FIU D10 SITE CHARACTERIZATION: SUMMARY

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See Configuration Management System for approval history.

Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
1.0	10/01/2009		Initial draft
2.0	10/06/2009		Incorporated FCC and LAD comments
A	10/08/2009	NEON.DSDV.FIU.000131.CRE	CCB approved submitted changes.
A.1	10/14/2009		Specify the locations for the precipitation gauges at 3 sites at DM 10
B	10/15/2009	NEON.DSDV.FIU.000186.CRE	CCB approved submitted changes
C	9/16/2010	NEON.FIU.000246.CRE	CCB approved submitted changes
D	12/10/2010	NEON.FIU.000278.CRE	UPDATES SEE CRE
E	9/23/2011	ECO-00279	Update to new document numbers/template throughout document.
F	5/15/2012	ECO-00556	Add wordings for tower placement, distance of sensors from ecosystem edge, and exclusion zone for each site.

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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 D10 Site Characterization: Supporting Data (AD[01]).

1.2 Scope

This document summarizes the FIU site characterization data for the three D10 tower locations: Pawnee (Core), North Sterling (Relocatable 1), and CASTNET (Relocatable 2).

2 RELATED DOCUMENTS AND ACRONYMS

2.1 Applicable Documents

AD[01]	NEON.DOC.011026	FIU D10 Site Characterization: Supporting Data
AD[02]	NEON.DOC.011018	WID between FIU and FCC
AD[03]	NEON.DOC.011008	FIU Tower Science Requirements
AD[04]	NEON.DOC.011000	FIU Technical and operating 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
CPER	Central Plains Experimental Range
ARS	Agricultural Research Service

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 PAWNEE SHORTGRASS STEPPE

3.1 Desired ecosystem

Table 1. Pawnee shortgrass steppe.

The core site and representative of the ecosystem type and management practice for Domain 10.

Ecosystem Type	Management activity
North American natural shortgrass steppe	Light grazed

The biotic communities of the shortgrass steppe ecosystem are particularly well-adapted for drought, with vegetative species such as blue grama (*Bouteloua gracilis*) and prickly-pear cactus (*Opuntia polyacantha*), large herbivores such as cattle (and previously, bison), and burrowing animals such as the black-tailed prairie dog (*Cynomys ludovicianus*) playing dominant roles in ecosystem function and maintenance.

The main natural plant communities are shortgrass steppe, floodplain shrubland, and salt meadow. The ecosystem is dominated by short grasses (64%), succulents (21%) and dwarf shrubs (8%). Blue grama predominates and contributes 60 to 80% percent of plant cover, biomass, and net primary productivity. Long-lived C4 grasses such as blue grama dominate under the characteristically dry conditions of the shortgrass steppe by efficiently accessing available water. Other important plants include buffalo grass (*Buchloe dactyloides*), prickly pear cactus, rabbitbrush (*Chrysothamnus nauseosa*) and saltbush (*Atriplex canescens*). The shortgrass steppe stores most biomass and resources belowground, so that aboveground disturbances do not drastically alter the vegetative community (information source: http://sgs.cnr.colostate.edu/about_location.aspx).

Table 2. Ecosystem and site attributes for the Pawnee core site.

The site is a confined grazed and fenced field. Within these bounds, there are two large experimental exclosure plots, which the tower should be >100 m distance from.

Ecosystem attributes	Measure and units
Mean canopy height	0.4 m
Surface roughness[a]	0.06 m
Zero place displacement height[a]	0.26 m
Structural elements	Short, uniform, homogeneous
Altitude	1651 [m] a.s.l.
Slope	0-3%
Aspect	±0
Time zone	Mountain
Magnetic declination	9° 11' E changing by 0° 8' W y^{-1}
Frost-free period	130 to 160 days

Note, [a]Arya 1988

3.2 Tower Attributes

Tower is the index; all other information is based on the center-point of the tower. Tower location is the center point. Assume the projected area of the tower is square, *i.e.*, 2 m x 2 m. If the tower has a rectangular design, then the short-side is perpendicular to the ***tower orientation vector,*** *which is* ***from*** the tower ***toward*** the airshed, Figure 10. The instrument hut vector is ***from*** the tower ***toward*** the instrument hut or designated orientation. The soil array vector is ***from*** the tower ***toward*** the soil array. The numbering of the measurement levels is that the lowest is level one, and each subsequent increase in height is numbered sequentially, in this case, level 4 being the upper most level at this tower site. The site is a confined grazed and fenced field. Within these bounds, there are two experimental exclosure plots which the tower should be >100m distance from.

Table 3. Tower oriented design attributes for the Pawnee core 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
Tower location	40.815540	-104.745430	--	--	Current site
Instrument hut vector	40.815531	-104.745157	90°		
Instrument hut distance z	--	--	--	23	
Anemometer/Temperature boom orientation	--	--	270°	--	
Height of the measurement levels					
Level 1				0.15	m.a.g.l.
Level 2				2.0	m.a.g.l.
Level 3				4.0	m.a.g.l.
Level 4				6.0	m.a.g.l.
Tower Height				6.0	m.a.g.l.

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

3.3 Soil Attributes

Soil type is Weld County, Colorado, Northern Part 5—Ascalon fine sandy loam with 6 to 9 percent slopes. During construction a soil profile shall be dug at each core site and samples throughout the profile will be extracted. PT FCC shall to identify a location where the soil profile can be excavated, and excavate (AD[02]). The location of the soil profile has to i) match the dominate soil type in the tower airshed, *i.e.*, Soil type is Weld Ascalon fine sandy loam, and ii) be outside the tower airshed to avoid disturbance issues (AD[03]). These soils are well-drained calcareous loamy alluvium. The soil array vector is ***from*** the tower ***toward*** the soil array. The site is a confined grazed and fenced field. Within these bounds, there are two large experimental exclosure plots which the closest portion of the soil array should be >15m distance from.

Table 4. Soil attributes for the Pawnee Core site design.

0° is true north with declination accounted for.

Attribute	**meters**			**notes**
Soil array pattern	**x**	**y**	**z**	
Pattern number A or C	35	25[a]	23	Figures 7, and 9
Attribute	**degree**			**notes**
Soil array vector from tower	315°			
Attribute	**meter**			**notes**
Depth to water table	> 2			
Expected soil depth	> 2			
Expected depth of soil horizons	**Range (m)**			**Measurement level (m)**
Level 1, ab, fine sandy loam	0-0.2			0.2
Level 2, b1, sandy clay loam	0.2-0.56			0.45
Level 3, b2-3, clay loam	0.56-1.53			1.0
Level 4, bc, stony clay loam	>1.53			1.75

Note, [a] is based on expected summer convective scale and peak contribution of the footprint, see AD[01].

Because the ecosystem has a height of the mean plant canopy < 1.75 m, the Tower has been sited to i) the minimize the remove foliage during the tower establishment, ii) optimize the temporal coverage of flow-based measurements over the representative environment, iii) minimize flow distortions caused by local ecosystem structure or topography (orography), and iv) allow the sensors on the tower booms to measure the representative surrounding environment. The location identified here and its final placement (e.g., construction activities, FCC micrositing) will have to be evaluated against these conditions and requirements.

To avoid edge effect on science measurements, tower, soil array, and sensor locations have been sited such that the meteorological sensors and soil sensors are ≥ 60 m away from the edge of the representative ecosystem in interest, and flux sensors are ≥ 180 m from the edge of the representative ecosystem. The sensor locations identified here and its (final) placement (e.g., during reviews,

construction activities, FCC micrositing) will have to be evaluated against these conditions and requirements.

3.4 Ecosystem Productivity Plots.

The CPER ARS plot boundaries are small relative to the tower footprint. The tower has been positioned to optimize the collection of the air/wind signals both temporally and spatially over the desired ecosystem. The CPER ARS plot boundaries (noted in Red, Figure 1) toward the west are ~635 m, and plot boundaries to the North and South are 1,227 and 345 m, respectively. Wind vectors from the tower dictate the Eastern most extent of the tower airshed. North of the tower, the eastern vector is 15°, and toward the South of the tower, the eastern vector is 163°. The FSU Ecosystem Productivity plots should be within these boundaries: property boundaries toward the North, West and south, and wind vectors toward the East.

3.5 Precipitation Gauge

Because of the CPER Pawnee is an advanced tower site at an open grassland, it meets the primary standard requirements for precipitation gauge. A double Fence Intercomparison Reference weighing gauge will be deployed at this site (AD[04]). The recommended location for the rain gauge is on the north side of the suggested walkway, in the middle of the access route from the fenceline (toward the Eastern boundary) to instrument hut. The design of the DFIR and dimension are described in a separate document.

DFIR location at this site has been chosen to meet USCRN class 1 or class 2 criteria. The DFIR location identified here and its (final) placement (e.g., during reviews, construction activities, FCC micrositing) will have to be evaluated against these conditions and requirements.

Because of the short canopy (only ~ 40 cm), throughfall precipitation gauges will be deployed below ground level with troughs at the ground level. The design of the throughfall collectors and dimension will be described in a separate document.

3.6 Exclusion Zone

To meet our Product Assurance metrics, our high quality Terrestrial Instrument System (TIS) measurements, and TIS requirements, no sampling, observations, or experiment shall be conducted within the tower exclusion zone without consulting and resolving any issues with TIS scientists as according to the 'NEON Research Collaboration Document' NEON.DOC.004312. The intent is to limit any activities that can either affect the wind flows (e.g., disturbance, buildings, structures, clear cutting, affect changes in structure), or the natural/expected process rates. Because we cannot think of all such future activities, each will have to be evaluated on a case-by-case basis.
The exclusion zone is an area with these features:

a) The shape of the exclusion zone appears as a pie splice (plan view) with center point of the tower foundation (plan view) as its origin.
b) There may be more than one exclusion zone per tower, depending on the diurnal, seasonal and annual wind patterns.
c) The exclusion zone is a sub-area (i.e., inside) the total tower source area

d) Windrose analyses determine the wind vectors that bound the outside of the exclusion zone, which is clockwise from 163 to 15 degrees at this site (major).

