Evaluating Residential Structure Ignition Potential

Structure Documentation and Installation on Site in the NWT

Progress Report for Helena Marken
FireSmart BC
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Contents

List of Figures

List of Tables

Background

The spring and summer of 2023 have been unprecedented in terms of wildfire across Canada from coast to coast. At times, it seemed like most of the country was burning. Recent disasters involving communities in both Canada and the US have forced us to look at the ignition potential and fire spread within communities largely due to embers generated by wildfires. Structure losses and the resulting costs, both financially and the toll they take on mental health, begs the question: How do structures ignite from wildfire-generated embers and how can we harden these structures to prevent these disasters in the future?

FireSmart BC has been very forward thinking and has aggressive programs for both evaluation of structure ignition potential within communities and doing fuel modifications surrounding communities to prevent wildfire flame fronts from entering. While both of these efforts are noble and are likely to result in reduced losses in wildfire events the actual cause of structure ignition from embers is largely speculation. There have been few studies to date that document the process by which embers lead to structure fires. That is not to say that there is no research dealing with ember transport, and what happens when embers land, just that the actual structure ignition mechanism is largely speculation. We know that embers generated by a forest fire land, potentially by the millions, and some find a receptive location and start a small fire. This fire grows over time and results in a structure fire, which then, via thermal radiation or additional ember generation, starts the next structure on fire. This chain of events propagates through the community and results in the losses that have been seen on an increasingly frequent basis.

Several areas have been identified as likely origins of structure fire starts from embers: roof, exterior wall, decks, soffits or eaves, vents, foundation plantings and mulches, fences, windows. In most cases, there are relatively simple material substitutions that can be made to lessen the likelihood of a structure catching fire (asphalt or steel roof vs wood shake or wood shingle). What has been identified as a need is a definitive study documenting how ember started fires get into structures and whether substitution of less flammable materials is sufficient to prevent or lessen these disasters.

To show what works, and what is less effective, a field study involving scale structures has been started with the construction of nine scaled buildings on one site and five others placed to allow the evaluation of the most effective means of protection using sprinklers. The nine structures, constructed with various common building materials, are located in a small "community" on the Community Protection site near Ft. Providence NWT. The structures have been placed in three groups of three at different distances from the edge of a test block (approximately 150 m x 150 m) and a high intensity fire will be started and run towards the community. The "community", placed on site in June 2023, will be allowed to "age" for approximately 1 year before testing. The reason for the aging is to allow the native plant species to recover after being trampled during construction.

The remaining five structures have been grouped (three and two) at two different locations on the community protection test site. The idea is that these are far enough away from the main "town site" that any use of sprinklers will not influence the main fire that will threaten the nine.

Each of the structures was built to highlight the features that are thought to result in structure ignition. To that end, each is T-shaped so that there are inside corners that typically catch debris during wind events. The structures each have three windows, decks, soffits and roof vents to be typical of the housing stock (present and future). Figure 1 shows a general representation of the structure models and highlights the features. Note that there are exterior variations (not all structures will be finished with the same materials) but the basic frame is identical for all and is shown in Figure 2.

Since the goal of the project is to determine if the use of more fire resistant building materials will result in more resilient structures three themes were adopted: vulnerable, current and fire resistant.

Vulnerable structures include those made with combustible materials such as cedar roofing, cedar siding, low mass wood decks, vinyl soffits and fascia and large mesh vents (mesh > 3 mm).

Current structures include asphalt shingle roofing, vinyl siding, wood deck (2x4 or 2x6 planking), metal soffit and fascia, and large mesh vents (mesh > 3 mm).

Fire resistant construction includes a class A roof (metal or asphalt), metal soffit and fascia, composite decking with a low flame spread rating, cement board siding and vents with a mesh size of less than 3 mm.

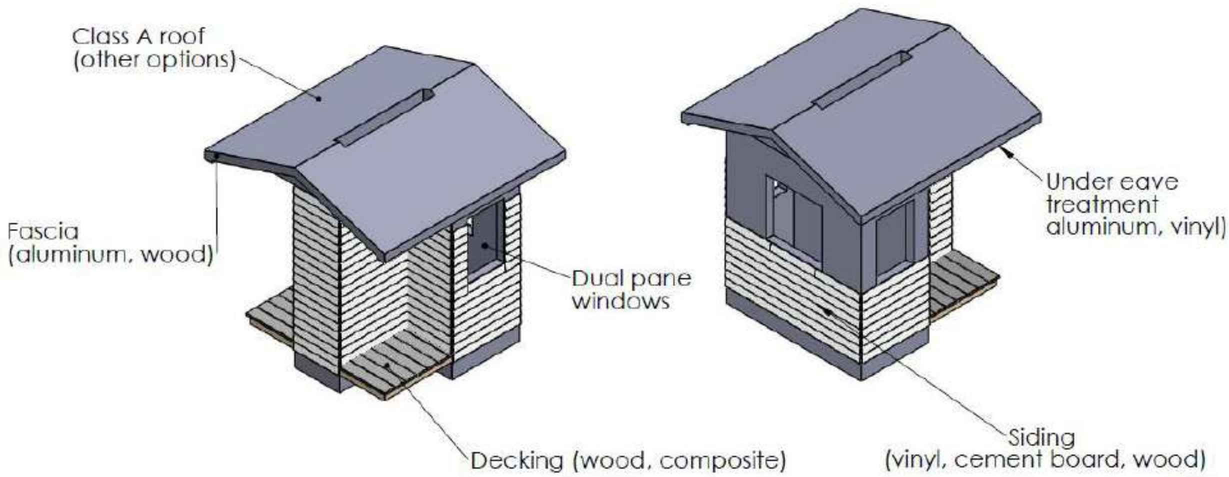

Figure 1 General View of Test Cabins

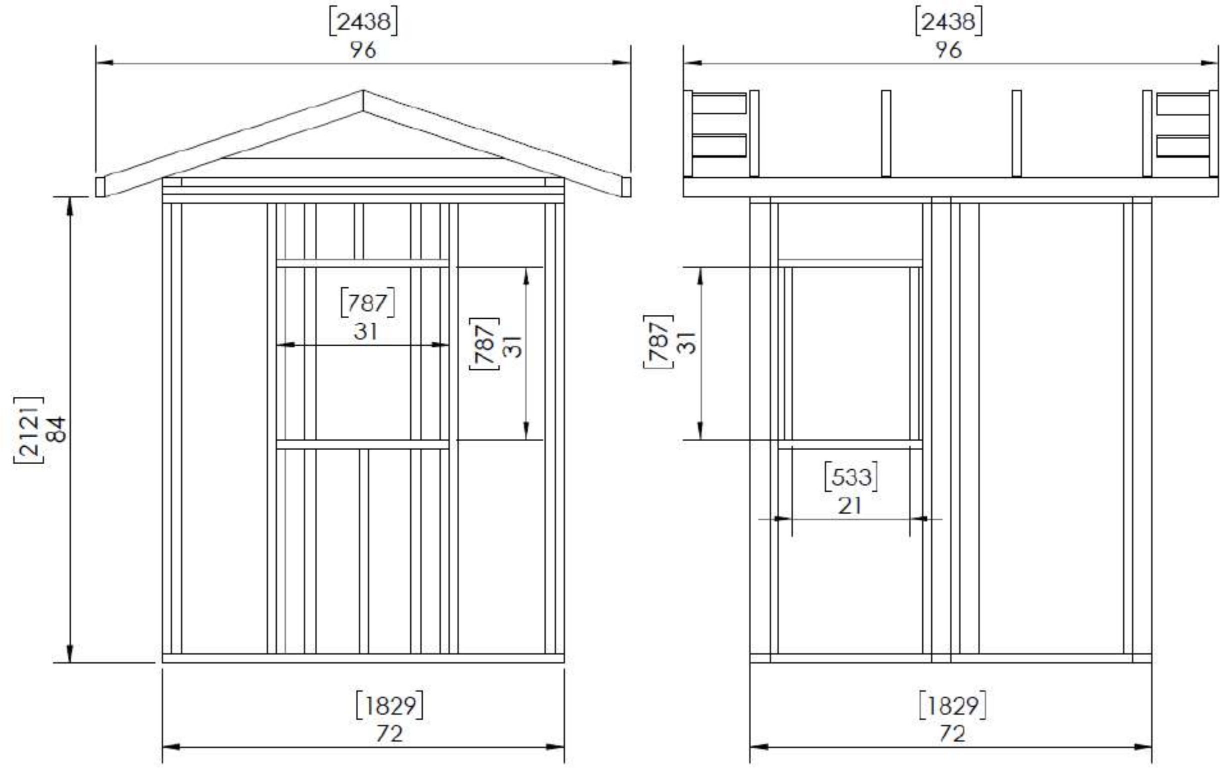

Figure 2 Framing Detail for Test Cabins

Prior to the initiation of the wildfire threat each of the structures will be loosely filled with woody materials to simulate the internal fuel supply that would be found in regular housing (cabinets, floors, furniture etc.). The reason for this is to ensure that in the event a structure catches fire and burns it produces a large enough fire with sufficient duration to place a high thermal radiation load on the adjacent structure. The radiation load on an adjacent structure is a function of the fire size and the separation distance between the structures, so this was set at ~2 m (6 ft.) to ensure a burning structure would produce a reasonable radiation load on an adjacent structure.

