D16 FIU SITE CHARACTERIZATION: SUMMARY

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See Configuration Management System for approval history.

Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	2/18/2011	ECO-00065	INITIAL RELEASE
B	09/26/2011	ECO-00279	Update to new document number's/template throughout document.

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1 DESCRIPTION

1.1 Purpose

The data summarized here is used to inform the site design activities for NEON project Teams, EHS (permitting), FCC, ENG and FSU. This document summarizes the FIU site characterization data collected, analyzed, and described in the FIU D16 Site Characterization: Supporting Data (AD[01]).

1.2 Scope

This document summarizes the FIU site characterization data for three D16 tower locations: Wind River site (Advanced), Thayer site (Relocatable 1), and Abby Road site (Relocatable 2). Issues and concerns for each site that need attention are also addressed in this document according to our best knowledge.

Disclaimer: all latitude and longitude points are subject to the tolerances of our measurement system, i.e., GPS

2 RELATED DOCUMENTS AND ACRONYMS

2.1 Applicable Documents

AD[01]	NEON.DOC.011065	FIU D16 Site Characterization Supporting Data.docx
AD[02]	NEON.DOC.011018	WID between FIU and FCC
AD[03]	NEON.DOC.011008	FIU Tower Science Requirements
AD[04]	NEON.DOC.011029	FIU Precipitation Collector Site Design Requirements

2.2 Reference Documents

RD[01]	NEON.DOC.000008	NEON Acronym List
RD[02]	NEON.DOC.000243	NEON Glossary of Terms
RD[03]		
RD[04]		

2.3 Acronyms

m.a.s.l.	Meters above sea level
m.a.g.l.	Meters above ground level

2.4 Verb Convention

"Shall" is used whenever a specification expresses a provision that is binding. The verbs "should" and "may" express non-mandatory provisions. "Will" is used to express a declaration of purpose on the part of the design activity.

3 WIND RIVER ADVANCE TOWER SITE

3.1 Desired ecosystem

Table 1. Ecosystem at the Wind River tower site.

Ecosystem Type	Management activity
Old-growth forest	Managed as a wildland

The site is located in the Wind River valley of the southern Washington Cascade Range, approximately 75 km east of Portland, Oregon, near Carson, Washington. The Wind River old-growth forest, in the southern Cascade Range of Washington State, is a cool (average annual temperature, 8.7"C), moist (average annual precipitation, 2223 mm), 500-year-old Douglas-fir-westem hemlock forest of moderate to low productivity at 371 m elevation on a less than 10% slope. There is a seasonal snowpack (November- March), and rain-on-snow and freezing-rain events are common in winter. The wind River old-growth forest has eight coniferous species, including Douglas-fir, western hemlock, western red cedar (Thuja plicata), Pacific yew (Taxus brevijolia), Pacific silver fir, noble fir (Abies procera), grand fir (Abies grandis), western white pine (Pinus monticola), and two small stature angiosperms, cascara (Rharnnus purshiana) and Pacific dogwood (Cornus nuttallii). Red alder (Alnus rubra) occurs in some canopy gaps along the ephemeral stream.

Table 2. Ecosystem and site attributes for Wind River Advanced tower site.

Ecosystem attributes	Measure and units
Mean canopy height	50 m
Surface roughness[a]	6 m
Zero place displacement height[a]	38 m
Structural elements	Tall old-growth conifer forest
Time zone	Pacific time zone
Magnetic declination	16° 14' E changing by 0° 9' W/year

Note, [a] From field observation.

3.2 Site Design and Tower Attributes

The site layout is summarized in the table below. **Anemometer/temperature boom arm direction** is ***from*** the tower ***toward*** the prevailing wind direction or designated orientation. **Instrument hut orientation vector** is parallel to the long side of the instrument hut. **Instrument hut distance z** is the distance from the center of tower projection to the center of the instrument hut projection on the ground. The numbering of the **measurement levels** is that the lowest is level one, and each subsequent increase in height is numbered sequentially.

Table 3. Site design and tower attributes for Wind River Advanced site.

0° is true north with declination accounted for. Color of Instrument hut exterior shall be tan to best match the surrounding environment.

Attribute	lat	long	degree	meters	notes
Airshed area			From 280° to		Clockwise from

			350°		first angle
Tower location	45.820488,	-121.951912	--	--	same site
Instrument hut					Use existing instrument hut location within the tower pad. Exact location within the pad requires landowner agreement.
Instrument hut orientation vector	--	--	135° - 315°		Pending landowner agreement
Instrument hut distance z	--	--	--	Unknown, didn't measure	
Anemometer/Temperature boom orientation	--	--	270°	--	
DFIR	45.81264,	-121.94910			
Height of the measurement levels					
Level 1				0.3	m.a.g.l.
Level 2				8.0	m.a.g.l.
Level 3				20.0	m.a.g.l.
Level 4				35.0	m.a.g.l.
Level 5				42.0	m.a.g.l.
Level 6				50.0	m.a.g.l.
Level 7				60.0	m.a.g.l.
Level 8				86.0	m.a.g.l.
Tower Height				86.0	m.a.g.l.

See AD 03 for technical requirement to determine the boom height for the bottom most measurement level.

According to the wind roses, wind can blow from any direction throughout the year. But wind blows most frequently from the airshed between 280° and 350° (clockwise from 280°). Eddy covariance, sonic wind and air temperature **boom arms** orientation toward the west will be best to capture signals from all wind directions. **Radiation boom arms** should always be facing south to avoid any shadowing effects from the tower structure.

DFIR location is at 45.81264, -121.94910, which is ~890 m southeast to tower. The rain gauge is located in the opening next to a parking lot. The distance between this location to the closest tree is ~135 m. Given the tree height around this opening is ~ 40 m, this distance is not far enough to meet USCRN class 1 siting criteria (>4 times the height of any obstacle taller in height) for DFIR, but meet the USCRN class 2 siting criteria (>2 times the height of any obstacle taller in height). **Wet deposition collector** will

collocate at the top of the tower. See AD 04 for further information and requirements for bulk precipitation collection and wet deposition collection.

Boardwalks. Ultimately, the decision to use a boardwalk will be, in part, based on owner's preferences. There are strong science requirements that minimize site disturbance to the surrounding area, which will be difficult to manage over a 30-y period. Traffic control is key to minimizing the site disturbance. Confining foot traffic to boardwalks minimizes site impact; this is particularly true in places where wear caused by foot traffic becomes noticeable and grows. For example, in places with snow part of the year, worn footpaths tend to have low places that collect water, or places where the snow pack becomes uneven causing personnel to walk farther and farther around the sides of the original path, causing the path to grow in width. This is a very common phenomenon. FIU assumes that all conduits will be either buried, or placed inside the boardwalk such that it does not extend beyond the 36" (0.914 m). The boardwalk to access the tower is not on any side that has a boom.
Specific Boardwalks at Wind River Advance site:

- A forest road goes directly to the tower pad, which is also where the instrument hut will be located, so no new boardwalk/path is necessary.
- Boardwalk to the soil array. Note that a narrow boardwalk (~0.4 m wide) is already present from the tower site towards the first soil plot. This boardwalk ends ~30 m before the first soil plot. The existing boardwalk is not wide enough for an ATV or track-based Geoprobe-type machine.
- No boardwalk from the soil array boardwalk to the individual soil plots.
- No boardwalk or path needed to DFIR site.

The relative locations between tower, instrument hut and boardwalk can be found in the Figure below:

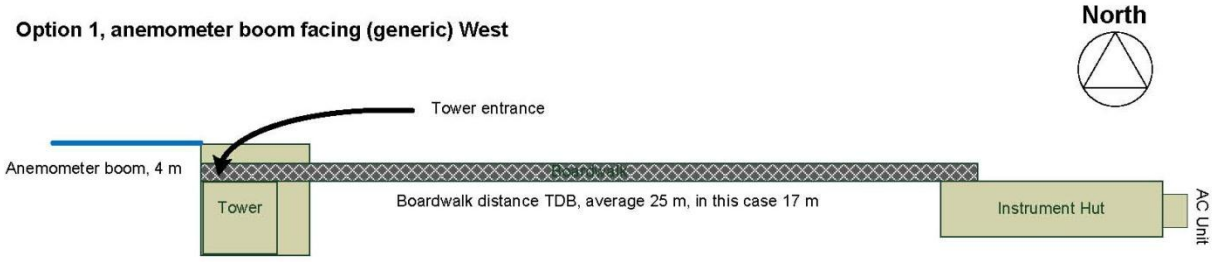


Figure 1. Generic diagram to demonstration the relationship between tower and instrument hut when boom facing south and instrument hut on the east towards the tower.

This is just a generic diagram. The actual layout of boardwalk (or path if no boardwalk required) and instrument hut position will be the joint responsibility of FCC and FIU. At Wind River Advanced site, the boom angle will be 270 degrees, instrument hut location is TBD, the distance between instrument hut and tower is unknown since the IH is TBD. The instrument hut vector will be SE-NW (135°-315°, longwise).

