REPORT ON SIGNIFICANT IMPACT TO THE HUMAN ENVIRONMENT

Pursuant to PUBLIC LAW 96-551 Art. VII, the Tahoe Regional Planning Agency shall utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision making which may have an impact on man's environment when acting upon matters that have a significant effect on the environment, and prepare and consider a detailed environmental impact statement before deciding to approve or carry out any project. In the spirit of the law, here is a report finding the significant effect(s) the 112-foot Ski Run cell tower, hereinafter, the "Antenna," will pose on the environment. In light of the issues raised in this report, the Tahoe Regional Planning Agency, hereinafter "TRPA," finding of no significant effect or impact (FONSE/FONSI) on the environment is unsubstantiated, entirely fails to consider an important aspect of the problem, offers explanation for its decision that runs counter to the evidence before the agency, and is so implausible that it could not be ascribed to a difference in view or the product of agency expertise,[1] [2] if not outright conclusory.[3]

The Antenna Will Have Significant Visual Impact

The proposed Antenna is to be constructed at the top of Hansen's Resort, a snow tubing park approximately a mile from Lake Tahoe. Two tube tracks run steeply downhill to a stormwater infiltration and retention basin adjacent to a storm drain, TRPA-designated Stream Environment Zone (SEZ),[4] and open stream. The TRPA land verification for the parcel is entirely bifurcated between "environmentally sensitive" and "stream environmental zone,"[5] the most sensitive ratings possible.

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[1] *C.f.,* 5 U.S.C. § 706(2).

[2] See, *Motor Vehicle Manufacturers Association v. State Farm Auto Mutual Insurance Co*., 463 U.S. 29, 42-44 (1983) (holding an agency decision is arbitrary and capricious if the agency has relied on factors which Congress has not intended it to consider, entirely failed to consider an important aspect of the problem, offered an explanation for its decision that runs counter to the evidence before the agency, or is so implausible that it could not be ascribed to a difference in view or the product of agency expertise; a court should […] invalidate agency determinations that fail to "examine the relevant data and articulate a satisfactory explanation for [the] action including a 'rational connection between the facts found and the choice made.'" When reviewing that determination, courts must "consider whether the decision was based on a consideration of the relevant factors and whether there has been a clear error of judgment").

[3] *See*, *United States v. Dierckman*, 201 F.3d 915, 926 (7th Cir. 2000) (quoting *Bagdonas v. Dep't of the Treasury*, 93 F.3d 422, 426 (7th Cir. 1996)); *Allied-Signal, Inc. v. Nuclear Reg. Comm'n*, 988 F.2d 146, 152 (D.C. Cir. 1993) (agency must be able to provide the "essential facts upon which the administrative decision was based" and explain what justifies the determination with actual evidence beyond a "conclusory statement").

[4] "While SEZs may only make up 5% of the land area in the Basin, they provide key habitat for 84% of the 250 wildlife species in the Basin and can help to reduce sediment and nutrient runoff concentrations by 70-90%. In addition to these enormous resource benefits, SEZs can also provide dispersed recreation opportunities, scenic open space, flood flow capacity, and buffers within urban areas." Cal. Tahoe Conservancy, "Watersheds & Stream Environment Zones," *available at* https://tahoe.ca.gov/programs/water-quality-watersheds/watersheds-stream-environment-zones/.

[5] EXHIBIT A(b). Fig. TRPA Land Verification of SEZ. *See also*, Stateline, NV. Tahoe Regional Planning Agency. Record ID 20050471STD, Application Information Table, https://aaweb.trpa.org/CitizenAccess/Cap/CapDetail.aspx?Module=Building&TabName=Building&capID1=05HIS&capID2=00000&capID3=07162.

The Antenna will initially be 34.1 meters tall, with statutorily and regulatory[6] authorized allowance for extension to 40.2 meters. The Applicant[7] misrepresented to the City of South Lake Tahoe permitting officials the visual impact that the proposed Antenna would have on the neighborhood in its photo simulations. The tallest trees are all located substantially downhill from the Antenna,[8] giving them a relative height that is substantially below the purported maximum height of 25 meters.[9] [10] The Applicant led the city to believe the Antenna will only extend 9.1 meters above the tree line, but because of understated tree heights[11] and the steep slope, it will effectively project above the tree line by nearly 15.2 meters, before the inevitable co-location extension to a functional 21.3-meter height differential.[12]

The Antenna would be visible from the Tahoe Regional Planning Agency (TRPA)-designated[13] Heavenly Ski Area "Recreational Scenic Zone" and U.S. Highway 50 "Scenic Corridor"[14]; geospatial analysis indicates it would be visible from Pioneer Trail "Scenic Corridor" as well.[15] The Antenna would impermissibly extend above the forest canopy[16] on a ridgeline. It would be viewable from a major arterial roadway from a greater-than-90-meter distance, a functional scenic turnout, and the waters of Lake Tahoe.[17]

A major aspen grove,[18] which would serve as screening vegetation between Pioneer Trail and the proposed Antenna loses its foliage in the fall, further increasing visibility from this designated scenic corridor. Quaking aspen (*Populus tremuloides*) groves are typically single living organisms having one massive underground root system,[19] making them particularly vulnerable to deleterious environmental encroachments. Because the trees are all clones stemming from a shared root system, poisoning or injury to individual trees can eventually kill the entire grove. The aspen grove is also under stress from invasive attack by the non-native satin moth (*Leucoma salicis*) and therefore may not continue to effectively serve as a visual barrier in the future, particularly if subject to increase strain from Antenna site operations.[20]

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[6] *See* 47 U.S.C. § 1455(a); 47 C.F.R. § 1.6100(b)(7)(i).
[7] For the purpose of this report, Verizon is being referred to as the Applicant.
[8] EXHIBIT (A)(a) Fig. "*Visual Impact of Proposed 112-Foot Tall Ski Run Cell Tower with 20-Foot Co-location*"; EXHIBIT (A)(h)(iii) Fig. *"Tree Heights and Topography stated by AT&T."*
[9] *See* Verizon Wireless Response to Appeal, *infra* note 112.
[10] EXHIBIT (A)(a), *supra* note 5.
[11] *Id.* (plotting TRPA LiDAR tree heights), *see also* 2013 AT&T measured tree heights *available at* EXHIBIT (A)(h)(iii).
[12] *Id., supra* note 5.
[13] Stateline, NV. Tahoe Regional Planning Agency. Record ID ERS P2019-0389, PDF page 74, https://parcels.laketahoeinfo.org/Parcel/Detail/025-580-007.
[14] EXHIBIT (A)(a) Fig. "*Visual Impact on Scenic Parkway*." *See also supra* note 5.
[15] *Id.* at Fig. "*Ski Run Tower Viewshed.*"
[16] *See* Tahoe Regional Planning Agency, Code of Ordinances—Ch. 37.7.7 (Amended 2019)(given there are feasible alternative sites and system designs that are less visually intrusive).
[17] *Supra* note 12.
[18] *See generally* EXHIBIT (A)(b) Fig. "*Bijou Park Creek Wetlands*"; EXHIBIT (A)(a) Fig. *"Visual impact on Scenic Parkway."*
[19] *Infra* note 151 at 63.
[20] *See Non-native satin moths impacting aspen foliage in Lake Tahoe*, Nevada Department of Conservation, (July 3, 2018), http://dcnr.nv.gov/uploads/press_releases/Satin_Moths_PR.pdf.

Moreover, multiple peer-reviewed research studies have shown that cell tower RF radiation adversely affects aspen trees,[21] as well as other plants,[22] by directly causing defoliation as well as by increasing the surrounding risk to a visually scarring wildfire.[23] The mottling of foliage spoils the natural scenic value of the area, which also harms the social and economic health of the region which in turn is dependent on these uniquely spectacular values.[24]

The record shows that, Verizon's evidence to the contrary, the tower would become increasingly visible as one moved farther away from the site or if one viewed the tower from the local roads. There was evidence that Verizon took photographs from carefully selected angles that would minimize the tower's apparent visibility in the neighborhood and that, in reality, the tower would be in plain sight from neighborhood homes.[25] There is evidence that some of Verizon's photo-simulations misplace the location of the Antenna by over 2,000 feet and are "clearly erroneous."[26]

The Antenna Poses Significant Risk to Water Quality and Nearby Wetlands

The proposed Antenna will require construction and installation of a diesel tank[27] for an emergency generator within 61 meters[28] of a stream that directly drains into Lake Tahoe. As diesel fuel is both completely immiscible and extremely buoyant, a leak would certainly be washed as a thin film along with melting snow into the stream or seep into the water table. Diesel could cause catastrophic and irreversible damage to the lake, its scenic shoreline, and the intermediate wetlands and riparian areas that are habitat for aquatic life, waterfowl, and fragile alpine plants. It could also contaminate a drinking water well on the lessor's property that is within 30 meters from the site.[29] A diesel spill would cause direct poisoning of wildlife and plants. A spill or leak could occur from a fueling accident, corrosion or cracking of the tank through earthquakes, land subsidence, frost heaving, extreme thermal stress,[30] or by blunt impact from the falling of any of the many surrounding pine trees during a violent winter storm.

Additionally, rainwater flushing down the Antenna will wash UV-degraded[31] microplastics,[32] particles of synthetic fiber, dyes, leached chemicals, detergents, and manufacturing residues from the artificial tree needles, intermixed with machine oils, hydraulic fluid, and printed circuit-board treatments from the Antenna mounts. This will introduce both

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[21] Katie Haggerty, *Adverse Influence of Radio Frequency Background on Trembling Aspen Seedlings*. International Journal of Forestry Research, Article ID 836278 (2010), https://doi.org/10.1155/2010/836278
[22] *See* EXHIBIT (A)(j).
[23] *Cf.,* Maria-Loredana Soran, *et.al., Influence of microwave frequency electromagnetic radiation on terpene emission and content in aromatic plants*, 171:15 Journal of Plant Physiology, 1436-1443 (2014), http://dx.doi.org/10.1016/j.jplph.2014.06.013.
[24] *See* PUBLIC LAW 96-551 Art I(a)(1),(3),&(6).
[25] *See AT & T Wireless PCS, Inc. v. Winston-Salem Zoning Bd. of Adjustment*, 172 F.3d 307, 315-316 (1999).
[26] *See* EXHIBIT (A)(a), Fig. Verizon's Clearly Erroneous Visual Simulation.
[27] *See* EXHIBIT (A)(h)(i)(1)-(2) Fig. "*Industrial Diesel Generator Species*"; Fig. *"Diesel Generator Outdoor Installation."*
[28] *See* EXHIBIT (A)(h)(ii), Fig. "*Well Site.*"
[29] *Id.*
[30] Temperature fluctuations regularly cycle from 80-degree days to 10°F nights, a ~70°F trans-freezing difference.
[31] Ultraviolet Light is abbreviated as "UV."
[32] *Plastics*, Tahoe Environmental Center, University of California, Davis, https://tahoe.ucdavis.edu/plastics.

microplastics,[33] and soapy, oily, toxic residues into Bijou Park Creek and thus Lake Tahoe. Microplastics have been identified as an emerging threat to the lake,[34] often entering it from urban runoff.[35] UV-degraded microplastic fallout from faux needles has already been documented as being profusely shed from the Angel's Roost "monopine" cell tower.[36] As the Angel's Roost antenna is nearly identical in design to the proposed Ski Run Antenna, and its debris field radius exceeds the Antenna's distance to the stream environment zone, hereinafter "SEZ," it is inevitable microplastics would be introduced directly into Bijou Park Creek. [37]

The scientific literature is in strong agreement that microplastics leach toxins into water, which get ingested by aquatic life, and subsequently enter the food chain resulting in human absorption and bio-accumulation.[38] [39] [40] [41] Medical literature on the uptake of micro- and nanoplastics by humans shows diverse effects varying from DNA damage, changes in gene and protein expression, cell clotting, necrosis, apoptosis, proliferation and loss of cell viability, oxidative stress, increased Ca ions, inflammation and bone osteolysis, to lesions in organs.[42]

Furthermore, TRPA land coverage limits[43] for the parcel will require the applicant to demolish two sheds, an asphalt apron, and a sidewalk totaling 68.5 square meters of surface area, including removal of underground plumbing and wiring.[44] Approximately 18.6 square meters of this disturbance will be occurring within the SEZ, or SEZ buffer, which is another opportunity for significant environmental impact.[45] Excavation will cause loose soil which will likely wash into the stream causing toxic turbidity,[46] which harms aquatic life.[47] Turbidity reduces photosynthesis, and suspended materials can clog fish gills, reducing resistance to disease in fish,

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[33] *Id.*
[34] *See Microplastics Research*, Desert Research Institute, https://www.dri.edu/microplastics-research (assessing microplastics pollution in Lake Tahoe).
[35] *See* Louis Sahagan, *Microplastics are found in Lake Tahoe's waters*, LOS ANGELES TIMES, Aug. 26, 2019, https://www.latimes.com/environment/story/2019-08-26/lake-tahoe-microplastic-pollution-detected.
[36] See EXHIBIT A(a) Fig. "*Angel's Roost Macro Tower & Lakeview Heights Small Cell.*"
[37] *See id*. The "Angel's Roost" Monopine's defoliation radius of faux microplastics needle fallout is in excess of 700 feet (213 meters) whereas the proposed Ski Run Monopine is less than half this distance to the SEZ.
[38] Fen Wang, *et. al.*, "*Interaction of toxic chemicals with microplastics: A critical review*," 139 Water Research, 208-219, (2018), https://doi.org/10.1016/j.watres.2018.04.003.
[39] Jingyi Li, *et. al.*, "*Microplastics in freshwater systems: A review on occurrence, environmental effects, and methods for microplastics detection*," 137 Water Research, 362-374, (2018), https://doi.org/10.1016/j.watres.2017.12.056.
[40] Pauline Pannetier, *et. al.*, "*Environmental samples of microplastics induce significant toxic effects in fish larvae*," 134 Environment International, 105047, (2020), https://doi.org/10.1016/j.envint.2019.105047.
[41] Rios Mendoza Lorena M., Jones Patrick R. "Characterisation of microplastics and toxic chemicals extracted from microplastic samples from the North Pacific Gyre." 12 Environmental Chemistry, 611-617, (2015), https://doi.org/10.1071/EN14236.
[42] Gallo, F., Fossi, C., Weber, R. et al. *"Marine litter plastics and microplastics and their toxic chemicals components: the need for urgent preventive measures*." 30:13 Environ Sci Eur., 1, 7-8 (2018), https://doi.org/10.1186/s12302-018-0139-z.
[43] *Infra* note 87.
[44] *See* EXHIBIT A(h)(iv) Fig. *"Demolition in Stream Environmental Zone (SEZ)."*
[45] *Id*.
[46] Water Monitoring & Assessment: Turbidity, Environmental Protection Agency, https://archive.epa.gov/water/archive/web/html/vms55.html.
[47] *Id*.

lowering growth rates, and affecting egg and larval development.[48] As the particles settle, they can blanket the stream bottom, especially in slower waters downstream, and smother fish eggs and benthic macroinvertebrates.[49] This toxic turbidity would then flow on into Lake Tahoe[50] where it would degrade its iconic clarity, in violation of TRPA's own environmental threshold standards,[51] as well as the community's cultural mandate requiring that it be "kept blue."[52]

The Bijou Park Creek watershed is currently in the process of being restored[53] and construction will make it difficult to address the environmental improvement program's fine sediment particle and pollutant loading threshold requirement.[54] There are some structural issues that will not be corrected by this restoration which further make EA necessary. The upper portion of the Keller Canyon watershed has been diverted into the Bijou Park Creek watershed.[55] As a result, the Bijou Park Creek SEZ[56] receives runoff from approximately 260 acres over and above the flows it would normally experience.[57] At Pioneer Trail immediately downstream of the Antenna, the Keller Canyon diversion represents a 73 percent increase in the drainage area over what occurred naturally.[58] Any diversion of this magnitude has undoubtedly increased peak snowmelt runoff flows in the Bijou Park Creek drainage, which, in turn, decreases the pollutant removal efficiencies of the main channel SEZ.[59] The Hansen's parcel itself has exceeded its impervious coverage capacity limits,[60] meaning the land cannot adequately absorb the precipitation on which it lands.[61]

Moreover, the aforementioned adverse impact to the health of aspen trees[62] and other riparian plants,[63] causes a degradation in water quality, because such foliage functions to slow and filter runoff reducing its turbidity which directly effects lake clarity. The degradation in the quality of vegetation also has a direct impact on wildlife. Without any assessment of these

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[48] *Id*.
[49] *Id*.
[50] *See* Toby Hanes *et al*., E. Pioneer Trail Watershed Hydrology Study, Lumos and Associates, Inc., p. 112, https://www.cityofslt.us/DocumentCenter/View/9835/2005-E-Pioneer-Trail-Watershed-Hydrology-Study.
[51] *See* Tahoe Regional Planning Agency, "*Threshold Standards and Regional Plan,*" pp. 6-5, 13 (2015) (WQ22—Achieve a 90 percentile concentration value for suspended sediment of 250 mg/1 in surface runoff directly discharged to a surface water body in the Basin; *see also,* F1-F4 (a non-degradation standard shall apply stream fisheries)).
[52] *See generally Keep Tahoe Blue*, The League to Save Lake Tahoe, https://www.keeptahoeblue.org/ (referring to the nationally famous "Keep Tahoe Blue" campaign).
[53] *Bijou Park Creek Watershed Restoration Project*, City of South Lake Tahoe, https://www.cityofslt.us/901/Bijou-Park-Creek.
[54] *See* Tahoe Regional Planning Agency, Code of Ordinances—Ch. 4.4.1 (Amended 2019), https://www.trpa.org/wp-content/uploads/TRPA-Code-of-Ordinances.pdf.
[55] *Supra* note 31, page 112, (quoting).
[56] *Upper Bijou Park Creek Watershed and SEZ Restoration Project*, TRPA Project No. 01.01.01.0118, Lake Tahoe Info platform, Tahoe Regional Planning Agency, https://laketahoeinfo.org/Project/Detail/4122.
[57] *Id*.
[58] *Id*.
[59] *Id*.
[60] *Supra* note 5.
[61] Robert. G. Bailey, "*Land Capability Classification of the Lake Tahoe Basin, California-Nevada*," (1974).
[62] *Supra* note 21.
[63] *Supra* note 22.

impacts,[64] the Tahoe Regional Planning Agency has no way of even reasoning or "finding" whether or not the proposed Antenna is in compliance with its required threshold carrying capacities.[65]

The City of South Lake Tahoe has already failed to exercise its environmental review authority and inappropriately exempted[66] the Antenna from California Environmental Quality Act (CEQA) review.[67] The City erroneously granted an exemption for "small structures," which to date has only been approved in the published legal opinions for use in much smaller projects, such as an 11-meter tower screened within a stand of similar height trees.[68] Likewise the Federal Communications Commission, hereinafter "FCC," has, to date, also failed to intervene under NEPA.[69] It therefore falls especially[70] on TRPA to ensure that an environmental analysis is conducted.[71] [72]

None of Verizon's objections or sponsored studies have addressed the valid concerns raised in this report regarding water quality impacts that may occur due to degradation of the plastic components of the Antenna camouflage, which could be washed into the nearby watershed with attendant impacts to Lake Tahoe and local species. Nor has Verizon addressed the associated impacts on and from blighted vegetation.

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[64] *See*, *United States v. Dierckman*, 201 F.3d 915, 926 (7th Cir. 2000) (quoting *Bagdonas v. Dep't of the Treasury*, 93 F.3d 422, 426 (7th Cir. 1996)); *Allied-Signal, Inc. v. Nuclear Reg. Comm'n*, 988 F.2d 146, 152 (D.C. Cir. 1993) (agency must be able to provide the "essential facts upon which the administrative decision was based" and explain what justifies the determination with actual evidence beyond a "conclusory statement"). *See generally*, *Motor Vehicle Manufacturers Association v. State Farm Auto Mutual Insurance Co.*, 463 U.S. 29, 42-44 (1983) (holding an agency decision is arbitrary and capricious if the agency has […] entirely failed to consider an important aspect of the problem, offered an explanation for its decision that runs counter to the evidence before the agency, or is so implausible that it could not be ascribed to a difference in view or the product of agency expertise).

[65] *See* PUBLIC LAW 96-551 Art. V(c). *See also*, Tahoe Regional Planning Agency, "*Threshold Standards and Regional Plan*," pp. 1- 26 (2015); TRPA Code of Ordinances 4.4.1.B.

[66] *See Staff Report Monopine Appeal*, City of South Lake Tahoe City Council Meeting, Jan. 14, 2020, Page 6, https://legistarweb-production.s3.amazonaws.com/uploads/attachment/pdf/506027/01-Staff_Report_Monopine_Appeal__January2020.pdf#page=6.

[67] *See* EXHIBIT (A)(i)(ii), "*CEQA Exemption.*"

[68] *See Don't Cell Our Parks v. City of San Diego*, 21 Cal. App. 5th 338 (2018).

[69] *See* 42 U.S.C. §§ 4331-4332; 47 C.F.R. § 1.1307.

[70] *See* 42 U.S.C. § 4332; PL 96-551, Arts. V(b)(i), VII(b), & X Sec 2; 40 C.F.R. § 1506.2. *Cf.*, 5 U.S.C. § 551(a); 42 U.S.C. § 4333.

[71] *Environmental Health Trust v. Federal Communications Commission*, 9 F.4th 893, 909 (2021) (While imitation may be the highest form of flattery, it does not meet even the low threshold of reasoned analysis required by the Administrative Procedure Act (APA) under the deferential arbitrary and capricious standard of review; thus, one agency's unexplained adoption of an unreasoned analysis just compounds rather than vitiates the analytical void, in other words, two wrongs do not make a right).

[72] *See* 47 C.F.R. § 1.1307(d) (FCC can order an EA on its own motion which would not be subject to any time limitation); *United Keetoowah Band of Cherokee Indians in Okla. v. FCC*, 933 F.3d 728, 735, 748 (D.C.Cir. 2019) (holding FCC has an ongoing obligation to comply with NEPA regardless of the date on which Verizon filed its national notice; request "the federal agency to reenter the consultation process at any time ... since the federal agency remains responsible for government-to-government consultation"). *See also*, 47 CFR §§ 1.1308, 1.1311, & 1.41-1.44 (FCC may inform applicant as to reduce, minimize, or eliminate environmental problems; regarding EA where another agency has assumed responsibility for determining whether of the facilities in question will have a significant effect on the quality of the human environment; and pleadings for FCC action).

Construction of the Antenna May Cause Significant Change in Surface Features

In addition to the aforementioned wetlands fill and water diversion[73] associated with coverage demolition within and adjacent to the SEZ, the applicant has proposed to remove a underground gas pipeline on the site[74] and deforest[75] the scenic parcel of thirteen[76] pine trees[77] in potential violation of an existing deed restriction.[78] The foundation will require pouring concrete directly adjacent to the trunks of pine trees[79] which is commonly known to eventually kill them.

Demolition of structures, removal of sidewalks, trenching, and relocation of an underground gas line falls squarely within the definition of a "significant change in surface features"[80] regardless of proximity to watersheds. Verizon concurs that such activity will occur. Moreover, some of this activity is occurring within the SEZ as defined by TRPA. That Verizon asserts that a wetland is depicted "approximately 200 feet to the north of the proposed Project Site" on a US FWS National Wetlands Inventory does not determine that the activity will not be occurring in a wetlands or SEZ. First, the TRPA data is more granular. Second, much of the activity will be occurring outside of the "project site," partly in order to reduce ground coverage as required by TRPA. Therefore, Verizon's contention does not address whether it will occur within a wetland as broadly considered. Verizon also argues that impacts will be addressed by various construction protocols, but if PUBLIC LAW 96-551 Arts. V(g) [81] & VII,[82] or TRPA Ordinance § 4.4.2.C,[83] or even 47 CFR. § 1.307(a)(7) are triggered, the law does not permit

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[73] *See,* Fish and Wildlife Coordination Act (16 U.S.C. § § 661-667e) (whenever the waters of any stream or other body of water are proposed or authorized to be impounded, diverted, the channel deepened, or the stream or other body of water otherwise controlled or modified for any purpose whatever, including navigation and drainage, by any department or agency of the United States, or by any public or private agency under Federal permit or license, such department or agency first shall consult with the United States Fish and Wildlife Service, Department of the Interior, and with the head of the agency exercising administration over the wildlife resources of the particular State wherein the impoundment, diversion, or other control facility is to be constructed, with a view to the conservation of wildlife resources by preventing loss of and damage to such resources as well as providing for the development and improvement thereof in connection with such water-resource development).

[74] *See* EXHIBIT (A)(h)(iv), *supra* note 25.

[75] *See* 47 C.F.R. § § 1.1307(a)(7) (referring to significant change in surface features e.g., wetland fill & deforestation).

[76] *See* EXHIBIT (A)(h)(iv), *supra* note 25.

[77] File ERSP2019-0389, *supra* note 10 (evidencing applicant's apparent misstatement on tree-cutting to TRPA).

[78] *See* EXHIBIT (A)(i)(iii), *"Deed Restriction: No Trees Shall Be Cut."*

[79] *See* EXHIBIT (A)(h)(ii), *supra* note 18, *see also* associated site plans, *supra* note 10.

[80] *C.f.,* 47 C.F.R. § 1.307(a)(7).

[81] PUBLIC LAW 96-551 Art. V(g) "The agency shall adopt ordinances prescribing specific written findings that the agency must make prior to approving any project in the region. These findings shall relate to environmental protection and shall insure that the project under review will not adversely affect implementation of the regional plan and will not cause the adopted environmental threshold carrying capacities of the region to be exceeded."

[82] PUBLIC LAW 96-551 Art. VII(a) "The Tahoe Regional Planning Agency when acting upon matters that have a significant effect on the environment shall: (1) Utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision making which may have an impact on man's environment; (2) Prepare and consider a detailed environmental impact statement before deciding to approve or carry out any project […];"

[83] TRPA Code of Ordinances § 4.4.2.C "[As part of the findings necessary to approve any project, TRPA shall:] Confirm that any resource capacity utilized by the project is within the amount of the remaining capacity available, as that remaining capacity has been identified in any environmental documentation applicable to the project, including the environmental impact statement for the Regional Plan package;"

Verizon to take advantage of categorical exemption, regardless of the mitigation measures that Verizon may take. The EBI Report is not adequate to demonstrate that no "significant change in surface features" will occur. Consequently, an EA is required under the circumstances.

The Antenna Exceeds Remaining Land Capacity as has been Identified in Environmental Documentation Applicable to the Project

To approve any project, TRPA shall find and confirm in accordance with PUBLIC LAW 96-551 Art. V(g) and with TRPA Code of Ordinances § 4.4.2.C that any resource capacity utilized by the project is within the amount of the remaining capacity available, as that remaining capacity has been identified in any environmental documentation applicable to the project. Land capacity is explicitly promulgated in the TRPA Threshold Standards and Code of Ordinances—which in the case of 1a and 1b land classification is one percent of impervious cover.[84] The proposed Antenna exceeds[85] [86] the land coverage base as established by environmental documentation applicable to the project,[87] and therefore shall not be approved. Approval is not governed by whether additional coverage capacity will or might be augmented sometime after project approval, what ultimately matters is that "any resource capacity utilized by the project" shall be "within the amount of the remaining capacity available, as that remaining capacity has been identified in any environmental documentation applicable to the project." Whereas the applicant has not actually mitigated[88] excess land coverage, application it is therefore at best speculative or incomplete, and at worse is in egregious violation of § 4.4.2.C.

The Antenna has Caused Tremendous Controversy

The proposed Antenna has caused enormous controversy in the City of South Lake Tahoe; hundreds of residents have been calling or mailing the city manager, council members, TRPA officers, and the TRPA Governing Board members about the Antenna since August 2019.[89] The pressure was so intense that the city held a town hall meeting that filled the city recreation facility, with nearly one-hundred signed attendants.[90] It also caused the city to create a new webpage specifically dedicated to quelling the surrounding controversy.[91] One local newspaper published a full front page headline article[92] and two editorial columns;[93] another

[84] Tahoe Regional Planning Agency, "*Threshold Standards and Regional Plan*," pp. 18, 2-6 (2019) ((SC1) Allowable percent of impervious cover in Land Capability subclass 1a - 1%; (SC2) Allowable percent of impervious cover in Land Capability subclass 1b - 1%.).
[85] *See* TRPA File # VBOC2021-0164, "Site Plan," Gregory J Cook, (Oct. 4 2020), https://parcels.laketahoeinfo.org/AccelaCAPRecord/Detail/VBOC2021-0164
[86] *See* Oct 14 2021 TRPA Hearings Officer Meeting, *Initial Environmental Checklist – ERSP2019-0389 (Agenda Item V. D.)*, p2, https://www.trpa.gov/wp-content/uploads/025-580-007-ERSP2019-0389-IEC-REVISED.pdf
[87] *See* TRPA File # 20050471STD, Land Capability Verification, Heather Gustafson/Beckman, (May 5, 2005), https://parcels.laketahoeinfo.org/AccelaCAPRecord/Detail/20050471STD
[88] *See* TRPA Code of Ordinances § 30.6.
[89] *See* 47 C.F.R. § 1.1311(a)(3).
[90] *November 20, 2019 Public Workshop*, Development Services, City of South Lake Tahoe, https://www.cityofslt.us/1061/Public-Workshop-on-Wireless-Facilites.
[91] *Wireless Communications Facility Updates*, Development Services, City of South Lake Tahoe, https://www.cityofslt.us/1060/Wireless-Communications-Facility-Updates.
[92] EXHIBIT (B)(b)(i), *Tower or Terror?*, TAHOE DAILY TRIBUNE, Nov. 23, 2019.
[93] EXHIBIT (B)(b)(ii).

local paper published two other columns on the Antenna.[94] Petitions circulated the city opposing the Antenna with over 4,300 signatures gathered.[95] There are over two-hundred written public comments on city record.[96] While much of the controversy pertains to human health-related radiofrequency (RF) concerns, there is substantial community objection to scenic and environmental impact of the physical structure and harm to wildlife from RF radiation. Twenty-five local residents wrote letters submitted to the city describing in painstaking detail how the specific Antenna would harm the aesthetics and values of their homes.[97] Seven real-estate brokers also confirmed this with expert testimony to the South Lake Tahoe City Council.[98] At a permit appeal hearing for the Antenna, public comment lamented for well over an hour mostly in opposition to the Antenna.[99] In the time since, intense opposition has been publicly expressed at subsequent city meetings, which continues to the present.[100] Likewise, the TRPA record has over 37 pages of public comment opposing the proposed antenna.[101] Both the City and TRPA records have scant public support. Controversy not only dictates enhanced due process precautions,[102] but environmental ones as well.[103]

The Antenna Will Have Significant Noise and Odor Impacts

The Antenna's loud diesel generator runs at 65dB,[104] and produces noxious odors which also disturb wildlife. The maximum community noise equivalent level for the Lakeview Heights Plan Area[105] is 55 CNEL.[106] The generator is therefore 10 times louder than the acceptable

[94] December, February, and March issues, TAHOE MOUNTAIN NEWS, https://mountainnews.net, *available at* EXHIBIT (B)(b)(iv)-(v).
[95] EXHIBIT (B)(a)(i)-(ii): Change.org petition (https://www.change.org/p/city-of-south-lake-tahoe-no-cell-towers-next-to-our-homes-and-schools), and hand petitions.
[96] *See* list of 203 public comments, *Appeal - Planning Commission Approval of File # 19-026*, City of South Lake Tahoe, https://legistarweb-production.s3.amazonaws.com/uploads/attachment/pdf/506092/Public_Comment_ListREV.pdf.
[97] Campanelli Brief, EXHIBIT (B)(c)(i).
[98] *Id.*, *see also* appeal hearing oral testimony by Mark Salmon, City of South Lake Tahoe City Council Meeting, Jan. 14 2020, https://slt.granicus.com/MediaPlayer.php?view_id=6&clip_id=1054&meta_id=112963.
[99] Laney Griffo, "*City council denies appeal*" TAHOE DAILY TRIBUNE, Jan. 14, 2020, *available at* EXHIBIT (B)(b)(iv).
[100] EXHIBIT B(b)(vi).
[101] EXHIBIT B(d)(ii).
[102] Henry J. Friendly, *Some Kind of Hearing*, 123 U. PA. L. Rev. 1267, 1278 (1975) ("The required degree of procedural safeguards varies directly with the importance of the private interest affected"); Todd Garvey. *A Brief Overview of Rulemaking and Judicial Review*, Congressional Research Service, p.2 (2017) ("the APA suggests that '[matters] of great importance, or those where the public submission of facts will be either useful to the agency or a protection to the public, should naturally be accorded more elaborate public procedures'"). *See also*, Administrative Procedure Act: Legislative History, S. Doc. No. 248, at 259 (1946); CHARLES H. KOCH JR., 1 ADMINISTRATIVE LAW AND PRACTICE 329-30 (2010 ed.).
[103] 47 C.F.R. § 1.1311(a)(3) (The EA shall contain a statement as to whether construction of the facilities has been a source of controversy on environmental grounds in the local community).
[104] EXHIBIT A(h)(i), *supra* note 17.
[105] *Cf.,* 47 C.F.R. § § 1.1311(a)(2) (pertaining to determinations made by zoning authorities on matters related to environmental effects).
[106] EXHIBIT (C)(c)(ii), TRPA Plan Area Statements 085, Lakeview Heights, Page 3., http://www.cityofslt.us/DocumentCenter/View/61/Plan-Area-Statement-085.

community limits.[107] The ecosystem is significantly strained by human presence and climate change and cannot afford these additional stressors, which must be evaluated.[108]

RF Emissions from the Antenna Will Significantly Impact the Human Environment

The design and placement of the Antenna has the potential to cause considerable harm to the "human environment"[109]—both from the construction of the Antenna and accessory equipment and the RF radiation from the Antenna. The Commission's RF emissions and exposure limits were designed only with respect to humans, not other life forms, and do not limit exposure to surrounding trees or wildlife. Therefore, the Commission, the TRPA, [110] and its cooperating agencies,[111] must look[112] to other metrics to evaluate potential significant environmental[113] effects[114] from RF.[115]

The most prestigious scientific journal *NATURE* published several articles on the effects of RF radiation on migratory birds,[116] butterflies,[117] bees,[118] other insects,[119] and mice,[120] which make it unequivocal that RF radiation has the potential to harm, harass, or stress wildlife populations. *NATURE* also recently published two new studies confirming RF radiation causes oxidative stress leading to DNA damage.[121] According to the Department of Interior's Office of Environmental Policy and Compliance, Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act "There is a growing level of anecdotal evidence linking effects of non-

[107] 65dB-55dB=10dB. A 10 dB difference is 10 times as loud by definition of a decibel.
[108] *Cf.,* Noise Pollution and Abatement Act (42 U.S.C. §§ 4901-4918).
[109] *See* 40 C.F.R. § 1508.14 (requiring Agencies to "interpret[] [NEPA's 'human environment'] comprehensively to include the natural and physical environment and the relationship of people with that environment"). *See also*, PUBLIC LAW 96-551., Art. VII. (a)(1) (decision making which may have an impact on man's environment).
[110] *See* PUBLIC LAW 96-551 Art. VII (b)&(c); see also 16 U.S.C. § 1536; 50 C.F.R. §§ 17.11 & 402.14 (TRPA must consult US FWS on impacts to endangered species, which may include a "biological opinion").
[111] *See* 16 U.S.C. § 1536.
[112] *See Jaeger v. Cellco P'ship* (D.Conn. Mar. 15, 2010, No. 3:09CV567) 2010 U.S.Dist.LEXIS 24394, at *26 (concerns regarding RF effects on "migratory birds, bald eagles and other wildlife" should be directed to FCC in a petition to conduct an EA).
[113] *Cf.*, 42 USC 7412(a)(7) (defining term adverse environmental effects).
[114] *See* 40 CFR § 1508.8 ("Effects and impacts as used in these regulations are synonymous. Effects includes ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative.").
[115] Clearly, the FCC has an obligation under NEPA to consider all potential environmental effects, including effects from RF, and is not restricted by 47 U.S.C. § 332(c)(7), which only applies to the regulatory activity of state or local governments.
[116] Engels, S. *et al., Anthropogenic electromagnetic noise disrupts magnetic compass orientation in a migratory bird*, 509 NATURE 353–356 (2014), https://doi.org/10.1038/nature13290.
[117] Guerra, P., *et al*., *A magnetic compass aids monarch butterfly migration*, 5 NAT COMMUN 4164 (2014), https://doi.org/10.1038/ncomms5164.
[118] Thielens, A. *et al., Radio-Frequency Electromagnetic Field Exposure of Western Honey Bees*, 10 SCI REP 461 (2020), https://doi.org/10.1038/s41598-019-56948-0.
[119] Thielens, A. *et al., Exposure of Insects to Radio-Frequency Electromagnetic Fields from 2 to 120 GHz*, 8 SCI REP 3924 (2018), https://doi.org/10.1038/s41598-018-22271-3.
[120] Houston, B.J., *et al*., *Whole-body exposures to radiofrequency-electromagnetic energy can cause DNA damage in mouse spermatozoa via an oxidative mechanism*, 9 SCI REP 17478 (2019), https://doi.org/10.1038/s41598-019-53983-9.
[121] *Id. See also,* Ioniţă, E., *et al*. *Radiofrequency EMF irradiation effects on pre-B lymphocytes undergoing somatic recombination*. 11 SCI REP 12651 (2021), https://doi.org/10.1038/s41598-021-91790-3.

thermal, non-ionizing electromagnetic radiation from communication towers on nesting and roosting wild birds and other wildlife in the U.S."[122]

Hundreds of scientific publications[123] demonstrate the potential for serious adverse environmental effects to the protected Lake Tahoe ecosystem. The Antenna site is located within a very fragile alpine ecosystem and along a salient migratory bird path; there is far more at stake than just the human populace. While the Antenna may have ground fencing sufficient to protect humans from RF exposure above the Commission's limits, migratory birds[124]—inclusive of northern goshawks, peregrine falcons, osprey, bald and golden eagles—regularly perch in the stand of trees where the Antenna would be installed. This federally protected wildlife[125] would be exposed to radiation levels that the Commission has determined is unsafe for humans.

Peregrine Falcons and Northern Goshawks are federally protected migratory birds,[126] that are further protected within TRPA's designated disturbance free zone.[127] Goshawks appear in the neighborhood. Also nearby are TRPA waterfowl sites (the Lake Christopher, Truckee Marsh,[128] and Edgewood sites are all within a two-mile radius of the tower).[129] [130] Other known bird congregation areas are in the immediate vicinity along Bijou Park Creek, which appears to be in the vicinity of where a main Antenna beam makes first direct contact with land.[131] Additionally, the site does not meet the U.S. Fish and Wildlife Service guidelines for cell towers. The guidelines were established because wireless "towers are some of the tallest structures across the landscape and birds are regularly found dead around these towers.[132] It is not definitively understood why this mortality occurs."[133] The guidelines recommend placing towers in existing "antenna farms," degraded areas and away from "ridgelines, coastal areas, wetlands or other known bird concentration areas." Specifically,

> Towers should not be sited in or near wetlands, other known bird concentration areas (e.g., state or federal refuges, staging areas, rookeries, and Important Bird Areas), or in known migratory bird movement routes,

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[122] W.R. Taylor, Dir., Office of Environ. Policy & Compliance, U.S. Dept. of Interior*, Letter to E. Veenendaal, Nat'l Telecomm. & Infor. Admin.* (Feb. 7, 2014). *See* EXHIBIT (B)(e)(iv)(1).
[123] *See, e.g.,* 3,337 page compilation: *Science on Health & Environmental Effects of Cell Tower Radiation*, Ordinance—Wireless Communication Facilities Outside Rights-of-Way, City of South Lake Tahoe Planning Commission Meeting, Feb. 20 2020, https://www.csltbusiness.com/WebLink/Browse.aspx?id=43514&dbid=0&repo=cityclerk.
[124] *E.g.*, 50 CFR § 10.13, *see also*, EO 13186, & 16 U.S.C. § 700 *et. seq*.
[125] *Id.*
[126] *Id.*
[127] *TRPA 2015 Threshold Evaluation – Wildlife*, Tahoe Regional Planning Agency, Page 8-31, https://www.trpa.org/regional-plan/threshold-evaluation.
[128] *Cf. infra* note 89.
[129] *Id.* at Page 8-26.
[130] *See infra* note 91 (*see* page referring to Waterfowl Habitat *available at* https://www.tahoeopendata.org/datasets/waterfowl-habitat).
[131] *See* EXHIBIT (A)(e) Fig. "*Radiation Pattern Surrounding Proposed Ski Run Macro Tower*."
[132] Longcore, T. *et a*l., *Avian mortality at communication towers in the United States and Canada: which species, how many, and where?*, 158 BIOLOGICAL CONSERVATION 410–419 (2013), http://dx.doi.org/10.1016/j.biocon.2012.09.019
[133] U.S. Fish & Wildlife Service, Migratory Bird Program, *Recommended Best Practices for Communication Tower Design, Siting, Construction, Operation, Maintenance, and Decommissioning* 1 (2018) a*vailable at* https://www.fws.gov/migratorybirds/pdf/management/usfwscommtowerguidance.pdf.

daily movement flyways, areas of breeding concentration, [or] in habitat of threatened or endangered species[.][134]

The monopine Antenna tower mimics predatory bird habitat, and hence invites eagles and hawks to perch, nest, or even hatch their brood within the intense near-field radiation of the 47,090-watt ERP[135] Antennas to their own peril. Research has shown cellular RF emissions are associated with significant avian embryo mortality.[136] [137] [138] [139] The Antenna is within two miles[140] [141] of the Bald Eagle Winter Nesting Habitat,[142] which is protected from harm by federal law.[143] [144] Bald Eagles are commonly sighted soaring over the site parcel. This Antenna, in this sensitive location raises unique environmental concerns that, under the NEPA framework, obligate the TRPA and the FCC, respectively, to order a more detailed analysis of potential environmental effects.

Verizon may attempt to claim that "EBI evaluated potential effects to migratory birds and found none." However, neither the TRPA's staff report nor the EBI report actually discuss specific birds or potential risks, and EBI only maintains that the antenna will "meet[] most of the USFWS's tower siting and design recommendations" without consideration of the actual impacts from the project—including cutting down of trees that may be an eagle or other protected bird habitat.[145]

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[134] *Id.* at 2.
[135] *See* EXHIBIT (A)(h)(vi)(1), Evaluation of 1360 Ski Run Blvd small cell, Hammett & Edison, Inc.
[136] Batellier, F. *et al*., *Effects of exposing chicken eggs to a cell phone in "call" position over the entire incubation period*. 69(6) Theriogenology 737-745 (Apr 1, 2008), https://doi.org/10.1016/j.theriogenology.2007.12.006
[137] Ingole IV, Ghosh SK. *Effect of exposure to radio frequency radiation emitted by cell phone on the developing dorsal root ganglion of chick embryo: a light microscopic study*. 14(4) N. Med Coll J. 337-341 (2012).
[138] Zareen, Nusrat et al., *Derangement of chick embryo retinal differentiation caused by radiofrequency electromagnetic fields*. 49,1 Congenital anomalies 15-9 (2009), https://doi.org/10.1111/j.1741-4520.2008.00214.x.
[139] D'Silva, Mary Hydrina et al. *Effect of Radiofrequency Radiation Emitted from 2G and 3G Cell Phone on Developing Liver of Chick Embryo - A Comparative Study*. 11(7) Journal of Clinical and Diagnostic Research, AC05–AC09 (2017), https://doi.org/10.7860/JCDR/2017/26360.10275.
[140] *See* EHXIBIT (A)(b) Fig. "*Truckee Marsh Bald Eagle Winter Habitat.*"
[141] *Infra* note 125.
[142] *See Bald Eagle Winter Habitat*, Tahoe Open Data, Tahoe Regional Planning Agency, Stateline, NV., https://www.tahoeopendata.org/datasets/bald-eagle-winter-habitat.
[143] 16 U.S.C. § 668 *et. seq.*
[144] *See also,* 47 C.F.R. § § 1.1307(a)(3), 1.1311(a)(6) (pertaining to facilities that may affect such species, and mandating use of the best scientific data for EA)
[145] *See*, *United States v. Dierckman*, 201 F.3d 915, 926 (7th Cir. 2000) (quoting *Bagdonas v. Dep't of the Treasury*, 93 F.3d 422, 426 (7th Cir. 1996)); *Allied-Signal, Inc. v. Nuclear Reg. Comm'n*, 988 F.2d 146, 152 (D.C. Cir. 1993) (agency must be able to provide the "essential facts upon which the administrative decision was based" and explain what justifies the determination with actual evidence beyond a "conclusory statement"). *See generally*, *Motor Vehicle Manufacturers Association v. State Farm Auto Mutual Insurance Co.*, 463 U.S. 29, 42-44 (1983) (holding an agency decision is arbitrary and capricious if the agency has […] entirely failed to consider an important aspect of the problem, offered an explanation for its decision that runs counter to the evidence before the agency, or is so implausible that it could not be ascribed to a difference in view or the product of agency expertise). An agency decision that is the product of "illogical" or inconsistent reasoning; that fails to consider an important factor relevant to its action, such as the policy effects of its decision or vital aspects of the problem in the issue before it, will similarly fail the arbitrary and capricious test (Todd Garvey. *A Brief Overview of Rulemaking and Judicial Review*, Congressional Research Service, 15 n.136-137 (2017)). *See also*, *Am. Fed'n of Gov't Emps., Local 2924 v. Fed.*

The Antenna will significantly impact migratory birds, including bald and golden eagles, which have been sighted in the trees on the proposed site.[146] Birds can roost in the trees adjacent to the Antenna and on the Antenna itself where Verizon's RF modeling shows the RF emissions will exceed the occupational limits. It is entirely consistent with the FCC's RF human exposure regulations to recognize that exposing birds, including eggs[147] and chicks, to RF levels that the FCC recognizes as unsafe even for trained workers would have determinantal environmental effects.[148]

Moreover, habitats suitable for the endangered Sierra Nevada Yellow-legged Frog (*Rana sierrae*) exist in the immediate downstream vicinity of the proposed Antenna site.[149] The wetland conditions in the TRPA-designated Stream Environmental Zone on the Hansen's Resort site are similar to TRPA-designated suitable habitat locations for this species. A map showing the site in relation to TRPA-suitable critical species habitats is included in the Exhibits.[150] A TRPA/City funded NEPA/CEQA pursuant study found "moderate potential" for the endangered frog in Bijou Park Creek.[151] As discussed, construction may directly damage the wetlands on the site and other downstream habitats, and the RF radiation harms trees and other vegetation.

Scientific research demonstrates significant frog egg and tadpole mortality when subject to non-ionizing RF radiation.[152] Amphibian sensitivity to magnetic fields has been documented for over 50 years (*see, e.g.,* W.C. Levengood, *A New Teratogenic Agent Applied to Amphibian Embryos*, J. Embryology & Exper. Morphology 23 (Feb. 1969)). Most relevant to the proposed Antenna, in a 2010 study by Balmori,[153] tadpoles exposed to two months of RF radiation from a cell tower 459 feet away developed "low coordination of movements, an asynchronous growth, in both big and small tadpoles, and a high mortality (90%)." In comparison, for tadpoles kept inside a RF-blocking faraday cage at the same location during the same period, the "coordination of movements was normal, the development was synchronous, and a mortality of 4.2% was obtained." This study and a literature review on the possible effects of RF on amphibians are included in the Exhibits.[154]

Given existing evidence demonstrating frog sensitivity to RF exposure and the proposed Antenna's close proximity to appropriate Sierra Nevada Yellow-legged Frog habitats, an EA

Labor Relations Auth., 470 F.3d 375, 380 (D.C. Cir. 2006); *Ctr. for Biological Diversity v. U.S. Bureau of Land Mgmt.*, 698 F.3d 1101, 1124 (9th Cir. 2012).

[146] *See* Report at 9 (listing observation of "northern goshawks, peregrine falcons, osprey, bald and golden eagle").

[147] *Supra* notes 136-139.

[148] *Infra* note 157.

[149] *See* Sierra Nevada Yellow-legged Frog Suitable Habitat, Tahoe Open Data, Tahoe Regional Planning Agency, Stateline, NV., https://www.tahoeopendata.org/datasets/sierra-nevada-yellow-legged-frog-suitable-habitat.

[150] *See* EXHIBIT (A)(b).

[151] Catalyst Environmental Solutions, *Bijou Park Creek Watershed Restoration Project*, p.67 (2020), https://www.cityofslt.us/DocumentCenter/View/14951/04-Bijou-Park-Creek-IS-IEC-CatEx-Final-Nov-2020.

[152] *Infra* note 153.

[153] Balmori A. *Mobile phone mast effects on common frog (Rana temporaria) tadpoles: the city turned into a laboratory*. 29(1-2) Electromagn Biol Med. 31-35 (2010), https://doi.org/10.3109/15368371003685363.

[154] *See* EXHIBIT (A)(j).

was required pursuant to 47 C.F.R. Section 1.1307(a)(3) for "facilities that: (i) May affect listed threatened or endangered species or designated critical habitats; or (ii) are likely to jeopardize the continued existence of any proposed endangered or threatened species." Likewise, an EIS is required by the TRPA under PUBLIC LAW 96-551 Art. VII, whereas it is "acting upon matters that have a significant effect on the environment."[155]

Verizon may attempt to distinguish the provided study that shows significant frog egg mortality when exposed to RF emissions as "one two-month study of tadpoles in close proximity to four roof-top mounted base stations." However, the emissions from the proposed Antenna will likely be similar to the one in the study in that there will be multiple antennae installed on this facility and species will be as close they were in the study (140 meters). Other studies exist as well and neither Verizon nor the TRPA have presented any evidence that undermines the validity of this study to the Antenna or its applicability to the endangered Sierra Nevada yellow-legged frog.[156]

The courts in *Jaeger v. Cellco Partnership* recently recognized that the FCC would be authorized to consider RF impacts to eagles for emissions within the FCC RF limits despite local authorities being preempted by the Telecommunications Act from considering such impacts.[157] Like the FCC, the congressionally created TRPA is "not in fact an arm of the State subject to its control"[158] and therefore is not preempted by the Telecommunications Act from regulating the Antenna on the basis of environmental effects, which would apply to a "state or local

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[155] 40 C.F.R. § 1508.1(b) (Affecting means will or may have an effect on); *American Bird Conservancy, Inc. v. F.C.C.*, 516 F.3d 1027, 1033-1034 (2008) (a precondition of certainty before initiating NEPA procedures would jeopardize NEPA's purpose to ensure that agencies consider environmental impacts before they act rather than wait until it is too late); *Sierra Club v. Norton*, 207 F.Supp.2d 1310, 1336 (2002) (Under NEPA, an agency cannot use the lack of existing information as a basis for acting without preparing an EIS). *See generally*, 42 U.S.C. §§ 4331-4332; 40 C.F.R. §§ 1500-1508.

[156] *See*, *United States v. Dierckman*, 201 F.3d 915, 926 (7th Cir. 2000) (quoting *Bagdonas v. Dep't of the Treasury*, 93 F.3d 422, 426 (7th Cir. 1996)); *Allied-Signal, Inc. v. Nuclear Reg. Comm'n*, 988 F.2d 146, 152 (D.C. Cir. 1993) (agency must be able to provide the "essential facts upon which the administrative decision was based" and explain what justifies the determination with actual evidence beyond a "conclusory statement"). *See generally*, *Motor Vehicle Manufacturers Association v. State Farm Auto Mutual Insurance Co.*, 463 U.S. 29, 42-44 (1983) (holding an agency decision is arbitrary and capricious if the agency has […] entirely failed to consider an important aspect of the problem, offered an explanation for its decision that runs counter to the evidence before the agency, or is so implausible that it could not be ascribed to a difference in view or the product of agency expertise). An agency decision that is the product of "illogical" or inconsistent reasoning; that fails to consider an important factor relevant to its action, such as the policy effects of its decision or vital aspects of the problem in the issue before it, will similarly fail the arbitrary and capricious test (Todd Garvey. *A Brief Overview of Rulemaking and Judicial Review*, Congressional Research Service, 15 n.136-137 (2017)). *See also*, *Am. Fed'n of Gov't Emps., Local 2924 v. Fed. Labor Relations Auth.*, 470 F.3d 375, 380 (D.C. Cir. 2006); *Ctr. for Biological Diversity v. U.S. Bureau of Land Mgmt.*, 698 F.3d 1101, 1124 (9th Cir. 2012).

[157] *See Jaeger v. Cellco P'ship*, (D.Conn. Mar. 15, 2010, No. 3:09CV567) 2010 U.S.Dist.LEXIS 24394, at *26.

[158] *See Lake County Estates v. Tahoe Reg. Planning Agency*, 440 U.S. 391 (Supreme Court, 1979) (holding that "TRPA is not in fact an arm of the State subject to its control," fn 22 citing *California v. TRPA*, 516 F.2d 215 (9th Cir. 1975)))

government or instrumentality thereof."[159] The TRPA staff report on the Antenna[160] acknowledges this truth wherein it stated: "TRPA, having been created by an interstate compact, is a creature of federal law, and the application of the TCA to its permitting process is not a matter of preemption. […] TRPA could choose to regulate RF in the region should cellular facilities be proven to have a particular adverse effect on the unique environment of the Tahoe Region." The daunting volume of scientific proof submitted to the agency,[161] and the reasoned application thereof in this report, warrant the director to "choose"—or even compels the TRPA—to regulate RF in this instant case; this proof is a public record.[162]

Under the Administrative Procedures Act,[163] an agency's decision not to initiate a rulemaking must have some reasoned basis, and an agency cannot simply ignore evidence suggesting that a major factual predicate of its position may no longer be accurate.[164] However, the TRPA staff report states that "TRPA will defer to the FCC regulations over general issues of human health and environmental impacts."[165] While imitation may be the highest form of flattery, it does not meet even the low threshold of reasoned analysis required by the Administrative Procedure Act (APA) under the deferential arbitrary and capricious standard of review; thus, one agency's unexplained adoption of an unreasoned analysis just compounds rather than vitiates the analytical void, in other words, two wrongs do not make a right.[166]

A recent ruling by the United States Court of Appeals, D.C. Circuit[167] has cast grave doubt upon the future validity of the current FCC RF emissions standards.[168] This substantively

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[159] 47 U.S.C. § 332(c)(7)(B)(iv) ("No State or local government or instrumentality thereof may regulate the placement, construction, and modification of personal wireless service facilities on the basis of the environmental effects of radio frequency emissions to the extent that such facilities comply with the Commission's regulations concerning such emissions").

[160] Bridget Cornell. *TRPA Hearings Officer Staff Report: Verizon/Guilliam New Cellular Monopine Cellular Tower; 1360 Ski Run Boulevard, City of South Lake Tahoe, El Dorado County, CA; Assessor's Parcel Number 025-580-07, TRPA File Number ERSP2019-0389*, p4 (October 2021), https://www.trpa.gov/wp-content/uploads/documents/Agenda-Item-No.-V.D-Bridget-Cornell.pdf

[161] *See T-Mobile Northeast LLC v. City Council of City of Newport News*, Va., 674 F.3d 380, 390 (2012) (the Telecommunications Act does not preclude residents from expressing health concerns to their representatives).

[162] *See* TRPA Rule of Procedure § 15.2. *See, e.g.,* TRPA Governing Board Meeting Minutes—§ III, Feb. 26th 2020. *See also*, EXHIBIT (B)(c)—TRPA Governing Board Public Comment. *See generally*, Henry J. Friendly, *Some Kind of Hearing*, 123 U. PA. L. Rev. 1267, 1291 (1975), https://scholarship.law.upenn.edu/penn_law_review/vol123/iss6/2 (due process requires that the tribunal prepare a record of the evidence presented).

[163] Todd Garvey. *A Brief Overview of Rulemaking and Judicial Review*, Congressional Research Service, 13 n.118 (2017) (There is a "strong presumption that Congress intends judicial review of administrative action"). *See also*, *Bowen v. Mich. Acad. of Family Phys.* 476 U.S. 667, 670 (1986); *Gutierrez De Martinez v. Lamagno*, 515 U.S. 417, 424 (1995); *Block v. Comm. Nutrition Inst.*, 467 U.S. 340, 349 (1984).

[164] *Environmental Health Trust v. Federal Communications Commission*, 9 F.4th 893, 905, 909 (2021) (holding FCC's conclusions regarding long-term exposure to RF radiation, pulsation, or modulation, and implications of recent technological developments were arbitrary and capricious; FCC's complete failure to respond to comments concerning environmental harm caused by RF radiation was arbitrary and capricious). *See also*, *American Horse Protection Ass'n, Inc. v. Lyng*, 812 F.2d 1, 5 (1987).

[165] *Supra* note 160.

[166] *Environmental Health Trust v. Federal Communications Commission*, 9 F.4th 893, 910-911 (2021).

[167] *Id.*

[168] *E.g.,* 47 C.F.R. § 15.209. *See generally,* 47 C.F.R. Part 15.

means the proposed facility is likely already outdated, and the design is harmful. This likely also means that the plethora of adverse environmental impacts from construction will have been fallaciously contravened by benefits that were less than materialized in the long term. Whereas a City of South Lake Tahoe ordinance requires the proposed Antenna to be in compliance with future RF emissions standards,[169] the facility will likely "be powered down" leaving a blighted eyesore, and a legacy of harmed persons, wildlife, and vegetation in the aftermath.

After declaring that the Lake Tahoe region was "threatened with deterioration or degeneration" and its "unique environmental and ecological values" are "irreplaceable,"[170] Congress promulgated upon the TRPA, the duty of creating threshold standards in excess of the broad federal baseline standards enforced by the many federal agencies.[171] Congress, either directly or through delegated regulatory authority, is responsible for the national baseline standards for clean air and water, forest health, land management, and other ecological protections. Having determined that higher environmental standards are required to implement the Bi-State compact's mandate to prevent further "deterioration or degeneration," the TRPA has routinely maintained threshold standards in excess of the bare minimum set by federal law.[172]

However, in declining to even to consider whether the TRPA needed to establish threshold standards regarding radiofrequency radiation emissions limits in order to comply with its mandate to prevent deterioration or degeneration of the Lake Tahoe region's unique environmental values, the staff report to the hearings officer on this Antenna argued, "one must reconcile the intent of Congress in passing both the TCA and the Compact and give meaning to both statutes should there be any conflict in implementation. In furtherance of that standard, the agency position to date is this: TRPA will defer to the FCC regulations over general issues of human health and environmental impacts."[173]

What was so blatantly omitted from § G of the Staff Report to the Hearings Officer, was that TRPA must also reconcile the intent of Congress in passing the National Environmental Policy Act (42 U.S.C. §§ 4321-4347), Endangered Species Act (16 U.S.C. §§ 1531-1544), the Migratory Bird Treaty Act (16 U.S.C. §§ 703-712), The Bald and Golden Eagle Protection Act (16 U.S.C. §§ 668-668c), the National Historic Preservation Act (54 U.S.C. §§ 300101 *et seq.*), the Clean Water Act (33 U.S.C. §§ 1251-1387), the Clean Air Act (42 U.S.C. §§ 7401-7671), the Noise Pollution and Abatement Act (42 U.S.C. §§ 4901-4918), the Toxic Substances Control Act (15 U.S.C. §§ 2601-2629), and the Tahoe Bi-state Compact (PUBLIC LAW 96-551) and give meaning to all those statutes should there be any conflict in implementation.[174] Whereas the

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[169] SLTCC § 6.75.110.8—Standard Conditions for Approved Permits—Compliance with Applicable Laws
[170] PUBLIC LAW 96-551 Art I.
[171] PUBLIC LAW 96-551 Art V(d).
[172] Tahoe Regional Planning Agency, "*Threshold Standards and Regional Plan*," pp. 5-10, 13-15, 17-18 (2019). *Compare,* Clean Water Act (33 U.S.C. §§ 1251-1387) & Clean Air Act (42 U.S.C. §§ 7401-7671).
[173] *Supra* note 160. *See also*, *Environmental Health Trust v. Federal Communications Commission*, 9 F.4th 893, 910-911 (2021) ("While imitation may be the highest form of flattery, it does not meet even the low threshold of reasoned analysis required by the APA under the deferential standard of review that governs here. One agency's unexplained adoption of an unreasoned analysis just compounds rather than vitiates the analytical void. Said another way, two wrongs do not make a right").
[174] Those federal acts may not be violated simply because a "significant gap" cell service is alleged.

intent of Congress was to create special heightened environmental threshold standards for the Tahoe Region,[175] because the national baseline protections[176] were inadequate to protect the basin's "endangered" and "irreparable" "unique environmental and ecological values," there is no conflict in TRPA's choosing to regulate RF in the region.

In fact, it is the express intent of Congress to enjoin all Agency action which results in the unlawful taking of protected species, or the degradation of the Tahoe Environment. That is, even delegated regulatory authority under the TCA is preempted by the ESA,[177] MTBA,[178] BGEPA,[179] NHPA,[180] CWA,[181] CAA,[182] TSCA,[183] or the Bi-State Compact. If Congress intended to profoundly legislate RF emissions standards at the same legal hierarchy as the Bi-State Compact or ESA, it would have done so. Instead, it delegated those environmental standards to be set by the Agencies—such as FCC and TRPA—which must exercise its delegated regulatory authority in compliance with all statutory mandates protecting the environment; in other words, Congress did not intend RF emissions to be statutalized on par with the aforementioned Acts. If the FCC wishes for some odd reason to have absolute uniformity in RF radiation emissions levels, it may do so by raising the national baseline such that it conforms to the ESA, MBTA, BGEA, CWA, CAA, or the Bi-State Compact. In that light, we are almost certain it would find that absolute uniformity is not that important.

There is a perverse irony that the TRPA maintains it must be in harmony with FCC regulation that is actually subordinate to Congress' legislative authority, but it can be in discord with Congress' NEPA,[184] ESA,[185] MTBA,[186] BGEPA,[187] NHPA,[188] CWA,[189] CAA,[190] TSCA,[191] or regulation by CEQ,[192] EPA,[193] US FWS,[194] or even FCC's own NEPA regulation.[195]

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[175] Tahoe Regional Planning Agency, "*Threshold Standards and Regional Plan*," pp. 5-18 (2019).
[176] *See, e.g.,* 42 U.S.C. § 7409(a)(2)&(b)(1)-(2) (setting national ambient air quality standards); 33 U.S.C. §§ 1311(b) & 1312 (setting national water quality effluent limitations).
[177] 16 U.S.C. §§ 1531-1544.
[178] 16 U.S.C. §§ 703-712.
[179] 16 U.S.C. §§ 668-668c.
[180] 54 U.S.C. §§ 300101 *et seq.*
[181] 33 U.S.C. §§ 1251-1387.
[182] 42 U.S.C. §§ 7401-7671.
[183] 15 U.S.C. §§ 2601-2629.
[184] 42 U.S.C. §§ 4321-4347.
[185] 16 U.S.C. §§ 1531-1544.
[186] 16 U.S.C. §§ 703-712.
[187] 16 U.S.C. §§ 668-668c.
[188] 54 U.S.C. §§ 300101 *et seq.*
[189] 33 U.S.C. §§ 1251-1387.
[190] 42 U.S.C. §§ 7401-7671.
[191] 15 U.S.C. §§ 2601-2629.
[192] 40 C.F.R. §§ 1500-1508.
[193] 40 C.F.R. Chapter I.
[194] 50 C.F.R. §§ 17.11 & 402.14; PUBLIC LAW 96-551 Art. VII (b)&(c).
[195] 47 C.F.R §§ 1.1307 & 1.1311.

One of the most probative means of establishing pretextual agency decision making is to demonstrate that similar situations are treated differently.[196] That demonstration has been met with the differential treatment of RF radiation in context to other environmental regulations.[197] As the administrative record will show, it has been a tremendous source of controversy that the TRPA director is a board member of the Tahoe Prosperity Center (TPC), a private group lobbying for cell tower densification. The TRPA has further published a so-called "Intelligent Transportation Systems Strategic Plan" that—insubstantially—purports that cellular coverage is critical to the plan's success and then identifies the TPC as responsible for addressing this aspect of their plan. The TRPA's pretextual—and thus arbitrary and capricious[198]—position on RF radiation, is readily explainable in light that the express cell tower densification agenda has been embraced by the TPRA director. The agency may not abdicate any of its congressionally delegated environmental mandates by manufacturing new economic ones.[199] The TRPA may not weigh its non-probative cell tower densification agenda under pretext to produce—a strictly environmental—finding of no significant impact (FONSI) from an RF radiation emitting Antenna.[200]

One factor that must be considered within TRPA environmental analysis is the "degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks.[201]" Towards which Verizon may even fallaciously attempt to assert that a study provided by this Report[202] "only concluded that RFE 'may' cause an increase in development and mortality" in frogs as support for the contention that no EA or EIS is required which would

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[196] An agency decision that is the product of "illogical" or inconsistent reasoning; ~~that fails to consider an important factor relevant to its action, such as the policy effects of its decision or vital aspects of the problem in the issue before it,~~ will similarly fail the arbitrary and capricious test (Todd Garvey. A Brief Overview of Rulemaking and Judicial Review, Congressional Research Service, 15 n.136-137 (2017)). *See also*, *Am. Fed'n of Gov't Emps., Local 2924 v. Fed. Labor Relations Auth.*, 470 F.3d 375, 380 (D.C. Cir. 2006); *Ctr. for Biological Diversity v. U.S. Bureau of Land Mgmt.*, 698 F.3d 1101, 1124 (9th Cir. 2012).

[197] *See, e.g.,* Tahoe Regional Planning Agency, "*Threshold Standards and Regional Plan*," pp. 5-9 (2015) (TRPA sets its own air and water quality standards rather than deferring to EPA regulatory standards).

[198] *C.f., Department of Commerce v. New York*, 139 S.Ct. 2551, 2573-2574, 2583 (2019) (inquiry into the mental processes of administrative decisionmakers may be warranted and may justify extra-record discovery, on a strong showing of bad faith or improper behavior; decision marks the Court has invalidated agency action as pretextual)

[199] See, *Motor Vehicle Manufacturers Association v. State Farm Auto Mutual Insurance Co.*, 463 U.S. 29, 43 (1983) (an agency decision is arbitrary and capricious if the agency has relied on factors which Congress has not intended it to consider).

[200] *Id.*

[201] *See* 40 C.F.R. § 1508.27(b)(5) or § 1508.1(b). *See also*, *Sierra Club v. Norton (friends of the Earth, Inc.)*, 207 F.Supp.2d 1310, 1336 (S.D.Ala. 2002) ("Under NEPA, it cannot use the lack of existing information as a basis for acting without preparing an EIS."); *American Bird Conservancy, Inc. v. F.C.C.*, 516 F.3d 1027, 1033-1034 (2008) (a precondition of certainty before initiating NEPA procedures would jeopardize NEPA's purpose to ensure that agencies consider environmental impacts before they act rather than wait until it is too late.).

