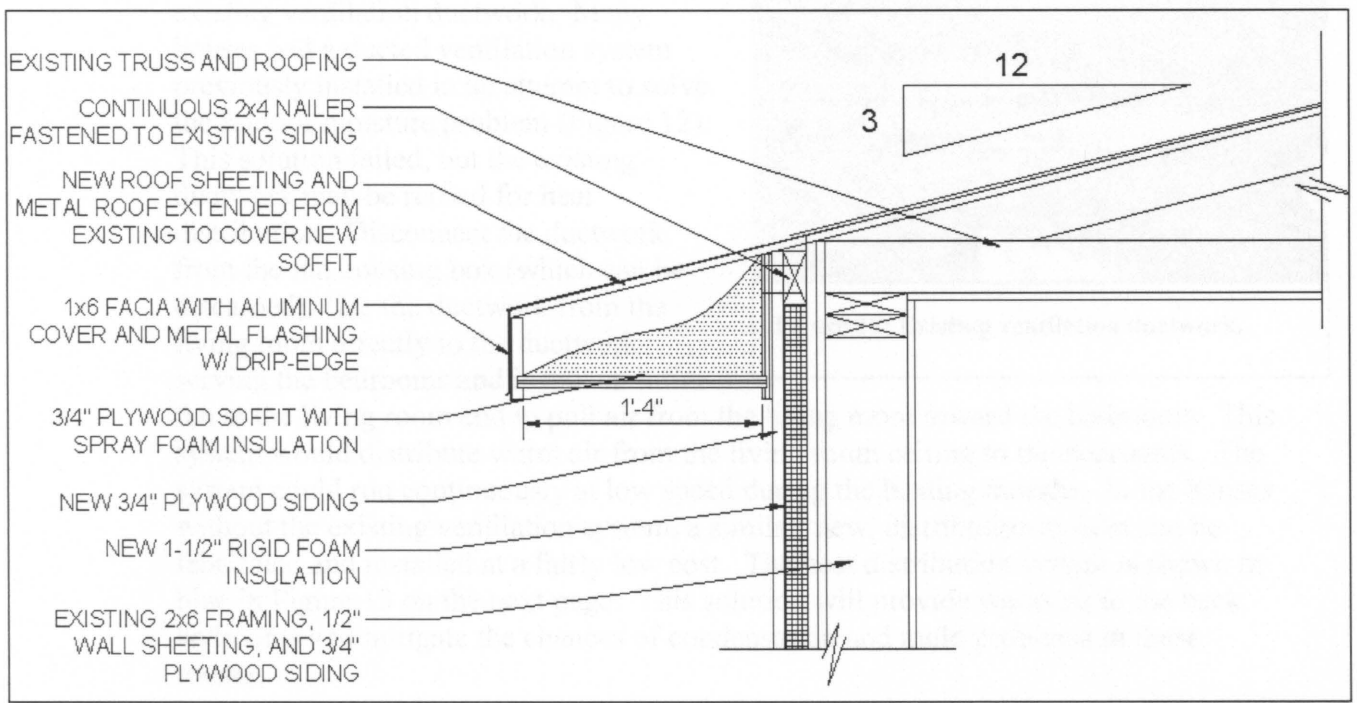


**Figure 10: Retrofit roof overhang and exterior renovation**

5.1.3 Replace or thermally protect the windows to prevent condensation on the window frames. Condensation occurs on the frames (rather than the glazing) of the existing triple glazed windows (Figure 11). Two options for addressing this are:

- Replace the windows during the exterior renovation.
- Detail the exterior renovation to wrap the EPS foam back to the window frames, providing the additional needed insulation.

**Figure 11: Ice on interior window indicate thermal bridging at the frames.**

Option 1 is the safest approach, but likely the most expensive. Option 2 would salvage the existing windows, but would require great care in detailing and execution. Replacement windows should be triple-paned with frames designed and insulated to prevent condensation under the winter conditions at Kwinhagak.

## 5.2 Interior Recommendations

No physical recommendation exists to deal with overcrowding. However, ventilation of the interiors with exterior air would reduce interior moisture levels. The following interior recommendations deal with heat distribution, whole house ventilation, and attic insulation.

5.2.1 Provide better heat distribution using the existing ventilation ductwork. Many houses had a ducted ventilation system previously installed in an attempt to solve the interior moisture problem (Figure 12). This solution failed, but the existing ductwork may be reused for heat distribution. Disconnect the ductwork from the fan housing box (which can be discarded). Tie the ductwork from the living room directly to the ductwork serving the bedrooms and install an inline fan at the living room end to pull air from the living room toward the bedrooms. This system would distribute warm air from the living room ceiling to the bedrooms. The system could run continuously at low speed during the heating months. In the houses without the existing ventilation system, a similar, new, distribution system can be fabricated and installed at a fairly low cost. The heat distribution system is shown in blue in Figure 13 on the next page. This solution will provide warm air to the back bedrooms and mitigate the chances of condensation and mold problems in these rooms.