Recent literature [1] has pointed to fencing materials as being a pathway to structure ignition and small fences will be added to each of the cabins prior to the testing. Materials used in the fences will consist of two wood types (lumber and cedar lattice and one non-combustible on the fire resistant cabins).

The features of each type of building (in the community group of nine) are shown below. Some of the features (windows, deck skirting, and fencing) have not yet been installed but will be placed prior to testing.

Vulnerable (3 of this type):

Cedar shake roof
Vinyl soffit
Wood fascia
No drip edge on roof
Low mass wood deck (5/4 cedar decking material over 2x6 frame)
Wood (cedar) siding
Vinyl double pane windows

Cedar lattice fence attached to structure
No deck skirting
Ridge vent (large mesh screens, ~ 6 mm)

Present Day (3 of this type):

Asphalt shingle roof
Metal soffit
Metal fascia
Drip edge on roof
Wood deck (2x6 deck boards over 2x6 frame)
Vinyl siding
Vinyl double pane windows
Wood fence attached to structure
Open lattice cedar deck skirting
Ridge vent (large mesh screens, ~ 6 mm)

Fire Resistant (3 of this type):

Metal roof
Metal soffit
Metal fascia
Drip edge on roof
Composite deck (over 2x6 frame)
Cement board siding
Vinyl Windows
Non-combustible fence
Deck skirting (non-combustible)
Ridge vent (< 3 mm mesh screens)

Test Site near Fort Providence, NWT

The structures were built in Edmonton, disassembled and shipped to the community protection site in June 2023. Prior to assembly, the test site was mulched to create an opening on the downwind edge of the test block.

The additional five cabins (3 located on one site and 2 located on a second site) will be used largely to evaluate how to most effectively protect structures using sprinklers. Construction of the additional five cabins was identical to the initial nine with minor variations in eave treatments or siding materials. Details of these structures are included below.

All structures were built specifically so they could be disassembled and handled on site. The site for the placement of the cabins (Community Protection Site) is a 1335 ha (3300 acre) plot of land located approximately 50 km North of Fort Providence, NWT. The site was originally chosen for the International Crown Fire Modeling Experiment (1997-1999) because of fuel types (mixed spruce and pine) and the proximity to nearby water sources for mop up operations after experimental fires. The site has been used for various forest related fire experiments for more than 25 years. Figure 3 shows a Google Earth view of the site (61° 34’ 57” N, 117° 10’ 11”W)

Figure 3 Community Protection Site Located Approximately 50 km North of Fort Providence, NWT (Image source Google Earth)

Figure 4 shows an overhead view of the test site, prior to mulching fireguards and an opening for the structures. The test plot consists of mixed spruce and pine and the intent is to ignite the site so that the fire progresses from SE to NW. This will require a SE wind to be successful – something that is very common at the site during peak burning season.

Figure 4 Enlarged View of Community Protection Site (each outlined test block ~75 m x 75 m) (Image source Google Earth)

Figures 5 through 7 show an overhead view of the structures after assembly and placement. Note that the structures were placed in three rows (separation distance ~ 6 m) of three cabins. Each row contains a vulnerable (cedar), present day (vinyl) and a fire resistant (cement board) structure. The vulnerable structure was placed in the center of each row so that, in the event it ignited, it would provide a significant threat to the adjacent structures. Present day and fire resistant structures were alternated in each row to remove any potential bias that might result from placement.

Figure 5 Overhead View of Nine Cabin Site at NW Corner of Block to be Burned (photo courtesy of Brandon MacKinnon – FP Innovations)

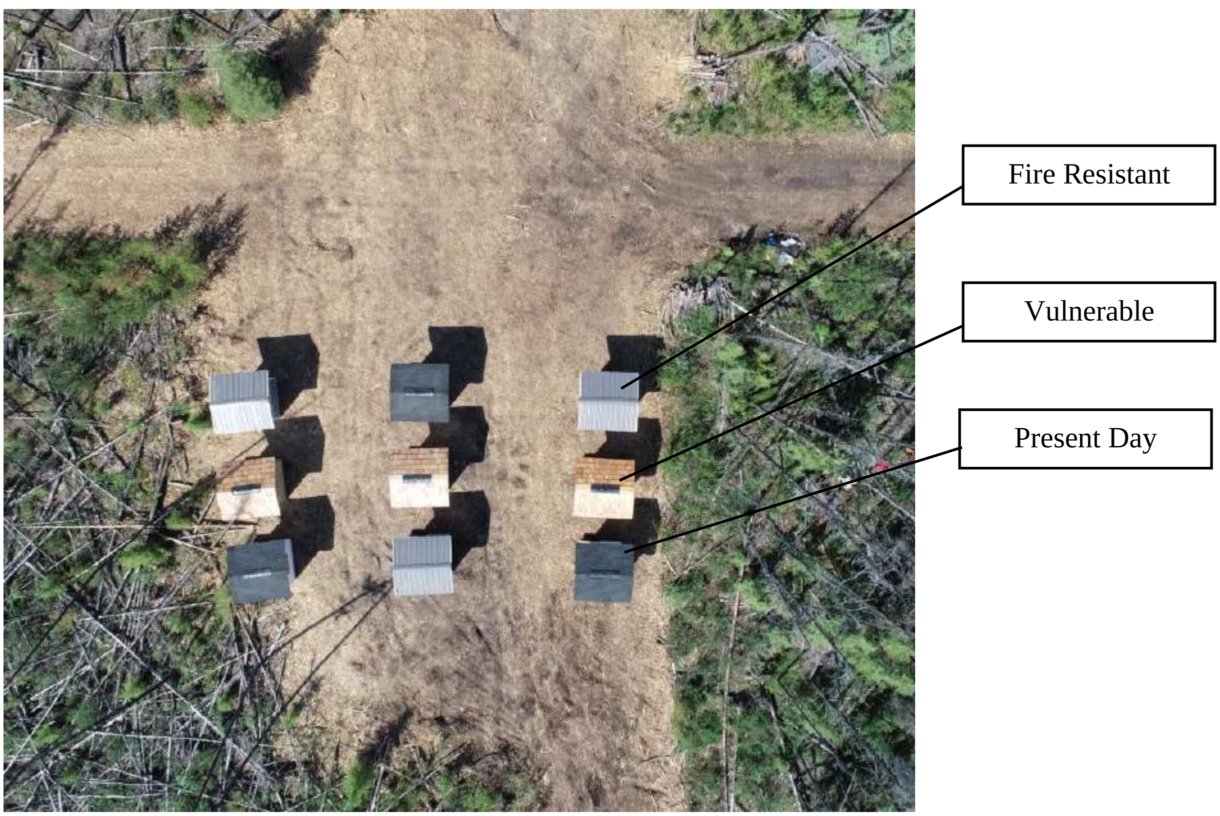

Figure 6 Overhead View of Nine Cabin Site (photo courtesy of Brandon MacKinnon – FP Innovations)