There are two criteria to determine the distance of the exclusion zone from the tower:

1) For all activities mentioned above, the distance from the tower is the maximum value of 90% cumulative flux of the source area at mean maximum wind speed under daytime convective (expected unstable) atmospheres, which is 600 m at this site.
2) Some large disturbance activities also cannot occur in the nighttime tower footprint (because the nighttime tower footprint extends out much farther than the daytime source area). For all high impact activities, the distance from the tower is the maximum value of 80% cumulative flux of the source area at mean maximum wind speed under nighttime, thermally stratified, (expected) stable atmospheric conditions, which is 400 m at this site.

4 NORTH STERLING AGRONOMIC SITE

4.1 Desired ecosystem

Table 5. The North Sterling is a relocateable site.

This relocatable site is designed to represent economic and argonomic decisions typically found in farming practices in eastern Colorado, which is a shifting agricultural site in Domain 10.

Ecosystem Type	Management activity
Argonomic	Shifting agriculture

The North Sterling relocatable tower site (Latitude: N 40°27'53.05", Longitude: W 103°01'46.49") is located near Sterling, CO at a elevation ~1350 m and is about 500 m on the south-west of the junction of the County Road 59 and County Road 6. It is at the edge of a non-tilled experimental field that is used for the long-term sustainable Dryland Agroecosystems Project (DAP), which was initiated in 1985 at three sites in eastern Colorado (Sterling, Stratton, and Walsh) to evaluate the effects of cropping intensity on production, water use efficiency, and selected soil chemical and physical properties (Peterson *et al.,* 1993). Summers are hot and low humid, winters are typically around freezing point, but can drop lower temperature. Occasional hail storms and thunderstorms are expected during the growing seasons. Seasonal high wind and tornados shall be considered in the tower design.

History: The DAP site was established in 1985 and was chosen because of the three representative soils present in the catena. Prior to establishment of the no-till cropping systems the site had been under conventional tillage since it was taken from native sod in about 1910. Conventional tillage from 1910 to 1985 ranged from moldboard plowing in the early years to sweep tillage in the later years. The primary crop was winter wheat grown in a wheat-fallow rotation. Proso millet also had been grown occasionally in a few years prior to 1985.

Cropping systems under no-till management were initiated in 1985. These systems included: winter wheat (Triticum aestivum L.)-fallow (WF); winter wheat-maize (Zea mays L.)-fallow (WMF); winter

wheat-maize-proso millet (Panicum miliaceum L.)-fallow (WMPF); continuous cropping (CC) (crops grown over the years included maize, sorghum, winter wheat, forage millet, and sunflower); and perennial grass (G). The systems represent a gradient of cropping intensity (crops divided by years in the rotation), Thus WF has an intensity factor of 0.50. Intensity factors for WMF, WMPF, and CC are 0.67, 0.75, and 1.0, respectively. The Native grass treatment does not have an intensity factor since it is a perennial system. Grass stands were established in the spring of 1986 and contain a mixture of perennial species including both warm and cool season grasses.

Table 6. Ecosystem and site attributes for the North Sterling relocatable site.

The site is a confined fenced field, adjacent to a Colorado State University no-till agronomic research site. Because tallest expected crop is corn, the tower height and measurement levels configured for this extreme agronomic condition. Currently (summer 2009), the field is fallow, open ground. 0° is true north with declination accounted for.

Ecosystem attributes	Measure and units
Mean canopy height[b]	0 - 4 m
Surface roughness[a, b]	0.05 - 0.2 m
Zero place displacement height[a, b]	0 - 3.0 m
Structural elements	Vertically homogeneous, non –stratified
Altitude	~1350 [m] a.s.l.
Slope	0-3%
Aspect	±0
Time zone	Mountain
Magnetic declination	9° 11' E changing by 0° 8' W y^{-1}
Frost-free period	130 to 160 days

Note, [a]Arya 1988, [b]Canopy height and surface roughness will vary with the types of agricultural plants, a range is applied here

4.2 Tower Attributes

Tower is the index, all other information is based on the center-point of the tower. Tower location is the center point. Assume the projected area of the tower is square, *i.e.*, 2 x 2 m. If the tower has a rectangular design, then the short-side is perpendicular to the ***tower orientation vector,*** *which is* ***from*** the tower ***toward*** the airshed, Figure 10. The instrument hut vector is ***from*** the tower ***toward*** the instrument hut or designated orientation. The soil array vector is ***from*** the tower ***toward*** the soil array. The numbering of the measurement levels is that the lowest is level one, and each subsequent increase in height is numbered sequentially, in this case, level 4 being the upper most level at this site.

Table 7. Tower oriented design attributes for the North Sterling Relocatable 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
Tower location	40.461903	-103.029266	--	--	
Instrument hut vector	--	--	0°	--	*suggested, 90° is also acceptable
Instrument hut distance z	--	--	--	20	
Tower face (perpendicular) orientation vector	--	--	270° to 90°	--	Parallel to 0° to 360°
Anemometer/Temperature boom orientation	--	--	270°	--	
Height of the measurement levels					
Level 1				0.15	m.a.g.l.
Level 2				2.0	m.a.g.l.
Level 3				5.0	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.

4.3 Soil Attributes

There are two co-dominate soil types: Logan County, Colorado 126—Weld loam, 1 to 3 percent slopes, and Logan County, Colorado 110—Wagonwheel-Stoneham complex. These soils are well-drained, calcareous loamy eolian deposits. Soil array vector is ***from*** the tower ***toward*** the soil array.

Table 8. Soil attributes for the North Sterling Relocatable site design.

0° is true north with declination accounted for.

Attribute	**meters**			**notes**
Soil array pattern	**x**	**y**	**z**	
Pattern number B	40	20[a]	20	Figure 7
Attribute	**degree**			**notes**
Soil array vector from tower	270°			Parallel to the row crops
Attribute	**meter**			**notes**
Depth to water table	> 2			
Expected soil depth	> 2			
Expected depth of soil horizons	**Range (m)**			**Measurement level (m)**
Level 1, ab, loam	0-0.17			0.11
Level 2, b1, silty clay loam	0.17-0.46			0.32
Level 3, b2-3, loam	0.46-0.82			0.64
Level 4, bc, sandy clay loam	0.82 to >1.53			1.25

Note, [a] is based on expected summer convective scale and peak contribution of the footprint, see AD[01], and the need to span the tractor road that runs the perimeter around both the desired field and the CSU plots.

Because the ecosystem has a height of the mean plant canopy 0-4 m, the Tower has been sited to i) optimize the temporal coverage of flow-based measurements over the representative environment, ii) minimize flow distortions caused by local ecosystem structure or topography (orography), and iii) allow the sensors on the tower booms to measure the representative surrounding environment. The location identified here and its final placement (e.g., construction activities, FCC micrositing) will have to be evaluated against these conditions and requirements.

To avoid edge effect on science measurements, tower, soil array, and sensor locations have been sited such that the meteorological sensors and soil sensors are ≥ 60 m away from the edge of the representative ecosystem in interest (crop ecosystem), and flux sensors are ≥ 180 m from the edge of the representative ecosystem. The sensor locations identified here and its (final) placement (e.g., during reviews, construction activities, FCC micrositing) will have to be evaluated against these conditions and requirements.

4.4 Ecosystem Productivity Plots.

The North Sterling plot boundaries from the owner are small relative to the tower footprint. The tower has been positioned to optimize the collection of the phenomenology of the air/wind both temporally and spatially over the desired ecosystem. The North Sterling plot boundaries toward the west are ~617

m, and plot boundaries to the North and South are 556 and 250 m, respectively (noted in Red, Figure 3). Wind vectors from the tower dictate the Eastern most extent of the tower airshed. North of the tower, the eastern vector is 358°, and toward the South of the tower, the eastern vector is 186°. The FSU Ecosystem Productivity plots should be within these boundaries: property boundaries toward the North, West and south, and wind vectors toward the East.

4.5 Precipitation gauge

Because North Sterling site is a relocatable site, a secondary standard tipping precipitation gauge will be mounted at the tower top at this site (AD[04]).

Because of the study area is in a private farm land, throughfall precipitation gauge will be deployed below ground level with troughs at the ground level. This will enable the measurement of throughfall regardless of the choice of crops from year-to-year. The design of the throughfall collectors and dimension will be described in a separate document.

4.6 Exclusion Zone

To meet our Product Assurance metrics, our high quality Terrestrial Instrument System (TIS) measurements, and TIS requirements, no sampling, observations, or experiment shall be conducted within the tower exclusion zone without consulting and resolving any issues with TIS scientists as according to the 'NEON Research Collaboration Document' NEON.DOC.004312. The intent is to limit any activities that can either affect the wind flows (e.g., disturbance, buildings, structures, clear cutting, affect changes in structure), or the natural/expected process rates. Because we cannot think of all such future activities, each will have to be evaluated on a case-by-case basis.
The exclusion zone is an area with these features:

e) The shape of the exclusion zone appears as a pie splice (plan view) with center point of the tower foundation (plan view) as its origin.
f) There may be more than one exclusion zone per tower, depending on the diurnal, seasonal and annual wind patterns.
g) The exclusion zone is a sub-area (i.e., inside) the total tower source area
h) Windrose analyses determine the wind vectors that bound the outside of the exclusion zone, which is clockwise from 135 to 25 degrees at this site (major).