**Figure 12: Existing ventilation ductwork.**

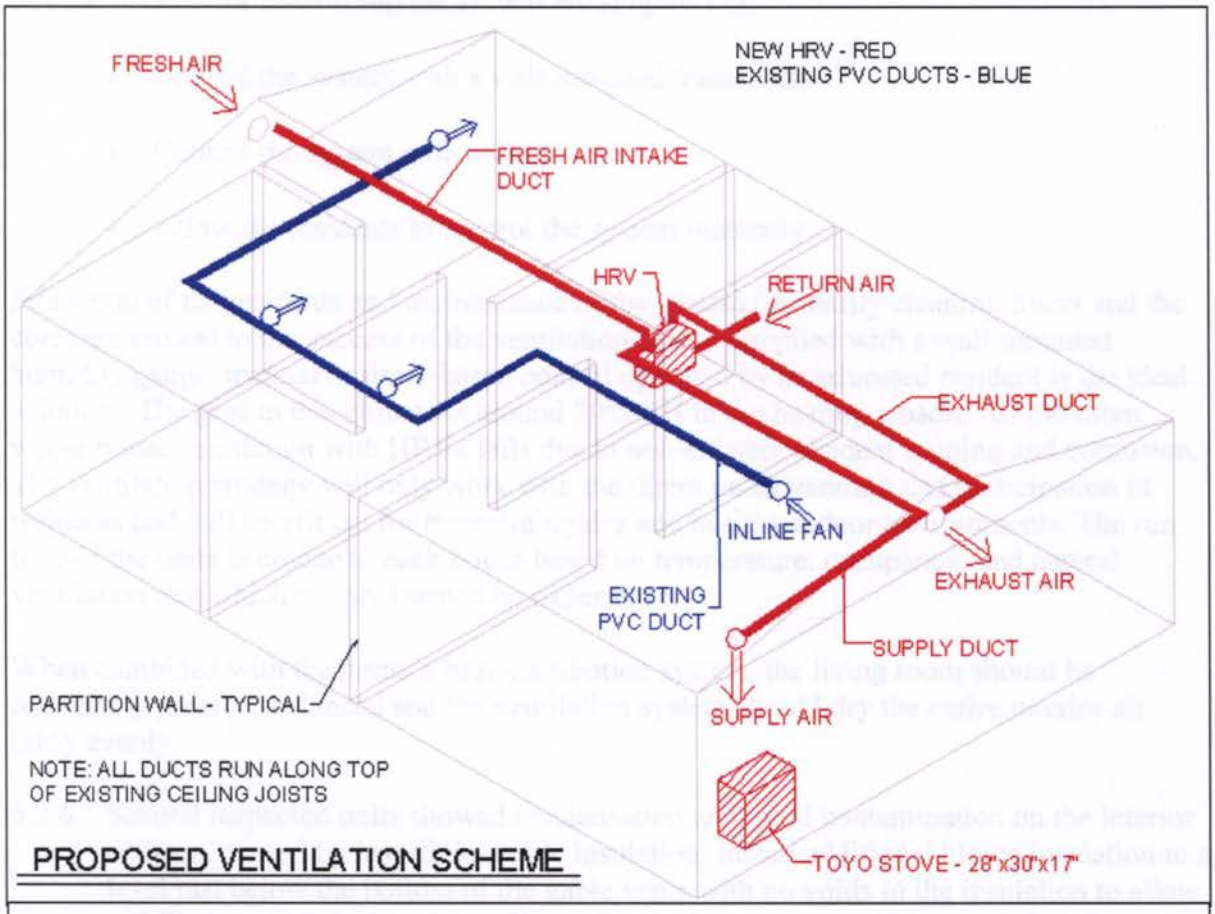


**Figure 13: Ventilation Plan**

5.2.2 Install a new system to provide whole house ventilation. Given the severity of the climate, a system with heat recovery is advised. The following details of a new ventilation system have been developed to be as simple as possible while responding to the realities of the climate.

5.2.3 Install a small air-to-air heat exchanger (HRV) on the shelf replacing the existing ventilation unit. Given the size of the houses, a large capacity is not necessary. The heat recovery unit should have an adequate defrosting cycle for the climate. A condensation tube will be required.

5.2.4 Locate the return inlet in the bathroom, adjacent to the HRV unit. Locate one supply grille in the ceiling directly above the TOYO stove in the living room. This location should limit uncomfortable drafts on residents, while quickly heating the supply air.

5.2.5 Run the supply and exhaust ducts on the bottom chord of the roof trusses, buried, as much as possible, in blown insulation. Locate the exterior grilles at the gable ends and boxed in, as is common with gable vents in this region.

Several options for controlling the system are (Figure 13):

- Control the system with a wall mounted humidistat.
- Control the system with a timer.
- Allow the residents to control the system manually.

