Microwave Path Survey Report

City of Portland
NA210924-57622PH1
Lookout Point- Water Bureau Filtration Plant

Release 1.0
December 2021

Issue Releases

Issue Number	Issue Release Date	Changes	Preparer
1.0	December 2021	Initial Release	Jun Li

TABLE OF CONTENTS

GENERAL

STATEMENT OF WORK

The following report summarizes the results of a microwave path survey conducted by Aviat Networks, Milpitas, California, for City of Portland. Field survey work was performed on December 1, 2021, by Larry Song.

The survey was undertaken to verify site locations and determine antenna sizes and centerlines required to establish a microwave communications system in conformance with customer requirements and current engineering practices.

SURVEY PROCEDURES

Preliminary path profiles will be drawn based on the supplied site coordinates and contour information extracted from the best available topographic mapping. A field site survey will be conducted to verify site coordinates and elevations based on North American Datum 1983 (NAD83) and gather information related to the proposed radio equipment and antenna locations, site access, and site development constraints. A field path survey will be conducted to verify path profile elevations, measure all natural and manmade potential obstructions and assess the reflective potential of all natural and manmade surfaces. Antenna centerline heights will be calculated for the proposed frequency band by applying suitable clearance criteria based on the propagation characteristics of the geographic area.

Path calculation sheets will then be generated for each hop, based upon the recommended centerline heights. Antenna sizes and the choice of propagation protection diversity will be chosen to meet the required fade margin and the desired path propagation reliability. Propagation outage and reliability calculations will be based on the Vigants model (ref. “Space Diversity Engineering”, BSTJ, 1/75).

DESIGN CRITERIA

Path clearance criteria must be established for each path on the basis of total system performance objectives, economic considerations, and careful analysis of local atmospheric conditions derived from published climatological data, where available, and reported microwave transmission experience pertinent to the area. Antenna heights much greater than actually needed cause an unwarranted increase in system cost, and on paths with significant ground reflections, it can increase the exposure to multipath and ground reflection signal fading. It is desirable to locate the antennas high enough so that even under severe super-standard atmospheric refractive conditions (surface ducting) there is adequate clearance such that signal entrapment does not significantly degrade the fade margin of the path or generate excessive multipath fade activity. The choice of clearance criteria for a microwave path is a balance between cost and performance.

The path clearance criterion as applied to a given geographic area is a function of the degree and direction of atmospheric beam bending and can conveniently be defined by the equivalent earth radius K factor:

$$K = \frac{Effective\ \ Earth's\ \ Radius}{Actual\ \ Earth's\ \ Radius}$$

The Median Propagation value of K = 4/3 allows the normal microwave horizon to be slightly extended when compared to the optical horizon; however, under certain meteorological conditions (for example, during nighttime super-refractivity usually associated with temperature inversions) the value of K increases to 2 or greater for periods of several minutes to several hours. This increases the path clearance and results in the heavy multipath fade activity seen on some reflective paths and antenna decoupling power fading on others.

CLEARANCE CRITERIA

The criteria used to design a radio path in regions where the X-factor is equal to or less than 1:

- Main to Main:
  - 100% first Fresnel zone radius over K=4/3, or
  - 60% first Fresnel zone radius over K=1, whichever is greater

- Main to Diversity:
  - 60% first Fresnel zone radius over K=4/3

The criteria used to design a radio path in regions where the X-factor is greater than 1:

- Main to Main:
  - 100% first Fresnel zone radius over K=4/3, or
  - 30% first Fresnel zone radius over K=2/3, whichever is greater

- Main to Diversity:
  - 60% first Fresnel zone radius over K=4/3

MICROWAVE PATH PERFORMANCE CALCULATIONS AND WARRANTIES

The microwave path design models most frequently employed within the industry (e.g., Vigants, and ITU PN-530) provide a reasonably accurate (and therefore usually guaranteed) estimate of the cumulative time a path will be out of service due to random atmospheric multipath fading under normal atmospheric conditions. **These models do not (and cannot) accommodate abnormal, unusual, anomalous, or otherwise unpredictable conditions of weather or atmospheric refractivity**.

MICROWAVE FREQUENCY ENGINEERING / INTER-SYSTEM INTERFERENCE ANALYSIS

Aviat Networks will partner with Comsearch, a CommScope company, to provide cost-effective frequency planning and FCC licensing services for radio communications systems (if required). The planning software used, considers specific operating parameters of both the proposed microwave system and the environment microwave systems (license and proposed) to properly consider the interference potential of the new path or system. Parameters and data elements incorporated into the modeling include, but are not limited to, antenna type, antenna height, elevation, antenna radiation pattern, receiver filter performance, terrain, radio modulation, path orientation, receiver threshold, etc. These elements are required to accurately predict specific interfering levels into and from the existing microwave systems. The accuracy of the calculations is ensured by “real time” maintenance of the Comsearch point-to-point microwave, earth station, radio equipment, antenna, interference objective, and contact database.