There are two criteria to determine the distance of the exclusion zone from the tower:

3) For all activities mentioned above, the distance from the tower is the maximum value of 90% cumulative flux of the source area at mean maximum wind speed under daytime convective (expected unstable) atmospheres, which is 600 m at this site.
4) Some large disturbance activities also cannot occur in the nighttime tower footprint (because the nighttime tower footprint extends out much farther than the daytime source area). For all high impact activities, the distance from the tower is the maximum value of 80% cumulative flux of the source area at mean maximum wind speed under nighttime, thermally stratified, (expected) stable atmospheric conditions, which is 790 m at this site.

5 CASTNET MID-ELEVATION ROCKY MOUNTAIN SITE

5.1 Desired ecosystem

Table 9. The CASTNET Ecosystem

This relocatable site is designed to represent the ecology of the mid-elevation Rocky Mountain and to be part of a prairie-to-basin atmospheric chemistry (front-range generated) to dust (basin generated) relocatable strategy.

This ecosystem is typically found at this elevation across the southern Rockies, and in Domain 10.

Ecosystem Type	Management type	Relocatable Site Strategy
Ponderosa Pine	Natural Forest	Dust/Atmospheric chemistry

The Rocky Mountain National Park Clean Air Status and Trends Network (RMNP CASTNET) Relocatable tower site is located within the boundaries of RMNP. Current tower stake (latitude N 40.278125° and longitude W 105.54568°) is at a relative flat clearing, which is surrounding by the heavily wooded mountain terrain, except some residential housing, clearing openings and some entertainment areas in the north-west direction. This direction happens to be the prevailing direction, which means, if current tower location is used to set up tower, our measurements will be heavily impacted by human's daily activity instead of the natural mountain forest ecosystem that we are interested in. Plus, the recirculation at the edge of the forest would be another big concern for our turbulent measurements. Therefore, to solve this source area problem and the edge effect issue, tower location is suggested to be moved ~200 m toward south-west direction into a ponderosa pine wood stand at latitude N 40.27587° and longitude W 105.54629°.

The elevation for the tower site is at ~2750 m, on the western side of the Long's Peak (4346 m). The air drainage during the nights along the large and extended mountain slope could be a concern for the accurate turbulence measurements, as well as the CO_2 profile measurements on the forest ecosystem that we are interested in.

Table 10. Ecosystem and site attributes for the CASTNET Relocatable site.

The site is a confined fenced plot of land, adjacent to a Colorado State University CASTNET research site.

Ecosystem attributes	Measure and units
mean canopy height	22 m
surface roughness[a]	1.8 m
zero place displacement height[a]	20 m
Structural elements	Stratified, developed and sparse understory, bottom branches form 6-13 m, mid canopy 14 m, open ground conditions
Altitude	~2750 [m] a.s.l.
Slope	0-11%
Aspect	±0
Time zone	Mountain
Magnetic declination	9° 11' E changing by 0° 8' W y^{-1}
Frost-free period	130 to 160 days

Note, [a]Arya 1988

5.2 Tower Attributes

Tower is the index, all other information is based on the center-point of the tower. Tower location is the center point. Assume the projected area of the tower is square, *i.e.*, 2 x 2 m. If the tower has a rectangular design, then the short-side is perpendicular to the ***tower orientation vector***. ***tower orientation vector,*** *which is* ***from*** the tower ***toward*** the airshed, Figure 10. The instrument hut vector is ***from*** the tower ***toward*** the instrument hut or designated orientation. The soil array vector is ***from*** the tower ***toward*** the soil array. The numbering of the measurement levels is that the lowest is level one, and each subsequent increase in height is numbered sequentially, in this case, level 4 being the upper most level at this site. This site is a confined and fenced field.

Table 11. Tower oriented design attributes for the CASTNET Relocateable site.

Micro-sited the tower location from a field with large edge effects (AD[03]), to a Ponderosa Pine canopy with larger fetch. 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
Old Tower location	40.278125	-105.54568	--	--	old site
New Tower location	40.27591	-105.54592	--	--	new site
Instrument hut vector	40.27613	-105.54594	339°	--	
Instrument hut distance z	--	--	--	20	
Anemometer/Temperature boom orientation	--	--	303°	--	
Height of the measurement levels					
Level 1				0.30	m.a.g.l.
Level 2				12.0	m.a.g.l.
Level 3				18.0	m.a.g.l.
Level 4				24.0	m.a.g.l.
Level 5				28.0	m.a.g.l.
Tower Height				28.0	m.a.g.l.

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

5.3 Soil Attributes

Rocky Mountain National Park, Colorado, Parts of Boulder, Grand, and Larimer Counties 4—Catamount gravelly coarse sandy loam, 5 to 20 percent slopes. These soils are well-drained, gravelly slope alluvium and/or residuum weathered from granite and/or schist and/or gneiss. Soil array vector is ***from*** the tower ***toward*** the soil array. The site is a confined fenced forest and open-field plot.

Table 12. Soil attributes for the CASTNET site design.

The property boundary does not extend into the tower footprint area. Hence, we are unable to place the soil array in the tower footprint area. Here, the soil array is positioned in similar soil within the CASTNET property boundary. 0° is true north with declination accounted for.

Attribute	**meters**			**notes**
Soil array pattern	**x**	**y**	**z**	
Pattern number A, or C	35	26[a]	24	Figures 7, and 9
Attribute	**degree**			**notes**
Soil array vector from tower		69°		Outside the tower footprint
Attribute	**meter**			**notes**
Depth to water table		> 1.6		
Expected soil depth		> 1.6		
Expected depth of soil horizons		**Range (m)**		**Measurement level (m)**
Level 0, O1, slightly decomposed plant material		0-0.03		na.
Level 1, b2-3, gravelly coarse sandy loam		0.03-0.07		0.08
Level 2, b3, very gravelly coarse sandy loam		0.07-0.25		0.20
Level 3, bc, very gravelly coarse sandy loam		0.25 -0.35		0.30
Level 4, bc, very gravelly coarse sandy loam		0.35-0.60		0.60

Note, [a] is based on expected summer convective scale and peak contribution of the footprint, see AD[01].

Because the ecosystems has a height of the mean plant canopy > 1.75 m and the tower has to pass through the plant canopy vertically, tower has been sited to i) allow the tower pass through the canopy with minimizing the remove foliage during the tower establishment, ii) optimize the temporal coverage of flow-based measurements over the representative environment, iii) minimize flow distortions caused by local ecosystem structure or topography (orography), and iv) allow the sensors on the tower booms to measure the representative surrounding environment. The location identified here and its (final) placement (e.g., during reviews, construction activities, FCC micrositing) will have to be evaluated against these conditions and requirements.

To avoid edge effect on science measurements, tower, soil array, and sensor locations have been sited such that the meteorological sensors and soil sensors are ≥ 60 m away from the edge of the representative ecosystem in interest, and flux sensors are ≥ 180 m from the edge of the representative ecosystem. The sensor locations identified here and its (final) placement (e.g., during reviews,

construction activities, FCC micrositing) will have to be evaluated against these conditions and requirements.

5.4 Ecosystem Productivity Plots.

The CASTNET plot boundaries are small relative to the tower footprint. The tower has been positioned to optimize the amount of air/wind signals both temporally and spatially over the desired ecosystem—*however*, the footprint/airshed extends far beyond the property boundary. Moreover, the ecosystem types within the CASTNET boundary are mixed, and present a challenge because of mixed ecosystem types, edge effects, and there are residential house within the airshed boundary. The CASTNET plot boundaries toward the west are ~75 m, and plot boundaries to the North and South are 275 and 75 m, respectively (noted in Red, Figure 5). The desired ecosystem in question is ponderosa Pine because of its expanse in Rocky Mountain National Park, and because it is representative of the area, and because it offers a homogeneous micrometeorology to access dust and atmospheric chemical environments. Unfortunately, FIU could not identify an appropriate expanse of Ponderosa Pine for the EP plots. There is a small patch of P. Pine. Limited by the boundaries, it is difficult to place soil array within tower airshed. Soil array vector of 69° (from the tower) can be considered. Alternatives should be sought.

5.5 Precipitation gauge

Because RMNP CASTNET site is a relocatable site, a secondary standard tipping precipitation gauge will be mounted at the tower top at this site to collect precipitation (AD[04]).

Because of the study area is forested, throughfall precipitation gauge will be deployed (mounted on) at ground level with troughs at the same height. The design of the throughfall collectors and dimension will be described in a separate document.

5.6 Exclusion Zone

To meet our Product Assurance metrics, our high quality Terrestrial Instrument System (TIS) measurements, and TIS requirements, no sampling, observations, or experiment shall be conducted within the tower exclusion zone without consulting and resolving any issues with TIS scientists as according to the 'NEON Research Collaboration Document' NEON.DOC.004312. The intent is to limit any activities that can either affect the wind flows (e.g., disturbance, buildings, structures, clear cutting, affect changes in structure), or the natural/expected process rates. Because we cannot think of all such future activities, each will have to be evaluated on a case-by-case basis.
The exclusion zone is an area with these features:

i) The shape of the exclusion zone appears as a pie splice (plan view) with center point of the tower foundation (plan view) as its origin.
j) There may be more than one exclusion zone per tower, depending on the diurnal, seasonal and annual wind patterns.
k) The exclusion zone is a sub-area (i.e., inside) the total tower source area
l) Windrose analyses determine the wind vectors that bound the outside of the exclusion zone, which is clockwise from 263 to 341 degrees at this site (major).