Education of the residents and maintenance of the system (primarily cleaning filters and the core) are critical to the success of the ventilation plan. Supplied with a wall-mounted humidity gauge, manual or timer-based control operated by an educated resident is the ideal solution. The goal in this climate is around 30% RH in the heating season. All too often, whole house ventilation with HRVs fails due to non-existent resident training and confusion. The ventilation strategy will only work with the direct understanding and participation of residents and will be critical for maintaining dry and healthy indoor environments. The run time of the units is unique to each house based on temperature, occupancy, and natural ventilation rate which is only learned by experience.

When combined with the home's heat distribution system, the living room should be reasonably pressure balanced and the ventilation system should dry the entire interior air fairly evenly.

5.2.6 Several inspected units showed condensation and mold contamination on the interior ceilings, caused by insufficient attic insulation. Install additional blown insulation to a level just below the bottom of the gable vents with no voids in the insulation to allow a chilled spot on the interior ceilings. Particular attention will be needed at the center of the modular houses, where the two house sections were joined.

5.2.7 Maintain basic maintenance and cleanup on the interiors where existing mold and moisture damage has occurred. Repair and replace drywall. Repair water damaged electrical outlets (Figure 14). Mold cleanup should follow the New York City Department of Health's *Guidelines on Assessment and Remediation of Fungi in Indoor Environments*.[2] Regularly maintain the TOYO stoves to ensure no spillage of flue gases into the house. A major byproduct of combustion is water vapor. If a combustion appliance is improperly vented, or not vented at all, the heating system can contribute enormous amounts of moisture into the interior air. Carbon monoxide, another by product of combustion, is a critical health concern.

**Figure 14: Water damage at base of exterior wall and the electrical outlet.**

[2] http://www.ci.nyc.ny.us/html/doh/html/epi/moldrpt1.html

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inspection Number | Address | HUD Program | Building Age | Occ. | Foundation Type | Model and Framing Type | Heat Type | Site Drainage Problems | Gutter System Problems | Leaks from Exterior | Ceiling Condensation | Window Condensation | Bottom Plate Condensation | Exhaust Ventilation | Wall to ceiling problems | Attic Problems | Visible Mold |
| 1-1 | N/A | NA | ~30 | 9 | Pier | Wood Frame | TOYO Stove | No | No Gutters | Yes | Yes | Yes | Yes | None | Yes | Not accessible | 12,13,14,16 |
| 1-2 | N/A | NA | ~30 | 7 | Pier | Wood Frame | TOYO Stove | No | No Gutters | Yes | Yes | Yes | Yes | None | Yes | Not accessible | 12,13,14,16 |
| 1-3 | N/A | NA | ~30 | 7 | Pier | Wood Frame | TOYO Stove | No | Partial Gutter System | Yes | Yes | Yes | Yes | None | Yes | Not accessible | 12,13,14,16 |
| 1-4 | N/A | NA | ~30 | 7 | Pier | Wood Frame | TOYO Stove | No | No Gutters | Yes | Yes | Yes | Yes | None | Yes | Not accessible | 12,13,14,16 |
| 1-5 | N/A | NA | ~30 | 6 to 15 | Pier | Wood Frame | TOYO Stove | No | Partial Gutter System | Yes | Yes | Yes | Yes | None | Yes | Not accessible | 12,13,14,16 |

**Inspection Number:** 1-1
**Address:** On the Tundra
**Type:** Frame one-story
**Foundation**: piers
**Heat Type:** TOYO Stove
**Bedrooms:** Three
**Occupancy:** 9 occupants
**Age:** Approximately 30 years
**Attic:** Not accessible

Figure 1: Exterior

**Mold and Moisture Conditions:** Many areas in this home had mold; at the entry door (Figure 2), at the wall to ceiling junction (Figure 3), at the base of walls (Figure 4), areas surrounding window sashes (Figure 5), and where the stove pipe penetrated the ceiling (Figure 6).

Figure 2: Mold at entry door

Figure 3: Mold at the bedroom wall to ceiling corner

**Site Drainage and Rainwater Management:** Site drainage was not an issue since the house was positioned approximately four feet above grade. However, rainwater management was an issue with the lack of roof overhangs and the improper installation of windows in the walls. The lack of overhangs allowed water to drain off the roof directly down the face of walls. This necessitated a water-tight seal between the roof and wall interface. Based on observation, this seal was probably not watertight and water entered walls at this junction. All the windows were missing flashing at the head of the window allowing water infiltration into walls. Heavy condensation and water leakage from the exterior caused the deterioration of interior walls and jambs around windows.

Figure 4: Mold at the bedroom base of exterior wall

Figure 5: Window sill mold and wall deterioration

Figure 6: Stove pipe at ceiling

**Foundation Conditions:** This home was situated on piles projecting approximately four feet from grade. Exposing the bottom side of the building platform necessitated that it be well insulated and sealed. Air leaked from either the interior or exterior into the platform cavity resulted in accelerated deterioration of platform components and interior condensation problems.