MICROWAVE FREQUENCY SELECTION

The interference analysis performed on the microwave system identifies available frequencies considering existing and proposed systems found in the Comsearch database. When applicable, an analysis of the systems in the adjacent bands can be done to ensure the microwave system does not receive unwanted threshold degradation. In bands shared with satellite systems, an analysis of potential interference with earth stations and with the geo-stationary satellite orbit can also be done. Additionally, co-located or nearby transmitters already licensed in the required frequency band can be identified in order to reduce the possibility of “bucking” an existing high/low frequency plan that could increase the possibility of receiver overload or reflective interference from a nearby system.

MICROWAVE FREQUENCY COORDINATION AND FCC LICENSING

The majority of microwave bands subject to FCC Rule Part 101 require prior coordination with existing licensees. Aviat Networks will partner with Comsearch to perform the frequency coordination and FCC licensing on behalf of the customer (if required). The procedure will include notification of the technical parameters of the proposed system to all existing and proposed licensees in the area and frequency band of operation. Frequency coordination will also be performed with Canadian and Mexican authorities in border areas when necessary. By FCC rule, recipients are given 30 days to respond, or in some cases an expedited response can be requested.

Upon completion of the prior coordination process, documentation required to satisfy FCC Rule Part 101.103 (d) can be prepared on behalf of the customer. This will include any necessary exhibits, including Supplemental Showings required upon submittal of the requested license application. The FCC filing process includes:

- Filing of the FCC Form 601 microwave application upon written approval from the customer and providing an electronic copy of the application to the customer via email.
- Tracking the status of the application until the license is granted by the FCC. Amendments will be handled expeditiously on behalf of the customer for any questions or concerns from the Commission.
- Email notifications to the licensee when the license is granted by the FCC.
- Filing of the required “Completion of Construction” notification with the FCC upon written approval from the licensee and notification of the filing via email.

SPECIAL CONSIDERATIONS

On all microwave radio paths traversing urban areas there exists the possibility of multiple on- and off-path structural reflections which generate long-delayed echoes, as well as "terrain scatter" RF intra- and inter-system interference. Long delayed, low-level echoes have no effect on digital radio performance; however, the terrain scatter mechanism cannot be accurately predicted nor precisely measured without an extensive and expensive field trial. Consequently, this mechanism is specifically excluded from all current industry-wide path survey and frequency coordination performance guarantees.

The structure supporting the microwave antenna can take many forms. The antenna is most often mounted on a tower, but can be mounted on a variety of structures such as roof tripods, penthouse wall, wooden telephone pole or metal monopole. It is recommended that the customer or end user conduct a structural analysis of the support structure to determine if the structure will support the additional loading imposed by the antenna and its mount. The structure must also meet the twist and sway requirements per EIA/ANSI 222G.

Certain geographic areas / frequency bands are restricted due to Radio Astronomy use or DOD and other Government top-secret installations. Even outside the absolute exclusion zone, there are areas where 18 GHz can be cleared by DOD. Coordinators must file applications and wait for the FCC to contact NTIA and NTIA to contact IRAC to analyze these before FCC licenses are granted. If the application is rejected, the proposed microwave link could be subject to redesign with another frequency band.

LIST OF SITES AND PATHS

SITES (in the order they appear in this report):

- Lookout Point
- Water Bureau Filtration Plant

PATHS (in the order they appear in this report):

- Lookout Point to Water Bureau Filtration Plant

SYSTEM INFORMATION

SYSTEM DESCRIPTION

The City of Portland in collaboration with Aviat has undertaken a project to expand its microwave backhaul network.

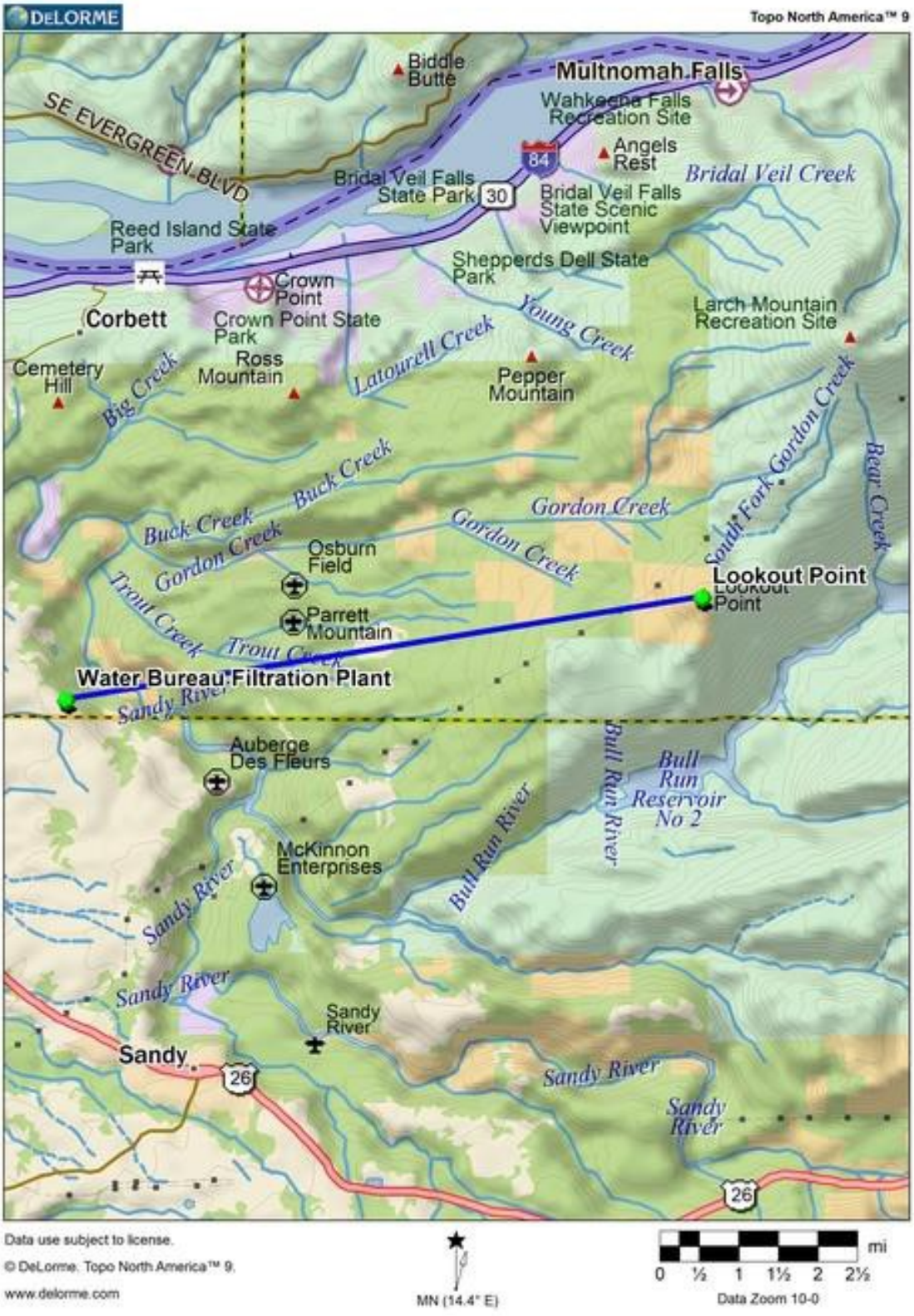
This report details the following microwave path as the part of the project:

- Lookout Point to Water Bureau Filtration Plant

The microwave path was surveyed to determine if proper line-of-sight clearances can be achieved using available antenna centerlines.

Antenna heights were used based on the following considerations:
• Clearance based on standard Vigants clearance criteria appropriate for the path area.
• All foliage growth along the route includes an added 10 ft of future growth factor.

SYSTEM LAYOUT



SITE INFORMATION – Lookout Point

SITE DESCRIPTION

Customer Supplied Site Coordinates, NAD 83
45° 29' 0.8"N 122° 7' 45.5"W Elev: 2650.59 ft / 807.9 m

Note: Site coordinates are verified by referencing the tower location to landmarks and reference points that are depicted on the USGS 7 ½ minute topo maps for the area. GPS readings may also be used to supplement the USGS topo data. Field verified ground elevations and/or site coordinates may differ from frequency coordinated/FCC licenses values. This is due to matching of existing ASR/FCC licenses where applicable.

Field Verified Site Coordinates, NAD 83
45° 29' 0.78"N 122° 7' 45.73"W Elev: 2560.89 ft / 780.6 m

ASR, NAD 83
° ' "N ° ' "W

FCC Licensed Coordinates, NAD 83
45° 29' 2.0"N 122° 7' 40.0"W Elev: 2640.0 ft / 804.7 m

Street Address: 4.16 Miles NE of 44510 SE Connett Rd
City: Corbett
County: Multnomah
State: Oregon

Tower Registration Number: N/A
Call Sign: WNTR802
Tower Owner: City of Portland

Tower Considerations:

- Tower Structure: ☑Existing ☐New
- Tower Type: ☐Guyed ☑Self Supporting ☐Monopole ☐Rooftop ☐Water tank ☐Building ☐Other:
- Tower Height: 180 ft.

Tower Legs Orientated: NW, SW and East

Antenna Mounting Considerations for each path:

- Path to Water Bureau Filtration Plant: Install the new antenna to Water Bureau Filtration Plant at 150' on the SW leg of the tower
  - Centerline: 150'
  - Azimuth: 260.91°
  - Tilt Angle: -2.61°

Transmission Line Considerations for each path:

- Path to Water Bureau Filtration Plant: The Eclipse ODU600 is a split mounted unit and an estimated 220 feet of cable is required from the radio to the equipment rack inside the shelter.

- Cable Ladder: ☑Use Existing ☐Recommended ☐Not Required
- Cable Ice Bridge: ☑Use Existing ☐Recommended
- Entry Ports: ☑Use Existing ☐New Entry Port Required
- Ground Bus Bar: ☑Use Existing ☐New Bus Bar Required

Site Access Considerations:

Site is accessible with 4 WD vehicle. Escort is required.