There are two criteria to determine the distance of the exclusion zone from the tower:

5) For all activities mentioned above, the distance from the tower is the maximum value of 90% cumulative flux of the source area at mean maximum wind speed under daytime convective (expected unstable) atmospheres, which is 600 m at this site.
6) Some large disturbance activities also cannot occur in the nighttime tower footprint (because the nighttime tower footprint extends out much farther than the daytime source area). For all high impact activities, the distance from the tower is the maximum value of 80% cumulative flux of the source area at mean maximum wind speed under nighttime, thermally stratified, (expected) stable atmospheric conditions, which is 1500 m at this site.

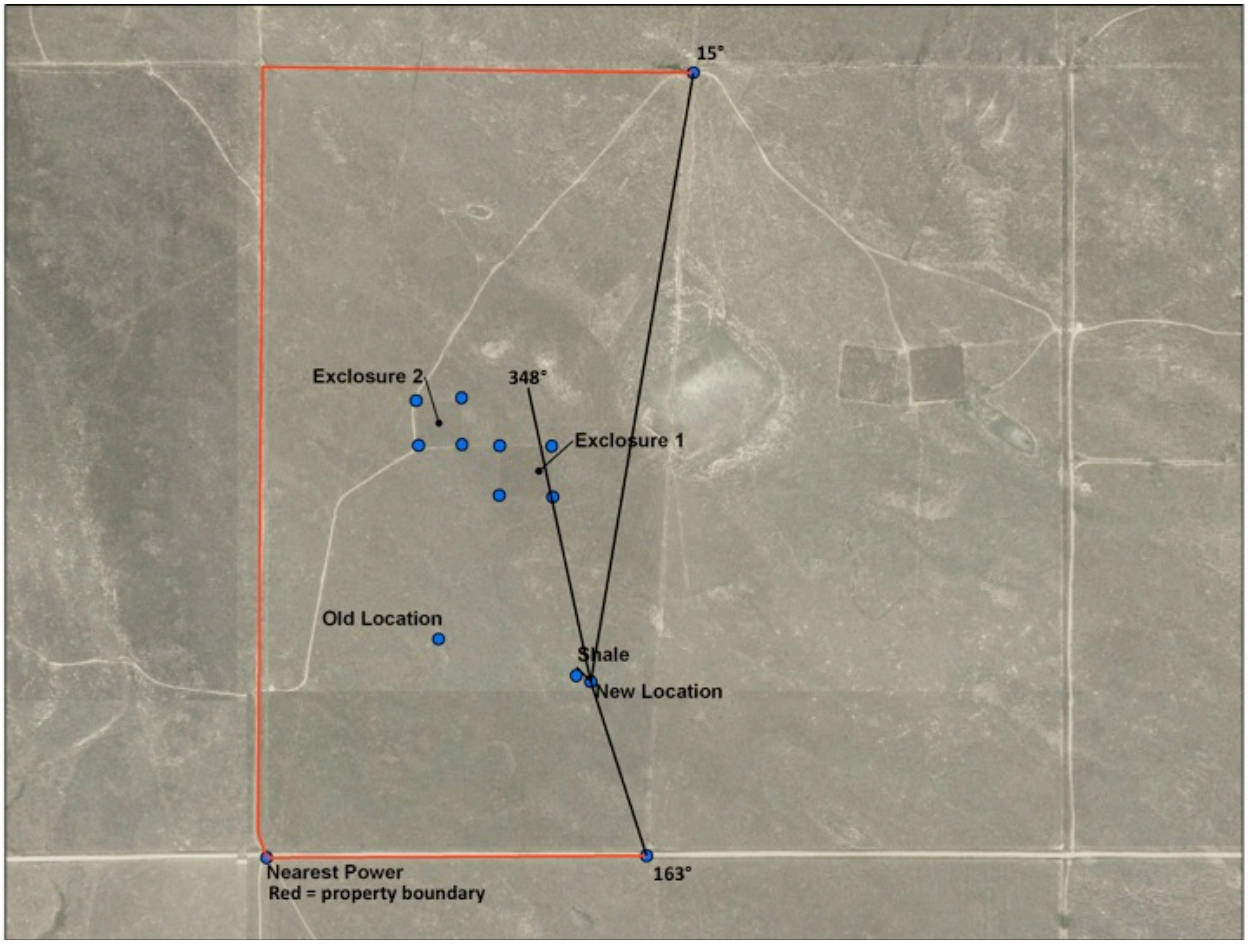


Figure 1. Plan view of the Pawnee site location

i) new location is the tower site, ii) vector 348° is the mean annual resultant wind vector, and iii) red lines are the property boundary. Vectors 163° and 15° are the South-eastern most—and North-eastern most vectors that would have quality wind data without causing flow distortions, respectively.

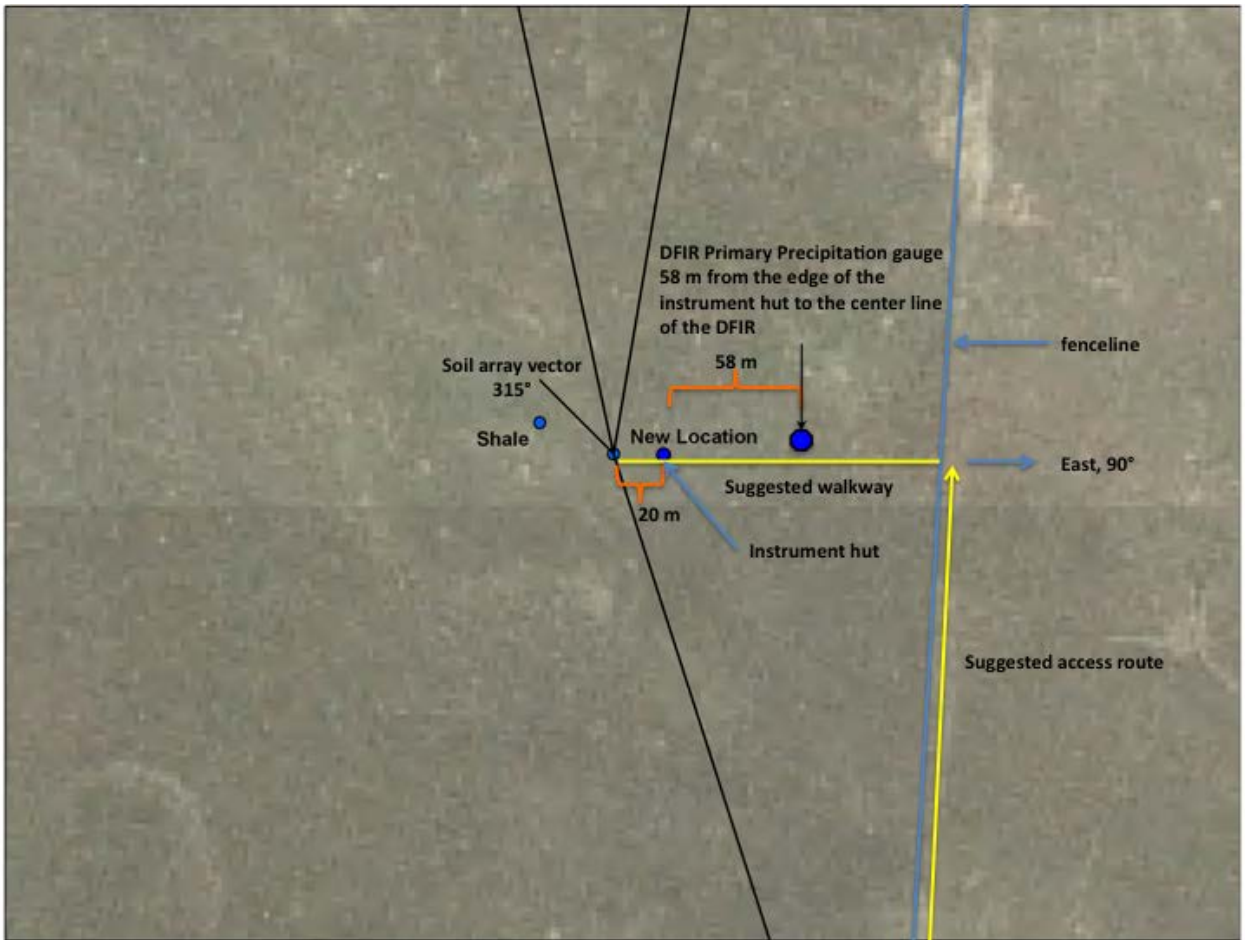


Figure 2. Plan view of the Pawnee site location

i) new location is the tower site, ii) vector 315° is the soil array vector, iii) yellow lines are the suggested access routes, iv) the DIFR primary precipitation gauge is located ½ way between the fence line and the closest side of the instrument hut, ~ 58 m on centerline. The DIFR primary precipitation gauge begins (closest distance) is 3 m North of the walkway.

Figure 3. Plan view of the North Sterling Relocatable location

i) tower location is the tower site, ii) vector 315° is the mean annual resultant wind vector, and iii) red lines are the property boundary. Vectors 186° and 358° are the South-western most—and North-western most vectors that would have quality wind data without causing flow distortions, respectively.