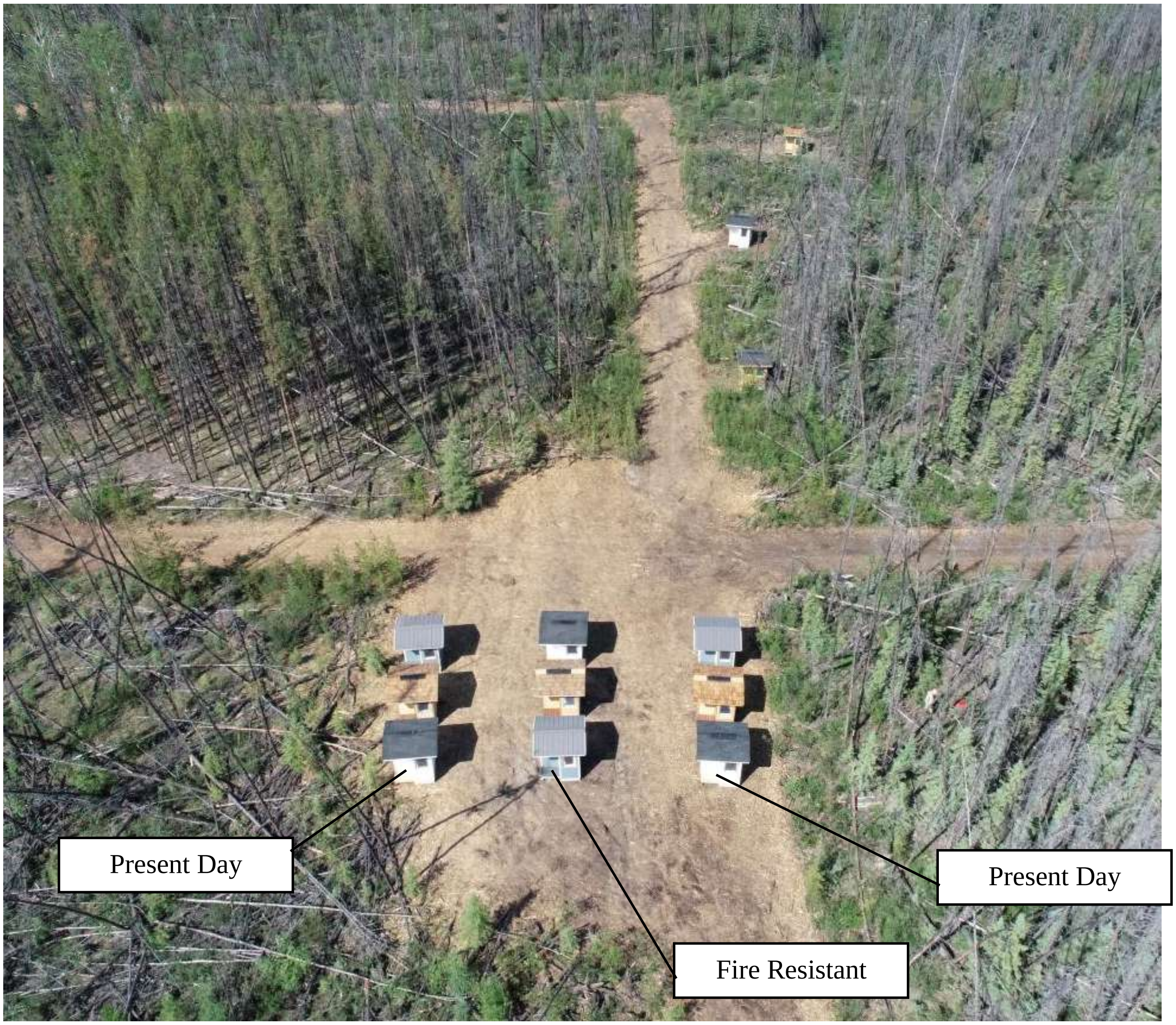

Figure 7 Additional View of Nine Cabin Site – looking approximately North (note that three of the additional five cabins are to the North of the site) (photo courtesy of Brandon MacKinnon – FP Innovations)

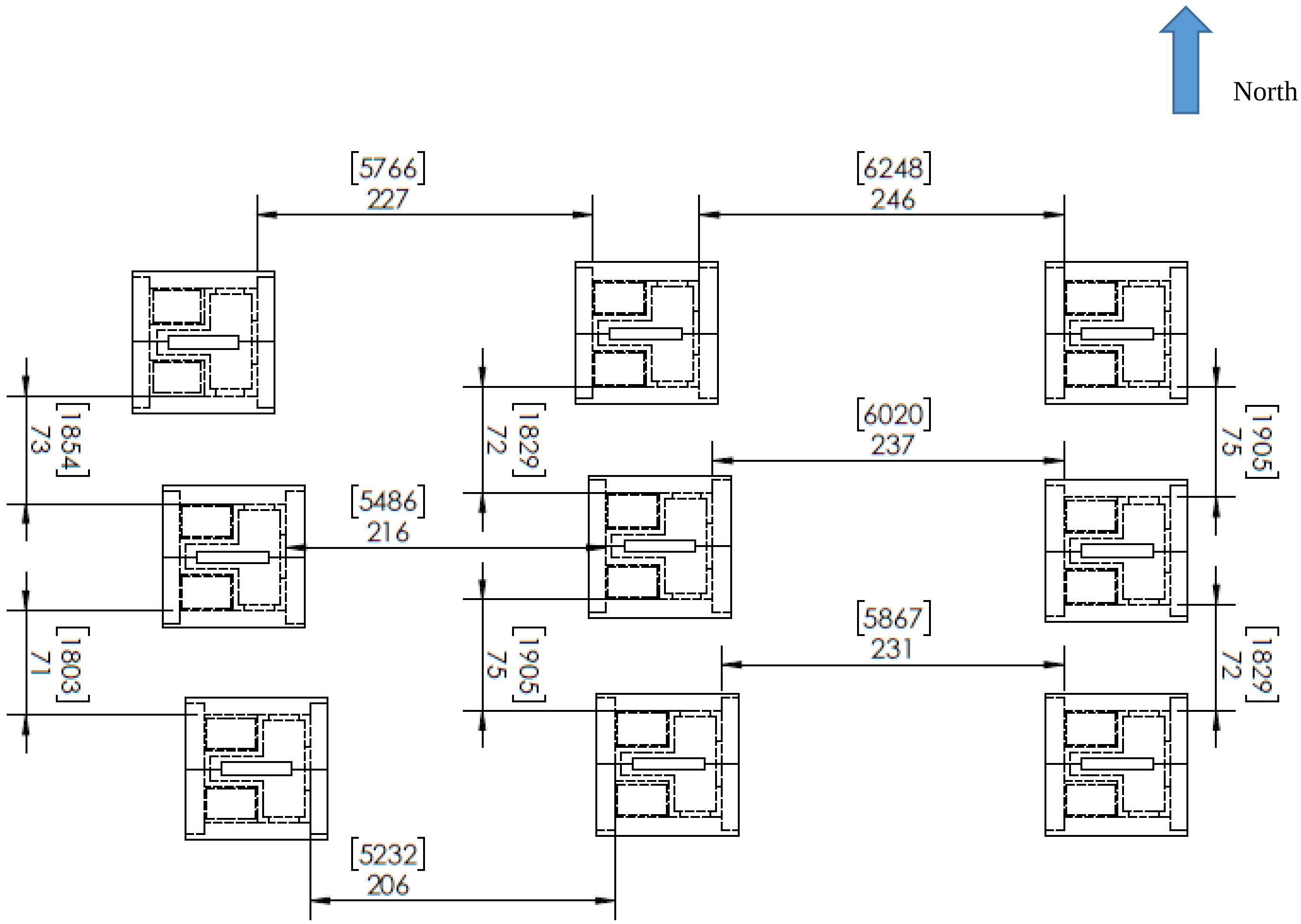

Figure 8 Approximate Locations of Cabins Installed in Nine Cabin Site

Three additional structures were placed in the test plot directly north of the FireSmart site to be used for the evaluation of sprinkler strategies for structure protection. Figure 8 shows the relative placement of each. Note that the intent is to ignite both test plots at the same time so both sites will be evaluated on the same day and in the same fire.