[202] Electromagnetic Biology and Medicine (2010), C. Navarra, "Mobile Phone Mast Effects on Common Frog (*Rana temporaria*) Tadpoles: The City Turned into a Laboratory."

be inconsistent with the text of the law; an activity that "may" cause significant environmental effects is precisely what requires an EA.[203]

Applicant's RF Emissions Analysis is Deficient

The Applicant paid Hammett & Edison, Inc. to determine the resulting ambient RF exposure levels surrounding two dozen cell towers to be installed within the City of South Lake Tahoe in 2019; many of the towers are within 300 meters of one another. While these calculations were performed around the same time, by the same engineers, they all generally certified that there were no other wireless base stations nearby. The RF exposure report in this instant matter also makes this declaration despite there being two existing small cell facilities within 275 meters to the proposed Antenna.[204] The small cell tower plans[205] themselves list the same owner as the proposed Antenna,[206] but each application has stated there are no other facilities nearby. In fact, the Woodbine,[207] Needle Peak,[208] and the Ski Run[209] radiofrequency emissions reports by the same consulting company and authors deceive *by omitting* that there are other facilities within 275 meters of each other that would co-contribute towards the RF radiation emissions limits. Therefore, the submitted assessment on environmental RF limit exceedance with the addition of the Antenna is deficient. Also, none of the assessments accounted for the dielectric properties of snow[210] into their RF modeling, which is significant for five months out of the year. RF propagation is enhanced when traveling over water and snow.[211]

The Antenna is Unlike Any Other Existing Wireless Facility in the City of South Lake Tahoe

There are no towers similar to the proposed Antenna in the Lake Tahoe area. All towers of similar or greater height are either: (1) in heavily industrial areas along U.S. Highway 50, or inside the regional sewage treatment facility; or (2) a single thin broadcast radio Antenna

[203] 40 C.F.R. § 1508.1(b) (Affecting means will or may have an effect on); *American Bird Conservancy, Inc. v. F.C.C.*, 516 F.3d 1027, 1033-1034 (2008) (a precondition of certainty before initiating NEPA procedures would jeopardize NEPA's purpose to ensure that agencies consider environmental impacts before they act rather than wait until it is too late); *Sierra Club v. Norton*, 207 F.Supp.2d 1310, 1336 (2002) (Under NEPA, an agency cannot use the lack of existing information as a basis for acting without preparing an EIS). *See generally*, 42 U.S.C. §§ 4331-4332; 40 C.F.R. §§ 1500-1508.

[204] *See* EXHIBIT (A)(h)(vi)(1), *supra* note 88.

[205] *See* Response to Public Records Requests, 2019 Public Records Requests-Large Files, PRA Reinhard—Small Cell Towers, PC_20180809, File 18-049, Attachment 6, PFD pages 2,4-14, City of South Lake Tahoe, *available at* https://www.csltbusiness.com/WebLink/DocView.aspx?id=40626&dbid=0&repo=cityclerk.

[206] *See* EXHIBIT (A)(h)(iv) Fig. "*Demolition*," listing corporate owner on Ski Run Site Plan.

[207] *See* EXHIBIT (A)(h)(vi)(3), Evaluation of 3764 Woodbine Road small cell., Hammett & Edison, Inc., ¶ 3, p. 2.

[208] *See* EXHIBIT (A)(h)(vi)(2), Evaluation of 3600 Needle Peak Road small cell, Hammett & Edison, Inc., ¶ 3, p. 2.

[209] *See* EXHIBIT (A)(h)(vi)(1), *supra* note 88, ¶ 3, p. 2.

[210] The dielectric properties of snow are understood; accurate modeling accounts for conductivity and permeability.

[211] This is a commonly known phenomenon. *Cf.*, Yee Hui Lee *et al.*, *Near Sea-Surface Mobile Radiowave Propagation at 5 GHz: Measurements and Modeling*, 23:3 RADIOENGINEERING 824, (Sept. 2014), *available at* https://www.radioeng.cz/fulltexts/2014/14_03_0824_0830.pdf.

approved in 1956,[212] before the City of South Lake Tahoe was incorporated and pre-dates the bi-state compact.[213]

The Applicant incorrectly claimed in the city permitting proceedings that the nearest home in proximity to the proposed Antenna is 76.2 meters ("250 feet") away,[214] when city officials acknowledge one residence within 37.2 meters,[215] and accurate measurements place the nearest residence around 27.1 meters away. Lake Tahoe is a very special place in dire need of protection.[216] The Antenna's inappropriate location necessitates ordering an EA.

Potential Impacts to Endangered Species

El Dorado County is also home to numerous candidate, threatened and endangered species[217] that may be impacted by the activity on the site.[218] The Applicant must confer with local and federal authorities to assure no direct or indirect impact on such species.[219] In addition to performing an EA/EIS, the TRPA has a concurrent duty to get biological opinions from the US FWS (16 U.S.C. § 1536; 50 C.F.R. § 402.14). The TRPA also has a duty to perform an EIS on the entire cellular network plan—of which the TRPA director not only had actual or constructive knowledge, but was implementing through her concurrent direction over the Tahoe Prosperity Center—and evaluate RF regulation as a mitigation measure for environmental harm.

The Applicant's Assessment of Alternative Site Locations is Deficient and Will Need to be Corrected in the EA

The Applicant's current assessment of the viability of alternative sites[220] is inadequate.[221] In its analysis presented to the City of South Lake Tahoe officials, and again to

[212] ASR Registration No. 1015362, Antenna Structure Registration (ASR) System, Federal Communications Commission, Washington DC., https://wireless2.fcc.gov/UlsApp/AsrSearch/asrRegistration.jsp?regKey=118340.
[213] *See* EXHIBIT (A)(f) Fig. *"ASR Referenced Towers Greater than 112 Feet"*
[214] *Supra* note 116, General Planning Application, p. 4, PDF page 13.
[215] *See* Response to Public Records Requests, 2020 Public Records Requests-Large Files, Greenfire Law 02 10 2020, *Verizon Mono-pine Buffer Map*, Email Attachment from City Manager "VerizonBufferMap [Converted].pdf," City of South Lake Tahoe, (Sept. 30, 2019), *available at* https://www.csltbusiness.com/WebLink/DocView.aspx?id=42141&dbid=0&repo=cityclerk.
[216] *See* PL 96-551, Art. I.
[217] *See* 47 C.F.R. § § 1.1307(a)(3), 1.1311(a)(6) (pertaining to facilities that may affect such species, and mandating use of the best scientific data for EA). *See also*, 40 C.F.R. § 1502.14.
[218] *See* EXHIBIT A(i)(iv), U.S. Fish & Wildlife Service, Species By County Report (El Dorado).
[219] *See* PUBLIC LAW 96-551 Art. VII (b)&(c); *see also* 16 U.S.C. § 1536; 50 C.F.R. §§ 17.11 & 402.14 (TRPA must consult US FWS on impacts to endangered species, which may include a "biological opinion").
[220] *See* 47 C.F.R. § § 1.1307(a)(4) (pertaining to discussion of any alternative sites or facilities which have been or might reasonably be considered.)
[221] *See Verizon's Alternative Cell Tower Sites Analysis*, City of South Lake Tahoe City Council Meeting, Jan. 14, 2020, https://legistarweb-production.s3.amazonaws.com/uploads/attachment/pdf/497731/02-Verizon_Wireless_Alternatives_Analysis_12.19.19.pdf.

TRPA, it hid (or failed to disclose)[222] the extent of the cell coverage by its existing tower sites[223] and omitted material facts that contradict the Applicant's claims that: (i) "there are no superior alternatives to the approved [Antenna]"[224]; (ii) the Applicant has "demonstrated a significant gap in service"[225]; and (iii) "the approved [Antenna] is the least intrusive means to fill the significant gap in service."[226]

Macro cell towers like the Antenna have a powerful broadcast radius potential of 30 km (18.5 mi), but more commonly reach to 20 km (12 mi) because of terrain, capacity, energy, and radiation exposure issues.[227] The Applicant cannot support its claim of huge coverage differences between potential sites that are within a two-mile radius to service two gap areas within a one-mile radius; this is especially true since there is no substantial difference in elevation, aspect, or obstructive terrain on the proposed sites to service this "gap." The Applicant's current so-called analysis is really a pretextual minimization of its own internal cost of implementing cell coverage that disregards the transfer of these costs to neighboring residents, and factors the ancillary benefit of permanent right-of-way acquisitions in very a valuable real estate market. The Applicant stated it will need to trench fiber optic cable to the Antenna[228]; thus, construction would be less expensive for them to deploy a macro cell tower in a residential neighborhood adjacent to an arterial roadway.

To visualize this issue with RF propagation modeling,[229] there are several coverage images appended to EXHIBIT A. The Longley-Rice Irregular Terrain Model (ITM)[230] shows[231] the viability of "*Angels Roost*," and the "*Water Tower*" sites as superior options in terms of

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[222] *See Verizon's purported Coverage Maps*, File 19-026, City of South Lake Tahoe City Council Meeting, Jan. 14, 2020, https://legistarweb-production.s3.amazonaws.com/uploads/attachment/pdf/374853/Attachment_05__1360_Ski_Run_Blvd-Coverage_Maps-5.20.19.pdf.

[223] *See* Cellmaper.net (providing public information on the surrounding cell towers, including Antenna orientation (azimuth)), https://www.cellmapper.net/map?MCC=311&MNC=480&type=LTE&latitude=38.93127470250417&longitude=-119.95021046735926.

[224] *Verizon Wireless Response to Appeal, File 19-026*, City of South Lake Tahoe City Council Meeting, Jan. 14, 2020, Page 3, https://legistarweb-production.s3.amazonaws.com/uploads/attachment/pdf/504721/20-Verizon_Wireless_Response_to_Appeal__File_19-026__1360_Ski_Run_Boulevard_-_City_Council_Agenda__January_14__2020__Ski_Run_Boulevard_.pdf#page=4.

[225] *Id.* at page 8.

[226] *Id.*

[227] *See* Professor Jean-Paul M.G. Linnartz, Ph.D., *Cell Sizes*, Cellular Telephone Networks, JPL's Wireless Communication Reference Website, http://www.wirelesscommunication.nl/reference/chaptr04/cellplan/cellsize.htm

[228] *See Attachment 03, General Planning Application, Ski Run Tower (the Antenna), Page 3, File # 19-026, Special Use Permit for a New Stealth Monopine Wireless Telecommunications Facility and Equipment Shelter to be located at 1360 Ski Run Blvd. (APN 025-580-07)*, City of South Lake Tahoe Planning Commission Meeting, June 13, 2019, PDF page 6, https://legistarweb-production.s3.amazonaws.com/uploads/attachment/pdf/374851/Attachment_03_19-026_1360SkiRun_Application.pdf#page=6.

[229] For a brief overview of RF modeling methods, *see* https://www.council-rock.com/wp-content/uploads/2017/05/RF_Propagation_Modeling.pdf.

[230] The ITM was federally developed by the National Telecommunications and Information Administration (NTIA), *see* https://www.its.bldrdoc.gov/resources/radio-propagation-software/itm/itm.aspx.

[231] The software used to execute this model is Radio Mobile. See *Radio Mobile Program Operating Guide*, p 11., http://www3.telus.net/hendersb/documents/Radio Mobile.pdf#page=11.

minimizing injury to wetlands and neighborhoods, while servicing their alleged "gap in coverage."[232] The "*Bat Yam*" site modeling also shows that a viable tower could be built there without needing to be a prohibitive 55-meter tall tower as asserted by the Applicant.[233] EXHIBIT A's "Best Sites for Coverage of Bijou Park and Heavenly Valley" grades the landscape on its potential to cover the Applicant's alleged "significant gap" on a 90% to 100% coverage scale.[234] As expected, there is a large area in which placement of the Antenna would cover this gap. There is a sizable subset within this area that is far away from residences, and within the jurisdiction of city limits; there is also a very large portion of this area that is within U.S. Forest Service jurisdiction and is very far away from any residence. Furthermore, when AT&T evaluated and declined the Ski Run site in 2013,[235] they subsequently placed their Macro Tower at 1066 Lyons Avenue[236]—the north end of the South Tahoe Middle School[237]—which is on the edge of the land zone able to provide 100% coverage to both *Bijou Park* and *Heavenly Valley*.[238]

Additionally, the Applicant's modeling appears to have used defective Antenna orientations, heights, and receiving Antenna sensitivity at the alternative sites[239] in order to support the Applicant's desired outcome. The Applicant also failed to disclose or misrepresented the existing level of service in its alleged "coverage gap."[240] Residents performed their own signal measurements test and were continuously able to make calls throughout the entire areas that the Applicant claimed to the City did not have service.[241] The RF modeling of cell coverage by existent towers[242] in EXHIBIT A exposes the actual current coverage of the "gap," and the empirical call tests[243] validate the model output. The Applicant appears to have altered or has hidden the orientations of is existent cell panel facilities in its own analysis—which substantially differ from that in the public record[244]—in the analysis it provided to the city and to TRPA, which informed the local government's belief that the preferred location is necessary to close the alleged "service gap."

Verizon has still not obtained a building permit, and the Antenna is not yet built and is not yet operational. There is still time to address the environmental effects of proposed significant federal action. The TRPA and FCC also have a concurrent ongoing obligation to

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[232] *See* EXHIBIT A(e) Figs. "*Radiation and Coverage Patterns.*"
[233] *Id.*
[234] *See* EXHIBIT A(d) Fig. "*Actual Best Site Locations to Serve the Alleged "Coverage Gaps."*"
[235] ASR Registration No. 1287635, Antenna Structure Registration (ASR) System, Federal Communications Commission, Washington DC., https://wireless2.fcc.gov/UlsApp/AsrSearch/asrRegistration.jsp?regKey=2687063.
[236] *See Wireless Telecommunications Facility Table*, City of south Lake Tahoe, https://www.cityofslt.us/ImageRepository/Document?documentId=13421.
[237] *See Wireless Telecommunications Facilities Location Map*, City of South Lake Tahoe, https://www.cityofslt.us/ImageRepository/Document?documentId=13422.
[238] *See* EXHIBIT A(d), *supra* note 122.
[239] *Supra* note 110.
[240] *See* MyStreetMyChoice "*Proof of No Significant Gap in Verizon Wireless Telecommunications Coverage*," http://mystreetmychoice.com/slt.html.
[241] *Id.*
[242] *See* EXHIBIT (A)(e), *supra* note 120.
[243] *Supra* note 128.
[244] *See* Cell Tower Mapper, *supra* note 111.

comply with NEPA regardless of the date on which Verizon filed its national notice.[245] Moreover, Verizon itself is obligated to initiate an Environmental Assessment (EA) under 47 C.F.R. § 1.312(d)[246] now that additional information has come to light. The TRPA and FCC can, and in light of the information provided must, order an EA or EIS on its own motion—*e.g.,* under 47 C.F.R. § 1.1307(d)[247]—which would not be subject to any time limitation.[248]

[245] *See United Keetoowah Band of Cherokee Indians in Okla. v. FCC*, 933 F.3d 728, 735 (D.C.Cir. 2019).
[246] "If, following the initiation of construction under this section, the licensee or applicant discovers that the proposed facility may have a significant environmental effect, it shall immediately cease construction which may have that effect, and submit the information required by § 1.1311 of this part."
[247] *See* PL 96-551, Art. VII(b) ("Prior to completing an environmental impact statement, the agency shall consult with and obtain the comments of any Federal, State or local agency which has jurisdiction by law or special expertise with respect to any environmental impact involved").
[248] "NEPA is a federal policy directive aimed at producing quality agency decisions that take into consideration environmental consequences. NEPA does not set a time frame in which to come into compliance with the law as environmental problems can change with time." https://www.fcc.gov/general/nepa-faq

EXHIBITS

(A) FIGURES
- a. Antenna Visibility & Viewshed
- b. Stream Environmental Zone & Protected Resources
- c. Coverage Gap
- d. Best Alternative Sites
- e. Radiation and Coverage Patterns
- f. Existing Commission ASR Towers
- g. Antenna Documentation
  - i. CommScope Specifications
  - ii. Antenna Pattern Visuals
- h. Verizon Documents
  - i. Diesel Generator
  - ii. Water Well Site
  - iii. Tree Heights & Removal
  - iv. Demolition in Stream Environmental Zone
  - v. Hammett & Edison, Inc.
    1. Ski Run
    2. Needle Peak
    3. Woodbine
  - vi. TRPA Scenic Impact Assessment & Checklist
  - vii. EBI Consulting
    1. Land Resources Map—Pony Express HNT
    2. Feigned Contacts
- i. Environmental Documents
  - i. ASR Application A1103190
  - ii. CEQA Exemption
  - iii. Deed Restriction
  - iv. U.S. Fish & Wildlife Service, Species in El Dorado County
- j. Scientific Literature
  - i. Cell Towers on Frog Embryos
  - ii. Amphibian Decline
  - iii. Cell Towers on Avian Embryos
- k. Concurrent Deployment
  - i. Heavenly Distributed Antenna System
  - ii. Tahoe Seasons Wireless Telecommunications Facility

(B) SOURCES OF CONTROVERSY
- a. Petitions
  - i. Hand Petitions
  - ii. Change.org Petition
- b. Newspaper Clips
  - i. Tahoe Tribune: “Cell Tower or Terror”
  - ii. Tahoe Tribune: “David Jinkens Columns”
  - iii. Tahoe Tribune: “Cease and Desist”
  - iv. Tahoe Mountain News: “The Bad and Ugly with Cell Towers”
  - v. Tahoe Mountain News: “Peggy Borland Columns”

vi. Tahoe Tribune: "Compendium of Recent Controversy"

c. Legal Briefs Submitted in Connection with City Permitting
   i. Campanelli & Associates, P.C.
   ii. Rob Perez
   iii. Rollston, Henderson & Johnson, LTD.

d. Public Speeches
   i. City Council Public Comment
   ii. TRPA Public Comment

e. Agency Letters
   i. DOI Letter
   ii. EPA Letter

(C) LOCAL ENVRIONMENAL PROTECTION AUTHORITIES

a. Presidential Executive Orders
   i. EO 13057—Federal Actions in the Lake Tahoe Region
   ii. EO 13186—Responsibilities of Federal agencies To Protect Migratory Birds
   iii. EO 11990—Protection of Wetlands
   iv. EO 13175—Consultation and Coordination With Indian Tribal Governments
   v. EO 13045—Protection of Children From Environmental Health Risks and Safety Risks

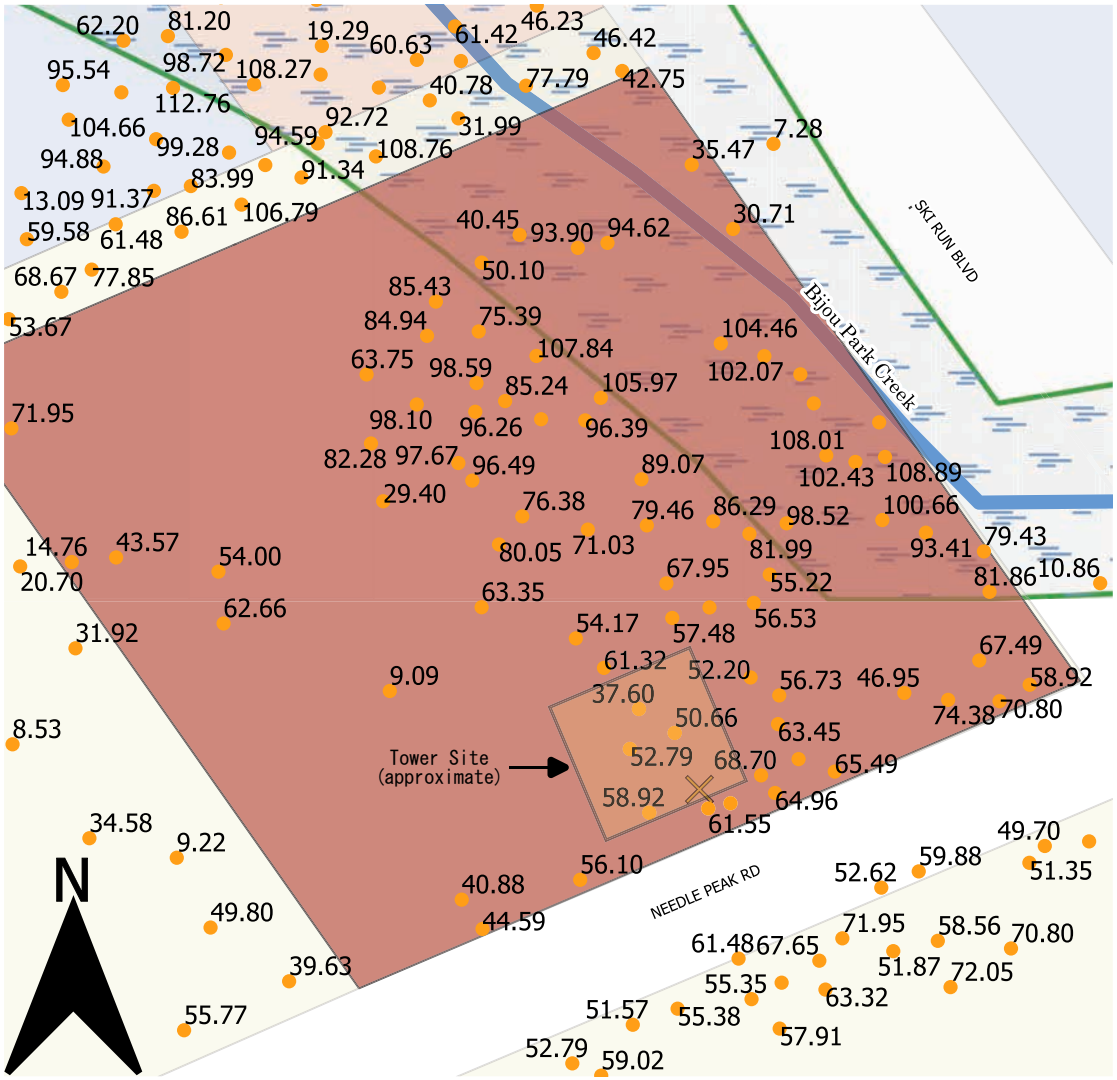
b. Bi-State Compact
   i. U.S. Const. Art. I § 10, cl. 3
   ii. Public Laws
      1. Public Law 96551
      2. Public Law 96586
   iii. California Government Code
      1. Cal. Gov. Code § 66800
      2. Cal. Gov. Code § 66801
      3. Cal. Gov. Code § 66802
      4. Cal. Gov. Code § 66802.5
   iv. Nevada Revised Statutes
      1. N.R.S. § 277.190
      2. N.R.S. § 277.200
      3. N.R.S. § 277.207
      4. N.R.S. § 277.210
      5. N.R.S. § 277.215
      6. N.R.S. § 277.220
   v. Tahoe Regional Planning Agency
      1. Code of Ordinances, Chapter 4: 4.4 Threshold-Related Findings
      2. Code of Ordinances, Chapter 37: Height

c. City of South Lake Tahoe
   i. City Code
      1. 6.10.090
      2. 6.55.010
      3. 6.55.620
   ii. General Plan
      1. Policy PQP-8.4
      2. Policy NCR-1

3. Policy NCR-2
4. Policy NCR-3
5. Policy NCR-6
6. Lakeview Heights Plan Area Statement

EXHIBIT A

EXHIBIT (A)(a) Fig.
Visual Impact of Proposed 112-Foot Tall Ski Run Cell Tower with 20-Foot Co-location



Tree locations and their respective heights in vicinity to the proposed tower site. Numbers denote height in feet. The proposed tower will be 112 feet tall, and the leassor plans to extended the tower an additional 20 feet for co-locations which must be allowed under 47 U.S.C. § 1455(a). The adjacent trees are generally 60' tall which means the tower will extend 70' above the forest canopy. The tower site is on a ridge which adds substantially to the height differential of all downhill trees.



Photo-simulation of tower as viewed from the top of Harrah's Casino on U.S. 50 "Scenic Corridor."

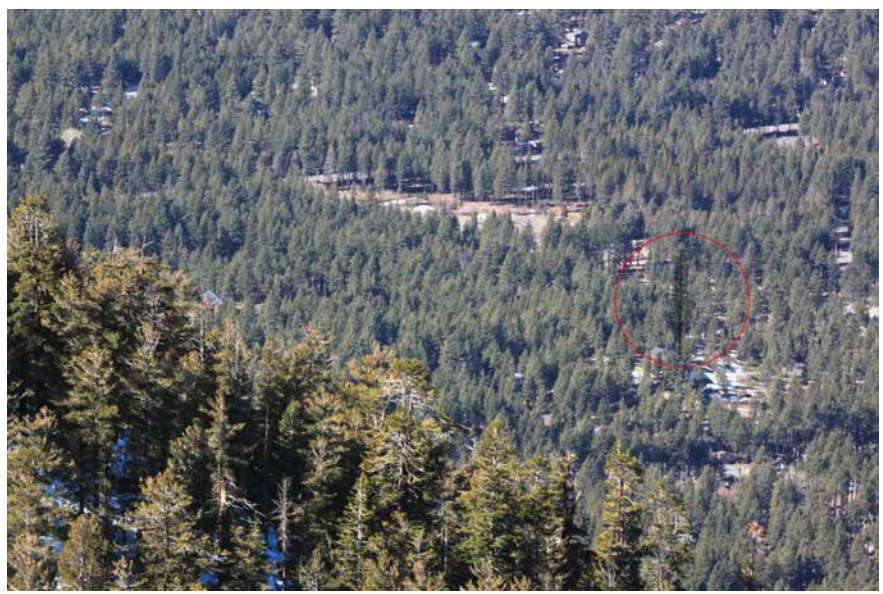
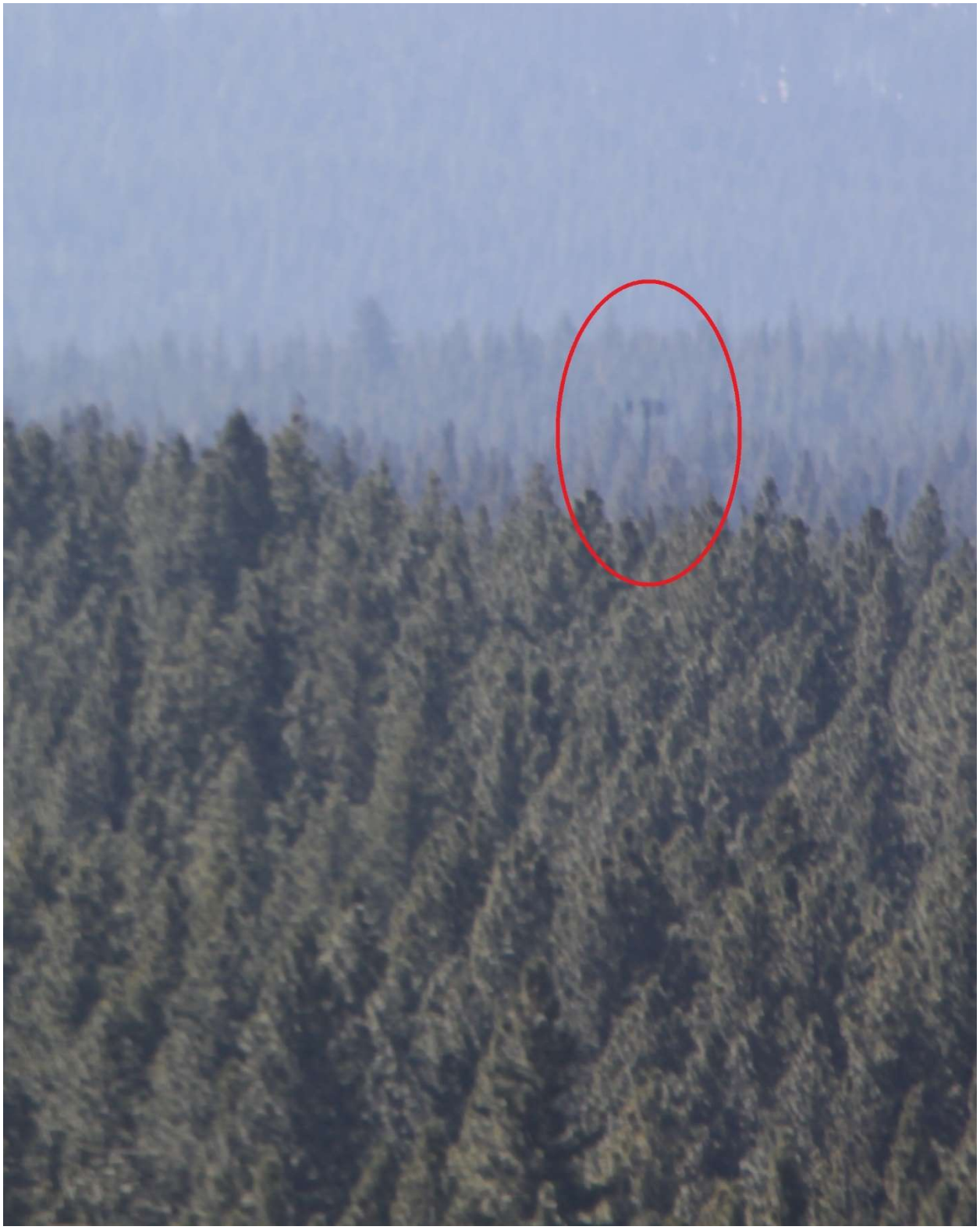


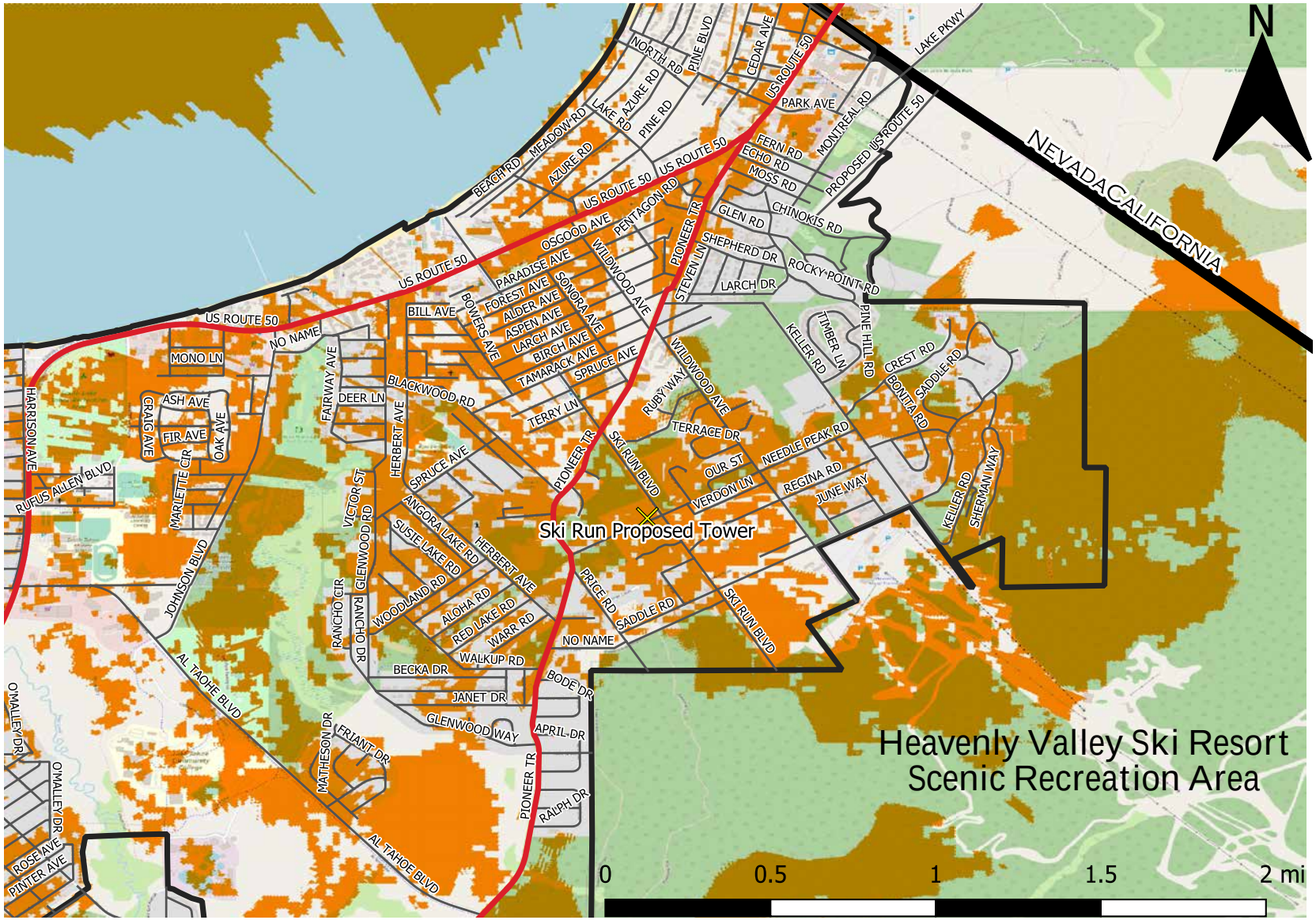
Photo-simulation of tower as viewed from Gondola Observation Deck, within Heavenly Ski Area "Recreational Scenic Zone."



In South Lake Tahoe, a 2005 Verizon Macro Cell Tower can be seen from Stateline Casinos nearly two-and-a-half miles away. If the tower were a “monopine,” design, it would require unnaturally long branches and a 10-foot “topper” which would paradoxically increase the silhouette by a substantial amount. This profile with an additional 47 U.S.C. § 1455(a) 20 foot co-location would extend to the top of the red oval. The closer proposed Ski Run Tower a mile-and-a-half away would be substantially more visible from the casinos. The “monopine” design may decrease discernibility at short range, but in creating a gargantuan “species” outlier in an otherwise homogeneous forest, it increases visibility at long range. It is harder to see a treetop (crown) from the very base of a tall tree.

EXHIBIT (A)(a) Fig.

Ski Run Tower Viewshed



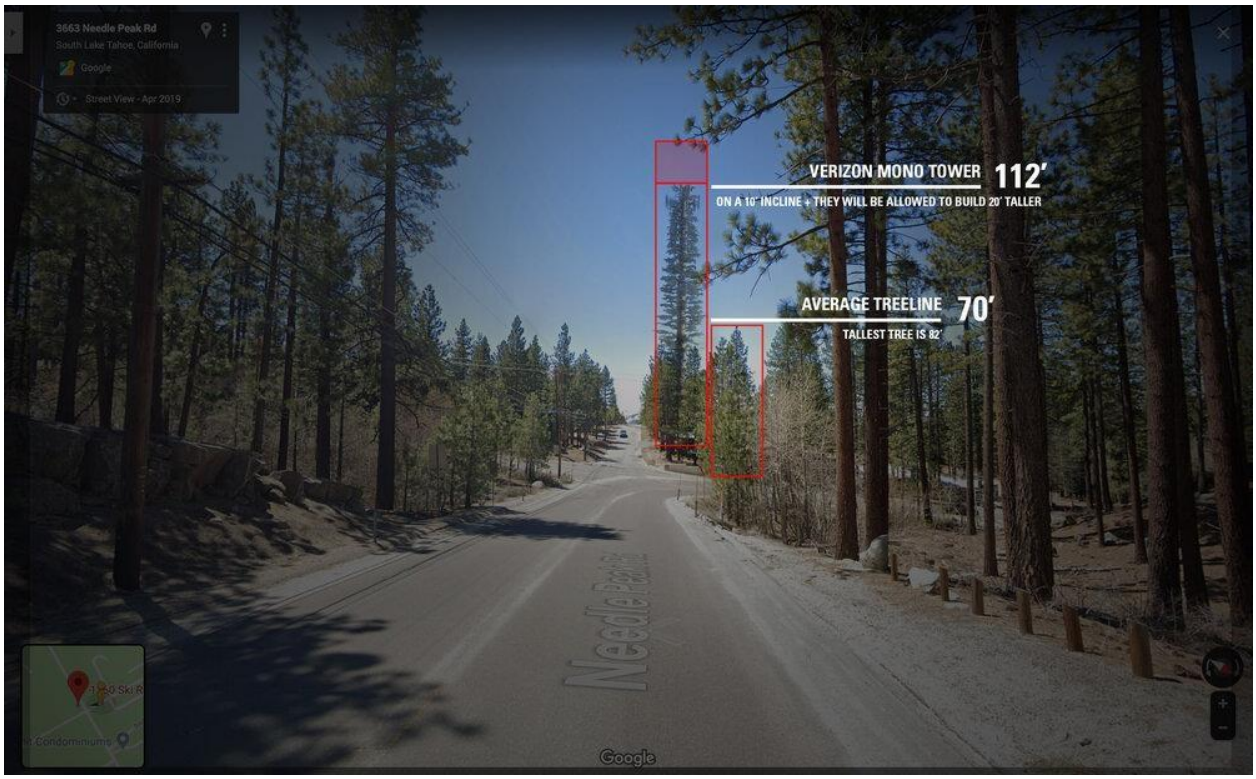
Geospatial Analysis indicates the proposed 112-foot tall Ski Run cell antenna tower would be visible from the areas in brown. This calculation is called a "viewshed" and considers the elevation, terrain, and the vegetation. The red colored US Route 50 and Pioneer Trail are both TRPA designated "scenic corridors." Likewise, Heavenly Valley Ski Resort is a designated "Scenic Recreation Area." The tower is known to be visible from the ski area's aerial tram and gondola observation deck, and also US 50's casino towers, and from the Lake Tahoe waterway.

Visual Impact on Scenic Parkway

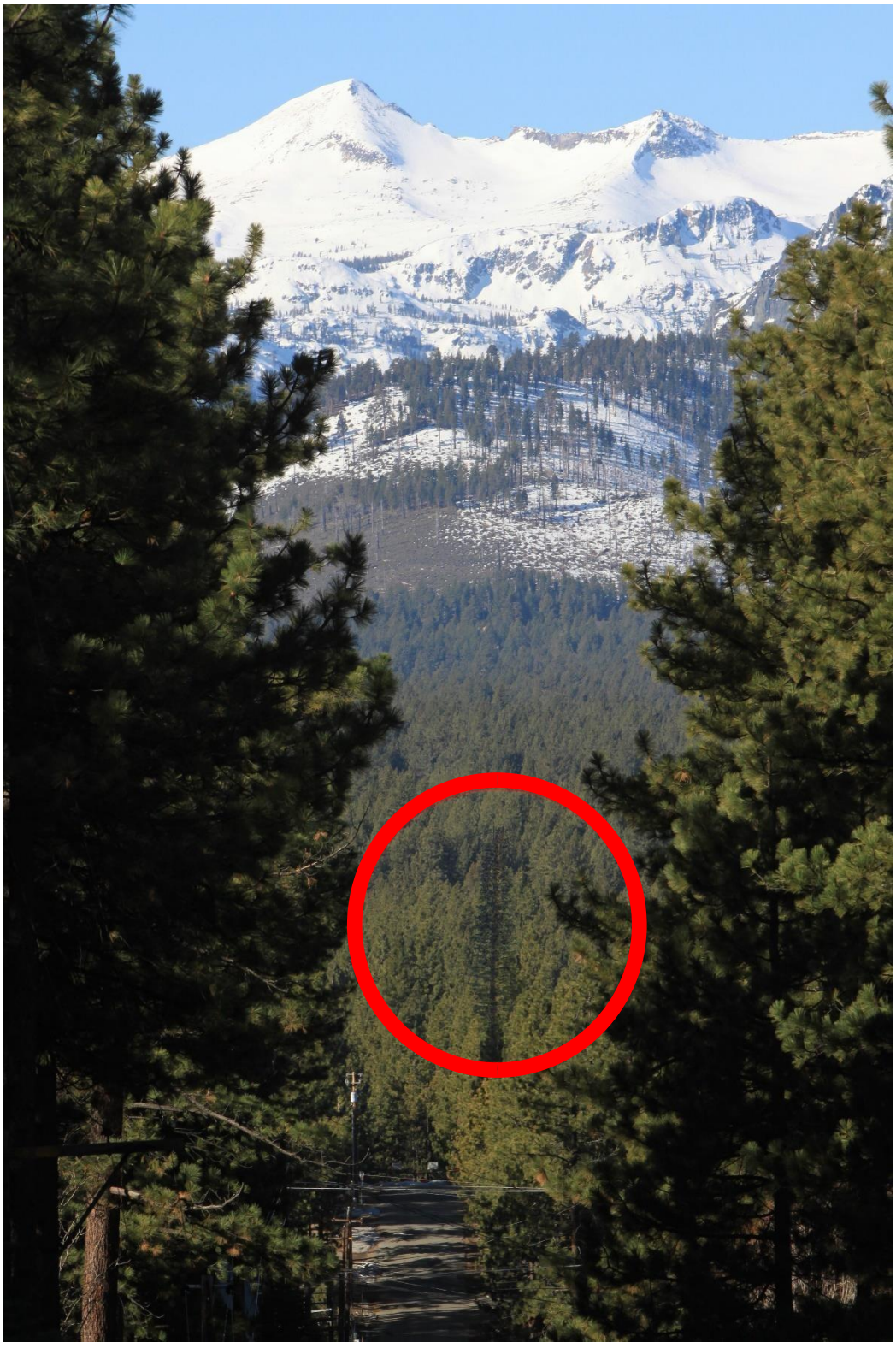
The Needle Peak Road-Ski Run Blvd. route is the designated parkway connecting tourist traffic from the TRPA designated Pioneer Trail “Scenic Corridor” to the world destination Heavenly Valley Ski Resort “Scenic Recreation Area.” The aspen grove that tangentially crosses Upper Ski Run Blvd., is a heavy scenic attraction during the fall. Visitors regularly turnout here to take souvenir photographs.



The proposal would deforest the above scenic turn of 13 trees, replacing them with a 112-foot tower.



The entire length of Needle Peak Road is directionally aligned to its spectacular allusion, the iconic “needle tipped” Pyramid Peak—for which congress created the federal Desolation Wilderness. Traffic departing Heavenly Valley Ski Resort “Scenic Recreation Area” enjoys this view on the return to Pioneer Trail “Scenic Corridor.” The tower also would be visible from the yards of many cabins along this road.



The spectacular Bijou Park Creek aspen grove runs along the right side of Ski Run Boulevard and crosses the street at the intersection with Needle Peak Road.

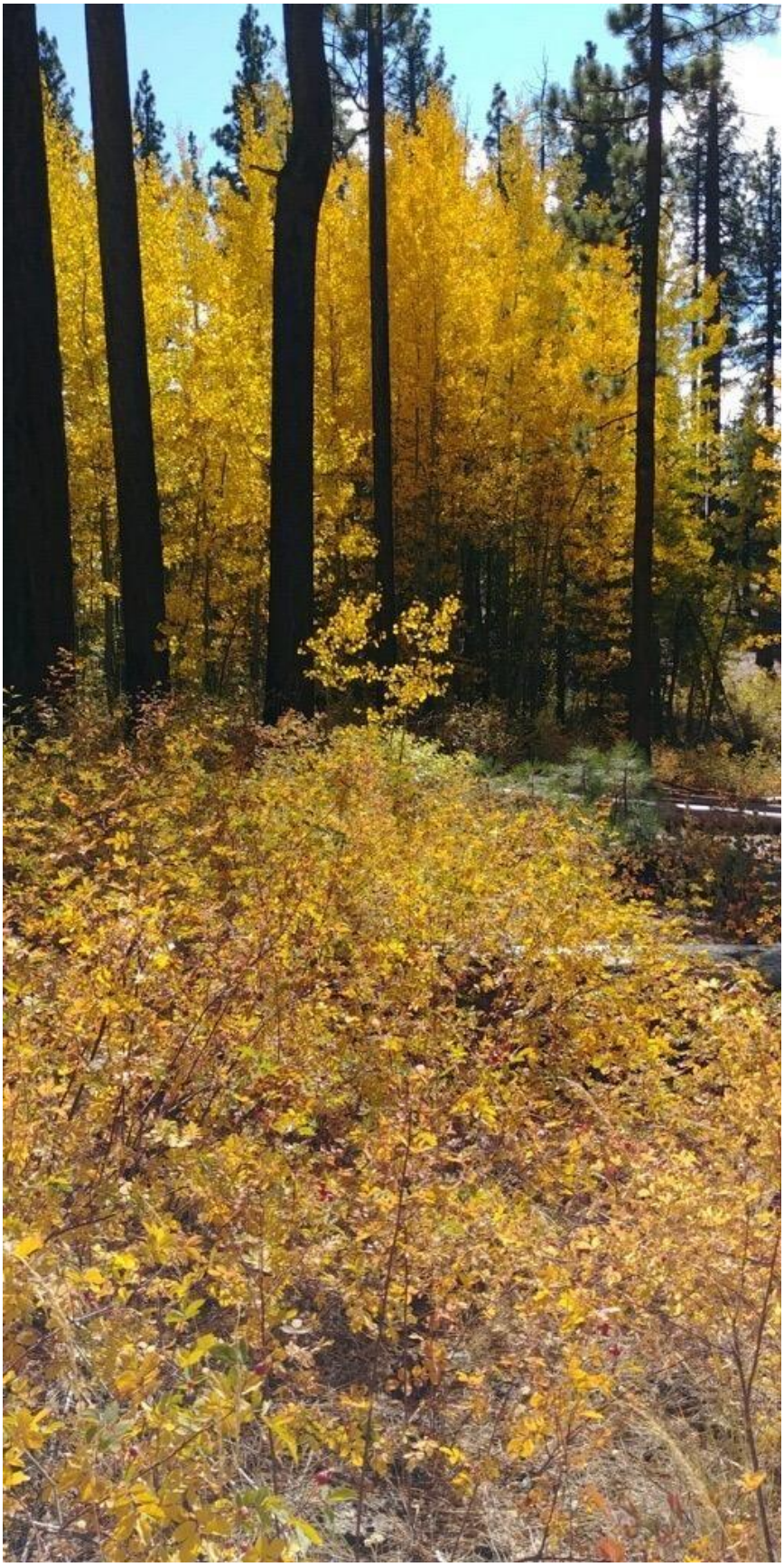


The Tower site parcel is marked by the red trapezoid. Thirteen of these pine trees are to be cut down to install one 112-foot tall monopole cell tower along this scenic drive. The heat generated by the antenna panels would conspicuously melt snow flocking the surrounding trees, an unnatural change in the view.



The Aspen Grove is a fall destination for tourists. A 12-story structure would ruin its photographic appeal. The tower could be especially visible in the winter after the aspen loses its foliage.

Locations like the Aspen Grove are used for wedding photographs. Quaking aspen (*Populus tremuloides*) forests are typically single living organisms having one massive underground root system, making them particularly vulnerable to deleterious environmental encroachments.



Tourists also stop for the abundant wildlife viewing as well. The riparian habitat along Upper Bijou Park Creek attracts rodents, bears, hawks, and eagles. This photograph of a federally protected osprey was taken less than 500 feet away from the proposed tower site. Eagles rest in the tallest trees in order to swoop down upon prey perched in shorter trees below. By mimicking their habitat, the proposed tower invites these protected birds into the harmful near-field radiation of the antenna.

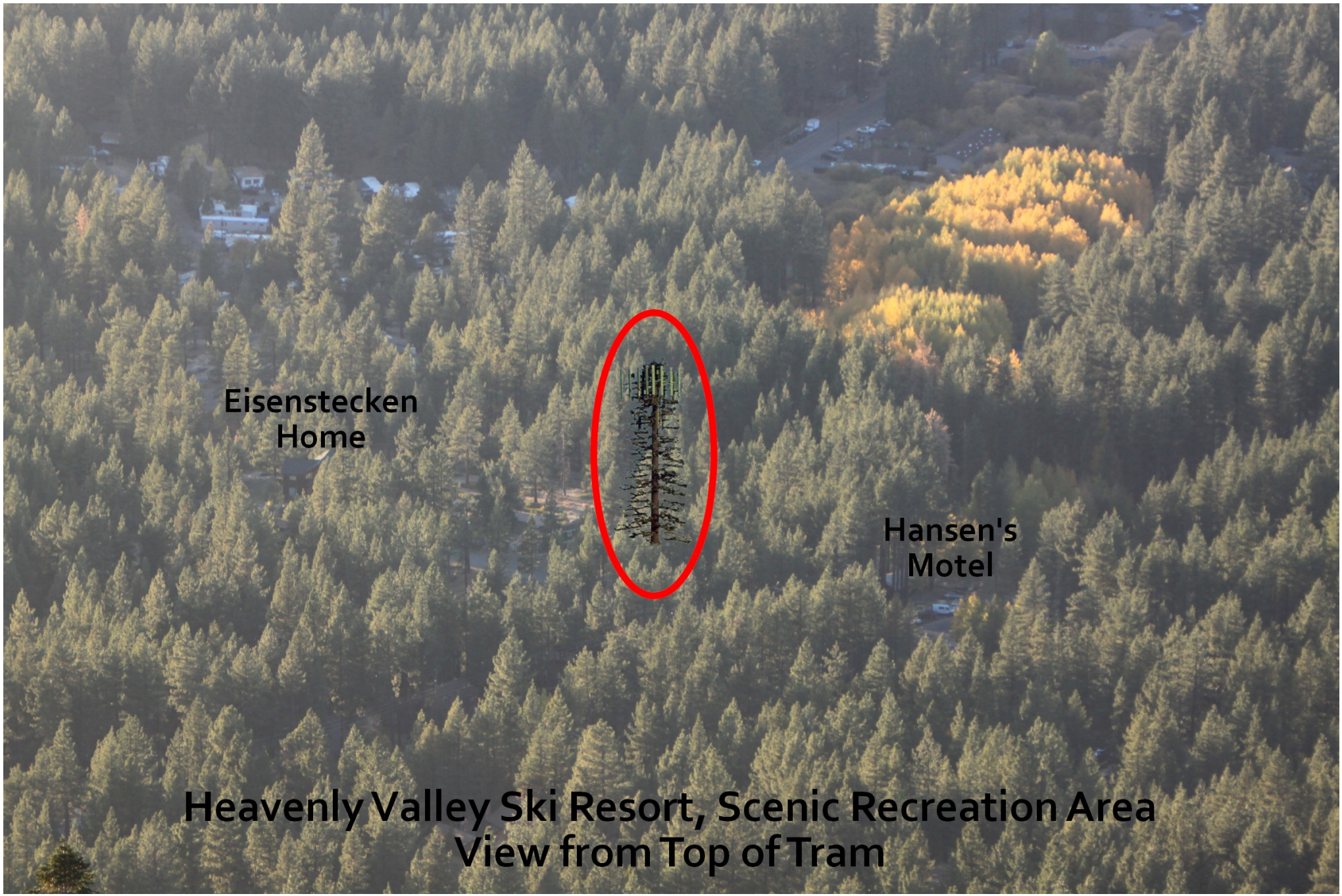



South Lake Tahoe, California
Google
Street View Apr 2019
VERIZON MONO TOWER 112'
ON A 10' INCLINE + THEY WILL BE ALLOWED TO GO TO 120"
AVERAGE TREELINE 65'
TALLEST TREE IS 75'
1360 Ski Ru
Condominiums
Google
Image capture: Apr 2019 © 2019 Google United States Terms Report a problem


3609 Needle Peak Rd
South Lake Tahoe, California
Google
Street View - Jun 2017
VERIZON MONO TOWER
112'
ON A 10' INCLINE + THEY WILL BE ALLOWED TO GO TO 120"
AVERAGE TREELINE
65'
TALLEST TREE IS 75'
Needle Peak Rd
1360 Ski R
Condominiums
Google
Image capture: Jun 2017
© 2019 Google
United States
Terms
Report a problem


VERIZON MONO TOWER 112'
ON A 10° INCLINE + THEY WILL BE ALLOWED TO BUILD 20' TALLER
AVERAGE TREELINE 65'
TALLEST TREE IS 82'
Google

Proposed Antenna will spoil view from the TRPA-designated Heavenly Valley Ski Resort Scenic Recreation Area



DATE: 10/12/2021

verizon

SKI RUN BLVD
PSL # 444780
1360 SKI RUN BLVD
SOUTH LAKE TAHOE, CA 96150

SAC WIRELESS
SAC AE DESIGN GROUP, INC.
9028 ACTIVITY ROAD
SAN DIEGO, CA 92126
www.sacw.com

PHOTOSIMULATION VIEWPOINT 4





NEW



EXISTING



DISCLAIMER: THIS PHOTOSIMULATION IS INTENDED AS A GRAPHICAL REPRESENTATION OF EXISTING AND PROPOSED SITE CONDITIONS BASED ON THE PROJECT / DRAWING PLANS. IT IS NOT INTENDED FOR CONSTRUCTION. ACTUAL, FINAL CONSTRUCTION MAY VARY

DATE: 10/12/2021

verizon

SKI RUN BLVD
PSL # 444780
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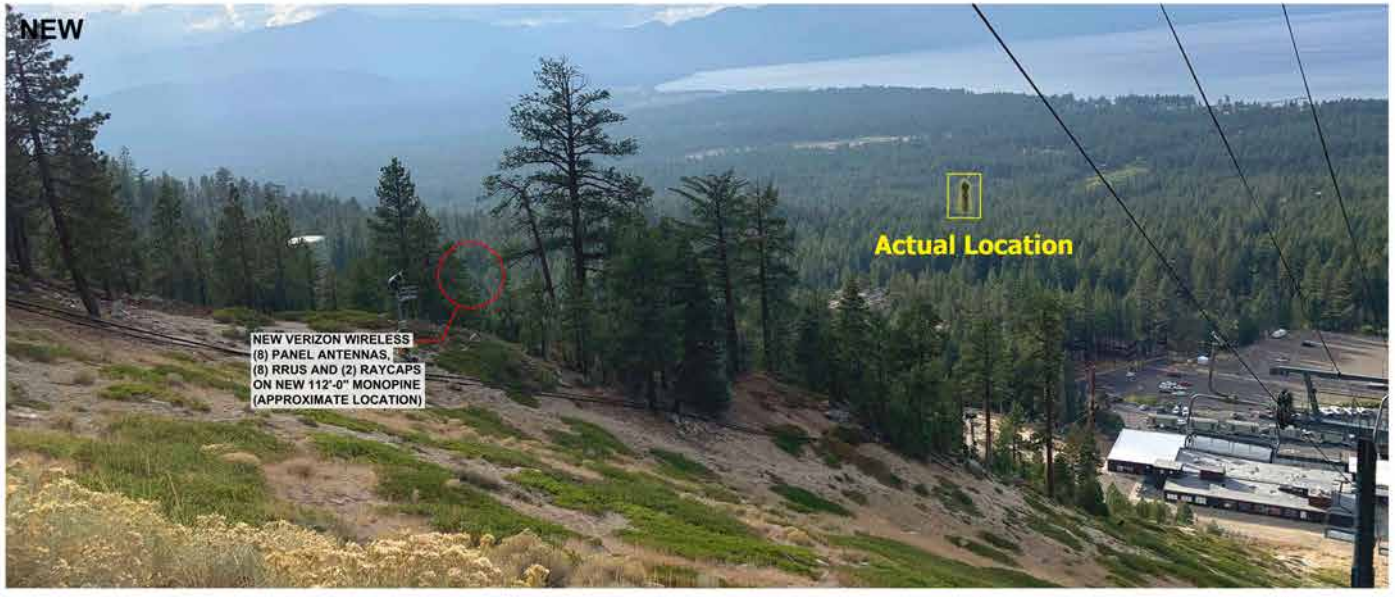
SAC WIRELESS
SAC AE DESIGN GROUP, INC.
9028 ACTIVITY ROAD
SAN DIEGO, CA 92126
www.sacw.com

PHOTOSIMULATION VIEWPOINT 5

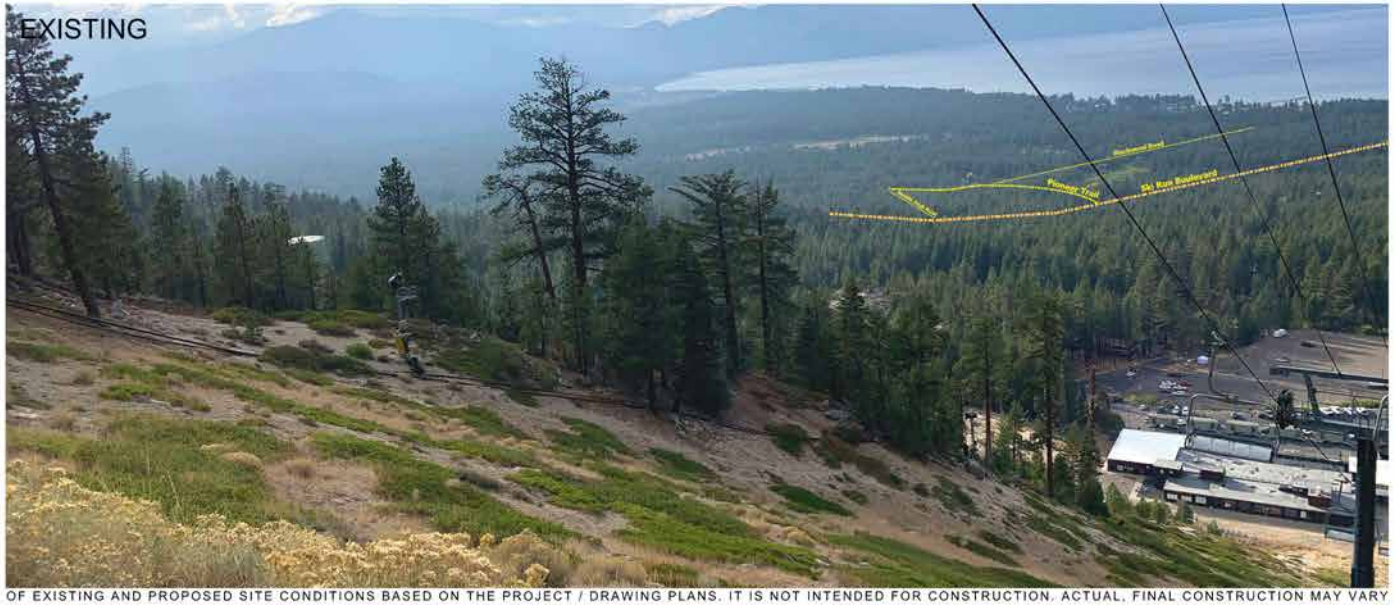




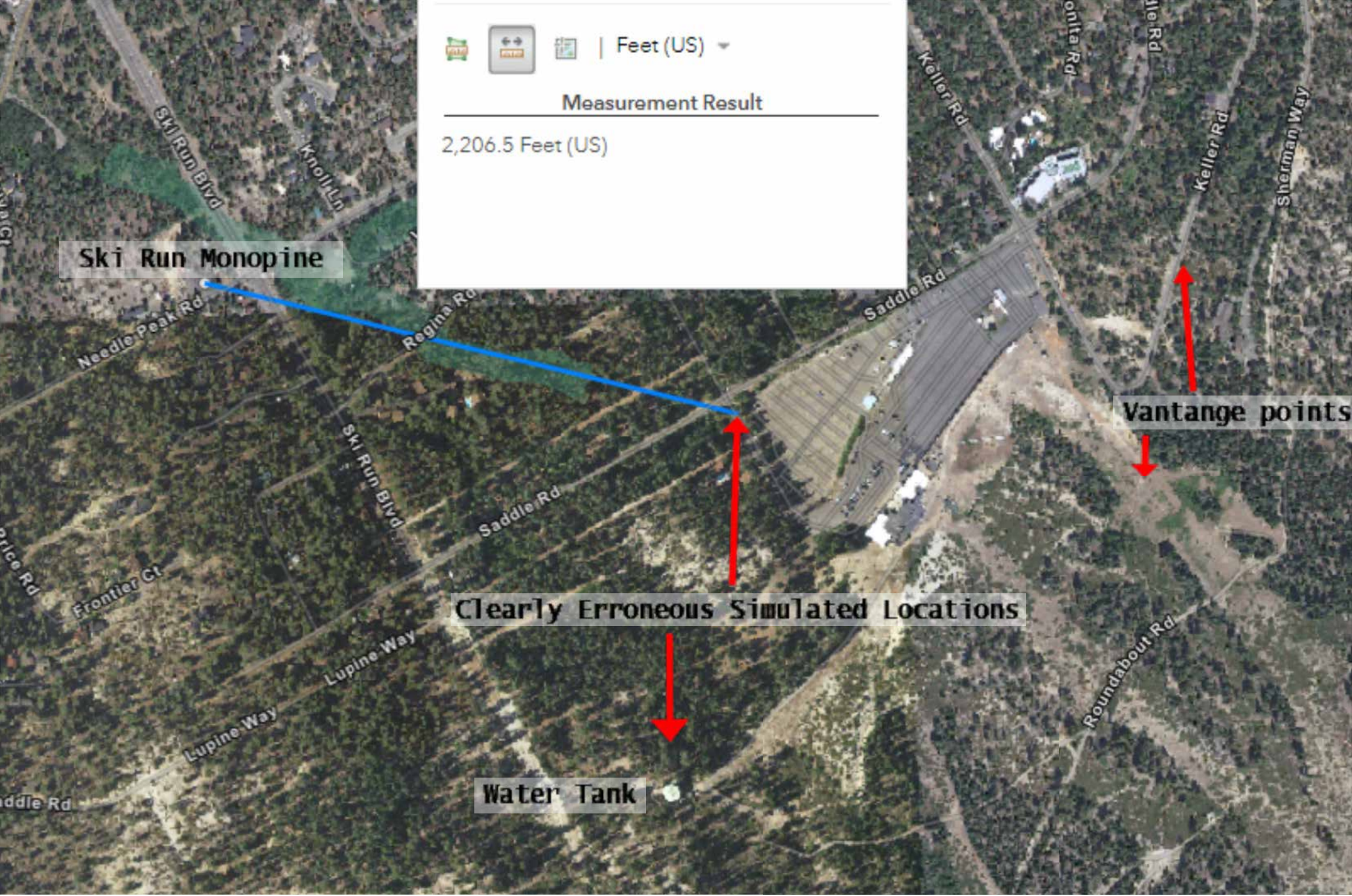
NEW



EXISTING



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Feet (US)
Measurement Result
2,206.5 Feet (US)
Ski Run Monopine
Vantange points
Clearly Erroneous Simulated Locations
Water Tank
Ski Run Blvd
Knoll Ln
Keller Rd
Sherman Way
Needle Peak Rd
Regina Rd
Saddle Rd
Frontier Ct
Lupine Way
Roundabout Rd

Angel's Roost Macro Tower & Lakeview Heights Small Cell



Angel's Roost Macro Tower antennas with faux plastic needles.



West Facing antenna array directly points at city center.

In the Ski Run Macro Tower application & appeal, Verizon lied to City of South Lake Tahoe Officials that: (1) Angel's Roost was entirely facing towards Monument Peak to service the Heavenly Ski Resort; (2) the panels couldn't face downward towards the City because of interference with the lake water—the elevation difference and the lake actually improve signal quality; (3) the monopine design was environmentally friendly.



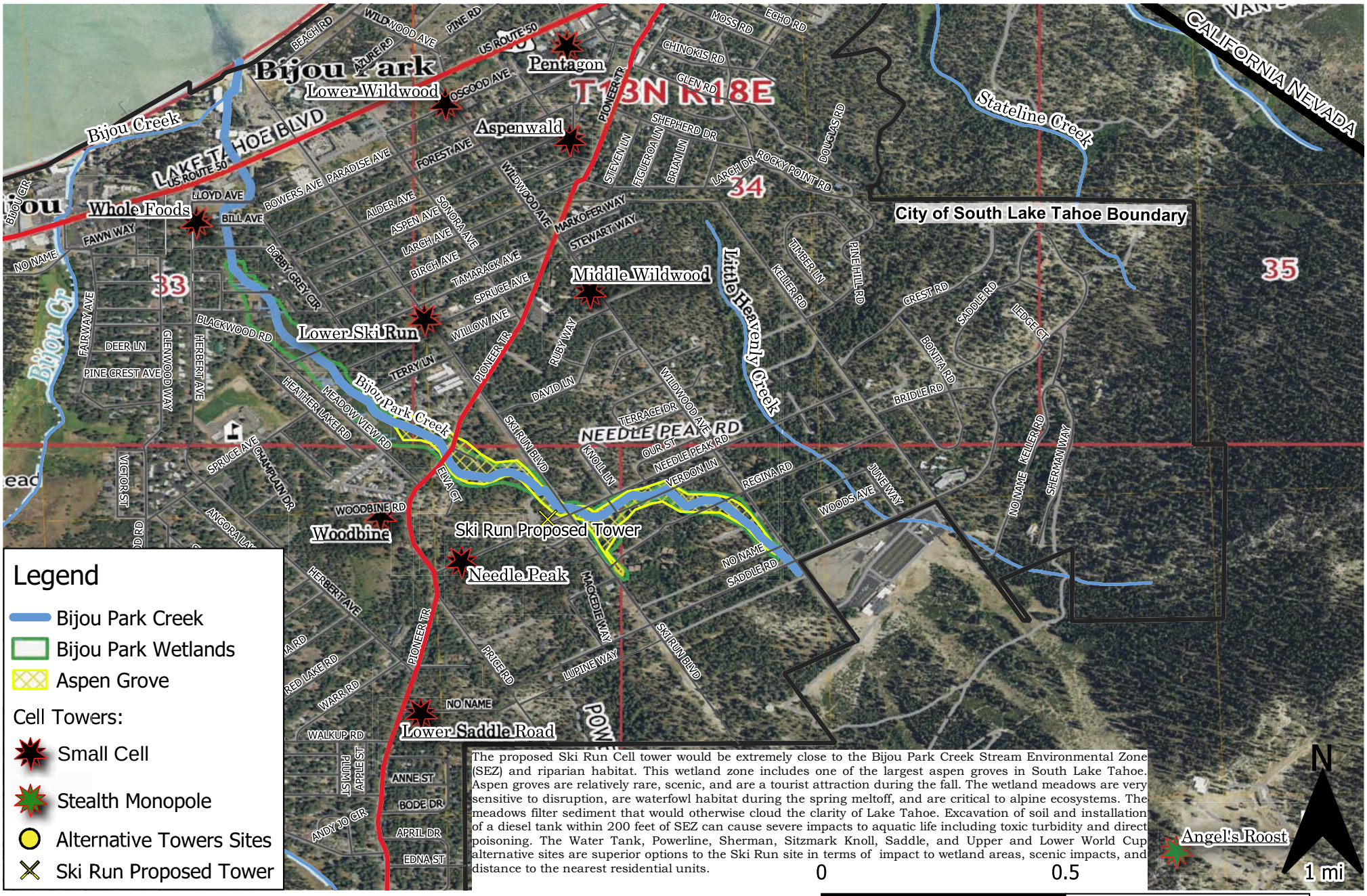
Nylon faux needles rapidly degrade into microplastics, which wash into protected Lake Tahoe.



Lakeview Heights Small Cell with Angel's Roost in the background (circled). All of the Angels Roost antennas face down upon the City of South Lake Tahoe.

EXHIBIT (A)(b) Fig.