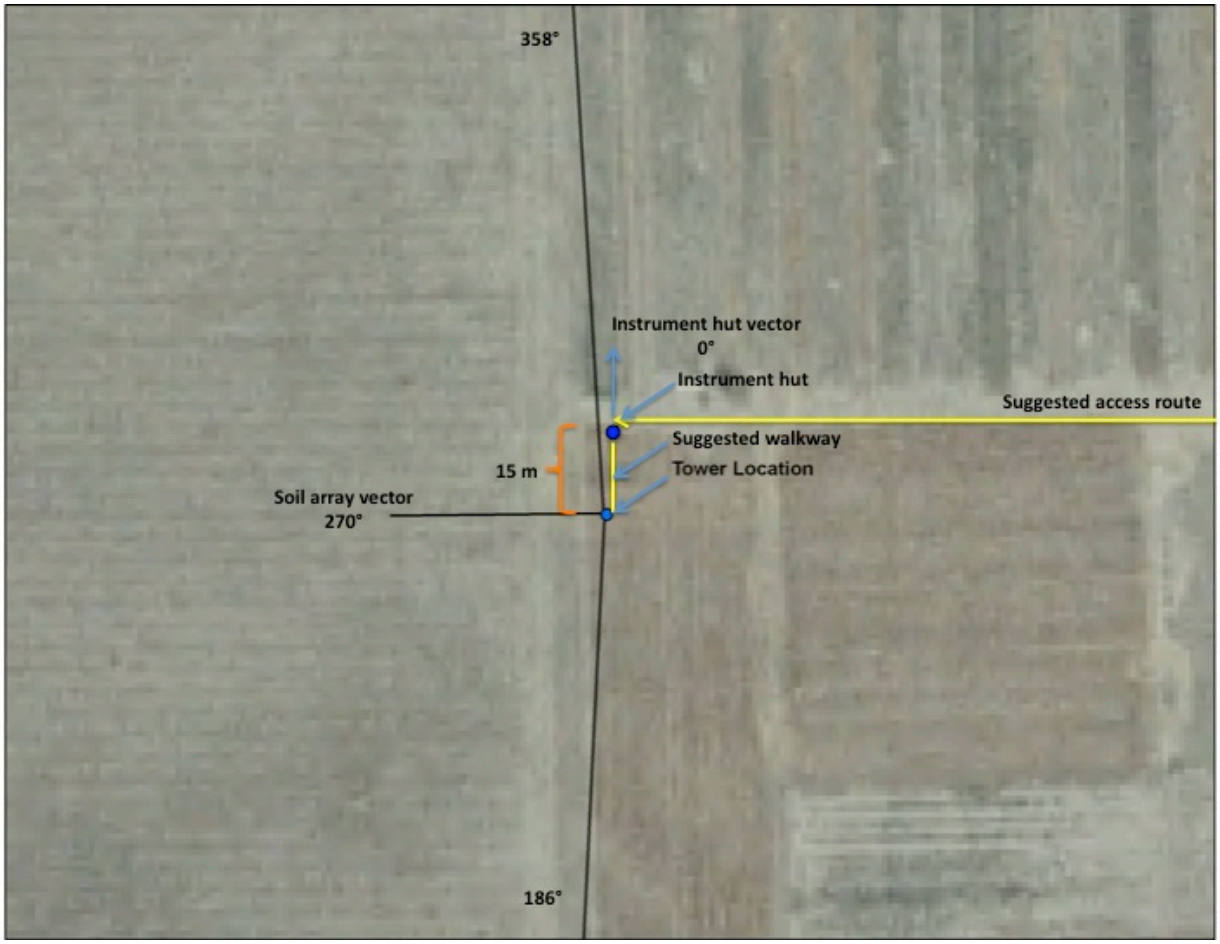


Figure 4. Plan view of the North Sterling Relocatable site location

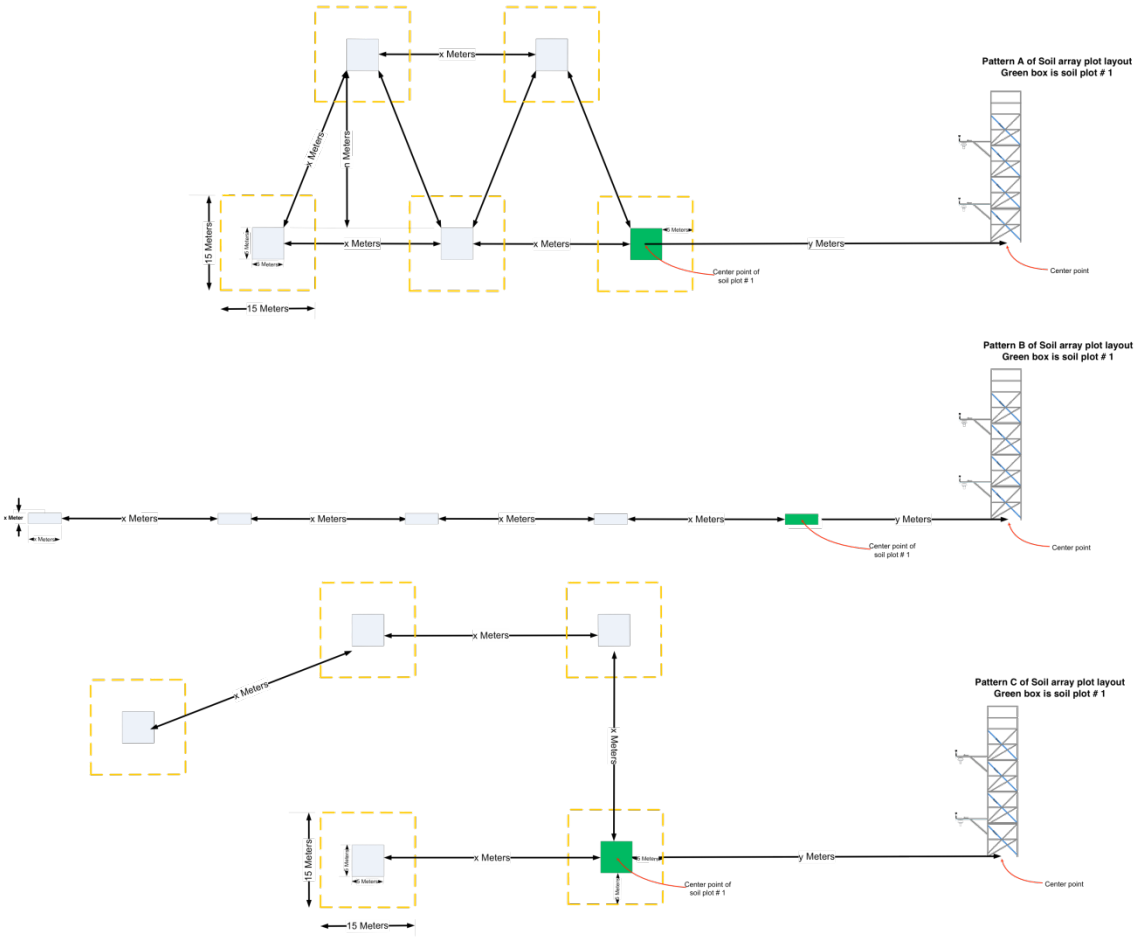
i) tower location is the tower site, ii) vector 270° is the soil array vector, and iii) yellow lines are the suggested access routes.

Figure 5. Plan view of the CASTNET Relocatable site location

i) tower location is the tower site, ii) vector 350° is the mean annual resultant wind vector, and iii) red lines are the property boundary. This map is not current. Tower and instrument hut locations have been changed. Please see tower attribute table for updated info.

Figure 6. Plan view of the CASTNET Relocatable site location

i) tower location is the tower site, ii) vector 69° is the soil array vector, iii) and vector 249° is the instrument hut vector, and iv) yellow lines are the suggested access routes. This map is not current. Tower and instrument hut locations have been changed. Please see tower attribute table for updated info.


Pattern A of Soil array plot layout
Green box is soil plot # 1
x Meters
x Meters
x 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 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

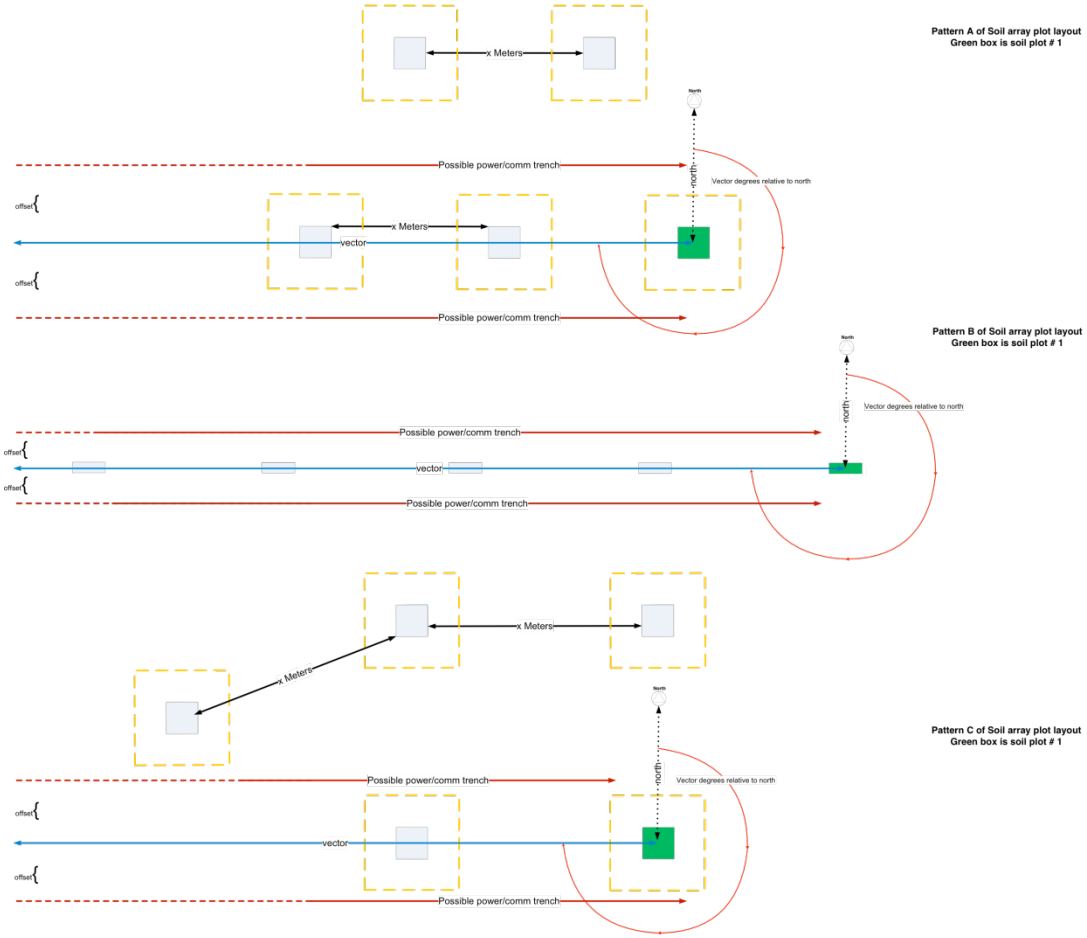
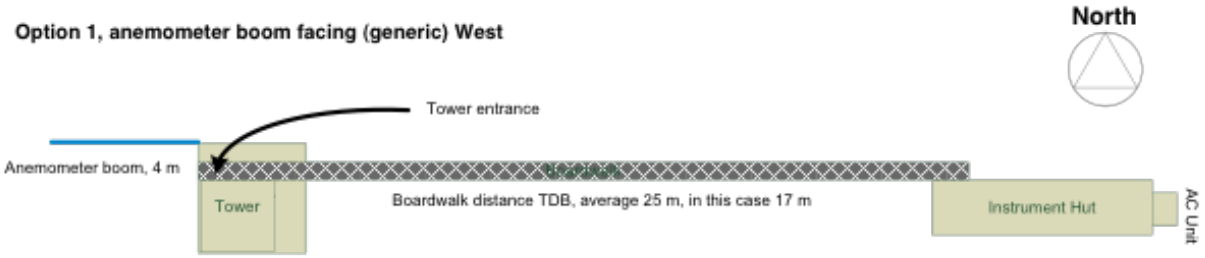