Figure 9 Three Cabin Site for Structure Protection Testing (photo courtesy of Brandon MacKinnon – FP Innovations)

Figure 10 Locations of Three Sites Where Cabins Were Placed (Image source Google Earth)

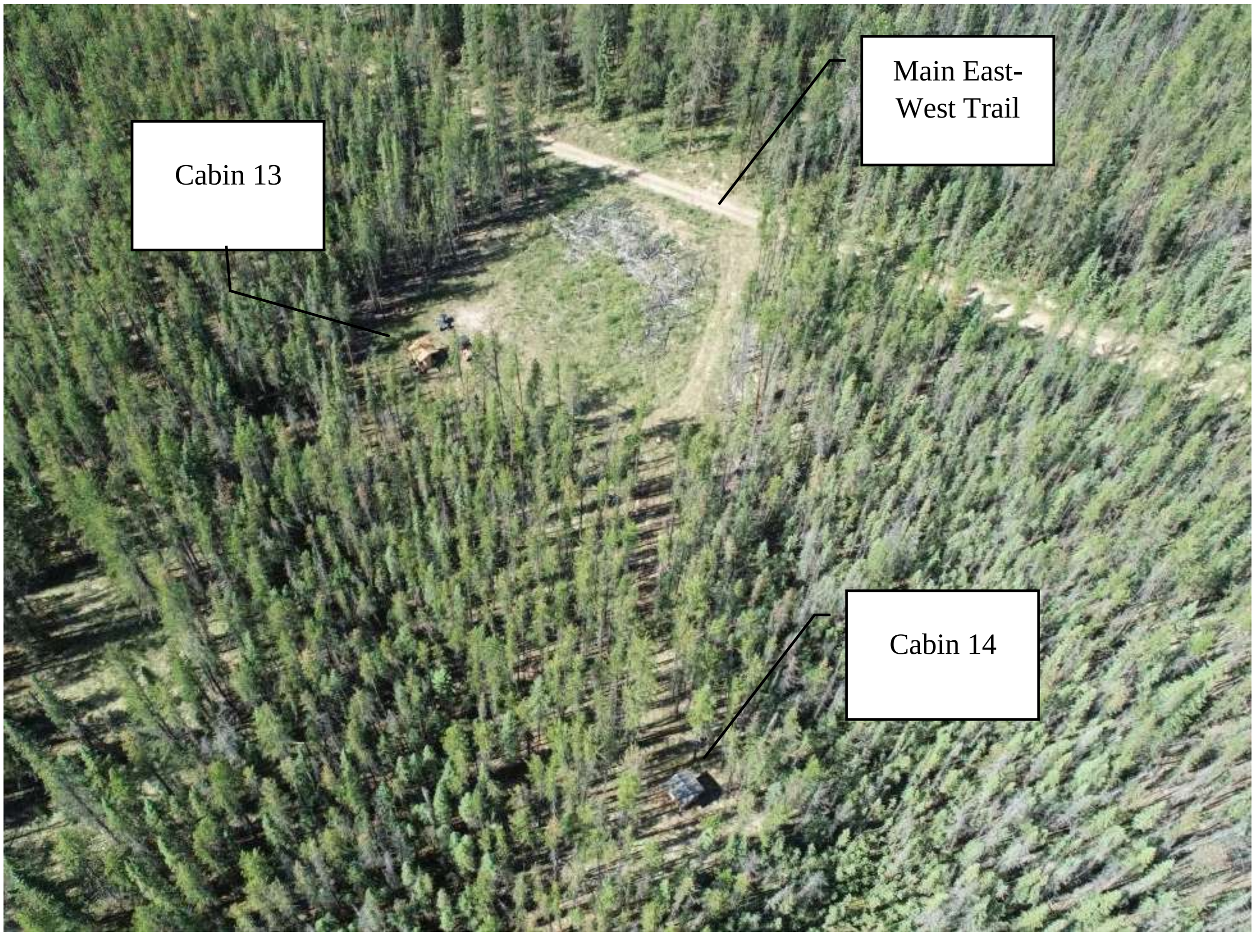

Figure 11 Third Site Containing Two Cabins Located South of the East-West Main Trail (photo courtesy of Brandon MacKinnon – FP Innovations)

Construction Details – Common Features

All cabins were constructed using nominal 2x4 frames covered in 9.5 mm (3/8 in) oriented strand board sheathing and a polyspun olefin moisture barrier (Tyvek or Typar). While it was recognized that most present day structures are constructed with nominal 2x6 framing the logistics of getting the structures to a remote site dictated some compromises in terms of mass. It was felt that this deviation from "normal" construction methods would not compromise the performance of the structures in terms of how they would behave when threatened with embers or flames. Figure 12 shows the framing system used for all cabins. Rough window openings were 760mm x 760mm (30 in x 30 in) (front window) and (510 mm x 760 mm) (20 in x 30 in) (side windows). Window units in all cabins are sealed (two glass panes) with vinyl frames. The roof structure used, Figure 13, was the same for all cabins in order to ensure the roof could be lifted off and transported as a unit. The structure frame was made to break into two pieces (main cabin body and tail) for ease of handling and transport (Figure 14). All cabins have a strip of cement board (approximately 200 mm tall) applied at ground level to simulate a foundation (non-combustible).

Figure 12 Basic Frame Common to All Cabins

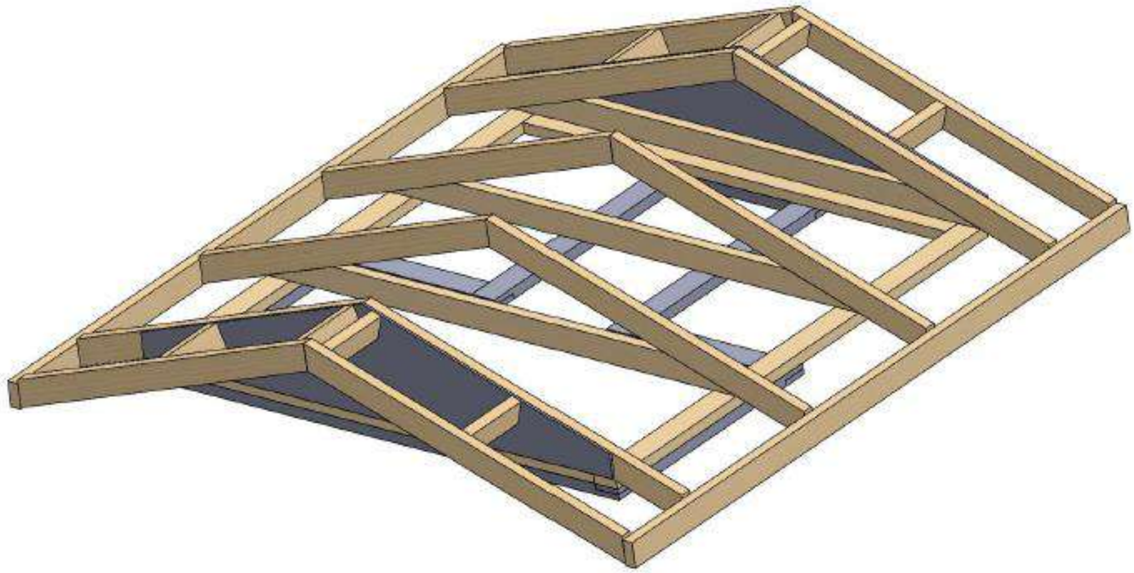

Figure 13 Basic Roof Structure Common to All Cabins

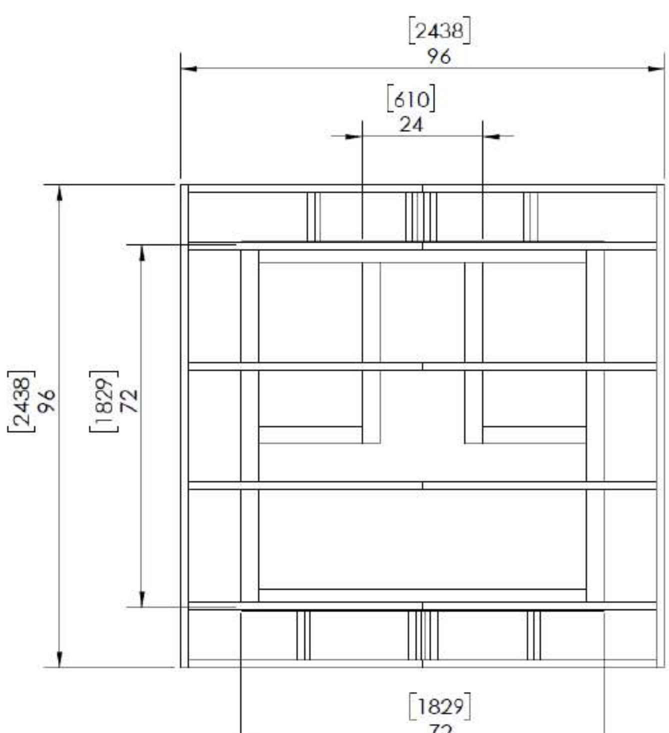

Figure 14 Roof Structure Top View

Figure 15 Basic Frame of Cabin Broken into Two Parts (main body on left and tail on right)