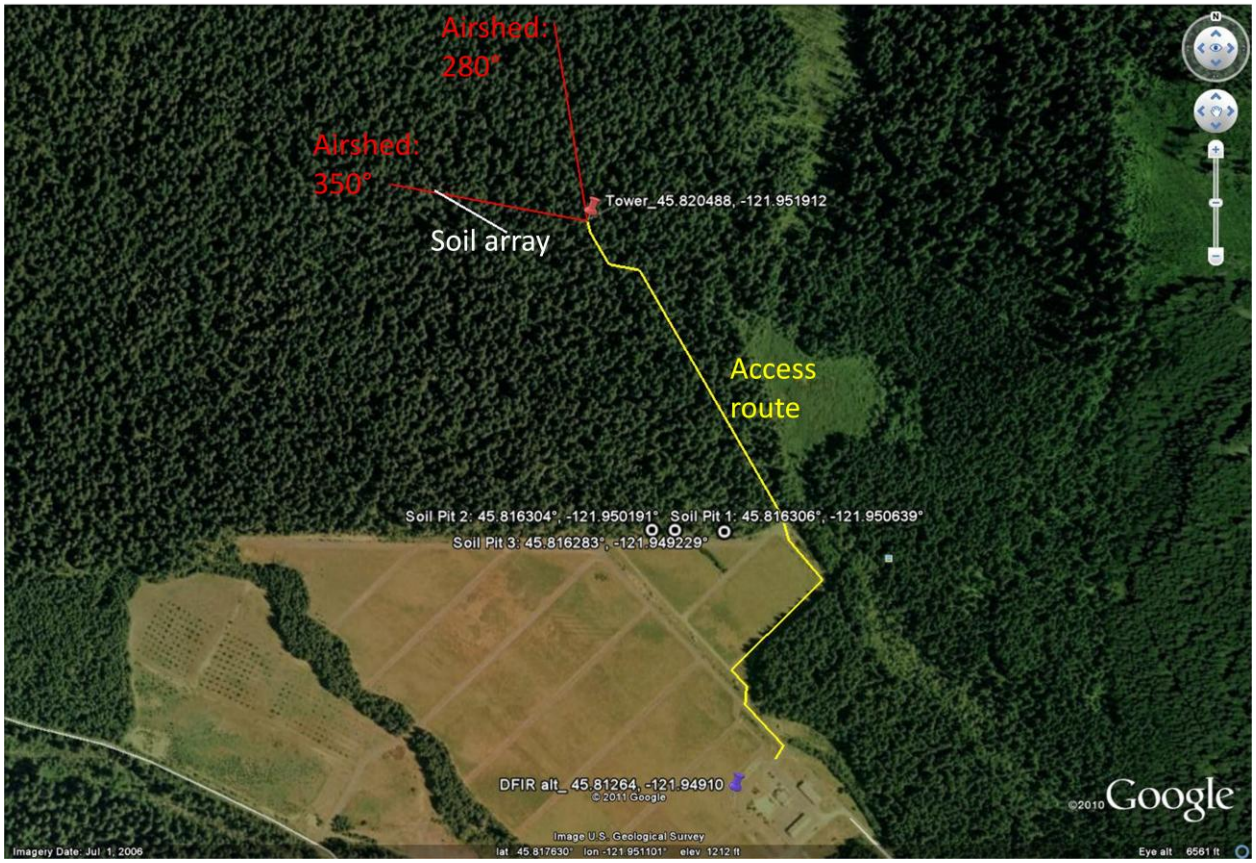


Figure 2. Site layout for Wind River Advanced tower site.
i) Tower location is presented (red pin), ii) red lines indicate the airshed boundaries. Vectors 280° to 350° (major airshed, clockwise from 280°) would have quality wind data without causing flow distortions, respectively.iii) Yellow line is the suggested access road to instrument hut. iv) Purple pin is DFIR location

3.3 Soil Attributes

The soil array vector is ***from*** the soil plot closest to the tower ***toward*** the farthest soil plot. The exact location of each soil plot will be chosen by an FIU team member during site construction to avoid placing a soil plot at an unrepresentative location (e.g., rock outcrop, drainage channel, large tree, etc).

Dominant soil series at the site: Stabler. The taxonomy of this soil is shown below:
Order: Andisols
Suborder: Udands
Great group: Hapludands
Subgroup: Vitric Hapludands
Family: Medial, amorphic, mesic Vitric Hapludands
Series: Stabler

Table 4. Summary of soil array and soil pit information at Wind River. 0° represents true north and accounts for declination.

Soil plot dimensions	5 m x 5 m
Soil array pattern	B
Distance between soil plots: x	25 m
Distance from tower to closest soil plot: y	123 m[§]
Latitude and longitude of 1st soil plot OR direction from tower	45.82033, -121.95348
Direction of soil array	300°
Latitude and longitude of FIU soil pit 1	45.816306°, -121.950639° (primary location)
Latitude and longitude of FIU soil pit 2	45.816304°, -121.950191° (alternate 1)
Latitude and longitude of FIU soil pit 3	45.816283°, -121.949229° (alternate 2)
Dominant soil type	Stabler
Expected soil depth	>2 m
Depth to water table	>2 m

Expected depth of soil horizons	**Expected measurement depths**[*]
0-0.23 m (Loam)	0.12 m[†]
0.23-0.94 m (Loam)	0.59 m[†]
0.94-1.52 m (Sandy loam)	1.23 m[†]
2 m	2.00 m

[*]Actual soil measurement depths will be determined based on measured soil horizon depths at the NEON FIU soil pit and may differ substantially from those shown here.
[†]Expected soil CO_2 sensor depth (actual depths will be determined based on the FIU soil pit)
[§]The land owner requested that the soil plots be located outside the reach of the crane boom arm. First soil plot location is near the end of an existing boardwalk from the crane.

3.3.1 Information for ecosystem productivity plots

The tower at Wind River Advanced site has been positioned to optimize the collection of the air/wind signals both temporally and spatially over the desired ecosystem (Douglas fir – hemlock forest). Wind can blow from any direction during the year, but has higher frequency from 280° to 350° (clockwise from 280°). 90% signals for flux measurements are mainly from a distance < 1250 m from tower during daytime, and 80% within 800 m. But during nighttime, signals can be from > 2 km away from tower during nighttime. We suggest FSU Ecosystem Productivity plots are placed within the boundaries of 280° to 350° (clockwise from 350°) from tower.

3.4 Issues and attentions

The tower at this site is a canopy crane. At all the other NEON candidate sites at tower designed with input from NEON will be used. It is possible that the difference in tower structure could influence the tower-based measurements, but given the relatively long boom arms that will be used by NEON, this is not expected to significanly impact the science.

The landowners require that the instrument hut be placed within the existing tower pad (exact location is to be determined). The FIU design would typically place the instrument hut outside of the dominant airshed and at least 14 m from the tower (in a forest ecosystem), but due to the land owners request this will not occur at this site.

The land owners would not allow the soil plots to be placed within the radius of the loading jib, which extends 85 m from the tower. Therefore, the first soil plot is 123 m from the tower. It is important that the soil measurements can be related to the tower measurements, therefore, at most NEON sites the first soil plot will typically be about 15-30 m from the tower. However, the forest structure is similar at the soil array and tower and given the expected large footprint for the flux measurements this is not expected to significantly impact the science at this site.

The soil array is on the edge of the dominant airshed, rather than within the airshed, because there was an existing boardwalk to the soil array location. If the soil array was placed directly within the airshed an additional boardwalk would have been necessary from the tower to the soil array, which would have increased disturbance to the site. The vegetation and soil at the soil array is similar to that within the airshed, therefore, the location of the soil array on the fringes of the airshed is not expected to significantly imapct the science at this site.

4 THAYER, RELOCATABLE TOWER 1

4.1 Desired ecosystem

Table 5. Ecosystem at the Thayer tower site.

Ecosystem Type	Management activity
Managed forest	Timber production (harvesting, fertilization, herbicide, etc)

The Thayer site is managed by the Washington Department of Natural Resources (WDNR). The site is harvested for timber, and managed according to WDNR guidelines. The site was privately owned at the time of the last timber harvest, but was acquired by WDNR prior to re-planting. The ecosystem around tower and inside the major airshed is young Douglas fir forest, which was planted after logging 10-12 years ago. Canopy height is currently ~10-12 m and average ~11 m and the forest is approaching canopy closure. Trees grow actively at a rate of ~0.5 m per year.

Table 6. Ecosystem and site attributes for Thayer Relocatable site.

Ecosystem attributes	Measure and units
Mean canopy height at construction [a]	12.0 m
Surface roughness at construction [a]	1.5 m
Zero place displacement height at construction [a]	8.0 m
Mean canopy height at 8th year of operation [b]	18.0 m
Surface roughness at 8th year of operation [b]	2.0 m
Zero place displacement height at 8th year of operation [b]	14.0 m
Structural elements	Planted young trees, actively grow
Time zone	Pacific time zone
Magnetic declination	16° 18' E changing by 0° 9' W/year

Note, [a] From field survey and best estimates for the time at the construction, which will require top measurement level at 24 m above ground.
[b] Best estimates by the time that NEON tower is decommissioned at the end of the 8 years' services, which will require top measurement level at 30 m above ground, therefore, FCC should design and budget adequate tower height ahead and allow the increase of the top measurement level to 30 m.

4.2 Site Design and Tower Attributes

The site layout is summarized in the table below. Assume the projected area of the tower is square. **Anemometer/temperature boom arm direction** is ***from*** the tower ***toward*** the prevailing wind direction or designated orientation. **Instrument hut orientation vector** is parallel to the long side of the instrument hut. **Instrument hut distance z** is the distance from the center of tower projection to the center of the instrument hut projection on the ground. The numbering of the **measurement levels** is that the lowest is level one, and each subsequent increase in height is numbered sequentially.

Table 7. Site design and tower attributes for Thayer Relocatable site

0° is true north with declination accounted for. Color of Instrument hut exterior shall be tan or best match the surrounding environment.

Attribute	lat	long	degree	meters	notes
Airshed area			130° to 190°		Clockwise from first angle
Tower location	45.71438,	-122.34024	--	--	new site
Instrument hut	45.71437,	-122.34046			
Instrument hut orientation vector	--	--	160° - 340°		
Instrument hut distance z	--	--	--	17	
Anemometer/Temperature boom orientation	--	--	180°	--	
Height of the measurement levels*					
Level 1				0.3	m.a.g.l.
Level 2				3.0	m.a.g.l.
Level 3				9.0	m.a.g.l.
Level 4				15.0	m.a.g.l.
Level 5				24.0	m.a.g.l.
Tower Height				24.0	m.a.g.l.

* These dimensions assume a late 2012 construction, see text above. Any change to this schedule the heights would have to be re-calculated.
See AD 03 for technical requirement to determine the boom height for the bottom most measurement level.

Eddy covariance, sonic wind and air temperature **boom arms** orientation toward the south will be best to capture signals from all major wind directions. **Radiation boom arms** should always be facing south to avoid any shadowing effects from the tower structure.

Secondary **precipitation collector** for bulk precipitation collection will be located the top of tower at this site. No **wet deposition collector** will be deployed at this site. See AD 04 for further information and requirements for bulk precipitation collection and wet deposition collection.

Boardwalks. Ultimately, the decision to use a boardwalk will be, in part, based on owner's preferences. There are strong science requirements that minimize site disturbance to the surrounding area, which will be difficult to manage over a 30-y period. Traffic control is key to minimizing the site disturbance. Confining foot traffic to boardwalks minimizes site impact; this is particularly true in places where wear caused by foot traffic becomes noticeable and grows. For example, in places with snow part of the year, worn footpaths tend to have low places that collect water, or places where the snow pack becomes uneven causing personnel to walk farther and farther around the sides of the original path, causing the path to grow in width. This is a very common phenomenon. Here FIU assumes that all conduits will be either buried, or placed inside the boardwalk such that it does not extend beyond the 36' wide footprint. While the final design is not yet known, there are some general criteria that can be outlined. We assume that the boardwalk width is 36" (0.914 m). Material is not known, but must be fire proof, and in some locations the site is seasonally flooded and inundated with water. Boardwalks may also provide a scratching structure for grazing animals that in turn, would wear and unduly impact the site. Site by site evaluations must be done.