**Figure 7: Bathtub storage**

**Bathrooms:** The bathtub in this house primarily functioned as a storage area (Figure 7). The subfloor next to the right front corner of the toilet was completely rotted through (Figure 8). The rotted area was immediately adjadent to a ventilation duct that had been installed in the late 1990's. This supply duct had become so cold during the winter months that condensation formed on the pipe, collected on the floor, and eventually rotted out the subfloor. The vanity had a bucket beneath the drain of sink (Figure 9).

**Figure 8: Hole through floor**

**Figure 9: Bucket beneath vanity**

**Kitchen:** The range hood was ducted to the exterior but due to cold air infiltration through the exhaust duct, the duct was packed with insulation leaving the range hood inoperable. A wood stove directly next to the range had mold and water problems where the stove pipe penetrated the ceiling.

**Bedrooms and Living Spaces:** Several areas had mold in the bedroom and living spaces. Heavy window coverings, used to reduce the drafts coming off the windows, contributed to moisture problems at windows. Most windows had condensation on their surfaces and mold growing around the perimeter, particularly at the bottom of the window and on the sill where the condensation collected and was heaviest. On the wall next to one bedroom window deterioration had occurred.

**Figure 10: TOYO Heater**

Near the base of walls, particularly where furniture and beds were placed against exterior walls, were significant moldy areas. The interior temperature was 72° F. and the areas at the base of wall ranged from 51° to 54° F and the temperature at the wall to ceiling junction measured 57° in the field and 51° at the outside corner.

**Attic:** The attic was not accessible.

**Mechanical Systems:** The primary heating system for the home was a free standing TOYO heater in the living room which burned #1 fuel oil (Figure 10) but there was no heat distribution system. An additional ventilation system installed in many houses in the late

1990's was a Fresh Air system (Figure 11 and 12). The system brought in outside air, mixed it with interior air, and distributed the mixed air around the house. The system was not used because the residents said it introduced very cold air. The intake duct was covered with insulation and duct-taped shut (Figure 13).


**Figure 11: Fresh air system**

**Occupant Notes:** Nine family members lived in this three bedroom house.

**Discussion / Recommendations:**

Institute several physical and mechanical retrofits at the same time the repairs are made to the home.

**On the Exterior:**

1. Renovate the exterior renovation of the house. See Part II, Section 5.1.1.
2. Install additional insulation, reside the house, and then attach an insulated overhang to the wall. Pack the perimeter of the attic along the base of the truss as full as possible with insulation. See Part II, Section 5.1.2 .
3. Replace the metal frame windows and install window flashing. Research replacement window types by contacting the Cold Climate Housing Research Center in Fairbanks Alaska for assistance. See Part II, Section 5.1.3.
4. Seal the underside of the building platform to make it airtight. Cold air leaking into the joist spaces cools the floor surface leading to condensation at those points. Seal all penetrations with spray foam to make them airtight and any piping penetrating from below needs a thermal break to keep conduction losses at a minimum.


**Figure 12: Interior of fresh air filter**

**Figure 13: Covered fresh air supply**

**On the Interior:**

Resolve the root source of the damage to the drywall at several locations. Remove and replace the drywall.

1. Reconfigure the Fresh Air ventilation system to draw air from the heated living area and then distribute this warm air to other rooms of the house. See Part II, Section 5.2.1.

2. Install a ventilation system to dilute interior winter moisture loads. See Part II,Section 5.2.2.

3. Remove the fresh air supply pipe penetrating the platform of the building, fill this void full of insulation, and seal the hole from both above and below. Repair the rotted floor next to the toilet at the same time.

4. Increase attic insulation. See Part II, Section 5.2.6.

5. Clean moldy areas in accordance with the NYC Department of Health Guidelines. Repaint if necessary. Remove and replace all drywall covered with heavy mold or badly deteriorated. Inspect and repair areas inside the wall as necessary before replacing interior cladding. Maintain the continuity of the vapor barrier.

6. Duct the kitchen exhaust fan out the side wall and install an outlet with a damper that provides a positive seal.

7. Remove the wood stove and seal all the stove pipe penetrations, if the resident is not using it. Inspect the flashing, if the stove is to remain. The damage to the ceiling surrounding the stove pipe could be due to flashing leaks or condensation occurring on the pipe in the attic which then runs down the pipe and saturates the ceiling.

8. Make residents aware that placing clothing and furniture against outside walls can precipitate moisture problems. Due to the high occupancy rate of these small residences and scarcity of storage space, clothes, boxes of goods, and miscellaneous personal items are often stored against walls. Resolving important moisture source issues are as critical as solving the construction deficiencies.

9. Educate residents how to prevent mold problems. Keep all surfaces clean and dry. The use of heavy window drapes may keep uncomfortable drafts from occurring, but the residents must ensure that window sills are free of standing water and the sashes are clean and dry.