Figure 16 Roof System being Unloaded in Compound in Ft. Providence NWT (June 2023)

Figure 17 Main Cabin Parts En Route to Community Protection Site, NWT

Figure 18 Main Cabin Parts in Staging Area at the Community Protection Site, NWT

Individual Cabin Descriptions

The following section describes the details of each test structure. Table 1 is a summary of the relevant component details and the sections that follow show the cabins and highlight construction details for each variant. The first nine cabins are intended for use in showing how structures ignite in response to a wild fire ember assault while the remaining five are intended to be used to evaluate strategies for protecting structures using sprinklers.

Table 1 Individual Cabin Characteristics

Structure	Roof	Fascia	Soffit	Drip Edge	Eaves Trough	Siding	Windows	Attic Vents	Deck Frame	Deck surface
1-3 Vulnerable	Cedar shingle	Cedar	Vinyl	None	Yes	Cedar	Vinyl	Ridge, soffit	2x6	5/4 wood
4-6 Present Day	Asphalt	Metal	Metal	Metal	Yes	Vinyl	Vinyl	Ridge, soffit	2x6	2x6 spruce
7-9 Fire Resistant	Metal	Metal	Metal	Metal	Yes	Cement Board	Vinyl	Ridge, soffit	2x6	Composite
10	Asphalt	Wood	Vinyl	Metal	No	Wood	Vinyl	Ridge, soffit	2x6	2x4 spruce
11	Asphalt	Metal	Metal	Metal	Yes	Vinyl	Vinyl	Ridge, soffit	2x6	2x4 spruce
12	Cedar shingle	Vinyl	Vinyl	None	Yes	Cedar	Vinyl	Ridge, soffit	2x6	5/4 wood
13	Cedar shingle	Cedar	None / osb	None		Cedar	Vinyl	Ridge, 75mm holes with 6mm screen	2x6	5/4 wood
14	Metal	Cedar	None / osb	None		Exterior grade plywood	Vinyl	Ridge, 75mm holes with 6mm screen	2x6	2x4 spruce

Vulnerable Cabins

The vulnerable cabins were covered in cedar on both the walls and roof as indicated in Figures 19 and 20. Fascia was constructed using cedar boards and soffit material used was vinyl. No drip edge was used with these structures. Attic venting consists of a ridge vent and soffit vents (in the vinyl soffits). The fine mesh supplied with the ridge vent was removed so maintain a minimum 6 mm opening size.

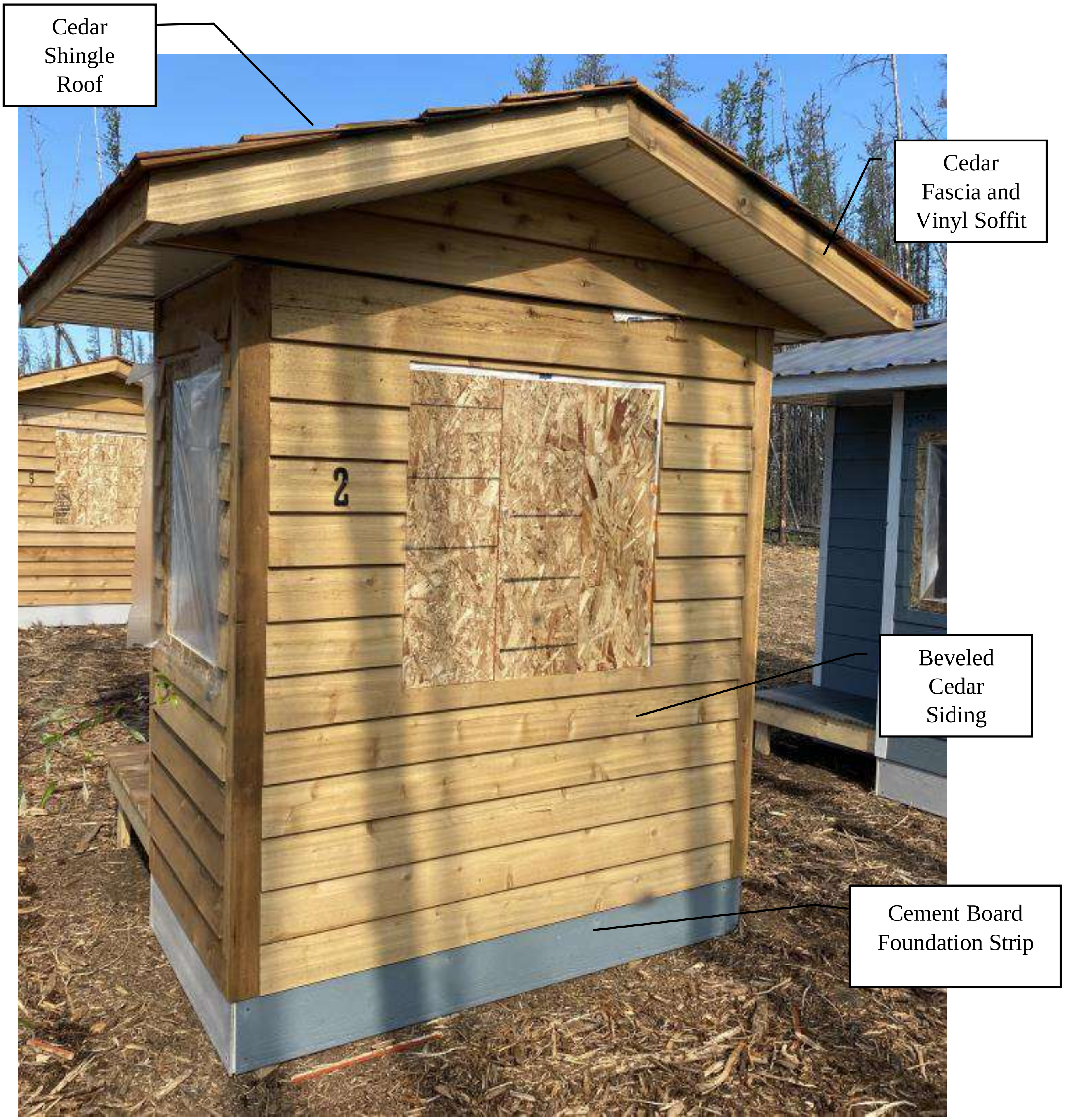

Figure 19 Front View of Vulnerable Cabin

Figure 20 Rear View of Vulnerable Cabin

Windows for the cedar cabins were dual pane vinyl framed sealed units. Decking consists of 5/4 treated boards as a surface over a spruce frame. As with all of the cabins a cement board trim (about 200 mm high) was placed around the entire perimeter to simulate a foundation.

Present Day Cabins

Present day cabins were constructed with the same basic frame as the rest of the test buildings. The differences between these and the vulnerable cabins is that these use vinyl siding, an asphalt shingle roof, metal soffit and fascia, and a spruce deck (framing and surface). A metal drip edge was used at the edge of the roof. Figures 21 and 22 show the basic structures with details highlighted.

Figure 21 Front View of Present Day Cabin

Figure 22 Rear View of Present Day Cabin

Attic venting consists of ventilated soffits and a 1200 mm (48”) ridge vent that has 6mm openings (Figure 23). In the present day cabins the mesh was removed to maintain a 6mm opening size.

Figure 23 Gaf Ridge Vent Used in both Vulnerable and Present Day Cabins

Fire Resistant Cabins

Fire resistant cabins were constructed using materials that are considered less vulnerable to either embers or direct flame. Exterior finish was cement board (Hardie board), roof surface is metal and both soffits and fascia are metal. A metal drip edge was used around the edge of the roof. Attic venting consists of vented soffits and a ridge vent using a 3 mm metal screen to prevent ember entry.