Specific boardwalks at the Thayer Relocatable site

- Boardwalk from the access point to the instrument hut, pending landowner decision.
- Boardwalk from the instrument hut to the tower to intersect on north face of the tower
- Boardwalk to the soil array
- No boardwalk to individual soil plots

The relative locations between tower, instrument hut and boardwalk can be found in the diagram below:

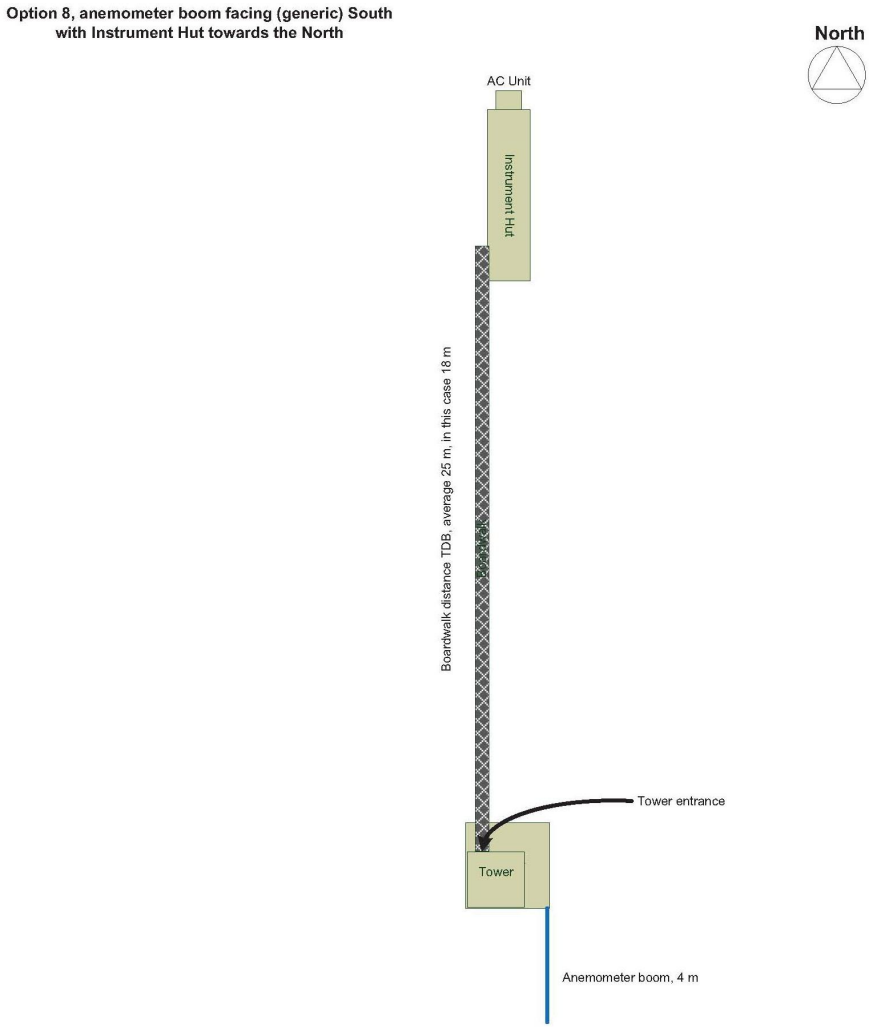


Figure 3. Generic diagram to demonstration the relationship between tower and instrument hut when boom facing south and instrument hut on the north towards the tower.

This is just a generic diagram. The actual layout of boardwalk (or path if no boardwalk required) and instrument hut position will be the joint responsibility of FCC and FIU. At Thayer Relocatable site, the boom angle will be 180^{o}, instrument hut will be on the west towards the tower, the distance between instrument hut and tower is ~17 m. The instrument hut vector will be SE-NE (160^{o}-340^{o}, longwise).

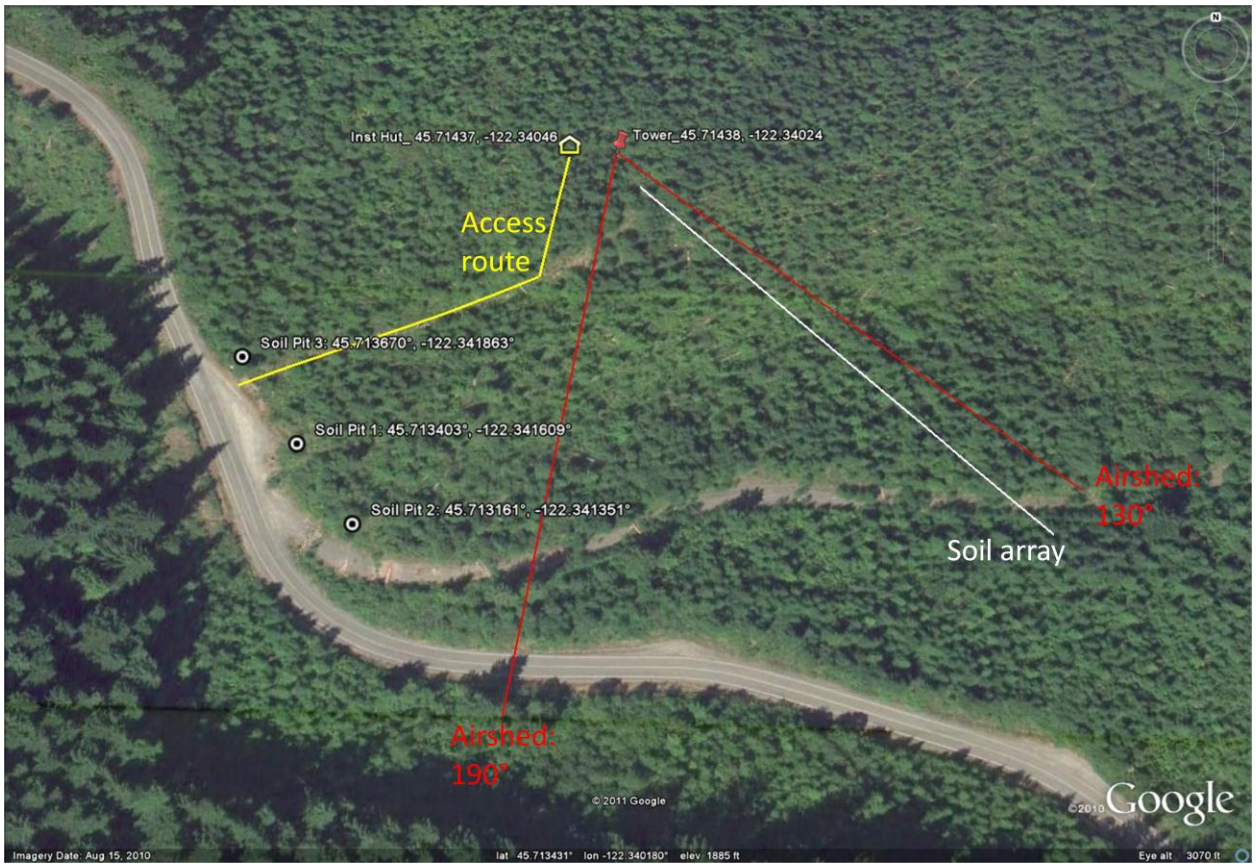


Figure 4. Site layout for Thayer Relocatable site.
i) tower location is presented (red pin), ii) red lines indicate the airshed boundaries. Vectors 130° to 190° (clockwise from 130°) would have quality wind data without causing flow distortions, respectively. iii) Yellow line is the suggested access road to instrument hut.

4.3 Soil Attributes

The soil array vector is ***from*** the soil plot closest to the tower ***toward*** the farthest soil plot. The exact location of each soil plot will be chosen by an FIU team member during site construction to avoid placing a soil plot at an unrepresentative location (e.g., rock outcrop, drainage channel, large tree, etc).

Dominant soil series at the site: Kinney silt loam, 30 to 50 percent slopes. The taxonomy of this soil is shown below:
Order: Inceptisols
Suborder: Udepts
Great group: Dystrudepts
Subgroup: Andic Dystrudepts
Family: Fine-loamy, isotic, mesic Andic Dystrudepts
Series: Kinney silt loam, 30 to 50 percent slopes

Table 8. Summary of soil array and soil pit information at Thayer. 0° represents true north and accounts for declination.

Soil plot dimensions	5 m x 5 m
Soil array pattern	B
Distance between soil plots: x	40 m
Distance from tower to closest soil plot: y	16 m
Latitude and longitude of 1st soil plot OR direction from tower	45.714261, -122.340126
Direction of soil array	133°
Latitude and longitude of FIU soil pit 1	45.713403°, -122.341609° (primary location)
Latitude and longitude of FIU soil pit 2	45.713161°, -122.341351° (alternate 1)
Latitude and longitude of FIU soil pit 3	45.713670°, -122.341863° (alternate 2)
Dominant soil type	Kinney silt loam, 30 to 50 percent slopes
Expected soil depth	>2 m
Depth to water table	>2 m

Expected depth of soil horizons	**Expected measurement depths***
0-0.13 m (Silt loam)	0.07 m†
0.13-1.52 m (Gravelly silty clay)	0.83 m†
2 m	2 m†

*Actual soil measurement depths will be determined based on measured soil horizon depths at the NEON FIU soil pit and may differ substantially from those shown here.

†Expected soil CO_2 sensor depth (actual depths will be determined based on the FIU soil pit)

4.3.1 Information for ecosystem productivity plots

The tower at Thayer relocatable site has been positioned to optimize the collection of the air/wind signals both temporally and spatially over the desired ecosystem (young Douglas fir forest). Prevailing wind blows from 130° to 190°, clockwise from 130°. Due to the actively growing ecosystem and adjustment of the height of top measurement level over time, tower fetch area will change accordingly. We expect that 90% signals for flux measurements during daytime are within a distance of 350 m from tower for mean wind speed conditions over the operation period of 8 years, and 80% within 250 m. But during nighttime stable calm wind conditions and daytime maximum wind speed, flux sensor on tower can detect signals beyond 1 km from tower. We suggest FSU Ecosystem Productivity plots are placed within the boundaries of 130° to 190° (major, clockwise from 130°) from tower.