**Inspection Number:** 1-2
**Address:** On the Tundra
**Type:** Frame one-story
**Foundation**: piers
**Heat Type:** TOYO Stove
**Bedrooms:** Three
**Occupancy:** 7 occupants
**Age:** Approximately 30 years
**Attic:** Not accessible

**Figure 1: Exterior On the Tundra**

**Mold and Moisture Conditions:** A number of areas had mold; at the entry door (Figure 2), several areas at the wall to ceiling junction (Figure 3, 4 & 5), at the base of walls (Figure 6), areas surrounding window sashes, and areas surrounding some of the electrical receptacles.


**Figure 2: Mold at the front entry door**

**Figure 3: Wall to ceiling mold**

**Figure 4: Interior wall to ceiling mold**

**Figure 5: Mold at wall to ceiling iuncture at truss bearing locations**

**Site Drainage and Rainwater Management:** Site drainage was not an issue since this house was positioned approximately four feet above grade. However, rainwater management was an issue due to the lack of roof overhangs and the improper installation of windows in walls. The lack of overhangs allowed water to drain off of the roof directly down the face of walls. The seal between the roof and wall interface was probably not watertight, allowing water to enter walls at this junction. All the windows were missing flashing at the head of the window allowing water infiltration into walls. The deterioration of interior walls and jambs around windows is probably due to a combination of heavy condensation and water leaking in from the exterior (Figure 7 & 8).

**Figure 6: Mold at wall base**

**Figure 7: Missing drywall & hole in floor next to wall**


**Figure 8: Moldy window sill**

**Foundation Conditions:** This home was situated on top of piles projecting approximately four feet from grade. Exposing the bottom side of the building platform necessitated that it be well insulated and sealed. Air leaks from either the interior or exterior into the platform cavity resulted in accelerated deterioration of platform components. Penetrations through the platform were not well sealed (Figure 9).

**Figure 9: Penetrations through platform**

**Bathrooms:** The bathtub area was instead a huge water tank. Investigators assumed this was for domestic kitchen and vanity use. The bathroom had no toilet. The location where the plumbing vent stack had penetrated the ceiling and roof was open to the sky (Figure 10).

**Figure 10: Vent open to sky**

**Bedrooms and Living Spaces:** Several areas in the bedroom and living spaces had mold. Heavy window coverings, used to reduce the drafts coming off windows, contributed to moisture problems at the windows. Most windows had condensation on their surfaces and mold growing around the perimeter, particularly at the bottom of the window and on the sill where the condensation collected and was heaviest. Beneath one bedroom window extending to and including the floor was significant wall deterioration. Also approximately a six inch by two foot long section of subfloor had completely rotted away beneath the window, probably due to more than just heavy condensation. Leakage of water into the wall system from improperly installed windows had more than likely contributed to this damage.

Areas near the base of walls, particularly where furniture and beds were placed against exterior walls had significant moldy areas. Wall to ceiling mold occurred not only along the perimeter of the structure, but also at certain interior areas. The surface temperature at this interior moldy wall to ceiling junctions was 48° F.

**Figure 11: Fresh air vent outlet**

**Attic:** The attic was not accessible.

**Mechanical Systems:** The primary heating system for the home was a free standing TOYO heater in the living room which burned #1 fuel oil located. No heat distribution system was in the home. An additional ventilation system installed in many of the houses in the late 1990's was a Fresh Air system which brought in outside air, mixed it with interior air, and distributed the mixed air around the house. This system was currently not in use. What was assumed to be the intake duct for the system was open to the environment beneath the platform (Figure 11). Note the openings around the pipe and adjacent penetrations that would allow cold air into the floor system.

**Electrical System:** The electrical system metal outlet boxes projecting into the walls allowed little space for insulation on their backside. The boxes got so cold that moisture condensed on their surfaces and deteriorated the receptacle itself and the surrounding drywall (Figure 12).

**Figure 12: Nonfunctioning outlet and a hole in the floor due to moisture**

**Occupant Notes:** Seven family members lived in this three bedroom house.

**Discussion / Recommendations:**

Institute several physical and mechanical retrofits at the same time repairs are made to this home.

**On the Exterior:**

1. An exterior renovation of the house is recommended. See Part II, Section 5.1.1.
2. Install insulation, reside the house, and then attach an insulated overhang to the wall. Pack the attic perimeter along the base of the truss as full as possible with insulation. See Part II, Section 5.1. 2.
3. Replace the metal frame windows and install window flashing. Research the replacement window type by contacting the Cold Climate Housing Research Center in Fairbanks Alaska for assistance. See Part II, Section 5.1.3.
4. Seal the underside of the building platform to make it airtight. Cold air leaking into the joist spaces cools the floor surface above which then leads to condensation at those points. Seal all penetrations with spray foam to make them airtight and any piping that penetrates from below needs to have a thermal break to keep conduction losses at a minimum.