Proposed Tower is Adjacent to Stream Environmental Zone (SEZ)



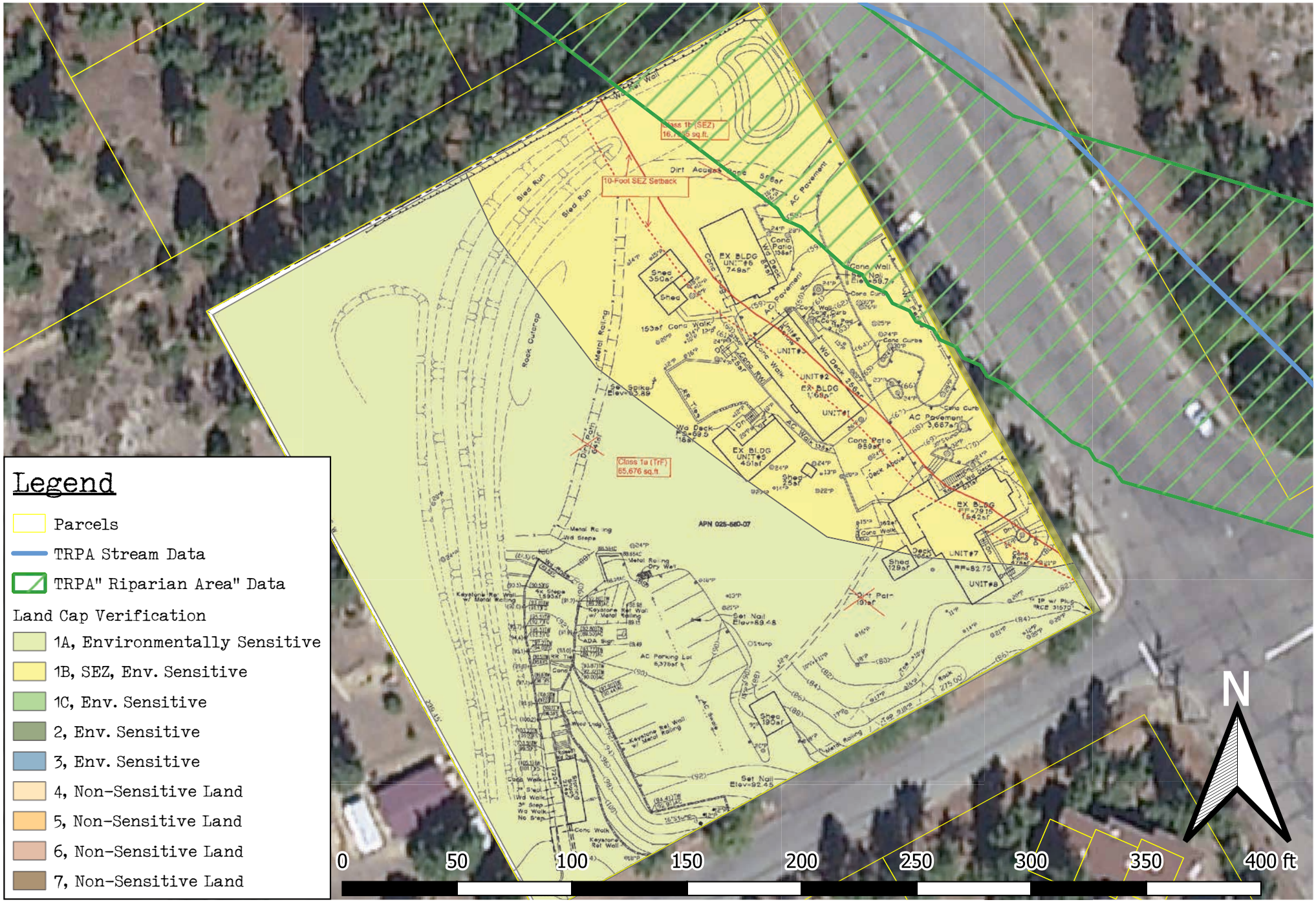
The proposed Ski Run Cell tower would be extremely close to the Bijou Park Creek Stream Environmental Zone (SEZ) and riparian habitat. This wetland zone includes one of the largest aspen groves in South Lake Tahoe. Aspen groves are relatively rare, scenic, and are a tourist attraction during the fall. The wetland meadows are very sensitive to disruption, are waterfowl habitat during the spring meltoff, and are critical to alpine ecosystems. The meadows filter sediment that would otherwise cloud the clarity of Lake Tahoe. Excavation of soil and installation of a diesel tank within 200 feet of SEZ can cause severe impacts to aquatic life including toxic turbidity and direct poisoning. The Water Tank, Powerline, Sherman, Sitzmark Knoll, Saddle, and Upper and Lower World Cup alternative sites are superior options to the Ski Run site in terms of impact to wetland areas, scenic impacts, and distance to the nearest residential units.

EXHIBIT (A)(b) Fig.

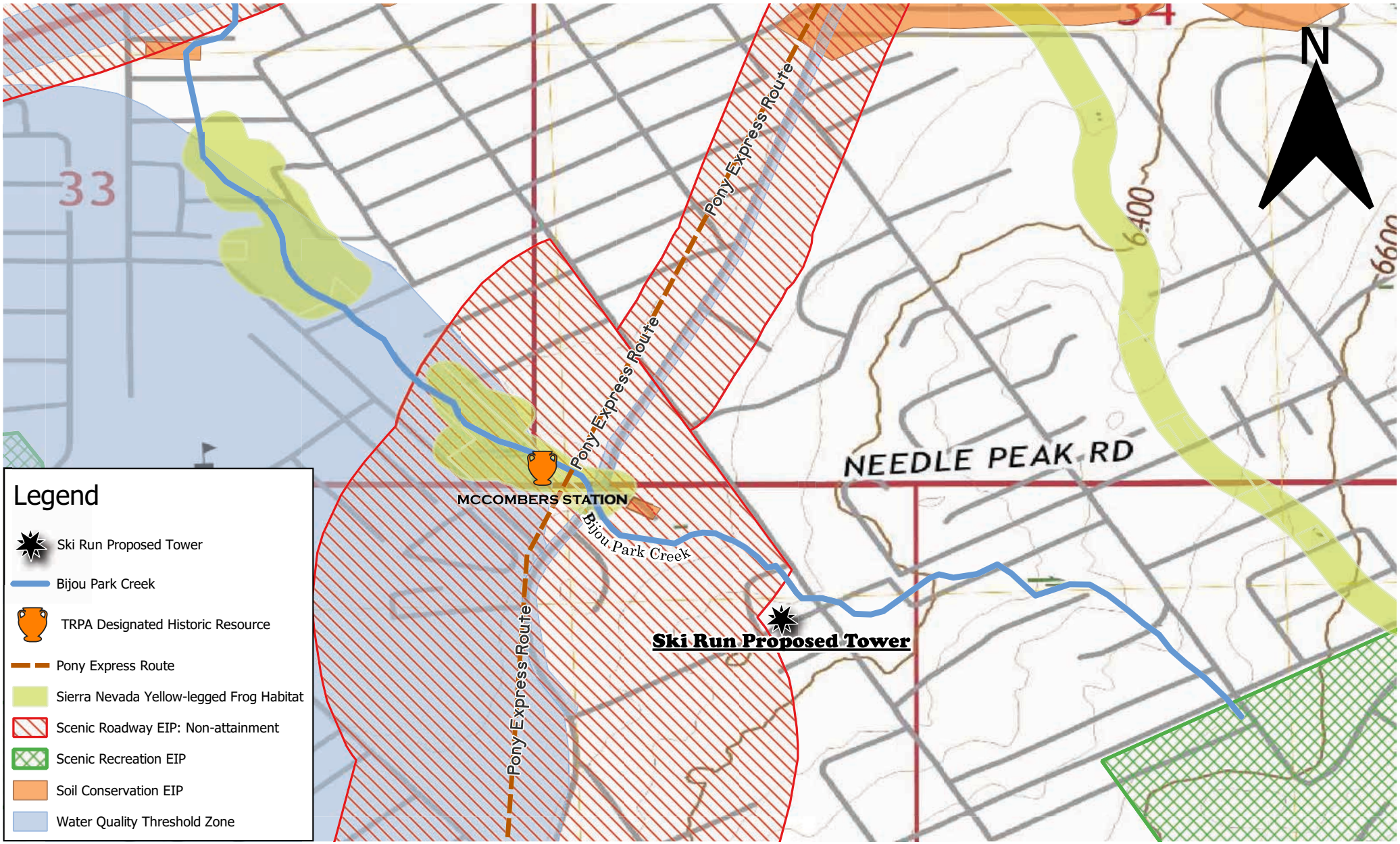
Bijou Park Creek Wetlands



The Gregory J. Cook Engineering Survey's Mapped SEZ in Relation to TRPA "Land Verification" Data.



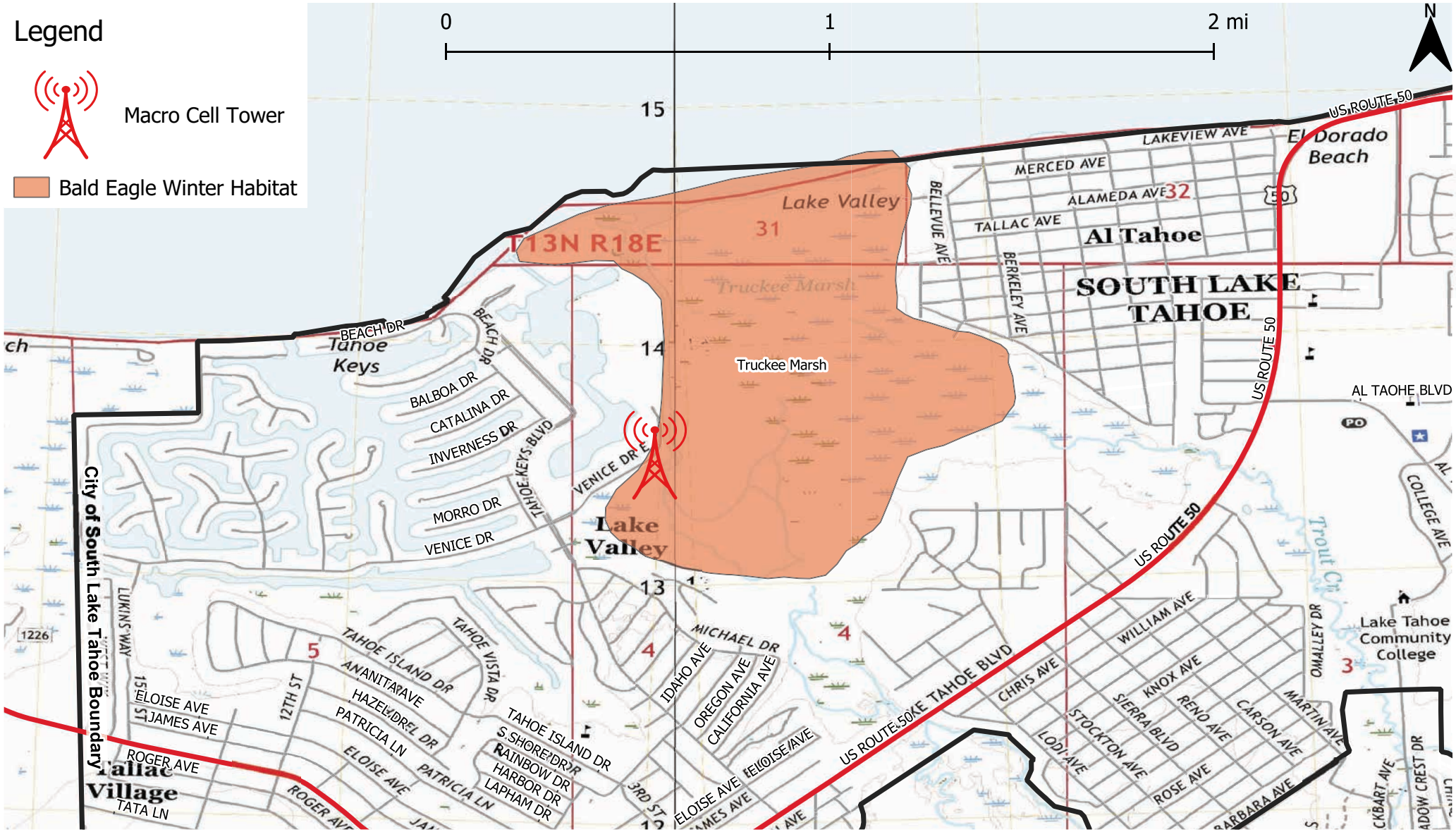
Applicant Neglected to Report Environmental and Cultural Resources



The NEPA Review performed by EBI Consulting on behalf of their client Verizon, omits the above sensitive environmental and cultural areas, as well as improvement (EIP) zones. In exercise of due diligence, this data ought to have been obtained by conferring with the local USFS field office and the Tahoe Regional Planning Agency.

EXHIBIT (A)(b) Fig.

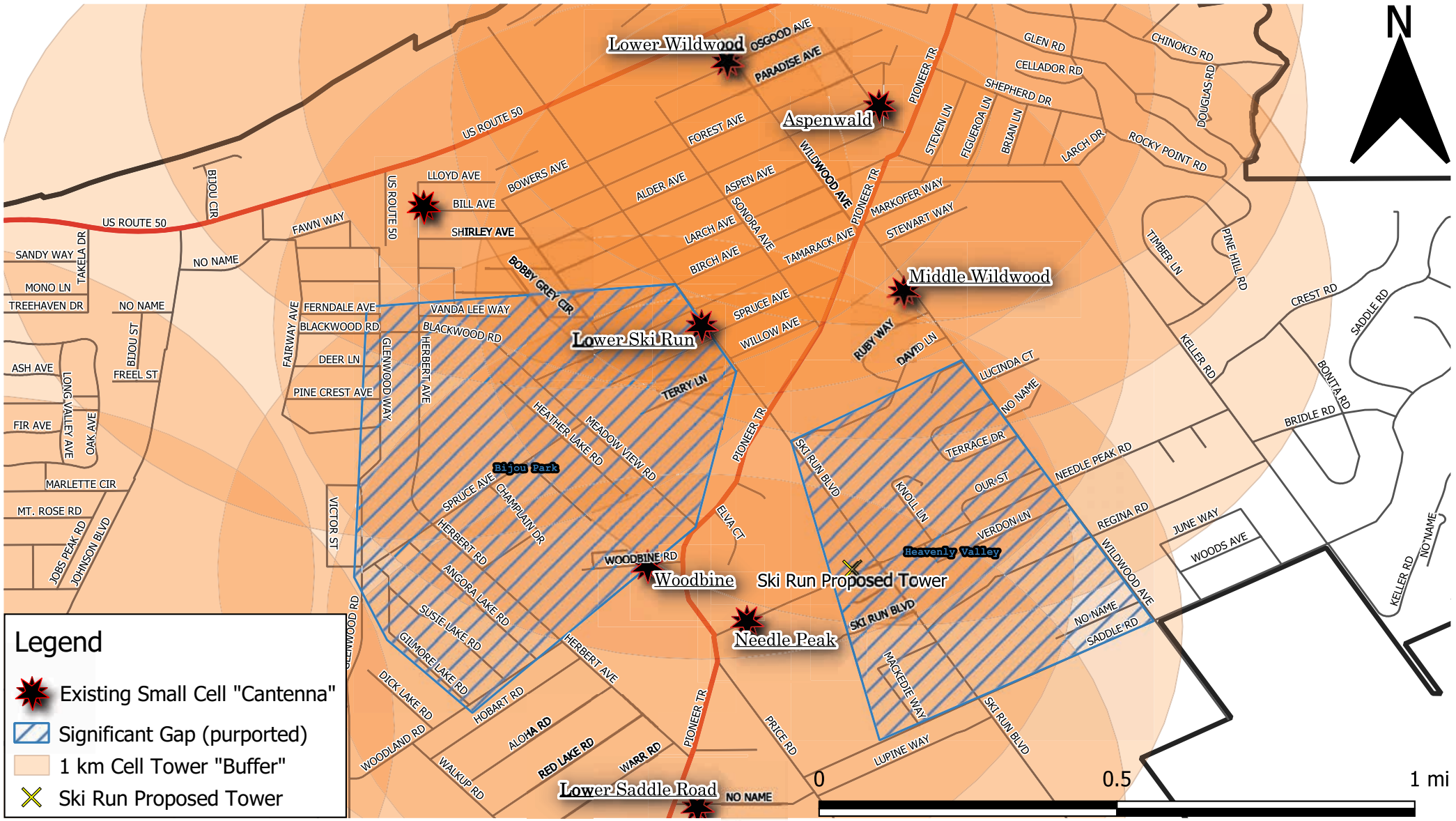
Truckee Marsh **Bald Eagle Winter Habitat**



This is the location of the Truckee Marsh Bald Eagle Winter Habitat, a mere two miles away from the proposed Ski Run Tower. Bald Eagles have an extensive flight range and regularly fly over the proposed tower site. The radiofrequency radiation exposure limits set by congressionally delegated agency regulation (47 C.F.R. §§ 1.1310, 22.913, 22.917, 22.982) are subordinate to Federal Statute protecting Bald Eagles (16 U.S.C. § 668 et. seq.). Notwithstanding agency limits, harassing or injuring Bald Eagles is expressly illegal. Presidential E.O. 13057 extends additional protections to the extraordinary natural, recreational, and ecological resources in the Lake Tahoe Region.

EXHIBIT (A)(c) Fig.

Prima Facie Evidence that Purported "Coverage Gap" is Incorrect

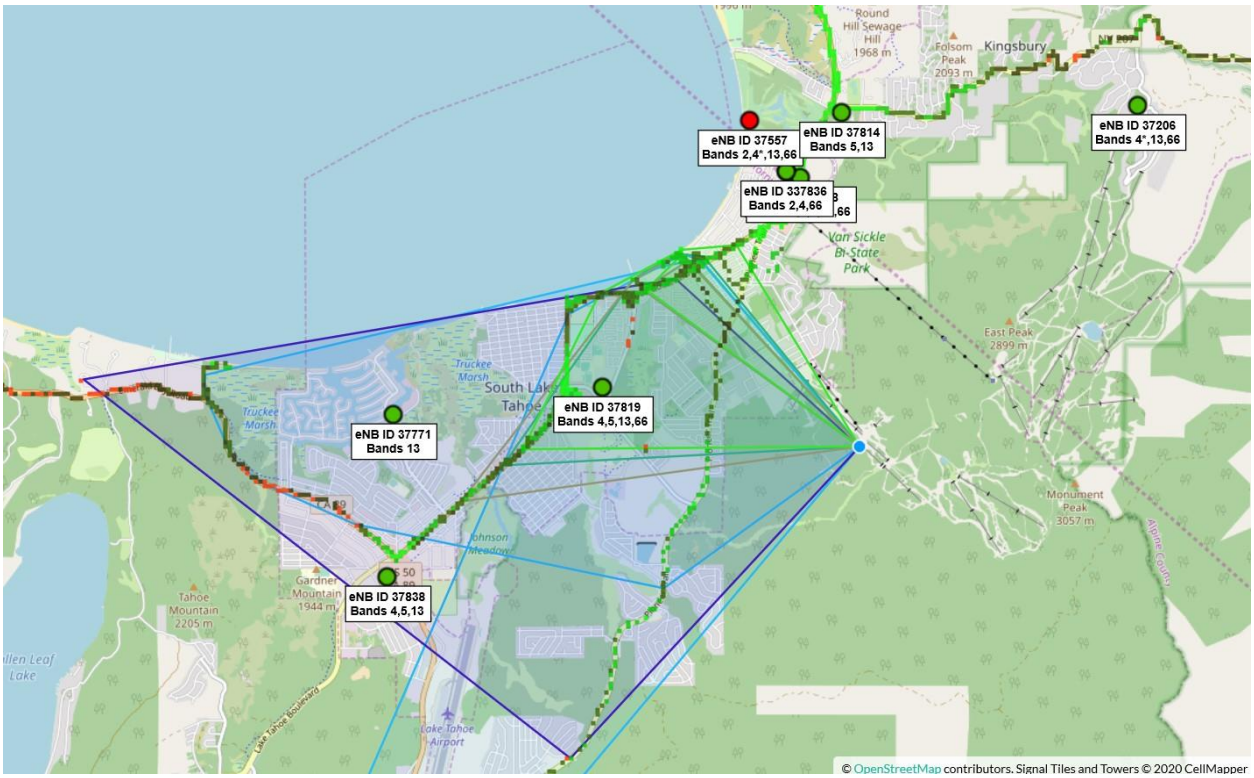


The blue cross-hatched area is where Verizon claims to have "a significant gap" in cell coverage, meaning that signal strength is inadequate to connect to their service—generally accepted to be less than -105 dBm. However, this purported gap is obviously surrounded by small cell towers. The manufacturer of these small cell "cantennas," Amphenol, claims they can reach 1-2km. The Bijou Park "significant gap" even has two directly adjacent cell towers. At first sight, it is facially clear that the gaps would have adequate service from the existent antennas. The ground truth is only ultimately proven by a signal measurement test; an adequate, well-documented test was performed by residents clearly proving adequate service. All RF modeling is inherently theoretical, being limited by the accuracy of the model, the software, the hardware, and the input data. Verizon lied with calculations of coverage by using dishonest model input data and never performing an actual signal measurement test.

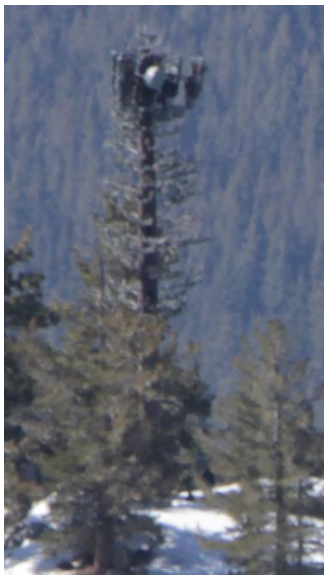
EXHIBIT (A)(c) Fig.

***Prima facie* evidence that the Angel's Roost Tower services the City of South Lake Tahoe**

The Angel's Roost macro cell tower has a large array of panels which are oriented to provide service to the town below. Macro cell towers have a powerful broadcast radius potential of 30 km (18.5 mi), greater than the width of Lake Tahoe; the alleged "significant gap" is a mile away.



It is also evident by direct inspection of the Angel's Roost cell facility, that its antenna panel arrays are directly pointed both northward and southwestward at the City of South Lake Tahoe. Verizon purported in its permit application to the city that the tower could only service the top of the seasonal ski resort, evidencing a "coverage gap," and hence the necessity of the Ski Run site.



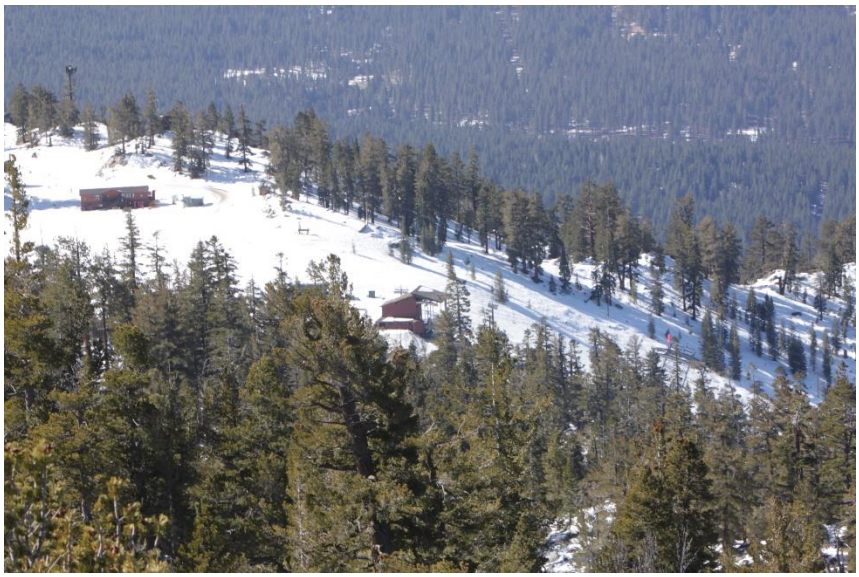
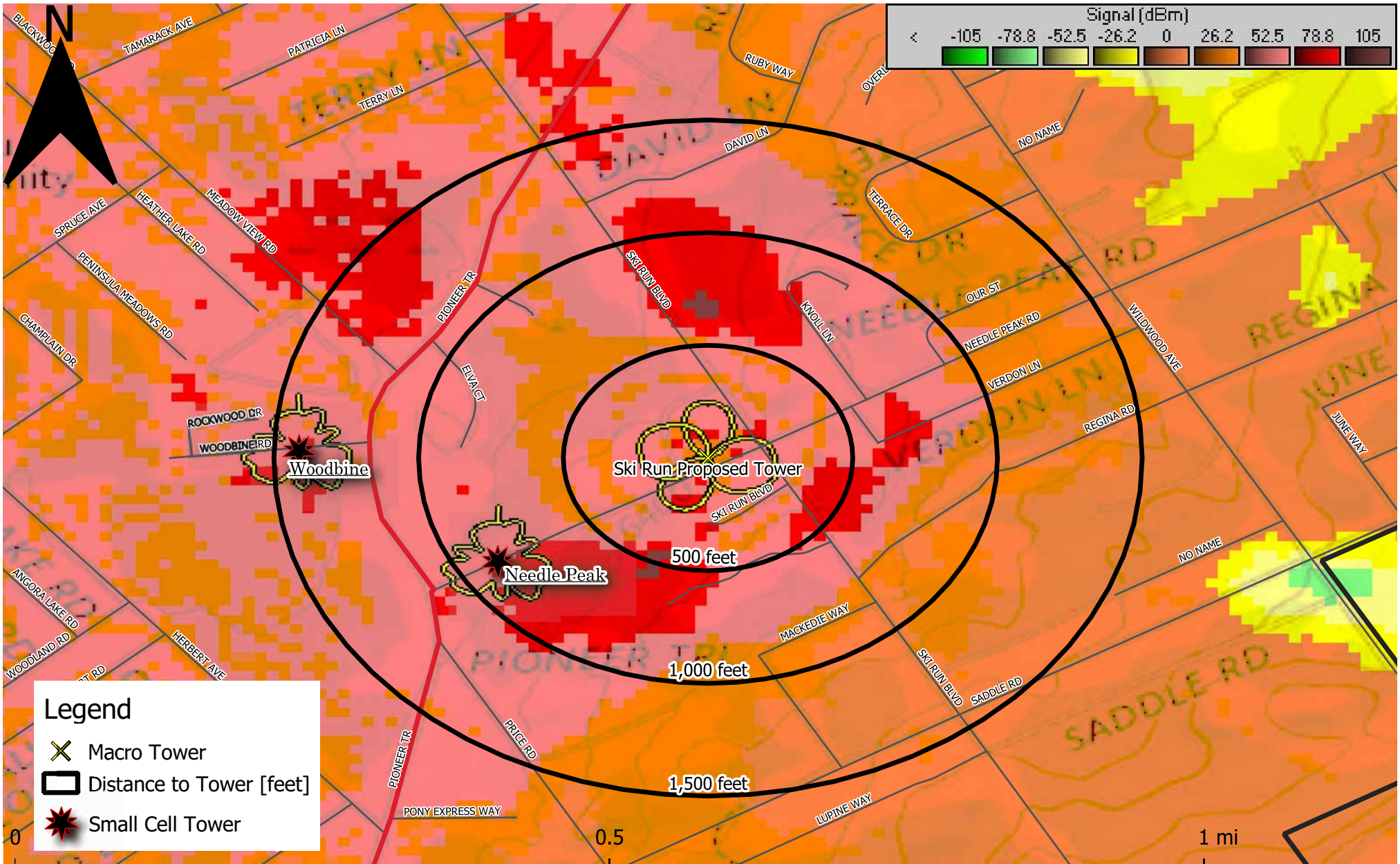


EXHIBIT (A)(e) Fig.

Radiation Pattern Surrounding Proposed Ski Run Macro Cell Tower



Macro cell towers are designed to reach up to 30 km (18.6 mi). The EMF intensity is colored in terms of signal intensity as measured in decibels. By definition, differences of 10 dBm are 10 times as strong. A signal strength greater than -105 dBm is an adequate signal strength, and -85 dBm is considered "very strong." The radiation intensity near the tower is +105 dBm! Maro cell towers are extremely powerful; the radiation intensity level within a 1-mile radius is far excessive of what's necessary to provide service. There is a high-intensity beam that makes contact with land in a portion of the Bijou Park Creek wetlands, adjacent to Blackwood/Meadowview Road; waterfowl have been seen to congregate here each spring.

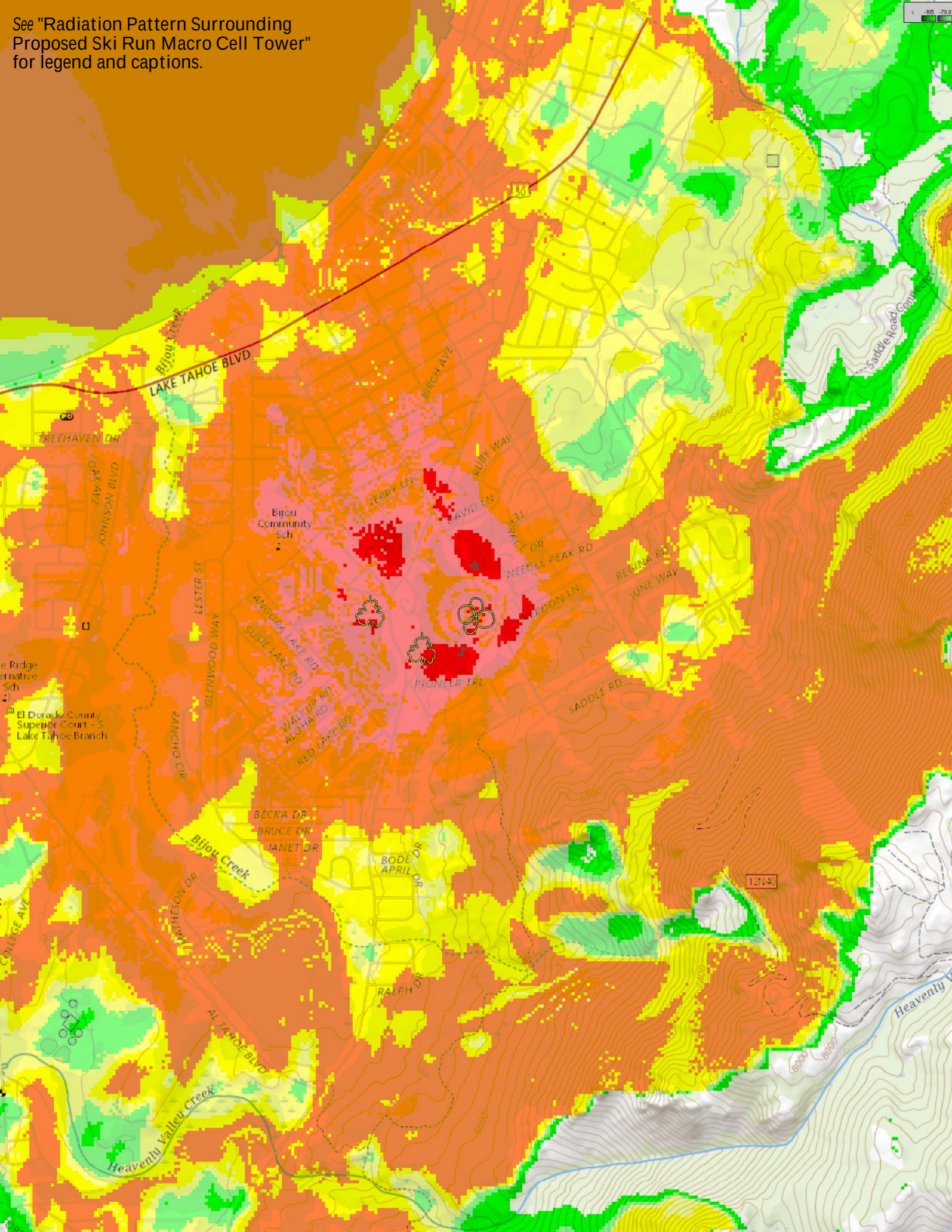
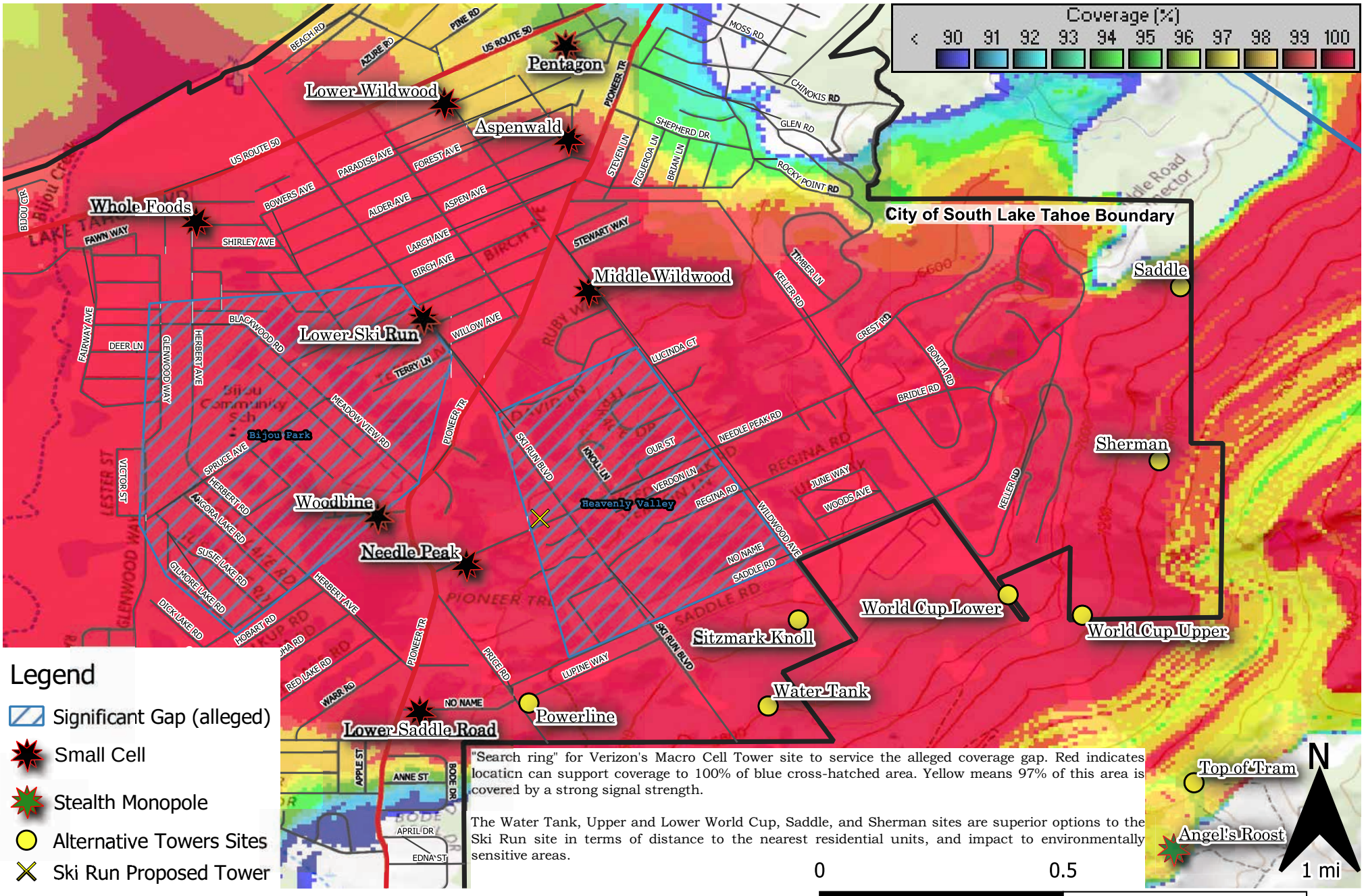

See "Radiation Pattern Surrounding Proposed Ski Run Macro Cell Tower" for legend and captions.
LAKE TAHOE BLVD
Bijou Creek
TREEHAVEN DR
OAK AVE
JOHNSON BLVD
LESTER ST
GLENWOOD WAY
BIRCH AVE
RUBY WAY
TERRY LN
DAVID LN
TERESA DR
NEEDLE PEAK RD
REGINA RD
JUNE WAY
LEDON LN
ANGORA LAKE RD
SUSIE LAKE RD
WALK UP RD
ALOHA RD
RED LAKE RD
PIONEER TRL
SADDLE RD
RANCHO CIR
BECKA DR
BRUCE DR
JANET DR
BODE DR
APRIL DR
MATHESON DR
COLLEGE AVE
RALPH DR
AL TAHOE BLVD
Heavenly Valley Creek
Saddle Road Connector
Heavenly
12N40
Bijou Community Sch
El Dorado County Superior Court - S Lake Tahoe Branch
6600
6800
7000
7200
7400
7600
8000

EXHIBIT (A)(d) Fig.

Actual Best Site Locations to Serve the Alleged "Coverage Gaps"



Legend

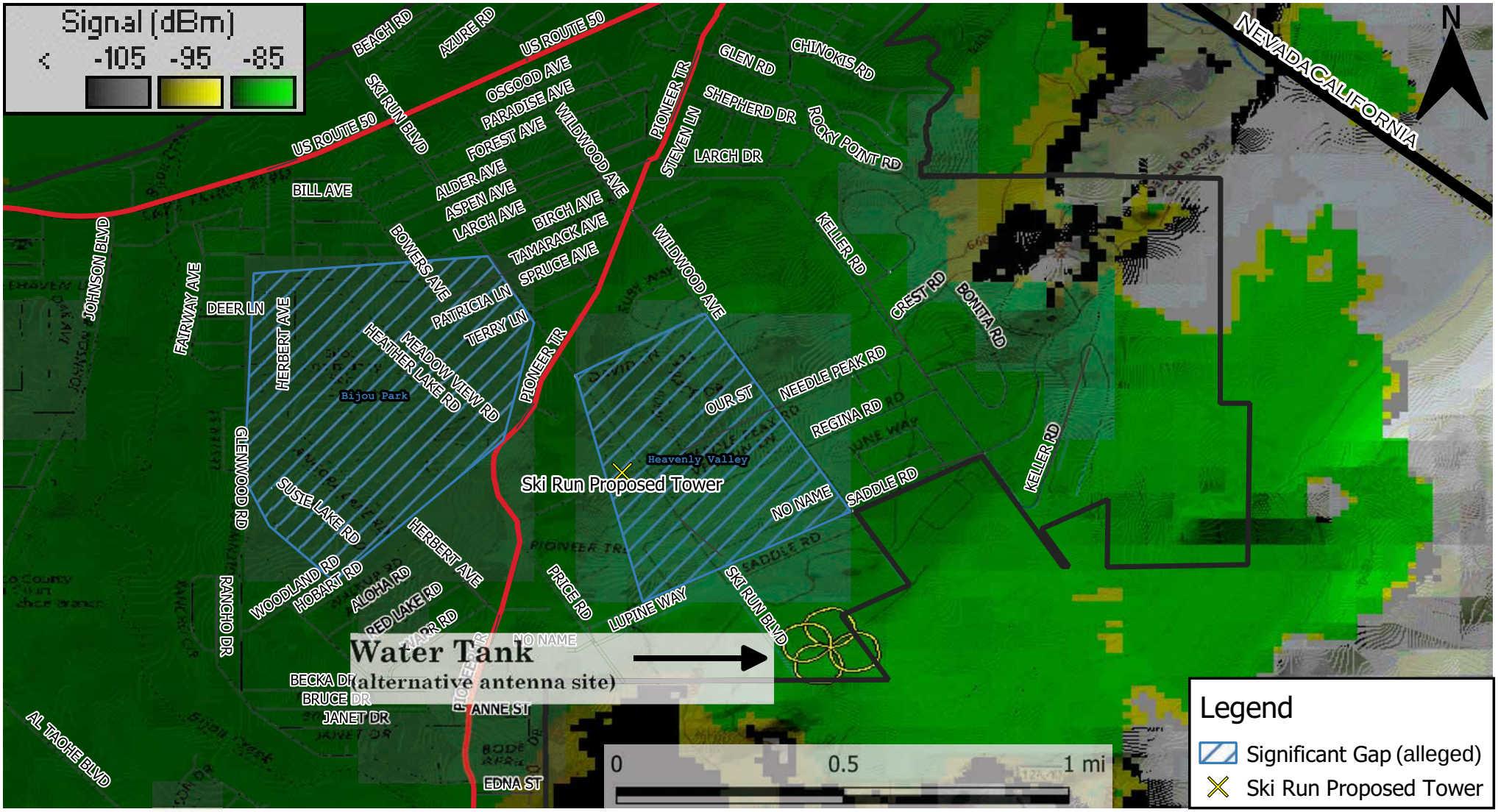
- Significant Gap (alleged)
- Small Cell
- Stealth Monopole
- Alternative Towers Sites
- Ski Run Proposed Tower

"Search ring" for Verizon's Macro Cell Tower site to service the alleged coverage gap. Red indicates location can support coverage to 100% of blue cross-hatched area. Yellow means 97% of this area is covered by a strong signal strength.

The Water Tank, Upper and Lower World Cup, Saddle, and Sherman sites are superior options to the Ski Run site in terms of distance to the nearest residential units, and impact to environmentally sensitive areas.

EXHIBIT (A)(e) Fig.

Alternative Site: Water Tank Services Purported "Coverage Gap"



Verizon alleged that the "Water Tank" prospective tower site is unable to provide coverage to the purported coverage gap. Their claim that this site will not work is easily proved false employing the Longley-Rice Propagation Model, and using the very CommScope Antennas—pattern files "NHH-65C" — proposed for the Ski Run Tower. The Yellow lobes depict the antenna orientation and 65-degree antenna pattern.

EXHIBIT (A)(e) Fig.

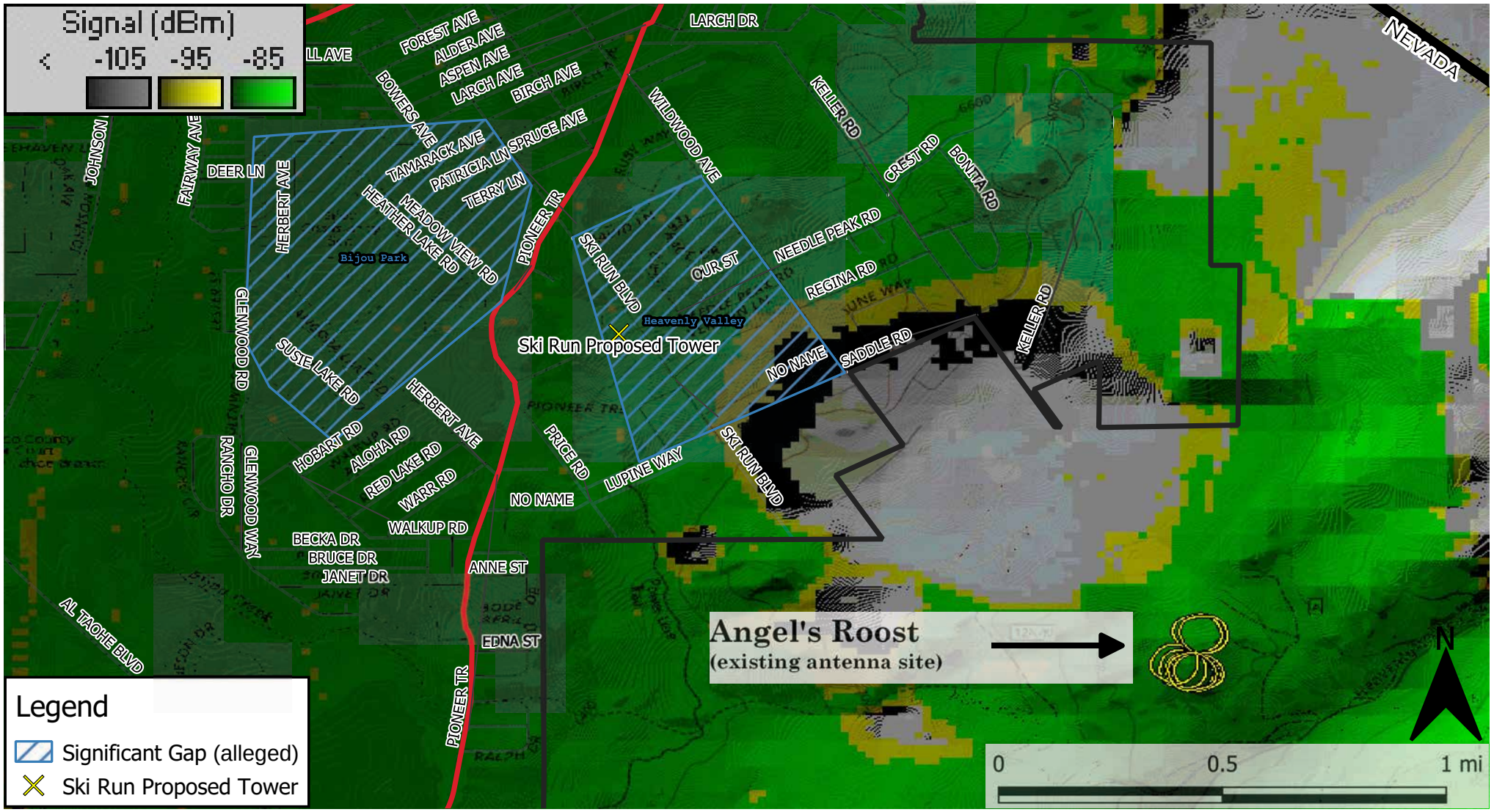
Alternative Site: Temple Bat Yam Services Purported "Coverage Gap"



Verizon alleged that the "Temple Bat Yam" prospective tower site is unable to provide coverage to the purported coverage gap. They asserted that the tower would need to be 180 feet tall in order to work and that such height would pose a danger to aircraft. However, this site is between three ASR registered towers that are 205 and 307 feet tall! Their claim that this height is necessary is easily proved false employing the Longley-Rice Propagation Model, and using the very CommScope Antennas—pattern files "NHH-65C" —proposed for the Ski Run Tower. The city manager requested Verizon use Temple Bat Yam as an alternative to the Ski Run site. The Yellow lobes depict the antenna orientation and 65-degree antenna pattern.

EXHIBIT (A)(e) Fig.

Alternative Site: Angel's Roost Services Purported "Coverage Gap"



Verizon alleged that the existing "Angel's Roost" macro tower is unable to provide coverage to the purported coverage gap. This claim is easily proved false employing the Longley-Rice Propagation Model, and using the very CommScope Antennas—pattern files "NHH-65C" —proposed for the Ski Run Tower. The Yellow lobes depict the antenna orientation and 65-degree antenna pattern. The lower right region of the Heavenly Valley "Coverage Gap" is devoid of residents, and can be serviced with a small or femtocell site. Verizon already has submitted an application for an adjacent stealth rooftop panel antenna array—atop the Tahoe Seasons Resort—that will certainly provide strong coverage to this corner.

EXHIBIT (A)(f) Fig.

ASR Referenced Towers Greater than 112 Feet



NHH-45C-R2B



6-port sector antenna, 2x 698–896 and 4x 1695–2360 MHz, 45° HPBW, 2x RETs and 2x SBTs. Both high bands share the same electrical tilt.

- Narrow beamwidth capacity antenna for higher level of densification and enhanced data throughput
- Internal SBT on low and high band allow remote RET control from the radio over the RF jumper cable
- Separate RS-485 RET input/output for low and high band
- One LB RET and one HB RET. Both high bands are controlled by one RET to ensure same tilt level for 4x Rx or 4x MIMO

Electrical Specifications

Frequency Band, MHz	**698–806**	**806–896**	**1695–1880**	**1850–1990**	**1920–2200**	**2300–2360**
Gain, dBi	18.1	18.4	19.5	20.0	20.4	20.8
Beamwidth, Horizontal, degrees	47	43	44	43	42	39
Beamwidth, Vertical, degrees	9.0	8.3	5.8	5.4	5.0	4.5
Beam Tilt, degrees	0–10	0–10	0–8	0–8	0–8	0–8
USLS (First Lobe), dB	17	20	19	20	20	21
Front-to-Back Ratio at 180°, dB	35	38	36	39	38	41
Isolation, Cross Polarization, dB	25	25	25	25	25	25
Isolation, Inter-band, dB	30	30	28	28	28	28
VSWR | Return Loss, dB	1.5 | 14.0	1.5 | 14.0	1.5 | 14.0	1.5 | 14.0	1.5 | 14.0	1.5 | 14.0
PIM, 3rd Order, 2 x 20 W, dBc	-153	-153	-153	-153	-153	-153
Input Power per Port, maximum, watts	300	300	300	300	300	250
Polarization	±45°	±45°	±45°	±45°	±45°	±45°
Impedance	50 ohm	50 ohm	50 ohm	50 ohm	50 ohm	50 ohm

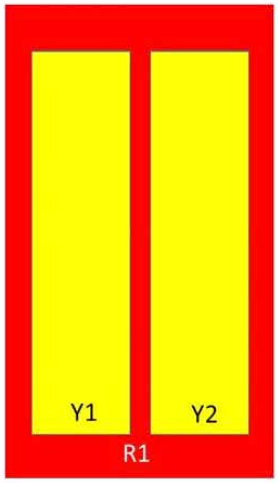
Electrical Specifications, BASTA*

Frequency Band, MHz	**698–806**	**806–896**	**1695–1880**	**1850–1990**	**1920–2200**	**2300–2360**
Gain by all Beam Tilts, average, dBi	17.8	18.3	19.1	19.8	20.1	20.6
Gain by all Beam Tilts Tolerance, dB	±0.4	±0.2	±0.5	±0.4	±0.3	±0.3
Gain by Beam Tilt, average, dBi	0 ° | 17.7 5 ° | 17.8 10 ° | 17.7	0 ° | 18.1 5 ° | 18.4 10 ° | 18.2	0 ° | 19.0 4 ° | 19.1 8 ° | 19.0	0 ° | 19.7 4 ° | 19.8 8 ° | 19.7	0 ° | 19.9 4 ° | 20.1 8 ° | 20.1	0 ° | 20.5 4 ° | 20.8 8 ° | 20.5
Beamwidth, Horizontal Tolerance, degrees	±1.3	±2.7	±1.8	±1.9	±1.6	±2.1
Beamwidth, Vertical Tolerance, degrees	±0.4	±0.2	±0.3	±0.2	±0.3	±0.1
USLS, beampeak to 20° above beampeak, dB	17	16	15	16	16	15
Front-to-Back Total Power at 180° ± 30°, dB	24	25	28	30	32	32
CPR at Boresight, dB	26	21	18	20	18	17
CPR at Sector, dB	19	17	12	13	15	16

* CommScope® supports NGMN recommendations on Base Station Antenna Standards (BASTA). To learn more about the benefits of BASTA, download the whitepaper Time to Raise the Bar on BSAs.

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Array Layout



Array	Freq (MHz)	Conns	RET (SRET)	AISG RET UID
R1	698-896	1-2	1	ANxxxxxxxxxxxxxxxx1
Y1	1695-2360	3-4	2	ANxxxxxxxxxxxxxxxx2
Y2	1695-2360	5-6		

(Sizes of colored boxes are not true depictions of array sizes)

Port Configuration



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NHH-45C-R2B

General Specifications

Operating Frequency Band	1695 – 2360 MHz | 698 – 896 MHz
Antenna Type	Sector
Band	Multiband
Performance Note	Outdoor usage | Wind loading figures are validated by wind tunnel measurements described in white paper WP-112534-EN
Total Input Power, maximum	800 W @ 50 °C

Mechanical Specifications

RF Connector Quantity, total	6
RF Connector Quantity, low band	2
RF Connector Quantity, high band	4
RF Connector Interface	4.3-10 Female
Color	Light gray
Grounding Type	RF connector body grounded to reflector and mounting bracket
Radiator Material	Aluminum | Low loss circuit board
Radome Material	Fiberglass, UV resistant
Reflector Material	Aluminum
RF Connector Location	Bottom
Wind Loading, frontal	1,485.0 N @ 150 km/h
Wind Loading, lateral	315.0 N @ 150 km/h
Wind Loading, maximum	1,485.0 N @ 150 km/h | 333.8 N @ 150 km/h
Effective Projected Area (EPA), frontal	1.40 m^2 | 15.07 ft^2
Effective Projected Area (EPA), lateral	0.30 m^2 | 3.23 ft^2
Wind Speed, maximum	241 km/h | 150 mph

Dimensions

Length	2437.0 mm | 95.9 in
Width	457.0 mm | 18.0 in
Depth	178.0 mm | 7.0 in
Net Weight, without mounting kit	39.5 kg | 87.1 lb

Remote Electrical Tilt (RET) Information

Input Voltage	10–30 Vdc
Internal Bias Tee	Port 1 | Port 3
Internal RET	High band (1) | Low band (1)
Power Consumption, idle state, maximum	1 W
Power Consumption, normal conditions, maximum	10 W
Protocol	3GPP/AISG 2.0 (Single RET)

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NHH-45C-R2B

RET Interface	8-pin DIN Female | 8-pin DIN Male
RET Interface, quantity	2 female | 2 male

Packed Dimensions

Length	2579.0 mm | 101.5 in
Width	608.0 mm | 23.9 in
Depth	346.0 mm | 13.6 in
Shipping Weight	64.8 kg | 142.9 lb

Regulatory Compliance/Certifications

Agency	**Classification**
RoHS 2011/65/EU	Compliant by Exemption
ISO 9001:2015	Designed, manufactured and/or distributed under this quality management system
China RoHS SJ/T 11364-2014	Above Maximum Concentration Value (MCV)

Included Products

BSAMNT-M — Middle Downtilt Mounting Kit for Long Antennas for 2.4 - 4.5 in (60 - 115 mm) OD round members. Kit contains one scissor bracket set.

BSAMNT-3 — Wide Profile Antenna Downtilt Mounting Kit for 2.4 - 4.5 in (60 - 115 mm) OD round members. Kit contains one scissor top bracket set and one bottom bracket set.

* Footnotes

Performance Note	Severe environmental conditions may degrade optimum performance

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BSAMNT-M



Middle Downtilt Mounting Kit for Long Antennas for 2.4 - 4.5 in (60 - 115 mm) OD round members. Kit contains one scissor bracket set.

General Specifications

Application	Outdoor
Includes	Brackets | Hardware
Package Quantity	1

Mechanical Specifications

Color	Silver
Material Type	Galvanized steel

Dimensions

Compatible Diameter, maximum	114.3 mm | 4.5 in
Compatible Diameter, minimum	61.0 mm | 2.4 in
Net Weight	4.5 kg | 9.9 lb

Regulatory Compliance/Certifications

Agency	Classification
RoHS 2011/65/EU	Compliant by Exemption
ISO 9001:2015	Designed, manufactured and/or distributed under this quality management system
China RoHS SJ/T 11364-2014	Above Maximum Concentration Value (MCV)

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BSAMNT-3



Wide Profile Antenna Downtilt Mounting Kit for 2.4 - 4.5 in (60 - 115 mm) OD round members. Kit contains one scissor top bracket set and one bottom bracket set.

General Specifications

Application	Outdoor
Includes	Brackets | Hardware
Package Quantity	1

Mechanical Specifications

Color	Silver
Material Type	Galvanized steel

Dimensions

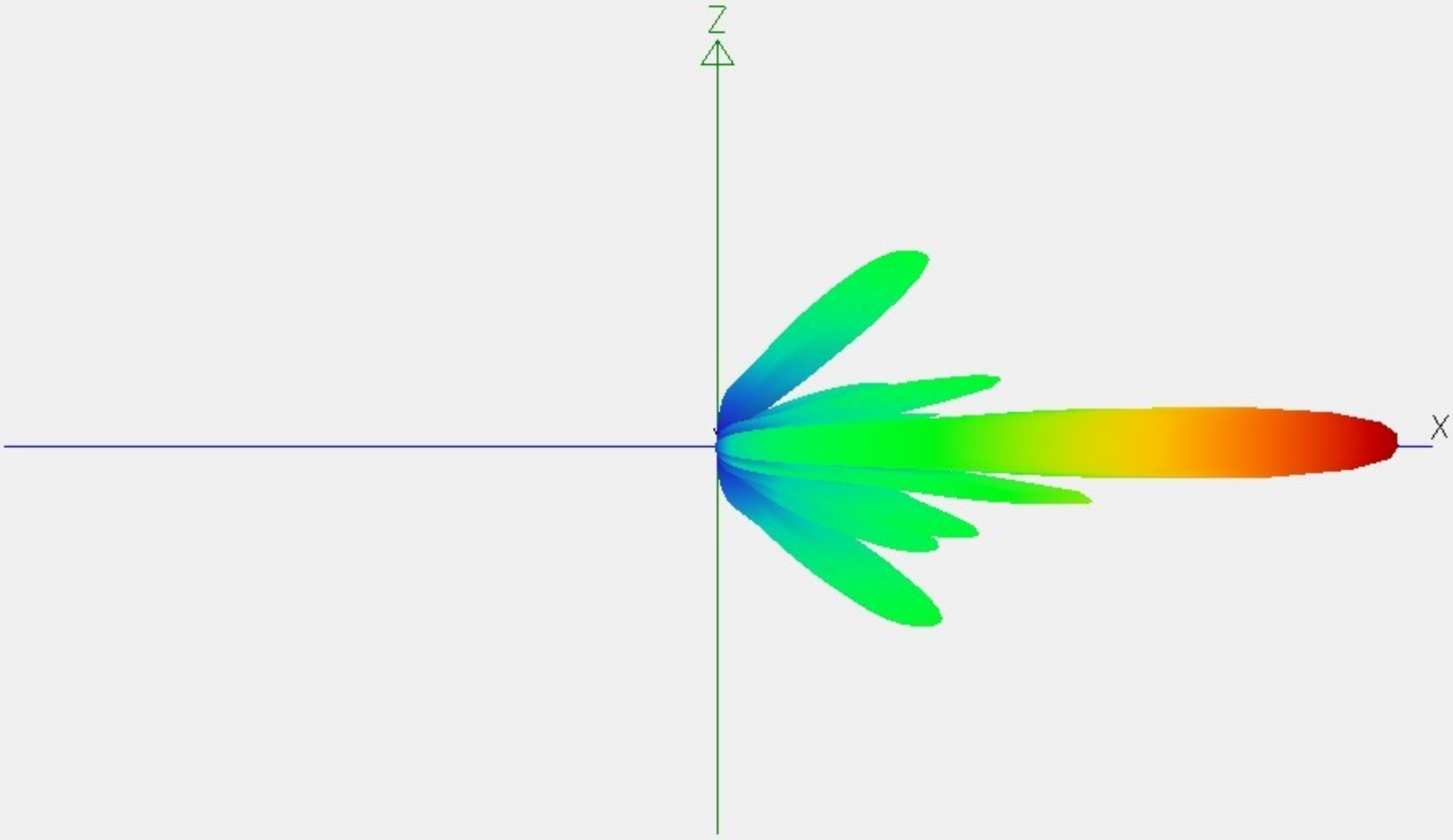
Compatible Diameter, maximum	114.3 mm | 4.5 in
Compatible Diameter, minimum	61.0 mm | 2.4 in
Net Weight	6.2 kg | 13.7 lb

Regulatory Compliance/Certifications

Agency	**Classification**
RoHS 2011/65/EU	Compliant by Exemption
ISO 9001:2015	Designed, manufactured and/or distributed under this quality management system
China RoHS SJ/T 11364-2014	Above Maximum Concentration Value (MCV)
CE	Compliant with the relevant CE product directives

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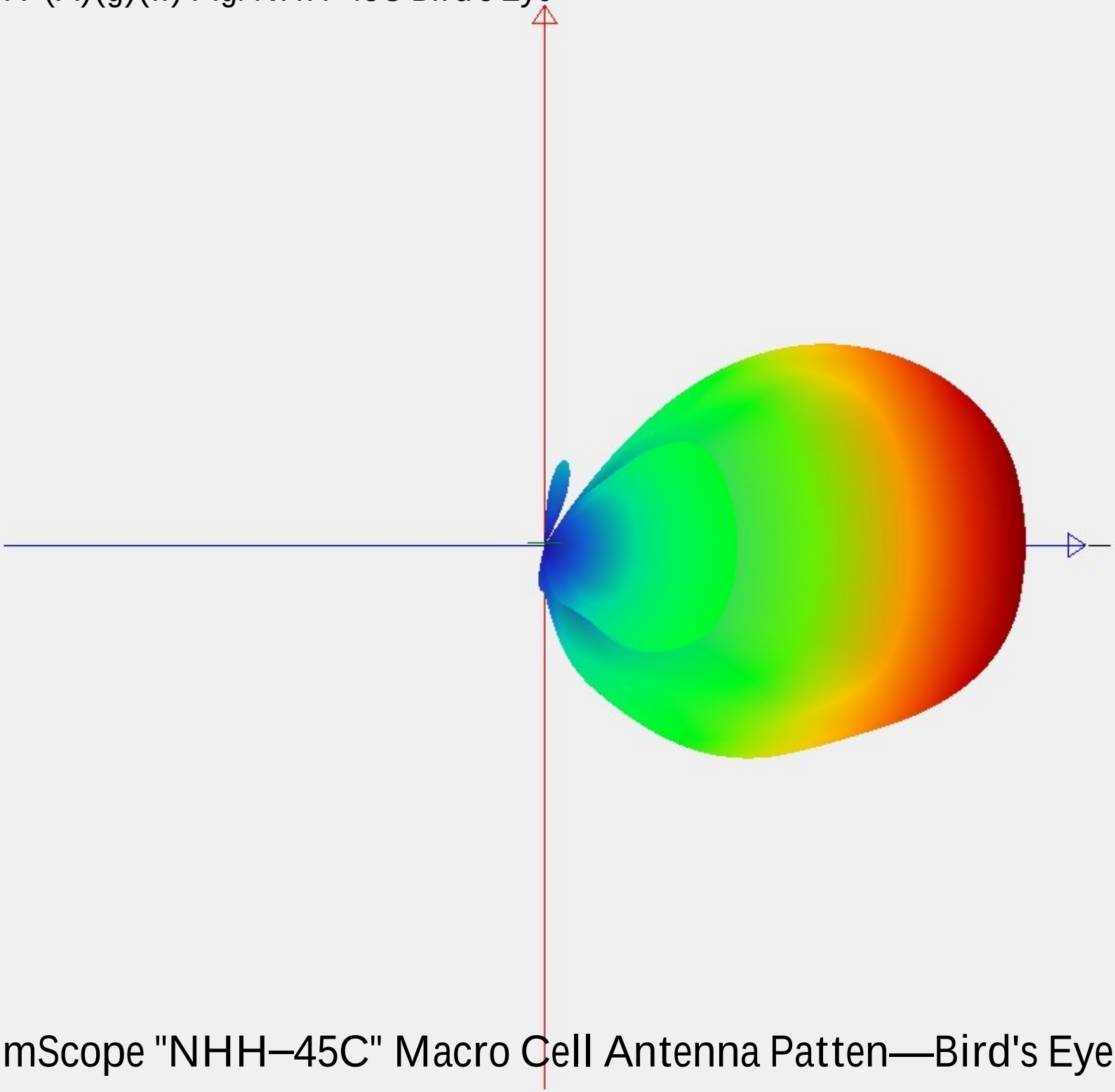
EXHIBIT (A)(g)(ii) Fig. NHH-45C Side View



CommScope "NHH–45C" Macro Cell Antenna Patten—Side View

Note: the small spikes are called "side lobes." These artifacts of the antenna pattern are considered wasted energy that is sent off–beam. The lower side lobes focus intense radiofrequency radiation down into adjacent residences and public areas.

EXHIBIT (A)(g)(ii) Fig. NHH-45C Bird's Eye



CommScope "NHH–45C" Macro Cell Antenna Patten—Bird's Eye View

EXHIBIT (A)(g)(i)

NHH-65C-R2B



6-port sector antenna, 2x 698–896 and 4x 1695–2360 MHz, 65° HPBW, 2x RET. Both high bands share the same electrical tilt.

- Interleaved dipole technology providing for attractive, low wind load mechanical package
- Internal SBT on low and high band allow remote RET control from the radio over the RF jumper cable
- Separate RS-485 RET input/output for low and high band
- One RET for low band and one RET for both high bands to ensure same tilt level for 4x Rx or 4x MIMO

Electrical Specifications

Frequency Band, MHz	**698–806**	**806–896**	**1695–1880**	**1850–1990**	**1920–2200**	**2300–2360**
Gain, dBi	16.0	16.1	17.3	17.7	18.3	18.2
Beamwidth, Horizontal, degrees	65	62	74	66	62	59
Beamwidth, Vertical, degrees	9.0	7.9	5.6	5.2	4.9	4.5
Beam Tilt, degrees	0–11	0–11	0–7	0–7	0–7	0–7
USLS (First Lobe), dB	21	18	19	20	22	18
Front-to-Back Ratio at 180°, dB	35	31	33	29	29	30
Isolation, Cross Polarization, dB	25	25	25	25	25	25
Isolation, Inter-band, dB	30	30	30	30	30	30
VSWR | Return Loss, dB	1.5 | 14.0	1.5 | 14.0	1.5 | 14.0	1.5 | 14.0	1.5 | 14.0	1.5 | 14.0
PIM, 3rd Order, 2 x 20 W, dBc	-153	-153	-153	-153	-153	-153
Input Power per Port, maximum, watts	400	400	350	350	350	300
Polarization	±45°	±45°	±45°	±45°	±45°	±45°
Impedance	50 ohm	50 ohm	50 ohm	50 ohm	50 ohm	50 ohm

Electrical Specifications, BASTA*

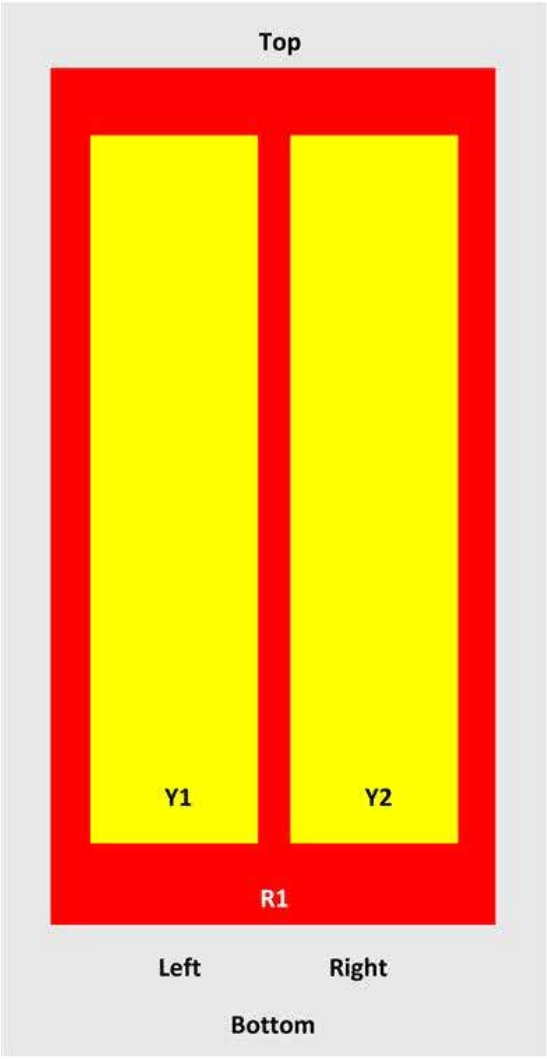
Frequency Band, MHz	**698–806**	**806–896**	**1695–1880**	**1850–1990**	**1920–2200**	**2300–2360**
Gain by all Beam Tilts, average, dBi	15.8	15.9	16.9	17.5	18.0	17.9
Gain by all Beam Tilts Tolerance, dB	±0.4	±0.4	±0.4	±0.3	±0.6	±0.4
Gain by Beam Tilt, average, dBi	0 ° | 15.9 5 ° | 15.9 11 ° | 15.5	0 ° | 15.8 5 ° | 16.0 11 ° | 15.7	0 ° | 16.9 4 ° | 17.0 7 ° | 16.9	0 ° | 17.4 4 ° | 17.5 7 ° | 17.4	0 ° | 17.9 4 ° | 18.0 7 ° | 18.0	0 ° | 17.8 4 ° | 17.9 7 ° | 17.9
Beamwidth, Horizontal Tolerance, degrees	±1.2	±1.6	±5.3	±3.4	±6	±3.1
Beamwidth, Vertical Tolerance, degrees	±0.6	±0.4	±0.3	±0.2	±0.2	±0.2
USLS, beampeak to 20° above beampeak, dB	15	14	17	16	17	15
Front-to-Back Total Power at 180° ± 30°, dB	26	24	28	25	25	24
CPR at Boresight, dB	18	26	20	25	20	17
CPR at Sector, dB	15	9	11	10	8	2

* CommScope® supports NGMN recommendations on Base Station Antenna Standards (BASTA). To learn more about the benefits of BASTA, download the whitepaper Time to Raise the Bar on BSAs.