4.4 Issues and attentions

Site is very small. Only ~70% flux signals during daytime are within the same management plot of young Doglas fir forest; ~ 30% daytime signal and some nighttime signals will be from the neighboring mature forest in the major airshed, which is south to southeast to tower. It will be challenging to intepret the measurement results. However, this cannot be easily avoided in this region, because landownership and forest management practices are based on small parcels in this region and Washington Department of Natural Resources guidelines do not allow adjacent forest units to be harvested within 6 years of each other.

The plant canopy is actively and rapidly accruing height. Design, construction and operations need to take this into account. During the site characterization visit mean canopy height was ~11 m. We assume the construction at this site will be in 2012 or 2013 and that the tree growth rate is ~0.5 m/yr, which will give canopy height ~ 12 m at construction. The mean canopy height is expected to reach ~ 18 m after 8 years of operation, which is approximately by the time NEON relocatable tower decommissioned at this site. For any change to this schedule the heights would have to be re-calculated. FCC should design and budget adequate tower height ahead and allow the increase of the top measurement level to 30 m. Tree height shall be reevaluated at the time of construction to ensure the tower height and boom heights are appropriate.

The landowner requests that the boardwalk goes around the trees at this site, rather than cut them down. The trees are relatively young (~10-12 years old) and may have stem diameters below the threshold diamieter usually recorded by a site surveyors for NEON's Facilities and Civel Construction (FCC) group. A special request to record smaller diameter stems may be necessary for the construction survey at this site.

5 ABBY ROAD, RELOCATEABLE TOWER 2

5.1 Desired ecosystem

Table 9. Ecosystem at the Abby Road Relocatable site.

Ecosystem Type	Management activity
Managed forest	Timber production (harvesting, fertilization, herbicide, etc)

The Abby Road site is managed by the Washington Department of Natural Resources (WDNR). The site is harvested for timber, and managed according to WDNR guidelines. There is a campground nearby (1-2 km from the site). Tower location is inside a small forest management parcel (approximately 450 m × 500 m), which is a typical size for management units in this region. This parcel was recently logged and re-planted with Douglas fir (seedlings are 4-6 years old). Large mature forests ~34 m are at the edge of all sides this management parcel. In addition, there are patches of matures trees within the parcel; WDNR managements practices require of proportion of mature trees to be retained when a parcel of land is harvested. This will result in large edge effects and uncertainties for flux measurements over this young forest. Canopy height is currently ~1 m. The trees are growing actively (~0.5 m per year).

Table 10. Ecosystem and site attributes for the Abby Road Relocatable site.

Ecosystem attributes	Measure and units
Mean canopy height at construction [a]	2.0 m
Surface roughness at construction [a]	0.5 m
Zero place displacement height at construction [a]	1.4 m
Mean canopy height at 8th year of operation [b]	6.0 m
Surface roughness at 8th year of operation [b]	0.8 m
Zero place displacement height at 8th year of operation [b]	3.0 m
Structural elements	Replanted young trees, actively grow
Time zone	Pacific time zone
Magnetic declination	16° 18' E changing by 0° 9' W/year

Note, [a] From field survey and best estimates for the time at the construction, which will require top measurement level at 8 m above ground.

[b] Best estimates by the time that NEON tower is decommissioned at the end of the 8 years' services, which will require top measurement level at 15 m above ground, therefore, FCC should design and budget adequate tower height ahead and allow the increase of the top measurement level to 15 m.

5.2 Site Design and Tower Attributes

The site layout is summarized in the table below. Assume the projected area of the tower is square. **Anemometer/temperature boom arm direction** is ***from*** the tower ***toward*** the prevailing wind direction or designated orientation. **Instrument hut orientation vector** is parallel to the long side of the instrument hut. **Instrument hut distance z** is the distance from the center of tower projection to the center of the instrument hut projection on the ground. The numbering of the **measurement levels** is that the lowest is level one, and each subsequent increase in height is numbered sequentially.

Table 11. Site design and tower attributes for Abby Road Relocatable site

0° is true north with declination accounted for. Color of Instrument hut exterior shall be tan or best match the surrounding environment.

Attribute	lat	long	degree	meters	notes
Airshed			130° to 190°		Clockwise from first angle
Tower location	45.76243,	-122.33033	--	--	
Instrument hut	45.76256,	-122.33023			
Instrument hut orientation vector	--	--	160°-340°		longwise
Instrument hut distance z	--	--	--	17	
Anemometer/Temperature boom orientation	--	--	180°	--	
Height of the measurement levels*					
Level 1				0.3	m.a.g.l.
Level 2				3.0	m.a.g.l.
Level 3				6.0	m.a.g.l.
Level 4				8.0	m.a.g.l.
Tower Height				8.0	m.a.g.l.

See AD 03 for technical requirement to determine the boom height for the bottom most measurement level.

Eddy covariance, sonic wind and air temperature **boom arms** orientation toward the south will be best to capture signals from all major wind directions. **Radiation boom arms** should always be facing south to avoid any shadowing effects from the tower structure.

Secondary **precipitation collector** for bulk precipitation collection will be located the top of tower at this site. No **wet deposition collector** will be deployed at this site. See AD 04 for further information and requirements for bulk precipitation collection and wet deposition collection.

Boardwalks. Ultimately, the decision to use a boardwalk will be, in part, based on owner's preferences. There are strong science requirements that minimize site disturbance to the surrounding area, which will be difficult to manage over a 30-y period. Traffic control is key to minimizing the site disturbance. Confining foot traffic to boardwalks minimizes site impact; this is particularly true in places where wear caused by foot traffic becomes noticeable and grows. For example, in places with snow part of the year, worn footpaths tend to have low places that collect water, or places where the snow pack becomes uneven causing personnel to walk farther and farther around the sides of the original path, causing the path to grow in width. This is a very common phenomenon. FIU assumes that all conduits will be either buried, or placed inside the boardwalk such that it does not extend beyond the 36' wide footprint. While the final design is not yet known, there are some general criteria that can be outlined. We assume that the boardwalk width is 36" (0.914 m). Material is not known, but must be fire proof, and in some locations the site is seasonally flooded and inundated with water. Boardwalks may also provide a scratching structure for grazing animals that in turn, would wear and unduly impact the site. Site by site evaluations must be done.

Specific boardwalks at this site:

- Boardwalk from logging access road to instrument hut (i.e. ~40 m in length), pending landowner decision.
- Boardwalk from the instrument hut to the tower to intersect on north face of the tower, pending landowner decision
- Boardwalk to soil array
- No boardwalk from soil array boardwalk to individual soil plots.

The relative locations between tower, instrument hut and boardwalk can be found in the diagram below:

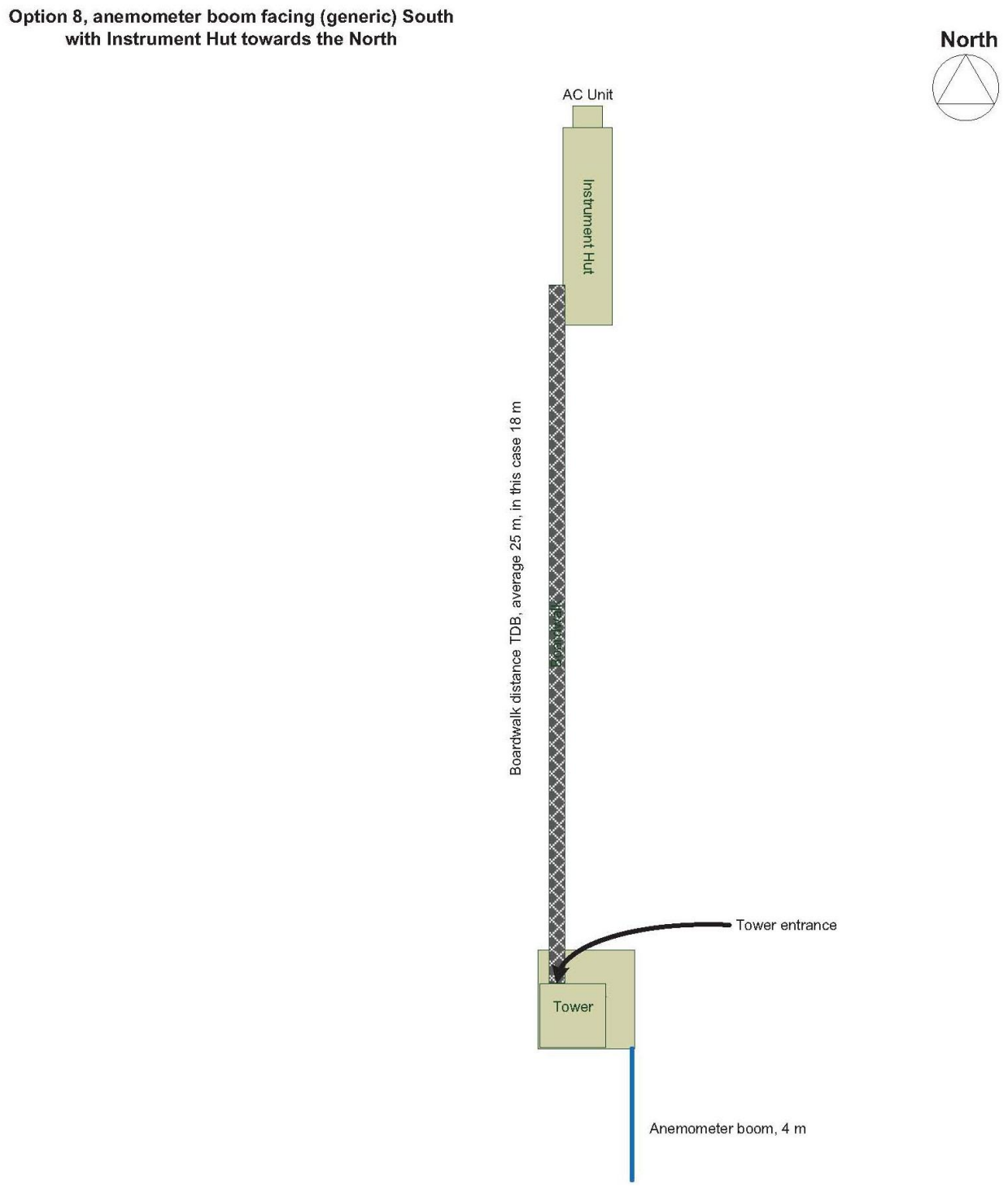


Figure 5. Generic diagram to demonstration the relationship between tower and instrument hut when boom facing south and instrument hut on the north towards the tower.