**On the Interior:**

Resolve the root source of the drywall damage. Remove and replace drywall.

1. Reconfigure the Fresh Air ventilation system to draw air from the heated living area and then distribute this warm air to the other rooms. See Part II, Section 5.2.1.
2. Provide a ventilation system to dilute interior winter moisture loads. See Part II, Section 5.2.2.
3. Remove the fresh air supply pipe penetrating the platform of the building, fill this void full of insulation, and seal the hole from both above and below. Repair the rotted floor next to the toilet at the same time.
4. Increase attic insulation. See Part II, Section 5.2.6.

5. Clean moldy areas in accordance with the NYC Department of Health Guidelines. Repaint if necessary. Remove and replace all drywall covered with heavy mold or badly deteriorated. Inspect and repair areas inside the wall as necessary before replacing interior cladding. Maintain the continuity of the vapor barrier.

6. Duct the kitchen exhaust fan out the side wall and install an outlet with a damper that provides a positive seal.

7. Remove the abandoned vent in the bathroom ceiling and seal the hole. The metal pipe conducted warm air and moisture out of the residence. Above the insulation, the moisture condensed and froze on the interior of the pipe, slowly melting as warm air passed over it, and then dripped back down into the bathroom. Having this open hole in the ceiling to the exterior acted as a chimney and caused air infiltration problems.

8. Educate residents that placing clothes and furniture against outside walls can precipitate problems. Due to the high occupancy rate in these small residences and scarcity of storage space, clothes, goods, and miscellaneous personal items are stored everywhere. Boxes and clothes are commonly stacked against walls. Resolving critical issues as this are as important as solving the construction deficiencies.

9. Inform residents how to prevent mold problems. Keep surfaces clean and dry. Heavy window drapes may be keep uncomfortable drafts from occurring, but ensure window sills do not have standing water on them. Keep window sashes clean and dry.

**Inspection Number:** 1-3
**Address:** On the Tundra
**Type:** Frame one-story
**Foundation**: Piers
**Heat Type:** TOYO Stove
**Bedrooms:** Three
**Occupancy:** 7 occupants
**Age:** Approximately 30 years
**Attic:** Not accessible


**Figure 1: Exterior On the Tundra**

**Mold and Moisture Conditions:** Several areas of this home have mold; at the entry door (Figure 2), areas at the wall to ceiling junction (Figure 3 & 6), at the attic hatch (Figure 4), and at several areas surrounding window sashes (Figure 5).

**Figure 2: Mold at entry door ceiling**

**Site Drainage and Rainwater Management:** This home had overhangs and plastic gutters. The gutters were used for harvesting rainwater and did not impact the rainwater management of the site.

**Foundation Conditions:** This home was situated on top of piles projecting approximately one and a half feet from grade. Exposing the bottom side of the building platform required good insulation and seals to prevent air leaks from either the interior or exterior into the platform cavity that accelerate deterioration of the platform components. The interior air temperature was 72° F, the floor surface temperature was 67° F in the center of the home, and 52° F at the perimeter.

**Figure 3: Mold at bedroom wall to ceiling junction**

**Bathroom:** The bathroom was used as a closet.

**Kitchen:** No range hood was installed in the kitchen.

**Bedrooms and Living Spaces:** Several areas in the bedroom and living spaces had mold. All the windows had condensation on their surfaces and mold growing around the perimeter, particularly at the bottom of the window and on the sill where the condensation collected heaviest (Figure 4). Two north windows had a significant amount of ice and water buildup at the base of the glass to sash junction (Figure 5). This house had double pane windows which allowed ice buildup at the bottom of the glazing.

**Figure 4: Mold at attic access hatch**

**Figure 5: Ice and water on window sill**

Wall to ceiling mold was present along the perimeter of the house. The interior air temperature was 72° F and the surface temperature at moldy wall to ceiling junctions ranged from 47° F to 50° F (Figure 6).


**Figure 6: Cold exterior corner**

A large plastic container partially filled with water stood in the hallway (Figure 7), appearing to be the households' primary water source.

**Attic:** The non-accessible attic was in one bedroom and had mold along one edge.

**Mechanical Systems:** The primary heating system located in the living room was a free standing TOYO heater which burned #1 fuel oil. There was no heat distribution system.

**Occupant Notes:** Seven family members lived in this three bedroom house.

**Figure 7: Bucket with water in hallway**

**Figure 8: Looking up through abandoned stove pipe**

**Discussion / Recommendations:**

**On the Exterior:**

1. The exterior of this plywood sided home was in good condition. The advantage of renovation would be the additional insulation over the walls, particularly in the areas of the top and bottom plates. Following the interior recommendations listed below regarding heat distribution and ventilation may solve the condensation problems without additional exterior insulation. In that case, lightly sand and repaint the siding and trim. Maintain the siding to increase its service life. Sand, prime and paint the fascia or cover it with metal flashing.