Array Layout

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NHH



Array	Freq (MHz)	Conns	RET (SRET)	AISG RET UID
R1	698-896	1-2	1	ANxxxxxxxxxxxxxxxx1
Y1	1695-2360	3-4	2	ANxxxxxxxxxxxxxxxx2
Y2	1695-2360	5-6		

View from the front of the antenna

(Sizes of colored boxes are not true depictions of array sizes)

General Specifications

Operating Frequency Band	1695 – 2360 MHz | 698 – 896 MHz
Antenna Type	Sector

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Band	Multiband
Performance Note	Outdoor usage | Wind loading figures are validated by wind tunnel measurements described in white paper WP-112534-EN
Total Input Power, maximum	500 W @ 50 °C

Mechanical Specifications

RF Connector Quantity, total	6
RF Connector Quantity, low band	2
RF Connector Quantity, high band	4
RF Connector Interface	7-16 DIN Female
Color	Light gray
Grounding Type	RF connector body grounded to reflector and mounting bracket
Radiator Material	Copper | Low loss circuit board
Radome Material	Fiberglass, UV resistant
Reflector Material	Aluminum
RF Connector Location	Bottom
Wind Loading, frontal	393.0 N @ 150 km/h | 88.8 lbf @ 150 km/h
Wind Loading, lateral	330.0 N @ 150 km/h | 74.2 lbf @ 150 km/h
Wind Loading, maximum	170.2 lbf @ 150 km/h | 757.0 N @ 150 km/h
Effective Projected Area (EPA), frontal	0.37 m^2 | 3.98 ft^2
Effective Projected Area (EPA), lateral	0.31 m^2 | 3.34 ft^2
Wind Speed, maximum	241 km/h | 150 mph

Dimensions

Length	2438.0 mm | 96.0 in
Width	301.0 mm | 11.9 in
Depth	180.0 mm | 7.1 in
Net Weight, without mounting kit	23.4 kg | 51.6 lb

Remote Electrical Tilt (RET) Information

Input Voltage	10–30 Vdc
Internal Bias Tee	Port 1 | Port 3
Internal RET	High band (1) | Low band (1)
Power Consumption, idle state, maximum	2 W
Power Consumption, normal conditions, maximum	13 W
Protocol	3GPP/AISG 2.0 (Single RET)
RET Interface	8-pin DIN Female | 8-pin DIN Male
RET Interface, quantity	2 female | 2 male

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Packed Dimensions

Length	2561.0 mm | 100.8 in
Width	409.0 mm | 16.1 in
Depth	299.0 mm | 11.8 in
Shipping Weight	36.1 kg | 79.6 lb

Regulatory Compliance/Certifications

Agency	**Classification**
RoHS 2011/65/EU	Compliant by Exemption
ISO 9001:2015	Designed, manufactured and/or distributed under this quality management system
China RoHS SJ/T 11364-2014	Above Maximum Concentration Value (MCV)

Included Products

BSAMNT-3 — Wide Profile Antenna Downtilt Mounting Kit for 2.4 - 4.5 in (60 - 115 mm) OD round members. Kit contains one scissor top bracket set and one bottom bracket set.

* Footnotes

Performance Note	Severe environmental conditions may degrade optimum performance

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BSAMNT-3



Wide Profile Antenna Downtilt Mounting Kit for 2.4 - 4.5 in (60 - 115 mm) OD round members. Kit contains one scissor top bracket set and one bottom bracket set.

General Specifications

Application	Outdoor
Includes	Brackets | Hardware
Package Quantity	1

Mechanical Specifications

Color	Silver
Material Type	Galvanized steel

Dimensions

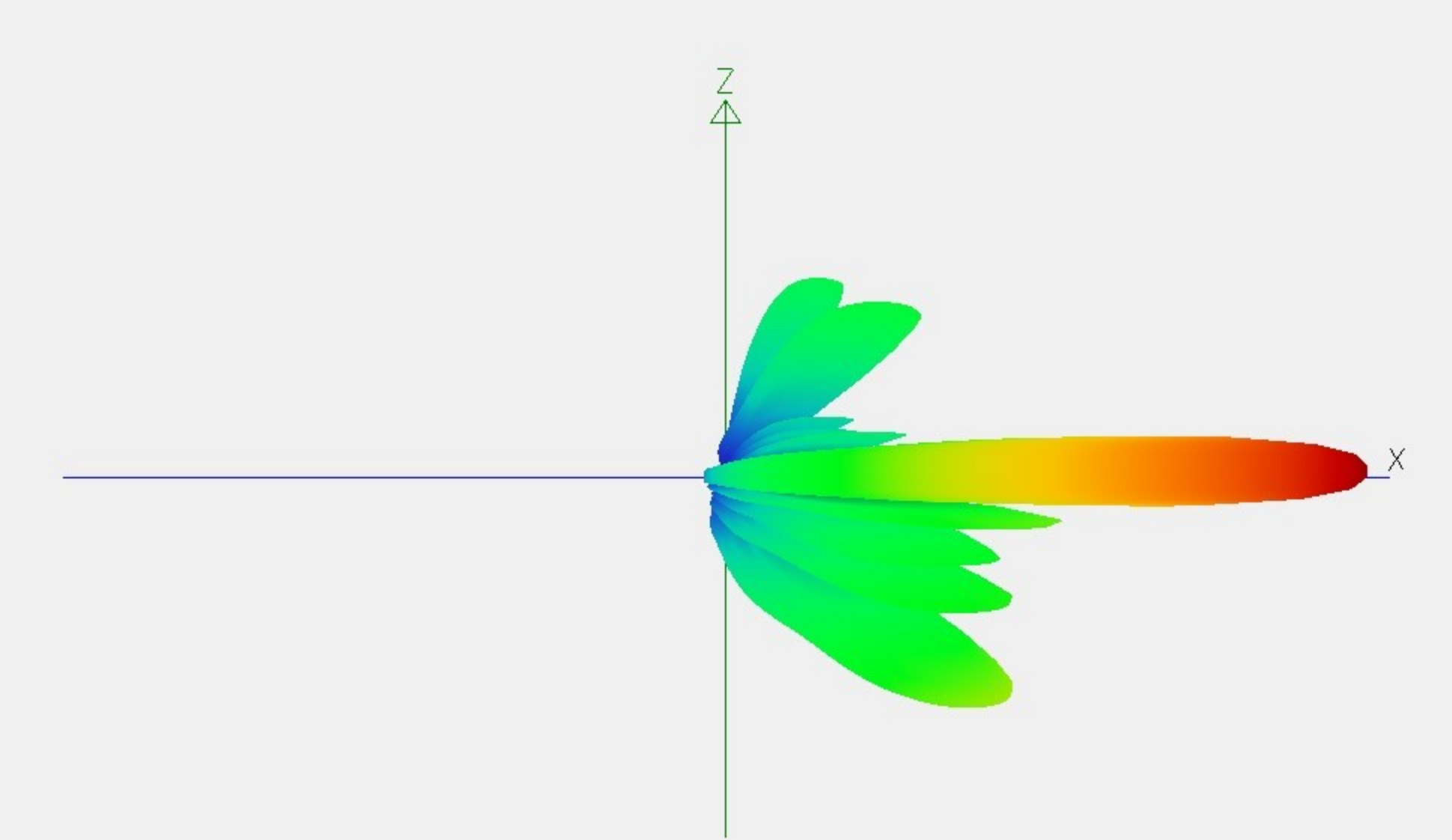
Compatible Diameter, maximum	114.3 mm | 4.5 in
Compatible Diameter, minimum	61.0 mm | 2.4 in
Net Weight	6.2 kg | 13.7 lb

Regulatory Compliance/Certifications

Agency	**Classification**
RoHS 2011/65/EU	Compliant by Exemption
ISO 9001:2015	Designed, manufactured and/or distributed under this quality management system
China RoHS SJ/T 11364-2014	Above Maximum Concentration Value (MCV)
CE	Compliant with the relevant CE product directives

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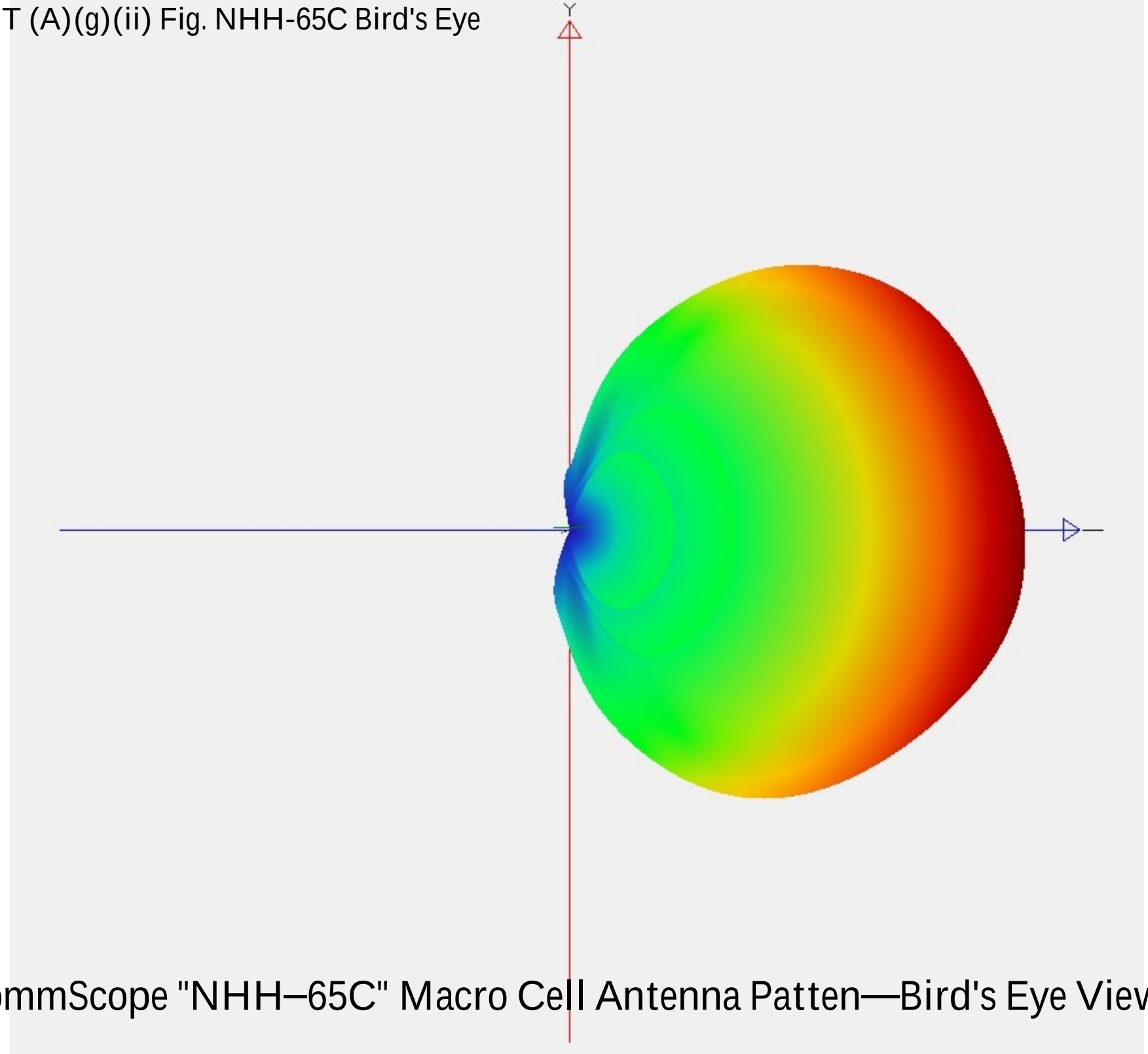
EXHIBIT (A)(g)(ii) Fig. NHH-65C Side View



CommScope "NHH–65C" Macro Cell Antenna Patten—Side View

Note: the small spikes are called "side lobes." These artifacts of the antenna pattern are considered wasted energy that is sent off–beam. The lower side lobes focus intense radiofrequency radiation down into adjacent residences and public areas.

EXHIBIT (A)(g)(ii) Fig. NHH-65C Bird's Eye



CommScope "NHH–65C" Macro Cell Antenna Patten—Bird's Eye View

EXHIBIT (A)(g)(i)

Amphenol ANTENNA SOLUTIONS

CUT360X12Fxyz0

DUAL BAND | OMNI | CANISTER ANTENNA | X-POL | FIXED TILT | 1219 MM (48.0 IN)

Features

- Omni configuration with 4 connectors
- Ideal for Small Cell / DAS applications
- Available with 4.3-10 *or* 7/16-DIN connectors
- Four unique mounting options
- Available for order with a grey, brown or black radome



Connector Description

The antenna has 4 connectors located at the bottom.

Low Band	R1	696-960 MHz	(2x) 4.3-10 *or* 7/16-DIN Female
Mid Band	Y1	1695-2700 MHz	(2x) 4.3-10 *or* 7/16-DIN Female

Electrical Characteristics	R1		Y1			
Frequency Bands (MHz)	696-960 MHz		1695-2700 MHz			
	696-806	824-960	1695-1880	1850-1990	1920-2200	2300-2700
Polarization	±45°		±45°			
Horizontal Beamwidth	360°	360°	360°	360°	360°	360°
Vertical Beamwidth	20.9° ± 1.3°	18.0° ± 1.8°	9.4° ± 0.7°	9.5° ± 0.4°	9.4° ± 0.5°	9.1° ± 2.4°
Gain (dBi)	8.6 ± 0.9	9.1 ± 0.6	12.0 ± 0.7	11.7 ± 0.7	10.9 ± 0.8	10.1 ± 2.4
Electrical Downtilt (°)	(x) 0, 6		(y) 0, 4			
Impedance	50Ω		50Ω			
VSWR	≤ 1.5:1		≤ 1.5:1			
Upper Sidelobe Suppression	> 14 dB	> 11 dB	> 13 dB	> 12 dB	> 11 dB	> 11 dB
Cross Polar Isolation	20 dB		25 dB			
Interband Isolation	25 dB		25 dB			
IM3 (2x20W carrier)	< -153 dBc		< -153 dBc			
Input Power	(2x) 500 W		(2x) 300 W			
Diplexed	No					
Number of Sectors, Sector Spacing and/or Pattern Shape	Omni					
Lightning Protection	Direct Ground					

Mechanical Characteristics

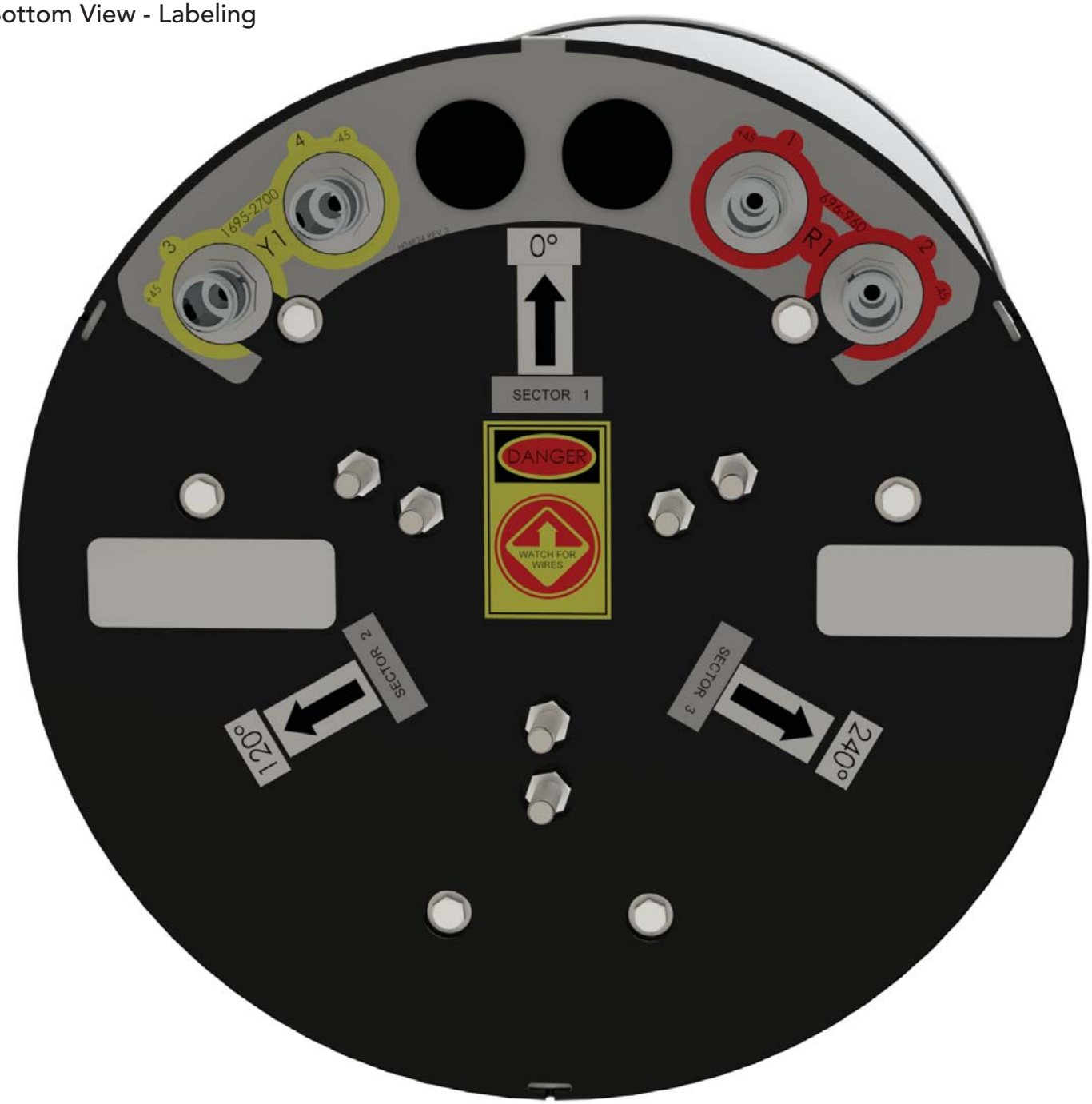
Antenna Dimensions (Height x Diameter)	1219 x 371	mm	48.0 x 14.6	in
Weight without Mounting Bracket Kit	17	kg	37.5	lbs
Antenna Volume	0.13	m^3	4.7	ft^3
Survival Wind Speed	241	km/hr	150	mph
Wind Area	0.47	m^2	5.0	ft^2
Wind Load (160 km/hr or 100 mph)	391	N	88	lbf

Quoted performance parameters are provided to offer typical, peak or range values only and may vary as a result of normal testing, manufacturing and operational conditions. Extreme operational conditions and/or stress on structural supports is beyond our control. Such conditions may result in damage to this product. Improvements to products may be made without notice.

CUT360X12Fxyz0

DUAL BAND | OMNI | CANISTER ANTENNA | X-POL | FIXED TILT | 1219 MM (48.0 IN)

Bottom View - Labeling

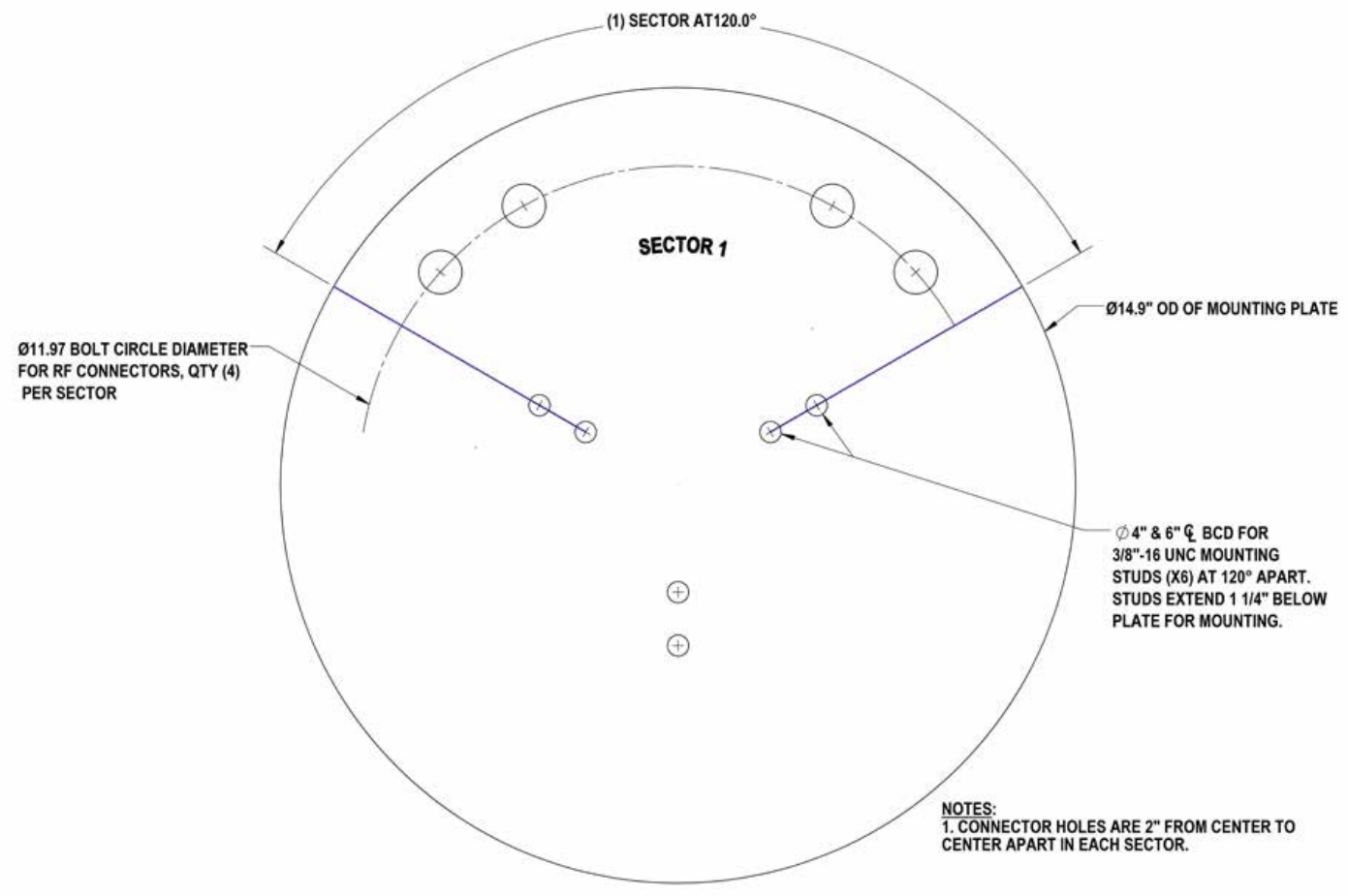


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CUT360X12Fxyz0

DUAL BAND | OMNI | CANISTER ANTENNA | X-POL | FIXED TILT | 1219 MM (48.0 IN)

Bottom View - Connector Diagram



Quoted performance parameters are provided to offer typical, peak or range values only and may vary as a result of normal testing, manufacturing and operational conditions. Extreme operational conditions and/or stress on structural supports is beyond our control. Such conditions may result in damage to this product. Improvements to products may be made without notice.

CUT360X12Fxyz0

DUAL BAND | OMNI | CANISTER ANTENNA | X-POL | FIXED TILT | 1219 MM (48.0 IN)

Ordering Options

When ordering, select the Radome Color, Degree of Electrical Downtilt for the Low (x) and Mid Band (y) and the Connector Type (z).

Radom Color	Electrical Downtilt Degree		Connector Type (z)	
	Low Band ■ R1 (x)	Mid Band ■ Y1 (y)	4.3-10 Female	7/16-DIN Female
Grey Pantone 420 C	0°	0°	CUT360X12F**00s**0	CUT360X12F**00D**0
	0°	4°	CUT360X12F**04s**0	CUT360X12F**04D**0
	6°	0°	CUT360X12F**60s**0	CUT360X12F**60D**0
	6°	4°	CUT360X12F**64s**0	CUT360X12F**64D**0
Brown Pantone 476 C	0°	0°	CUT360X12F**00s0BR**	CUT360X12F**00D0BR**
	0°	4°	CUT360X12F**04s0BR**	CUT360X12F**04D0BR**
	6°	0°	CUT360X12F**60s0BR**	CUT360X12F**60D0BR**
	6°	4°	CUT360X12F**64s0BR**	CUT360X12F**64D0BR**
Black RAL 9011	0°	0°	CUT360X12F**00s0BK**	CUT360X12F**00D0BK**
	0°	4°	CUT360X12F**04s0BK**	CUT360X12F**04D0BK**
	6°	0°	CUT360X12F**60s0BK**	CUT360X12F**60D0BK**
	6°	4°	CUT360X12F**64s0BK**	CUT360X12F**64D0BK**

Quoted performance parameters are provided to offer typical, peak or range values only and may vary as a result of normal testing, manufacturing and operational conditions. Extreme operational conditions and/or stress on structural supports is beyond our control. Such conditions may result in damage to this product. Improvements to products may be made without notice.

CUT360X12Fxyz0

DUAL BAND | OMNI | CANISTER ANTENNA | X-POL | FIXED TILT | 1219 MM (48.0 IN)

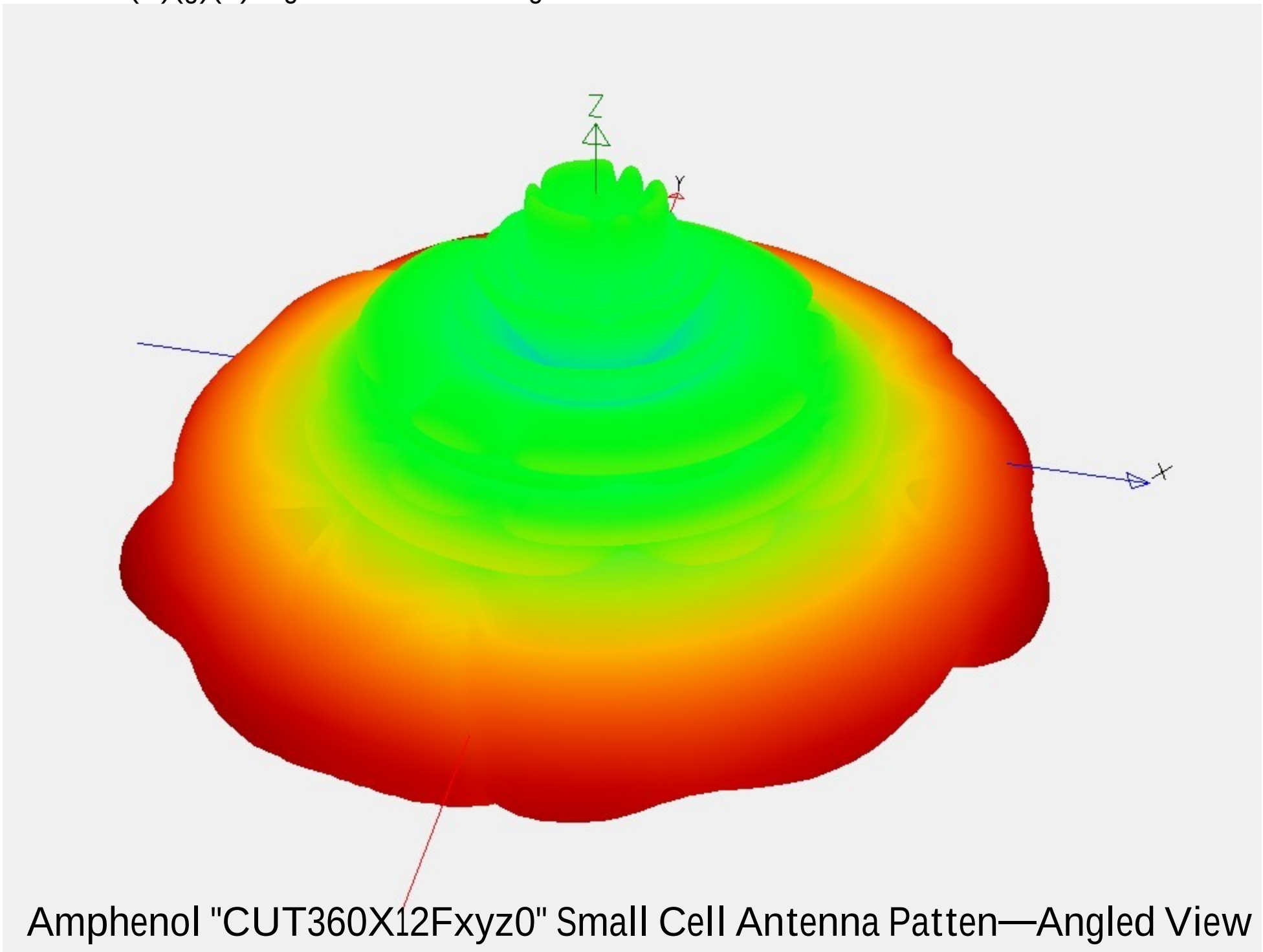
Mounting Kits

This antenna can be mounted using any of the following mounting kits. Mounting kits must be ordered separately.

Side Mounting Bracket Kit	Top Mounting Bracket Kit	Utility Pole Mounting Bracket Kit	Wide Diameter Pole Top Mounting Bracket Kit
CWT-MKS-SIDE	CWT-MKS-TOP	WB3X-MKS-01	CWT-MKS-BASE-xx
			

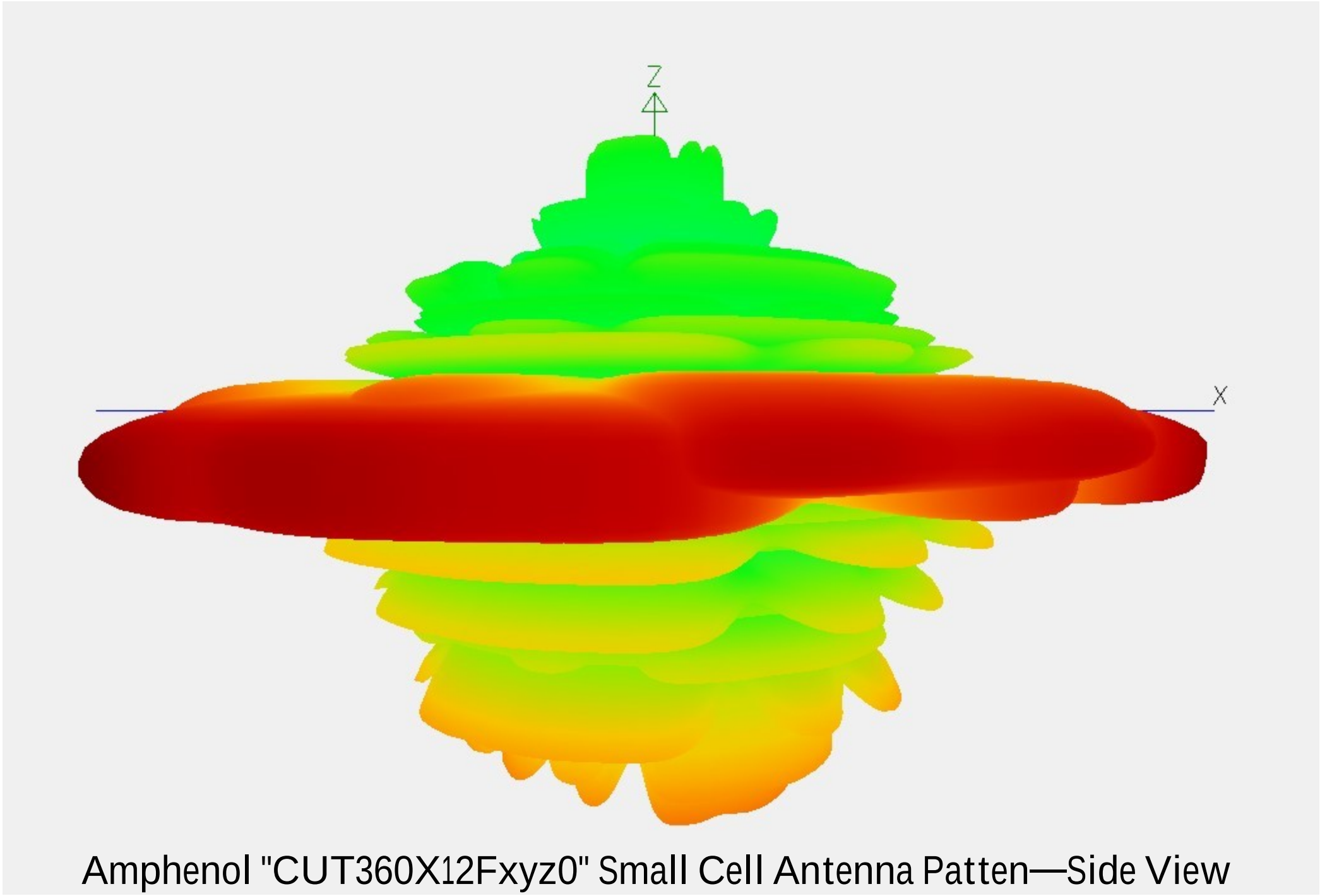
Quoted performance parameters are provided to offer typical, peak or range values only and may vary as a result of normal testing, manufacturing and operational conditions. Extreme operational conditions and/or stress on structural supports is beyond our control. Such conditions may result in damage to this product. Improvements to products may be made without notice.

EXHIBIT (A)(g)(ii) Fig. CUT360X12F Angled View



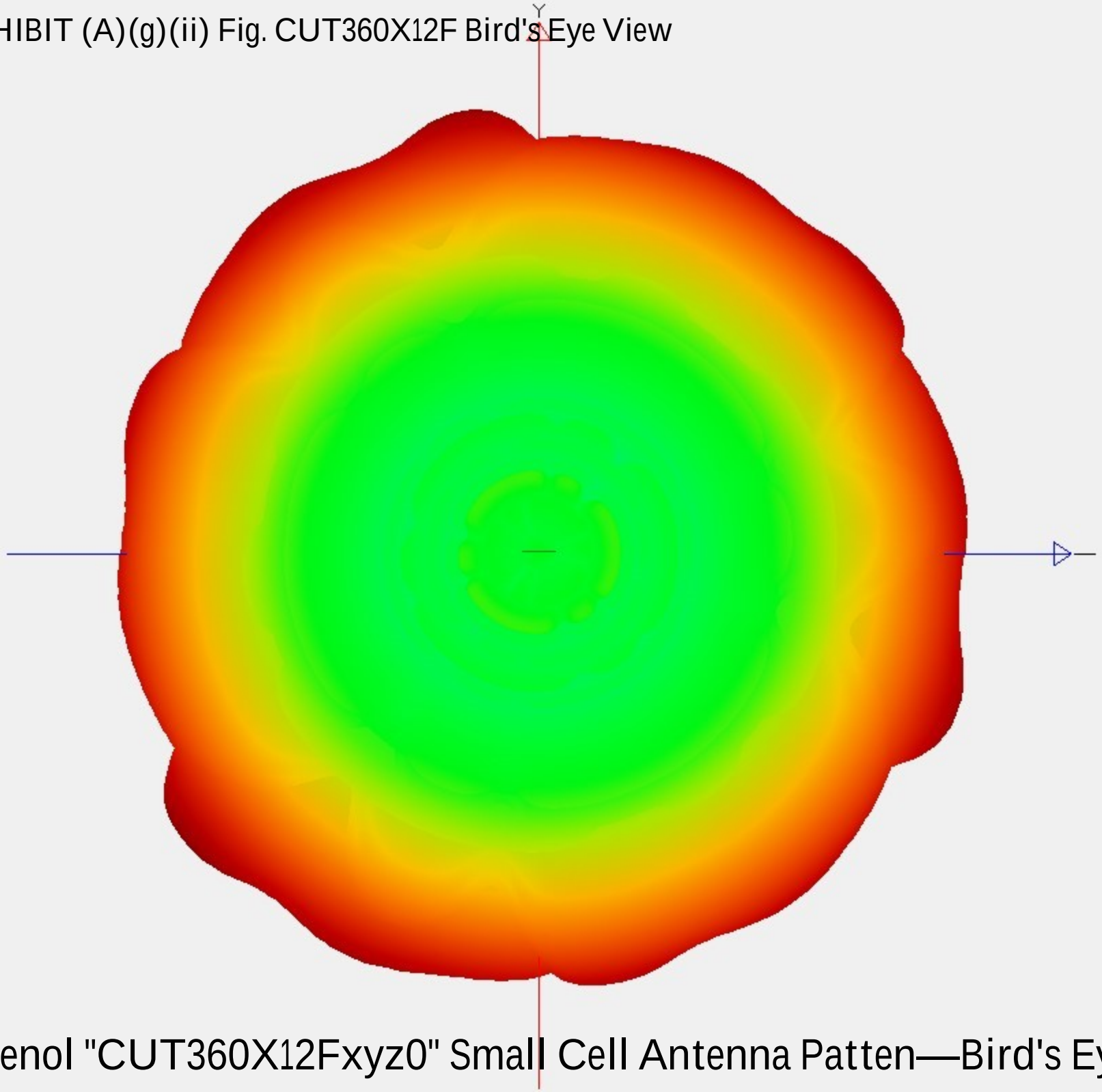
Amphenol "CUT360X12Fxyz0" Small Cell Antenna Patten—Angled View

EXHIBIT (A)(g)(ii) Fig. CUT360X12F Side View



Amphenol "CUT360X12Fxyz0" Small Cell Antenna Patten—Side View

EXHIBIT (A)(g)(ii) Fig. CUT360X12F Bird's Eye View



Amphenol "CUT360X12Fxyz0" Small Cell Antenna Patten—Bird's Eye View

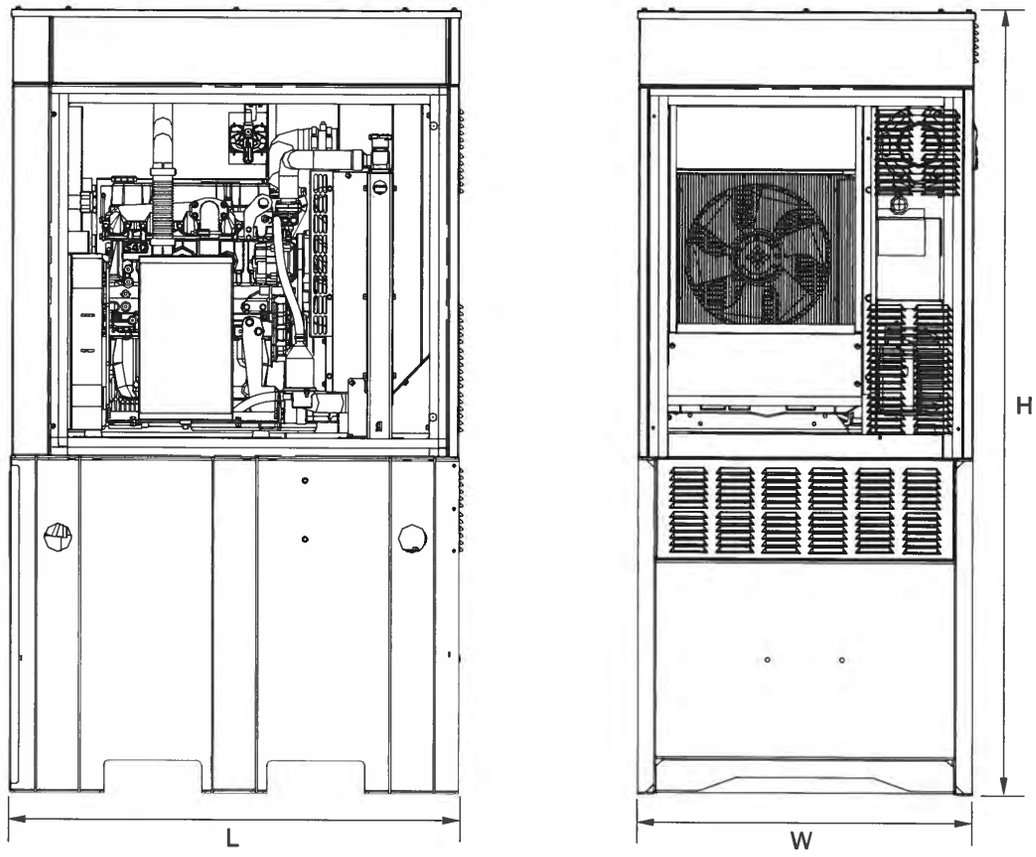
SDC20 | 2.5L | 20 kW - AC

INDUSTRIAL DIESEL GENERATOR SET

EPA Certified Stationary Emergency

GENERAC | INDUSTRIAL POWER

DIMENSIONS AND WEIGHTS*



Level 2 Sound Attenuation Enclosure

Run Time Hours	48
Usable Capacity Gal (L)	92 (348.2)
L x W x H in (mm)	48 x 36 x 91 (1219 x 915 x 2299)
Weight lbs (kg)	2400 (1089) (wet engine/dry tank)

* All measurements are approximate and for estimation purposes only.

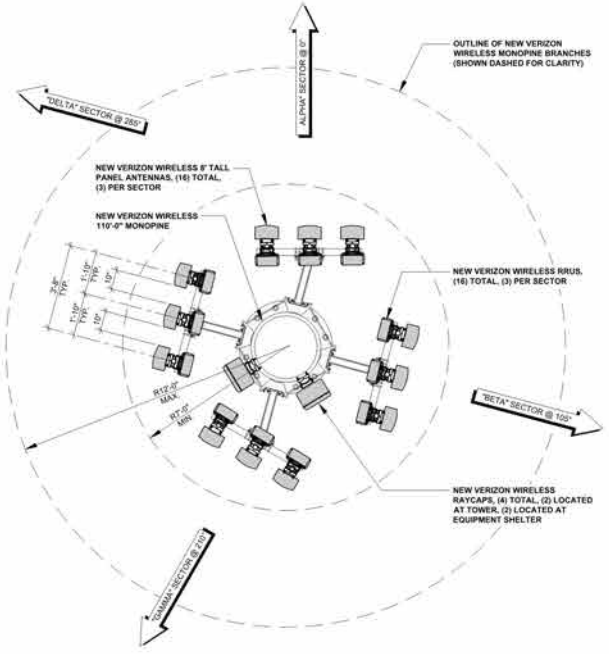
YOUR FACTORY RECOGNIZED GENERAC INDUSTRIAL DEALER

Specification characteristics may change without notice. Dimensions and weights are for preliminary purposes only. Please consult a Generac Power Systems Industrial Dealer for detailed installation drawings.

Generac Power Systems, Inc. | P.O.Box 8 | Waukesha, WI 53189
P: (262) 544-4811 ©2017 Generac Power Systems, Inc. All rights reserved. All specifications are subject to change without notice.

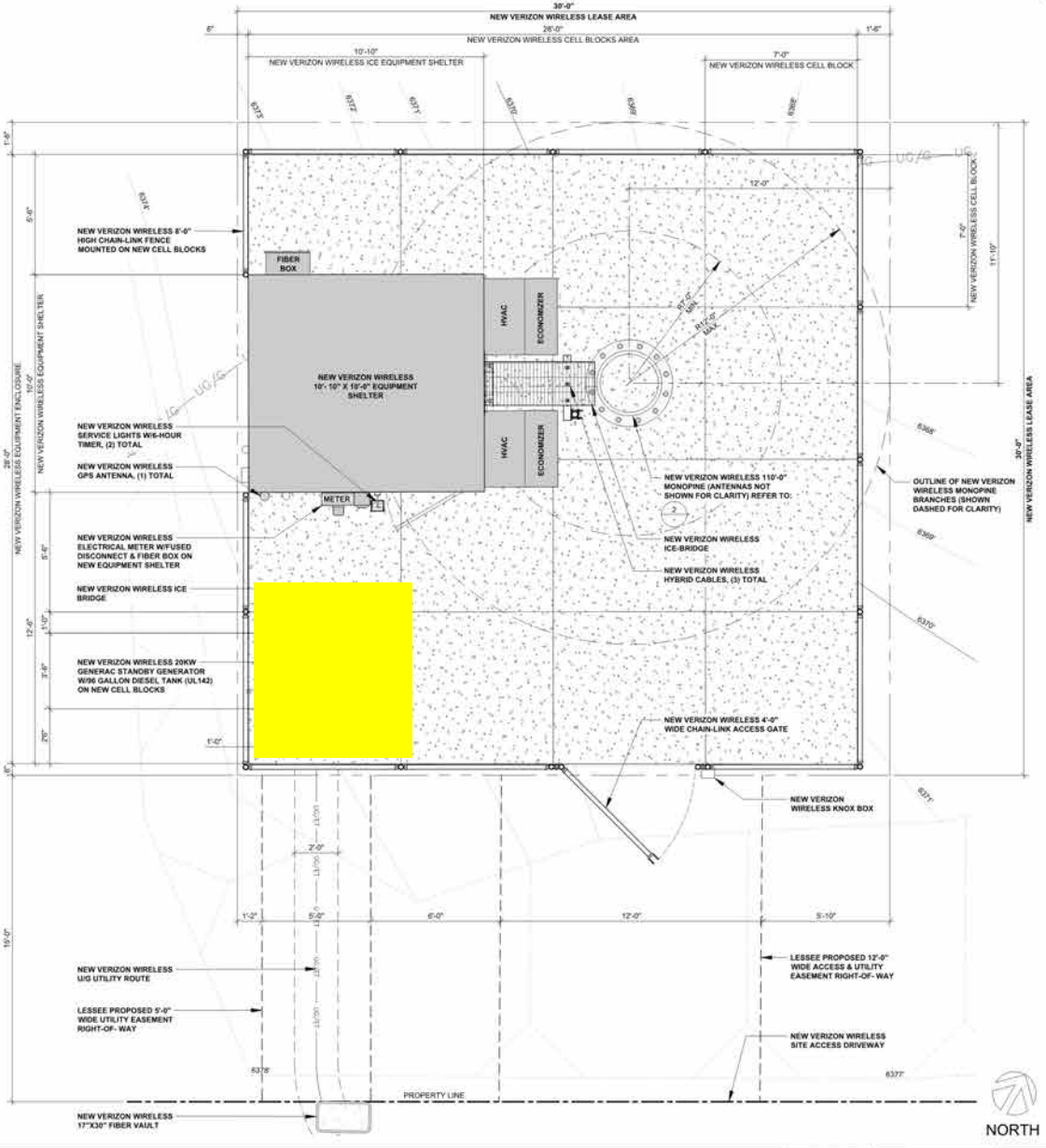
Document No. 10000000844
Rev. J 2/27/17

EXHIBIT (A)(h)(i)(2) Fig. Diesel Generator Outdoor Installation



PANEL ANTENNAS @ 103'-0" CENTERLINE

PANEL ANTENNA LAYOUT | SCALE: 3/8" = 1'-0" (24x36) (OR) 3/16" = 1'-0" (11x17) | 2



EQUIPMENT LAYOUT | SCALE: 3/8" = 1'-0" (24x36) (OR) 3/16" = 1'-0" (11x17) | 1

ISSUE STATUS

REV.	DATE	DESCRIPTION	BY
0	02/05/18	90% ZONING	FA
1	03/01/18	100% ZONING	FA
2	03/09/18	100% ZONING	FA

SC WIRELESS
9015 SHOREHAM PLACE, STE. 150
SAN DIEGO, CA 92122
www.scw.com
619.736.2706

PROPRIETARY INFORMATION
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verizon
2785 MITCHELL DRIVE, BLDG 9
WALNUT CREEK, CA 94598

SKI RUN BLVD
PSL# 444780
1360 SKI RUN BLVD
SOUTH LAKE TAHOE, CA 96150

SHEET TITLE:
EQUIPMENT & ANTENNA LAYOUTS

A-2

EXHIBIT (A)(h)(ii) Fig. Well Site

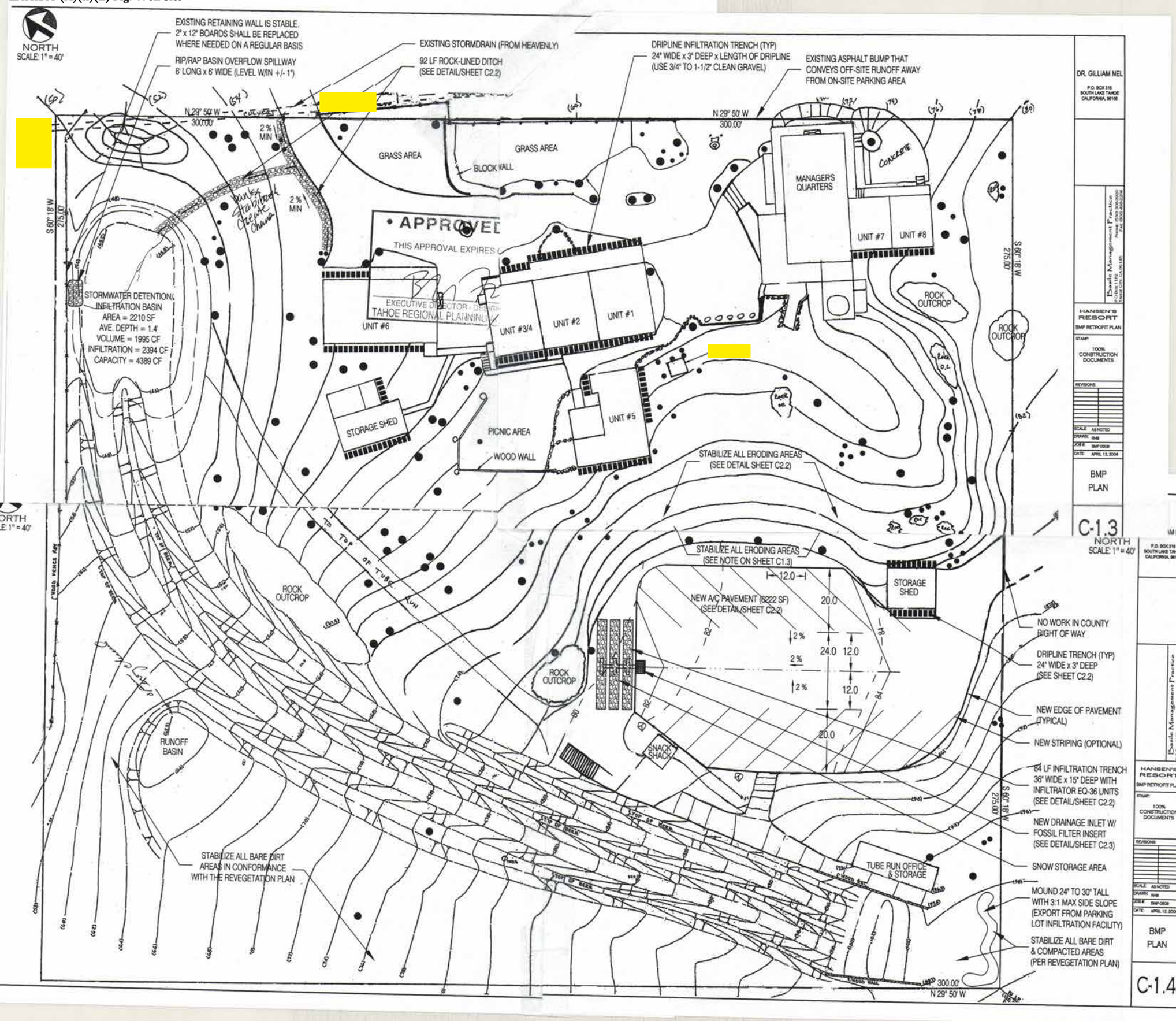


EXHIBIT (A)(h)(iii) Fig. Incorrect Tree Heights Stated by Verizon

NOTES

APN: 025-580-07-100

OWNER(S): NEL GUILLIAM, AN UNMARRIED MAN

THIS DRAWING DOES NOT REPRESENT A BOUNDARY SURVEY OF ANY PARCEL OF LAND, NOR DOES IT IMPLY OR INFER THAT A BOUNDARY SURVEY WAS PERFORMED. THIS IS A SPECIALIZED TOPOGRAPHIC MAP WITH PROPERTY AND EASEMENTS BEING A GRAPHIC DEPICTION BASED ON INFORMATION GATHERED FROM VARIOUS SOURCES OF RECORD AND AVAILABLE MONUMENTATION. PROPERTY LINES AND LINES OF TITLE WERE NEITHER INVESTIGATED NOR SURVEYED AND SHALL BE CONSIDERED APPROXIMATE ONLY. NO PROPERTY MONUMENTS WERE SET.

THE EASEMENTS (IF ANY) THAT APPEAR ON THIS MAP HAVE BEEN PLOTTED BASED SOLELY ON INFORMATION CONTAINED IN THE CONDITION OF TITLE REPORTS BY: FIRST AMERICAN TITLE COMPANY, FILE NO. 5628064, DATED JANUARY 17, 2018. WITHIN SAID TITLE REPORT THERE ARE TEN (10) EXCEPTIONS LISTED, NONE (0) OF WHICH ARE EASEMENTS.

THE UNDERGROUND UTILITIES (IF ANY) THAT APPEAR ON THIS MAP HAVE BEEN LOCATED BY FIELD OBSERVATION. THE SURVEYOR MAKES NO GUARANTEE THAT THE UNDERGROUND UTILITIES SHOWN COMPRISE ALL SUCH UTILITIES IN THE AREA, EITHER IN SERVICE OR ABANDONED. THE SURVEYOR FURTHER DOES NOT WARRANT THAT THE UNDERGROUND UTILITIES SHOWN ARE IN THE EXACT LOCATION INDICATED ALTHOUGH HE DOES STATE THAT THEY ARE LOCATED AS ACCURATELY AS POSSIBLE FROM THE INFORMATION AVAILABLE.

THE FEDERAL EMERGENCY MANAGEMENT AGENCY FLOOD RATE MAP FOR COMMUNITY NO. 060040, PANEL NO. 0580F, DATED APRIL 3, 2012 SHOWS THAT THE LOCATION OF THIS SITE FALLS WITHIN ZONE X, WHICH ARE AREAS DETERMINED OUTSIDE THE 0.2% ANNUAL CHANCE FLOODPLAIN.

THE LATITUDE AND LONGITUDE AT THE LOCATION AS SHOWN WAS DETERMINED BY GPS OBSERVATIONS.

LAT. 38° 56' 14.60" N. NAD 83
LONG. 119° 57' 00.55" W. NAD 83
ELEV. 6374.5' NAVD 88 (BASIS OF DRAWING)

The information shown above meets or exceeds the requirements set forth in FAA order 8260.19D for 1-A accuracy (± 20' horizontally and ± 3' vertically). The horizontal datum (coordinates) are expressed as degrees, minutes and seconds, to the nearest tenth of a second. The vertical datum (heights) are expressed in feet and decimals thereof and are determined to the nearest 0.1 foot.

LESSOR'S PROPERTY LEGAL DESCRIPTION PER TITLE REPORT:

REAL PROPERTY IN THE CITY OF SOUTH LAKE TAHOE, COUNTY OF EL DORADO, STATE OF CALIFORNIA, DESCRIBED AS FOLLOWS:

BEGINNING AT A 3/4 INCH CAPPED IRON PIPE SET IN THE WESTERLY LINE OF BIJOU PARK BOULEVARD, FROM WHICH THE NORTHEAST CORNER OF SAID SECTION 2 BEARS NORTH 29°50' WEST 30.0 FEET, AND NORTH 55°42' 30" 782.6 FEET; THENCE FROM POINT OF BEGINNING AND ALONG SAID WESTERLY LINE OF BIJOU PARK BOULEVARD, SOUTH 29°50' EAST 300.0 FEET A 3/4 INCH CAPPED IRON PIPE; THENCE LEAVING SAID LINE SOUTH 60°18' WEST 275.0 FEET A SIMILAR PIPE; THENCE NORTH 29°50' WEST 300.0 FEET A SIMILAR PIPE; THENCE NORTH 60°18' EAST 275.0 FEET TO THE POINT OF BEGINNING.

PROPOSED VERIZON WIRELESS DEMISED PREMISE DESCRIPTION:

ALL THAT PORTION OF THE HEREON DESCRIBED LESSOR'S PROPERTY, MORE PARTICULARLY DESCRIBED AS FOLLOWS:

COMMENCING AT THE EASTERLY MOST CORNER OF SAID LESSOR'S PROPERTY, THENCE S 59°18'12" W, ALONG THE SOUTHEAST LINE OF SAID LESSOR'S PROPERTY, A DISTANCE OF 116.05 FEET; THENCE LEAVING SAID SOUTHEAST LINE, N 30°41'48" W, A DISTANCE OF 20.00 FEET TO THE POINT OF BEGINNING;

COURSE 1) THENCE S 59°18'12" W, A DISTANCE OF 26.00 FEET;
COURSE 2) THENCE N 30°41'48" W, A DISTANCE OF 24.00 FEET;
COURSE 3) THENCE N 59°18'12" E, A DISTANCE OF 26.00 FEET;
COURSE 4) THENCE S 30°41'48" E, A DISTANCE OF 24.00 FEET TO THE POINT OF BEGINNING.

CONTAINING 624 SQUARE FEET, MORE OR LESS.

PROPOSED LESSEE ACCESS & UTILITY EASEMENT RIGHT-OF-WAY DESCRIPTION:

A 5.00 FOOT WIDE STRIP OF LAND, LYING 2.50 FEET ON EACH SIDE OF THE FOLLOWING DESCRIBED CENTERLINE:

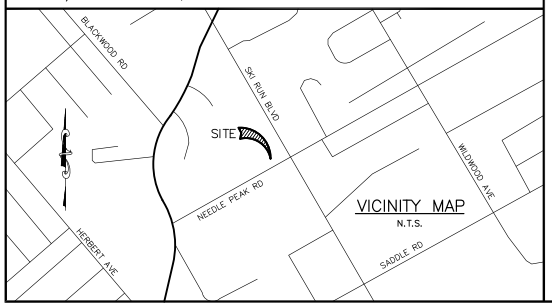
COMMENCING AT THE EASTERLY MOST CORNER OF SAID LESSOR'S PROPERTY, THENCE S 59°18'12" W, ALONG THE SOUTHEAST LINE OF SAID LESSOR'S PROPERTY, A DISTANCE OF 134.55 FEET TO THE POINT OF BEGINNING;

COURSE 1) THENCE N 30°41'48" W, A DISTANCE OF 20.00 FEET TO THE TERMINUS OF THIS DESCRIPTION.

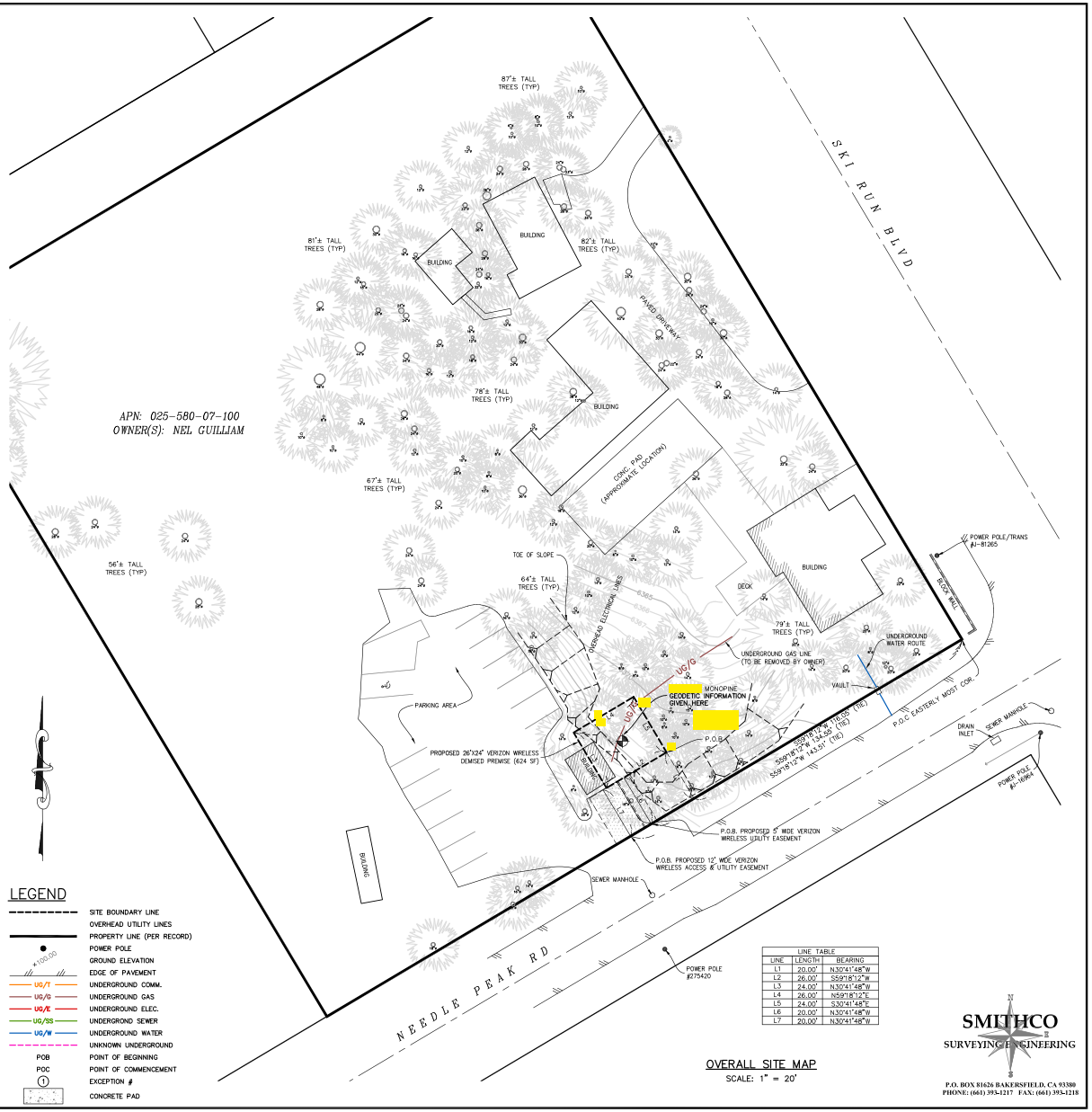
TOGETHER WITH A 12.00 FOOT WIDE STRIP OF LAND, LYING 6.00 FEET ON EACH SIDE OF THE FOLLOWING DESCRIBED CENTERLINE:

COMMENCING AT THE EASTERLY MOST CORNER OF SAID LESSOR'S PROPERTY, THENCE S 59°18'12" W, ALONG THE SOUTHEAST LINE OF SAID LESSOR'S PROPERTY, A DISTANCE OF 143.51 FEET TO THE POINT OF BEGINNING;

COURSE 1) THENCE N 30°41'48" W, A DISTANCE OF 20.00 FEET TO THE TERMINUS OF THIS DESCRIPTION.



VICINITY MAP
N.T.S.