SITE PHOTOS

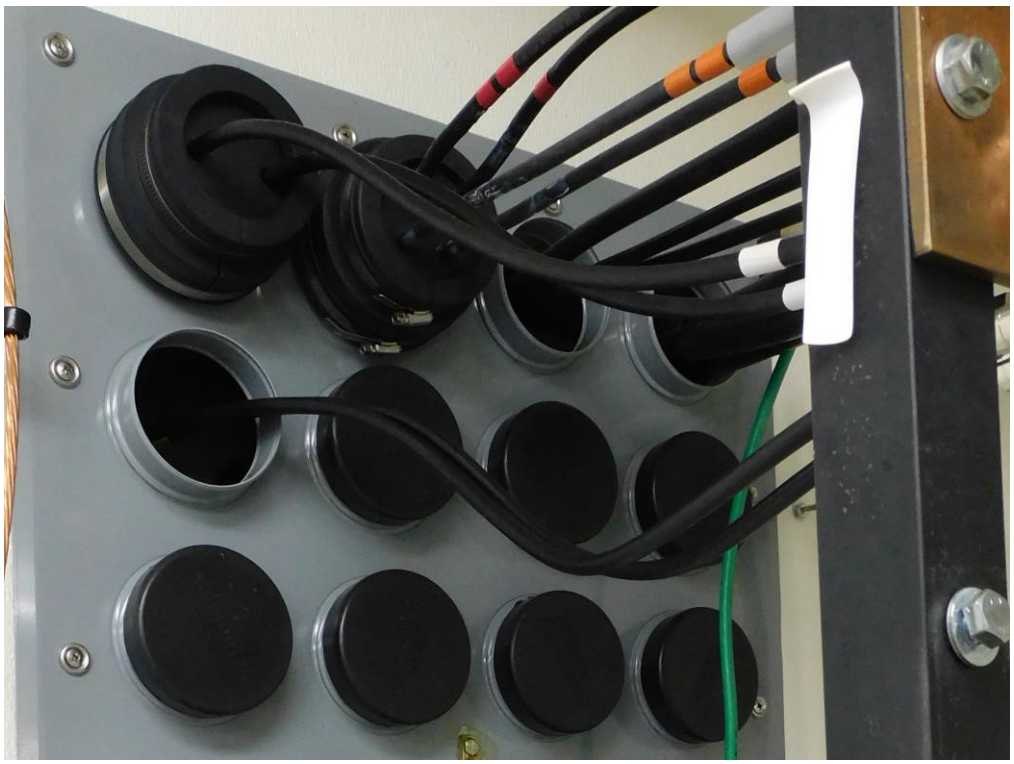
Full Tower Photo Looking West

Antenna Main Photo to Water Bureau Filtration Plant

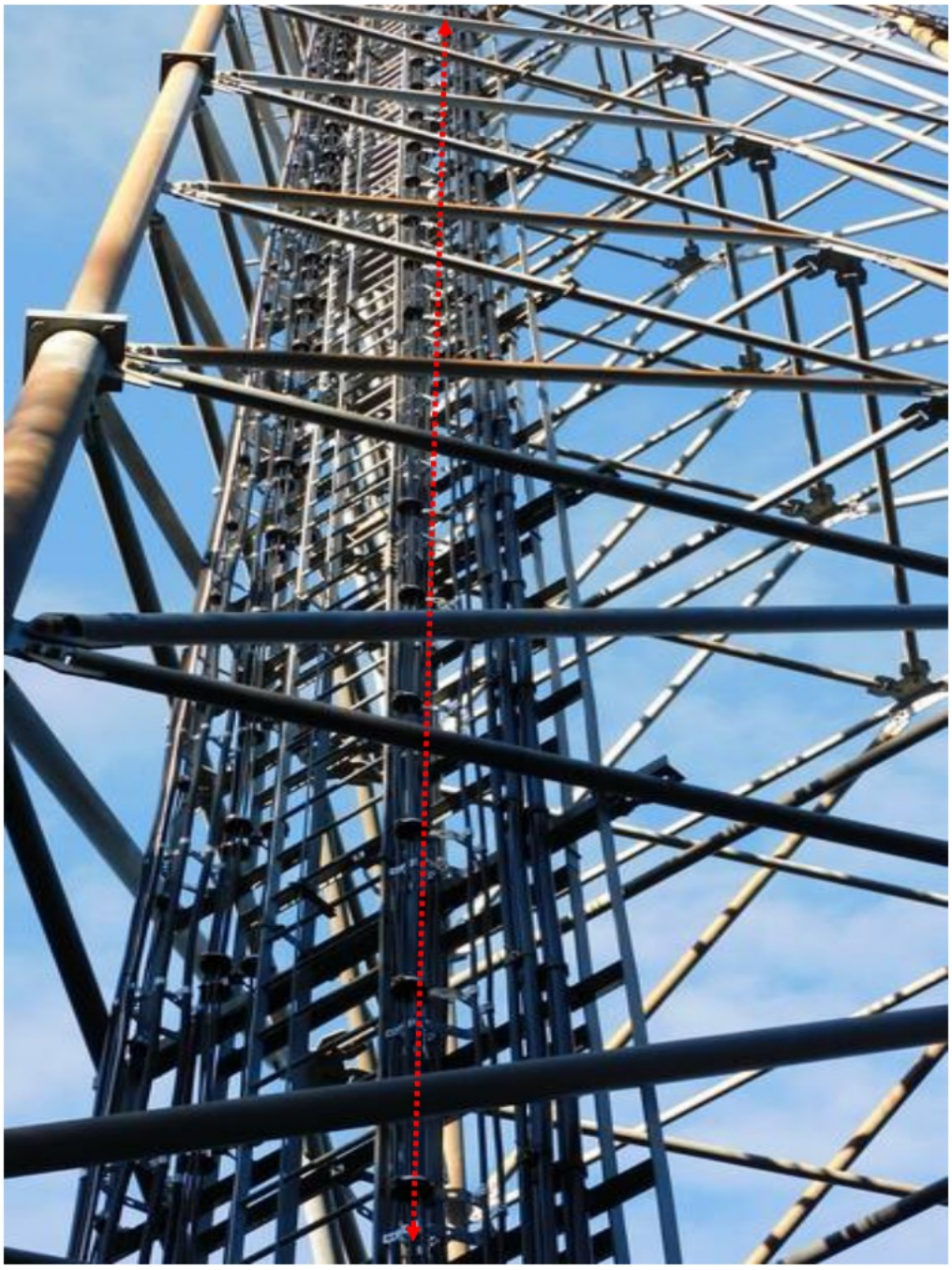
Exterior Photo of Shelter

Antenna Cable Ice Bridge

Antenna Exterior Entry Port



Antenna Interior Entry Port



Antenna Waveguide Photo

Photo of Equipment Rack Location
New rack space is available if needed

Photo of Azimuth to Water Bureau Filtration Plant

MAP EXTRACT

Lookout Point

NAD 83	
45° 29' 0.78"N 122° 7' 45.73"W Elev: 2560.89 ft / 780.6 m	State: Oregon County: Multnomah

SITE INFORMATION – Water Bureau Filtration Plant

SITE DESCRIPTION

Customer Supplied Site Coordinates, NAD 83
45° 27' 53.17"N 122° 17' 42.6"W

Note: Site coordinates are verified by referencing the tower location to landmarks and reference points that are depicted on the USGS 7 ½ minute topo maps for the area. GPS readings may also be used to supplement the USGS topo data. Field verified ground elevations and/or site coordinates may differ from frequency coordinated/FCC licenses values. This is due to matching of existing ASR/FCC licenses where applicable.

Field Verified Site Coordinates, NAD 83
45° 27' 53.17"N 122° 17' 42.6"W Elev: 722.88 ft / 220.3 m

ASR, NAD 83
° ' "N ° ' "W

FCC Licensed Coordinates, NAD 83