2. Replace the windows before further damage to the structure occurs. Severe rot will occur at the window sills and jambs, eventually migrating further into the wall framing. Research the type of replacement window carefully. Contact the Cold Climate Housing Research Center in Fairbanks Alaska for assistance in this task. The team suggests a triple pane window with an insulated vinyl jamb. Install the new windows following the manufacturer's recommendations. Install flashing at the top of the window units to keep water out of walls.

3. Inspect the floor framing, insulation, and airtightness of the floor assembly. Insulate and weatherseal as required to reduce chilling of the floor surfaces.

**On the Interior:**

The painted plywood ceilings and paneling on the walls of this home have fared better than drywall.

1. Develop a heat distribution system to draw air from the heated living area and then distribute this warm air to other rooms of the house. See Part II, Section 5.21.
2. Provide a ventilation system to dilute interior winter moisture loads. See Part II, Section 5.2.2.
3. Increase attic insulation. See Part II, Section 5.2.6.
4. Improve the conditions around the abandoned stove pipe capped with a plastic bucket. Dry it out, fill with approximately 18 inches of fiberglass insulation, seal well from below to keep moist air from migrating up into the pipe, and replace the bucket with a metal cap sealed tightly to the stove pipe.
5. Clean, repair, or replace the window sills, jambs, and window trim when replacing the windows.
6. Add more insulation to the attic hatch, since mold had formed along one edge of the hatch. Glue several layers of rigid insulation to the top side of the hatch and thoroughly seal the perimeter of the hatch. Any voids in the insulation or seal will promote mold.
7. Clean moldy areas in accordance with the NYC Department of Health Guidelines. Repaint if necessary.
8. Duct the kitchen exhaust fan out the side wall and install an outlet with a damper that provides a positive seal.
9. Make residents aware that placing clothes and furniture against outside walls can precipitate problems. Due to the high occupancy rate of these small residences and scarcity of storage space; clothes, goods, and miscellaneous personal items are stored everywhere, with boxes and clothes often stacked against walls. Resolving this type of issues is as critical as solving some of the construction deficiencies.
10. Educate residents how to prevent mold problems. Keep surfaces clean and dry. Heavy window drapes may prevent uncomfortable drafts, but the resident must ensure window sills have no standing water on them. Keep windowsills and sashes clean and dry.

**Inspection Number:** 1-4
**Address:** On the Tundra
**Type:** Frame one-story
**Foundation**: Piers
**Heat Type:** TOYO Stove
**Bedrooms:** Three
**Occupancy:** 7 occupants
**Age:** Approximately 30 years
**Attic:** Not accessible

**Figure 1: Exterior On the Tundra**

**Figure 2: Mold at exterior corner**

**Figure 3: Gaps between window trim and siding**

**Figure 4: Hole in exterior sheathing**


**Figure 5: Hole through siding**

**Mold and Moisture Conditions:**
This home had less mold than other inspected homes because the interior moisture levels were moderated by the high infiltration rate into the home. Mold was evident at one wall to ceiling corner (Figure 2) and near the base of exterior walls.

**Site Drainage and Rainwater Management:** This home had overhangs but no gutters. The home was situated approximately 14 to 16 inches above grade. The piers that the support beams rested upon were settling and tilted.

**Exterior Condition:** This home had 2x4 inch wall framing and some material similar to Celotex exterior sheathing with an impregnated finish. Due to deterioration from UV light, most of the exterior surface finish of the sheathing was gone, except where it was shielded from the sun. Large gaps were present between the window trim and the sheathing (Figure 3) and several holes were through the siding (Figures 4 & 5). Both conditions allowed water and air infiltration into the walls. Overall, the exterior of the residence was in poor condition.

**Kitchen:** No range hood was in this residence.

**Bedrooms and Living Spaces:** The one inspected bedroom had mold in an upper outside corner (Figure 2). Evidence of water damage to the ceiling was at the stove pipe penetration through the ceiling (Figure 6). The windows did not have mold because the house interior was dry due to the large infiltration rate.

**Figure 6: Stove pipe**

The interior air temperature was approximately 70° F and the wall surface temperature beneath some coats hanging on it was 39° F.

**Attic:** The attic was not accessible.

**Mechanical Systems:** The primary heating system for the home was a free standing TOYO heater located in the living room and which burned #1 fuel oil. There was no heat distribution system.

**Occupant Notes:** No information was available.

**Discussion / Recommendations:**

**On the Exterior:**

If this home were located in the lower continental United States, the team would suggest demolishing it. However, considering the scarcity of resources and difficulty of importing materials to this remote community, the tribe may determine it necessary to repair this residence as follows:

1. Renovate the exterior of the house from foundation piers to roof. See Part II, Section 5.1.1.
2. Replace the existing windows and install window flashing. Research the replacement window types by contacting the Cold Climate Housing Research Center in Fairbanks Alaska for assistance. See Part II, Section 5.1.3.
3. Inspect the floor framing, insulation, and airtightness of the floor assembly. Insulate and weatherseal as required to reduce chilling of the floor surfaces. Seal all penetrations with spray foam to make them airtight.
4. Inspect the flashing around all roof penetrations and repair as necessary

**Figure 7: Pier, support beam and floor joists**

**On the Interior of the house:**

1) Develop a heat distribution system to draw air from the heated living area and then distribute this warm air to other rooms. See Part II, Section 5.2.1.
2) Provide a ventilation system to dilute interior winter moisture loads. See Part II, Section 5.2.2.
3) Increase attic insulation. See Part II, Section 5.2.6.