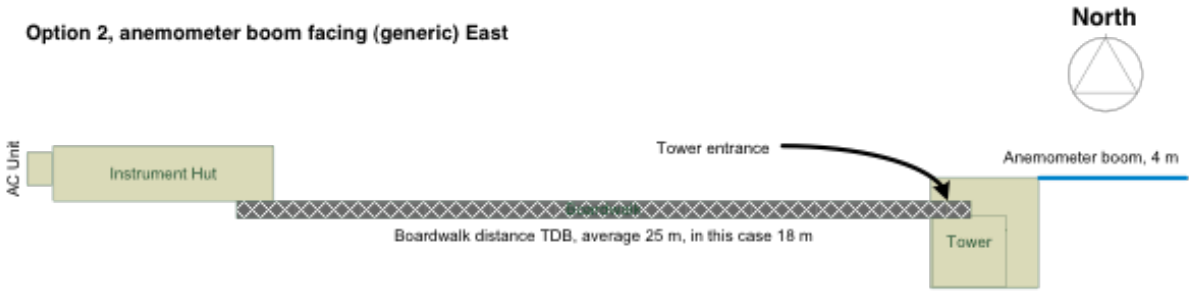
Figure 7. Conceptual diagram of Soil Array Patterns

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.

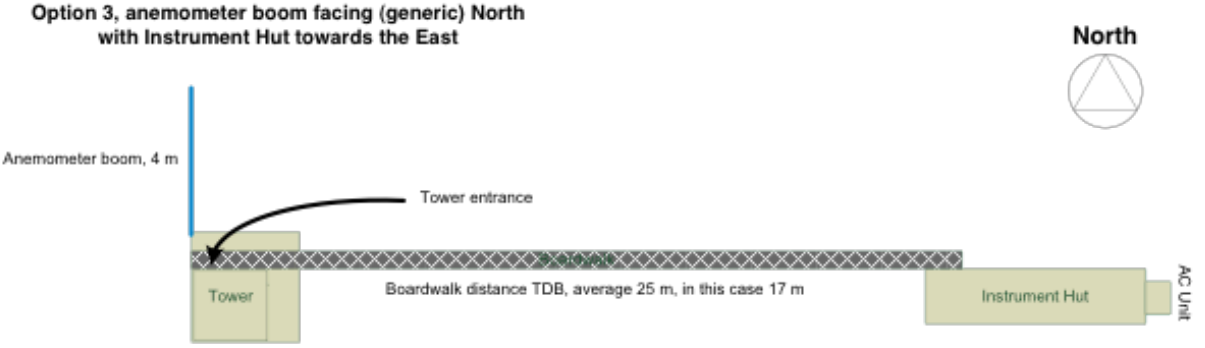
Option 1, anemometer boom facing (generic) West



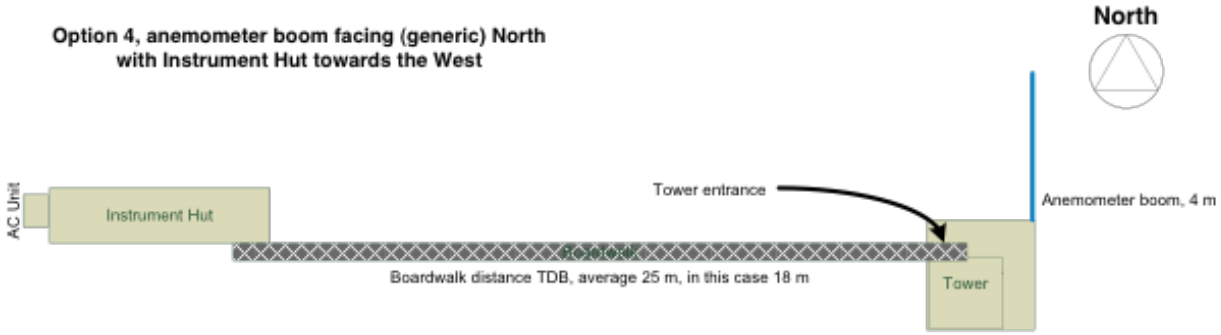
Option 2, anemometer boom facing (generic) East



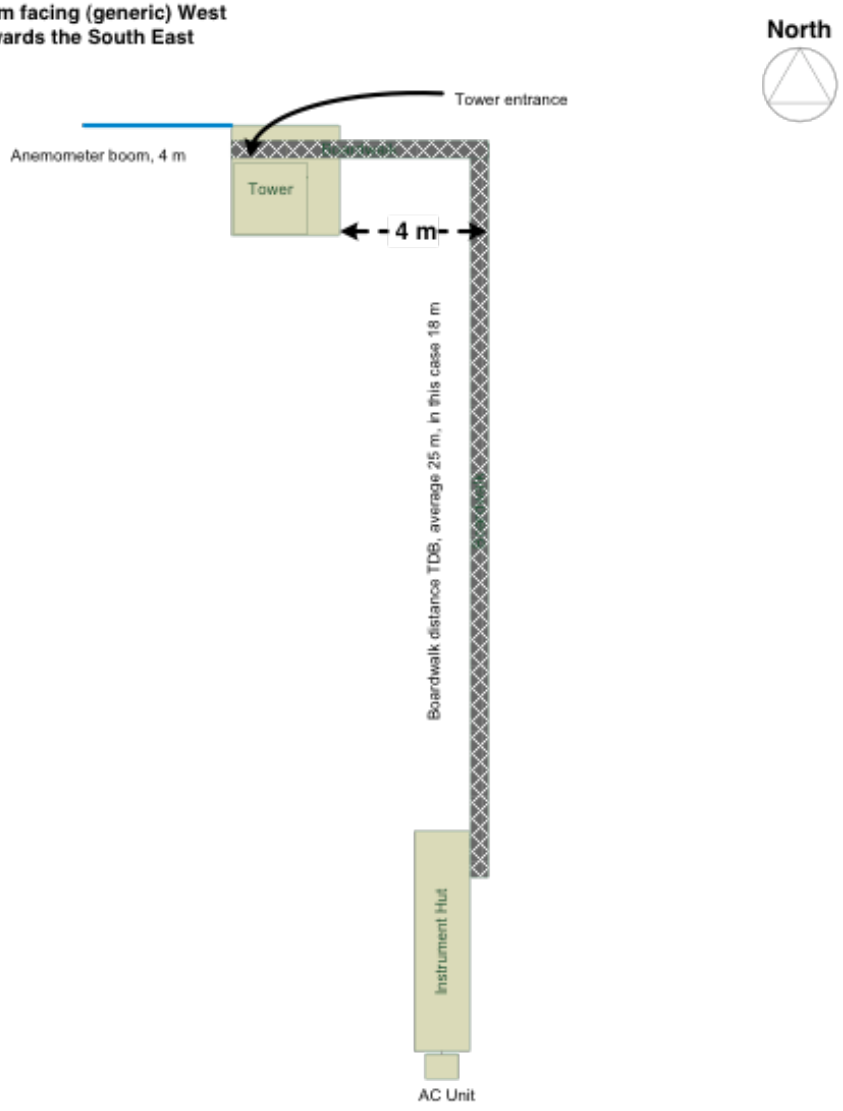
Option 3, anemometer boom facing (generic) North with Instrument Hut towards the East