Figure 24 Front View of Fire Resistant Cabin

Figure 25 Additional Views of Fire Resistant Cabin

Windows for the structure are vinyl framed, dual pane, sealed units. Wood framed windows were considered but are rarely used in new construction.

As with all of the cabins a cement board strip (~200 mm) was placed around the base of the structure. The decks were constructed using composite boards over a spruce frame. The decks will be completed with the installation of a non-combustible skirt that will prevent any accumulation of embers below. This was not done during the initial installation but will be completed prior to testing.

Cabin 10

Cabins 10 through 14 are each unique and were placed to examine structure protection using sprinkler systems.

Cabin 10 (Figure 26) consists of cedar siding, an asphalt shingle roof and cedar fascia and vinyl soffits.

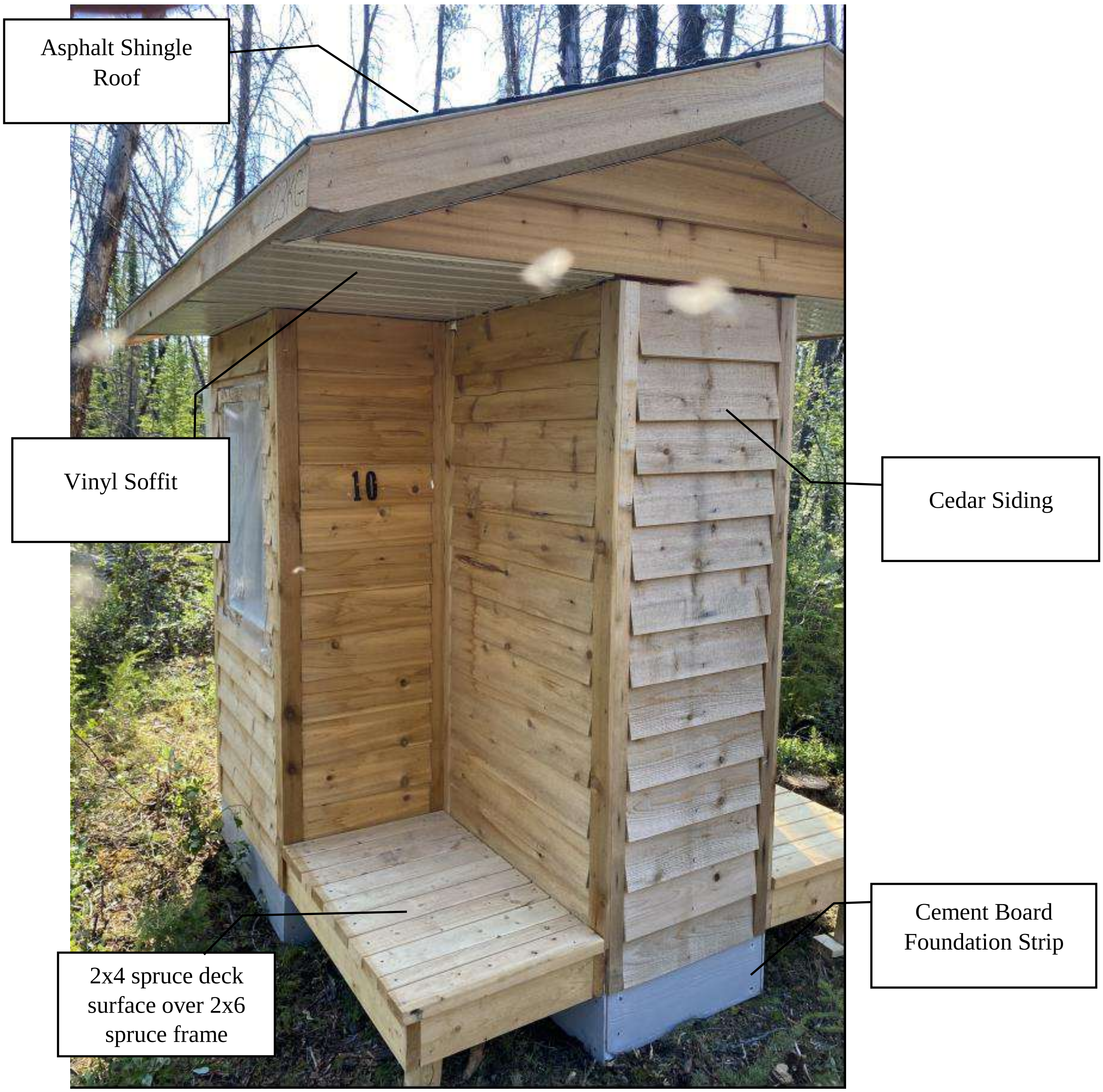

Figure 26 Rear View of Cabin 10

Figure 27 Additional Views of Cabin 10

Windows are dual pane, sealed units, with vinyl frames. Decking consists of nominal 2x4 spruce as a surface over a spruce frame. As with all of the cabins, a 200 mm cement board strip was placed around the base of the perimeter to simulate a foundation.

Cabin 11

Cabin 11 (Figures 28 and 29) has vinyl siding, an asphalt shingle roof, metal soffit and fascia.