This is just a generic diagram when boom facing south and instrument hut on the northern side of the tower. The actual design of boardwalk (or path if no boardwalk required) and instrument hut position

will be joint responsibility of FCC and FIU. At Abby Road Relocatable site, the boom angle will be 180 degrees, instrument hut will be on the northeast towards the tower, the distance between instrument hut and tower is ~17 m. The instrument hut vector will be SW-NE (160°-340°, longwise).

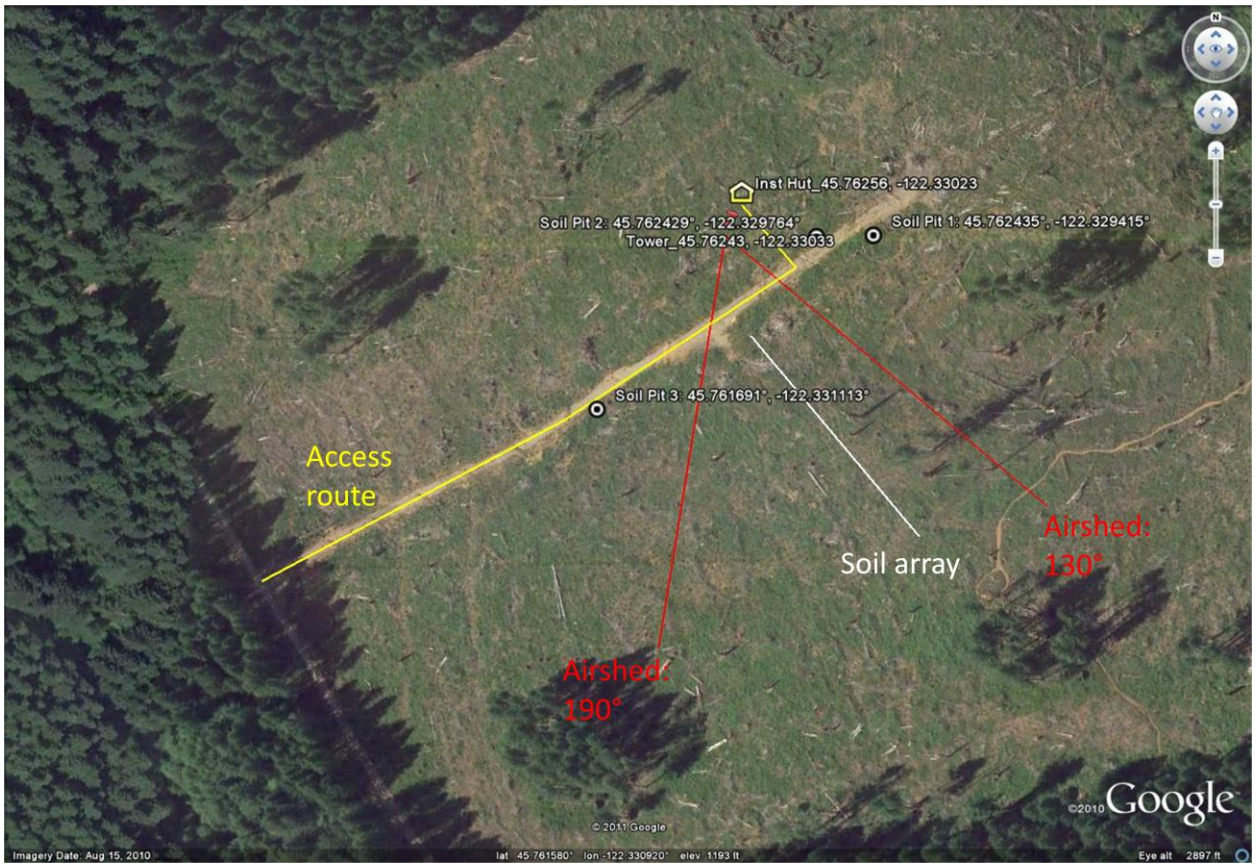


Figure 6. Site layout for Abby Road Relocatable site.
i) Tower location is presented (red pin), ii) Airshed boundary lines are not presented. Prevailing winds blow from 130^{o} to 190^{o} (clockwise from 130^{o}). iii) Yellow line is the suggested access road to instrument hut.

5.3 Soil Attributes

The soil array vector is ***from*** the soil plot closest to the tower ***toward*** the farthest soil plot. The exact location of each soil plot will be chosen by an FIU team member during site construction to avoid placing a soil plot at an unrepresentative location (e.g., rock outcrop, drainage channel, large tree, etc).

Dominant soil series at the site: Cinebar silt loam, 8 to 20 percent slopes. The taxonomy of this soil is shown below:
Order: Andisols
Suborder: Xerands
Great group: Haploxerands
Subgroup: Humic Haploxerands
Family: Medial, mixed, mesic Humic Haploxerands

Series: Cinebar silt loam, 8 to 20 percent slopes

Table 12. Summary of soil array and soil pit information at Abby Road. 0° represents true north and accounts for declination.

Soil plot dimensions	5 m x 5 m
Soil array pattern	B
Distance between soil plots: x	25 m
Distance from tower to closest soil plot: y	49 m
Latitude and longitude of 1st soil plot OR direction from tower	45.76200, -122.33017
Direction of soil array	140°
Latitude and longitude of FIU soil pit 1	45.762435°, -122.329415° (primary location)
Latitude and longitude of FIU soil pit 2	45.762429°, -122.329764° (alternate 1)
Latitude and longitude of FIU soil pit 3	45.761691°, -122.331113° (alternate 2)
Dominant soil type	Cinebar silt loam, 8 to 20 percent slopes
Expected soil depth	>2 m
Depth to water table	>2 m

Expected depth of soil horizons	**Expected measurement depths***
0-0.33 m (Silt loam)	0.17 m†
0.33-1.22 m (Silt loam)	0.78 m†
1.22-1.52 m (Loam)	1.37 m†
2 m	2 m

*Actual soil measurement depths will be determined based on measured soil horizon depths at the NEON FIU soil pit and may differ substantially from those shown here.

†Expected soil CO_2 sensor depth (actual depths will be determined based on the FIU soil pit)

5.3.1 Information for ecosystem productivity plots

The tower at Thayer relocatable site has been positioned to optimize the collection of the air/wind signals both temporally and spatially over the desired ecosystem (young Douglas fir forest). Prevailing wind blows from 130° to 190°, clockwise from 130°. Due to the actively growing ecosystem and adjustment of the height of top measurement level over time, tower fetch area will change accordingly. We expect that 90% signals for flux measurements during daytime are within a distance of 700 m from tower for the operation period of 8 years, 80% within 400 m, and 70% within 300 m. Because of the small size of the management parcel (approximately 450 m × 500 m), and the distance between tower and the forest edge in the major airshed is only ~ 300 m, 30% of the flux signals will likely come from the taller forest (34 m) outside our measurement parcel. Uncertainty is large but cannot be avoided.We suggest FSU Ecosystem Productivity plots are placed within the boundaries of 130° to 190° (major, clockwise from 130°) from tower.

5.4 Issues and attentions

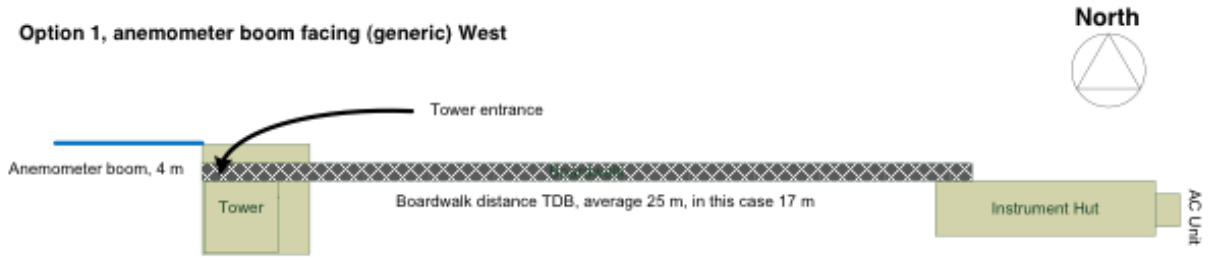
The forest parcel for the tower site is small. The fetch area for flux measurements will likely to extend into neighboring managements parcels with tall trees (34 m). Only ~70% flux signals are from the area within the same management plot of young Douglas fir forest. It will be challenging to intepret the measurement results. However, this cannot be easily avoided in this region, because landownership and forest management practices are for small parcels in this region.

The plant canopy is actively and rapidly accruing height. Design, construction and operations need to take this into account. During the site characterization visit mean canopy height was ~1 m. We assume the construction at this site will be in 2012 or 2013 and that the tree growth rate is ~0.5 m/yr, which will give canopy height ~ 2 m at construction. The mean canopy height is expected to reach ~ 6 m after 8 years of operation, which is approximately by the time NEON relocatable tower decommissioned at this site. For any change to this schedule the heights would have to be re-calculated. FCC should design and budget adequate tower height ahead and allow the increase of the top measurement level from 8 m to 15 m. Tree height shall be reevaluated at the time of construction to ensure the tower height and boom heights are appropriate.

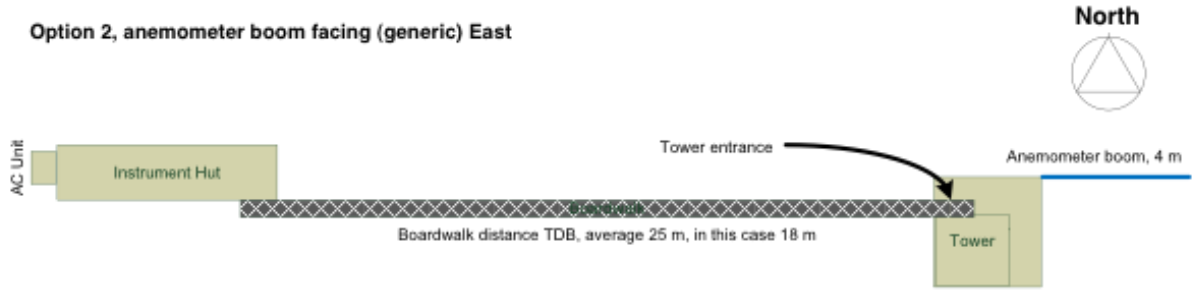
The landowner requests that the boardwalk goes around the trees at this site, rather than cut them down. The trees are young (~4-6 years old) and may have stem diameters below the threshold diamieter usually recorded by a site surveyors for NEON's Facilities and Civel Construction (FCC) group. A special request to record smaller diameter stems may be necessary for the construction survey at this site.