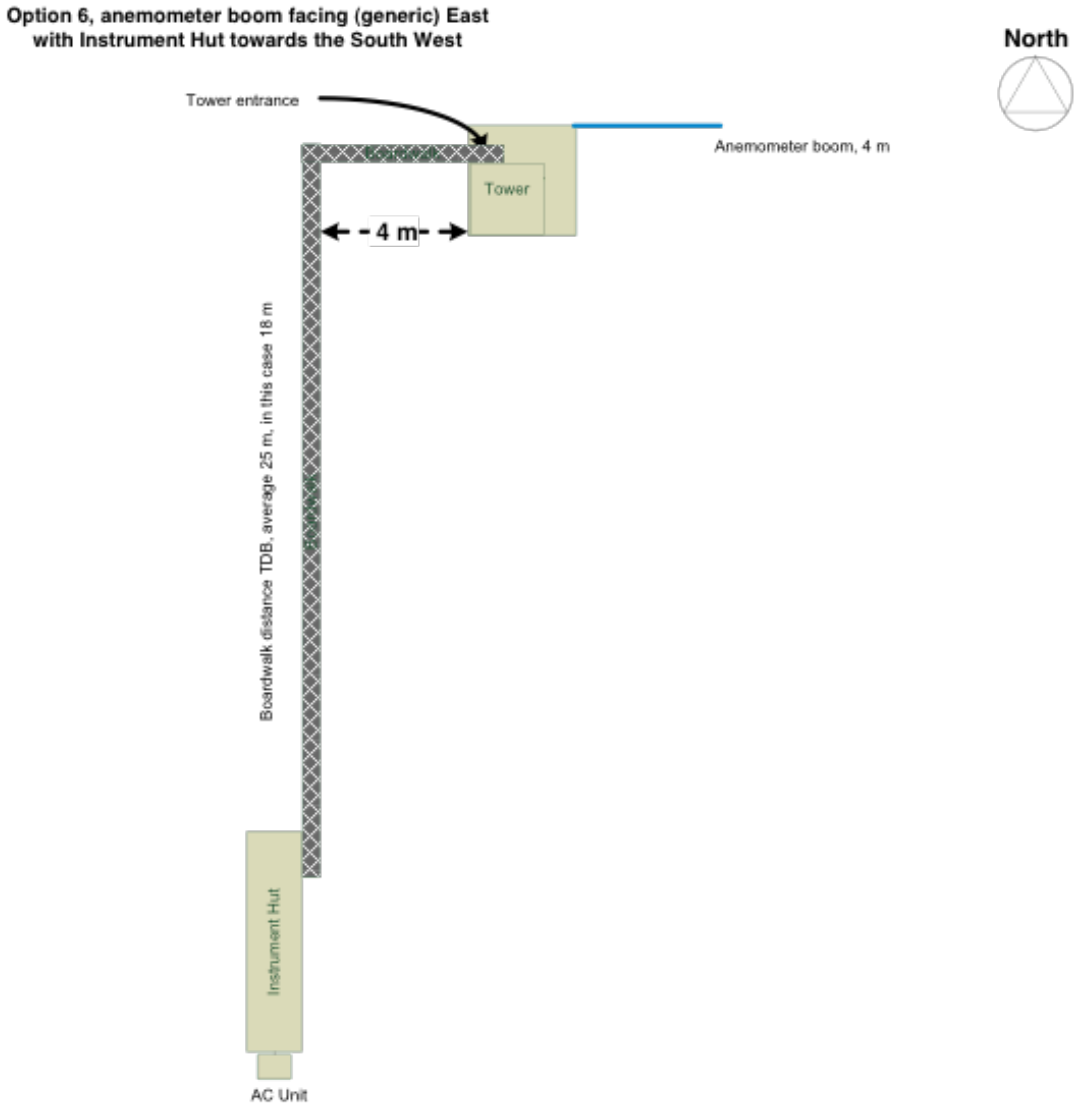


Option 4, anemometer boom facing (generic) North with Instrument Hut towards the West

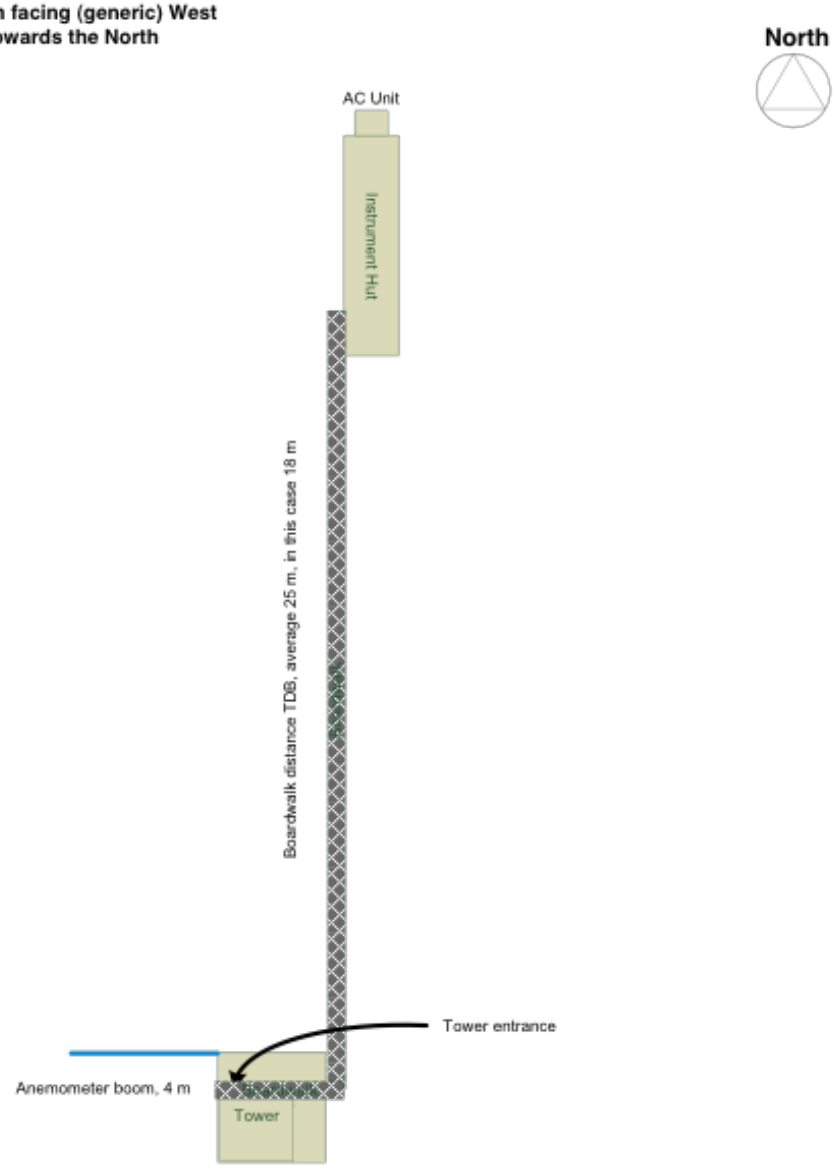


Option 5, anemometer boom facing (generic) West with Instrument Hut towards the South East




Option 6, anemometer boom facing (generic) East
with Instrument Hut towards the South West
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

Option 7, anemometer boom facing (generic) West with Instrument Hut towards the North