LEGEND

- SITE BOUNDARY LINE
- OVERHEAD UTILITY LINES
- PROPERTY LINE (PER RECORD)
- POWER POLE
- GROUND ELEVATION
- EDGE OF PAVEMENT
- UG/T UNDERGROUND COMM.
- UG/G UNDERGROUND GAS
- UG/E UNDERGROUND ELEC.
- UG/SS UNDERGROUND SEWER
- UG/W UNDERGROUND WATER
- UNKNOWN UNDERGROUND
- POB POINT OF BEGINNING
- POC POINT OF COMMENCEMENT
- (1) EXCEPTION #
- CONCRETE PAD

LINE TABLE		
LINE	LENGTH	BEARING
L1	20.00'	N30°41'48"W
L2	26.00'	S59°18'12"W
L3	24.00'	N30°41'48"W
L4	26.00'	N59°18'12"E
L5	24.00'	S30°41'48"E
L6	20.00'	N30°41'48"W
L7	20.00'	N30°41'48"W

OVERALL SITE MAP
SCALE: 1" = 20'

SMITHCO
SURVEYING & ENGINEERING
P.O. BOX 81626 BAKERSFIELD, CA 93380
PHONE: (661) 393-1217 FAX: (661) 393-1218

ISSUE STATUS

REV	DATE	DESCRIPTION	BY
0	01/22/18	PRELIMINARY	EJ
1	02/05/18	REVISION	EJ
2	03/19/18	ADD TITLE NOTES	DA
3	04/03/18	ADD LEASE LABELS	DA
4	06/06/18	STAMP & SIGN	DA
5	01/31/19	REDLINES	SL
6	09/23/19	REVISION	EJ
7	09/24/19	ADD TREE HEIGHTS	SL
8	10/01/19	ADD TREE HEIGHTS	SL

SMITHCO JOB NO.: 82-1029

SAC WIRELESS
ENGINEERING GROUP
5015 SHOREHAM PL, SUITE 150
SAN DIEGO, CA 92122
www.sacw.com
619.736.3766

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verizon

444780
SKI RUN BLVD

1360 SKI RUN BLVD
SOUTH LAKE TAHOE, CA
96150

EL DORADO COUNTY

SHEET TITLE:
SITE SURVEY
FOR EXAMINATION ONLY

C-1

Exhibit D

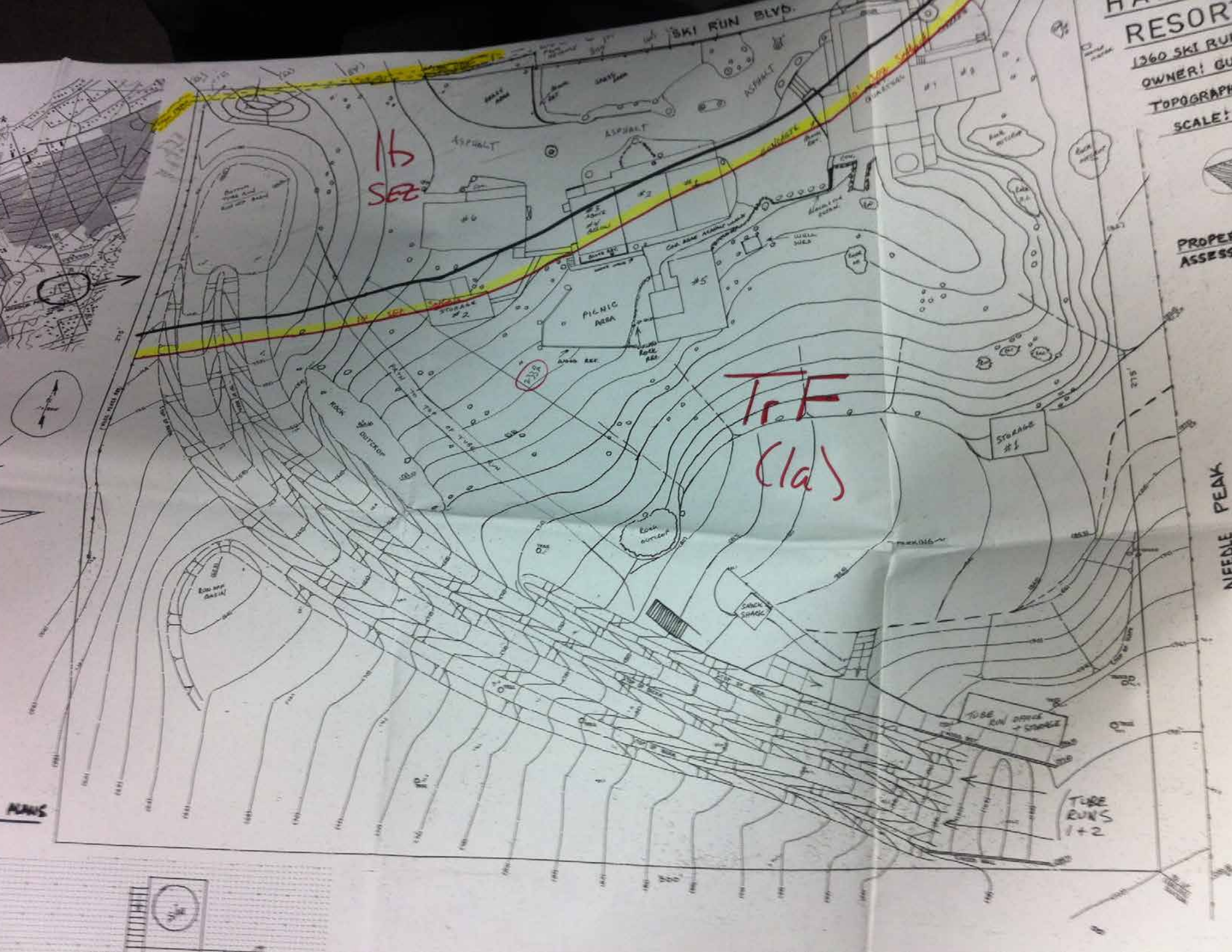
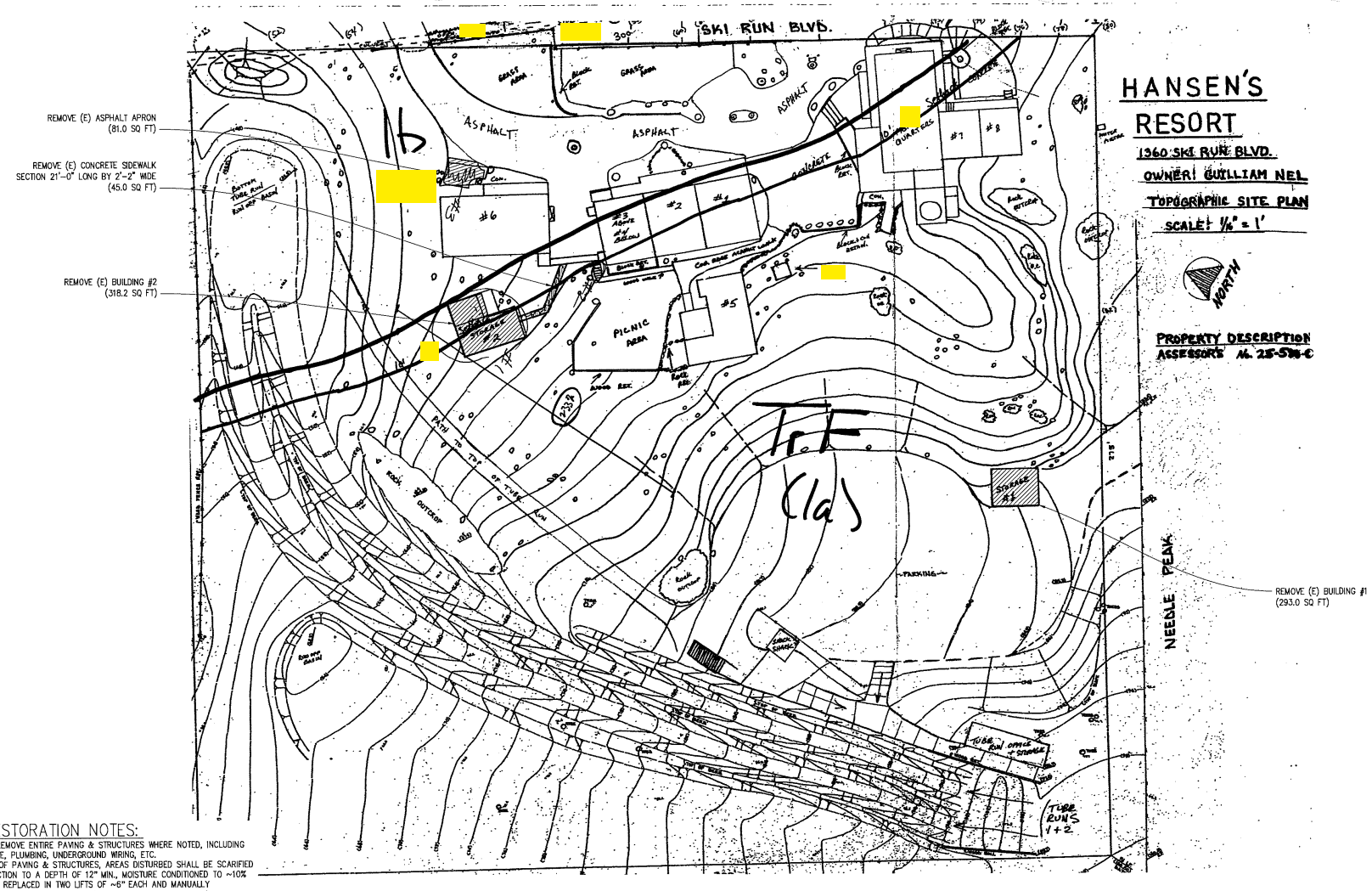

SKI RUN BLVD.
ASPHALT
PICNIC AREA
STORAGE #1
STORAGE #2
TUBE RUNS 1+2
1b
SEE
TrF
(1a)

EXHIBIT (A)(h)(iv) Fig. Stream Environmental Zone (SEZ)



COVERAGE RESTORATION NOTES:

1. CONTRACTOR SHALL REMOVE ENTIRE PAVING & STRUCTURES WHERE NOTED, INCLUDING FOUNDATION CONCRETE, PLUMBING, UNDERGROUND WIRING, ETC.
2. FOLLOWING REMOVAL OF PAVING & STRUCTURES, AREAS DISTURBED SHALL BE SCARIFIED TO ELIMINATE COMPACTION TO A DEPTH OF 12" MIN., MOISTURE CONDITIONED TO ~10% MOISTURE BY WEIGHT, REPLACED IN TWO LIFTS OF ~6" EACH AND MANUALLY COMPACTED BY WALKING ON THE AREA ONLY (NO MECHANICAL COMPACTION), THEN RAKED EVEN ALONG THE SURFACE.
3. ALL SURFACE TREATMENT MATERIALS INCLUDING PINE NEEDLE ROOLS, MULCH, SEED & PLANTS SHALL BE NATIVE AND OBTAINED FROM LOCAL NURSERY STOCK FROM WITHIN THE TAHOE BASIN OR TRUCKEE.
4. BROADCAST NON-TURF TYPE GRASS SEED MIX AT THE RATE OF 2#/100sq.ft. CONSISTING OF APPROXIMATELY EQUAL PARTS:
   SQUIRRELTAIL, (ELYMUS ELYMOIDES spp CALIFORNICUS)
   SLENDER WHEATGRASS (ELYMUS TRACHYCAULUS)
   WILDRYE, CREEPING (ELYMUS TRITICOIDES)
5. AT AREAS OF ASPHALT & BUILDING #2 REMOVAL, PLACE 8ea. 1 GAL PINEMAT MANZANITA (ARCHTOSTAPHYLOS NEVADENSIS) IN RANDOM PATTERN PER PLANTING DETAIL HEREIN, AND WATER IN. CONTRACTOR SHALL GUARANTEE PLANT REPLACEMENT FOR MIN. 2 YEARS FOR ANY DEAD SHRUBS.
6. PLACE 2" MIN. LOOSE BROADCAST PINE NEEDLE MULCH OVER ALL REMEDIATED AREAS IN ADDITION TO ANY BMP's NOTED ON PLANS.

PIONEER TRAIL

CVU0588
1360 SKI RUN BLVD
SOUTH LAKE TAHOE, CA 96150

ISSUE STATUS

△	DATE	DESCRIPTION	
	02/24/13	ZD 100%	A.M.
	05/13/14	CLIENT REV	A.M.
	09/10/13	CLIENT REV	R.M.
	03/28/14	CLIENT REV	J.S.
	06/30/14	CD 90%	M.D.
	08/25/14	CD 100%	M.D.

DRAWN BY:	K. PURDY
CHECKED BY:	C. MATHISEN
APPROVED BY:	J. SPORE
DATE:	08/25/14

Streamline Engineering and Design, Inc.
8445 Sierra College Blvd, Suite F, Granite Bay, CA 95746
Contact: Kevin Schmidt Phone: 916-660-1930
E-Mail: kevin@streamlineeng.com Fax: 916-660-1941

THESE PLANS ARE SPECIFICATIONS AS INSTRUMENTS OF SERVICE, ARE AND SHALL REMAIN THE PROPERTY OF STREAMLINE ENGINEERING AND DESIGN, INC. WHETHER THE PROJECT FOR WHICH THEY ARE MADE IS EXECUTED OR NOT. THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF SERVICE, ARE THE PROPERTY OF STREAMLINE ENGINEERING AND DESIGN, INC. AND ARE NOT TO BE USED IN ANY WAY FOR ANY PURPOSE WITHOUT THE WRITTEN CONSENT OF STREAMLINE ENGINEERING AND DESIGN, INC. ALL RIGHTS RESERVED. Copyright ©2013 STREAMLINE ENGINEERING AND DESIGN, INC. ALL RIGHTS RESERVED

REGISTERED PROFESSIONAL ENGINEER
JAMES R. SPORE
NO. 70937
CIVIL
STATE OF CALIFORNIA

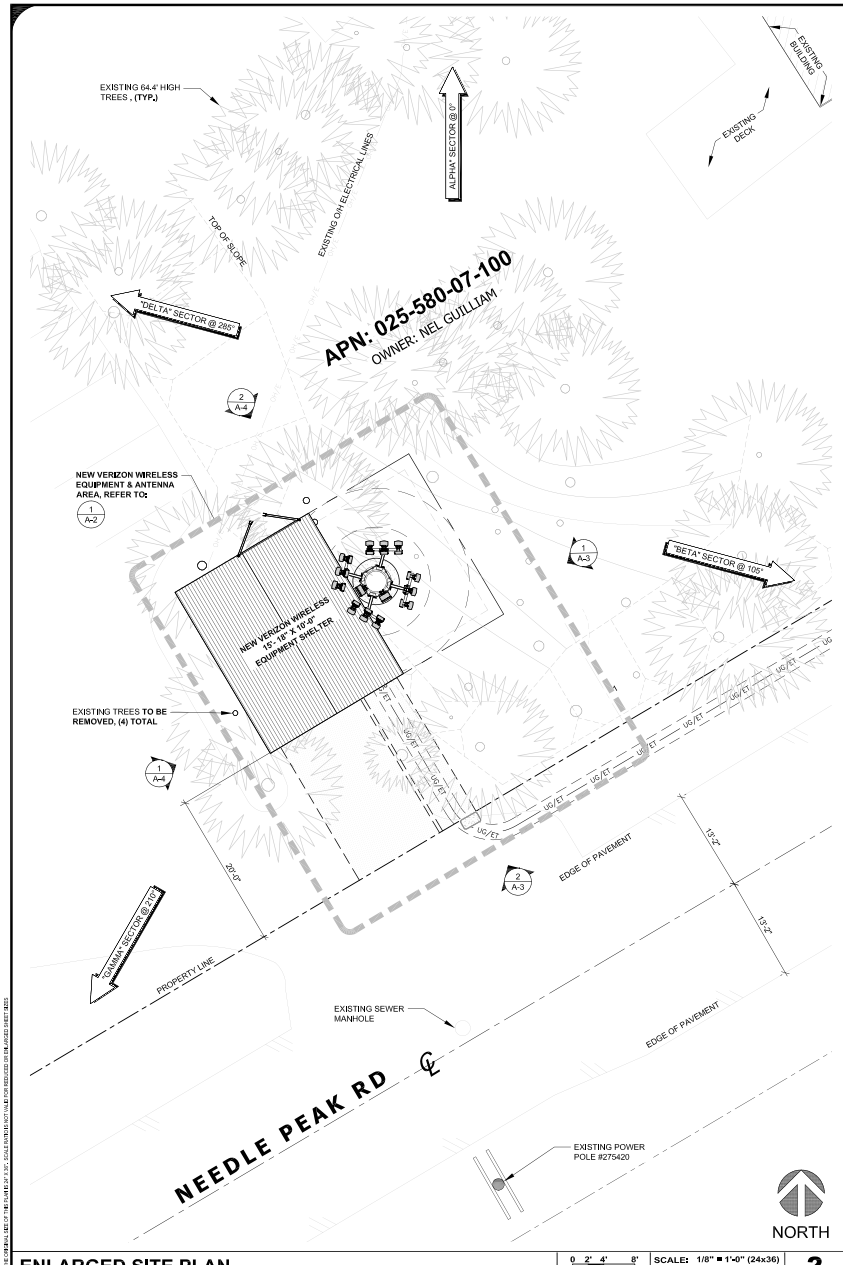
at&t

2600 CAMINO RAMON, 4TH FLOOR, WEST WING
SAN RAMON, CA 94583

SHEET TITLE:
TRPA PLAN

SHEET NUMBER:
A-1.1

EXHIBIT (A)(h)(iv) Fig. Demolition in Stream Environmental Zone (SEZ)

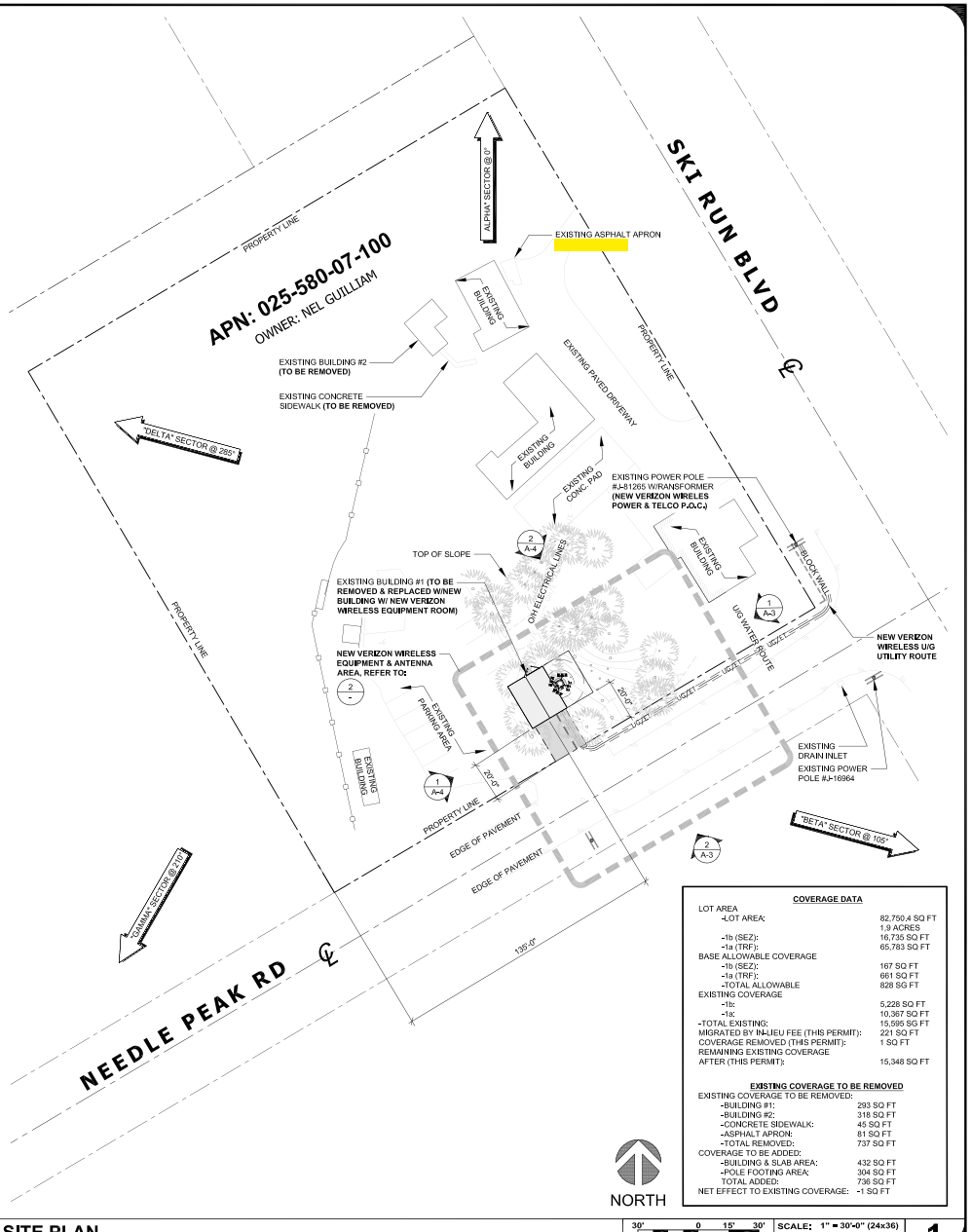


ENLARGED SITE PLAN

0 2' 4' 8'

SCALE: 1/8" = 1'-0" (24x36)
(OR) 1/16" = 1'-0" (11x17)

2



COVERAGE DATA

LOT AREA	
-LOT AREA:	82,750.4 SQ FT
	1.9 ACRES
-1b (SEZ):	16,735 SQ FT
-1a (TRF):	65,783 SQ FT
BASE ALLOWABLE COVERAGE	
-1b (SEZ):	167 SQ FT
-1a (TRF):	661 SQ FT
-TOTAL ALLOWABLE	828 SG FT
EXISTING COVERAGE	
-1b:	5,228 SQ FT
-1a:	10,367 SQ FT
-TOTAL EXISTING:	15,595 SG FT
MIGRATED BY IN-LIEU FEE (THIS PERMIT):	221 SQ FT
COVERAGE REMOVED (THIS PERMIT):	1 SQ FT
REMAINING EXISTING COVERAGE AFTER (THIS PERMIT):	15,348 SQ FT

EXISTING COVERAGE TO BE REMOVED

EXISTING COVERAGE TO BE REMOVED:	
-BUILDING #1:	293 SQ FT
-BUILDING #2:	318 SQ FT
-CONCRETE SIDEWALK:	45 SQ FT
-ASPHALT APRON:	81 SQ FT
-TOTAL REMOVED:	737 SQ FT
COVERAGE TO BE ADDED:	
-BUILDING & SLAB AREA:	432 SQ FT
-POLE FOOTING AREA:	304 SQ FT
TOTAL ADDED:	736 SQ FT
NET EFFECT TO EXISTING COVERAGE:	-1 SQ FT

SITE PLAN

30' 0 15' 30'

SCALE: 1" = 30'-0" (24x36)
(OR) 1/2" = 30'-0" (11x17)

1

ISSUE STATUS

REV.	DATE	DESCRIPTION	BY
0	01/31/19	90% ZONING	FA
1	03/14/19	100% ZONING	FA

SAC WIRELESS
SAC AE DESIGN GROUP, INC.
5015 SHOREHAM PLACE, STE. 150
SAN DIEGO, CA 92122
www.sacw.com
619.736.3766

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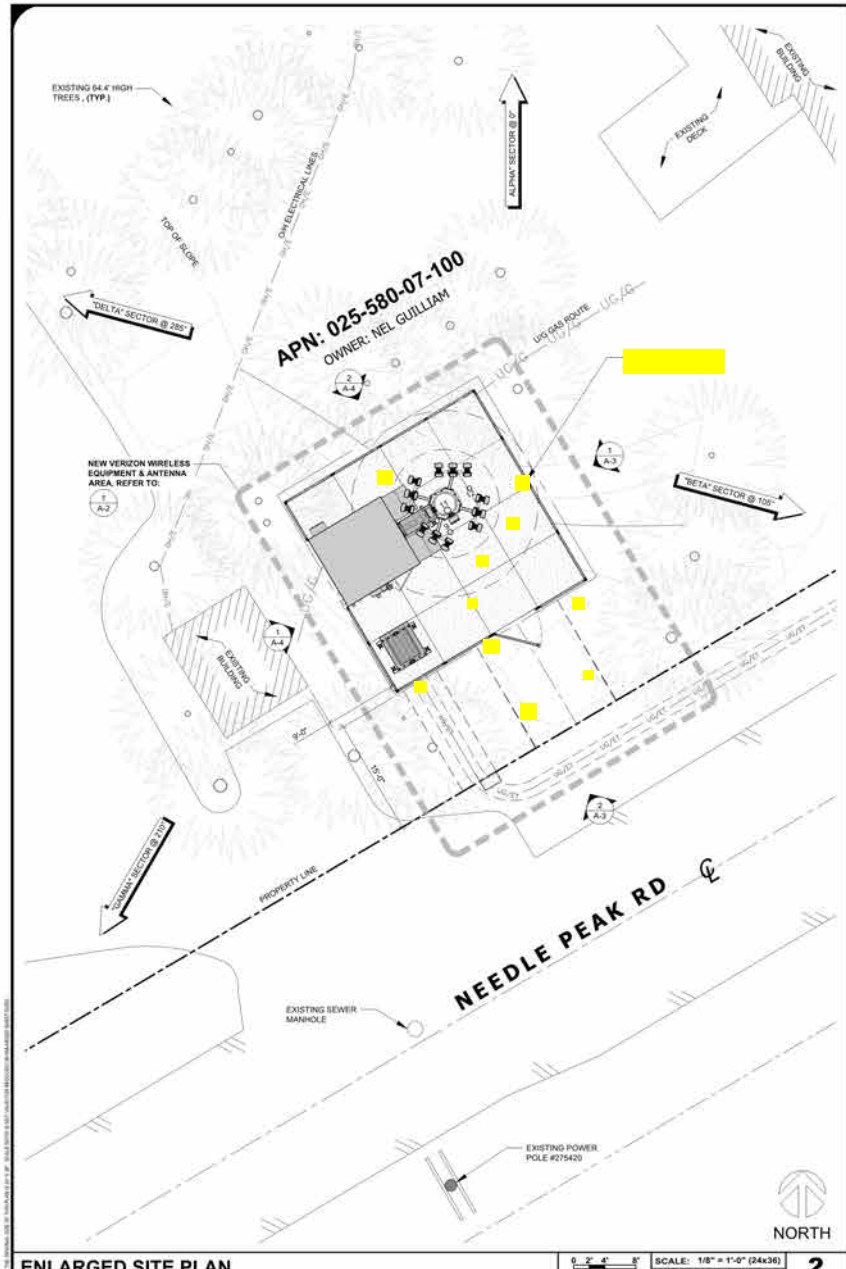
2785 MITCHELL DRIVE, BLDG 9
WALNUT CREEK, CA 94598

SKI RUN BLVD
PSL# 444780
1360 SKI RUN BLVD
SOUTH LAKE TAHOE, CA 96150

SHEET TITLE:
SITE PLAN

A-1

EXHIBIT (A)(h)(iii) Fig. Removal of Thirteen Trees

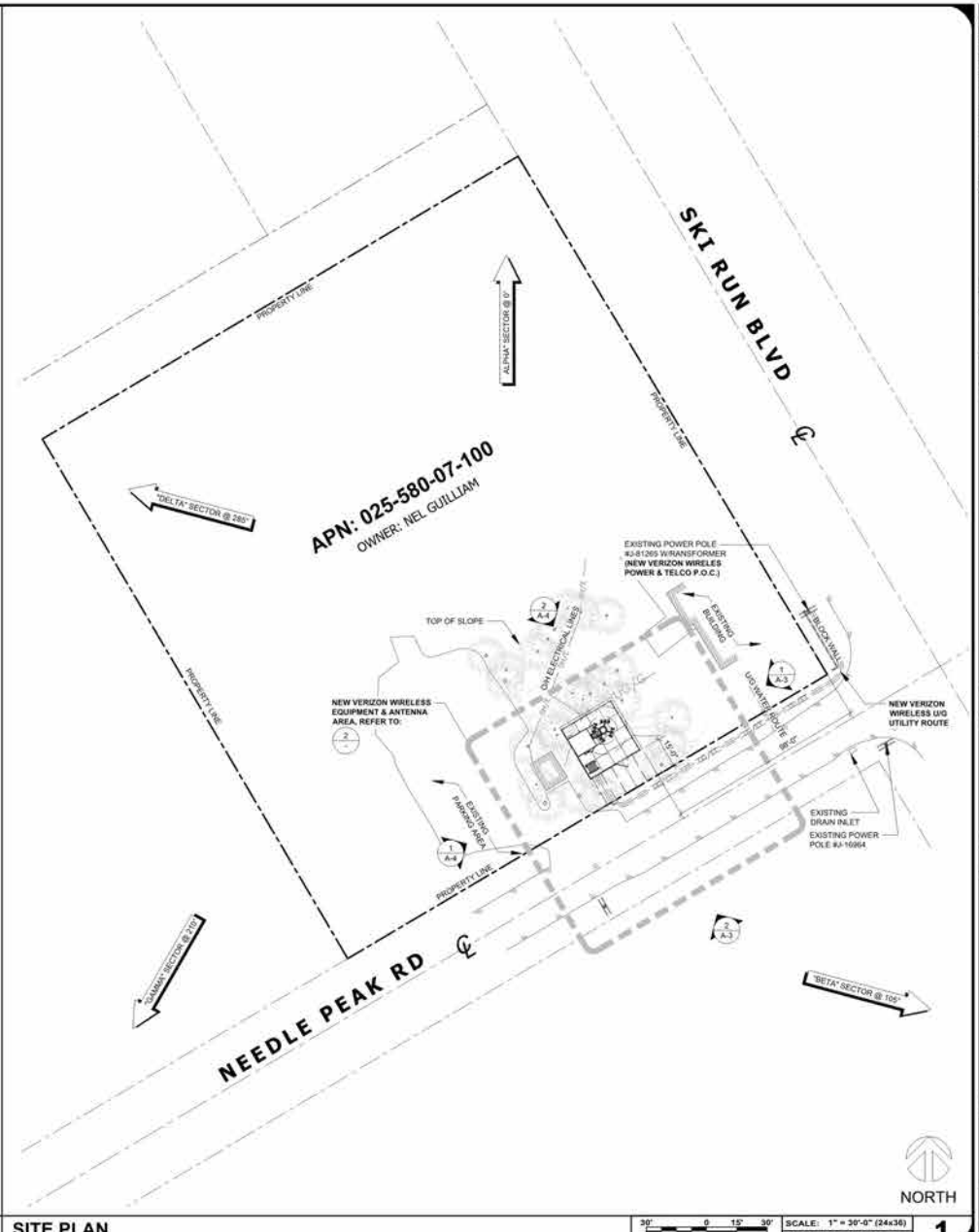


ENLARGED SITE PLAN

0 2' 4' 8'

SCALE: 1/8" = 1'-0" (24x36)
(OR) 1/16" = 1'-0" (11x17)

2



SITE PLAN

30' 0 15' 30'

SCALE: 1" = 30'-0" (24x36)
(OR) 1/2" = 30'-0" (11x17)

1

ISSUE STATUS

REV.	DATE	DESCRIPTION	BY
0	02/05/18	90% ZONING	FA
1	03/01/18	100% ZONING	FA
2	03/09/18	100% ZONING	FA

SC WIRELESS
9015 SHOREHAM PLACE, STE. 150
SAN DIEGO, CA 92122
www.scwi.com
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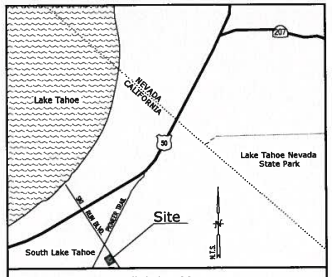
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verizon

SKI RUN BLVD
PSL# 444780
1360 SKI RUN BLVD
SOUTH LAKE TAHOE, CA 96150

SHEET TITLE:
SITE PLAN

A-1



Vicinity Map

Title Report

PREPARED BY: PLACER TITLE COMPANY
ORDER NO.: 1415-13484
DATED: JULY 28, 2011

Legal Description

REAL PROPERTY IN THE CITY OF SOUTH LAKE TAHOE, COUNTY OF EL DORADO, STATE OF CALIFORNIA DESCRIBED AS FOLLOWS:

BEGINNING AT A 3/4 INCH CAPPED IRON PIPE SET IN THE WESTERLY LINE OF BIJOU PARK BOULEVARD, FROM WHICH THE NORTHEAST CORNER OF SAID SECTION 2 BEARS NORTH 29° 50' WEST, 30.0 FEET, AND 55° 42' 30" WEST, 782.6 FEET; THENCE FROM POINT OF BEGINNING AND ALONG SAID WESTERLY LINE OF BIJOU PARK BOULEVARD, SOUTH 29° 50' EAST 300.0 FEET A 3/4 INCH CAPPED IRON PIPE; THENCE LEAVING SAID LINE SOUTH 60° 18' WEST, 275.0 FEET A SIMILAR PIPE; THENCE NORTH 29° 50' WEST, 300.0 FEET A SIMILAR PIPE; THENCE NORTH 60° 18' EAST, 275.0 FEET TO THE POINT OF BEGINNING.

Assessor's Parcel No.

025-580-07-100

Easements

NO EASEMENTS REPORTED PER TITLE REPORT

Lease Area

AS SHOWN

Geographic Coordinates at Proposed Monopine

1983 DATUM: LATITUDE 38° 56' 14.53" N LONGITUDE 119° 57' 00.45" W
ELEVATION = 6374.3 FEET ABOVE MEAN SEA LEVEL

CERTIFICATION:
THE LATITUDE AND LONGITUDE SHOWN ABOVE ARE ACCURATE TO WITHIN +/- 15 FEET HORIZONTALLY AND THAT THE ELEVATIONS SHOWN ABOVE ARE ACCURATE TO WITHIN +/- 3 FEET VERTICALLY. THE HORIZONTAL DATUM (GEOGRAPHIC COORDINATES) IS IN TERMS OF THE NORTH AMERICAN DATUM OF 1983 (NAD 83) AND IS EXPRESSED IN DEGREES (°), MINUTES (') AND SECONDS ("), TO THE NEAREST HUNDREDTH OF A SECOND. THE VERTICAL DATUM (ELEVATIONS) IS IN TERMS OF THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88) AND IS DETERMINED TO THE NEAREST TENTH OF A FOOT.

Basis of Bearings

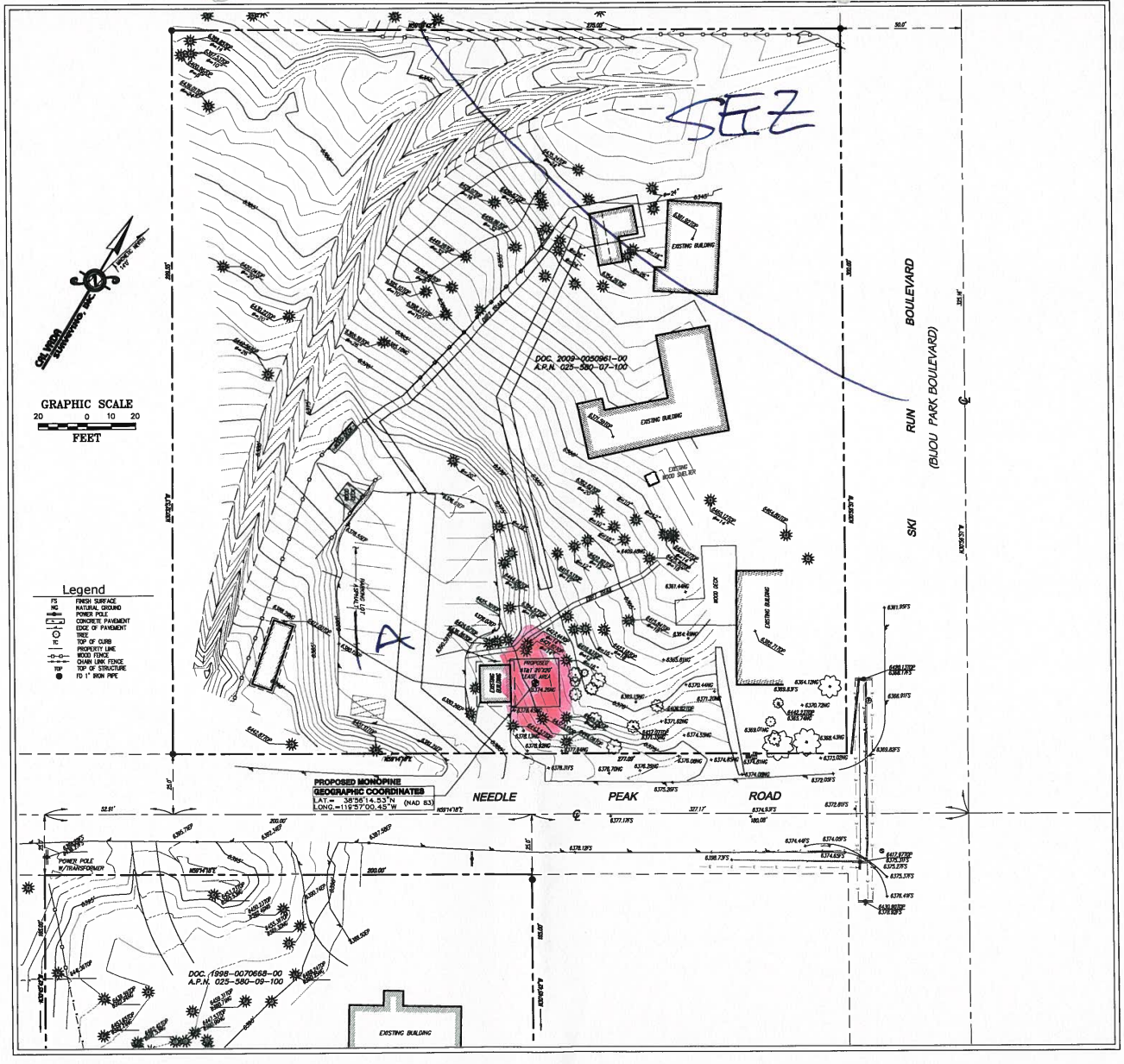
THE STATE PLANE COORDINATE SYSTEM OF 1983 (NAD 83), CALIFORNIA ZONE 2.

Bench Mark

THE CALIFORNIA SPATIAL REFERENCE C.O.R.S "P140".
ELEVATION = 3629.27 FEET (NAVD 88)

Dates of Survey

AUGUST 10, 2011 & OCTOBER 31, 2012



AT&T
AT&T MOBILITY
4420 ROSEWOOD DRIVE
PLEASANTON, CA 94588

PROJECT INFORMATION:

PIONEER TRAIL
CV0588C
1360 SKI RUN BLVD.
SOUTH LAKE TAHOE, CA 96150
EL DORADO COUNTY

REV.:	DATE:	DESCRIPTION:	BY:
5	10/10/12	GEOGRAPHIC COORDINATES	AL
4	11/02/12	ADDITIONAL TOPO	MN
3	01/17/12	TITLE REPORT/ FINAL	RG
	08/29/11	SUBMITTAL	HN

PLANS PREPARED BY:

Streamline Engineering and Design Inc.
8445 Sierra College Blvd., Suite F, Granite Bay, Ca 95746
Contact: Larry Houghtby Phone: 916-660-1930
E-Mail: larry@streamlineeng.com Fax: 916-660-1941

CONSULTANT:

CALVADA SURVEYING, INC.
411 Jenks Cir., Suite 205, Corona, CA 92880
Phone: 951-280-9960 Fax: 951-280-9740
Toll Free: 800-CALVADA www.calvada.com
JOB NO. 11987

SEAL OF APPROVAL:

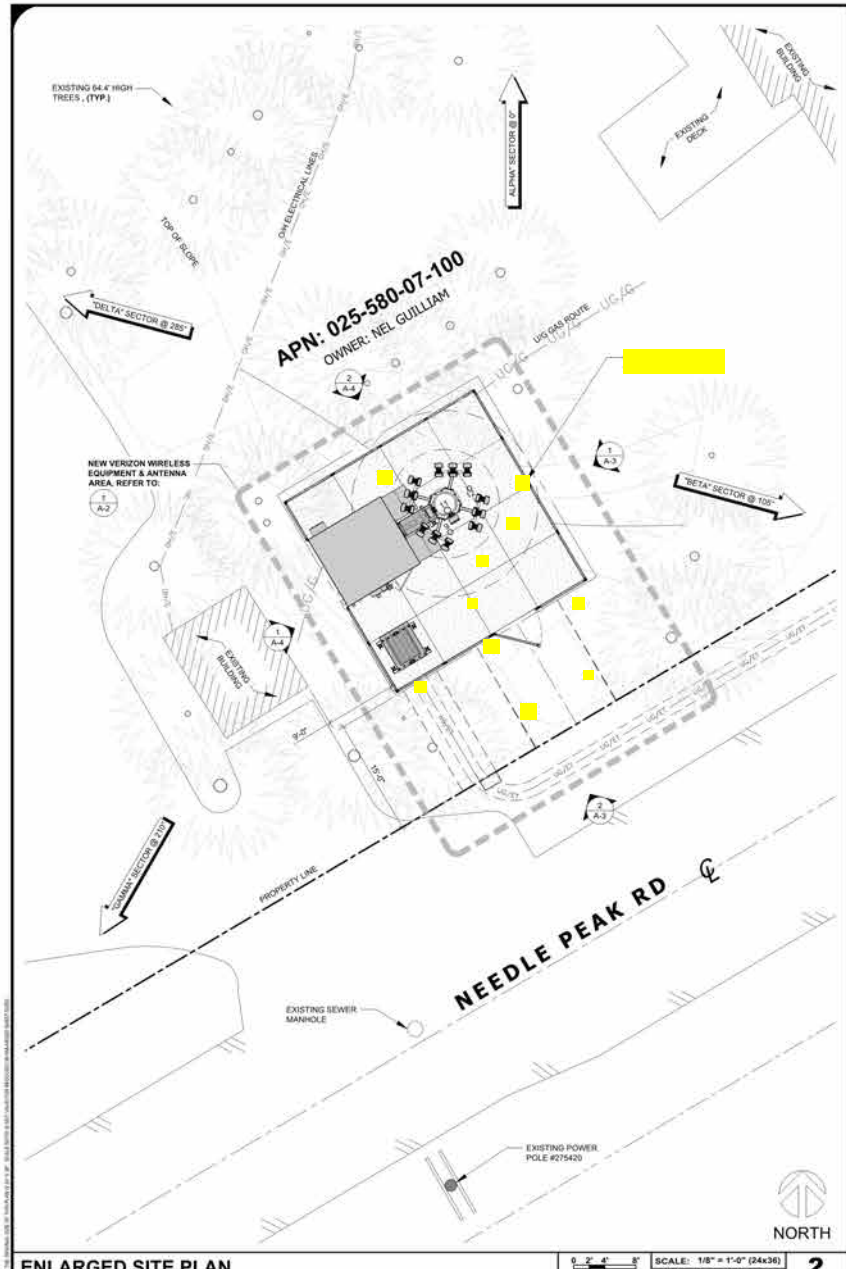
SHEET TITLE:

TOPOGRAPHIC SURVEY

SHEET NUMBER: C-1
SHEET 1 OF 1

REVISION:

EXHIBIT (A)(h)(iii) Fig. Removal of Thirteen Trees

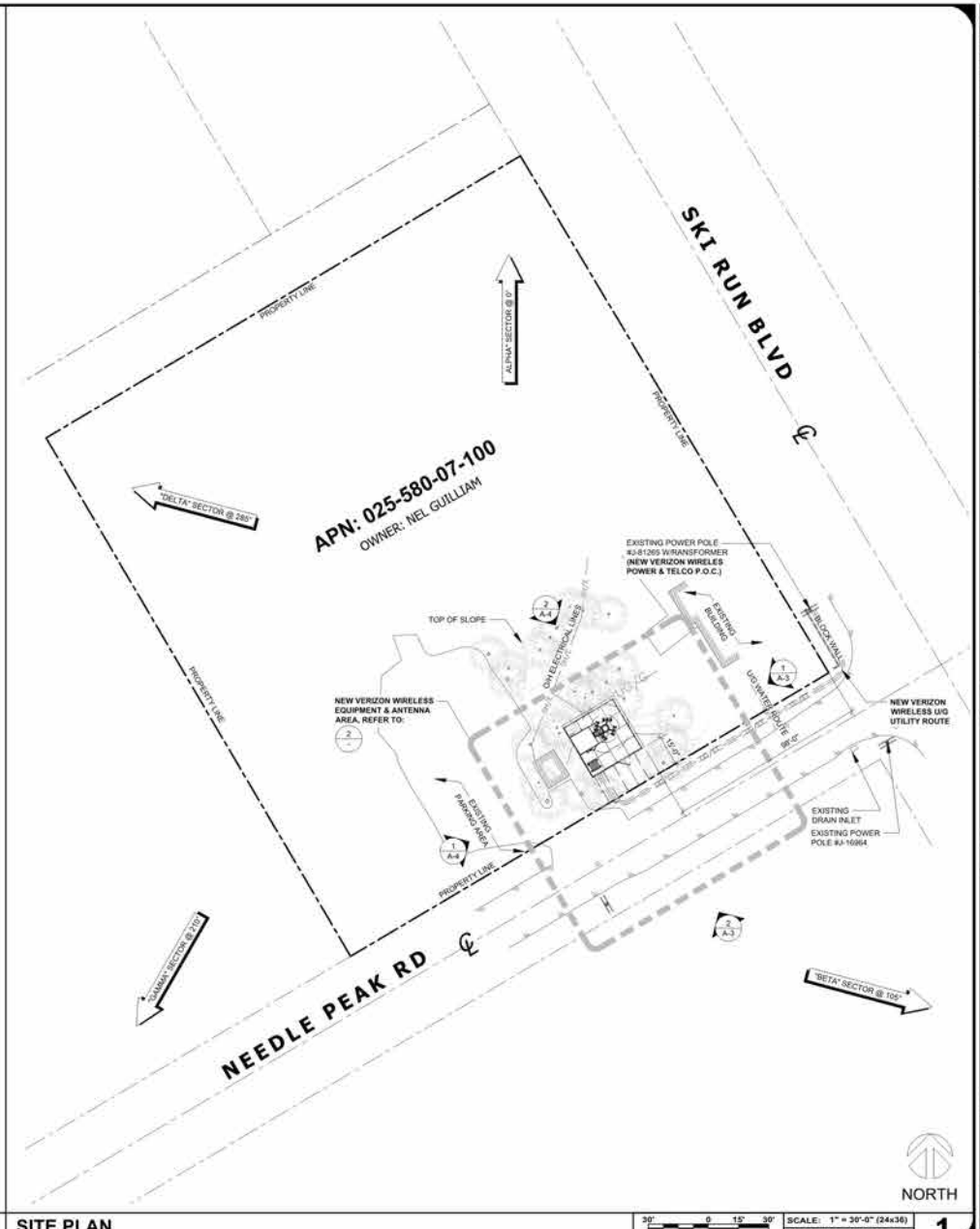


ENLARGED SITE PLAN

0 2' 4' 8'

SCALE: 1/8" = 1'-0" (24x36)
(OR) 1/16" = 1'-0" (11x17)

2



SITE PLAN

30' 0 15' 30'

SCALE: 1" = 30'-0" (24x36)
(OR) 1/2" = 30'-0" (11x17)

1

ISSUE STATUS

REV.	DATE	DESCRIPTION	BY
0	02/05/18	90% ZONING	FA
1	03/01/18	100% ZONING	FA
2	03/09/18	100% ZONING	FA

SC WIRELESS
9015 SHOREHAM PLACE, STE. 150
SAN DIEGO, CA 92122
www.scwi.com
619.736.2706

PROPRIETARY INFORMATION

THE INFORMATION CONTAINED IN THIS SET OF DRAWINGS IS PROPRIETARY & CONFIDENTIAL TO VERIZON WIRELESS

ANY USE OR DISCLOSURE OTHER THAN AS IT RELATES TO VERIZON WIRELESS IS STRICTLY PROHIBITED

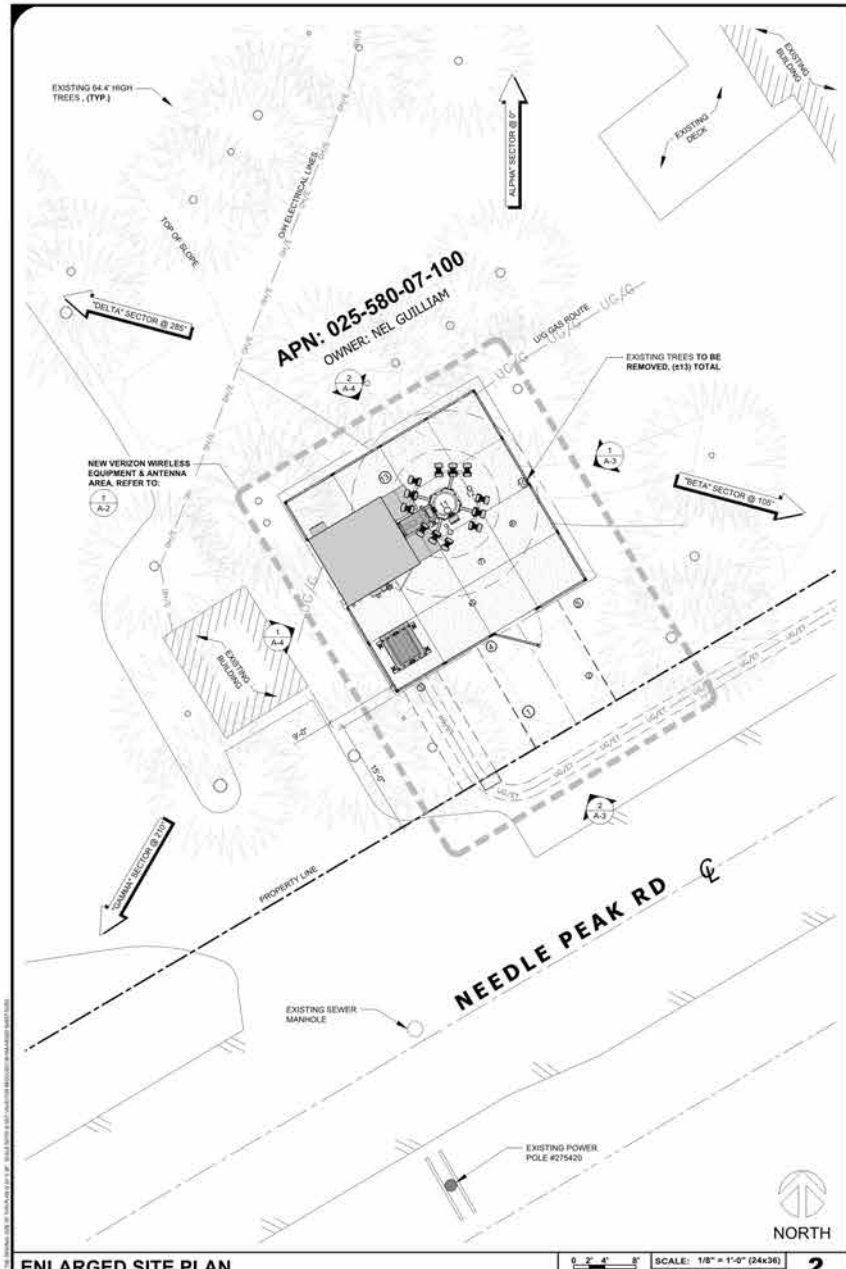
verizon

SKI RUN BLVD
PSL# 444780
1360 SKI RUN BLVD
SOUTH LAKE TAHOE, CA 96150

SHEET TITLE:
SITE PLAN

A-1

EXHIBIT (A)(h)(iii) Fig. Removal of Thirteen Trees

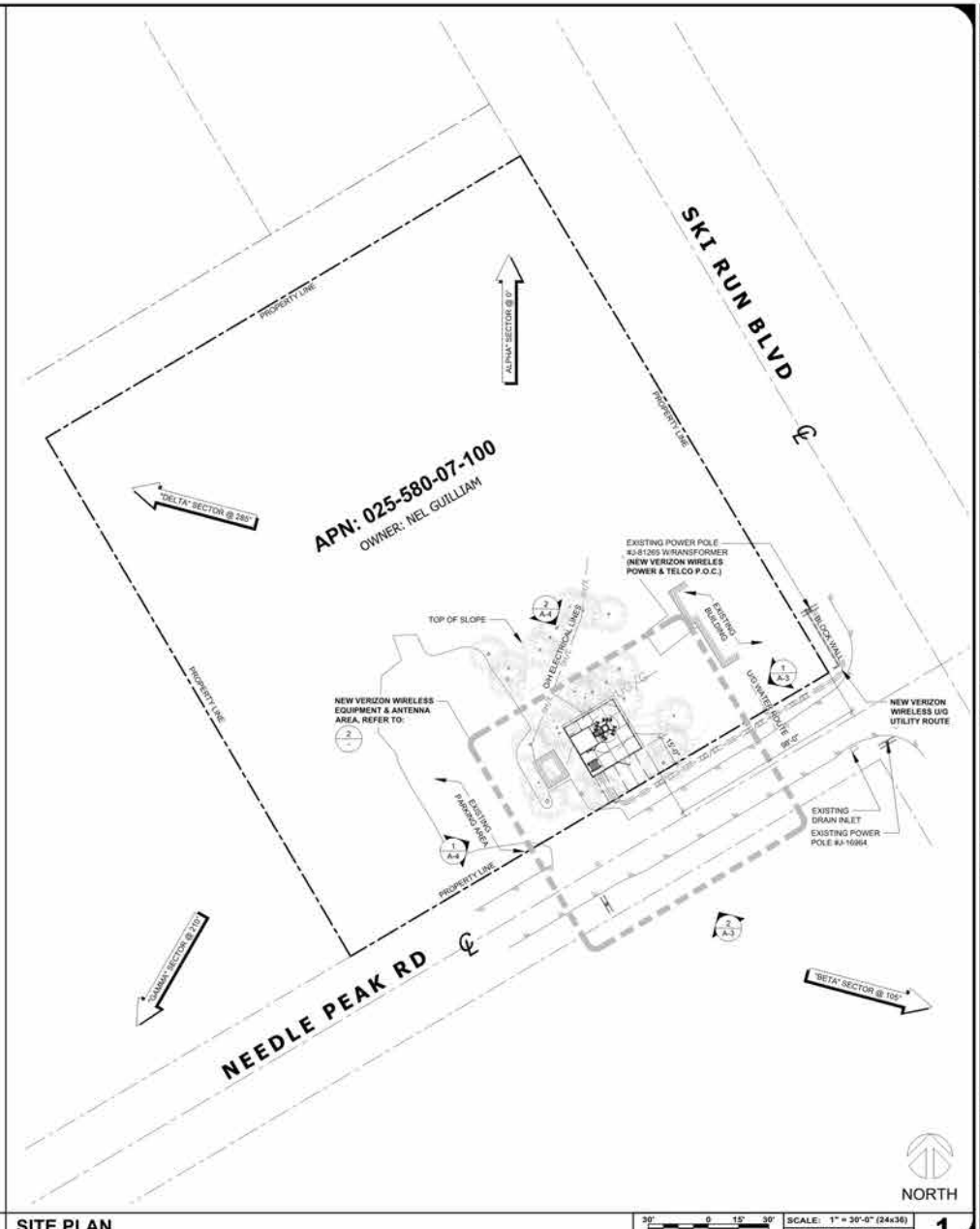


ENLARGED SITE PLAN

0 2' 4' 8'

SCALE: 1/8" = 1'-0" (24x36)
(OR) 1/16" = 1'-0" (11x17)

2



SITE PLAN

30' 0 15' 30'

SCALE: 1" = 30'-0" (24x36)
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verizon

2785 MITCHELL DRIVE, BLDG 9
WALNUT CREEK, CA 94598

SKI RUN BLVD
PSL# 444780
1360 SKI RUN BLVD
SOUTH LAKE TAHOE, CA 96150

SHEET TITLE:
SITE PLAN

A-1

Verizon Wireless • Proposed Base Station (Site No. 444780 "Ski Run Boulevard")
1360 Ski Run Boulevard • South Lake Tahoe, California

Statement of Hammett & Edison, Inc., Consulting Engineers

The firm of Hammett & Edison, Inc., Consulting Engineers, has been retained on behalf of Verizon Wireless, a personal wireless telecommunications carrier, to evaluate the base station (Site No. 444780 "Ski Run Boulevard") proposed to be located at 1360 Ski Run Boulevard in South Lake Tahoe, California, for compliance with appropriate guidelines limiting human exposure to radio frequency ("RF") electromagnetic fields.

Executive Summary

Verizon proposes to install directional panel antennas on a new tall pole, configured to resemble a tree, to be sited behind Hansen's Resort located at 1360 Ski Run Boulevard in South Lake Tahoe. The proposed operation will comply with the FCC guidelines limiting public exposure to RF energy.

Prevailing Exposure Standards

The U.S. Congress requires that the Federal Communications Commission ("FCC") evaluate its actions for possible significant impact on the environment. A summary of the FCC's exposure limits is shown in Figure 1. These limits apply for continuous exposures and are intended to provide a prudent margin of safety for all persons, regardless of age, gender, size, or health. The most restrictive limit for exposures of unlimited duration at several wireless service bands are as follows:

Wireless Service Band	Transmit Frequency	"Uncontrolled" Public Limit	Occupational Limit (5 times Public)
Microwave (point-to-point)	1–80 GHz	1.0 mW/cm^2	5.0 mW/cm^2
Millimeter-wave	24–47	1.0	5.0
Part 15 (WiFi & other unlicensed)	2–6	1.0	5.0
BRS (Broadband Radio)	2,490 MHz	1.0	5.0
WCS (Wireless Communication)	2,305	1.0	5.0
AWS (Advanced Wireless)	2,110	1.0	5.0
PCS (Personal Communication)	1,930	1.0	5.0
Cellular	869	0.58	2.9
SMR (Specialized Mobile [illegible])	854	0.57	2.85
700 MHz	716	0.48	2.4
[illegible]	[illegible]	[illegible]	1.0

General Facility Requirements

Base stations typically consist of two distinct parts: the electronic transceivers (also called "radios" or "channels") that are connected to the traditional wired telephone lines, and the passive antennas that send the wireless signals created by the radios out to be received by individual subscriber units. The transceivers are often located at ground level and are connected to the antennas by coaxial cables.

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A small antenna for reception of GPS signals is also required, mounted with a clear view of the sky. Because of the short wavelength of the frequencies assigned by the FCC for wireless services, the antennas require line-of-sight paths for their signals to propagate well and so are installed at some height above ground. The antennas are designed to concentrate their energy toward the horizon, with very little energy wasted toward the sky or the ground. This means that it is generally not possible for exposure conditions to approach the maximum permissible exposure limits without being physically very near the antennas.

Computer Modeling Method

The FCC provides direction for determining compliance in its Office of Engineering and Technology Bulletin No. 65, "Evaluating Compliance with FCC-Specified Guidelines for Human Exposure to Radio Frequency Radiation," dated August 1997. Figure 2 describes the calculation methodologies, reflecting the facts that a directional antenna's radiation pattern is not fully formed at locations very close by (the "near-field" effect) and that at greater distances the power level from an energy source decreases with the square of the distance from it (the "inverse square law"). The conservative nature of this method for evaluating exposure conditions has been verified by numerous field tests.

Site and Facility Description

Based upon information provided by Verizon, including zoning drawings by SAC AE Design Group, Inc., dated March 14, 2019, it is proposed to install twelve CommScope directional panel antennas – six Model NHH-65C and six Model NHH-45C – on a new 107-foot steel pole,* configured to resemble a pine tree, to be sited near the east side of the parking lot behind Hansen's Resort located at 1360 Ski Run Boulevard in South Lake Tahoe. The antennas would employ up to 8° downtilt, would be mounted at an effective height of about 103 feet above ground, and would be oriented in groups of three: the -45C antennas toward 0°T and 210°T, and the -65C antennas toward 105°T and 285°T. The maximum effective radiated power in the 0°T and 210°T directions would be 47,090 watts, representing simultaneous operation at 19,060 watts for AWS, 5,000 watts for PCS, 12,030 watts for cellular, and 11,000 watts for 700 MHz service. The maximum effective radiated power in the 105°T and 285°T directions would be 30,750 watts, representing simultaneous operation at 11,750 watts for AWS, 5,000 watts for PCS, 7,080 watts for cellular, and 6,920 watts for 700 MHz service. There are reported no other wireless telecommunications base stations at the site or nearby.

Study Results

For a person anywhere at ground, the maximum RF exposure level due to the proposed Verizon operation is calculated to be 0.025 mW/cm^2, which is 4.6% of the applicable public exposure limit.

* Foliage atop the pole puts the overall height at 112 feet.

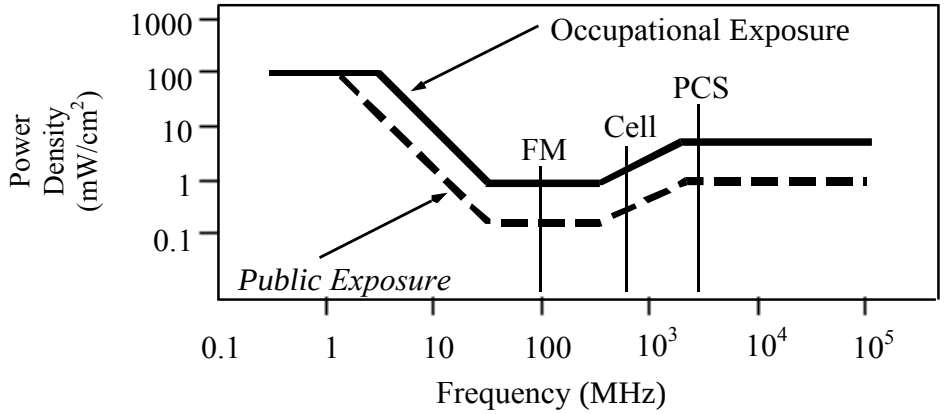
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FCC Radio Frequency Protection Guide

The U.S. Congress required (1996 Telecom Act) the Federal Communications Commission ("FCC") to adopt a nationwide human exposure standard to ensure that its licensees do not, cumulatively, have a significant impact on the environment. The FCC adopted the limits from Report No. 86, "Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields," published in 1986 by the Congressionally chartered National Council on Radiation Protection and Measurements ("NCRP"). Separate limits apply for occupational and public exposure conditions, with the latter limits generally five times more restrictive. The more recent standard, developed by the Institute of Electrical and Electronics Engineers and approved as American National Standard ANSI/IEEE C95.1-2006, "Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz," includes similar limits. These limits apply for continuous exposures from all sources and are intended to provide a prudent margin of safety for all persons, regardless of age, gender, size, or health.

As shown in the table and chart below, separate limits apply for occupational and public exposure conditions, with the latter limits (in *italics* and/or dashed) up to five times more restrictive:

Frequency	Electromagnetic Fields (f is frequency of emission in MHz)					
Applicable Range (MHz)	Electric Field Strength (V/m)		Magnetic Field Strength (A/m)		Equivalent Far-Field Power Density (mW/cm^2)	
0.3 – 1.34	614	*614*	1.63	*1.63*	100	*100*
1.34 – 3.0	614	*823.8/ f*	1.63	*2.19/ f*	100	*180/ f^2*
3.0 – 30	1842/ f	*823.8/ f*	4.89/ f	*2.19/ f*	900/ f^2	*180/ f^2*
30 – 300	61.4	*27.5*	0.163	*0.0729*	1.0	*0.2*
300 – 1,500	$3.54\sqrt{f}$	*$1.59\sqrt{f}$*	$\sqrt{f}/106$	*$\sqrt{f}/238$*	f/300	*f/1500*
1,500 – 100,000	137	*61.4*	0.364	*0.163*	5.0	*1.0*



Higher levels are allowed for short periods of time, such that total exposure levels averaged over six or thirty minutes, for occupational or public settings, respectively, do not exceed the limits, and higher levels also are allowed for exposures to small areas, such that the spatially averaged levels do not exceed the limits. However, neither of these allowances is incorporated in the conservative calculation formulas in the FCC Office of Engineering and Technology Bulletin No. 65 (August 1997) for projecting field levels. Hammett & Edison has built those formulas into a proprietary program that calculates, at each location on an arbitrary rectangular grid, the total expected power density from any number of individual radio sources. The program allows for the description of buildings and uneven terrain, if required to obtain more accurate projections.

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The maximum calculated level at the second floor elevation of any nearby building† is 5.7% of the public exposure limit. It should be noted that these results include several "worst-case" assumptions and therefore are expected to overstate actual power density levels from the proposed operation.

No Recommended Mitigation Measures

Due to their mounting location and height, the Verizon antennas would not be accessible to unauthorized persons, and so no mitigation measures are necessary to comply with the FCC public exposure guidelines. It is presumed that Verizon will, as an FCC licensee, take adequate steps to ensure that its employees or contractors receive appropriate training and comply with FCC occupational exposure guidelines whenever work is required near the antennas themselves.

Conclusion

Based on the information and analysis above, it is the undersigned's professional opinion that operation of the base station proposed by Verizon Wireless at 1360 Ski Run Boulevard in South Lake Tahoe, California, will comply with the prevailing standards for limiting public exposure to radio frequency energy and, therefore, will not for this reason cause a significant impact on the environment. The highest calculated level in publicly accessible areas is much less than the prevailing standards allow for exposures of unlimited duration. This finding is consistent with measurements of actual exposure conditions taken at other operating base stations.

Authorship

The undersigned author of this statement is a qualified Professional Engineer, holding California Registration No. E-18063, which expires on June 30, 2019. This work has been carried out under his direction, and all statements are true and correct of his own knowledge except, where noted, when data has been supplied by others, which data he believes to be correct.



Rajat Mathur, P.E.
707/996-5200

May 22, 2019

† Including the residences located at least 110 feet away, based on photographs from Google Maps.

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Verizon Wireless • Proposed Small Cell (No. 434889 "SC South Lake Tahoe 017")
3500-3604 Needle Peak Road • South Lake Tahoe, California

Statement of Hammett & Edison, Inc., Consulting Engineers

The firm of Hammett & Edison, Inc., Consulting Engineers, has been retained on behalf of Verizon Wireless, a personal wireless telecommunications carrier, to evaluate its small cell (No. 434889 "SC South Lake Tahoe 017") proposed to be sited in South Lake Tahoe, California, for compliance with appropriate guidelines limiting human exposure to radio frequency ("RF") electromagnetic fields.

Executive Summary

Verizon proposes to install a cylindrical antenna on a utility pole sited in the public right-of-way on the south side of Needle Peak Road in South Lake Tahoe. The proposed operation will comply with the FCC guidelines limiting public exposure to RF energy.

Prevailing Exposure Standard

The U.S. Congress requires that the Federal Communications Commission ("FCC") evaluate its actions for possible significant impact on the environment. A summary of the FCC's human exposure limits is shown in Figure 1. These limits apply for continuous exposures and are intended to provide a prudent margin of safety for all persons, regardless of age, gender, size, or health. The FCC limit for exposures of unlimited duration to radio frequency energy for various wireless services are as follows:

Wireless Service	Frequency Band	Occupational Limit	Public Limit
Microwave (Point-to-Point)	5–80 GHz	5.00 mW/cm^2	1.00 mW/cm^2
WiFi (and unlicensed uses)	2–6	5.00	1.00
BRS (Broadband Radio)	2,600 MHz	5.00	1.00
WCS (Wireless Communication)	2,300	5.00	1.00
AWS (Advanced Wireless)	2,100	5.00	1.00
PCS (Personal Communication)	1,950	5.00	1.00
Cellular	870	2.90	0.58
SMR (Specialized Mobile Radio)	855	2.85	0.57
700 MHz	700	2.40	0.48
[most restrictive frequency range]	30–300	1.00	0.20

Power line frequencies (60 Hz) are well below the applicable range of these standards, and there is considered to be no compounding effect from simultaneous exposure to power line and radio frequency fields.

General Facility Requirements

Small cells typically consist of two distinct parts: the electronic transceivers (also called "radios") that are connected to the traditional wired telephone lines, and the passive antennas that send the wireless signals created by the radios out to be received by individual subscriber units. The transceivers are typically mounted on the support pole or placed in a cabinet at ground level, and they are connected to

RFR.CALC™ Calculation Methodology

Assessment by Calculation of Compliance with FCC Exposure Guidelines

The U.S. Congress required (1996 Telecom Act) the Federal Communications Commission ("FCC") to adopt a nationwide human exposure standard to ensure that its licensees do not, cumulatively, have a significant impact on the environment. The maximum permissible exposure limits adopted by the FCC (see Figure 1) apply for continuous exposures from all sources and are intended to provide a prudent margin of safety for all persons, regardless of age, gender, size, or health. Higher levels are allowed for short periods of time, such that total exposure levels averaged over six or thirty minutes, for occupational or public settings, respectively, do not exceed the limits.

Near Field.
Prediction methods have been developed for the near field zone of panel (directional) and whip (omnidirectional) antennas, typical at wireless telecommunications base stations, as well as dish (aperture) antennas, typically used for microwave links. The antenna patterns are not fully formed in the near field at these antennas, and the FCC Office of Engineering and Technology Bulletin No. 65 (August 1997) gives suitable formulas for calculating power density within such zones.

For a panel or whip antenna, power density $S = \frac{180}{\theta_{BW}} \times \frac{0.1 \times P_{net}}{\pi \times D \times h}$, in mW/cm^2,

and for an aperture antenna, maximum power density $S_{max} = \frac{0.1 \times 16 \times \eta \times P_{net}}{\pi \times h^2}$, in mW/cm^2,

where θ_{BW} = half-power beamwidth of antenna, in degrees,
P_{net} = net power input to antenna, in watts,
D = distance from antenna, in mete
h = aperture height of antenna, in meters, and
η = aperture efficiency (unitless, typically 0.5-0.8).

The factor of 0.1 in the numerators converts to the desired units of power density.

Far Field.
OET-65 gives this f calculating power density in the far field of an individual RF source:

power density $S = \frac{2.56 \times 1.64 \times 100 \times RFF^2 \times$

where ERP = total ERP (all polarizations), in kilowatts,
RFF = three-dimensional relative field factor toward point of calculation, and
D = distance from antenna effective height to point of calculation, in meters.

The factor of 2.56 accounts for the increase in power density due to ground reflection, assuming a reflection coefficient of 1.6 (1.6 x 1.6 = 2.56). The factor of 1.64 is the gain of a half-wave dipole relative to an isotropic radiator. The factor of 100 in the numerator converts to the desired units of power density. This formula is used in a computer program capable of calculating, at thousands of locations on an arbitrary grid, the total expected power density from any number of individual radio frequency sources. The program also allows for the inclusion of uneven terrain in the vicinity, as well as any number of nearby buildings, to obtain more accurate projections.

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Recommended Mitigation Measures

Due to its mounting location and height, the antenna would not be accessible to unauthorized persons, and so no mitigation measures are necessary to comply with the FCC public exposure guidelines. To prevent occupational exposures in excess of the FCC guidelines, it is recommended that appropriate RF safety training, to include review of personal monitor use, be provided to all authorized personnel who have access to the antenna. No access within 7 feet at the same height as the antenna, such as might occur during certain maintenance activities at the top of the pole, should be allowed while the small cell is in operation, unless other measures can be demonstrated to ensure that occupational protection requirements are met. It is recommended that an explanatory sign* be posted at the antenna and/or on the pole below the antenna, readily visible from any angle of approach to persons who might need to work within that distance.