There is a campground near the site (1-2 km away), but whether and how often people enter this site is unknown. Signs and fences may be required to minimize disturbance to NEON infracstructure and instruments.

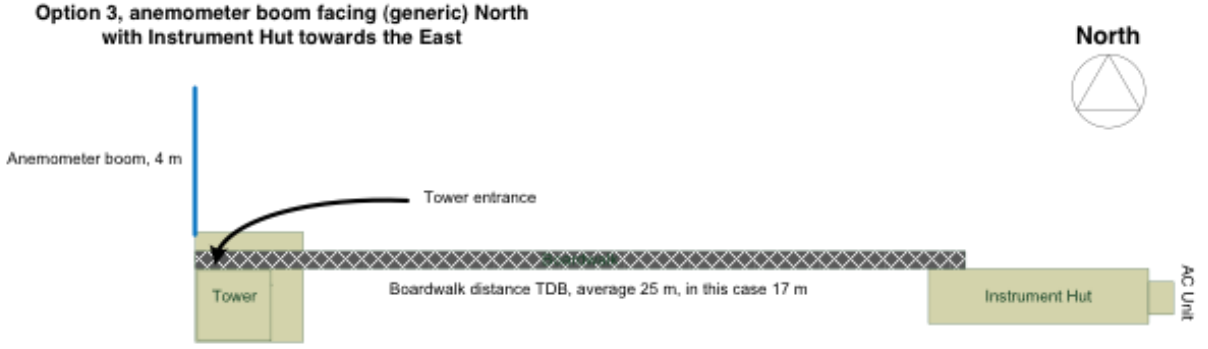
Option 1, anemometer boom facing (generic) West



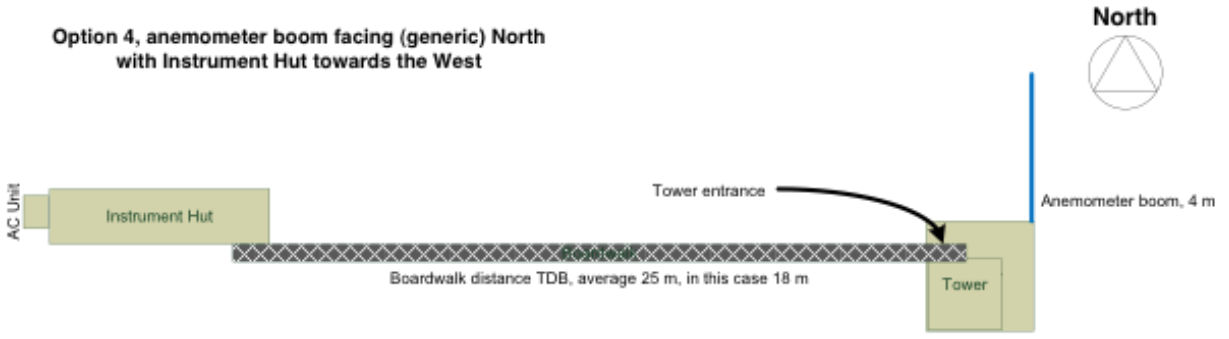
Option 2, anemometer boom facing (generic) East



Option 3, anemometer boom facing (generic) North with Instrument Hut towards the East



Option 4, anemometer boom facing (generic) North with Instrument Hut towards the West



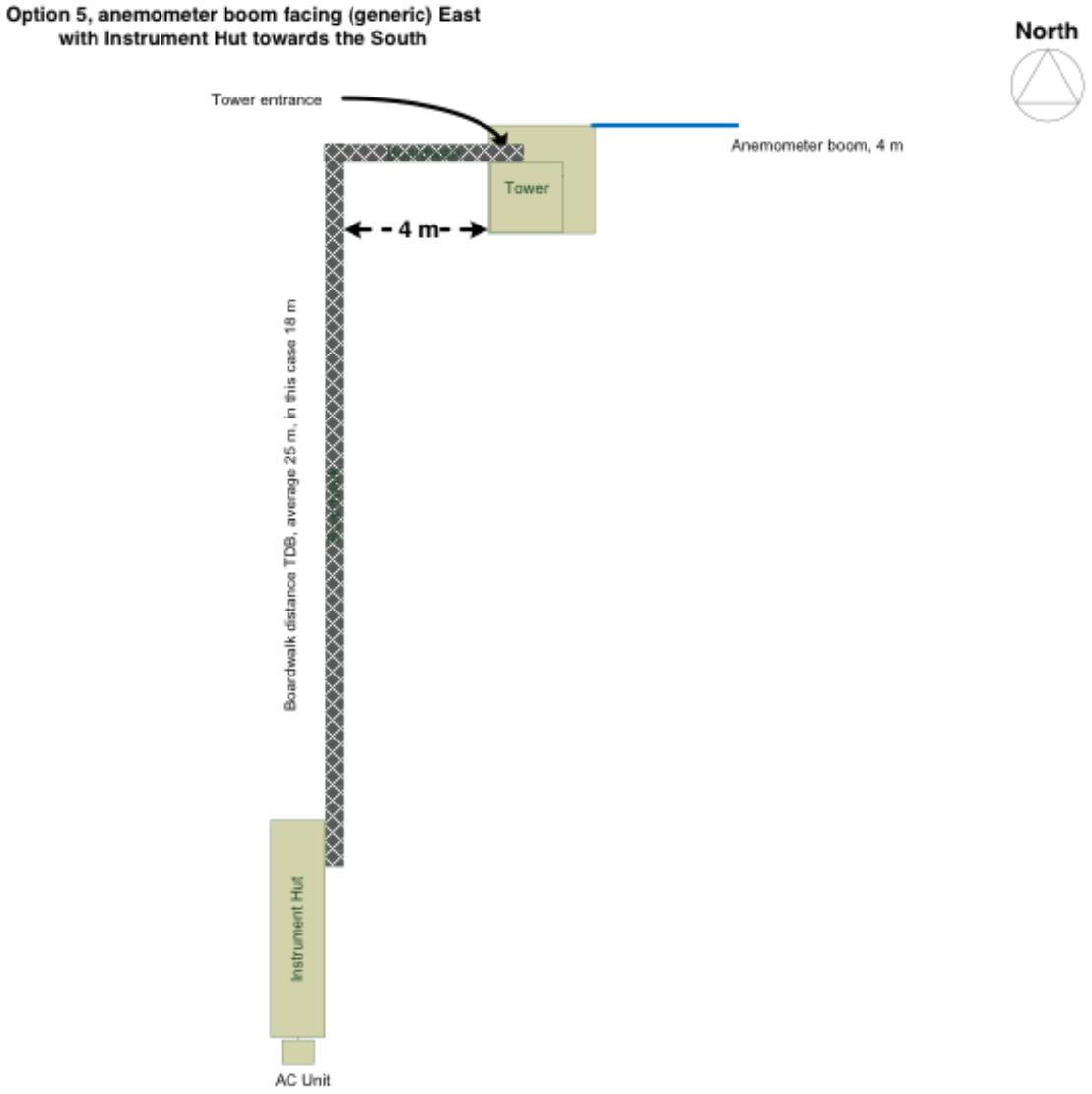
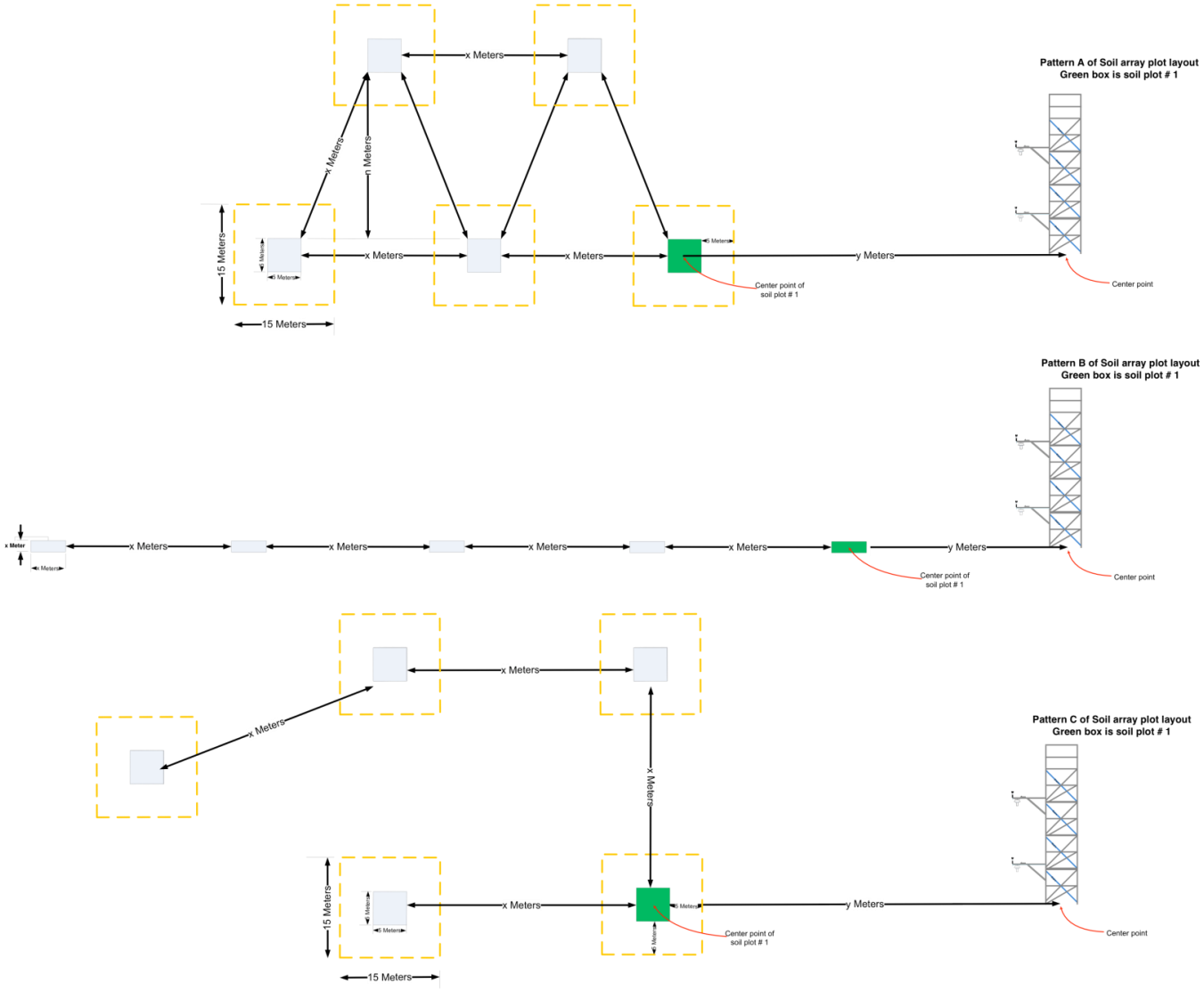