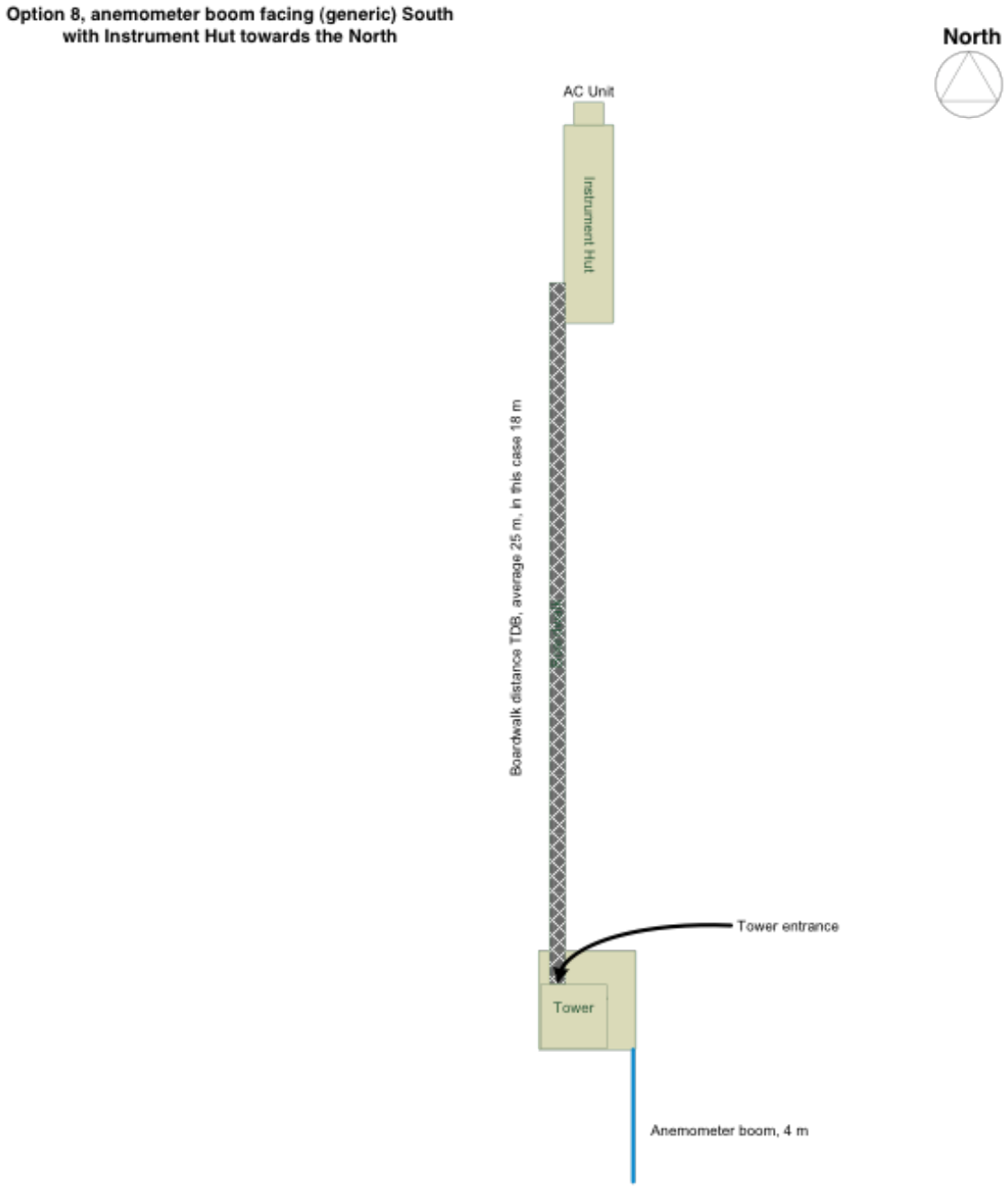


Figure 8. Generic plan view of the tower, Instrument hut and boardwalk pathways

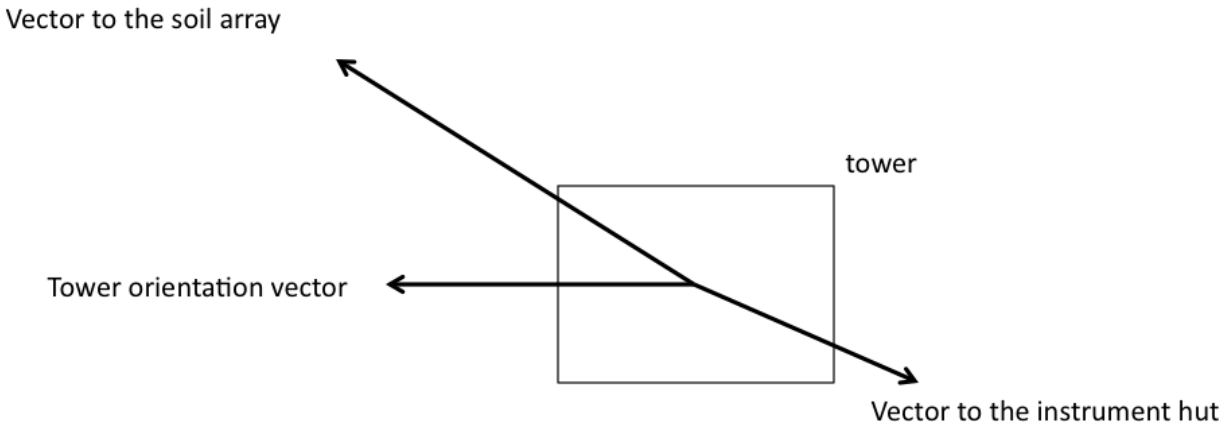


Figure 10. Conceptual plan view of the tower

Conceptual plan view of the tower showing the relationship between the associated vectors and tower positioning. Note all the vectors are indexed ***from*** the centerpoint of the tower. All vectors are ***from*** the tower centerpoint ***to*** the designated attribute.

6 APPENDIX A. FCC SUMMARY TABLES

Table A1. FCC Summary Table for FIU site components at D10 CPER Core

Site Component				**units**
Tower location	40.815540°	-104.745430°		Lat, Long
Tower height	6.0			meters
Tower guying	no			yes/none, notes
Instrument Hut location	40.815531°	-104.745157°	2% approval good	Lat, Long
IH orientation[a]	90°-270°			IH longwise vector
boom orientation[b]	270°			degrees
distance from center of tower to IH CPiont (z)		23	Option 1	vector, distance (m), option #
how the Bwalk intersects the tower access	Boardwalk intersects the north-side of the tower from the east.			description
how the Bwalk intersects the tower access	Straight section of Boardwalk from IH to tower			description
Air shed vector(s)[c]	135° to 25°	Clockwise from 135°		vector, notes
Boardwalk from AP to IH	no	access straight W (270°) from the road access to IH		yes/none, notes
Boardwalk from tower to soil array	no	Maybe later		yes/none, notes
Boardwalk needed to DFIR	none			yes/none
DFIR location	40.815630	-104.744481	2% approval good	Lat, Long
DFIR power supply	needs line power			description
Soil plot 1st location	40.815702°	-104.745714°		Lat, Long (center point)
Soil plot distance between plots (x)	35 m	25	6	X, Y, offset (meters)
Soil array pattern and vector[d]	B	315°		A, B, or C, vector
Soil plot dimensions	5 m x 5 m			L x W (meters)
Soil profile pit primary	40.812969°	-104.744536°	>1.53 m	Lat, Long, and expected depth
Soil profile pit alternative 1	40.815193°	-104.752628°	>1.53 m	Lat, Long, and expected depth
Soil profile pit alternative 2	40.822820°	-104.747068°	>1.53 m	Lat, Long, and expected depth
Fencing needs	Yes, to protect the lower level booms,			IH, Soil Arrays, Guy anchors
Presence of large grazing animals	yes, cattle			description
Site management*	Light grazed			description
Any additional site specific information	North American natural shortgrass steppe			description
Magnetic declination	9° 11' E changing by 0° 8' W y^{-1}			At time of site visit

Table A2. FCC Summary Table for FIU site components at D10 Sterling Relocatable

Site Component				**units**
Tower location	40.461903°	-103.029266°		Lat, Long
Tower height	8.0			meters
Tower guying	no			yes/none, notes
Instrument Hut location	As per 2% review		90°	Lat, Long, vector from tower to IH
IH orientation[a]	270°-90°		90°	Orientation vector
boom orientation[b]	270°			degrees
distance from center of tower to IH CPiont	90°	20	Option 1	vector, distance (m), option #
how the Bwalk intersects the tower access	Boardwalk intersects the north-side of the tower from the east.			description
how the Bwalk intersects the tower access	Straight section of Boardwalk from the east of tower to IH			description
Air shed vector(s)[c]	186° to 358°	Clockwise from 186°		vector, notes
Boardwalk from AP to IH	no			yes/none, notes
Boardwalk from tower to soil array	no			yes/none, notes
Boardwalk needed to DFIR	none			yes/none
DFIR location				Lat, Long
DFIR power supply	na			description
Soil plot 1st location			As per 2% review	Lat, Long (center point)
Soil plot distance between plots (x)	40 m		3 m	Meters, "", offset
Soil array pattern and vector[d]	Modified A	69°	As per 2% review	A, B, or C, vector
Soil plot dimensions	1 m x 5 m			L x W (meters)
Soil profile pit primary	40.459843°	-103.030073°	0.70 m	Lat, Long, and expected depth
Soil profile pit alternative 1	40.459837°	-103.030799°	0.70 m	Lat, Long, and expected depth
Soil profile pit alternative 2	40.459832°	-103.031532°	0.70 m	Lat, Long, and expected depth
Fencing needs	none			IH, Soil Arrays, Guy anchors
Presence of large grazing animals	none			description
Site management*	Typically corn/soybean rotation, includes tilling			description
Any additional site specific information	Shifting Agriculture			description
Magnetic declination	9° 11' E changing by 0° 8' W y^{-1}			At time of site visit

Table A3. FCC Summary Table for FIU site components at D10 CASTNET Relocatable

Site Component				**units**
Tower location	40.27591°	-105.54592 °		Lat, Long
Tower height	28.0			meters
Tower guying	no			yes/none, notes
Instrument Hut location	40.27613°	-105.54594 °	339°	Lat, Long, vector from tower to IH
IH orientation[a]	123°-303°			IH longwise vector
boom orientation[b]	303°			degrees
distance from center of tower to IH CPiont (z)		24	Option 7	vector, distance (m), option #
how the Bwalk intersects the tower access	Boardwalk intersects the north-side of the tower from the north.			description
how the Bwalk intersects the tower access	Straight section of Boardwalk from the north of tower to IH			description
Air shed vector(s)[c]	263° to 341°	Clockwise from 263°		vector, notes
Boardwalk from AP to IH	yes			yes/none, notes
Boardwalk to soil array	yes			yes/none, notes
Boardwalk needed to DFIR	na			yes/none
DFIR location				Lat, Long
DFIR power supply	na			description
Soil plot 1st location			As per 2% review	Lat, Long (center point)
Soil plot distance between plots (x)	35 m	26	5	X, Y, offset (meters)
Soil array pattern and vector[d]	Modified A	69°	As per 2% review	A, B, or C, vector
Soil plot dimensions	5 m x 5 m			L x W (meters)
Soil profile pit primary	40.277003°	-105.544866°	0.70 m	Lat, Long, and expected depth
Soil profile pit alternative 2	40.276993°	-105.546832°	0.70 m	Lat, Long, and expected depth
Soil profile pit alternative 1	40.277025	-105.545349	0.70 m	Lat, Long, and expected depth
Fencing needs	none			IH, Soil Arrays, Guy anchors
Presence of large grazing animals	none			description
Site management*	National Park Property			description
Any additional site specific information	Natural regenerated Ponderosa Pine Forest			description
Magnetic declination	9° 11' E changing by 0° 8' W y^{-1}			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

[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.

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

7 REFERENCES

Peterson, GA, Westfall, DG, and Cole, CV. 1993. Agroecosystem approach to soil and crop management research. *SSSA J.* **57(5),** 1354-1360.

Arya, S. P. S. 1988, Introduction to micrometeorology. Academic Press, San Diego