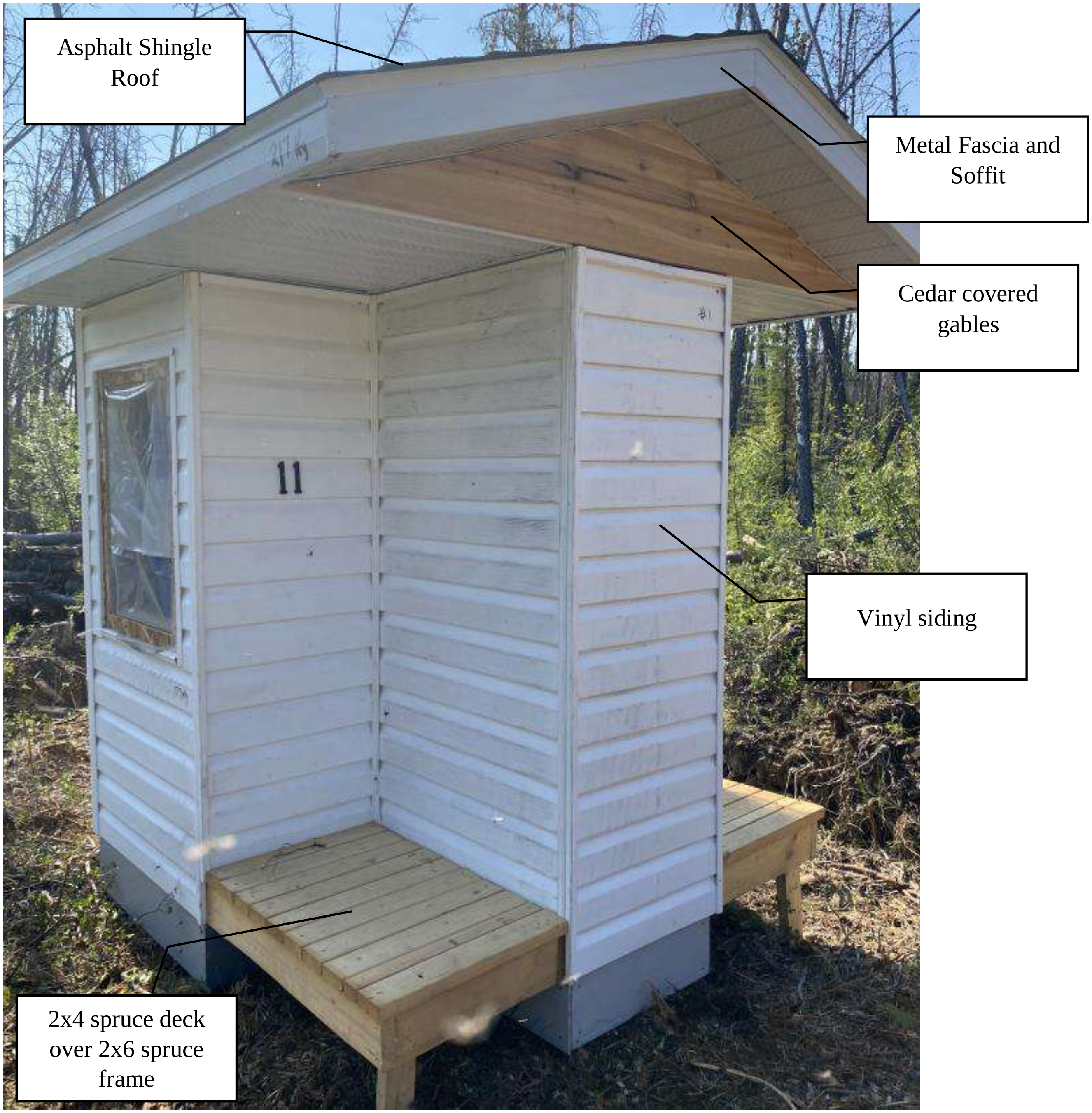

Figure 28 Rear View of Cabin 11

Figure 29 Additional Views of Cabin 11

Windows are dual pane, sealed, vinyl framed, on both the front and sides. The deck was constructed using nominal 2x4 spruce boards as a surface over a 2x6 spruce frame. A 200 mm tall strip of cement board was placed around the perimeter at ground level to simulate a foundation. Attic ventilation consists of perforations in the soffit as well as a ridge vent (nominally 1200 mm long) with 6 mm openings as was shown in Figure 23. The fine mesh supplied with the vent was removed to maintain 6 mm openings.

Cabin 12

Cabin 12 (Figures 30 and 31) used cedar siding and a cedar shingle roof. No metal drip edge was used on the roof. Soffit and fascia were both vinyl.

Figure 30 Rear View of Cabin 12

Figure 31 Additional Views of Cabin 12

The decks were constructed using 5/4 treated wood as a surface over a nominal 2x6 frame. A 200 mm cement board was placed around the perimeter at ground level to simulate a foundation. Windows are dual pane, sealed units with vinyl frame. Attic ventilation consists of a ridge vent with 6 mm openings as well as perforations in the vinyl soffit material.

Cabin 13

Cabin 13 is cedar sided with a cedar shingle roof. Fascia was wood (cedar) and windows are dual pane, sealed, vinyl framed units.

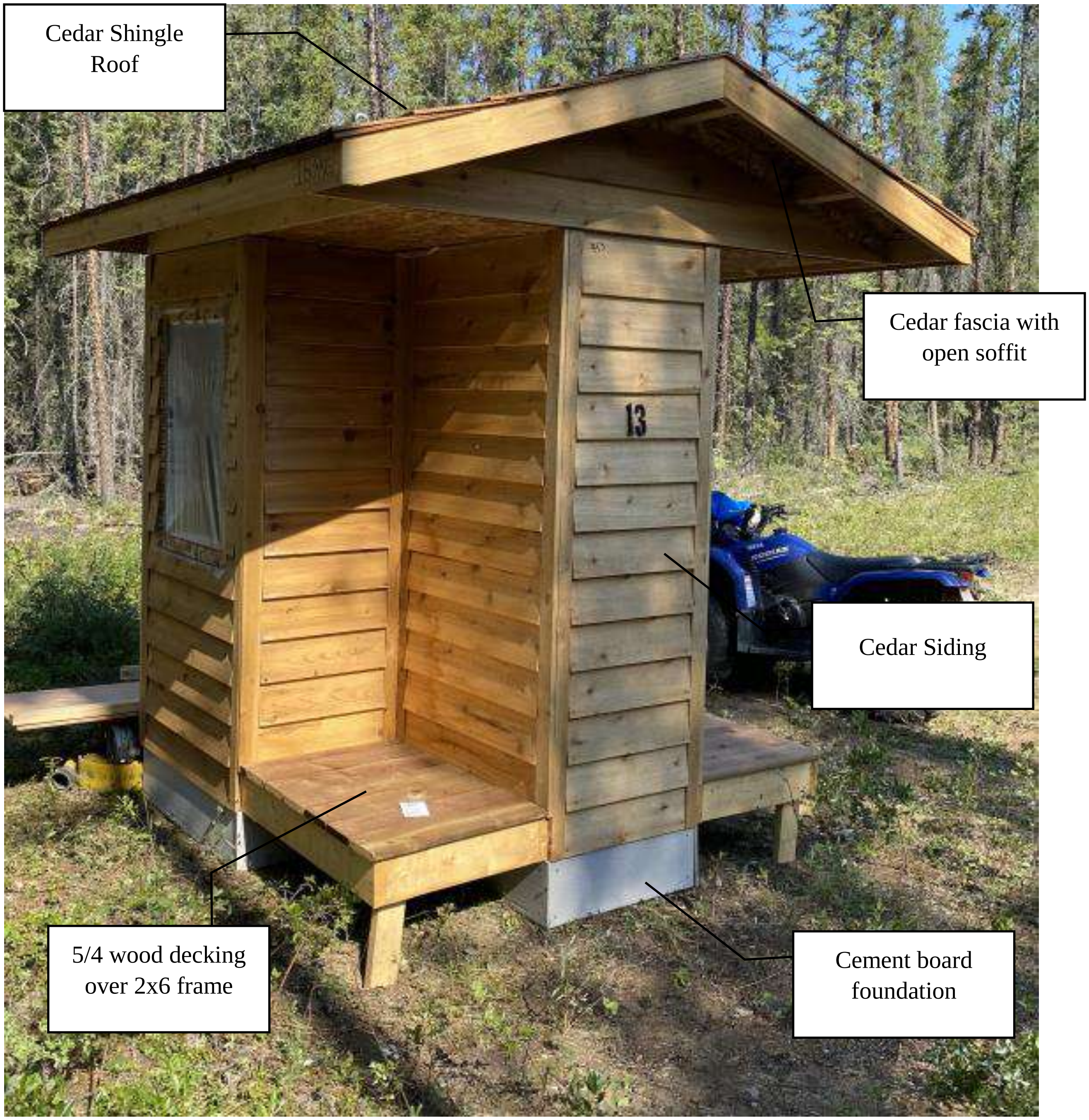

Figure 32 Rear View of Cabin 13

Figure 33 Additional Views of Cabin 13

The wood deck was constructed using 5/4 treated wood decking material as a surface over a 2x6 spruce frame. Attic ventilation consists of a ridge vent (Figure 23) with the fine mesh insert removed to preserve 6 mm openings. There were no soffits used in this cabin but ventilation is provided using several 75 mm diameter holes covered with a nominal 6 mm mesh spacing screen as indicated in Figure 34. The soffit area above the deck on each side is 9.5 mm thick oriented strand board (OSB).

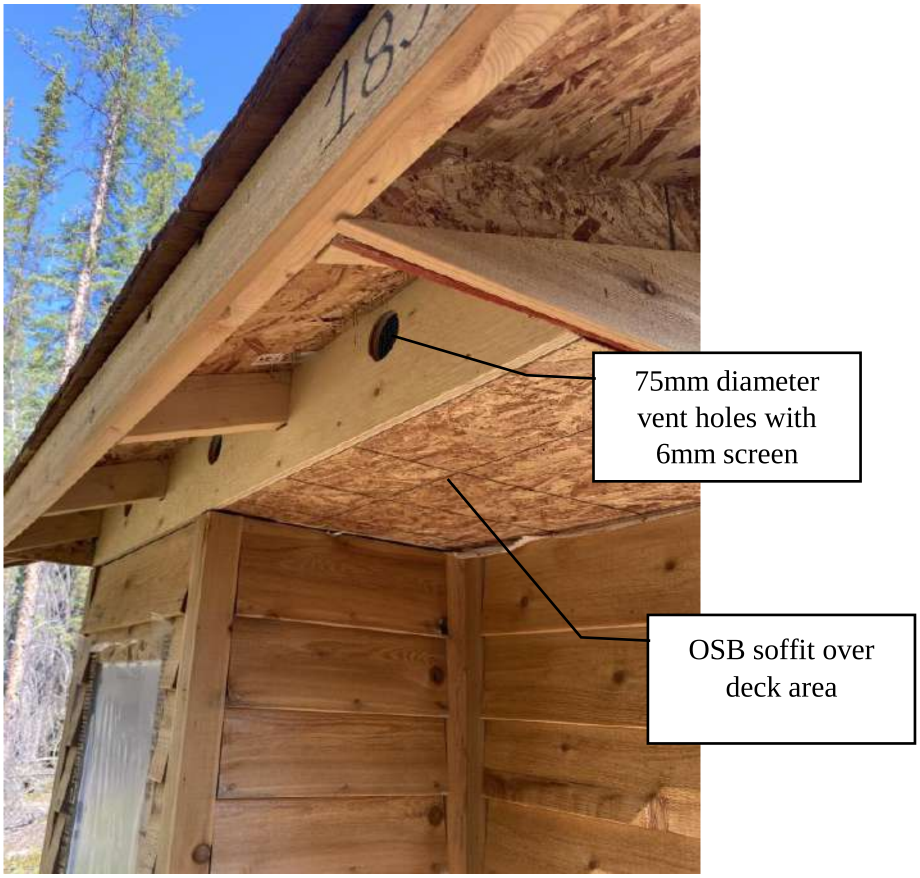

Figure 34 Soffit Detail for Cabin 13

Cabin 14

Cabin 14 is unique among the group in that there is no sheathing or olefin moisture barrier. This variant was constructed using exterior grade plywood placed directly over the cabin frame. The roof on this structure consists of metal. Fascia is cedar boards and there are no soffits.