Option 5, anemometer boom facing (generic) East
with Instrument Hut towards the South
North
Tower entrance
Anemometer boom, 4 m
Tower
- 4 m-
Boardwalk distance TDB, average 25 m, in this case 18 m
Instrument Hut
AC Unit

Figure 7. Generic patterns for the boardwalk configuration

These generic configurations are from the instrument hut to the tower based on 5 generic scenarios. The five options are based on anemometer boom orientation and the leeward side of the tower where the instrument hut is located. The tower entrance is always on the North side of the tower. Exact tower and instrument hut location and orientation will be specified at each location and presented in the site characterization document.


Pattern A of Soil array plot layout
Green box is soil plot # 1
x Meters
x Meters
n Meters
15 Meters
15 Meters
x Meters
x Meters
y Meters
Center point of soil plot # 1
Center point
Pattern B of Soil array plot layout
Green box is soil plot # 1
x Meter
x Meters
x Meters
x Meters
x Meters
y Meters
Center point of soil plot # 1
Center point
Pattern C of Soil array plot layout
Green box is soil plot # 1
x Meters
x Meters
x Meters
15 Meters
15 Meters
x Meters
y Meters
Center point of soil plot # 1
Center point

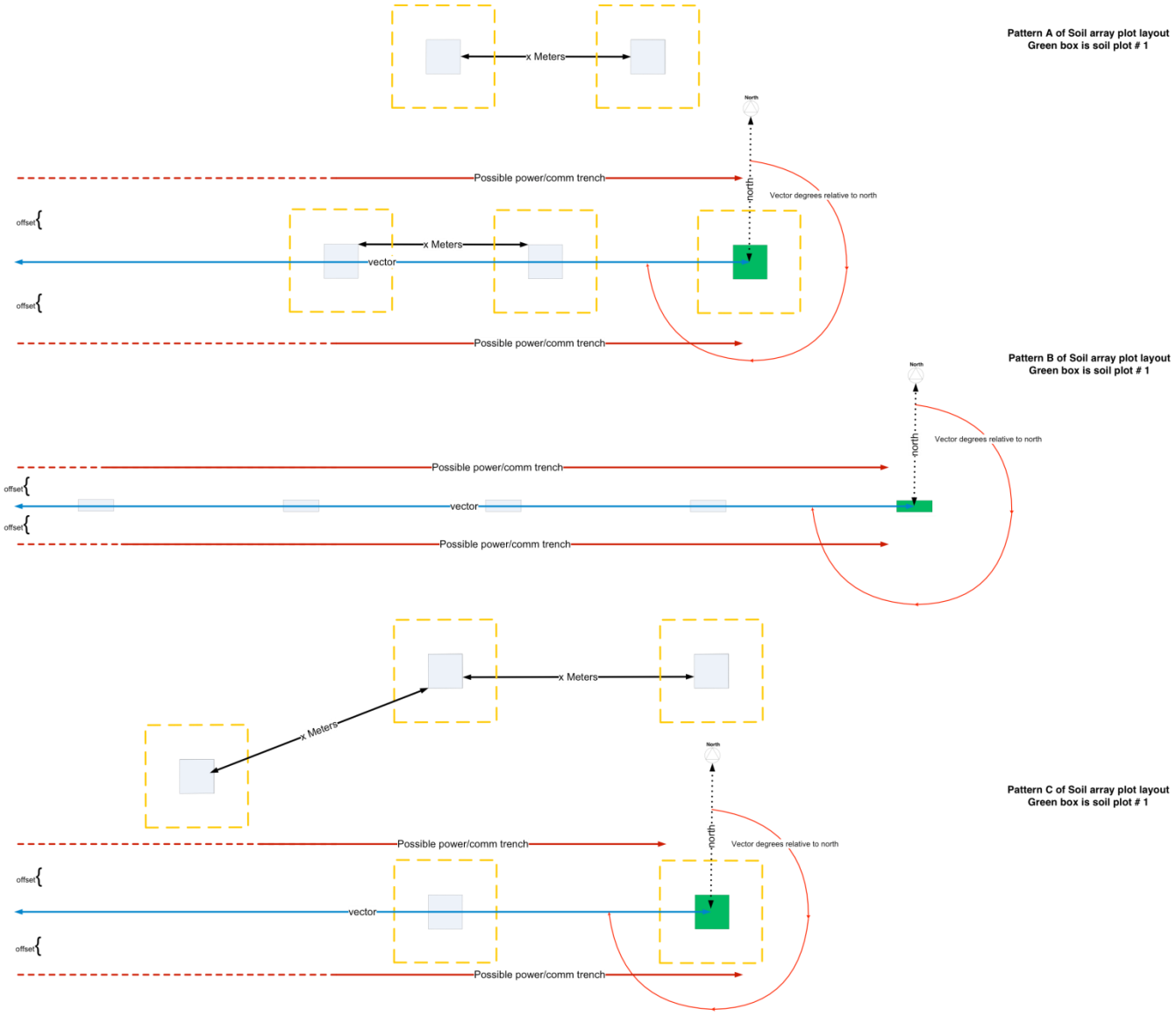


Figure 8. Conceptual diagram of Soil Array Patterns

Outlines the orientation for the soil array and instrument hut from the center point of the tower. The x, y, z distances are i) the distance between soil plots, ii) distance between the tower centerpoint and the closest edge of soil plot, and iii) the distance between the tower centerpoint and the closest edge of the instrument hut, respectively. The yellow outline around each soil plot is the 5 m perimeter keep out zone.

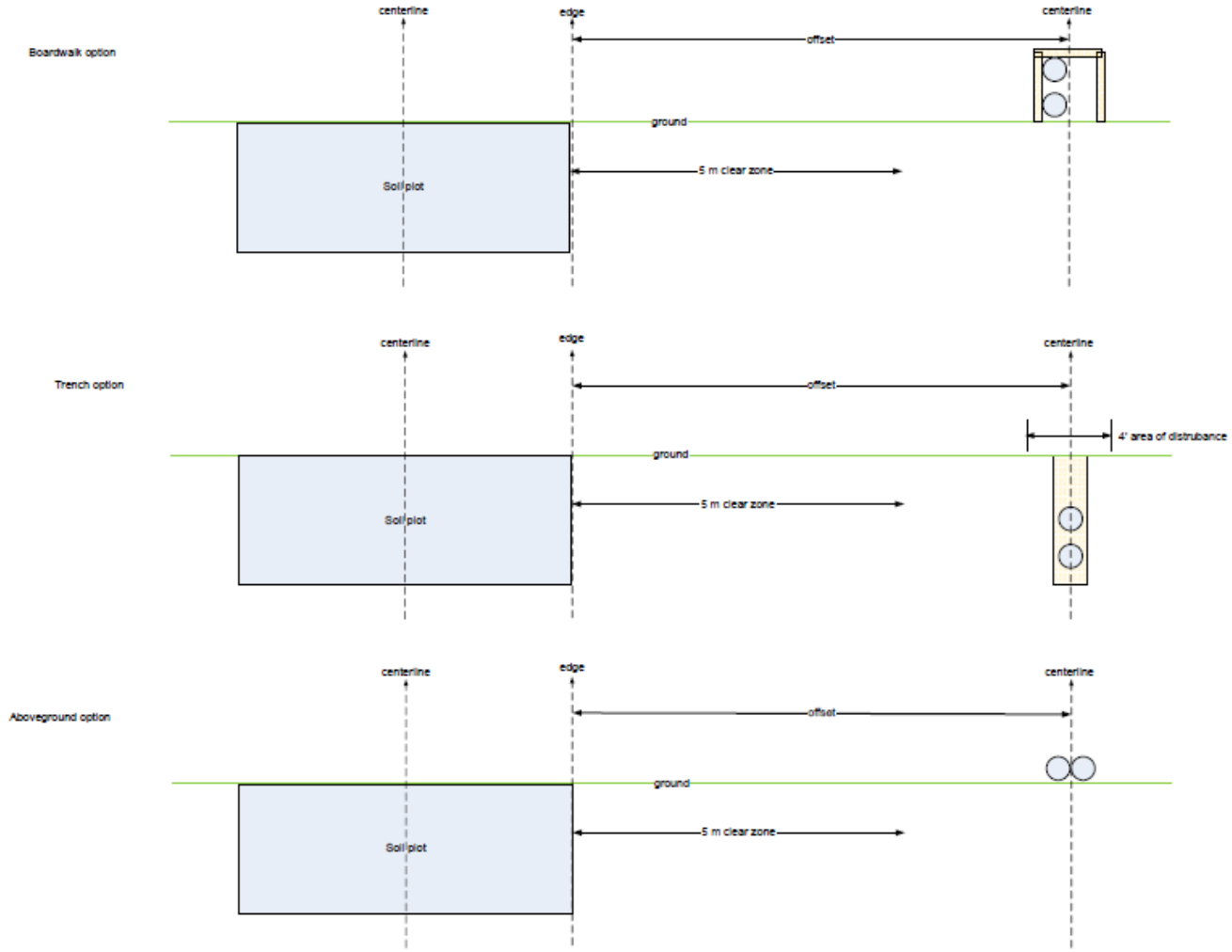


Figure 9. Conceptual diagram of power/communications line and boardwalk/path options in relation to FIU soil plots.