Conclusion

Based on the information and analysis above, it is the undersigned's professional opinion that operation of the small cell proposed by Verizon Wireless on the south side of Needle Peak Road in South Lake Tahoe, California, will comply with the prevailing standards for limiting public exposure to radio frequency energy and, therefore, will not for this reason cause a significant impact on the environment. The highest calculated level in publicly accessible areas is much less than the prevailing standards allow for exposures of unlimited duration. This finding is consistent with measurements of actual exposure conditions taken at other operating small cells. Training authorized personnel and posting explanatory signs are recommended to establish compliance with occupational exposure limits.

Authorship

The undersigned author of this statement is a qualified Professional Engineer, holding California Registration No. E-21306, which expires on September 30, 2019. This work has been carried out under his direction, and all statements are true and correct of his own knowledge except, where noted, when data has been supplied by others, which data he believes to be correct.



Neil J. Olij, P.E.
707/996-5200

April 12, 2018

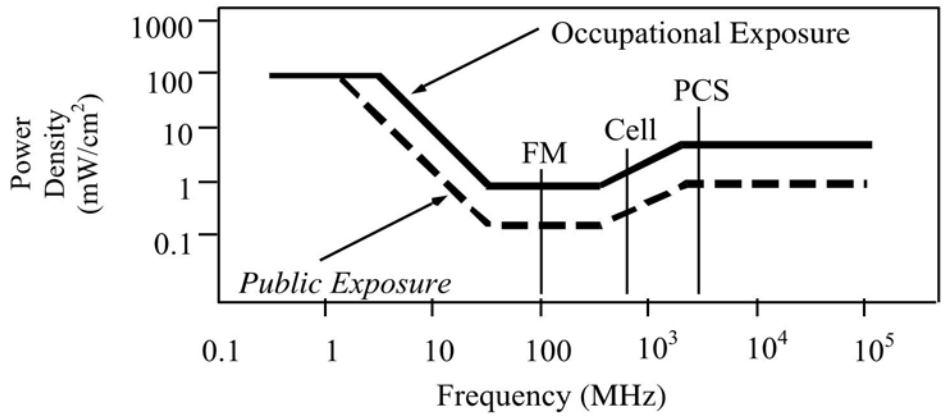
* Signs should comply with OET-65 color, symbol, and content recommendations. Contact information should be provided (*e.g.*, a telephone number) to arrange for access to restricted areas. The selection of language(s) is not an engineering matter, and guidance from the landlord, local zoning or health authority, or appropriate professionals may be required. Signage may also need to comply with the requirements of California Public Utilities Commission General Order No. 95.

FCC Radio Frequency Protection Guide

The U.S. Congress required (1996 Telecom Act) the Federal Communications Commission ("FCC") to adopt a nationwide human exposure standard to ensure that its licensees do not, cumulatively, have a significant impact on the environment. The FCC adopted the limits from Report No. 86, "Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields," published in 1986 by the Congressionally chartered National Council on Radiation Protection and Measurements ("NCRP"). Separate limits apply for occupational and public exposure conditions, with the latter limits generally five times more restrictive. The more recent standard, developed by the Institute of Electrical and Electronics Engineers and approved as American National Standard ANSI/IEEE C95.1-2006, "Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz," includes similar limits. These limits apply for continuous exposures from all sources and are intended to provide a prudent margin of safety for all persons, regardless of age, gender, size, or health.

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0.3 – 1.34	614	*614*	1.63	*1.63*	100	*100*
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300 – 1,500	$3.54\sqrt{f}$	*$1.59\sqrt{f}$*	$\sqrt{f}/106$	*$\sqrt{f}/238$*	f/300	*f/1500*
1,500 – 100,000	137	*61.4*	0.364	*0.163*	5.0	*1.0*



Higher levels are allowed for short periods of time, such that total exposure levels averaged over six or thirty minutes, for occupational or public settings, respectively, do not exceed the limits, and higher levels also are allowed for exposures to small areas, such that the spatially averaged levels do not exceed the limits. However, neither of these allowances is incorporated in the conservative calculation formulas in the FCC Office of Engineering and Technology Bulletin No. 65 (August 1997) for projecting field levels. Hammett & Edison has built those formulas into a proprietary program that calculates, at each location on an arbitrary rectangular grid, the total expected power density from any number of individual radio sources. The program allows for the description of buildings and uneven terrain, if required to obtain more accurate projections.

RFR.CALC™ Calculation Methodology

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Near Field.

Prediction methods have been developed for the near field zone of panel (directional) and whip (omnidirectional) antennas, typical at wireless telecommunications base stations, as well as dish (aperture) antennas, typically used for microwave links. The antenna patterns are not fully formed in the near field at these antennas, and the FCC Office of Engineering and Technology Bulletin No. 65 (August 1997) gives suitable formulas for calculating power density within such zones.

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and for an aperture antenna, maximum power density $S_{max} = \frac{0.1 \times 16 \times \eta \times P_{net}}{\pi \times h^2}$, in mW/cm^2,

where θ_{BW} = half-power beamwidth of the antenna, in degrees, and
P_{net} = net power input to the antenna, in watts,
D = distance from antenna, in meters,
h = aperture height of the antenna, in meters, and
η = aperture efficiency (unitless, typically 0.5-0.8).

The factor of 0.1 in the numerators converts to the desired units of power density.

Far Field.

OET-65 gives this formula for calculating power density in the far field of an individual RF source:

power density $S = \frac{2.56 \times 1.64 \times 100 \times RFF^2 \times ERP}{4 \times \pi \times D^2}$, in mW/cm^2,

where ERP = total ERP (all polarizations), in kilowatts,
RFF = relative field factor at the direction to the actual point of calculation, and
D = distance from the center of radiation to the point of calculation, in meters.

The factor of 2.56 accounts for the increase in power density due to ground reflection, assuming a reflection coefficient of 1.6 (1.6 x 1.6 = 2.56). The factor of 1.64 is the gain of a half-wave dipole relative to an isotropic radiator. The factor of 100 in the numerator converts to the desired units of power density. This formula has been built into a proprietary program that calculates, at each location on an arbitrary rectangular grid, the total expected power density from any number of individual radiation sources. The program also allows for the description of uneven terrain in the vicinity, to obtain more accurate projections.

Verizon Wireless • Proposed Small Cell (No. 481974 "SC South Lake Tahoe 073")
3764 Woodbine Road • South Lake Tahoe, California

Statement of Hammett & Edison, Inc., Consulting Engineers

The firm of Hammett & Edison, Inc., Consulting Engineers, has been retained on behalf of Verizon Wireless, a personal wireless telecommunications carrier, to evaluate its small cell (No. 481974 "SC South Lake Tahoe 073") proposed to be sited in South Lake Tahoe, California, for compliance with appropriate guidelines limiting human exposure to radio frequency ("RF") electromagnetic fields.

Executive Summary

Verizon proposes to install a cylindrical antenna on a utility pole sited in the public right-of-way at 3764 Woodbine Road in South Lake Tahoe. The proposed operation will comply with the FCC guidelines limiting public exposure to RF energy.

Prevailing Exposure Standard

The U.S. Congress requires that the Federal Communications Commission ("FCC") evaluate its actions for possible significant impact on the environment. A summary of the FCC's human exposure limits is shown in Figure 1. These limits apply for continuous exposures and are intended to provide a prudent margin of safety for all persons, regardless of age, gender, size, or health. The FCC limit for exposures of unlimited duration to radio frequency energy for various wireless services are as follows:

Wireless Service	Frequency Band	Occupational Limit	Public Limit
Microwave (Point-to-Point)	5–80 GHz	5.00 mW/cm^2	1.00 mW/cm^2
WiFi (and unlicensed uses)	2–6	5.00	1.00
BRS (Broadband Radio)	2,600 MHz	5.00	1.00
WCS (Wireless Communication)	2,300	5.00	1.00
AWS (Advanced Wireless)	2,100	5.00	1.00
PCS (Personal Communication)	1,950	5.00	1.00
Cellular	870	2.90	0.58
SMR (Specialized Mobile Radio)	855	2.85	0.57
700 MHz	700	2.40	0.48
[most restrictive frequency range]	30–300	1.00	0.20

Power line frequencies (60 Hz) are well below the applicable range of these standards, and there is considered to be no compounding effect from simultaneous exposure to power line and radio frequency fields.

General Facility Requirements

Small cells typically consist of two distinct parts: the electronic transceivers (also called "radios") that are connected to the traditional wired telephone lines, and the passive antennas that send the wireless signals created by the radios out to be received by individual subscriber units. The transceivers are typically mounted on the support pole or placed in a cabinet at ground level, and they are connected to

the antennas by coaxial cables. Because of the short wavelength of the frequencies assigned by the FCC for wireless services, the antennas require line-of-sight paths for their signals to propagate well and so are installed at some height above ground. The antennas are designed to concentrate their energy toward the horizon, with very little energy wasted toward the sky or the ground. This means that it is generally not possible for exposure conditions to approach the maximum permissible exposure limits without being physically very near the antennas.

Computer Modeling Method

The FCC provides direction for determining compliance in its Office of Engineering and Technology Bulletin No. 65, "Evaluating Compliance with FCC-Specified Guidelines for Human Exposure to Radio Frequency Radiation," dated August 1997. Figure 2 describes the calculation methodologies, reflecting the facts that a directional antenna's radiation pattern is not fully formed at locations very close by (the "near-field" effect) and that at greater distances the power level from an energy source decreases with the square of the distance from it (the "inverse square law"). The conservative nature of this method for evaluating exposure conditions has been verified by numerous field tests.

Site and Facility Description

Based upon information provided by Verizon, including drawings by Meridian Management LLC, dated March 16, 2018, it is proposed to install one [redacted] 4-foot tall, omnidirectional cylindrical antenna on an extension above the top of the existing utility pole sited in the public right-of-way on the south side of Needle Peak Road, about 220 feet northeast of its intersection with Pioneer Trail in South Lake Tahoe. The antenna would employ no downtilt and would be mounted at an effective height of about 51 feet above ground. The maximum effect[redacted]power in any direction would be 2,240 watts, representing simultaneous operation at 840 watts for AWS, 750 watts for PCS, 340 watts for [redacted]r wireless base stations at the site or nearby.

Study Results

For a person anywhere at ground, the maximum RF exposure level due to the proposed Verizon operation is calculated to be 0.011 mW/cm^2, which is 1.5% of the applicable public exposure limit. The maximum calculated level at any nearby building is 0.50% of the public exposure limit. It should be noted that these results include several "worst-case" assumptions and therefore are expected to overstate actual power density levels from the proposed operation.

prevent occupational exposures in excess of the FCC guidelines, it is recommended that appropriate RF safety training, to include review of personal monitor use, be provided to all authorized personnel who have access to the antenna. No access within 7 feet at the same height as the antenna, such as might occur during certain maintenance activities at the top of the pole, should be allowed while the small cell is in operation, unless other measures can be demonstrated to ensure that occupational protection requirements are met. It is recommended that an explanatory sign* be posted at the antenna and/or on the pole below the antenna, readily visible from any angle of approach to persons who might need to work within that distance.

Conclusion

Based on the information and analysis above, it is the undersigned's professional opinion that operation of the small cell proposed by Verizon Wireless at 3764 Woodbine Road in South Lake Tahoe, California, will comply with the prevailing standards for limiting public exposure to radio frequency energy and, therefore, will not for this reason cause a significant impact on the environment. The highest calculated level in publicly accessible areas is much less than the prevailing standards allow for exposures of unlimited duration. This finding is consistent with measurements of actual exposure conditions taken at other operating small cells. Training authorized personnel and posting explanatory signs are recommended to establish compliance with occupational exposure limits.

Authorship

The undersigned author of this statement is a qualified Professional Engineer, holding California Registration No. E-21306, which expires on September 30, 2019. This work has been carried out under his direction, and all statements are true and correct of his own knowledge except, where noted, when data has been supplied by others, which data he believes to be correct.



Neil J. Olij, P.E.
707/996-5200

April 12, 2018

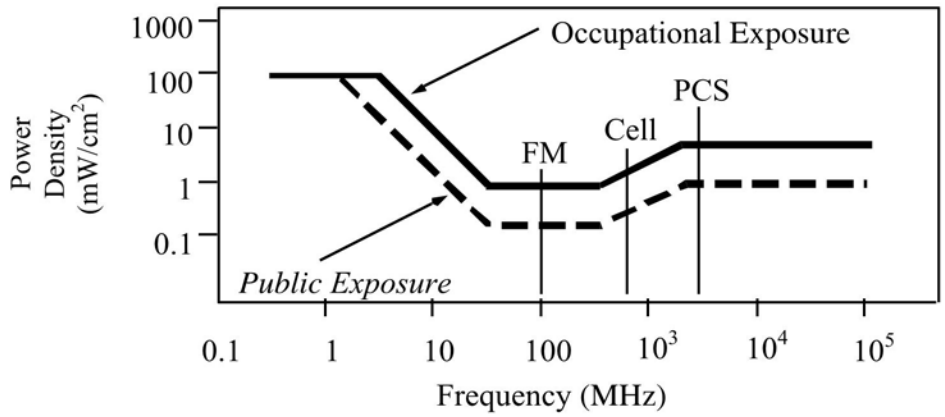
* Signs should comply with OET-65 color, symbol, and content recommendations. Contact information should be provided (*e.g.*, a telephone number) to arrange for access to restricted areas. The selection of language(s) is not an engineering matter, and guidance from the landlord, local zoning or health authority, or appropriate professionals may be required. Signage may also need to comply with the requirements of California Public Utilities Commission General Order No. 95.

FCC Radio Frequency Protection Guide

The U.S. Congress required (1996 Telecom Act) the Federal Communications Commission ("FCC") to adopt a nationwide human exposure standard to ensure that its licensees do not, cumulatively, have a significant impact on the environment. The FCC adopted the limits from Report No. 86, "Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields," published in 1986 by the Congressionally chartered National Council on Radiation Protection and Measurements ("NCRP"). Separate limits apply for occupational and public exposure conditions, with the latter limits generally five times more restrictive. The more recent standard, developed by the Institute of Electrical and Electronics Engineers and approved as American National Standard ANSI/IEEE C95.1-2006, "Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz," includes similar limits. These limits apply for continuous exposures from all sources and are intended to provide a prudent margin of safety for all persons, regardless of age, gender, size, or health.

As shown in the table and chart below, separate limits apply for occupational and public exposure conditions, with the latter limits (in *italics* and/or dashed) up to five times more restrictive:

Frequency	Electromagnetic Fields (f is frequency of emission in MHz)					
Applicable Range (MHz)	Electric Field Strength (V/m)		Magnetic Field Strength (A/m)		Equivalent Far-Field Power Density (mW/cm^2)	
0.3 – 1.34	614	*614*	1.63	*1.63*	100	*100*
1.34 – 3.0	614	*823.8/ f*	1.63	*2.19/ f*	100	*180/ f^2*
3.0 – 30	1842/ f	*823.8/ f*	4.89/ f	*2.19/ f*	900/ f^2	*180/ f^2*
30 – 300	61.4	*27.5*	0.163	*0.0729*	1.0	*0.2*
300 – 1,500	$3.54\sqrt{f}$	*$1.59\sqrt{f}$*	$\sqrt{f}/106$	*$\sqrt{f}/238$*	f/300	*f/1500*
1,500 – 100,000	137	*61.4*	0.364	*0.163*	5.0	*1.0*



Higher levels are allowed for short periods of time, such that total exposure levels averaged over six or thirty minutes, for occupational or public settings, respectively, do not exceed the limits, and higher levels also are allowed for exposures to small areas, such that the spatially averaged levels do not exceed the limits. However, neither of these allowances is incorporated in the conservative calculation formulas in the FCC Office of Engineering and Technology Bulletin No. 65 (August 1997) for projecting field levels. Hammett & Edison has built those formulas into a proprietary program that calculates, at each location on an arbitrary rectangular grid, the total expected power density from any number of individual radio sources. The program allows for the description of buildings and uneven terrain, if required to obtain more accurate projections.

RFR.CALC™ Calculation Methodology

Assessment by Calculation of Compliance with FCC Exposure Guidelines

The U.S. Congress required (1996 Telecom Act) the Federal Communications Commission ("FCC") to adopt a nationwide human exposure standard to ensure that its licensees do not, cumulatively, have a significant impact on the environment. The maximum permissible exposure limits adopted by the FCC (see Figure 1) apply for continuous exposures from all sources and are intended to provide a prudent margin of safety for all persons, regardless of age, gender, size, or health. Higher levels are allowed for short periods of time, such that total exposure levels averaged over six or thirty minutes, for occupational or public settings, respectively, do not exceed the limits.

Near Field.

Prediction methods have been developed for the near field zone of panel (directional) and whip (omnidirectional) antennas, typical at wireless telecommunications base stations, as well as dish (aperture) antennas, typically used for microwave links. The antenna patterns are not fully formed in the near field at these antennas, and the FCC Office of Engineering and Technology Bulletin No. 65 (August 1997) gives suitable formulas for calculating power density within such zones.

For a panel or whip antenna, power density $S = \frac{180}{\theta_{BW}} \times \frac{0.1 \times P_{net}}{\pi \times D \times h}$, in mW/cm^2,

and for an aperture antenna, maximum power density $S_{max} = \frac{0.1 \times 16 \times \eta \times P_{net}}{\pi \times h^2}$, in mW/cm^2,

where θ_{BW} = half-power beamwidth of the antenna, in degrees, and
P_{net} = net power input to the antenna, in watts,
D = distance from antenna, in meters,
h = aperture height of the antenna, in meters, and
η = aperture efficiency (unitless, typically 0.5-0.8).

The factor of 0.1 in the numerators converts to the desired units of power density.

Far Field.

OET-65 gives this formula for calculating power density in the far field of an individual RF source:

power density $S = \frac{2.56 \times 1.64 \times 100 \times RFF^2 \times ERP}{4 \times \pi \times D^2}$, in mW/cm^2,

where ERP = total ERP (all polarizations), in kilowatts,
RFF = relative field factor at the direction to the actual point of calculation, and
D = distance from the center of radiation to the point of calculation, in meters.

The factor of 2.56 accounts for the increase in power density due to ground reflection, assuming a reflection coefficient of 1.6 (1.6 x 1.6 = 2.56). The factor of 1.64 is the gain of a half-wave dipole relative to an isotropic radiator. The factor of 100 in the numerator converts to the desired units of power density. This formula has been built into a proprietary program that calculates, at each location on an arbitrary rectangular grid, the total expected power density from any number of individual radiation sources. The program also allows for the description of uneven terrain in the vicinity, to obtain more accurate projections.

TRPA SCENIC IMPACT ASSESSMENT FORM

Assessor's Parcel Number (APN) 025-580-07-100 County El Dorado

Previous APN _____ (if changed by county assessor since 1987)

Owner Gulliam Nel

Mailing Address PO Box 19531 City South Lake Tahoe State CA

Zip Code 96150 Email info@hansensresort.com Phone (530) 544-3361 FAX _____

Representative or Agent Joseph Sharp, SAC Wireless

Mailing Address 8880 Cal Center Dr, Ste 130 City Sacramento State CA

Zip Code 95826 Email joseph.sharp@sacw.com Phone (916) 205-9305 FAX _____

I have reviewed the TRPA Scenic Corridors, Recreation Areas and Bikeways (listed on the following page) and have determined that the above referenced parcel(s) is (check one):

☒ **not visible.**

☐ **visible from** _____

If visible, provide the following Scenic Resource Inventory Information:
Refer to the Scenic Resources Inventory available at TRPA offices, or online at www.trpa.org. Information and maps for these items are available on the Scenic Resources page of the TRPA website and at the TRPA main office. List all unit numbers the parcel(s) is located in. Then list any scenic points from which the parcel(s) can be seen.

Roadway Unit No. **Status:** ☐ Attainment ☐ Non-attainment

Roadway Scenic Resource Point No. _____

Shoreline Unit No. _____ **Status:** ☐ Attainment ☐ Non-attainment

Shoreline Scenic Resource No. _____

Is this a Shorezone Project? ☐ Yes ☐ No

Shoreline Character Type _____

Current and/or Prior Shorezone Project(s) on site? ☐ Yes ☐ No TRPA File # _____

If yes, and scenic mitigation measures were required, please clearly identify location(s) of any approved mitigation measures on lakefront façade/landscape elevation drawings.

If property boundaries are not clearly defined, all property corners must be located and staked before the site visit. Use one inch by two inch boards about 3 feet long, driven solidly into the ground at the property corners. In cases where there is heavy brush or tree cover, surveyors tape (brightly colored plastic ribbon) shall be tied to the stakes. The address must be posted on the property.

Print Name: Joseph Sharp obo Verizon Wireless **Date:** 3/22/19

Signature of Property Owner or Authorized Agent: _____

TRPA STAFF WILL DETERMINE IF ADDITIONAL SCENIC ANALYSIS IS NEEDED BASED ON REVIEW OF THE FOLLOWING CHECKLIST ITEMS AND STAFF FIELD VISITS TO THE SITE.

(continued on next page)

the antennas by coaxial cables. Because of the short wavelength of the frequencies assigned by the FCC for wireless services, the antennas require line-of-sight paths for their signals to propagate well and so are installed at some height above ground. The antennas are designed to concentrate their energy toward the horizon, with very little energy wasted toward the sky or the ground. This means that it is generally not possible for exposure conditions to approach the maximum permissible exposure limits without being physically very near the antennas.

Computer Modeling Method

The FCC provides direction for determining compliance in its Office of Engineering and Technology Bulletin No. 65, "Evaluating Compliance with FCC-Specified Guidelines for Human Exposure to Radio Frequency Radiation," dated August 1997. Figure 2 describes the calculation methodologies, reflecting the facts that a directional antenna's radiation pattern is not fully formed at locations very close by (the "near-field" effect) and that at greater distances the power level from an energy source decreases with the square of the distance from it (the "inverse square law"). The conservative nature of this method for evaluating exposure conditions has been verified by numerous field tests.

Site and Facility Description

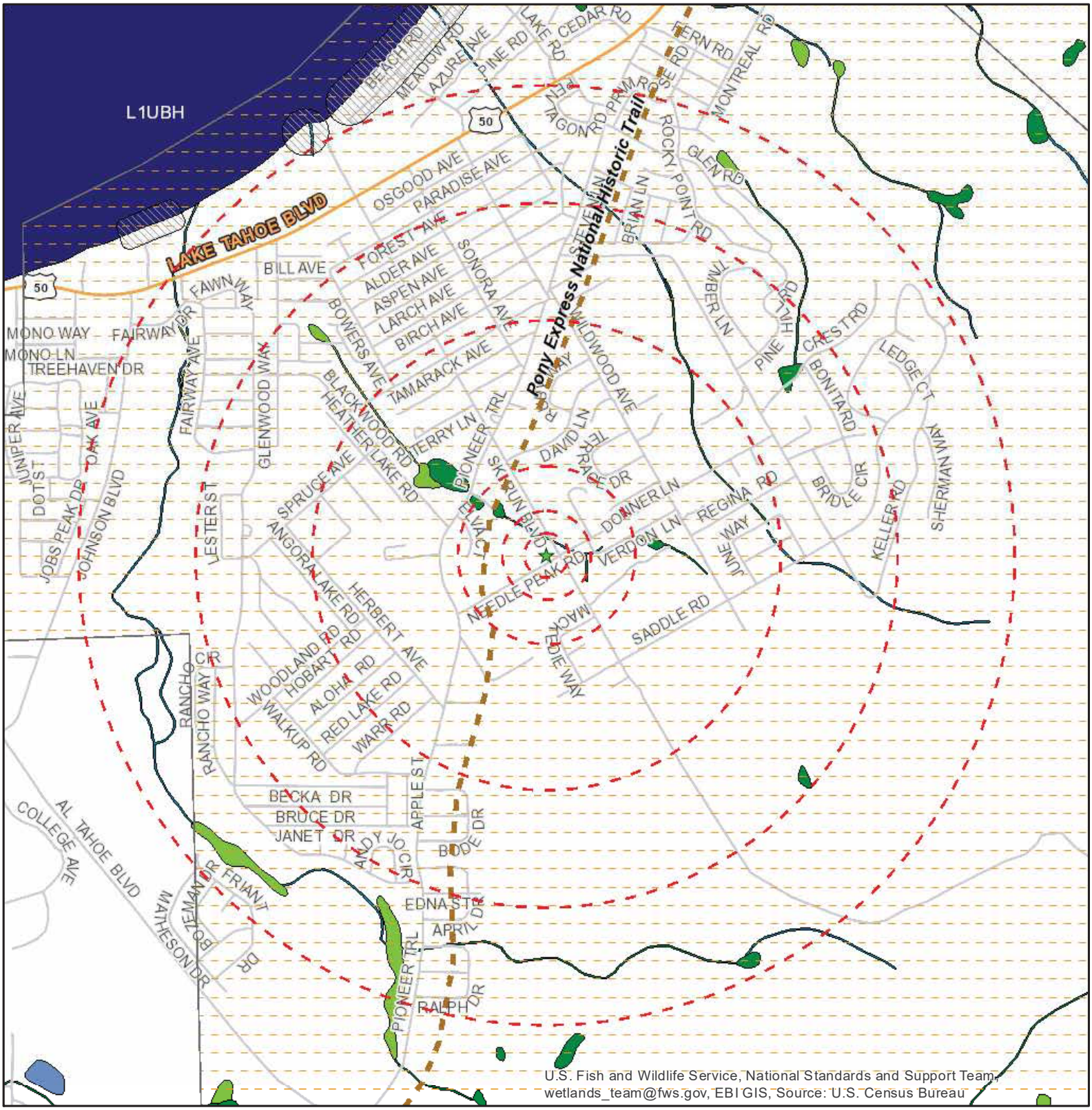
Based upon information provided by Verizon, including drawings by Meridian Management LLC, dated March 16, 2018, it is proposed to install one Amphenol Model CUUT360X12F 4-foot tall, omnidirectional cylindrical antenna on an extension above the top of the existing utility pole sited in the public right-of-way in front of the residence located at 3764 Woodbine Road in South Lake Tahoe. The antenna would employ no downtilt and would be mounted at an effective height of about 48 feet above ground. The maximum effective radiated power in any direction would be 2,240 watts, representing simultaneous operation at 800 watts for AWS, 750 watts for PCS, 340 watts for cellular, and 310 watts for 700 MHz service. There are reported no other wireless base stations at the site or nearby.

Study Results

For a person anywhere at ground, the maximum RF exposure level due to the proposed Verizon operation is calculated to be 0.0031 mW/cm^2, which is 0.54% of the applicable public exposure limit. The maximum calculated level at the second-floor elevation of a nearby building is 0.60% of the public exposure limit. It should be noted that these results include several "worst-case" assumptions and therefore are expected to overstate actual power density levels from the proposed operation.

Recommended Mitigation Measures

Due to its mounting location and height, the antenna would not be accessible to unauthorized persons, and so no mitigation measures are necessary to comply with the FCC public exposure guidelines. To



Legend

★ Project Site

Site Radius at 250', 500', 1000', ½, ¾ & 1 mile

* See associated map legend for additional source information.

Date: 9/13/2018

Land Resources Map

FUZE 616083859 (444780) SKI RUN BLVD - A
1360 SKI RUN BLVD.
SOUTH LAKE TAHOE, CA 96150

PN: 6118004920

N

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Land Resources Legend

Scenic Parkways, Rivers & Trails

- National Scenic Parkway
- National Park Service Trail / Appalachian Trail
- AZ - BLM Historic Trail
- CT - DEP Trail
- MT- Lewis & Clark Trail
- NY - Trails
- NY - Scenic Landmark Area
- NY - Statewide Area of Scenic Significance
- National Wild, Scenic River
- CA, MT, PA - Wild or Scenic River

Sources: National Park Service http://www.nps.gov/gis/data_info/ ; Bureau of land management http://www.blm.gov/wo/st/en.html ; CT DEP http://www.ct.gov/deep/cwp/view.asp?a=2698&q=323342&deepNav_GID=1707%20 ; NY GIS Clearinghouse http://gis.ny.gov/ ; National W & S Rivers http://www.rivers.gov/rivers/mapping-gis.php ; Montana GIS http://nris.mt.gov/gis ; California Atlas http://atlas.ca.gov/

State Conservation, Lands & Wildlife Areas

- CT - DEP Property
- CO - Public Access Wildlife Area
- FL - Wildlife Management Area
- MT - National Wildlife Refuge
- NH - WMNF Management Area
- ME - Conservation Land
- TN - Wildlife Resource Land
- TX - State Park or Wildlife Mgt Area
- TX - Audubon Sanctuary
- CT - DEP Municipal and Open Space
- NH - Conservation Land
- NY - DEC State Lands
- NY - Agricultural District

*Sources: CT DEP http://www.ct.gov/deep/cwp/view.asp?a=2698&q=323342&deepNav_GID=1707%20
CO Wildlife Space http://ndis.nrel.colostate.edu/ftp/ftp_response.asp ;
Florida Fish and Wildlife www.MyFWC.com ; Montana GIS http://nris.mt.gov/gis ; NH GRANIT ttp://www.granit.unh.edu/data/downloadfreedata ; ME GIS http://megis.maine.gov/catalog ; TN GIS http://www.state.tn.us/environment/parks/gis/data/ ; TX GIS http://www.glo.state.tx.us/nri/data/index.html ; NY GIS Clearinghouse http://gis.ny.gov/*

US FWS NWI Wetland Type

- Estuarine and Marine Deepwater
- Estuarine and Marine Wetland
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Lake
- Other
- Riverine

State Endangered Threatened & Protected Species

- AZ - Areas of Environmental Concern
- CA - Spotted Owl Territory
- CA - NDDB T & E Species
- CT - NDDB Area Feature
- CT - DEP Critical Habitat
- MA - NHESP Estimated Habitats of Rare Wildlife
- TX - Protected Species
- MA - NHESP Priority Habitats of Rare Species
- FL - Conservation Species
- MA - NHESP Certified Vernal Pool
- ME - Candidate Vernal Pool
- NY - Important Bird Area
- TX - Ecologically Unique Rivers Streams

Sources: AZ BLM Page http://www.blm.gov/az/st/en/prog/maps/gis_files.html ; CNDDB http://www.dfg.ca.gov/biogeodata/cnddb/ ; CT DEP http://www.ct.gov/deep/cwp/view.asp?a=2698&q=323342&deepNav_GID=1707%20 ; MAGIS http://www.mass.gov/mgis/laylist.htm ; TX GIS http://www.glo.state.tx.us/nri/data/index.html ; Florida Fish and Wildlife www.MyFWC.com; NY GIS Clearinghouse http://gis.ny.gov/

Federal & National Coverage Data Layers

- USFWS Critical Habitat
- USFWS Critical Habitat Area
- National Park Service
- National Wildlife Area or Refuge
- Federally Owned Land
- National Wilderness Areas
- National Park Service Site

FEMA Q3 Flood Zone 2006

- 500-year inundation area.
- 100-year inundation area.
- 100-year inundation area with velocity hazard.
- Undetermined but possible flood hazard area.
- Floodway area, including watercourse extent.

No Flood Data No Flood Data Available

Sources: National Park Service http://www.nps.gov/gis/data_info/ ; USFWS http://crithab.fws.gov/ ; National Park Service http://science.nature.nps.gov/nrdata/index.cfm ; The National Map http://nationalmap.gov/ ; Wilderness.net http://www.wilderness.net/ ; FEMA - Q3 Flood Data https://msc.fema.gov

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Local Government Involvement

Local Government Agency

1) FCC Registration Number (FRN):
2) Name: **South Lake Tahoe Planning Commission**

Contact Name

3) First Name: **Judy**	4) MI:	5) Last Name: **Brown**	6) Suffix:
7) Title: **Chair**			

Contact Information

8) P.O. Box:	**And /Or**	9) Street Address: **1901 Airport Rd.**		
10) City: **South Lake Tahoe**			11) State: **CA**	12) Zip Code: **96150**
13) Telephone Number: **(000)000-0000**		14) Fax Number:		
15) E-mail Address:				
16) Preferred means of communication: ( ) E-mail (**X**) Letter ( ) Both				

Dates & Response

17) Date Contacted **09/06/2018** 18) Date Replied _____

(**X**) No Reply

( ) Replied/No Interest

( ) Replied/Have Interest

( ) Replied/Other

Additional Information

19) Information on local government's role or interest (optional):

Other Consulting Parties

Other Consulting Parties Contacted

1) Has any other agency been contacted and invited to become a consulting party?	(**X**) **Y**es ( ) **N**o

Consulting Party

2) FCC Registration Number (FRN):
3) Name: **The Lake Tahoe Historical Society & Museum**

Contact Name

4) First Name: **to whom it**	5) MI:	6) Last Name: **may concern**	7) Suffix:
8) Title:			

Contact Information

9) P.O. Box: **18501**	**And /Or**	10) Street Address:	
11) City: **South Lake Tahoe**		12) State: **CA**	13) Zip Code: **96151**
14) Telephone Number: **(000)000-0000**		15) Fax Number:	
16) E-mail Address:			

17) Preferred means of communication:

( ) E-mail

(**X**) Letter

( ) Both

Dates & Response

18) Date Contacted **09/06/2018** 19) Date Replied _____

(**X**) No Reply

( ) Replied/No Interest

( ) Replied/Have Interest

( ) Replied/Other

Additional Information

20) Information on other consulting parties' role or interest (optional):

SCENIC IMPACT CHECKLIST

If either the parcel or proposed project is visible from a scenic corridor, recreation area or bikeway, the following information must be submitted to TRPA along with the project application. Refer to the TRPA *Master Checklist* for an explanation of each item. Following this checklist closely can avoid costly delays in reviewing your project.

☐ 5a. Photographs from scenic corridor, recreation area or bikeway location to project area, clearly showing all existing development within the project area.

☐ 5b. Color and material samples for proposed structures. Samples can be no larger than 8.5" x 11". Photographs of sample colors will not be accepted. However, to assist TRPA in the review of your project, you may also submit close-up photographs of outer walls with the applicable color sample from a Munsell® Color Chart held against the wall. A chart of TRPA-approved Munsell® colors is available at TRPA offices.

☐ 5c. Preliminary landscape plan (can be included on the submitted site plan).

☐ 5d. Dimensions of structure(s). Scale drawings showing the exact dimensions of all walls, roofs and structural façades visible from scenic areas or points.

☐ 5e. Written discussion of proposed scenic mitigation measures.

☐ 5f. For Shoreland and Shorezone Projects, TRPA-verified contrast rating score resulting from the Baseline Scenic Assessment. See Baseline Scenic Assessment Application for more information.

SCENIC CORRIDORS, RECREATION AREAS & BIKEWAYS

Scenic Corridors

Lake Tahoe	State Route 28	U.S. Highway 50
State Route 89	State Route 207	State Route 267
State Route 431	Pioneer Trail	

Scenic Recreation Areas

Nevada Beach	Zephyr Cove	Cave Rock
Sand Harbor	Hidden Beach	Diamond Peak
Incline Beach	Burnt Cedar Beach	Kings Beach State Park
Agatam Beach	Patton Beach	Moondunes Beach
Lake Forest Beach	Lake Forest Campground/Boat Ramp	Tahoe State Recreation Area
Tahoe City Commons Beach	William Kent Beach & Campground	Granlibakken Ski Resort
Kaspian Recreation Area	Ski Homewood/Tahoe Ski Bowl	Meeks Bay Resort
Sugar Pine Point State Park	Meeks Bay Campground	D.L. Bliss State Park
Vikingsholm, Emerald Bay Picnic Area	Eagle Falls Picnic Area	Eagle Point Campground
Fallen Leaf Lake Campground	Baldwin Beach	Taylor Creek
Kiva Picnic Area/Tallac Historic Site	Camp Richardson	Pope Beach
El Dorado Beach and Campground	Heavenly Valley Ski Resort	Reagan Beach

Bikeway Segments

Tahoe City to River Ranch	Tahoe City to Dollar Point	Tahoe Tavern
Sunnyside to Timberland	Timberland to Tahoe Pines	Tahoe Pines to Tahoma
City of SLT Recreation Area	Al Tahoe Boulevard	Tahoe Valley Route
Tahoe Valley to SLT City Limits	City of SLT to Tallac Creek	

TO DETERMINE THE THRESHOLD STATUS OF AN AREA, REFER TO THE SCENIC RESOURCES INVENTORY AVAILABLE AT TRPA OFFICES, OR ONLINE AT www.trpa.org.

ADAM CROSBIE
6177151878
EBI CONSULTING
21 B ST
BURLINGTON MA 01803

1 LBS

1 OF 1

SHIP TO:
C/O MS. JUDY BROWN, CHAIR
SOUTH LAKE TAHOE PLANNING COMMISSIO
1901 AIRPORT RD.
SOUTH LAKE TAHOE CA 96150-7009

CA 957 1-01

UPS GROUND

TRACKING #: 1Z X61 224 03 9768 1426

BILLING: P/P

CS 20.5.13. WNINV50 03.0A 07/2018

EBI Consulting
environmental | engineering | due diligence

6876 Susquehanna Trail South
York, PA 17403
Tel: (717) 428-0401
www.ebiconsulting.com

September 6, 2018

South Lake Tahoe Planning Commission
c/o Ms. Judy Brown, Chair
1901 Airport Rd.
South Lake Tahoe, California, 96150

Subject: Invitation to Comment
FUZE 616083859 (444780)/SKI RUN BLVD - A
1360 Ski Run Blvd., South Lake Tahoe, El Dorado County, CA 96150
EBI Project #6118004920

Dear Ms. Brown:

Pursuant to Section 106 of the National Historic Preservation Act, the regulations promulgated thereunder and interagency agreements developed thereto, EBI Consulting, Inc. on behalf of Cellco Partnership and its controlled affiliates doing business as Verizon Wireless (Verizon Wireless) provides this notice of a proposed telecommunications facility installation at the address listed above.

EBI would like to inquire if you would be interested in commenting on this proposed project. Verizon Wireless proposes to install a 112-foot monopine telecommunications tower. Please refer to the attached project plans for complete details regarding this proposed project.

Please note that we are requesting your review of the attached information as part of the Section 106 process only and not as part of the local zoning process. We are only seeking comments related to the proposed project's potential effect to historic properties.

Please submit your comments regarding the proposed project's potential effect on historic properties to EBI Consulting, to my attention at 6876 Susquehanna Trail South, York, PA 17403 or contact me via telephone at the number listed below. Please reference the EBI project number. We would appreciate your comments as soon as possible within the next 30 days. Please do not hesitate to contact me if you have any questions or concerns about the proposed project.

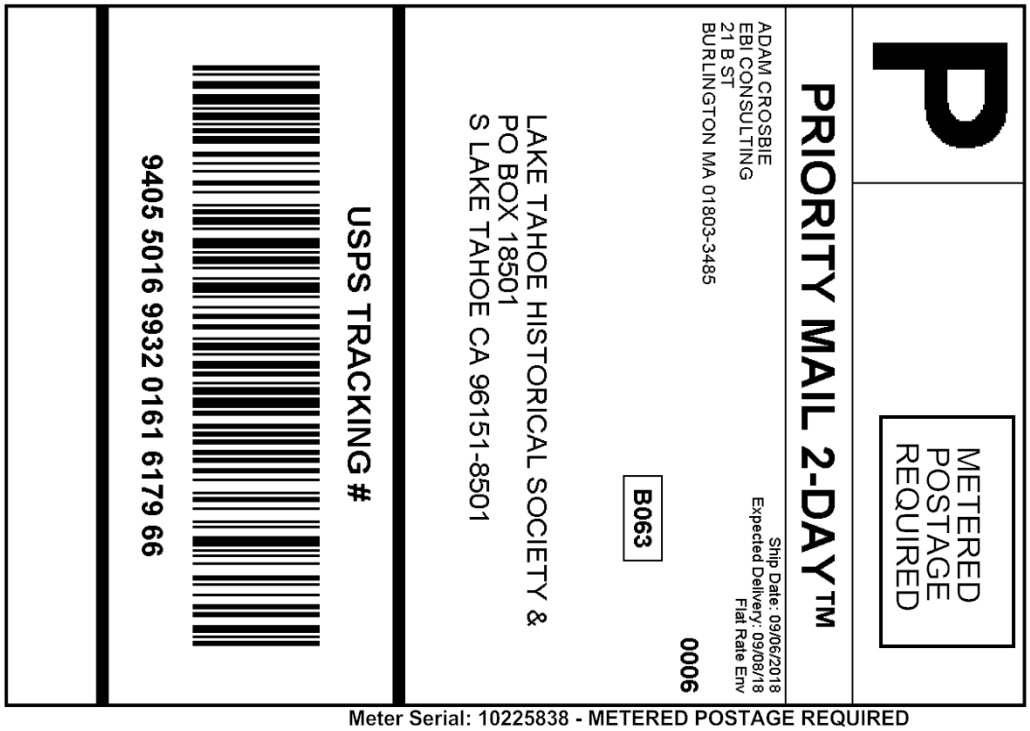
Respectfully Submitted,



Cory Johnson
Architectural Historian
219.313.5458
cory.johnson@ebiconsulting.com

Attachment A – Figures and Project Drawings

USPS® METER LABEL SOLUTION COMMERCIAL BASE PRICE - LABEL TOTAL: $6.55



Meter Serial: 10225838 - METERED POSTAGE REQUIRED

Cut on dotted line.

Instructions

1. Please use a laser or laser-quality printer.
2. Adhere shipping label to package with tape or glue - DO NOT TAPE OVER BARCODE. Be sure all edges are secure. Self-adhesive label is recommended.
3. Place label so that it does not wrap around the edge of the package.
4. Affix Priority Mail service postage. There is no extra fee for option USPS Tracking® service.
5. Stamped packages weighing more than 13 ounces may not be placed in Postal Service collection boxes. For information on Package Pickup, go to USPS.com.
6. Each shipping label number is unique and can be used only once - DO NOT PHOTOCOPY.
7. Please use this shipping label on the "ship date" selected when you requested the label.
8. If a mailing receipt is required, present the article and Online e-Label Record at a Post Office for postmark.

Online e-Label Record

USPS Tracking® Service Number:
9405 5016 9932 0161 6179 66
PRIORITY MAIL 2-DAY™ with electronic option
USPS Tracking® service*
Print Date: 09/06/18 Ship Date: 09/06/18
Electronic Option USPS Tracking® Service Fee: 0.00

From: ADAM CROSBIE
EBI CONSULTING
21 B ST
BURLINGTON MA 01803-3485

To:
LAKE TAHOE HISTORICAL SOCIETY &
PO BOX 18501
S LAKE TAHOE CA 96151-8501

Label Total: $6.55

*Regular Priority Mail Service postage rates apply. There is no fee for USPS Tracking service on Priority Mail service with use of this electronic option shipping label. Delivery information is not available by phone for the electronic option.

UNITED STATES POSTAL SERVICE ***Thank you for shipping with the United States Postal Service!***
Check the status of your shipment on the Track & Confirm page at www.usps.com

Former mayor remembered for service

Ryan Hoffman
rhoffman@tahoedailytribune.com

SOUTH LAKE TAHOE, Calif. — Give her an opportunity to give back, and Judy Brown would seize it.


Judy Brown

The two-term member of City Council was a fervent volunteer in addition to being a business owner, mother, wife and grandmother. She died Saturday in Reno at the age of 72.

South Lake Tahoe city flags are flying half-mast through Friday, Dec. 14, in honor of her dedicated service to the city, which spanned more than two decades.

Her tenure on City Council came at a time of great change that was not free of contentious issues and debates.

"She was definitely a collaborator," said Mayor Brooke Laine, whose first year on council came when Brown was mayor.

At the time, the city was navigating complicated development issues, including what was then known as the Park Avenue Redevelopment Project, which led to the creation of Heavenly Village.

As Laine noted, redevelopment issues require a super-majority vote — meaning a minimum of four out of five councilors must vote in favor.

"We had to deal with some very difficult decisions and she was one of those people who was diligent about making sure that everybody had a piece."

Part of that ability, said former Councilor Tom Davis, came from her inherent kindness.

"Never ever heard a harsh word from her. (She) always looked for compromise," said Davis, who also served on council with Brown.

Along with her time on council, Brown served on the South Lake Tahoe Planning Commission, bringing leadership and knowledge that was unparalleled.

"Her passing will be felt greatly," Laine said.

Brown's involvement with the city, however, was just one aspect of her life.

She and her husband, Alan, owned and operated Tahoe Manor for more than 20 years. Running the residential care facility was a full-time job, Brown told the Tribune in 2004.

"I've never spent a Thanksgiving or Christmas at home," she said at the time.

Despite the demands and the challenges, the experiences and relationships made the job worth doing.

Always looking to help those in need, the Browns opened Tahoe Manor to displaced seniors in the wake of Hurricane Katrina in 2005.

Brown also loved animals, which fueled her nearly two-decade-long involvement with the Lake Tahoe Humane Society.

A fundraising effort is underway to help pay for medical expenses. Visit bit.ly/JudyBrown to donate.

The Lake Tahoe History
Museum is open
11 a.m. - 3 p.m.
Thursdays - Saturdays
through the summer.

ASR Application Search

Application A1103190

Application Detail

File Number	A1103190	Constructed	
Registration Number	1309237	Dismantled	
NEPA		EMI	No

Application Information

Status	Granted	Date Received	01/31/2019
Purpose	Amendment	Entered	01/31/2019
Mode	Interactive		

Antenna Structure

Structure Type	MTOWER - Monopole

Location (in NAD83 Coordinates)

Lat/Long	38-56-14.7 N 119-57-00.3 W	Address	1360 Ski Run Blvd (2517609)
City, State	South Lake Tahoe , CA		
Zip	96150	County	EL DORADO
Center of AM Array		Position of Tower in Array	

Heights (meters)

Elevation of Site Above Mean Sea Level	Overall Height Above Ground (AGL)
1941.6	34.1
Overall Height Above Mean Sea Level	Overall Height Above Ground w/o Appurtenances
1975.7	32.6

Proposed Marking and/or Lighting

None

FAA Notification

FAA Study	2018-AWP-9356-OE	FAA Issue Date	05/31/2018

Owner & Contact Information

FRN	0002972149	Owner Entity Type	Limited Partnership

Owner

Sacramento Valley Limited Partnership
Attention To: Network Regulatory
5055 North Point Pkwy
NP2NE Network Engineering
Alpharetta , GA 30022

P: (770)797-1070
F:
E: Network.Regulatory@VerizonWireless.com

Contact

Manager , Regulatory
Attention To: Network Regulatory
5055 North Point Pkwy
NP2NE Network Engineering
Alpharetta , GA 30022

P: (770)797-1070
F:
E: Network.Regulatory@VerizonWireless.com

Environmental Compliance

Does the applicant request a Waiver of the Commission's rules for environmental notice?	Is the applicant submitting an Environmental Assessment?
No	No
Is another Federal Agency taking responsibility for environmental review?	Does the applicant certify to No Significant Environmental Effect pursuant to Section

No	Yes
Reason for another Federal Agency taking responsibility for environmental review	Basis for Certification The FCC issued a Finding of No Significant Impact.
Name of Federal Agency	Local Notice Date 10/12/2018
National Notice Date 01/09/2019	

Certification

Authorized Party	Gebhardt, Laurie	Title	Authorized Representative
Receipt Date	01/31/2019		

Comments

Comments

None

History

Date	Event
02/19/2019	Amendment Received
02/19/2019	Application Granted
02/19/2019	Supercede - Internal Correction Applied

All History (4)

Trans Log

Date	Description	Existing Value	Requested Value
06/01/2018	Structure : Marking and/or Lighting Code	FAA Style A	None
06/01/2018	Structure : The date the FAA determination was issued		05/31/2018
06/01/2018	Structure : The FAA study number		2018-AWP-9356-OE

All Trans Log (9)

Pleadings

Pleading Type	Filer Name	Description	Date Entered

None

Automated Letters

Date	Description

None

Attachments

Type	Description	Date Entered

None

CLOSE WINDOW

Notice of Exemption ***Supplementary Document Q***

To: ☐ Office of Planning and Research
State Clearinghouse
P.O. Box 3044
Sacramento, CA 95812-3044

☒ County Clerk
County of El Dorado

From: City of South Lake Tahoe
1052 Tata Lane
South Lake Tahoe, CA 96150

Project Title: Verizon Stealth Monopine Wireless Telecommunications Facility
Project Location - Specific: 1360 Ski Run Blvd.
Project Location - City: South Lake Tahoe
Project Location - County: El Dorado

Description of Project: The proposed project is a special use permit to allow the construction of a new stealth monopine wireless telecommunications facility with an associated equipment shed.

Name of Public Agency Approving Project: City of South Lake Tahoe

Name of Person or Agency Carrying out Project: Joseph Sharp for Verizon Wireless

Exempt Status: *(check one)*

☐ Ministerial (Sec. 21080(b)(1); 15268);
☐ Declared Emergency (Sec. 21080(b)(3); 15269(a));
☐ Emergency Project (Sec. 21080(b)(4); 15269(b)(c));
☒ Categorical Exemption. State type and section number: New Construction or Conversion of Small Structures, Section 15303 & Infill Development Projects, Section 15332
☐ Statutory Exemptions. State code number:

Reasons why project is exempt:

The proposed Verizon Wireless stealth monopine wireless telecommunications facility and equipment shed are categorically exempt under Section 15303 and Class Number 3 – *New Construction or Conversion of Small Structures*. Class 3 consists of construction and location of limited numbers of new, small facilities or structures; installation of small new equipment and facilities in small structures; and the conversion of existing small structures from one use to another where only minor modifications are made in the exterior of the structure. Examples of this exemption include water main, sewage, electrical, gas, and other utility extensions, including street improvements, of reasonable length to serve such construction.

The proposed stealth monopine and equipment shed are also categorically exempt under Section 15332 and Class Number 32, which consists of projects characterized as in-fill development meeting the following conditions:

1) The project is consistent with the applicable general plan designation and all applicable general plan policies as well as with applicable zoning designations and regulations.
2) The proposed development occurs within city limits on a project site of no more than five acres substantially surrounded by urban uses.

FILED

JUN 14 2019

JANELLE K. HORNE, Recorder-Clerk
By

09-0215-91

3) The project site has no value as habitat for endangered, rare or threatened species.
4) Approval of the project would not result in any significant effects relating to traffic, noise, air quality, or water quality.
5) The site can be adequately served by all required utilities and public services.

Lead Agency Contact Person: Candace H. Stowell, AICP
Area Code/Telephone: (530) 544-7405

Signature: Candace H. Stowell **Title:** Associate Planner

Date: June 13, 2019

☒ Signed by Lead Agency
☐ Signed by Applicant

Date received for filing at OPR:

State of California - Department of Fish and Wildlife

2019 ENVIRONMENTAL FILING FEE CASH RECEIPT

DFW 753.5a (REV. 12/01/18) Previously DFG 753.5a

Print | StartOver | Finalize&Email

RECEIPT NUMBER:
09 — 06/14/19 — 91

STATE CLEARINGHOUSE NUMBER *(If applicable)*

SEE INSTRUCTIONS ON REVERSE. TYPE OR PRINT CLEARLY.

LEAD AGENCY	LEAD AGENCY EMAIL	DATE
City of So Lake Tahoe		06/14/19

COUNTY/STATE AGENCY OF FILING	DOCUMENT NUMBER
El Dorado	09-2019-91

PROJECT TITLE

Verizon Stealth Monopine Telecomunication Facility -Ski Run

PROJECT APPLICANT NAME	PROJECT APPLICANT EMAIL	PHONE NUMBER
City of SLT		(530) 544-6022

PROJECT APPLICANT ADDRESS	CITY	STATE	ZIP CODE
1052 Tata Lane	SLT	CA	96150

PROJECT APPLICANT *(Check appropriate box)*

☑ Local Public Agency ☐ School District ☐ Other Special District ☐ State Agency ☐ Private Entity

CHECK APPLICABLE FEES:

☐ Environmental Impact Report (EIR)	$3,271.00	$	0.00
☐ Mitigated/Negative Declaration (MND)(ND)	$2,354.75	$	0.00
☐ Certified Regulatory Program (CRP) document - payment due directly to CDFW	$1,112.00	$	0.00

☑ Exempt from fee

- ☐ Notice of Exemption (attach)
- ☐ CDFW No Effect Determination (attach)

☐ Fee previously paid (attach previously issued cash receipt copy)

☐ Water Right Application or Petition Fee (State Water Resources Control Board only)	$850.00	$	0.00
☑ County documentary handling fee		$	50.00
☐ Other		$	

PAYMENT METHOD:

☐ Cash ☐ Credit ☐ Check ☑ Other #250 **TOTAL RECEIVED** $ 50.00

SIGNATURE	AGENCY OF FILING PRINTED NAME AND TITLE
X DBaumflek	Janelle Horne, Recorder/Clerk by Diane Baumflek

ORIGINAL - PROJECT APPLICANT | COPY - CDFW/ASB | COPY - LEAD AGENCY | COPY - COUNTY CLERK | DFW 753.5a (Rev. 12012018)

EBI Consulting
environmental | engineering | due diligence

6876 Susquehanna Trail South
York, PA 17403
Tel: (717) 428-0401
www.ebiconsulting.com

September 6, 2018

The Lake Tahoe Historical Society & Museum
PO Box 18501
South Lake Tahoe, California, 96151

Subject: Invitation to Comment
FUZE 616083859 (444780)/SKI RUN BLVD - A
1360 Ski Run Blvd., South Lake Tahoe, El Dorado County, CA 96150
EBI Project #6118004920

To whom it may concern:

Pursuant to Section 106 of the National Historic Preservation Act, the regulations promulgated thereunder and interagency agreements developed thereto, EBI Consulting, Inc. on behalf of Cellco Partnership and its controlled affiliates doing business as Verizon Wireless (Verizon Wireless) provides this notice of a proposed telecommunications facility installation at the address listed above.

EBI would like to inquire if you would be interested in commenting on this proposed project. Verizon Wireless proposes to install a 112-foot monopine telecommunications tower. Please refer to the attached project plans for complete details regarding this proposed project.

Please note that we are requesting your review of the attached information as part of the Section 1[illegible]rocess only and not as part of the local zoning process. We are only seeking comments related to the [illegible]posed project's potential effect to historic properties.

Please submit your comments regarding the proposed project's potential effect on historic proper[illegible]to EBI Consulting, to my attention at 6876 Susquehanna Trail South, York, PA 17403 or contact me via te[illegible]one at the number listed below. Please reference the EBI project number. We would appreciate your co[illegible]ents as soon as possible within the next 30 days. Please do not hesitate to contact me if you have any qu[illegible]ons or concerns about the proposed project.

Respectfully Submitted,

Cory Johnson
Architectural Historian
219.313.5458
Houston, TX | 77096
cory.johnson@ebiconsulting.com

Attachment A – Figures and Project Drawings

EXHIBIT (A)(i)(iii) Fig. Deed Restriction: No Trees Shall Be Cut

Placer Title Company
Preliminary Report

Issued By:

Order No. 1415-13907

PLACER TITLE COMPANY
SPECIAL PROJECTS
2145 LARKSPUR LANE, SUITE A
REDDING, CA 96002
Escrow Officer: Christy Rudkin
Phone: 530-244-2122
Fax: 530-244-1009
Escrow Officer Email: crudkin@placertitle.com
Email Loan Docs To: N/A

Customer Reference: APN 025-580-07/CN0588

Property Address: 1360 SKI RUN BLVD., SOUTH LAKE TAHOE, CA 96150

In response to the above referenced application for a policy of title insurance, Placer Title Company hereby reports that it is prepared to issue, or cause to be issued, through one of its authorized underwriters, as of the date hereof, a Policy or Policies of Title Insurance describing the land and the estate or interest therein hereinafter set forth, insuring against loss which may be sustained by reason of any defect, lien or encumbrance not shown or referred to as an Exception below or not excluded from coverage pursuant to the printed Schedules, Conditions and Stipulations of said Policy forms.

The printed Exceptions and Exclusions from the coverage and Limitations on Covered Risks of said Policy or Policies are set forth in the attached. The policy to be issued may contain an arbitration clause. When the Amount of Insurance is less than that set forth in the arbitration clause, all arbitrable matters shall be arbitrated at the option of either the Company or the Insured as the exclusive remedy of the parties. Limitations on Covered Risks applicable to the CLTA and ALTA Homeowner's Policies of Title Insurance which establish a Deductible Amount and a Maximum Dollar Limit of Liability for certain coverages are also set forth in the attached. Copies of the Policy forms should be read. They are available from the office which issued this report.

PLEASE READ THE EXCEPTIONS SHOWN OR REFERRED TO BELOW AND THE EXCEPTIONS AND EXCLUSIONS SET FORTH IN THE ATTACHED CAREFULLY. THE EXCEPTIONS AND EXCLUSIONS ARE MEANT TO PROVIDE YOU WITH NOTICE OF MATTERS WHICH ARE NOT COVERED UNDER THE TERMS OF TITLE INSURANCE POLICY AND SHOULD BE CAREFULLY CONSIDERED.

IT IS IMPORTANT TO NOTE THAT THIS PRELIMINARY REPORT IS NOT A WRITTEN REPRESENTATION AS TO THE CONDITION OF TITLE AND MAY NOT LIST ALL LIENS, DEFECTS AND ENCUMBRANCES AFFECTING TITLE TO THE LAND.

This report (and any supplements or amendments hereto) is issued solely for the purpose of facilitating the issuance of a policy of title insurance and no liability is assumed hereby. If it is desired that liability be assumed prior to the issuance of a policy of title insurance, a Binder or Commitment should be requested.

Dated as of September 24, 2012 at 7:30 a.m.

Title Officer: Steve Wipfler

Order No. 1415-13907

The form of policy of title insurance contemplated by this report is:
CLTA Standard Coverage Policy

The estate or interest in the land hereinafter described or referred to covered by this Report is:

A FEE SIMPLE

Title to said estate or interest at the date hereof is vested in:

GUILLIAM NEL , AN UNMARRIED MAN

The land referred to herein is described as follows:

SEE EXHIBIT "A" ATTACHED

Order No. 1415-13907

EXHIBIT "A"
LEGAL DESCRIPTION

THE LAND DESCRIBED HEREIN IS SITUATED IN THE STATE OF CALIFORNIA, COUNTY OF EL DORADO, CITY OF SOUTH LAKE TAHOE, AND IS DESCRIBED AS FOLLOWS:

BEGINNING AT A 3/4 INCH CAPPED IRON PIPE SET IN THE WESTERLY LINE OF BIJOU PARK BOULEVARD, FROM WICH THE NORTHEAST CORNER OF SAID SECTION 2 BEARS NORTH 29° 50' WEST 30.0 FEET, AND NORTH 55° 42'30" 782.6 FEET; THENCE FROM POINT OF BEGINNING AND ALONG SAID WESTERLY LINE OF BIJOU PARK BOULEVARD, SOUTH 29° 50' EAST 300.0 FEET A 3/4 INCH CAPPED IRON PIPE; THENCE LEAVING SAID LINE SOUTH 60° 18' WEST 275.0 FEET A SIMILAR PIPE; THENCE NORTH 29° 50' WEST 300.0 FEET A SIMILAR PIPE; THENCE NORTH 60° 18' EAST 275.0 FEET TO THE POINT OF BEGINNING.

A.P.N. 025-580-07

Order No. 1415-13907

EXCEPTIONS

At the date hereof exceptions to coverage in addition to the printed Exceptions and Exclusions in said policy form would be as follows:

1. TAXES, SPECIAL AND GENERAL, ASSESSMENT DISTRICTS AND SERVICE AREAS FOR THE FISCAL YEAR 2012-2013:
   1ST INSTALLMENT: $3,150.33 OPEN
   2ND INSTALLMENT: $3,150.33 OPEN
   ASSESSED VALUATIONS:
   LAND: $138,016.00
   IMPROVEMENTS: $407,311.00
   PARCEL NO.: 025-580-07
   CODE AREA: 002-002

   NOTE: FIRST INSTALLMENT IS DUE NOVEMBER 1 AND DELINQUENT DECEMBER 10. SECOND INSTALLMENT IS DUE FEBRUARY 1 AND DELINQUENT APRIL 10.

2. THE LIEN OF SUPPLEMENTAL TAXES, IF ANY, ASSESSED PURSUANT TO THE PROVISIONS OF CHAPTER 3.5, (COMMENCING WITH SECTION 75) OF THE REVENUE AND TAXATION CODE, OF THE STATE OF CALIFORNIA.

3. ANY TAXES OR ASSESSMENTS LEVIED BY:

   A. SOUTH LAKE TAHO PUBLIC UTILITY DISTRICT
   B. SOUTH LAKE TAHOE COMMUNITY FACILITIES DISTRICT NO. 2000-1

4. RIGHTS OF THE PUBLIC AND OF THE COUNTY OF EL DORADO, AS TO THAT PORTION OF THE HEREIN DESCRIBED PROPERTY LYING WITHIN SKI RUN ROAD, A PUBLIC ROAD.

5. COVENANTS, CONDITIONS AND RESTRICTIONS AS CONTAINED IN THE DEED FROM JOHN E. KELLER, ET AL, RECORDED JULY 13, 1943, AS BOOK 202, PAGE 33, OFFICIAL RECORDS.

   NOTE: SECTION 12956.1 OF THE GOVERNMENT CODE PROVIDES THE FOLLOWING: "IF THIS DOCUMENT CONTAINS ANY RESTRICTION BASED ON RACE, COLOR, RELIGION, SEX, SEXUAL ORIENTATION, FAMILIAL STATUS, MARITAL STATUS, DISABILITY, NATIONAL ORIGIN, SOURCE OF INCOME AS DEFINED IN SUBDIVISION (P) OF SECTION 12955, OR ANCESTRY THAT RESTRICTION VIOLATES STATE AND FEDERAL FAIR HOUSING LAWS AND IS VOID, AND MAY BE REMOVED PURSUANT TO SECTION 12956.2 OF THE GOVERNMENT CODE. LAWFUL RESTRICTIONS UNDER STATE AND FEDERAL LAW ON THE AGE OF OCCUPANTS IN SENIOR HOUSING OR HOUSING FOR OLDER PERSONS SHALL NOT BE CONSTRUED AS RESTRICTIONS BASED ON FAMILIAL STATUS."

U.S. Fish & Wildlife Service

Search ECOS

ECOS Environmental Conservation Online System

Conserving the Nature of America

ECOS / Species Reports / Species By County Report

Species By County Report

The following report contains Species that are known to or are believed to occur in this county. Species with range unrefined past the state level are now excluded from this report. If you are looking for the Section 7 range (for Section 7 Consultations), please visit the IPaC application.

County: El Dorado, California

CSV

Need to contact a FWS field office about a species? Follow this link to find your local FWS Office.

Group	Name	Population	Status	Lead Office	Recovery Plan	Recovery Plan Action Status
Amphibians	California tiger Salamander (*Ambystoma californiense*)	U.S.A. (CA - Sonoma County)	Endangered	Sacramento Fish and Wildlife Office	Recovery Plan for the Santa Rosa Plain	Implementation Progress
Amphibians	California tiger Salamander (*Ambystoma californiense*)	U.S.A. (Central CA DPS)	Threatened	Sacramento Fish and Wildlife Office	Recovery Plan for the Central California Distinct Population Segment of the California Tiger Salamander (Ambystoma californiense)	Implementation Progress
Amphibians	California red-legged frog (*Rana draytonii*)	Wherever found	Threatened	Sacramento Fish and Wildlife Office	Recovery Plan for the California Red-legged Frog (Rana aurora draytonii)	Implementation Progress
Amphibians	Yosemite toad (*Anaxyrus canorus*)	Wherever found	Threatened	Sacramento Fish and Wildlife Office		
Amphibians	Sierra Nevada Yellow-legged Frog (*Rana sierrae*)	Wherever found	Endangered	Sacramento Fish and Wildlife Office		

Group	Name	Population	Status	Lead Office	Recovery Plan	Recovery Plan Action Status
Birds	Yellow-billed Cuckoo (*Coccyzus americanus*)	Western U.S. DPS	Threatened	Arizona Ecological Services Field Office		
Birds	Greater sage-grouse (*Centrocercus urophasianus*)	Bi-State	Proposed Threatened	Reno Fish and Wildlife Office		
Conifers and Cycads	Whitebark pine (*Pinus albicaulis*)	Wherever found	Candidate	Wyoming Ecological Services Field Office		
Crustaceans	Conservancy fairy shrimp (*Branchinecta conservatio*)	Wherever found	Endangered	Sacramento Fish and Wildlife Office	Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon	Implementation Progress
Crustaceans	Vernal pool fairy shrimp (*Branchinecta lynchi*)	Wherever found	Threatened	Sacramento Fish and Wildlife Office	Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon	Implementation Progress
Crustaceans	Vernal pool tadpole shrimp (*Lepidurus packardi*)	Wherever found	Endangered	Sacramento Fish and Wildlife Office	Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon	Implementation Progress
Fishes	Cui-ui (*Chasmistes cujus*)	Wherever found	Endangered	Reno Fish and Wildlife Office	Cui-ui (Chasmistes cujus) Recovery Plan, Second Revision	Implementation Progress
Fishes	Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*)	Wherever found	Threatened	Reno Fish and Wildlife Office	Lahontan Cutthroat Trout (Oncorhynchus clarki henshawi) Recovery Plan	Implementation Progress
Fishes	Delta smelt (*Hypomesus transpacificus*)	Wherever found	Threatened	San Francisco Bay-Delta Fish and Wildlife	Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes	Implementation Progress

Group	Name	Population	Status	Lead Office	Recovery Plan	Recovery Plan Action Status
Fishes	longfin smelt (*Spirinchus thaleichthys*)	San Francisco Bay delta DPS	Candidate	San Francisco Bay-Delta Fish and Wildlife		
Flowering Plants	Stebbins' morning-glory (*Calystegia stebbinsii*)	Wherever found	Endangered	Sacramento Fish and Wildlife Office	Recovery Plan for Gabbro Soil Plants of the Central Sierra Nevada Foothills	Implementation Progress
Flowering Plants	Pine Hill ceanothus (*Ceanothus roderickii*)	Wherever found	Endangered	Sacramento Fish and Wildlife Office	Recovery Plan for Gabbro Soil Plants of the Central Sierra Nevada Foothills	Implementation Progress
Flowering Plants	Pine Hill flannelbush (*Fremontodendron californicum ssp. decumbens*)	Wherever found	Endangered	Sacramento Fish and Wildlife Office	Recovery Plan for Gabbro Soil Plants of the Central Sierra Nevada Foothills	Implementation Progress
Flowering Plants	El Dorado bedstraw (*Galium californicum ssp. sierrae*)	Wherever found	Endangered	Sacramento Fish and Wildlife Office	Recovery Plan for Gabbro Soil Plants of the Central Sierra Nevada Foothills	Implementation Progress
Flowering Plants	Layne's butterweed (*Senecio layneae*)	Wherever found	Threatened	Sacramento Fish and Wildlife Office	Recovery Plan for Gabbro Soil Plants of the Central Sierra Nevada Foothills	Implementation Progress
Flowering Plants	Sacramento Orcutt grass (*Orcuttia viscida*)	Wherever found	Endangered	Sacramento Fish and Wildlife Office	Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon	Implementation Progress

Group	Name	Population	Status	Lead Office	Recovery Plan	Recovery Plan Action Status
Insects	Valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*)	Wherever found	Threatened	Sacramento Fish and Wildlife Office	Revised Recovery Plan for Valley Elderberry Longhorn Beetle (Desmocerus californicus dimorphus)	Recovery efforts in progress, but no implementation information yet to display.
Mammals	North American wolverine (*Gulo gulo luscus*)	Wherever found	Proposed Threatened	Montana Ecological Services Field Office		
Mammals	Fisher (*Pekania pennanti*)	West coast DPS	Proposed Threatened	Yreka Fish and Wildlife Office		
Reptiles	Giant garter snake (*Thamnophis gigas*)	Wherever found	Threatened	Sacramento Fish and Wildlife Office	Recovery Plan for the Giant Garter Snake (Thamnophis gigas)	Implementation Progress

Electromagnetic Biology and Medicine, 29: 31–35, 2010
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ISSN: 1536-8378 print/1536-8386 online
DOI: 10.3109/15368371003685363

informa
healthcare

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Mobile Phone Mast Effects on Common Frog (*Rana temporaria*) Tadpoles: The City Turned into a Laboratory

ALFONSO BALMORI

C/Navarra, Valladolid, Spain

*An experiment has been made exposing eggs and tadpoles of the common frog (*Rana temporaria*) to electromagnetic radiation from several mobile (cell) phone antennae located at a distance of 140 meters. The experiment lasted two months, from the egg phase until an advanced phase of tadpole prior to metamorphosis. Measurements of electric field intensity (radiofrequencies and microwaves) in V/m obtained with three different devices were 1.8 to 3.5 V/m. In the exposed group (*n = 70*), low coordination of movements, an asynchronous growth, resulting in both big and small tadpoles, and a high mortality (90%) was observed. Regarding the control group (*n = 70*) under the same conditions but inside a Faraday cage, the coordination of movements was normal, the development was synchronous, and a mortality of 4.2% was obtained. These results indicate that radiation emitted by phone masts in a real situation may affect the development and may cause an increase in mortality of exposed tadpoles. This research may have huge implications for the natural world, which is now exposed to high microwave radiation levels from a multitude of phone masts.*

Keywords Electromagnetic pollution; Microwaves; Phone masts; *Rana temporaria*; Tadpoles.