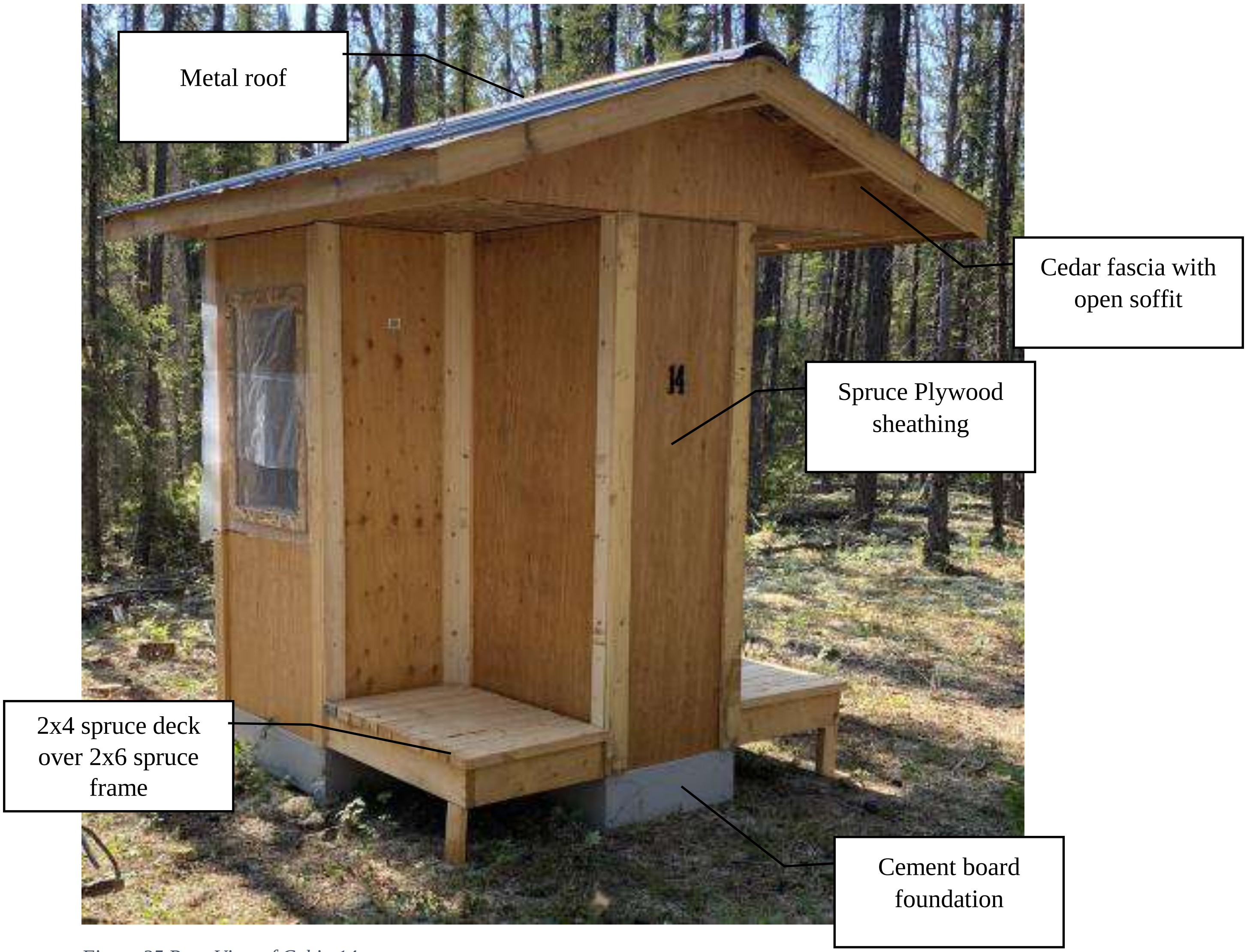

Figure 35 Rear View of Cabin 14

Attic ventilation is accomplished using a combination of a ridge vent (length approximately 1200 mm) and 75 mm diameter holes covered in 6 mm mesh screen (Figure 37). The soffit area above each deck was closed in using 9.5 mm oriented strand board.

Figure 36 Additional Views of Cabin 14

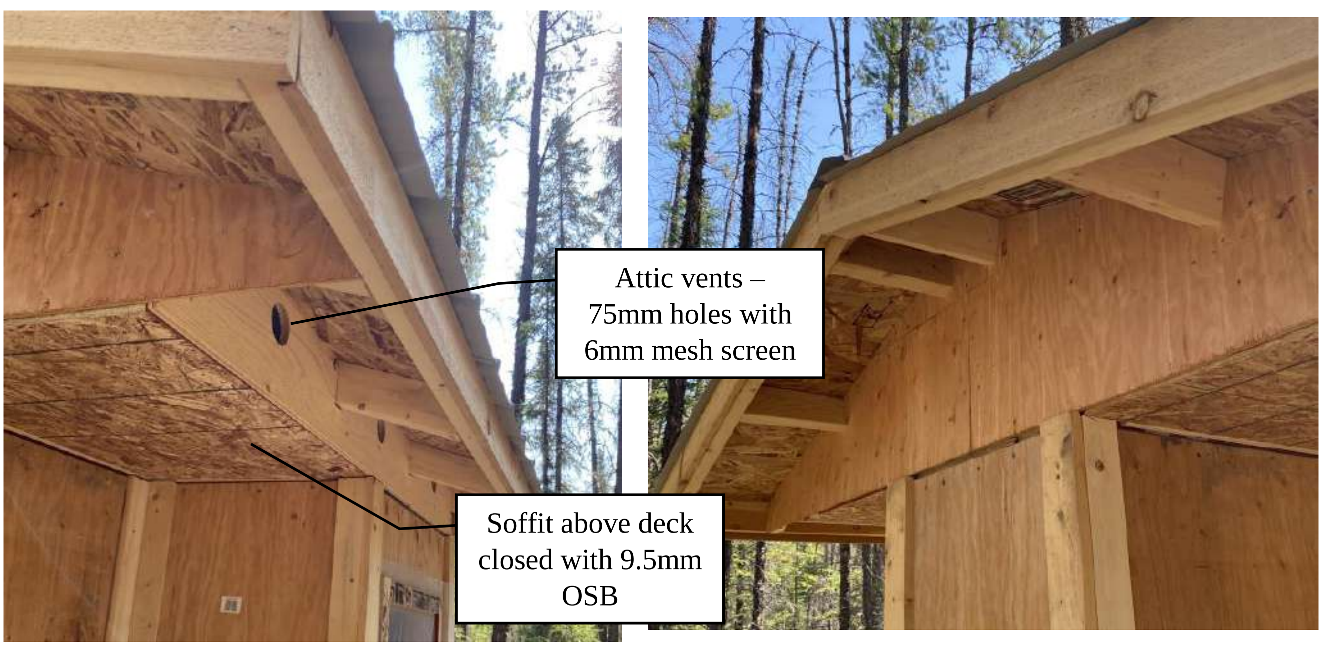

Figure 37 Soffit Details for Cabin 14

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