Boardwalk option: When a boardwalk is present the power and communication lines will typically follow the route of the boardwalk and be mounted aboveground (underneath the boardwalk). When no boardwalk is present (or the power/communication lines follow a different route than the boardwalk) the lines can be buried (Trench option) or run aboveground (Aboveground option). The aboveground option will be used instead of the trench option when trenching would be expected to cause significant disturbance to an ecosystem (e.g. cutting the roots of trees), pending landowner approval.

6 APPENDIX A. FCC SUMMARY TABLES

Table 13. FCC Summary Table for FIU site components at D16 Windriver Advanced site

Site Component				**units**
Tower location	45.820488,	-121.951912		Lat, Long, in degrees
Tower location	45° 49' 13.7562"	-121° 57' 6.8826"		Lat, Long in deg min sec
Tower height[f]	86			meters
Tower guying	none	Use existing tower		yes/none, notes
Instrument Hut location	Use existing instrument hut location within the tower pad. Exact location within the pad requires landowner agreement			Lat, Long, in degrees
Instrument Hut location	See above			Lat, Long in deg min sec
IH orientation[a]	135° - 315°			vector
boom orientation[b]	270°			degrees
distance from center of tower to IH center (z)		unknown	option 1	distance (m), option #, (location chosen to meet National Park approval)
how the Bwalk intersects the tower access	A forest road goes directly to the tower pad and instrument hut, so, no BW needed between tower and IH			description
Air shed vector(s)[c]	280° to 350°			Vector, clock wise from first angle
Boardwalk from AP to IH	no	A forest road goes directly to the tower pad and instrument hut		yes/none, notes
Boardwalk to soil array	yes	Note that a narrow boardwalk (~0.4 m wide) is already present from the tower site towards the first soil plot. This boardwalk ends ~30 m before the first soil plot. The existing boardwalk is not wide enough for an ATV or track-based Geoprobe-type machine.		yes/none, notes
Boardwalk needed to DFIR	no			yes/none

Power and Communication trench	10 m from edge of soil plot to the centerline of the power/comms line	whichever side is easiest [e], line above ground		offset, notes
DFIR location	45.81264,	-121.94910		Lat, Long in degrees, notes
DFIR location	45° 48' 45.504"	-121° 56' 56.76"		Lat, Long in deg min sec
DFIR power supply	30 amp AC power from tower			description
Soil plot 1st location	45.82033,	-121.95348		Lat, Long in degrees (center point)
Soil plot 1st location	45° 49' 13.1874"	-121° 57' 12.5274"		Lat, Long in deg min sec
Soil plot distance between plots (x) and from tower (y)	25 m	123 m[§]		x, y (meters)
Soil array pattern and vector[d]	B	300°		A, B, or C, vector
Soil plot dimensions	5 m x 5 m			L x W (meters)
Soil profile pit primary	45.816306°,	-121.950639°	>2 m	Lat, Long, and expected depth
Soil profile pit primary	45° 48' 58.701"	-121° 57' 2.2998"		Lat, Long in deg min sec
Soil profile pit alternative 1	45.816304°,	-121.950191°	>2 m	Lat, Long, and expected depth
Soil profile pit alternative 1	45° 48' 58.6944"	-121° 57' 0.6876"		Lat, Long in deg min sec
Soil profile pit alternative 2	45.816283°,	-121.949229°	>2 m	Lat, Long, and expected depth
Soil profile pit alternative 2	45° 48' 58.6182"	-121° 56' 57.2244"		Lat, Long in deg min sec
Fencing needs	none	none	none	IH, Soil Arrays, Guy anchors
Presence of large grazing animals	Likely, wild animals like moose, dear, etc			description
Site management*	Managed as a wild land			description
Any additional site specific information	Tall closed conifer forest ecosystem. Level 1 is 0.3 m a.g.l. in our design. If boom is on tower, sensor will be right on top of the gravel tower pad and measurements will not be meaningful. Therefore, a field array outside the tower pad will be needed for the level 1 measurement.			description
Magnetic declination	16° 14' E changing by 0° 9' W/year			At time of site visit

[§]The land owner requested that the soil plots be located outside the reach of the crane boom arm. First soil plot location is near the end of an existing boardwalk from the crane.

Table 14. FCC Summary Table for FIU site components at D16 Thayer Relocatable 1

Site Component				**units**
Tower location	45.71438,	-122.34024		Lat, Long in degrees
Tower location	45° 42' 51.7674"	-122° 20' 24.8634"		Lat, Long in deg min sec
Tower height[f]	24 m			meters
Tower guying	Yes (growth of surrounding trees must be considered when placing guy wires)			yes/none, notes
Instrument Hut location	45.71437,	-122.34046		Lat, Long in degrees
Instrument Hut location	45° 42' 51.732"	-122° 20' 25.6554"		Lat, Long in deg min sec
IH orientation[a]	160°-340°			vector
boom orientation[b]	180°			degrees
distance from center of tower to IH center (z)		17	Option 8	vector, distance (m), option #
how the Bwalk intersects the tower access	Boardwalk intersects the north-side of the tower from the IH on west.			description
Air shed vector(s)[c]	130° to 190°			vector, clockwise from first angle
Boardwalk from AP to IH	yes			yes/none, notes
Boardwalk to soil array	Yes	No BW to individual soil plots		yes/none, notes
Boardwalk needed to DFIR	NA			yes/none
DFIR location	NA			Lat, Long
Power and Communication line	10 m from edge of soil plot to the centerline of the power/comms line	whichever side is easiest[e], line above ground		offset, notes
DFIR power supply	na.			description
Soil plot 1st location	45.714261,	-122.340126		Lat, Long (center point)
Soil plot 1st location	45° 42' 51.3396"	-122° 20' 24.453"		Lat, Long in deg min sec
Soil plot distance between plots (x) and from tower (y)	40 m	16 m		x, y (meters)
Soil array pattern and vector[d]	B	133°		A, B, or C, vector
Soil plot dimensions	5 m x 5 m			L x W (meters)
Soil profile pit primary	45.713403°,	-122.341609°	>2 m	Lat, Long, and expected depth

Soil profile pit primary	45° 42' 48.2502"	-122° 20' 29.7924"		
Soil profile pit alternative 1	45.713161°,	-122.341351°	>2 m	Lat, Long, and expected depth
Soil profile pit alternative 1	45° 42' 47.379"	-122° 20' 28.8636"		Lat, Long in deg min sec
Soil profile pit alternative 2	45.713670°,	-122.341863°	>2 m	Lat, Long, and expected depth
Soil profile pit alternative 2	45° 42' 49.212"	-122° 20' 30.7068"		Lat, Long in deg min sec
Fencing needs	none	none	none	IH, Soil Arrays, Guy anchors
Presence of large grazing animals	Likely, wild animals like moose, dear, etc			description
Site management*	Logging then replanting plantation			description
Any additional site specific information	Forest is young and actively growing. FCC should design and budget adequate tower height ahead and allow the increase of the top measurement level from 24 m to 30 m.			description
Magnetic declination	16° 18' E changing by 0° 9' W/year			At time of site visit

Table 15. FCC Summary Table for FIU site components at D16 Abby Road Relocatable 2

Site Component				**units**
Tower location	45.76243,	-122.33033		Lat, Long in degrees
Tower location	45° 45' 44.748"	-122° 19' 49.188"		Lat, Long in deg min sec
Tower height[f]	8.0			meters
Tower guying	None			yes/none, notes
Instrument Hut location	45.76256,	-122.33023		Lat, Long in degrees
Instrument Hut location	45° 45' 45.216"	-122° 19' 48.828"		Lat, Long in deg min sec
IH orientation[a]	160° - 340°			vector
boom orientation[b]	180°			degrees
distance from center of tower to IH center (z)		17	Option 8	distance (m), option #
how the Bwalk intersects the tower access	Boardwalk intersects the north-side of the tower from IH on northeast.			description
Air shed vector(s)[c]	130° to 190 °			vector, Clockwise from first angle
Boardwalk from AP to IH	Yes	BW from existing logging access road to instrument hut		yes/none, notes
Boardwalk to soil array	Yes	No BW to individual soil plots		yes/none, notes
Boardwalk needed to DFIR	NA			yes/none
Power and Communication line	10 m from edge of soil plot to the centerline of the power/comms line	whichever side is easiest [e], line above ground		offset, notes
DFIR location	NA			Lat, Long
DFIR power supply	NA			description
Soil plot 1st location	45.76200,	-122.33017		Lat, Long in degrees (center point)
Soil plot 1st location	45° 45' 43.2"	-122° 19' 48.6114"		Lat, Long in deg min sec
Soil plot distance between plots (x) and from tower (y)	25 m	49 m		X, Y (meters)
Soil array pattern and vector[d]	B	140°		A, B, or C, vector, notes
Soil plot dimensions	5 m x 5 m			L x W (meters)

Soil profile pit primary	45.762435°,	-122.329415°	> 2 m	Lat, Long, and expected depth
Soil profile pit primary	45° 45' 44.766"	-122° 19' 45.8934"		
Soil profile pit alternative 1	45.762429°,	-122.329764°	> 2 m	Lat, Long, and expected depth
Soil profile pit alternative 1	45° 45' 44.7438"	-122° 19' 47.1498"		Lat, Long in deg min sec
Soil profile pit alternative 2	45.761691°,	-122.331113°	> 2 m	Lat, Long, and expected depth
Soil profile pit alternative 2	45° 45' 42.087"	-122° 19' 52.0068"		Lat, Long in deg min sec
Fencing needs	none	none	none	IH, Soil Arrays, Guy anchors
Presence of large grazing animals	Likely, wild animals like moose, dear, etc			description
Site management*	Logging then replanting Douglas fir plantation.			description
Any additional site specific information	Forest is young and actively growing. FCC should design and budget adequate tower height ahead and allow the increase of the top measurement level from 8 m to 15 m.			description
Magnetic declination	16° 18' E changing by 0° 9' W/year			At time of site visit

Notes;
[a]parallel to the long side of the IH
[b]From tower point to this direction
[c]Clockwise from first angle, recommend reviewing FIU site characterization summary report
[d]From 1st plot toward other plots if pattern B, from 1st plot toward nearest neighbor (see diagram of the patterns)
[e]see Appendix A. Options for Soil Array, second figure.
[f]Tower Height is for FIU requirements; actual tower height will increase toward the next section height.
IH = instrument hut
AP = auxillary portal
*burn information that may affect boardwalk, IH, or tower infrastructure, or other management activities