° ' "N ° ' "W

Street Address: 0.20 Mile SE of 35321 SE Carpenter Ln
City: Gresham
County: Multnomah
State: Oregon

Tower Registration Number: N/A
Call Sign: Pending
Tower Owner: City of Portland

Tower Considerations:

- Tower Structure: ☐Existing ☑New
- Tower Type: ☐Guyed ☐Self Supporting ☐Monopole ☐Rooftop ☐Water tank ☐Building ☑Other: TBD
- Tower Height: TBD

A new tower will be constructed at this location.

Antenna Mounting Considerations for each path:

- Path to Lookout Point: Install the new antenna to Lookout Point at 145' on the East side of the new tower
  - Centerline: 145'
  - Azimuth: 80.79°
  - Tilt Angle: 2.52°

Transmission Line Considerations for each path:

- Path to Lookout Point: The Eclipse ODU600 is a split mounted unit and an estimated 175 feet of cable is required from the radio to the equipment rack inside the shelter. Transmission line length is an estimate and should be confirmed upon construction of tower and shelter.

- Cable Ladder: ☐Use Existing ☑Recommended ☐Not Required
- Cable Ice Bridge: ☐Use Existing ☑Recommended
- Entry Ports: ☐Use Existing ☑New Entry Port Required
- Ground Bus Bar: ☐Use Existing ☑New Bus Bar Required

Site Access Considerations:

Site is accessible with 4 WD vehicle. Escort is required.