Introduction

In recent years, a large number of mobile phone antennae have been installed, especially in urban areas. The scientific literature review shows that pulsed telephony microwave radiation may produce effects, especially on nervous, cardiovascular, immune, and reproductive systems (Balmori, 2009), but few studies on effects from phone masts on wildlife in the cities have been conducted (Balmori, 2005; Balmori and Hallberg, 2007; Everaert and Bauwens, 2007).

Concerning the effects of electromagnetic radiation on amphibians, several investigations in the laboratory have been conducted (Levengood, 1969; Landesman and Douglas, 1990; Grefner et al., 1998), but as far as we know there have not been any published studies on effects from phone antennae on amphibian populations in their natural habitat.

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Balmori (2006) suggested that microwaves from phone masts might be responsible along with other factors in the decline of some populations of amphibians.

The objective of this research was to investigate the possible effects of phone mast radiation on exposed tadpoles (*Rana temporaria*) in a real situation.

Materials and Methods

The experiment has been made in Valladolid (Spain) exposing eggs and tadpoles of the common frog (*Rana temporaria*) obtained from an anonymous supplier to several mobile (cell) phone antennae.

The tadpoles were placed in two tanks with oxygen and food every day, which were set out in the fifth floor terrace at a distance of 140 meters from four base stations located opposite. The base stations are on the roof of an eight story high building (see the picture at http://www.hese-project.org/hese-uk/en/issues/nature.php?id = frogs).

In both experimental and control groups ($n = 70$ in each) the experiment lasted two months, from the egg phase until an advanced phase of tadpole prior to metamorphosis. The control group was inside a Faraday cage (metallic shielding component: EMC-reinforcement fabrics 97442 Marburg Technic).

According to official database (Ministerio de Industria Turismo y Comercio, 2009), the type and frequency range of emissions was:

- Vodafone: GSM 948.0–959.8 MHz.
- Vodafone: DCS 1,830.2–1,854.8 MHz.
- Vodafone: UMTS 1,905–1,910; 1,950–1,965; 2,140–2,155 MHz.
- Amena (Orange): DCS 1,855.2–1,879.8 MHz.

However, as we shall see later, in reality there exist more frequencies than this, which do not correspond with the frequencies contained in the database official.

The measurements of electric field intensity (radiofrequencies and microwaves in V/m) in the two tanks containing the tadpoles were made with the following meters:

- Nuova Elettronica device Model LX 1435 with 10% sensitivity, with unidirectional probe (range: 1 MHz–3 GHz).
- PCE–EM 29 device with an isotropic probe and calibration certificate (range: 50 MHz–3.5 GHz). Resolution: 0.1 mV/m. Absolute error: $\pm$ 1.0 dB.
- Spectrum analyzer Advantest R-3272 (range: 9 KHz–26 GHz), probe Rhode & Schwarz HE-200 (Official measurements of the Ministry of Science and Technology from Spain).

Results

The results of electric field intensity to which the tadpoles were exposed with the different devices were:

- LX 1435: Electromagnetic field intensity 2.5–3.5 V/m.
- PCE–EM 29: Electromagnetic field intensity 1,847–2,254 V/m.
- Advantest R-3272: Results in decibels (Table 1).

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Table 1
Results of spectrum analyzer advantest R-3272 (official measurements of the ministry of science and technology from Spain)

VODAFONE		VODAFONE		AMENA	
Frequency (MHz)	Decibels	Frequency (MHz)	Decibels	Frequency (MHz)	Decibels
88,5	69	93,1	67	98,1	67
104,5	64	487,25	43	671,25	43,9
727,25	37	751,25	37	949,2	81
953,8	77	957,2	76	958,8	57
935	57	1875,4	63	1875,6	61
1873,6	60	1871,2	62	1869	61

Note: The frequencies that exist in reality are several more and do not correspond with the frequencies contained in the database official.

Some observations on the tadpoles were as follows (Balmori, 2008; see the video clips at http://www.hese-project.org/hese-uk/en/issues/nature.php?id):

- Experimental group ($n = 70$).

Low coordination of movements, an asynchronous growth, resulting in both big and small tadpoles, and a high mortality (90%) was observed. Most of the deaths occurred after six weeks of continuous exposure.

The tadpoles' tails waved only slowly. Only about half of them reacted to a sudden stimulus in the form of a stroke on the wall of the aquarium. Some remained sideways or tilted and swam describing closed circles (Balmori, 2008; http://www.hese-project.org/hese-uk/en/issues/nature.php?id). Generally, their movements were uncoordinated. They showed low interest and few tadpoles reacted to the food. For lack of resources, we could not investigate the anatomical or physiological reasons for the problems observed.

- Control group ($n = 70$, under the same conditions but inside a Faraday cage).

The coordination of movements was normal, the development was synchronous, and a mortality of 4.2% was obtained. No deaths occurred at a particular time.

The tail moved fast and they reacted quickly to a sudden stimulus (a stroke on the wall of the aquarium). No tadpoles remained sideways or tilted and the direction of swimming was correct. Their movements were coordinated. When food was supplied most of them reacted quickly.

Discussion

The literature contains much data hinting at an important role for bioelectromagnetic phenomena as a mediator of morphogenetic information in many contexts relevant to embryonic development (Levin, 2003). The underlying mechanism by which an

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endogenous electrical field may exert an influence on development remains to be discovered. Most prevailing hypotheses suggest that a field acts to directionally guide the growth and migration of some embryonic cells (Hotary and Robinson, 1992).

Strong magnetic fields (1.74–16.7 T) disrupt cell division of exposed frog eggs (*Xenopus laevis*) (Denegre et al., 1998). Valles (2002) proposed a model to explain their influence.

Several studies on effects of electromagnetic fields on amphibians have been conducted in laboratories. When amphibian eggs and embryos of *Ambystoma maculatum* and *Rana sylvatica* were exposed to high magnetic fields (6.3×10^3 G), a brief treatment of early embryos produced several types of abnormalities, incuding microcephaly, retarded (abnormal) growth, edema, and scoliosis (Levengood, 1969).

Adult newts (*Notophthalmus viridescens*) exposed to a pulsed electromagnetic field (1 T and 0.15 V/m, approx.) for the first 30 days post forelimbs were amputated and produced more abnormalities in their skeletal patterns than the native limbs or the normal regenerates. Twelve percent exhibited unique abnormalities not observed in either the native or regenerate limb population. These forelimbs demonstrated one or more of the following gross defects: acheiria (lack of carpus and digits), aphalangia, or oligodactylia (loss of digits) as well as carpal bone and long bone (radius and ulna) abnormalities (Landesman and Douglas, 1990).

Exposed frog tadpoles (*Rana temporaria*) developed under electromagnetic field (50 Hz, 260 A/m) show an increase in mortality. Exposed tadpoles developed more slowly and less synchronously than control tadpoles and remained at the early stages for longer. Tadpoles developed allergies and EMF caused changes in their blood counts (Grefner et al., 1998). These results are consistent with the observations of this work.

Deformities and disappearance of amphibians and other organisms is part of the global biodiversity crisis (Blaustein and Johnson, 2003). Some authors consider that the electromagnetic pollution is destroying nature (Warnke, 2007; Firstenberg, 1997). Balmori (2006) proposed that electromagnetic pollution (in the microwave and radiofrequency range) along with other environmental factors is a possible cause for decline and deformations of some wild amphibian populations exposed. The results of this experiment conducted in a real situation in the city of Valladolid (Spain) indicate that the tadpoles that live near such facilities, exposed to relatively low levels of environmental electromagnetic fields (1.8–3.5 V/m) may suffer adverse effects (low coordination of movements, asynchronous growth, and high mortality), and this may be a cause (together with other environmental factors) of decline of amphibian populations.

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Acknowledgment

The author is grateful to Sarah Wright and Denise Ward.

Declaration of Interest: The author report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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Toxicological & Environmental Chemistry, Apr.–June 2006; 88(2): 287–299

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The incidence of electromagnetic pollution on the amphibian decline: Is this an important piece of the puzzle?

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(Received 26 October 2005)

Abstract
A bibliographical review on the possible effects of radiofrequency radiation (RFR) from wireless telecommunications on living organisms and its impact on amphibians is presented. The technical characteristics of this new technology and the scientific discoveries that are of interest in the study of their effects on wild fauna and amphibians are described. Electromagnetic pollution (in the microwave and in the radiofrequency range) is a possible cause for deformations and decline of some amphibian populations. Keeping in mind that amphibians are reliable bio-indicators, it is of great importance to carry out studies on the effects of this new type of contamination. Finally, some methodologies that could be useful to determine the adverse health effects are proposed.

Keywords: *Athermal effects, electromagnetic pollution, effects on amphibians, microwaves, phone masts*

Introduction

Amphibians are important components of the ecosystem and reliable bio-indicators; their moist skin, free of flakes, hair or feathers, is highly permeable to water chemicals (particularly larvae) and air pollutants (especially adults). Amphibian eggs are also directly exposed to chemicals and radiation. These characteristics make amphibians especially sensitive to environmental conditions, changes of temperature, precipitation or ultraviolet (UV) radiation and reliable monitors of local conditions [1].

A recent report from the International Union for Conservation of Nature (IUCN), prepared by 500 scientists from 60 countries, analyzed populations of 5743 amphibian

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ISSN 0277-2248 print/ISSN 1029-0486 online © 2006 Taylor & Francis
DOI: 10.1080/02772240600687200

species in the world and concluded that 1856 (32%) of them were considered threatened of extinction. Nine species have become extinct since 1980 and another 113 have not been observed in the recent years, and probably are also extinct [2]. The results demonstrate that amphibians are far more threatened than either birds or mammals, and the factors causing 'enigmatic' declines are driving the species toward extinction particularly rapidly. Unless these declines are quickly understood and reversed, hundreds of amphibian species can be expected to become extinct over the next few decades [3]. The disappearance of amphibians together with other organisms is a part of the global biodiversity crisis [4,5].

An associated phenomenon is the appearance of large numbers of deformed amphibians, with absent or extra limbs [5]. From 1995, at least 60 different species were affected with a high incidence of deformities, with several species affected in one place, in 46 states of United States and in regions of Japan, Canada, and several European countries [5,6]. The problem seems to have become more prevalent, with deformity rates of up to 25% in some populations, which is significantly higher than in previous decades [6].

The problem of deformities is complex because it is related to water quality, physiology, development, anatomy, and ecology [5]. The reduction in populations and the increase in deformities are a warning of serious environmental degradation [5].

Evidence exists that several populational declines are probably the result of complex interactions among several biotic and abiotic factors [1,4,7,8]. The proposed explanations are an increase of ultraviolet radiation (UV-B)[1,5,9–14]; chemical pollutants (pesticides, herbicides, fungicides, fertilizers, etc.) [5,15]; pathogen and parasites [1,6,16], destruction and alteration of habitat, changes in meteorological patterns (climatic change) [4,17], and introduced species [1,5].

The amphibian population declines are also occurring in relatively pristine places such as National Parks, or rural areas far from urban centers [3,14]. Humans and other animals can also be affected by the same environmental factors that damage amphibians [6].

A type of contamination whose effects on amphibians have not been studied up to now, is the electromagnetic pollution, especially microwaves and radiofrequencies from mobile telecommunications and radio station transmitters that will be discussed in this review. Before the 1990s, radiofrequencies were mainly from a few radio and television transmitters, located in remote areas and/or very high places. Since the introduction of wireless telecommunication in the 1990s, the rollout of phone networks has seen a massive increase in the electromagnetic contamination in cities and in the wilderness [18,19]. At the moment, new types of antennas are being investigated to reduce the power needed to establish communication [20,21]. Recently, there has also been an increase of other wireless transmitters (radio or television stations).

The objective of this review is to detail advances in the knowledge of biological mechanisms and effects from radiofrequencies and microwaves on animals, and some considerations are made on its possible relationship with deformations and the population decline of amphibians.

Main causes of populational decline and appearance of deformations in amphibian populations

Ultraviolet radiation

UV-B radiation (1) induces mutations and cellular death, (2) weakens the immune system, (3) reduces growth, and (4) induces several types of damage, like malformations

of the limbs, body, and eyes [1,5,12,14]. Not all the species respond in the same way [14]. Embryos with higher photolyase levels (DNA photorepair enzyme) are more resistant to UV-B radiation [11,12].

The eggs of some of the amphibian species experienced high mortality that may contribute to the populational declines [9]. UV acts in conjunction with other agents like pesticides to induce defects in the development [10]. UV also decreases defense mechanisms against illnesses making individuals more susceptible to pathogen and parasites, affecting normal development and increasing mortality that consequently impacts on the decline of some populations [10]. The egg mass protected from UV-B radiation have significantly more hatching, less deformities, and develop more quickly [10].

Synergy between a pathogenic fungus and UV-B radiation increased mortality among amphibian embryos [12]. The synergy may occur when developing amphibians have reduced ability to respond to a stressor in the presence of another stressor. For example, contamination exerts more deleterious effects with UV-B [1]. Animals use molecular and physiologic mechanisms and certain behaviors [22] to limit their exposure to UV-B and repair from UV-B damage [14].

Although cellular repair mechanisms of several species are not effective in the presence of persistent increase in UV-B radiation levels [14], amphibians are relatively resistant to this radiation if they can repair the damage effectively [14]. In some species, photoreactivation is the most important repair mechanism of UV-damaged DNA [9]. Heat shock proteins may also play a role in protecting cells from UV-B damage, since they prevent the denaturation of proteins during exposure to environmental stress [14].

Chemical pollutants

Chemical pollutants appear in areas where pesticides and fertilizers are applied extensively and produce mortality and deformities in amphibians. Although on a broad scale, no correlation between pesticide contamination and amphibian deformities was found, pesticides cannot be completely ruled out as causal agents [5].

Pathogens and parasites

Three pathogens received attention recently for having produced an amphibian populational decline in some areas: *Batrachochytrium denderobatidis*, *Saprolegnia ferax*, and an iridovirus (*Ambystoma tigrinum virus*) [1]. The parasite *Ribeiroia ondatrae* is an important source of malformations of amphibian extremities in western USA [16]. Larvae with malformations experience higher mortality before and during metamorphosis than the normal ones. The relevance of infection by *Ribeiroia* and the influence of habitat alteration on the pathology and biological cycle of this trematode, requires further investigation [16]. In relative pristine environments, the incidence of snails infected with *Ribeiroia* is low, but the habitat alteration can increase the rate of infestation [16]. Infection of amphibian larvae by the trematode *R. ondatrae* may represent a threat to amphibians or species in decline. Although deformities can be the cause of declines in some places, numerous populations of amphibians have greatly declined in the absence of any deformity, for which there must be other factors [6].

Climatic change

Climatic change influences breeding patterns of certain organisms which affect their populational structure and may be reflected in the populational declines of very sensitive

species such as amphibians. The pattern found up to now in the published studies is that some anurans of temperate areas show an early reproduction tendency [17]. Climate-induced reductions in water depth at egg-laying sites produced high embryo mortality by increasing their exposure to UV-B radiation which is more worrying than the reduction in ozone layer. Climate also increases their vulnerability to *S. ferax* [4].

Physical and technological characteristics of mobile telephone

Electromagnetic radiation (EMR) transmits small packages of energy denominated photons [23]. The radiofrequencies occupy the range from 10 MHz to 300 GHz. Cellsite antennae emit a frequency of 900 or 1800 MHz, pulsed at low frequencies, generally known as microwaves (300 MHz–300 GHz). Microwaves carry sound information by blasts or pulses of short duration, with small modulations of their frequency, that are transferred between wireless phones and base stations over dozens of kilometres.

The main variable that measures these radiations is 'power density' (measured in $W\,m^{-2}$, or $\mu W\,cm^{-2}$) expressing radiant power that impacts perpendicularly to a surface, divided by the surface area; and 'electric field intensity' (measured in $V\,m^{-1}$), a vectorial magnitude to the force exercised on a electric loaded particle, independent of their position in space.

For a concrete address with relationship to an antenna, the power density at a point varies inversely proportional to the square of the distance to the source. Though EMR have many and varied outputs, at a distance of 50 m the power density is about $10\,\mu W\,cm^{-2}$ [24], while at distances of 100 m at ground level it measures above $1\,\mu W\,cm^{-2}$ (pers. obs.). Between 150 and 200 m, the power density of the main lobe near the ground is typically some tenth of $1\,\mu W\,cm^{-2}$ [25].

Experimental difficulties

Experiments that study the effects of EMR on living organisms are complex, since a high number of variables exist that need to be controlled. Microwave radiation produces different effects depending on certain methodological positions such as frequency, power, modulation, pulses, time of exposure, etc. [26–28]. Some studies demonstrated different microwave effects depending on the wavelength in the range of mm, cm or m [28,29]. The dose–response relationships (of non-thermal effects), are not simple to establish since they present a non-linear relationship [30–32].

Pulsed waves (in blasts), as well as certain low frequency modulations exert greater biological activity [26,28,31,33]. These radiations also have accumulative effects that depend on the duration of exposure [19,34,35]. It is possible that each species and each individual, show different susceptibility to radiations, since the vulnerability depends on the genetic tendency, and the physiologic and the neurological state of the irradiated organism [31,36–41].

Effects and action mechanisms on biological systems

One of the well known effects of microwaves is their capacity to excite water molecules and other components in food, elevating their temperature. The resulting heating level depends on the radiation intensity and the exposure time. At a power density above $500\,\mu W\,cm^{-2}$

(microwave ovens) heating effects take place, below that level the effects are 'athermal non-heating'.

Animals are sensitive complex electrochemical systems that communicate with their environment through electrical impulses. In cellular membranes and body fluids, ionic currents and electrical potential exist [42]. Electromagnetic fields (EMFs) generated in biological structures, are characterized by certain specific frequencies. It is possible a frequency-specific, non-thermal electromagnetic influence, of an informational nature exists [25,31,43]. Some organs or systems like the brain, heart, and nervous system are especially vulnerable.

The wave systems have properties such as the frequency, which affect resonance capacity of living organisms to absorb the energy of an electromagnetic field [25]. Electromagnetic fields induce biological effects at ''windows of frequency'' (window effect) [44]. Living organisms are exposed to variable levels of radiofrequency electromagnetic fields, according to (1) distance to phone masts, (2) presence of metallic structures which are able to reflect or obstruct the waves (buildings or other obstacles), (3) number of phone masts, and (4) orientation and position [24].

Microwaves emitted by phone antennae affect organisms living in their vicinities, like vertebrate [45–47], insects [48–55], vegetables [56–58], and humans [25,31,59–63]. Small organisms are especially vulnerable: size approach to resonance frequency and thinner skull, facilitates an elevated penetration of radiation into the brain [24,31,64]. In a recent study carried out with bees in Germany, only few irradiated bees returned to the beehive and required more time to reach the hive. The weight of honeycombs is also smaller in the bees that were irradiated [54].

The microwave effects were investigated in a variety of living organisms, but the results found in vertebrates have special interest to amphibians. For more than 30 years, there is growing evidence on the existence of athermal effects on birds [65,66]. The exposed animals suffer a deterioration of health in the vicinity of phone masts [67,68]. Rats spent more time in the halves of shuttle boxes that were shielded from illumination by 1.2 GHz microwaves. The average power density was about 0.6 mW cm^{-2}. Data revealed that rats avoided the pulsed energy, but not the continuous energy, and less than 0.4 mW cm^{-2} average power density was needed to produce aversion [69]. Navakatikian and Tomashevskaya [70] described a complex series of experiments in which they observed disruption of a rat behavior (active avoidance) by radiofrequency radiation (RFR). Behavioral disruption was observed at 0.1 mW cm^{-2} (0.027 W kg^{-1}) power density.

It has been documented that the radiofrequencies induce biological effects on biomolecules [27,51,71] that include changes in intracellular ionic concentration [72,73], cellular proliferation [74], interferences with immune system [19,75,76], effects on animals reproductive capacity [77,78], effects on stress hormones [79], in intrauterine development [80], genotoxic effects [81–87], effects on the nervous system [32,88–92], the circulatory system [93,94], and a decline in the number of births [47,95]. Firstenberg [18] proposed a connection between EMR, deformations, and the worldwide decline and extinction of amphibians.

Evidence that electromagnetic contamination may be responsible for the appearance of deformities and decline of amphibians

Some athermal effects of EMR on amphibians have been well known for more than 35 years [96,97]. The radiation of frogs with 30–60 μW cm^{-2} produced a change in the heart

rhythm, probably due to the nervous system activation (Levitina, 1966 cited in [96]). When toad hearts were irradiated with pulses of 1425 MHz at a power density of $0.6\,\mu W\,cm^{-2}$, an increase in the heart rate and arrhythmia were observed [96]. Radiofrequency burst-type dilated arterioles were observed on the web of the anaesthetized frog (*Xenopus laevis*) by a athermal non-heating mechanism [93].

The exposure to magnetic fields on two species of amphibians induced deformities [48].

Frog tadpoles (*Rana temporaria*) developed under electromagnetic field (50 Hz, $260\,A\,m^{-1}$) have increased mortality. Experimental tadpoles developed more slowly and less synchronously than control tadpoles, remain at the early stages for a longer time. Tadpoles developed allergies and EMF causes changes in the blood counts [98].

Amphibians can be specially sensitive: thresholds of an overt avoidance response to weak electrical field stimuli down to $0.01\,V\,m^{-1}$ were found in *Proteus anguinus* and $0.2\,V\,m^{-1}$ in *Euproctus asper* at 20–30 Hz, but sensitivity covered a total frequency range of below 0.1 Hz to 1–2 kHz [99].

Deformities in nature

Ultraviolet radiation, UV-B. UV-B radiations produce deformities in amphibian embryos that go from lateral flexure of the tail to abnormal skin, eye damage, and lower survival rate [6,10]. However, numerous experiments carried out did not provide evidence that this exposure induces all types of deformities observed in nature, nor the appearance of extra limbs, one of the most frequent deformities noted [5,6]. On the other hand, most of the deformations for UV-B radiation occur in the legs or in reduction of the number of bilateral fingers. However, in the wild, amphibians exhibit a wide diversity of aberrations that are limited to only one side of the body, including problems in the skin, loss of legs, and twisted internal organs, reasons for which it was considered that this radiation is not the only source [5]. Similar abnormalities found in the wild and not induced by UV-B radiation have been obtained in laboratory studies, by exposing amphibian larvae to magnetic fields [48]. A similarity exists in the deformations of amphibians observed by Levengood [48] and Blaustein and Johnson [5]. Several studies addressed behavior and teratology in young birds exposed to electromagnetic fields [39,41]. Typical abnormalities include malformation of the neural tube and abnormal twisting of the chicken embryo. The electric currents are believed to have a significant role in the control of development and it is also possible that external EMR could influence these control systems [100]. The appearance of morphological abnormalities influenced by pulsed electromagnetic fields during embryogenesis in chickens [33,101] are similar to those produced by ultraviolet radiation [36]. The pulses are in fact a characteristic of mobile telephone radiations that have increased from 1995, when a marked rise in deformations started. Several experimental studies point out that the exposure to UV-B produced deferred effects (early exposure causes delayed effects in later stages) [1]. The exposure to electromagnetic fields also induces delayed effects and the tadpoles are the same as the control until the beginning of metamorphosis. The extra limbs and blistering were induced during the gastrula stage of the development which appeared to be the most sensitive stage [48]. The early *Rana pipiens* embryonic development was also inhibited by magnetic fields [97]. In rats, brief intermittent exposure to low-frequency EMFs during the critical prenatal period for neurobehavioral sex differentiation can demasculinize male scent marking behavior and increase accessory sex organ weights in adulthood [102]. Biological effects resulting from EMR field exposures might depend on the dose (e.g. duration of exposure). Short-term exposures up-regulate cell repair

mechanisms, whereas long-term exposures appear to down-regulate protective responses to UV radiation [103].

Parasites. The parasite *R. ondatrae* is an important and extensive cause of malformations in amphibian extremities in western USA [16]. Tadpoles with malformations experience higher mortality than the normal ones before and during metamorphosis. The *Ribeiroia* infection represents a threat for amphibian populations that are in decline. However, with a growing volume of data based on the experimental evidence, the infection from parasites does not seem to be the cause of all the malformations on limbs, since in some places with the presence of deformations, the parasite *R. ondatrae* was absent [5]. Further certain deformities like the absence of eyes, limbs, and twisted internal organs was not induced by the parasite [5].

In a laboratory study, eggs and embryos of *Rana sylvatica* and *Ambystoma maculatum* were exposed to magnetic fields at several development stages. A brief treatment of the early embryo produced several types of abnormalities: microcephalia, scoliosis, edema, and retarded growth [48]. Several of the treated tadpoles developed severe leg malformations and extra legs, as well as a pronounced alteration of histogenesis which took the form of subepidermal blistering and edema [48]. In chick embryos exposed to pulsed EMR a potent teratogenic effect was observed: microphthalmia, abnormal trunkal torsion, and malformations on the neural tube [33,36,101,104]. One of the possible reasons for these deformities appearing more often [5], may be due to wireless telecommunications and exponential increase of electromagnetic contamination.

Bioelectric fields have long been suspected to play a causal role in embryonic development. The electrical field may directly affect the differentiation of some tail structures, in particular those derived from the tail bud. Alteration of the electrical field may disrupt the chemical gradient and signals received by embryo cells. It appears that in some manner, cells sense their position in an electrical field and respond appropriately. The disruption of this field alters their response. Endogenous current patterns are often correlated with a specific morphogenetic events such a limb bud formation. The most common defect in chick embryos experimental group was in tail development. Internally, tail structures (neural tube, notochord, and somites) were frequently absent or malformed. Defects in limb bud and head development were also found in experimentally treated chick embryos, but less often than the tail defects [105]. Amphibians can be especially sensitive because their skin is always moist, and they live close to, or in water, which conducts electricity easily.

Populations' decline

Deformities found in nature can directly affect embryonic mortality and survival after hatching [10]. It seems interactions that exist among UV-B radiation and additional factors contribute to embryo mortality [9]. Water pollution and excessive ultraviolet radiation act jointly, producing specific problems and alter the immune system, making amphibians more vulnerable to parasitic invasions and pathogen infections [6,8,12,14]. It is proposed that there exists a possible relationship between the decline of amphibians and exponential increase of electromagnetic pollution. Several experiments with bird eggs showed a high mortality of embryos exposed to EMR from mobile phones [36,106,107]. EMFs increases mortality of tadpoles [98]. The EMR alters the immune, nervous, and endocrine systems, and operates independent or together with other factors like UV-B radiation or chemical pollutants. Death of embryos in nature is not due to UV radiation

as the capacity of DNA repair mechanisms like photolyase (photoreactivating enzyme) is effective [9]. EMR produces stress on the immune system [76,98] that obstructs DNA repair [42,108,109]. Heat shock proteins may play a role in protecting amphibians from UV-B damage [14] and animals exposed to EMR [27,51,71,110,111]. Different susceptibility to UV among species and even among populations exists [112], as seen with EMR [31,40].

Hallberg and Johansson [108,109] proposed that radiofrequencies increase the effects of UV radiation. A study on the causes of melanoma in humans conclude that the incidence increases and the mortality associated with this skin tumor cannot only be explained by the elevation in UV sun radiation, but rather by the continuous alterations on mechanisms of cellular repair, produced by EMR (radiofrequencies) resonant with the body, that amplify the carcinogenic effects of the cellular damage induced by the UV-B radiation. The cases of melanoma experienced a significant increase from the 1960–70s [108] that continues today, and also asthma and several types of cancer associated with deterioration of immune system. Data suggest there is an increase of electromagnetic pollution [108,113]. The public health situation in Sweden has become worse since the autumn of 1997. There is a correlation between the massive roll-out of GSM mobile phone antennae and adverse health effects [109].

Enigmatic decline of amphibian species are positively associated with streams at high elevations in the tropics and negatively associated with still water and low elevations [3]. In high places, the electromagnetic contamination is usually higher [47]. Microwave measurements of power density as low as $0.0006\,\mu W\,cm^{-2}$ show strong correlation with symptoms like depressive tendency, fatigue, and insomnia in humans [63].

Proposed research

To demonstrate the conclusive effect of microwave radiation on amphibians it is necessary to approach research with a control (non-exposed) and an experimental group. This methodological position is complicated at present due to the ubiquity of these radiations [98]. Studies that try to correlate populational evolution, appearance of deformities, or the presence or absence of amphibians with measurements of electromagnetic fields from radiofrequencies will be of great interest. Field investigations of urban park populations and phone masts surrounding territories need to be high-priority. A radius of $1\,km^2$ laid out in concentric circumferences at intermediate distances may be useful to investigate the differential results among areas, depending on their vicinity and corresponding levels of EMR. Laboratory studies on amphibians exposed to pulsated and modulated microwaves would also be of great interest.

Acknowledgments

The author is grateful to Denise Ward who revised the English version of this article and thanks Sam Kacew and Miguel Lizana for the valuable suggestions to a first manuscript of this article. The author would like to thank ‘‘Centro de Información y Documentación Ambiental’’ in Castilla y León (Spain) and Roberto Carbonell for providing some articles.

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JOHN E. KELLER et al

-to-

HENRY C. RINN et ux

GRANT DEED

U. S. INTERNAL REVENUE STAMPS $1.65 CANCELLED

We, John E. Keller; and Marion Atwood, a widow, Edith B. Baer, a widow, and Guy E. Wentworth, a single man, by and through John E. Keller, their Attorney in Fact, in consideration of Ten Dollars, to them in hand paid the receipt of which is hereby acknowledged, do hereby grant to Henry C. Rinn and Ellen J. Rinn, his wife, as joint tenants with rights of survivorship, all that certain real property situate in the County of El Dorado, State of California bounded and described as follows:

Commencing at corner No. 1, located on the Westerly side of Bijou Park Boulevard, a 3/4 inch galvanized pipe, 2 ft. long 17 inches deep in a mound of rocks, with cap stamped 28 1, 29 1, 3863; from which the closing corner of Section 1 and 2, T 12 N, R 18 E, M. D. M. bears N. 55 degrees 42' 30" E, 782.6 ft. distant. Thence along said boulevard, S 29 degrees 42' E, 330 ft. to Corner No. 2, a similar pipe 18 inches deep in a mound of rocks with cap stamped 28 2, 3863. Thence S 60 degrees 18' W, 660 feet to Corner No. 3, a similar pipe, 18 inches deep with cap stamped 28 3, 3863_ Thence N. 29 degrees 42' W, 330 ft. to Corner No. 4, a similar pipe, 20 inches deep in a mound of rocks, with cap stamped 28 4, 29 2, 3863. Thence N. 60 degrees 18' E, 660 feet to corner No. 1, the place of beginning. Containing 5 acres and designated on plat as lot number 28 of Bijou Park Properties El Dorado County, State of California.

The above property is made subject to the following restrictions: The above described property shall not be used or occupied by persons not of the Caucasian Race, and no trees shall be cut on said propety without the permission of the undersigned.

Dated this 10th day of July, 1943:

JOHN E. KELLER
MARION ATWOOD
GUY E. WENTWORTH
EDITH B. BAER

BY JOHN E. KELLER
THEIR ATTORNEY IN FACT:

STATE OF CALIFORNIA }
COUNTY OF EL DORADO } SS.

On this 13th day of July, in the year One Thousand Nine Hundred and Forty three, before me, PATRICIA DARLINGTON, a Notary Public, in and for the County of El Dorado, State of California, residing therein, duly commissioned and sworn, personally appeared JOHN E. KELLER known to me to be the person whose name is subscribed to the within instrument, and acknowledged to me that he executed the same.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my Official Seal, at my office, in the said County of El Dorado, State of California, the day and year in this certificate first above written.

PATRICIA DARLINGTON
Notary Public in and for the County of El Dorado, State of California.

(SEAL)

My Commission expires April 21, 1947

DOI: 10.7860/JCDR/2017/26360.10275

Original Article

Anatomy Section

Effect of Radiofrequency Radiation Emitted from 2G and 3G Cell Phone on Developing Liver of Chick Embryo – A Comparative Study

MARY HYDRINA D'SILVA[1], RIJIED THOMPSON SWER[2], J. ANBALAGAN[3], BHARGAVAN RAJESH[4]

ABSTRACT

Introduction: The increasing scientific evidence of various health hazards on exposure of Radiofrequency Radiation (RFR) emitted from both the cell phones and base stations have caused significant media attention and public discussion in recent years. The mechanism of interaction of RF fields with developing tissues of children and fetuses may be different from that of adults due to their smaller physical size and variation in tissue electromagnetic properties. The present study may provide an insight into the basic mechanisms by which RF fields interact with developing tissues in an embryo.

Aim: To evaluate the possible tissue and DNA damage in developing liver of chick embryo following chronic exposure to Ultra-High Frequency/Radiofrequency Radiation (UHF/RFR) emitted from 2G and 3G cell phone.

Materials and Methods: Fertilized chick embryos were incubated in four groups. Group A-experimental group exposed to 2G radiation (60 eggs), Group B- experimental group exposed to 3G radiation (60 eggs), Group C- sham exposed control group (60 eggs) and Group D– control group (48 eggs). On completion of scheduled duration, the embryos were collected and processed for routine histological studies to check structural changes in liver. The nuclear diameter and karyorrhexis changes of hepatocytes were analysed using oculometer and square reticule respectively. The liver procured from one batch of eggs from all the four groups was subjected to alkaline comet assay technique to assess DNA damage. The results were compared using one-way ANOVA test.

Results: In our study, the exposure of developing chick embryos to 2G and 3G cell phone radiations caused structural changes in liver in the form of dilated sinusoidal spaces with haemorrhage, increased vacuolations in cytoplasm, increased nuclear diameter and karyorrhexis and significantly increased DNA damage.

Conclusion: The chronic exposure of chick embryo liver to RFR emitted from 2G and 3G cell phone resulted in various structural changes and DNA damage. The changes were more pronounced in 3G experimental group. Based on these findings it is necessary to create awareness among public about the possible ill effects of RFR exposure from cell phone.

Keywords: Cell phone radiation, Cytoplasmic vacuolations, Double strand breaks, DNA damage, Hydropic changes, Karyorrhexis, Nucleomegaly

INTRODUCTION

The past decade has seen tremendous development in the wireless telecommunications industry with the introduction of cellular phones (cell phones/mobile phones). The development has revolutionized the telecom industry by making telecommunication faster, economical and more convenient [1]. With the introduction of new applications and multifunctional features in the mobile hand set, the telecom industry is wooing both young and old generation.

Pulsed electromagnetic radiations are created when the cell phone is in operation [2] most of which are absorbed by body surface particularly the head region. This absorbed energy causes both thermal and non-thermal stress in the body [3,4]. Non-thermal stress is more deleterious than thermal stress and is known to cause oxidative stress [5], production of free radicals [6], structural changes in plasma membrane [7], changes in ionic transport [8] and also increased DNA damage [9].

Contradictory reports are available regarding the structural changes in various tissues like retina, liver, kidney and testis in different animal models on exposure to electromagnetic radiation of 900- 1800 MHz. The exposure resulted in impaired retinal growth, malformed brain [10] hyperpigmentation of Retinal Pigment Epithelium (RPE) [11] structural changes in the retina [12] and lens [1]. Nevertheless, several studies showed no histopathological changes in the various ocular tissues [13,14]. Structural changes were also observed in the kidney [15] and liver [16-18] of different animal models on RFR exposure. However, Rajaei F et al., reported no significant structural changes in liver on exposing mice models to electromagnetic fields of 50 MHz [19].

Contradictory reports are available on the role of RFR in causing oxidative stress in various biological tissues of different animal models [20-22]. A long term exposure of albino Wistar rats to RFR from 900 MHz mobile phones resulted in decreased concentration of antioxidant enzyme Glutathione Peroxidase (GPx), catalase and Superoxide Dismutase (SOD) [20] and increased Reactive Oxygen Species (ROS) by means of Fenton reaction [21]. However, no significant change in the antioxidant activities was observed in albino Wistar rats on exposure to RFR emitted from 3G mobile phone [22].

Several scientific reports are available to establish the role of RFR emitted from cell phones in causing DNA damage in various biological tissues in both human and animal models [23-26]. The long term exposure resulted in increased DNA strand breaks, Single Strand Breaks (SSB's) and Double Strand Breaks (DSB's), and rearrangement of DNA segments in testis [23], brain [24] and eyes [25] of different animal models and also in human lymphocyte culture [26]. However, various authors reported no significant DNA damage in different tissues of various animal models [27] and in human lymphocyte culture [28].



[Table/Fig-1]: A photograph showing the experimental set up. The Mobile phone (red arrow) is hung with a distance of 5 cm separating it from the fertilized chicken eggs. A RF meter is kept inside the incubator to check the intensity of radiation (yellow arrow).

The cell phone once considered as a status symbol in early 90's has now become an integral part of everyone's life. They are used extensively by all age groups, including the children, elderly and pregnant women. Researches involving children and pregnant women are very less due to various ethical issues. The present study may provide an insight into basic mechanisms by which RF fields interact with developing tissues in an embryo. We have designed this study to evaluate the possible effects of chronic exposure to RFR emitted from 2G and 3G mobile phones on developing chick embryo liver.

MATERIALS AND METHODS

The present work was an experimental study that has been carried out during the year 2011-2015. All the procedures were followed as per Ethical Guidelines for care and use of experimental animals approved by Institutional Animal Ethical Committee (IAEC). Fresh fertile hen eggs (*Gallus domesticus*) having approximately similar weight (65-70 gm±5 gm) was procured from Rajiv Gandhi College of Veterinary and Animal Sciences, Puducherry, India. The eggs were incubated in 19 batches of 12 eggs each (total-228±20 eggs) in a standard egg incubator at 37±0.5°C and 50%-55% of humidity and ventilation.

The first four batches (48 eggs) were grouped as control (Group–D) and they were incubated without any external factors interfering with their developmental process. Next five batches (60 eggs) were treated as sham exposed group (Group-C). They were incubated along with a popular brand cell phone with the SAR of 0.310 watts/kilogram hung from above with 5 cm distance separating the egg and kept in null status (switched off). Morphological features and structure of liver of both these groups were analysed and found to be similar. So, we have considered the sham exposed group as the control group for the present study.

The experimental group, Group–A (exposed to 2G cell phone radiation) and Group–B (exposed to 3G cell phone radiation), were also incubated (60+60 eggs) in a similar manner with the cell phone kept in silent operative mode with head phone plugged in (switched on). This arrangement ensured that the cell phone got activated automatically each time it received a call and the intensity of radio frequency waves were measured using radiofrequency meter (RF meter, Less EMF Inc, USA) [Table/Fig-1].

A popular brand cell phone hand set and a service provider were used for network connection for both 2G and 3G exposure. For exposure activation, the cell phone was rung from another cell phone for duration of three minutes each, every half an hour, with the first exposure given at 12th hour of incubation (4.30 am-4.30 pm). The total exposure for a 12 hour period was 75 minutes followed by 12 hour of exposure-free period. This was repeated daily up to 12th day of incubation.

Six embryos per day were terminated from 5th day to 12th day. The embryos were carefully transferred to a petridish containing normal saline and the various growth parameters (weight, volume and CR length) were recorded. The embryos were then fixed in 10% formalin and processed for routine histological studies. Five micron thick sections were cut in sagittal plane, coronal plane and in transverse plane and stained with H&E and PAS stain. Degenerative changes in hepatocytes were observed and compared in all groups. The nuclear diameter of hepatocytes was measured from a randomly selected field of every fifth section of a slide using calibrated oculometer under oil immersion. The healthy nuclei showing prominent nucleoli were used for the measurement. The number of nuclei showing karyorrhexia (nuclear fragmentation) was counted in a randomly selected field using square reticule under oil immersion and the values obtained were statistically analysed using one-way ANOVA using Graph Pad Instat 3.

The liver of fifth batch of embryos of all the three groups (12+12+12) were subjected to alkaline comet assay technique developed by Singh NP [29] with modifications in staining procedure [30], for assessing the DNA damage. The slides were stained with silver nitrate and then analysed using automated comet scoring software (Comet Score IV) to assess and quantify the levels of DNA damage in three groups. The mean comet length, the mean tail length, mean % of DNA in the tail and mean tail moment of all three groups were statistically compared using one-way ANOVA with Graph Pad Instat 3.

RESULTS

The growth parameters like volume, weight and CR length of exposed groups showed significant changes in comparison with the control group. The growth parameters were increased in 2G exposure group than control group. The 3G exposure resulted in decreased growth parameters in correlation with control and 2G exposure groups. However, by 11th and 12th day all the three growth parameters became more or less equal in all the three groups [Table/Fig-2-4].

Histological evaluation of control embryo liver in all the age groups (5th–12th day) showed normal architecture with hepatocytes arranged in the form of hepatic cords and sinusoids separating

Age in days	Control group (Group-C) (in cc)	2G group (Group-A) (in cc)	3G group (Group- B) (in cc)
5	0.12 ± 0.01	0.09 ± 0.01	0.09 ± 0.008
6	0.3 ± 0	0.3 ± 0	0.18 ± 0.01***
7	0.53 ± 0.03	0.8 ± 0.08**	0.5 ± 0**
8	1 ± 0	1.02 ± 0.025	1 ± 0
9	1.21 ± 0.09	1.76 ± 0.13	1 ± 0.20*
10	1.5 ± 0	2.35 ± 0.16**	1.6 ± 0.16**
11	2.16 ± 0.10	2.5 ± 0.12	2.2 ± 0.12
12	3.41 ± 0.15	3.25 ± 0.17	3.3 ± 0.12

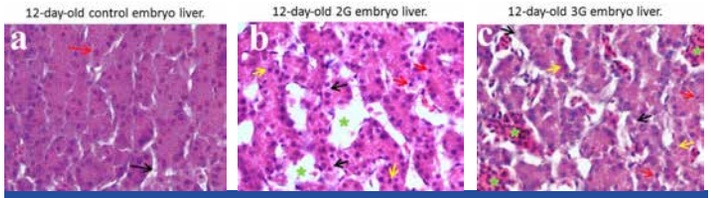
[Table/Fig-2]: Mean volume of chick embryos in all the three groups.
Values are means ± SEM taken from six samples per day for control, 2G and 3G group (n = 48 chick embryos) (analysis < 0.05* significant, < 0.01** highly significant and < 0.001 *** extremely significant)

Age in days	Control group (Group-C) (in gm)	2G group (Group-A) (in gm)	3G group (Group- B) (in gm)
5	0.143 ± 0.007	0.129 ± 0.01	0.087 ± 0.002**
6	0.298 ± 0.01	0.316 ± 0.007	0.216 ± 0.01**
7	0.613 ± 0.009	0.738 ± 0.05*	0.582 ± 0.03
8	0.864 ± 0.01	1.098 ± 0.02***	0.945 ± 0.03
9	1.290 ± 0.04	1.643 ± 0.15	1.066 ± 0.20
10	1.468 ± 0.01	2.239 ± 0.11***	1.837 ± 0.09*
11	2.189 ± 0.04	2.477 ± 0.08	2.146 ± 0.16
12	3.433 ± 0.11	3.200 ± 0.14	3.345 ± 0.11

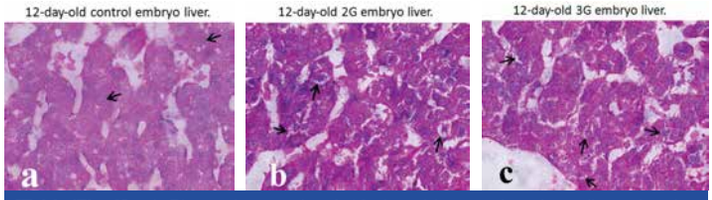
[Table/Fig-3]: Mean weight of chick embryos in all the three groups. Values are means ± SEM taken from six samples per day for control, 2G and 3G group (n = 48 chick embryos) (analysis < 0.05* significant, < 0.01** highly significant and < 0.001 *** extremely significant)

Age in days	Control group (Group-C) (in mm)	2G group (Group-A) (in mm)	3G group (Group- B) (in mm)
5	11 ± 0.31	8.98 ± 2.04	11 ± 0.25
6	13.6 ± 0.4	14 ± 0	12.3 ± 0.49
7	19.16 ± 0.40	18.75 ± 0.62	16.75 ± 0.25**
8	21.12 ± 0.31	22.5 ± 0.28	20.16 ± 0.40
9	23.41 ± 0.41	24.33 ± 1.2	22.37 ± 1.4
10	25.16 ± 0.87	28 ± 0.44*	27.33 ± 0.49
11	29 ± 0.73	31.5 ± 0.5	30 ± 1.51
12	35.16 ± 0.54	34.16 ± 1.4	34.8 ± 0.37

[Table/Fig-4]: Mean CR length of chick embryos in all the three groups.
Values are means ± SEM taken from six samples per day for control, 2G and 3G group (n = 48 chick embryos) (analysis< 0.05* significant, < 0.01** highly significant and < 0.001 *** extremely significant)



[Table/Fig-5]: a) Photomicrograph of 12-day-old control embryo liver showing normal looking hepatocytes with eosinophilic cytoplasm and large vesicular nuclei (red arrow) and normal hepatic sinusoids (black arrow) (H&E x 1000); b,c) Photomicrograph of 12-day-old 2G and 3G embryo liver showing hepatocytes with vacuolations in the cytoplasm (black arrow), pyknotic nuclei (red arrow), karyorrhexis (yellow arrow) and dilatedhepatic sinusoids with RBCs (green asterix) (H&E x 1000).



[Table/Fig-6]: a) Photomicrograph of 12-day-old control embryo liver showing normal looking hepatocytes in hepatic cords (black arrow) (PAS x 1000); b,c) Photomicrograph of 12-day-old 2G and 3G embryo liver showing vacuolations in the cytoplasm of hepatocytes (black arrow) (PAS x 1000).

them. The sinusoids showed mild to moderate numbers of RBC's. The hepatocytes showed eosinophilic granular cytoplasm and centrally placed large vesicular nuclei with prominent nucleoli. The cytoplasmic changes in the form of vacuolations and nuclear changes (karyorrhexis, pyknosis) were indistinct in the control group.

The liver structure in 2G and 3G experimental groups (5th day- 12th day) showed marked dilation of sinusoidal spaces (peliosis hepatis) with moderate to more numbers of RBC's indicating haemorrhage in the parenchyma. The cytoplasm of hepatocytes showed vacuolations rendering them foamy appearance. These vacuolations were PAS negative that indicated fatty changes (steatosis). The nuclei showed karyorrhexis and pyknotic changes [Table/Fig-5,6].

The nuclear diameter of hepatocytes in all the three groups showed a gradual increase in diameter as the age advanced. The nuclear changes observed in our study were swollen appearance (nucleomegaly) of hepatic nuclei in 2G and 3G group embryos. Both the 2G and 3G exposed groups showed increased nuclear diameter than the control group which was significant on all days (p<0.001). On comparing 2G and 3G groups, 3G group embryos showed increased diameter and was significant on all days [Table/Fig-7].

Both 2G and 3G group embryos showed increased karyorrhexis than the control group embryos. The increase was significant on 5th and 12th day for 2G group embryos (p<0.01) and for 3G group embryos the increase was significant on 5th, 7th, 9th, 11th and 12th day of incubation (p<0.001, p<0.01, p<0.01, p<0.001 and p<0.001 respectively). On comparing between 2G and 3G group, 3G group showed increased karyorrhexis than 2G group but the increase was significant only on 5th, 7th, 9th and 11th day (p<0.05, p<0.05, p<0.05 and p<0.001 respectively) [Table/Fig-8].

On assessing the DNA damage in the form of DSB's, we found significant increase in all the four parameters of both 2G and 3G group embryos in all the days (9th – 12th day) in comparison with the control group embryos (p<0.001 and p<0.001 respectively) [Table/Fig-9]. On comparing between 2G and 3G group embryos, it was found that the 3G group embryos showed significant increase in all the four parameters than the 2G group embryos [Table/Fig-10].

Age in days	Control group (Group-C) (in mm)	2G group (Group-A) (in mm)	3G group (Group- B) (in mm)
5	0.0039 ± 0.00002	0.0041 ± 0.00003**	0.0042 ± 0.00004***
6	0.0039 ± 0.00002	0.0042 ± 0.00004***	0.0043 ± 0.00004***
7	0.0040 ± 0.00002	0.0042 ± 0.00003***	0.0043 ± 0.00004***
8	0.0040 ± 0.00001	0.0042 ± 0.00004***	0.0044 ± 0.00004***
9	0.0041 ± 0.00002	0.0043 ± 0.00004***	0.0045 ± 0.00004***
10	0.0041 ± 0.00003	0.0044 ± 0.00004**	0.0045 ± 0.00005***
11	0.0042 ± 0.00004	0.0044 ± 0.00004*	0.0047 ± 0.00004***
12	0.0043 ± 0.00004	0.0046 ± 0.00004***	0.0049 ± 0.00004***

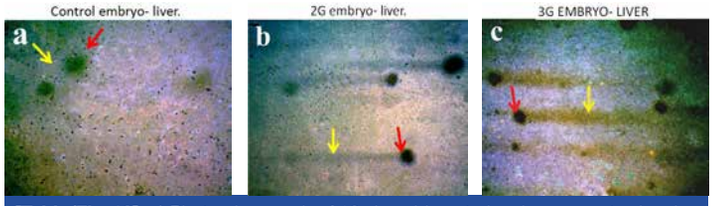
[Table/Fig-7]: Mean nuclear diameter of hepatocytes in all the three groups of chick embryo.
Values are means ± SEM taken from six samples per day for control, 2G and 3G group (n = 48 chick embryos) (analysis< 0.05* significant, < 0.01** highly significant and < 0.001 *** extremely significant)

Age in days	Control group (Group-C)	2G group (Group-A)	3G group (Group- B)
5	0.84 ± 0.08	1.42 ± 0.13**	1.5 ± 0.12***
6	1.14 ± 0.09	1.32 ± 0.13	1.5 ± 0.13
7	1.06 ± 0.16	1.22 ± 0.14	1.72 ± 0.12**
8	1.5 ± 0.14	1.5 ± 0.10	1.92 ± 0.16
9	1.1 ± 0.11	1.3 ± 0.11	1.74 ± 0.13**
10	1.21 ± 0.11	1.22 ± 0.11	1.38 ± 0.13
11	1.27 ± 0.10	1.32 ± 0.09	2.02 ± 0.16***
12	0.72 ± 0.13	1.32 ± 0.11**	1.62 ± 0.10***

[Table/Fig-8]: Karyorrhexis in nuclei of hepatocytes in all the three groups of chick embryo.
Values are means ± SEM taken from 6 samples per day for control, 2G and 3G group (n = 48 chick embryos) (analysis< 0.05* significant, < 0.01** highly significant and < 0.001 *** extremely significant

Age in days	Mean comet length (µm)	Mean tail length (µm)	Mean % of DNA in tail (µm)	Mean tail moment (µm)
9 (CON)	4.03 ± 0.15	4.18 ± 0.1	21.63 ± 0.6	80.55 ± 3.0
9 (2G)	7.9 ± 0.18**	6.06 ± 0.1***	31.76 ± 1.6***	184.89 ± 6.2***
9 (3G)	7.8 ± 0.22***	6.12 ± 0.2***	47.16 ± 1.7***	258.69 ± 11.5***
10(CON)	4.6 ± 0.19	3.90 ± 0.1	21.23 ± 0.5	84.49 ± 3.1
10(2G)	7.3 ± 0.14***	6.40 ± 0.2***	34.05 ± 1.3***	157.13 ± 5.8***
10(3G)	7.4 ± 0.15***	6.39 ± 0.2***	48.07 ± 1.4***	260.53 ± 12.3***
11(CON)	5.2 ± 0.18	3.70 ± 0.1	22.46 ± 0.6	92.48 ± 3.0
11(2G)	8.3 ± 0.24***	6.35 ± 0.2***	42.43 ± 1.2***	240.54 ± 15.1***
11(3G)	9.5 ± 0.14***	8.30 ± 0.2***	48.94 ± 1.5***	292.16 ± 11.6***
12(CON)	6.0 ± 0.13	4.38 ± 0.1	23.10 ± 0.6	93.99 ± 3.2
12(2G)	8.9 ± 0.17***	7.15 ± 0.1***	47.14 ± 1.8***	248.08 ± 14.1***
12(3G)	9.8 ± 0.15***	8.24 ± 0.2***	49.67 ± 1.5***	298.69 ± 15.3***

[Table/Fig-9]: Estimation of DNA damage in liver in all the three groups (9-12 days).
Values are means ± SEM taken from 3 samples per day for control, 2G and 3G group (n = 36 chick embryos) (analysis< 0.05* significant, < 0.01** highly significant and < 0.001 *** extremely significant)



[Table/Fig-10]: a) Photomicrograph of 12-day-old control embryo comets showing minimal DNA damage. Head diameter is large (red arrow) and tail length is shorter (yellow arrow) 10X; b,c) Photomicrograph of 12-day-old 2G and 3G embryo comets showing severe DNA damage. Head diameter is decreased (red arrow) and tail length is increased (yellow arrow) 10X.

DISCUSSION

In the present study, increased growth parameters of 2G group embryos could be due to increased cellular proliferation coupled with Ca^{2+} influx into the cells on exposure to RFR [31]. Similar observation was reported earlier by Fatima Al Qudsi et al. In their study, the exposure of chick embryos (900-1800 MHz) increased the growth parameters (the CR length, body length and beak length) and also increased the eye development (eye weight, eye diameter, eye area, eye perimeter) on the tenth day of incubation and a decrease in these parameters was observed on further exposure [10].

However, the decreased growth parameters for 3G group embryos in the present study, probably could be due to RFR interactions at cellular level (free radical production) and molecular level (DNA damage) resulting in genotoxicity. This in turn might affect cell proliferation either by increasing or reducing the proliferation rate and thus plays an important role during early embryonic development [31,32]. A number of studies are available reporting retarded growth on exposure to RFR of similar frequency [12,33,34]. Decreased foetal weight and crown-rump length was observed in intrauterine exposure of rat and mouse animal models to RFR ranging from 27.12 MHz to 2450 MHz [12].

The similar growth parameters observed in all the three groups of embryos on 11th and 12th day probably could be due to difference in cellular responses to RFR at different embryological periods and the cells might be trying to rebalance their growth and differentiation rate to normal by activating various cellular stress response mechanisms [10].

In the present study, the cytoplasmic vacuolations observed in hepatocytes of 2G and 3G group embryos were similar to the observations reported by different researchers. The exposure of white leghorn chicken embryos to 50 Hz electromagnetic fields showed fibrotic bands in hepatocytes, severe steatohepatitis, degenerated hepatocytes, abnormal lipid accumulation and lipid droplets pushing hepatocytes nuclei to the corner of the cell [16]. The exposure of pregnant albino rats to 900 MHz for 1 hour per day from 13th to 21st day of pregnancy resulted in histopathological changes in the liver of 21 day old neonatal rats. The changes observed were necrotic hepatocytes with hydropic changes in the liver parenchyma especially near peri-central area and irregular nuclei [17]. Tarantino P et al., reported vacuolations in cytoplasm and presence of granules in hepatocytes of rabbit liver on exposure to 650 MHz electromagnetic fields for 18 months continuously [18]. However, in the present study necrotic changes were not observed. In one of the studies, the exposure of mice to electromagnetic fields of 50 MHz and intensity of 0.5 mT 4 hours per day for two months showed no significant increase in necrotic cells and kuffer cells and no structural changes in liver [19]. Khalil A et al., exposed Balb/c mice to RFR of 900 MHz for 30 minutes/day for one month. Their study showed no significant histopathological changes in different tissues including liver [35].

In our study, the dilated sinusoidal spaces of both 2G and 3G group embryos might probably be due to endothelial injury caused by RFR that would have allowed blood to accumulate in spaces of Disse with resultant formation of the cavities [36]. Sinusoidal dilatations in hepatic parenchyma have been reported earlier by other researchers. The exposures of young male rats to electromagnetic radiations lead to sinusoidal dilatation in the parenchyma and periportal area of liver tissue [37]. Sinusoidal expansion and irregular sinusoidal lumen diameter was observed in rabbit liver on exposure to 650 MHz radiation for 12 and 18 months respectively. Moreover, infiltrations within the sinusoids of chick embryo liver were also reported by Lahijani MS et al., [16]. In our study also sinusoids showed infiltrations and were engorged with RBCs.

The nucleomegaly observed in the hepatocytes of 2G and 3G group embryos of the present study might be due to hydropic changes/oncosis triggered by RFR exposure. Glycogenated nuclei or hydropic nuclei could be encountered in various pathological conditions [36]. Previous studies have reported the presence of dentated nuclei in chick embryo liver on exposure to 50 Hz electromagnetic radiations [16] and necrotic hepatocytes with irregular nuclei [17]. In the present study, the increased nuclear diameter and karyorrhexis observed in the 3G group embryos, on comparing with 2G and control group embryos, might be due to increased lethality of 3G radiations.

RFR emitted from cell phone contains electric and magnetic energy moving together in space [38]. RFR enhances the production of free radicals and its magnetic component could make the free radical stay for longer time, thus, giving them the potential to do more damage. The high levels of free radicals could overwhelm the cellular antioxidant capacity and above a certain threshold level could result in cellular damage. The free radicals if added to unsaturated cell membrane lipids can damage membrane lipids thus changing the integrity of membrane. This could lead to influx of water, Na^{+} and Ca^{2+} ions causing swelling and vacuolization of the cytoplasm (cytomegaly), nuclear swelling (nucleomegaly), rupture of nucleus and nucleolus, pyknosis, karyorrhexis, karyolysis and cytolysis [39].

In the present study, the increased DNA damage observed in 2G and 3G group embryos were in correlation with the previous studies. Increased DNA damage was observed in the liver cells of Wistar rats on exposure to 915 MHz radiations with a power density of 2.4 W/m^2 and SAR of 0.6 W/kg one hour per day, seven days per week for two weeks [40]. In our study, the increased parameters showed by 3G group embryos on comparing with 2G group embryos, indicates their increased lethality.

DNA are remarkably stable macromolecules that controls growth and function of cells. Researchers have postulated different mechanisms by which an EMF interacts with DNA causing damages. The energy associated with RFR cannot directly break the chemical bonds within the molecules. However, it could enhance the free radical activity especially hydroxyl ions (HO•) in the cells by Fenton reaction. HO• thus produced are unique in that they get added to DNA very rapidly in vivo yielding altered bases or SSB and DSB [39]. Another possible mechanism is that, RF radiation is known to produce alterations in the structure of proteins [41]. Thus, structural alteration in DNA repair enzymes might have caused changes in its function, leading to DNA damage [42].

LIMITATION

The direct extrapolation of the outcome of the present study to human population may be limited due to differences in species, volume and size, life span, functional and anatomical organization of tissues. Further research is warranted to enhance better understanding of underlying principles of RFR interaction with biological tissues.

CONCLUSION

From our experimental outcome, we conclude that the chronic exposure of chick embryo liver to RFR emitted from 2G and 3G cell phone resulted in various structural changes and DNA damage. The changes were more pronounced in 3G experimental group. Many researchers now opine that cell phones may turn out to be the cigarettes of 21st century as their effects or interactions with biological tissues on long term exposure are yet to be explored especially in foetuses and children. Hence, children and pregnant women should use the cell phone with caution. Introduction of new

Hindawi Publishing Corporation
International Journal of Forestry Research
Volume 2010, Article ID 836278, 7 pages
doi:10.1155/2010/836278

Research Article

Adverse Influence of Radio Frequency Background on Trembling Aspen Seedlings: Preliminary Observations

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Received 21 June 2009; Revised 31 October 2009; Accepted 17 February 2010

Academic Editor: Terry L. Sharik

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Numerous incidents of aspen decline have been recorded in North America over the past half century, and incidents of very rapid mortality of aspen clones have been observed in Colorado since 2004. The radio frequency (RF) environment of the earth has undergone major changes in the past two centuries due to the development and use of electricity in power and communications applications, and the anthropogenic RF background continues to increase in intensity and complexity. This study suggests that the RF background may have strong adverse effects on growth rate and fall anthocyanin production in aspen, and may be an underlying factor in aspen decline.

1. Introduction

Incidents of aspen decline in North America have been observed since the mid-20th Century [1–3]. Stands at the limits of aspen's lower elevation range, on sites with poor drainage, with limited water [4] or nutrient supply [5], are more susceptible to decline. Stand age and clonal differences are also factors in susceptibility to decline [6]. Factors initiating decline include: defoliation by insects, damage caused by wildlife, severe drought, and extreme weather incidents [7]. Damage caused by these factors can diminish the vigor of affected clones and make them vulnerable to opportunistic fungal pathogens and insects [8]. The concept of forest decline has been used to describe the interaction of these various factors; however, the underlying causes of aspen decline are not well understood [9]. Since 2004, incidents of very rapid aspen clone mortality have been seen in Colorado [10]. Because the electromagnetic (EM) environment of the earth has changed radically in the past two centuries, this study investigates the possibility that anthropogenic changes in this environment, particularly in the radio frequency (RF) spectrum, are adversely affecting growth and health of aspen populations, making them vulnerable to decline.

Electromagnetic energy from the sun is essential for life on earth. Plants rely on inputs of EM energy for photosynthesis and for regulation of periodic functions (flowering, shoot and root growth, respiration, and dormancy). A plant's response to EM energy is dependant on frequency, timing, and intensity of the signal. The source of the EM input, however, makes no difference. Timing of plant processes is an important mechanism for plant protection and efficient functioning in changing day/night and seasonal environmental conditions [11]. Although photosynthesis requires fairly strong energy input in the blue and red visual frequencies (full sun/shade) [12], photoperiodic responses in plants are typically triggered by energy inputs in the red and far-red frequencies that are in the range of 10^{-4} times the energy required for photosynthesis, and even a brief flash of light during a plant's subjective night can be enough to trigger a short night response, strongly affecting plant behavior and morphology [13]. The radio frequencies, lower than 300 gigahertz, are below visual and infrared frequencies in the electromagnetic spectrum. The earth's natural RF environment has a complex periodicity that has been more or less the same within the lifespan of modern tree taxa. Before 1800, the major components of this environment were broadband radio noise from space (galactic noise), from

lightning (atmospheric noise), and a smaller RF component from the sun [14]. Because of the periodic nature of the naturally occurring RF background, plants may have evolved to use those environmental signals, as well as visible light, to regulate periodic functions, and therefore they may be sensitive to anthropogenic RF input. The intensity of the human-generated RF environment has increased gradually since about 1800. This background of RF pollution is now many times stronger than the naturally occurring RF environment. From the perspective of evolutionary time, the change can be considered sudden and dramatic [14, 15].

Many experiments have been conducted investigating possible effects of RF exposure on plants and animals. Generally, exposures to particular single frequencies at particular, usually fairly high intensities, have been used in these previous experiments [16]. However, the assumption seems to have been made that the low-level background of RF pollution has no effect on biological systems. Therefore, not only has this particular phenomenon not been studied, but it has been generally disregarded in earlier experiments designed to look for effects of RF exposure. Results of those previous experiments are often difficult to duplicate, and it may be that the anthropogenic RF background has been a confounding factor. However, for some RF effects on biological systems, consistent results have been documented in previous experiments: growth rates of plants [17] and fungi [18] can be increased or decreased by RF exposure. Exposure to RF signals can induce plants to produce more meristems [19], affect root cell structure [20, 21], and induce stress response in plant species, causing biochemical changes [22]. Effects on circadian rhythms in several animal species have been documented [23]. Some possible mechanisms of effect have been identified [24]. This experiment investigates the effects of the radio frequency background on aspen seedlings. The objective of this preliminary study was to determine if aspens respond to the current RF background in ways that result in reduced growth, or in increased susceptibility to pathogens.

1.1. Study Area. The experiment was conducted in a rural area near Lyons, Colorado: at 40.29° Latitude and −105.28° Longitude, at an altitude of 1,700 meters, and on a north-facing slope. The ecological system in the area of the experiment is Rocky Mountain Lower Montane. The site was about 400 meters below the lower elevation of aspen's natural range in Colorado. The north-facing slope was chosen as a somewhat cooler microclimate than other aspects. Vegetation included various grasses, which were mowed on the 8 × 10 m experimental plot. Vegetation in the east, south, and west directions from the experiment included: wild grasses and various low shrubs, rabbit brush (*Chrysothamnus nauseosus*), sage (*Artemisia tridentata*), wild currant (*Ribes cereum*), chokecherry (*Prunus virginiana*), yucca (*Yucca angustifolia*), and skunkbush (*Rhus trilobata*). North of the experiment, there were large cottonwood trees along the river, with grass and chokecherry undergrowth.

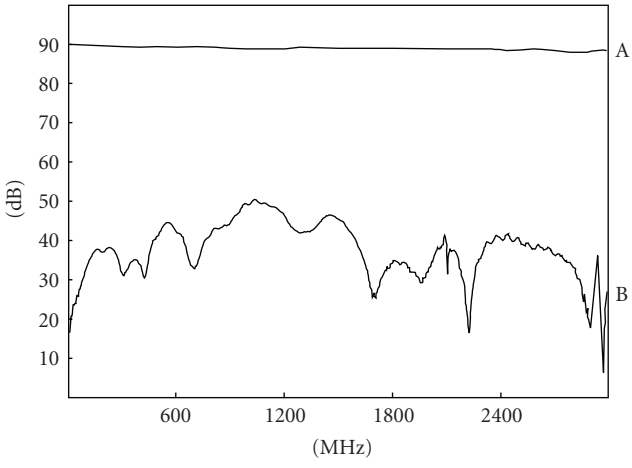


Figure 1: The aluminum screen material in the configuration used for this experiment was tested at NIST in Boulder, CO. From 1.0 MHz to 3.0 GHz, its effectiveness in blocking RF signals was found to vary from 40 dB to 73 dB across the entire range of frequencies. **X** axis = Radio frequency from 1.000 MHz to 3000.000 MHZ in increments of 300.000 MHz left to right. **Y** axis = Decibel scale. Reference signal level was 90 dB. A = Reference signal. B = Attenuated signal.