4) Clean moldy areas in accordance with the NYC Department of Health Guidelines. Repaint if necessary. Remove and replace all drywall covered with heavy mold or badly deteriorated. Inspect and repair areas inside the wall as necessary before replacing interior cladding. Maintain the continuity of the vapor barrier.

5) Duct the kitchen exhaust fan out the side wall and install an outlet with a damper that provides a positive seal.

6) Remove the wood stove and seal all the stove pipe penetrations, if unused. Inspect the flashing, if the stove is used. The damage to the ceiling surrounding the stove pipe could be due to flashing leaks or condensation occurring on the pipe in the attic which then runs down the pipe and saturates the ceiling

7) Inform residents that placing clothes and furniture against outside walls can precipitate mold problems. Due to the high occupancy rate of these small residences and scarcity of storage space, clothes, goods, and miscellaneous personal items are stored everywhere, including boxes and clothes stacked against walls (Figure 8). Resolving these issues is as critical as solving some of the construction deficiencies.

**Figure 8: Clothes against exterior walls**

8) Educate residents how to prevent mold problems. Keep surfaces clean and dry. Heavy window drapes keep uncomfortable drafts from occurring, but residents must ensure window sills are free of standing water. Keep windowsills and sashes clean and dry.

**Inspection Number:** 1-5
**Address:** On the Tundra
**Type:** Frame one-story
**Foundation**: Piers
**Heat Type:** TOYO Stove
**Bedrooms:** Three
**Occupancy:** 6 winter occupants,
15 summer occupants
**Age:** Approximately 30 years
**Attic:** Not accessible

**Figure 1: Exterior On the Tundra**

**Mold and Moisture Conditions:** Mold was evident at the base of a wall behind a bed (Figure 2)

**Figure 2: Moldy base of paneling behind a bed**

**Site Drainage and Rainwater Management:** This home had overhangs and a partial gutter system. The home was situated approximately 14 to 16 inches above grade.

**Exterior Condition:** The exterior of this home was in fairly good condition but needed painting.

**Bedrooms and Living Spaces:** The home was tidy but packed with personal belongings. Several cold spots were present throughout the house, particularly at the base and top of walls where there would be more framing lumber and less insulation, i.e. more of a thermal bridge. The floor in one bedroom measured 36° F while in another bedroom at the base of the wall the surface temperature was 46° F. The wall to ceiling junction measured 46° F.

**Attic:** The attic was not accessible.

**Mechanical Systems:** The primary heating system for the home was a free standing TOYO heater located in the living room and which burned #1 fuel oil. There was no heat distribution system.

**Occupant Notes:** One woman living in the house had asthma and suspected that mold aggravated the condition.

**Discussion / Recommendations:**

**On the Exterior:**

1. The exterior of this plywood sided home was in good condition. However, renovation would allow installation of additional insulation over the walls, particularly in the areas of the top and bottom plates. Following the interior recommendations listed below regarding heat distribution and ventilation may solve the condensation problems without additional exterior insulation. Additional insulation is required primarily in the areas of the bottom plates of the exterior walls. Maintain the siding to increase its service life.

**On the Interior:**

1. Develop a heat distribution system to draw air from the heated living area and then distribute this warm air to other rooms of the house. See Part II, Section 5.2.1.

2. Provide a ventilation system to dilute interior winter moisture loads. See Part II, Section 5.2.2.

3. Increase attic insulation. See Part II, Section 5.2.6.

4. Clean moldy areas in accordance with the NYC Department of Health Guidelines. Repaint if necessary. Remove and replace all drywall covered with heavy mold or badly deteriorated. Inspect and repair areas inside the wall as necessary before replacing interior cladding. Maintain the continuity of the vapor barrier.

5. Make residents aware that placing clothes and furniture against outside walls can precipitate problems. Due to the high occupancy rate of these small residences and scarcity of storage space, clothes, goods, and miscellaneous personal items are stored everywhere, with boxes and clothes stacked against walls. In this residence, the one area with severe mold contamination was on an exterior wall behind a bed. Resolving issues such as this are as critical as solving some of the construction deficiencies.

6. Educate residents how to prevent mold problems. Keep surfaces clean and dry. Heavy window drapes keep uncomfortable drafts from occurring, but the resident must ensure window sills are free of standing water. Keep windowsills and sashes clean and dry.