SITE PHOTOS

Photo of Stake Marking

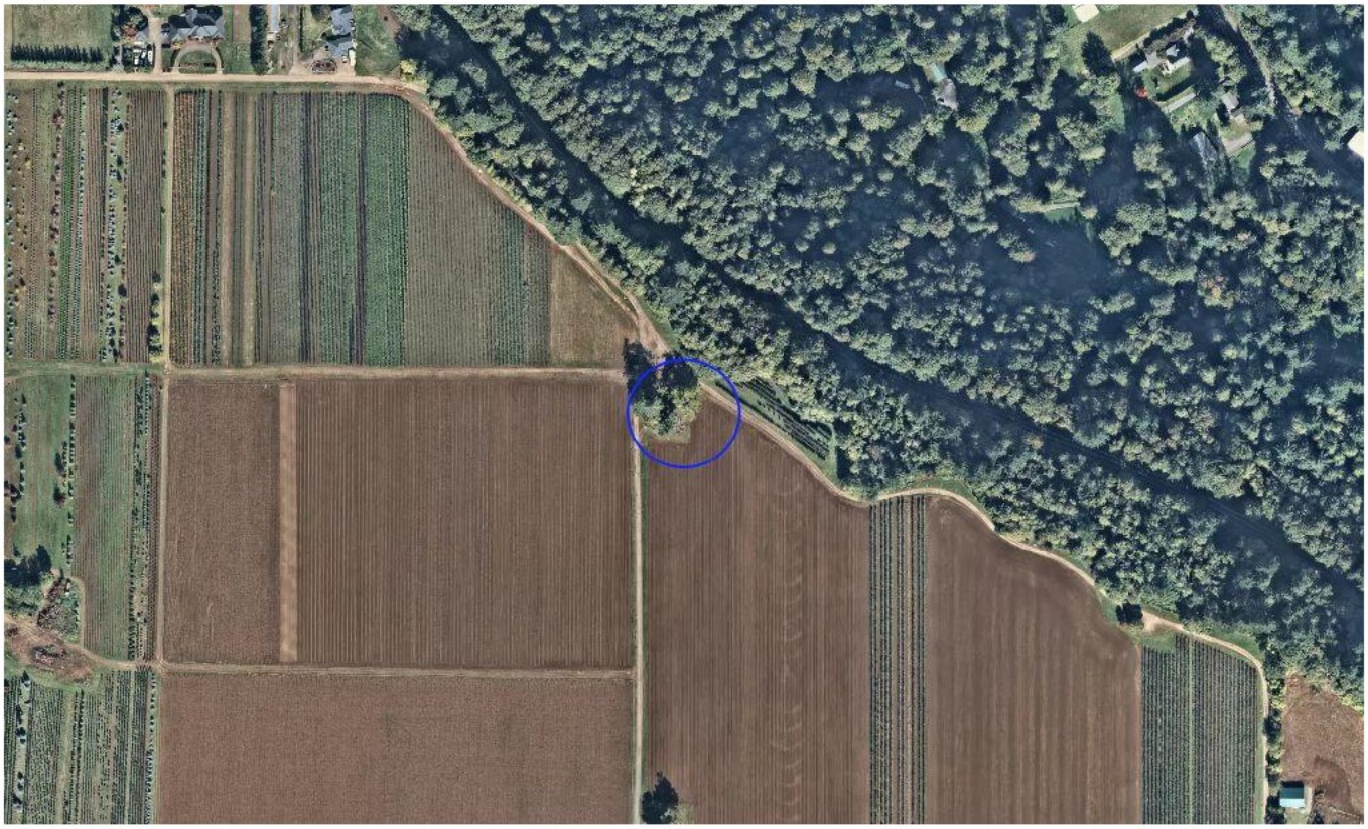
Photo of Stake Looking North

Photo of Stake Looking South

Photo of Stake Looking SE

Photo of Azimuth to Lookout Point

MAP EXTRACT



Water Bureau Filtration Plant

NAD 83	
45° 27' 53.17"N 122° 17' 42.6"W Elev: 722.88 ft / 220.3 m	State: Oregon County: Multnomah County

PATH INFORMATION

PATH DESCRIPTIONS

Lookout Point to Water Bureau Filtration Plant

Path Length: 8.14 Miles
Frequency Band: 11.2GHz

General Path Description:

From an existing self-support tower location at Lookout Point , the path traverses over rolling terrain, heavily wooded areas, agricultural fields and arrives at a greenfield site location at Water Bureau Filtration Plant. The natural area vegetation is generally deciduous and pine trees.

There are path controlling trees located at miles 0.01-0.05 and 8.121.

The path is clear at the centerlines in design.

Path Climate considerations:

The path is in a region that is considered as “average” for radio wave propagation, with the area being defined as "Csb" (Mediterran Climate) by the Köppen classification system.

This area receives approximately 79.7 inches of rain per year and the average annual snowfall is 15.9 inches.

The July high is approximately 65.2 degrees F. The January low is 38.3 degrees F. The average annual temperature is approximately 51.4 degrees F.

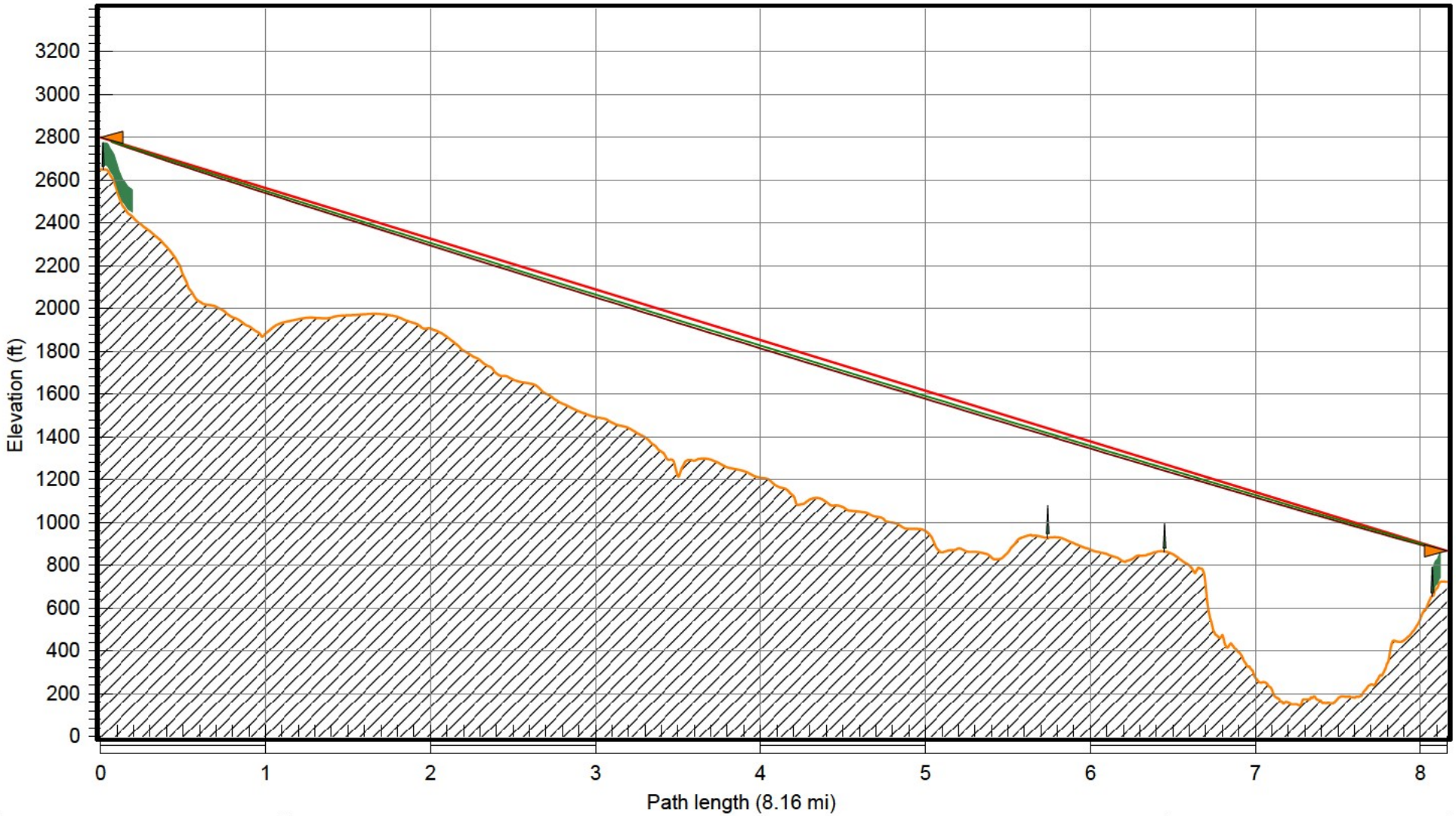
Path Calculations

	Lookout Point	Water Bureau Filtration Plant
Latitude	45 29 00.78 N	45 27 53.17 N
Longitude	122 07 45.73 W	122 17 42.60 W
True azimuth (°)	260.91	80.79
Vertical angle (°)	-2.61	2.52
Elevation (ft)	2650.89	722.88
Tower height (ft)	180.00	
Antenna model	SC 3 - W100A (TR)	SC 3 - W100A (TR)
Antenna file name	sc3-w100a(10.7-11.7 ghz), 121009	sc3-w100a(10.7-11.7 ghz), 121009
Antenna gain (dBi)	38.30	38.30
Antenna height (ft)	150.00	145.00
Orientation loss (dB)	0.00	0.00
TX line model	Direct Mount	Direct Mount
TX line length (ft)	220.00	175.00
Circulator branching loss (dB)	1.60	1.60
Frequency (MHz)	11200.00	
Polarization	Horizontal	
Path length (mi)	8.17	
Free space loss (dB)	135.83	
Atmospheric absorption loss (dB)	0.21	
Net path loss (dB)	62.63	62.63
Radio model	E6v2H11_40M64Q 178R70_G	E6v2H11_40M64Q 178R70_G
Radio file name	e6v2h1140m178r7	e6v2h1140m178r7
TX power (dBm)	27.50	27.50
Emission designator	40M0D7W	40M0D7W
EIRP (dBm)	64.20	64.20
RX threshold criteria	1E-6 BER	1E-6 BER
RX threshold level (dBm)	-73.50	-73.50
Receive signal (dBm)	-35.13	-35.13
Thermal fade margin (dB)	38.37	38.37
Dispersive fade margin (dB)	58.00	58.00
Dispersive fade occurrence factor	1.00	
Effective fade margin (dB)	38.32	38.32
Climatic factor	1.00	
Terrain roughness (ft)	77.53	
C factor	0.57	
Average annual temperature (°F)	44.75	
Fade occurrence factor (Po)	8.628E-003	
Annual multipath availability (%)	99.99997	99.99997
Annual multipath unavailability (sec)	8.97	8.97
Annual 2 way multipath availability (%)	99.99994	

Guaranteed Tx/Rx Specifications over time and operational range

	Lookout Point	Water Bureau Filtration Plant
Annual 2 way multipath unavailability (%)	0.00006	
Annual 2 way multipath unavailability (sec)	17.93	
Polarization	Horizontal	
Rain region	Portland, Oregon	
Rain rate (mm/hr)	124.73	
Flat fade margin - rain (dB)	38.37	
Rain attenuation (dB)	38.40	
Annual rain availability (%)	99.99997	
Annual rain unavailability (min)	0.16	
Annual rain + multipath availability (%)	99.99991	
Annual rain + multipath unavailability (min)	0.46	

Multipath fading method - Vigants - Barnett
Rain fading method - Crane



Lookout Point	
Latitude	45 29 00.78 N
Longitude	122 07 45.73 W
Azimuth	260.91°
Elevation	2651 ft ASL
Antenna CL	150.0 ft AGL

Frequency (MHz) = 11200.0
Main 1 K = 1.330 %F1 = 100.00
Main 2 K = 0.670 %F1 = 30.00

Water Bureau Filtration Plant	
Latitude	45 27 53.17 N
Longitude	122 17 42.60 W
Azimuth	80.79°
Elevation	723 ft ASL
Antenna CL	145.0 ft AGL

TERMS AND CONDITIONS

PATH ENGINEERING/ TRANSMISSION ENGINEERING

Path Engineering Services

Aviat Networks will perform radio path surveys and path calculations to determine the normal path loss and antenna heights as defined in TIA/EIA Standard RS-252-A

When Aviat Networks performs reliability calculations or path studies (path profiles from mapping or digitized data only) based solely on information supplied by or on behalf of the Customer, these calculations and studies are provided solely for budgetary purposes and shall not be construed as or be used for an installable design.

When conducting a path survey, Aviat Networks will verify site coordinates and ground elevations, and record trees and man-made fixed obstructions on the path. This information will be recorded on the profile for that particular path. Aviat Networks will assign an appropriate growth factor to tree heights.

When Aviat Networks performs frequency planning based, in part, on data provided by the Customer at the time of the study, Aviat Networks will not be responsible for any interference case that arises due to errors or omissions in such data. As the usage of microwave bands increase and there is more sharing with satellite services, it may be necessary to perform frequency interference studies and additional path surveys (to determine blockage) to alleviate the possibility of interference from satellite earth stations.

Warranty of Path Engineering Services

Aviat Networks warrants that the installed radio communication path will conform to Customer's multipath performance reliability objectives when Aviat Networks has performed the path survey, recommended the path design, and Aviat Networks has implemented such recommendations. **This warranty is for a period of 15 months from the date of the survey or one year from the date of installation of the microwave path, whichever expires first.** All Aviat Networks field activities and path propagation analysis will utilize current hardware, software, and engineering practice and judgment with the goal of meeting normal Path Loss, as defined in TIA/EIA Standard RS-252-A.

Aviat Networks is not responsible for paths that it does not survey, nor for changes in path design beyond those specifically allowed in the path survey report or in writing after the field survey is completed, including but not limited to:

- Any change in path design;
- Any movement in site locations;
- Any building or other structure built on-path after date of survey;
- Any disturbance of the terrain which may cause blockage or reflection;
- Any additional frequency interference source;
- Any change of available antenna mounting space on tower.

Any one or more of the changes listed on page one will nullify this warranty, and the Customer shall in such case bear the total cost of determining that such change was the cause.

Aviat Networks will not be responsible for degraded path performance when such degradation is due to such anomalous propagation conditions as:

- Long-term loss of fade margin due to antenna decoupling misalignment caused by widely-varying k-factor changes;
- Long-term loss of fade margin due to Atmospheric Boundary Layering ("ABL") causing wavefront defocusing (beam spreading), signal entrapment (blackout fading), ducting, and other such occurrence.
- Excessive rain outage rates beyond the published crane and/or chart data used in the calculation;
- Degradation resulting from certain types of multipath interference attributed to unidentifiable off-path terrain features or structures;

- Any other technological or atmospheric condition not foreseeable through the exercise of prudent engineering knowledge and judgment.

Additionally, Aviat Networks will not be responsible for degraded path performance when:

- Non-Aviat Networks radio equipment is installed on a surveyed path;
- Aviat Networks radio equipment is not installed by Aviat Networks;
- Existing antenna and waveguide system is used without test and inspection performed by Aviat Networks.

Aviat Networks designs the microwave path based upon best engineering practices and standards common to the industry, and it selects a transmission configuration based upon the most economical method for meeting the path performance objectives. When path loss or reliability objectives are not achieved, exclusive of anomalous propagation or path changes as described above, then Customer's sole remedy, and Aviat Networks' exclusive liability in connection with path engineering, shall be that Aviat Networks will provide incremental labor and material to optimize the antenna system beyond what would have been required during initial installation.

Where anomalous propagation is suspected in an installed microwave path, Aviat Networks will work with the Customer to obtain reasonable evidence that such condition exists. The total retroactive costs for such study shall be the responsibility of the Customer with Aviat Networks providing in-office engineering support. The cost of relocating towers, antennas, passive reflectors or other measures required to remedy this type of problem shall solely be the responsibility of the Customer.

Limitations

The foregoing warranties are in lieu of all other warranties whether oral, written, expressed, implied, or statutory. In particular, THE IMPLIED WARRANTIES OF A FITNESS FOR A PARTICULAR PURPOSE AND MERCHANTABILITY ARE HEREBY DISCLAIMED and shall not be applicable, either from Aviat Networks or any other equipment or software manufacturer. Aviat Networks' warranty obligations and Customer's remedies thereunder are solely and exclusively as stated herein. IN NO CASE SHALL AVIAT NETWORKS BE LIABLE FOR INDIRECT KINDS OF DAMAGES, INCLUDING BUT NOT LIMITED TO SPECIAL, INCIDENTAL, AND CONSEQUENTIAL DAMAGES, OR LOSS OF CAPITAL, REVENUE, OR PROFITS. In no event shall Aviat Networks' liability to customer, or any party claiming through Customer, be in excess of the actual sales price paid by Customer for any service supplied to Customer by Aviat Networks.