1.2. Materials and Methods. In order to create an environment free of RF signals, a Faraday cage was built, using two layers of aluminum window screen supported by a bamboo frame. Cage dimensions were 75 cm by 75 cm by 120 cm. The aluminum screen material in the configuration used for this experiment was tested at a laboratory of the National Institute of Standards and Technology (NIST) in Boulder, CO. From 1.0 MHz to 3.0 GHz, its effectiveness in attenuating RF signals was found to vary from 40 dB to 73 dB across the entire range of frequencies (Figure 1). Theoretically, an enclosure made of this material would reduce signal intensity by a factor of 10^{-4} to $10^{-7.3}$, blocking essentially all ambient RF energy, including the naturally occurring RF background. In practice, the shielding effectiveness of a Faraday cage made of this material could be somewhat less than that of the material itself due to gaps or imperfect electrical contact at seams and closures, and to the internal RF acoustical properties of the cage. A similar cage was constructed as a control, with fiberglass screen, which is not conductive and which does not block RF signals, instead of aluminum. A transistor radio was used to test the effectiveness of the cages to block the RF background. No radio stations could be picked up inside the Faraday cage. In both the mock-Faraday cage and the uncaged area, numerous stations were received in the AM and FM bands. A sweep of RF background at the site, June 6, 2009, using an *Anritsu* spectrum analyzer, showed that field intensity ranged from −117 dBm to −87 dBm at frequencies from 1 to 1,000 MHz. Mean field intensity was −109 dBm.

On May 28, 2007, 30 aspen seedling plugs were obtained from the Colorado State Forest Service (CSFS) nursery in Fort Collins, Colorado. Seed for these seedlings came from Caffey County near Salida Colorado, approximately



Figure 2: October 6, 2007. Mock-shielded seedlings on the left and shielded seedlings on the right, the latter showing more total leaf area, stronger fall leaf coloration, and minimal leaf necrosis symptoms.



Figure 3: Unshielded seedling, showing green to yellow leaf coloration and gray to brown necrotic leaf tissue, Oct. 6, 2007.



Figure 4: Mock-shielded seedling, exhibiting yellow leaf coloration and brown lesions, Oct. 6, 2007.

195 km SSW of the experiment site, at an elevation of about 2,100 meters. The seeds were germinated in June 2006 at the CSFS Nursery, and the resulting seedlings were grown in a shade house in a Styrofoam planter-block of 30 seedling plugs. The seedlings had leafed out in early spring and, when purchased on May 28, 2007, were not producing new leaves. Seedlings were transplanted into no. 1 black gallon plastic pots on June 5, 2007 using a commercial potting medium, Black Gold, composed of: 45–55% Canadian sphagnum peat moss, compost, pumice, perlite, and composted worm castings (N .05%: water soluble .006%, water insoluble .044%). Since only 27 seedlings were needed for the experiment, due to space restrictions, the three smallest seedlings were discarded. The remaining seedlings were relatively uniform in height, stem diameter, and leaf development, and the leaves appeared healthy and green. The 27 seedlings were assigned to 3 groups of 9 seedlings each, with variation in size distribution distributed equally among the 3 groups. After potting, the three groups were photographed and randomly assigned to the mock-shielded cage, the shielded cage, or to the unshielded area. The experiment began June 6, 2007. All treatments in the experiment were exposed to full sun from sunrise to late afternoon. There was a distance of three meters between treatment enclosures. All seedlings in the experiment were watered at the same time 1-2× per week, depending on the weather, using Lyons water. Seedlings were watered with a weak solution of fertilizer (5-10-5) on July 29, 2007, and otherwise were not fertilized.

Two sets of a calibrated thermometer and humidity gauge were used to compare temperature and humidity readings between cages under various weather conditions and times of day and night. The monitoring devices were placed in the middle of the monitored treatment enclosure, just above the top of the pots. A board was placed south of the devices to provide shade. A lux meter was used to measure light intensity in the treatment areas. Shielding reduced light intensity by 35% for the mock-shielded enclosure and 40% for the RF-shielded enclosure. Naturally occurring sunlight intensity was not reduced for the group that was not shielded. Except for the difference in RF background intensity, conditions in the shielded and mock-shielded enclosures were very similar. The unshielded seedlings were exposed to higher light levels (full sun), higher airflow, and generally lower humidity than the shielded and mock-shielded treatments since they were not in a screened enclosure.

1.3. Measurements. After seedlings were transplanted and placed in the three treatment enclosures in early June, they began to grow again. Because of that, there was a shoot node dividing spring growth from the summer growth phase that was easy to identify. Measurement of active leader (shoot) length was taken from the tip of the shoot down to that first shoot node, so leader length measured was only that produced after the experiment began on June 6, 2007. For leaves emerging directly from a main stem, leader length was recorded as 0.00 cm.

On July 28-29, 2007, measurements of active leader length and width of each leaf on each active leader were made on all seedlings in the experiment. Leaves had not begun to drop at that time, and the great majority of them in all treatment groups appeared healthy and green. Leaf width was converted into estimated leaf area using an algorithm (Leaf Area $(\text{cm}^2) = 0.637 * \text{Leaf Diameter } (\text{cm})^{1.951}$) developed by W.D. Shepperd of the USDA forest Service's Rocky Mountain Research Station [25]. After measurements were taken, all seedlings were returned to their cages. October 5-6 photos



Figure 5: Shielded seedling, showing red petioles and veins on light green leaf tissue, and very little leaf tissue affected by necrosis. Oct. 6, 2007.



Figure 6: Shielded seedling. Combination of red veins and green leaf tissue makes leaves look black (left side of photo), Oct. 6, 2007.



Figure 7: Shielded seedling, with leaves on active leaders mainly free of necrotic lesions, and leaf veins and petioles red, Oct. 6, 2007.



Figure 8: Mock-shielded seedling, showing all leaves affected by necrotic lesions to some extent, leaf veins yellow or green, and petioles light red to pink, Oct. 6, 2007.

were taken showing differences in leaf coloration, and relative leaf area affected by necrotic lesions.

2. Results

Seven seedlings in each RF-exposed group and eight seedlings in the shielded group produced active leaders and new leaves during the experiment. The RF shielded group evidenced more vigorous growth, producing 74% more total leader length and 60% more leaf area than the mock-shielded group, though the number of leaves produced by both groups was nearly the same (Table 1). The two RF-exposed groups' morphology and behavior were very similar and within the current norm for aspen, including absence of fall anthocyanin production, and extensive leaf area affected by necrotic lesions in fall senescing leaves. On active leaders, the shielded group showed fall production of anthocyanins far outside the norm, absence of fall leaf tissue necrotic lesions, and a wide range of fall colors: bright orange, yellow, green, dark red, and black (a combination of dark green leaf tissue with red veins). Shielded leaves produced in the spring flush (before treatment), however, were similar in appearance to leaves in the two exposed groups in color, size, and incidence of lesions. All of the shielded leaves on active leaders had dark to bright red veins and petioles indicating strong anthocyanin production (Figure 2). On October 5, 2007, unshielded and mock-shielded seedlings had leaf tissue ranging in color from yellow to green, and a high percentage of leaf tissue in both exposed groups displayed necrotic lesions (Figures 3 and 4). Shielded seedlings had larger leaves, petioles and leaf veins were red, and tissue colors varied from yellow to dark green (Figure 5). Some shielded leaves looked black because of the combination of red veins and dark green tissue (Figure 6). Leaves on active leaders in the shielded group were substantially free of leaf tissue lesions (Figure 7), but unshielded and mock-shielded leaves were all affected to some extent by leaf tissue necrosis (Figure 8).

Table 1: Various characteristics of aspen seedlings following one of three RF treatments.

	Treatment		
Seedling Characteristic	Not-Shielded	Mock-Shielded	Shielded
No. leaders	4 (0, 6)*	2 (0, 7)	3 (0, 3)
Leader length (cm)	22 (0, 52)	17 (0, 43)	31 (0, 53)
No. Leaves	27 (0, 37)	16 (0, 34)	16 (0, 31)
Leaf area (cm^2)	87.4 (0, 165.8)	72.8 (0, 186.7)	170 (0, 219.8)
No. seedlings producing leaders and leaves	7	7	8
No. seedlings out of 9 producing anthocyanins	0	0	8

*Median (min, max) **n** = **9**.

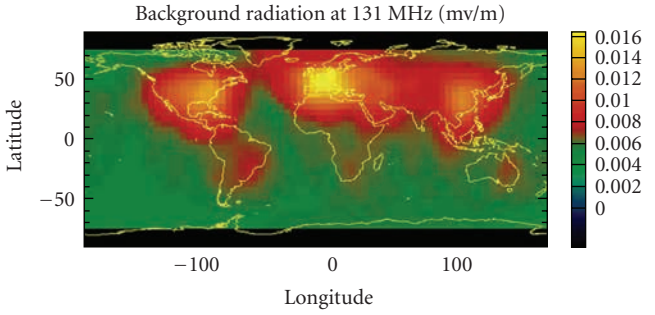


Figure 9: Forte Satellite: 131 MHz RF background 2000. Areas of highest radio background intensity occur in the eastern United States, central Europe, and China. Acquired by the Los Alamos National Laboratory FORTE spacecraft. Principal investigator A.R. Jacobson.

3. Discussion

Because only one treatment enclosure was established for each treatment, differences among groups could not be analyzed statistically. Results of this experiment do, however, suggest several possible effects of RF exposure on aspen. Those effects include reduction of shoot length and leaf area, suppression of fall anthocyanin production, and increased incidence of necrotic leaf tissue in fall senescing leaves. Reduced vigor in the two RF-exposed groups is demonstrated by lower total leader length and diminished production of leaf area relative to the shielded group. A study [26] comparing mutant nonanthocyanin-producing strains of fall anthocyanin-producing species, *Cornus sericea, Vaccinium elliottii*, and *Viburnum sargentii*, showed very similar results to this experiment with regard to fall color in that extensive necrotic leaf tissue was seen in nonanthocyanin-producing mutants during fall leaf senescence and leaves dropped while still green. Wild-type strains of those species, which produced anthocyanins, did not exhibit necrotic lesions. In that study, leaf tissue damage in mutant strains was shown to be caused by photooxidative stress. During fall leaf senescence photosynthetic mechanisms become vulnerable to damage by visible light. Anthocyanins shield the photosynthetic apparatus from high light levels, preventing photoinhibition and damage to leaf tissue due to light stress. Transport of foliar nutrients requires energy provided by photosynthesis [27], and since the majority of nutrients in overwintering deciduous trees are derived from foliar nutrient transport during autumn leaf senescence, differences in anthocyanin production could have major effects on plant fitness [28].

Since all leaves on active leaders in the shielded aspen group showed striking fall coloration, and since each of the seedlings was genetically distinct, it appears that the Faraday cage environment favored strong production of anthocyanins during fall leaf senescence. Five bright sunny days, Sept. 30–Oct. 4, accompanied by cool nights (~5°C) preceding the appearance of red leaf coloration, provided optimal conditions for anthocyanin production. Although shielding materials substantially reduced light levels in the two caged groups (mock-shielded and shielded), the behavior and appearance of the two RF-exposed groups (mock-shielded and unshielded) were most similar, both showing no apparent anthocyanin production, leaf tissue remaining light green or yellow, and a high percentage of leaf tissue affected by necrotic lesions.

3.1. Radio Frequency Environment. Beginning around 1800, EM experimentation, establishment of electrical telegraph systems, generation and distribution of electricity, and the use of broadcast signals gradually began to fill the region of the electromagnetic spectrum below 300 GHz. Currently, the RF spectrum is quite crowded, and new technologies are constantly being developed to allow more information to be transmitted on the available frequencies [29]. Unintended broadband RF noise is created as a by-product of electrical power generation, transmission, and use. These human-made RF sources create a background noise (as differentiated from signal) level generally 10 to 100 times stronger than the naturally occurring background of galactic noise and atmospheric noise at frequencies below 30 MHz [14]. Human-generated signal intensities in large regions of the RF spectrum are in the range of 10^3–10^6 times stronger than the naturally occurring RF background in urban areas [15]. Because terrestrial and satellite RF sources are numerous and widely dispersed globally, and since below 30 MHz radio signals can travel great distances around the earth by bouncing between the ionosphere and the earth's surface [14], currently a strong human-generated RF background exists at every point on the earth's surface, although radio field strength is relatively greater in the most populous and urbanized areas. Globally, the highest field strengths occur in central Europe, the eastern United States, and in China (Figure 9). Forest decline was first recognized and defined based on observed events in central Europe and the eastern US, and China, at this time, is experiencing rapid desertification.

3.2. Forest Decline. The first widely recognized incidents of forest decline [30] began in the late 1970s. In a European study [31], stress factors related to forest defoliation were

found to be age, altitude, drought, and various types of air pollution, in descending order of importance. Although the statistical correlation was high for some of these effects, because the number of samples was large, the effects documented were quite small and altogether could account for only 15–55% of the observed decline, depending on species. No temperature variables were found to have significant effects. In several studies, climate change was found not to be a causal agent in forest decline [32, 33]. There is evidence, however, that trees involved in forest decline are less tolerant of extreme weather conditions. Freeze damage, possibly indicating disrupted dormancy, for instance, has been noted as one symptom of forest decline where temperature and/or precipitation pattern changes were not evident [32, 34]. More recently, it has been shown that mortality rates of all dominant tree species in the western United States have been doubling every 17–29 years in old growth forests, and that recruitment of new trees is now occurring at a lower rate than mortality [35]. Since aspen decline and other tree decline incidents worldwide have similar symptoms, and since no definitive explanation has been found for those events, it seems plausible that their decline may be related to RF exposure.

Changes in health and growth rates of aspen and other plants, due to increasing RF exposure, would have been difficult to detect for two reasons: first, because the RF background is widely dispersed globally, comparisons between plant populations, even over great distances, would always have been between RF-exposed groups, even though exposure levels would vary with relative proximity to RF sources. Second, it is difficult to compare the health and appearance of plants living today to those living 200 years ago, though some comparisons can be made from previous research data, tree ring data, and pollen samples, for instance. Changes would have occurred very slowly over time, from the human perspective, and would have been widely dispersed geographically so that, at any particular time, RF-altered plant morphology and behavior would have been normal, the norm, by definition. Plants and animals have in previous experiments been shown to respond in various ways to RF exposure. Growth of organisms may be inhibited or accelerated by RF exposure, thus possibly affecting interactions at the level of communities and ecosystems from microscopic to global scales. In the case of aspen, reduced plant vigor and adverse effects on fall storage of nutrients due to RF exposure could leave seedlings vulnerable to pathogens and less able to accommodate other environmental stress.

4. Conclusions

The results of this preliminary experiment indicate that the RF background may be adversely affecting leaf and shoot growth and inhibiting fall production of anthocyanins associated with leaf senescence in trembling aspen seedlings. These effects suggest that exposure to the RF background may be an underlying factor in the recent rapid decline of aspen populations. Further studies are underway to test this hypothesis in a more rigorous way.

Acknowledgments

The author wishes to thank an anonymous reviewer for many helpful comments, Dr Wayne Shepperd for advice and encouragement, the Marbrook Foundation, Sangha Foundation, Brian Haggerty, Alan Haggerty, Hoshi Motors, and Barbara and Bruce Leaf for financial support, Brigitte Lause for editorial advice, and Patricia Kluck and Roland Rodriguez for technical support.

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Science of the Total Environment 572 (2016) 554–569

Contents lists available at ScienceDirect

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Radiofrequency radiation injures trees around mobile phone base stations

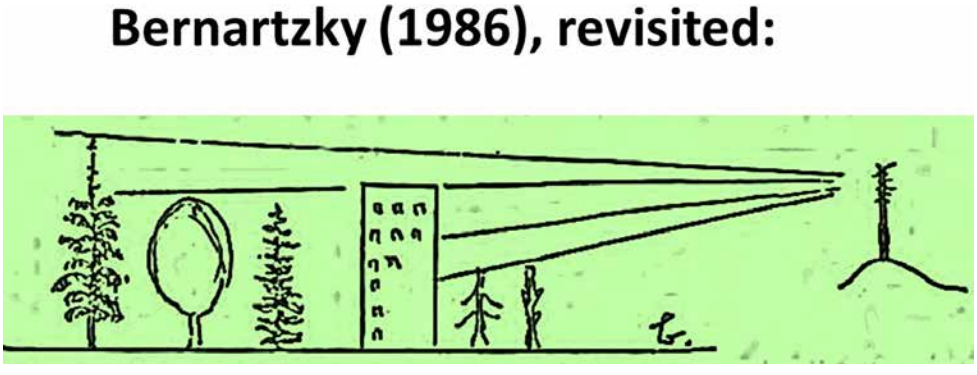
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HIGHLIGHTS

- High frequency nonionizing radiation is becoming increasingly common.
- This study found a high level of damage to trees in the vicinity of phone masts.
- Deployment has been continued without consideration of environmental impact.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 6 June 2016
Received in revised form 19 July 2016
Accepted 6 August 2016
Available online xxxx

Editor: D. Barcelo

Keywords:
Electromagnetic radiation
Effects on trees
Phone masts
Radiofrequencies

ABSTRACT

In the last two decades, the deployment of phone masts around the world has taken place and, for many years, there has been a discussion in the scientific community about the possible environmental impact from mobile phone base stations. Trees have several advantages over animals as experimental subjects and the aim of this study was to verify whether there is a connection between unusual (generally unilateral) tree damage and radiofrequency exposure. To achieve this, a detailed long-term (2006–2015) field monitoring study was performed in the cities of Bamberg and Hallstadt (Germany). During monitoring, observations and photographic recordings of unusual or unexplainable tree damage were taken, alongside the measurement of electromagnetic radiation. In 2015 measurements of RF-EMF (Radiofrequency Electromagnetic Fields) were carried out. A polygon spanning both cities was chosen as the study site, where 144 measurements of the radiofrequency of electromagnetic fields were taken at a height of 1.5 m in streets and parks at different locations. By interpolation of the 144 measurement points, we were able to compile an electromagnetic map of the power flux density in Bamberg and Hallstadt. We selected 60 damaged trees, in addition to 30 randomly selected trees and 30 trees in low radiation areas (n = 120) in this polygon. The measurements of all trees revealed significant differences between the damaged side facing a phone mast and the opposite side, as well as differences between the exposed side of damaged trees and all other groups of trees in both sides. Thus, we found that side differences in measured values of power flux density corresponded to side differences in damage. The 30 selected trees in low radiation areas (no visual

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http://dx.doi.org/10.1016/j.scitotenv.2016.08.045
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contact to any phone mast and power flux density under 50 μW/m^2) showed no damage. Statistical analysis demonstrated that electromagnetic radiation from mobile phone masts is harmful for trees. These results are consistent with the fact that damage afflicted on trees by mobile phone towers usually start on one side, extending to the whole tree over time.

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1. Introduction

For many years, there has been a discussion in the scientific community about whether artificial radiofrequency radiation has harmful effects on living organisms and, more specifically, on the environmental impact from mobile phone base stations (Panagopoulos et al., 2016). Trees have several advantages over animals as experimental subjects: they are continuously exposed to radiation in a constant orientation in the electromagnetic field due to their inability to move (Vian et al., 2016). Additionally, it is possible to easily document changes over time, such as disturbed growth, dying branches, and premature colour change of leaves. Moreover, the damage to trees is objective and cannot be attributed to psychological or psychosomatic factors.

Plants are specialized in the interception of electromagnetic radiation (light) but radiofrequency radiation impact on plants, which is becoming common in the environment because of the exponential use of mobile phone technology, has received little attention and his physiological effect has long been considered negligible.

Since the mid-twentieth century, several researchers have investigated the effects of electromagnetic radiation on plants, both in the laboratory (Kiepenheuer et al., 1949; Brauer, 1950; Harte, 1950, 1972; Jerman et al., 1998; Lerchl et al., 2000; Sandu et al., 2005; Roux et al., 2006, 2008; Sharma et al., 2009; Tkalec et al., 2005, 2009; Beaubois et al., 2007; Kundu and IEEE, 2013; Pesnya and Romanovsky, 2013; Cammaerts and Johansson, 2015; Grémiaux et al., 2016; Vian et al., 2016), and in nature (field observations) (Bernatzky, 1986; Volkrodt, 1987, 1991; Selga and Selga, 1996; Balodis et al., 1996; Haggerty, 2010). Both kinds of study have frequently found pernicious effects.

Around the world, phone masts have been deployed in the last two decades everywhere. Preliminary published studies have indicated deleterious effects of radiofrequency radiation on trees (Balmori, 2004; Van't Wout, 2006; Schorpp, 2011; Waldmann-Selsam, 2007; Waldmann-Selsam and Eger, 2013), cautioning that research on this topic is extremely urgent (Balmori, 2015). However, these early warnings have had no success and deployment has been continued without consideration of environmental impact.

In a review of the effects of environmental microwaves on plants (Jayasanka and Asaeda, 2013), it was indicated that effects depend on the plant family and the growth stage, as well as the exposure duration, frequency, and power density. This review concluded that most studies that address the effects of microwaves on animals and plants have documented effects and responses at exposures below limits specified in the electromagnetic radiation exposure guidelines and it is therefore necessary to rethink these guidelines (Jayasanka and Asaeda, 2013).

Since 2005, on the occasion of medical examinations of sick residents living near mobile phone base stations, changes in nearby trees (crown, leaves, trunk, branches, growth…) were observed at the same time as clinical symptoms in humans occurred. Since 2006 tree damages in the radiation field of mobile phone base stations were documented (http://kompetenzinitiative.net/KIT/KIT/baeume-in-bamberg/). In the radio shadow of buildings or that one of other trees, the trees stayed healthy.

Additionally, unilateral crown damage, beginning on the side facing an antenna, pointed to a possible link between RF-EMF (Radiofrequency Electromagnetic Fields) and tree damage. We carried out measurements on both sides of unilaterally damaged trees. Most of the trees had been exposed to RF-EMF for at least five years. Each time we found considerable differences between the measured values on the damaged and on the healthy side.

The aim of the present study was to verify whether there is a connection between unusual (generally unilateral) tree damage and radiofrequency exposure.

2. Materials and methods

The official information of 65 mobile phone sites in the neighbouring cities Bamberg and Hallstadt was extracted from the EMF database (EMF-Datenbank) of the German Federal Network Agency (Bundesnetzagentur, in March 2011 and October 2015). Each site certificate ("Standortbescheinigung") provides information on the mounting height of antennas, the number and main beam direction of the sector antennas, the number of omnidirectional antennas (ND), the number of other transmitters, as well as the horizontal and vertical safety distances. The current specifications of the transmission facilities are available at: http://emf3.bundesnetzagentur.de/karte/Default.aspx

On most of the 65 mobile phone sites several sector antennas emitting RF-EMF with differences in frequency, modulation and other physical characteristics are installed (GSM 900, GSM 1800, UMTS, LTE (4th generation), TETRA). In 2011 there was a total of 483 sector antennas, in 2015 a total of 779 sector antennas.

Numerical code, address and UTM 32N coordinates for the 65 Mobile phone (base stations) sites in Bamberg and Hallstadt are shown in Table 1.

Between 2006 and 2015 there was observation and documentation of tree damages. There were some preliminary measurements on both sides of unilaterally damaged trees and approximately 700 trees in Bamberg and Hallstadt were visited. The condition of numerous trees has been documented in photographs. The photographs record the state of trees showing damage patterns not attributable to diseases, pests, drought or other environmental factors in order to monitor damage and growth over several years (in 2006, Olympus FE-100 was used; since 2007, Panasonic DMC-FZ50 was used).

In 2015 we selected a polygonal study site, with an approximate area of 30 km^2, which includes partial municipalities of Bamberg and Hallstadt (70 km^2). The study area with the location of the phone masts in the layer of natural areas and municipalities is shown in Fig. 1. In this area, different measurements (see below) were done both for having a radiation map and for knowing which are the incident power densities beside different trees. In spite of the fact that measurements are changing continuously, they do not show significant differences between times (own data, see below).

In this polygon, we performed 144 measurements of the radiofrequency electromagnetic fields at a height of 1.5 m at different points in the city. These measurements were taken in streets and parks and allowed the preparation of an electromagnetic map of Bamberg and Hallstadt with their interpolation. The measurements were carried out with an EMF-broadband analyzer HF 59B (27–3300 MHz) and the horizontal-isotrope broadband antenna UBB27_G3, (Gigahertz Solutions). Measurements of the sum peak values of power flux density were in μW/m^2, which can be converted in V/m.

In general, a sector antenna covers an angle of 120° and the radiation of the sector antennas is distributed in main and secondary beams, bundled vertically and horizontally. The high-frequency emissions are reflected/diffracted and/or absorbed by buildings and trees. Therefore,

Table 1
Official information of the 65 mobile phone base stations in Bamberg and Hallstadt.

Code number	Adress in Bamberg and Hallstadt	X	Y	Code number	Adress in Bamberg and Hallstadt	X	Y
1	Altenburg	634268	5527019	34	Ludwigstr. 25 (Post)	636318	5529177
2	Am Borstig 2	636070	5531636	35	Luitpoldstr. 51	636241	5529232
3	Am Hirschknock	637511	5532267	36	Mainstraße, Ladekai 2	633924	5530319
4	An der Breitenau 2	637253	5530650	37	Mainstraße, Ladekai 3	633816	5530130
5	(An der Breitenau, P&R) ca.	637259	5526912	38	Margaretendamm 28	635341	5529331
6	(Artur-Landgraf-Straße)	635183	5526912	39	Memmelsdorfer Straße (Post) ca.	637769	5531392
7	Breitäckerstr. 9	632965	5529621	40	Memmelsdorfer Str. 208a	637568	5531191
8	Coburger Str. 6a	635877	5529951	41	Memmelsdorfer Str. 208a	634861	5528541
9	Coburger Str. 35	635252	5530468	42	Mußstr. 1	634949	5528827
10	Erlichstr. 47/51	637291	5527903	43	Pödeldorfer Str. 144	637828	5529305
11	Franz-Ludwig-Str. 7	635843	5528490	44	Rheinstr. 16 ca.	632910	5530367
12	Geisfelder Str. 30	637689	5528020	45	Robert-Bosch-Str. 40	637767	5528292
13	Grüner Markt 1	635624	5528370	46	Schildstr. 81	637049	5529049
14	Grüner Markt 23	635640	5528565	47	Schranne 3	635511	5528166
15	Gutenbergstr. 20	638448	5527180	48	Schützenstr. 23	636197	5527961
16	Hainstr. 4	635945	5528229	49	Schwarzenbergstr. 50	636762	5528732
17	Hainstr. 39	636341	5527550	50	Siemensstr. 37-43	638091	5528505
18	Hauptsmoorstr. 26a	638223	5530558	51	Theresienstr. 32	637487	5527866
19	Hauptsmoorwald, Pödeldorfer Straße	639683	5529635	52	Unterer Kaulberg 4	635350	5528084
20	Hauptsmoorwald, Geisfelder Straße	639890	5528022	53	Von-Ketteler-Str. 2	637905	5527553
21	Heiliggrabstr. 15	636054	5529240	54	Wilhelmsplatz 3	636316	5528259
22	Heinrichsdamm 1	635849	5528723	55	Zollnerstr. 181	637772	5530133
23	Heinrichsdamm 33a, P&R	636748	5527529	56	Heganger 18	634327	5530982
24	Hohenlohestr. 7	634794	5526480	57	Biegenhofstr. 13	633963	5531045
25	Kantstr. 33	637161	5530333	58	Seebachstr. 1	634399	5531764
26	Katzenberg	635374	5528266	59	Landsknechtstr.	634800	5531918
27	Kirschäckerstr. 37	636649	5530756	60	Lichtenfelser Str.	634864	5532621
28	(Kloster-Langheim-Str. 8)	637190	5529182	61	Michelinstr. 130 ca.	635629	5532106
29	Kronacher Str. 50	636722	5531496	62	Margaretendamm	634991	5529497
30	Lagerhausstr. 4-6	634850	5529871	63	Mainstr. 36a/Kiliansplatz	634326	5532386
31	Lagerhausstr. 19	634304	5530136	64	Bamberger Straße	635964	5526050
32	(Laurenziplatz 20)	635207	5527404	65	Würzburger Str. 76	635359	5526709
33	Ludwigstr. 2	635207	5529103				

due to existing obstacles there is an inhomogeneous radiofrequency field distribution. Buildings and vegetation (trees and foliage) can shield and reduce radiation and thus affect the quality of signal propagation (e.g. Meng and Lee, 2010). Living material is not a perfect dielectric object and interferes with high frequency electromagnetic fields in a way that depends upon several parameters, including the general shape, conductivity, and density of the tissue, and the frequency and amplitude of the electromagnetic radiation (Vian et al., 2016).

In the polygon mentioned before we selected 60 trees showing unilateral damage. The selection was limited by the fact that we were able to measure with the telescopic rod only up to a height of 6 m. Many trees (*Tilia, Betula, Quercus, Populus, Picea*) showing damage above the

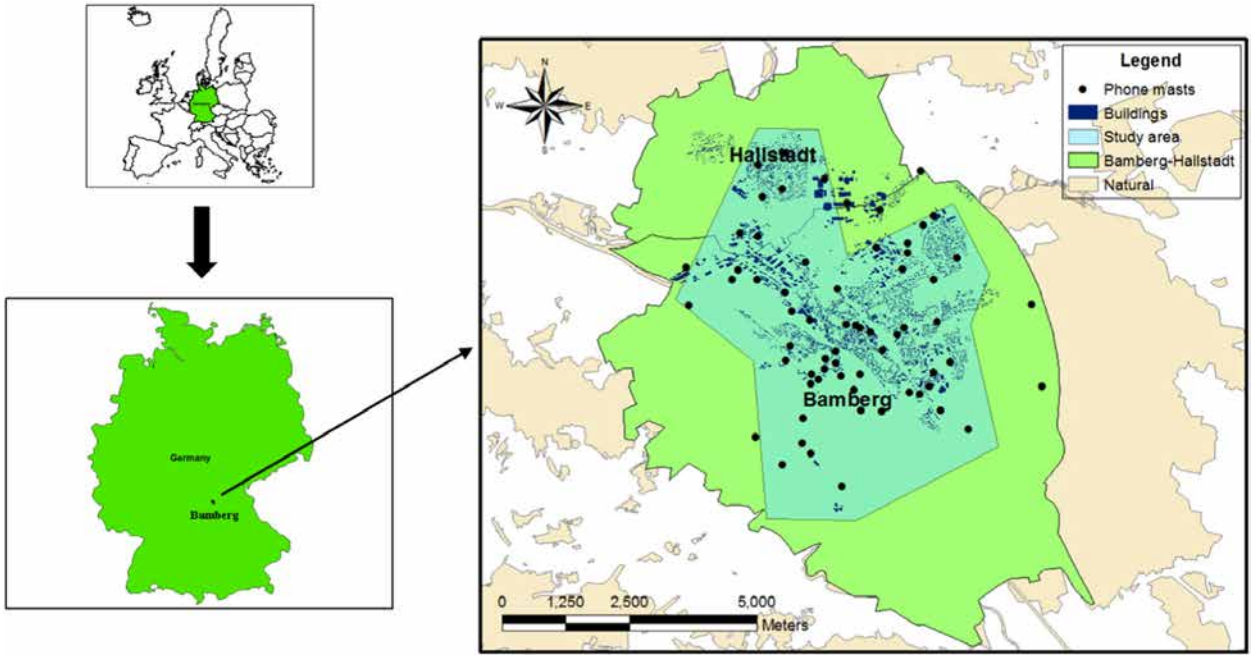


Fig. 1. The study area with the location of the phone masts in the layer of natural areas, buildings, and municipalities.

height of 6 m could not be included. The measurements at the trees were done between April and October 2015. *Acer platanoides*, *Carpinus betulus*, *Tilia* sp., *Taxus baccata* and *Thuja occidentalis* are widely spread in Bamberg and Hallstadt and can be reached for measurements. Therefore they are the most represented species.

The selected 60 trees from the study polygon show damage patterns that are not usually attributable to harmful organisms, such as diseases (fungi, bacteria, viruses) and pests (insects, nematodes) or other environmental factors (water stress, heat, drought, frost, sun, compaction of the soil, air and soil pollutants).

The main features of damage from this source are:

- Trees are mainly affected on one side (showing side differences and unilateral damage) and can appear in any orientation. The damage only originates on one side.
- Damage appears without external indications that the tree is infested with insects, nematodes, fungi, bacteria or viruses.
- Damage appears on trees, which have previously grown well. Damage appears on once healthy trees within one or two years after Antennas were put into operation.
- Damage increases from the outside to the inner part of the crown over time.
- Trees of different species in the same location also show damage.
- Damage appears in favourable (gardens, parks) as well as in unfavourable locations.
- Trees in the same location, but that are shielded by buildings or other trees, are healthy.

For these damaged trees, we used 13 damage codes that may be recognised with the naked eye (for explanations, see Table 2). In order to explain each type of damage visually, a photograph was added for each damage code.

Table 2
Tree damage codes.

01 Damage only on one side: The tree shows damage only on one side. The damage can be recognized with the naked eye.	
02 Crown transparency (sparse leaves or needles): The number of leaves or needles is reduced. The crown transparency increases from year to year.	
03 Brown leaves (start at leaf margins): The leaves begin to turn brown in june. The browning starts at the leaf margins. It looks similar to effects by salt.	
04 Colour change of leaves prematurely: Leaves become yellow, red or brown (in the whole) early in the year.	
05 Tree leaves fall prematurely: The leaves begin to fall already from june on.	
06 Dead branches: Over a period of some years it can be observed how little and big branches die.	
07 Tip of the main guide dried.	
08 Irregular growth. The growth of deciduous and coniferous trees can be disturbed in different manners. One observation is that trees bend to a side.	
09 Not grow in height: Trees often stop to grow in height. The height was not measured. Only the visual impression was valuated.	
10 Colour change of needles. Needles can change their colour to yellow, red or brown.	
11 Dead parts were trimmed down: When bigger branches die, it becomes necessary to remove these parts for the sake of security of people passing.	
12 Damage on different sides: The trees show damages on different sides.	
13 No damage: The tree shows the typical habitus of its species. With the naked eye no damage can be seen.	

Table 3
144 selected points in Bamberg and Hallstadt with their measurements and UTM coordinates.

Number	Streets and parks in Bamberg and Hallstadt	Measurement μW/m²	X	Y	Number	Streets and parks in Bamberg and Hallstadt	Measurement μW/m²	X	Y
1	Wassermannpark	2300	637395	5530345	73	Ludwigstraße/Zollnerstraße	50	636228	5529444
2	Memmelsdorfer Str. 209	1830	637581	5531113	74	Landratsamt, Ludwigstraße, Einfahrt	670	636422	5529044
3	Holunderweg	10	638125	5530967	75	Wilhelmsplatz, Mitte	460	636250	5528263
4	Hauptsmoorstraße/Seehofstraße	3600	638039	5530857	76	Amalienstr. 16	16570	636303	5528086
5	Greifffenbergstr. 79	4210	638349	5530855	77	Otttostr. 7a	120	636133	5527878
6	Heimfriedweg 16	870	638393	5530621	78	Schönbornstr. 3	3640	636251	5527696
7	AWO, Innenhof, Parkplatz	3920	638223	5530584	79	Hainspielplatz	1530	636229	5527403
8	Ferdinand-Tietz-Str. 40	2600	637883	5530616	80	P&R Heinrichsdamm, Parkplatz bei Kirschen	3400	636706	5527667
9	Ferdinand-Tietz-Str. 38	80	637889	5530601	81	P&R Heinrichsdamm, südöstlich des Senders, Eichen	1690	636755	5527504
10	Petrinistr. 20	1340	637797	5530514	82	Luisenhain, Höhe Wasserwerk	260	636895	5526482
11	Petrinistr. 32	4700	637891	5530449	83	Kapellenstraße	2120	637050	5528148
12	Zollnerstraße 181	9300	637773	5530102	84	Geisfelder Str. 9, Gärtnerei	740	637410	5528164
13	Wassermannstr. 14	540	637424	5530125	85	Gereuthstr. 8	30	637621	5527424
14	Feldkirchenstraße/Kantstraße	2620	636803	5530069	86	Distelweg, Innenhof	15	637881	5527160
15	Breslaustr. 20	3890	637392	5530431	87	Am Sendelbach BSC 1920	30	637331	5526877
16	Berliner Ring	16920	637188	5530786	88	Am Sendelbach, Kleingartenanlage	10	637542	5526222
17	Rodezstr. 3	3780	637044	5530765	89	Robert-Bosch-Straße	2060	637504	5528200
18	Am Spinnseyer 3	880	637545	5530764	90	Ludwigstraße/Memmelsdorfer Straße	1000	635974	5529708
19	Kirschäckerstr. 24	4290	636655	5530857	91	Coburger Straße, Neubau Studentenwohnheim	3460	635867	5529878
20	Kammermeisterweg	810	636283	5530282	92	Coburger Straße, junge Platane	3400	635835	5529941
21	Eichendorff-Gymnasium, Hof	6340	637194	5529084	93	Gundelsheimer Str. 2	9000	635783	5529680
22	Starkenfeldstraße/Pfarrfeldstraße	3660	637092	5529138	94	Hallstadter Straße	12	635232	5530212
23	Parkplatz auf der Westseite der Polizei	9020	636921	5528970	95	Gerberstraße/Benzstraße	1280	635108	5530546
24	Starkenfeldstraße, Höhe Polizei	1120	636975	5529061	96	Coburger Straße, Einfahrt Fitnesszentrum	2000	635326	5530508
25	Starkenfeldstr. 2	860	637527	5529216	97	Kleintierzuchtanlage	890	635380	5530622
26	Pödeldorfer Str., Haltestelle	2180	636965	5529217	98	Margaretendamm, Eingang ehemaliges Hallenbad	1300	635455	5529178
27	Kindergarten St. Heinrich, Eingang	6450	637712	5529364	99	Margaretendamm/Europabrücke	1890	635200	5529365
28	Pödeldorfer Straße, Haltestelle Wörthstraße	1620	637654	5529433	100	Margartendamm 38, nahe Sendeanlage	5560	635003	5529497
29	Pödeldorfer Str. 142, Nordseite	30	637840	5529437	101	Hafenstraße/Regnitzstraße	7610	634719	5529740
30	Pödeldorfer Str. 142, Südseite	17060	637824	5529410	102	Lagerhausstraße	210	634556	5530102
31	Berliner Ring, Höhe Pödeldorfer Str. 144	4480	637900	5529380	103	Hafenstr. 28, Bayerischer Hafen	3200	634192	5530370
32	Schwimmbad Bambados, Vorgarten mit Bambus	1620	638074	5529315	104	Laubanger 29	160	634202	5530561
33	Schwimmbad Bambados, Parkplatz, Feldahorn	2540	638202	5529346	105	Heganger	1400	634341	5530812
34	Carl-Meinelt-Str.	5360	638043	5529094	106	Emil-Kemmer-Str. 2	5000	633822	5530863
35	Volkspark, FC Eintracht, Ostseite	120	638343	5529065	107	Emil-Kemmer-Str. 14	2500	634342	5531099
36	Michelsberger Garten, Teil Streuobst	5450	634831	5528673	108	Dr. Robert-Pfleger-Straße 60	90	634448	5530978
37	Michelsberger Garten, Terrassengarten, bei Eibe	2500	634988	5528508	109	Friedhof Gaustadt, Haupteingang	13100	632981	5529677
38	Michelsberger Garten, Südostecke, bei Holunder	910	635036	5528455	110	Friedhof Gaustadt, Ahornpaar	1400	632929	5529728
39	Michelsberg, Aussichtsterrasse, oberhalb Weinberg	1260	634924	5528463	111	Herzog-Max-Str. 21	1600	636245	5528071
40	Michelsberg, Aussichtsterrasse, Aussichtspunkt	780	634911	5528537	112	Gaustadter Hauptstr. 116	10	634042	5529457
41	Michelsberg, Nordostecke, bei jungen Linden	390	634874	5528565	113	Landesgartenschaugelände, Hafenerlebnispfad	2000	633789	5529894
42	Storchsgasse/Michelsberg	200	634725	5528415	114	Landesgartenschau, junge Baumgruppe	1270	633949	5529718
43	St. Getreu-Kirche, Südseite	55	634518	5528405	115	Würzburger Str.	340	635283	5527151
44	Villa Remeis, Garten	390	634295	5528203	116	Würzburger Straße/Arthur-Landgraf-Straße	1380	635355	5526862
45	Villa Remeis, Treppe	300	634400	5528237	117	Hohe-Kreuz-Straße/Würzburger Straße, Haltestelle	590	635383	5526733
46	Maienbrunnen 2	3920	634744	5528838	118	Hohe-Kreuz-Straße	10950	635469	5526729
47	Am Leinritt	2140	635071	5528617	119	Am Hahnenweg 6	3420	635332	5526729
48	Abtsberg 27	130	634526	5528935	120	Am Hahnenweg/Viktor-von-Scheffel-Straße	640	635307	5526710
49	Welcome Hotel, Garten	3200	634788	5529012	121	Am Hahnenweg 28 a	145	635028	5526654
50	Mußstraße, eingang Kindergarten	1670	634864	5529011	122	Schlüsselberger Straße	200	634712	5526534
51	Mußstraße/Schlüsselstraße	710	634846	5529034	123	Schlüsselberger Str./Haltestelle Hezilostr., Parkdeck	460	634749	5526549
52	Nebingerhof	2040	635069	5528901	124	Hezilostr. 13	70	634604	5526563
53	Graf-Stauffenberg-Platz	100	635120	5529009	125	Sückleinsweg, junge Hainbuchenhecke	75	634512	5526654
54	Don-Bosdo-Straße, Innenhof	10	635176	5529056	126	Rößleinsweg, oberes Ende	300	634708	5526789
55	Pfeuferstraße/Weide	1100	635222	5528820	127	Große Wiese	1500	634874	5526810

Table 3 (*continued*)

Number	Streets and parks in Bamberg and Hallstadt	Measurement μW/m²	X	Y	Number	Streets and parks in Bamberg and Hallstadt	Measurement μW/m²	X	Y
56	Weidendamm/Don-Bosco-Straße	1860	635166	5529195	128	Suidgerstraße	195	634508	5526409
57	Katzenberg/Karolinenstraße	1720	635316	5528239	129	Waizendorfer Straße	280	635317	5525864
58	Vorderer Bach	450	635305	5528141	130	Waizendorfer Straße, Einfahrt Gärtnerei	210	635326	5525582
59	Obere Brücke	8000	635565	5528289	131	Klinikum, Nähe Spielplatz	175	635732	5525672
60	Judenstraße	6	635479	5528040	132	Klinikum Weiher	100	635759	5525520
61	Tourist Information	4920	635674	5528172	133	Buger Straße/Bamberger Straße	2730	635829	5526082
62	Universität, Am Kranen 14, Innenhof	10	635501	5528535	134	Dunantstraße	470	635848	5526176
63	Fleischstraße	10	635703	5528683	135	Buger Straße/Paradiesweg	90	635743	5526286
64	ZOB	600	635882	5528541	136	Buger Straße/Abzweigung Münchner Ring	470	635528	5526499
65	Schönleinsplatz, Ostseite	900	636004	5528300	137	Hallstadt, Markplatz, bei Linde	2000	634582	5532426
66	Friedrichstraße, Parkplatz	165	635984	5528360	138	Hallstadt, Markplatz 21, Innenhof	8	634632	5532488
67	Franz-Ludwig-Straße/Luisenstraße	1720	636158	5528410	139	Hallstadt, Lichtenfelser Str. 12	4000	634659	5532474
68	Franz-Ludwig-Str, Strassenbauamt	90	636246	5528408	140	Hallstadt, Lichtenfelser Str. 8	9000	634720	5532516
69	Heiliggrabstraße, Nähe Sender	4740	636072	5529245	141	Hallstadt, Am Gründleinsbach/Kemmerner Weg	200	634743	5532784
70	Heiliggrabstr. 29, Landesjustizkasse	20	636063	5529399	142	Hallstadt, Valentinstraße/Seebachstraße	2200	634232	5532237
71	Heiliggrabstr. 57, Aussichtspunkt Schiefer Turm	4500	635797	5529410	143	Hallstadt, Johannisstr. 6	5000	634805	5532078
72	Bahnhof, ParkplatzWestseite	1600	636300	5529374	144	Hallstadt, Bamberger Straße/Michael-Bienlein-Straße	1860	634805	5531969

For each selected tree, the types of damage and the Universal Transversal Mercator (UTM) coordinates were recorded. In addition, two measurements were recorded: on the side showing damage and on the side without damage, generally corresponding to opposite sides of each tree. On both sides, the measurements were carried out at a variable height of 1–6 m (depending on the height of the tree), using a telescopic rod, a ladder, and the broadband radiofrequency meter.

Most measurements were done in the afternoon or in the evening on different days between April and October 2015. But the measurements on the two sides of each single tree were done one after another immediately on the same day and at the same time. The measurements took about 5 min on each side. When we stood on the ground or on a ladder we measured the peak values. When we used the telescopic rod we measured the peak hold values. Using the telescopic rod and measuring peak hold values it took longer, because the measurements had to be repeated often in cases where RF-EMF emitting cars or passengers disturbed the results. At each single tree the two measurements were done in the height where the damage had appeared. Because the height of the 120 trees differed, it was necessary to do the measurements at different heights.

In theory, although measurements are changing continuously there is no evidence about significant changes in power densities of electromagnetic radiation produced by phone masts over time. One study carried over one year in the city of Madrid showed no changes in terms of radiation intensity between the three rounds of measurements

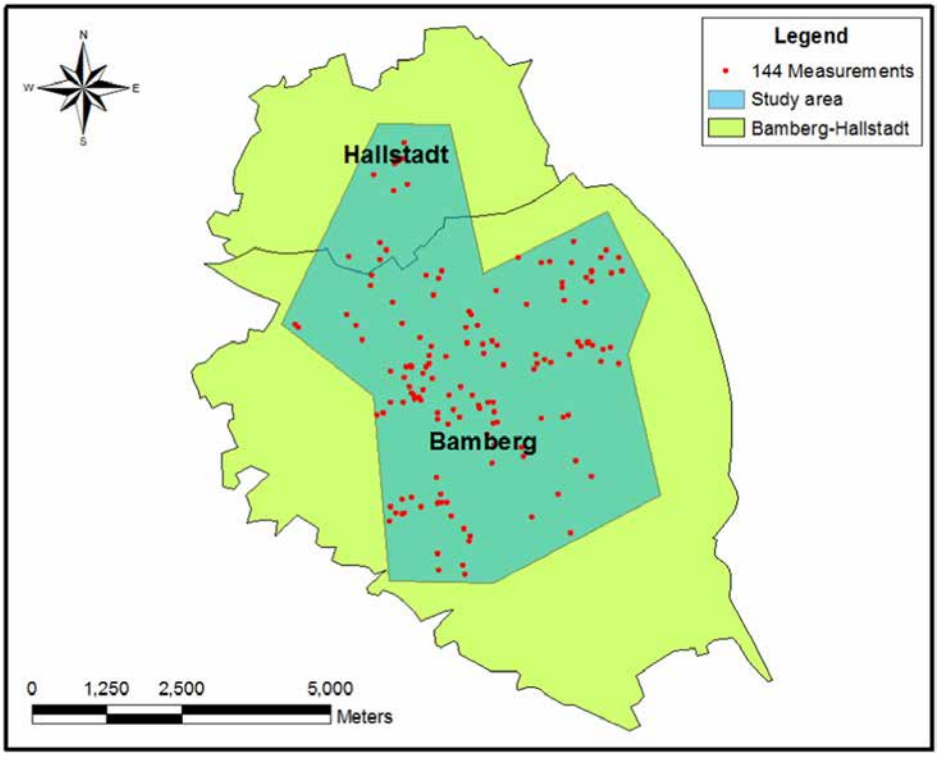


Fig. 2. Location of the 144 measurements points in Bamberg and Hallstadt in the study area.

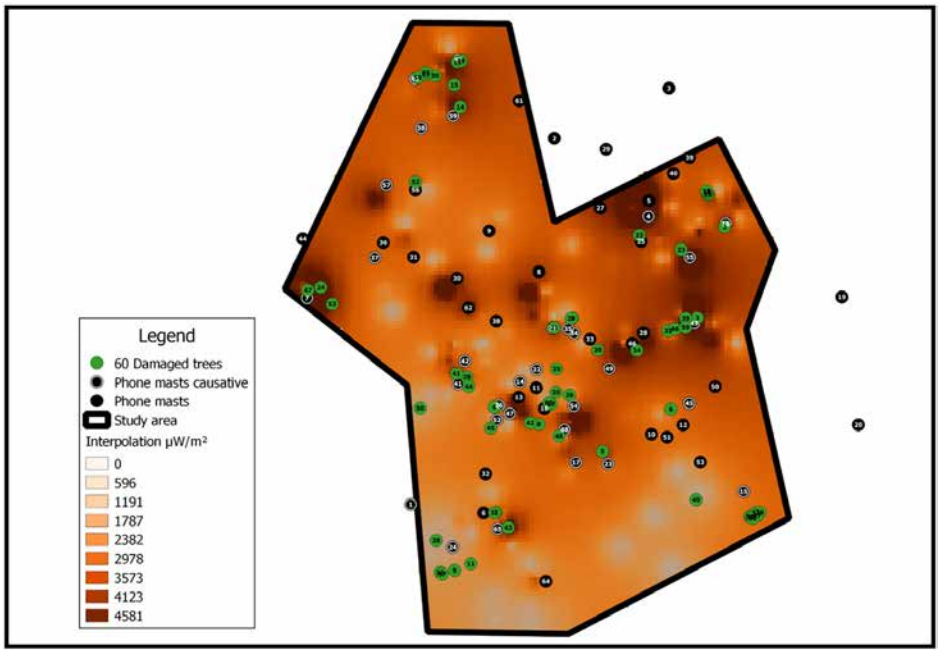


Fig. 3. Map showing the 60 damaged trees and phone masts (both with code numbers) over the interpolation electromagnetic map of the 144 measurement points.

performed in about 200 sampling points (own data). Repeatability analysis checked this. Despite the fact that the increase in sector antennas (observed between 2011 and 2015) would have probably increased the radiation in the environment of the study area, measurements used in this study were mostly done in 2015.

In an attempt to link the electromagnetic radiation measured at every tree to specific phone masts, the distances to the three nearest antennas that could be mainly responsible for the radiation measurements at each tree were calculated in meters with Geographical Information System (GIS) programs, following the general approach criteria of proximity. However, it must be taken into account that buildings and vegetation diminish radiation intensity and, in many cases, the nearest phone mast or masts may be obscured by obstacles. In other cases, the phone mast is in direct line of sight from the tree and the radiation can reach the tree directly.

Additionally, 30 random points were generated inside the polygonal study area and outside a layer of buildings, downloaded from: http://www.mapcruzin.com/free-germany-arcgis-maps-shapefiles.htm using a Random Points tool of QGIS 2.6.0-Brighton (QGIS Development Team, 2014) allowing create random points inside a specific layer. Therefore the points were randomly situated in specific places in the study area outside buildings but not frequently concur with the location of trees. That is why measurements were taken from the nearest tree for each random point, generating a random tree group. Measurements and damage characteristics were scored in the same way as with 60 damaged trees explained above, measuring the maximum value of radiation corresponding to opposite sides of each tree.

In areas of the city with low measurements of electromagnetic radiation (no visual contact to any phone mast and power flux density <50 µW/m^2), we scored another 30 trees in the same way as with 60 damaged trees and 30 random points. The UTM coordinates and the three nearest phone masts of each tree in these last two groups (random and low radiation trees) were also recorded.

To generate electromagnetic maps, we used ArcGis 9.3 (ESRI, 2008) and QGIS 2.6.0-Brighton (QGIS Development Team, 2014). To check possible differences between groups of data and taking into account that there were two measures made in each tree, repeated measures analysis of variance were applied, considering a repeated measures factor (within-subjects) and another between-subjects. The post hoc Bonferroni test was used in all cases to elucidate significant differences. Statistics were performed using STATISTICA 7 program (StatSoft, Inc, 2004).

3. Results

The results of radiation measurements obtained at 144 points in Bamberg and Hallstadt at a height of 1.5 m were between 6 µW/m^2 (0.047 V/m) and 17,060 µW/m^2 (2.53 V/m) (for measurements and UTM coordinates, see Table 3). The measured values are far below the current limit values (41 V/m for GSM system and 61 V/m for UMTS; ICNIRP, 1998).

The locations of these points in the study area are shown in Fig. 2. By interpolation of the 144 measurements points (Table 3), we prepared a map of the power flux density in Bamberg and Hallstadt (Fig. 3). This map is theoretical and approximate, since many factors affect the true electromagnetic values. However, the map is useful to provide approximate differences in exposure (electromagnetic pollution) throughout the city.

The 60 selected trees showing damage patterns not attributable to diseases, pests or other environmental factors are presented in Table 4. In this Table, we added the tree code number, the scientific name, the UTM coordinates, the measurements (power flux density) on both sides of each tree, and the distances (meters) and code numbers to the three nearest antennas for each tree, which may be mainly responsible for the electromagnetic radiation measured. We also included the orientation of the tree damage and the number of main (nearest) phone mast(s) in direct line of sight, whose lobe of radiation most directly affected each tree. Finally, we included the codes of damage observed in the 60 trees.

From all 60 selected trees, one or more phone mast(s) could be seen, with no obstacles between the phone mast and damaged tree. In many cases, one of the three closest antennas caused the main radiation on the tree surface. In ten trees (codes: 4, 7, 9, 10, 15, 26, 27, 31, 35, and 50), another antenna in direct line of sight caused the measured radiofrequency exposure. This was determined using topography and existing buildings (Table 4 and Fig. 3).

The 60 damaged trees (with their code number) and the phone masts are overlaid on the electromagnetic map prepared by interpolation of the 144 measurements points (Fig. 3). The likely antenna or

antennas causing radiation damage to each tree are also shown (Fig. 3). The measurements at all selected trees revealed significant differences between the damaged side facing a phone mast and the intact (or less damaged) opposite side. On the side facing a phone mast, the measured values were 80–13,000 μW/m^2 (0.173–2.213 V/m). On the opposite side the values were 8–720 μW/m^2 (0.054–0.52 V/m).

Table 4
60 selected trees showing damage patterns not attributable to diseases, drought or other environmental factors.

														Effect codes												
														1	2	3	4	5	6	7	8	9	10	11	12	13
N°	Scientific name	X	Y	Side antenna measurement μW/m²	Opposite side measurement μW/m²	Number of Phone Mast 1	Distance a 1	Number of Phone Mast 2	Distance a 2	Number of Phone Mast 3	Distance a 3	Direction of damage	Number of main phone mast(s) causing the radiation	Damage only on one side	Sparse leaves or needles (crown transparency)	Brown leaves (start at leaf margins)	Colour change of leaves prematurely	leaves fall prematurely	Dead branches (Peak branches dried).	Tip of the main guide dried	Irregular growth	Not grow in eight	Color change of needles	Dead parts were trimmed down	damage on different sides	no damage
1	*Acer platanoides*	636298	5529366	970	130	35	145,6	34	190,1	21	274,6	S, SW	35,34,21	+	+	+		+	+	+		+				
2	*Acer platanoides*	638211	5530518	680	80	18	41,76	55	583,9	40	930,8	N	18	+	+	+		+	+			+		+		
3	*Acer platanoides*	637868	5529371	2100	290	43	77,18	28	703,9	55	768	S	43	+	+	+		+	+	+		+				
4	*Acer platanoides*	635316	5528245	2300	130	26	61,68	52	164,6	47	210,4	E, S	26,52,47, 14	+	+	+		+	+	+		+		+		
5	*Acer platanoides*	636677	5527688	3600	290	23	174,1	17	363,2	48	552,2	S	23	+	+	+		+	+	+		+		+		
6	*Acer platanoides*	637536	5528219	700	140	45	242,3	12	251	51	356,4	E	45	+	+	+		+	+	+						
7	*Acer platanoides*	635339	5526919	270	30	6	156,2	65	211	32	502,6	W	1	+		+		+	+	+		+		+		
8	*Acer platanoides*	635876	5528029	80	10	16	211,6	48	328,1	47	389,9	W	47	+	+	+		+								
9	*Acer platanoides*	634819	5526187	160	20	24	294,1	65	751,1	6	811,2	N	24, 1		+	+		+	+					+		
10	*Acer platanoides*	634638	5526163	180	55	24	353,3	65	904,4	6	926,3	N	24, 1		+	+		+	+							
11	*Acer platanoides*	635022	5526270	95	20	24	310	65	553,4	6	661,9	NW	24	+	+			+								
12	*Acer platanoides*	634854	5532596	11800	400	60	26,93	63	568,2	59	680,1	N	60	+	+	+		+	+	+		+				
13	*Acer platanoides*	634455	5532438	9900	620	63	139,1	60	448,1	59	624	W	63	+			+							+		
14	*Acer platanoides*	634890	5532028	3380	500	59	142,1	58	557,5	60	593,6	SW	59	+	+	+		+	+	+		+		+		
15	*Acer platanoides*	634815	5532307	1050	50	60	317,8	59	389,3	63	495,3	SW	58	+	+	+		+	+	+		+		+		
16	*Carpinus betulus*	638001	5530928	1210	120	18	431,5	40	506,6	39	518,8	S	18	+	+	+		+	+							
17	*Carpinus betulus*	637996	5530945	2520	150	18	448,7	40	493,7	39	501,3	S	18	+	+	+		+	+							
18	*Carpinus betulus*	637987	5530959	890	90	18	465,3	40	478,9	39	484,8	S	18	+	+	+		+								
19	*Carpinus betulus*	637984	5530970	670	10	40	471,1	39	473,6	18	476,3	S	18	+	+	+		+								
20	*Carpinus betulus*	636619	5528966	1000	200	33	169,6	49	274,2	34	367,6	SE	49		+	+		+	+			+		+		
21	*Carpinus betulus*	636068	5529245	430	20	21	14,87	35	173,5	34	259,1	W	21	+	+	+		+				+		+		
22	*Carpinus betulus*	637138	5530413	4340	110	25	83,24	4	263,4	5	450,6	NE	4	+	+	+		+	+	+		+				
23	*Carpinus betulus*	637664	5530231	990	60	55	145,8	25	513,2	4	586,9	E	55	+	+	+		+	+							
24	*Carpinus betulus*	633137	5529754	2700	50	7	217,4	44	653,7	37	776,2	E	37	+	+	+		+	+							
25	*Tilia sp.*	636098	5528729	870	150	22	249,1	11	349,5	14	486,5	W	22	+	+	+		+	+							
26	*Tilia sp.*	636261	5528398	410	20	54	149,5	16	358,4	11	428	W	14	+		+		+								
27	*Tilia sp.*	636030	5528283	680	160	16	100,7	11	279	54	287	S	48	+	+		+	+	+					+		
28	*Tilia sp.*	634972	5528626	660	170	41	139,8	42	202,3	26	539,6	SW	41	+	+	+		+	+	+		+		+		
29	*Tilia sp.*	636283	5529365	2450	160	35	139,5	34	191,2	21	260,9	SW	35, 34, 21	+		+		+				+		+		
30	*Tilia sp.*	634573	5532422	3800	420	63	249,6	60	352,5	59	552,8	NE	60	+	+	+		+	+					+		
31	*Tilia sp.*	635319	5526914	380	120	6	136	65	208,9	32	502,6	W	1	+	+		+	+	+	+						
32	*Quercus robur*	638598	5526911	860	130	15	308	53	944,7	12	1434	NW	15		+			+	+							
33	*Quercus rubra*	637501	5529207	1340	120	28	312	43	341,4	46	478,8	E	43	+	+			+	+							
34	*Quercus rubra*	637107	5528961	1650	250	46	105,4	28	236,1	49	414,1	SW	49	+	+				+							
35	*Aesculus hippocastanum*	636092	5528434	400	20	16	252,3	11	255,2	54	284,3	W	14	+	+	+		+	+	+		+				
36	*Robinia pseudoacacia*	638653	5526920	1300	40	15	331,1	53	979,9	12	1463	NW	15	+			+		+	+		+				

Table 4 *(continued)*

37	*Robinia pseudoacacia*	638619	5526874	660	240	15	350,5	53	985,3	12	1476	NW	15	+			+		+					+		
38	*Sorbus occuparia*	634587	5526564	84	8	24	223,4	1	555,7	6	690,2	N	1	+	+	+		+	+	+		+				
39	*Acer negundo*	637722	5529366	3060	310	43	122,3	28	562,9	46	743,9	SE	43	+	+			+	+			+		+		
40	*Acer saccharinum*	637852	5527078	840	180	53	477,9	15	604,7	51	868,4	E	15	+	+			+								
41	*Juglans regia*	634841	5528669	4500	590	41	129,6	42	191,4	26	668,2	N, E	42	+	+			+	+	+	+	+				
42	*Taxus baccata*	635767	5528046	300	70	16	255,3	47	282,7	13	354,2	NW	47	+	+				+					+	+	
43	*Taxus baccata*	635491	5526727	8970	190	65	133,2	6	359,3	32	734,2	W	65	+	+				+					+	+	
44	*Taxus baccata*	634997	5528506	2500	240	41	140,4	42	324,6	26	446,9	N,E,W	41,42		+				+					+	+	
45	*Taxus baccata*	635272	5527980	2700	70	52	130	47	302,8	26	303,6	NE	52	+	+				+					+	+	
46	*Taxus baccata*	637586	5529231	1520	190	43	253,1	28	399	46	567	E	43	+	+									+	+	
47	*Thuja occidentalis*	632975	5529719	910	30	7	98,51	44	651,3	37	936,1	S	7	+	+				+					+		
48	*Thuja occidentalis*	636128	5527881	120	10	48	105,6	16	393,2	17	393,6	S	17	+	+				+					+		
49	*Thuja occidentalis*	634900	5532611	13000	520	60	37,36	63	616,5	59	700,2	NW	60	+	+				+					+		
50	*Thuja occidentalis*	634387	5528232	290	50	41	565,8	42	818,5	52	974,3	S	1	+	+				+	+				+		
51	*Picea pungens*	638525	5526863	770	90	15	326,2	53	927,6	12	1427	NE	15	+	+				+					+		
52	*Picea pungens*	634328	5531086	3080	310	56	104	57	367,3	58	681,7	W	57		+				+			+		+		
53	*Picea pungens*	633280	5529546	1350	200	7	323,8	37	792,7	44	900,5	W	7	+	+				+		+			+		
54	*Pinus sylvestris*	638542	5526861	790	50	15	332,6	53	940,5	12	1439	NE	15		+				+		+	+		+		
55	*Pinus sylvestris*	634461	5532462	5300	130	63	154,9	60	433,2	59	641	SW	63	+	+									+		
56	*Pseudotsuga menziesii*	638560	5526844	1720	60	15	354,2	53	965,2	12	1463	NE	15	+	+				+	+		+		+		
57	*Juniperus communis*	634664	5526141	160	20	24	363,1	65	897,6	6	929,4	N	24	+	+				+					+		
58	*Corylus avellana 'Contorta'*	634355	5532399	420	80	63	31,78	60	555,3	58	636,5	W	63	+	+	+		+	+							
59	*Corylus avellana*	637720	5529249	3880	720	43	121,7	28	534,2	46	700,2	N	43	+	+	+		+							+	
60	*Symphoricarpos albus*	636002	5528299	1200	320	16	90,27	11	248,5	54	316,5	E	54	+	+			+	+						+	

In the five most represented species ($n \geq 4$) among the 60 affected trees, most trees showed damage only on one side: unilateral damage (Damage code 1, Tables 2 and 4). By species and percentages: *Acer platanoides* (86%), *Carpinus betulus* (88%), *Tilia* sp. (100%), *Taxus baccata* (80%) and *Thuja occidentalis* (100%). On the seven trees not given code 1, the damage spread over the whole tree, but trees still showed side differences. Most of these trees were characterized with sparse leaves or needles (crown transparency) (Damage code 2, Tables 2 and 4). By species and percentages: *Acer platanoides* (86%), *Carpinus betulus* (100%), *Taxus baccata* (100%) and *Thuja occidentalis* (100%). In many of the trees with the one-sided damage, the leaves turned prematurely yellow or brown in June – this always began at the leaf margins (Damage code 3, Tables 2 and 4). The species with higher percentages were: *Acer platanoides* (86%) and *Carpinus betulus* (100%). In many trees leaves fall prematurely: *Acer platanoides* (93%), *Carpinus betulus* (100%) and *Tilia sp.* (100%) (Damage code 5, Tables 2 and 4). Many trees of the species *Acer platanoides* (80%), *Taxus baccata* (80%) and *Thuja occidentalis* (100%) had dead branches (Peak branches dried) (Damage code 6, Tables 2 and 4). All the trees of the species *Taxus baccata* (100%) and *Thuja occidentalis (100%)* exhibited color change of the needles (Damage code 10, Tables 2 and 4). Finally, in all trees of the species *Taxus baccata*, dead parts were trimmed (Damage code 11, Tables 2 and 4). Some trees stopped growing in height while, in others, the main guide died (see Tables 2 and 4).

The 30 randomly selected trees are presented in Table 5 with the tree code number, the scientific name, the UTM coordinates, the measurements (power flux density) on both sides of each tree, the distance (meters) to the three nearest antennas, their code number and the damage codes. Trees in these locations may be in areas with either high or low radiation. Seventeen trees in this group were situated in places with low radiation and showed no signs of damage. The measurements were 8–50 $\mu W/m^2$ (0.054–0.137 V/m) and showed no difference between the two opposite sides. Thirteen trees stood in the radiation field of one or more phone mast. Six of these had damage only on the side facing a phone mast, and five had damages on other sides. The measurements on the exposed sides were 40–4600 $\mu W/m^2$ (0.122–1.316 V/m).

The 30 trees selected in areas with low radiation (radio shadow of hills, buildings or trees) are presented in Table 6 with the tree code number, scientific name, UTM coordinates, measurements (power flux density) on both sides of each tree, distance (meters) to the three nearest antennas, their code number and the damage codes. All trees selected in low radiation areas showed no damage (code 13). The power flux density values measured were 3–40 $\mu W/m^2$ (0.033–0.122 V/m) and no significant differences were found between the two opposite sides.

The trees in random points and the trees in areas of low radiation are represented In Fig. 4 over the electromagnetic map prepared by interpolation of the 144 measurements points.

We performed a Repeated Measures ANOVA analysis in order to include the measurements of the exposed and shielded side of each tree (R1 = within subjects factor) in the three groups of trees (damaged, random, and low radiation), and to avoid pseudoreplication. The comparisons of all factor levels revealed significant differences, including the interaction between factors. A post hoc Bonferroni comparisons test, recommended for different sized groups of samples, revealed significant differences between measurements from the exposed side of damaged trees and all other groups (Table 7). Fig. 5 shows the measurements (mean and standard error) in all groups.

In the "Random points" group of trees, we performed another Repeated Measures ANOVA (R1 = within subjects factor) for trees damaged and undamaged within this group (Table 8). The results showed significant differences in both factors, including the interaction, which means that depending on the group of tree (damaged or undamaged),

Table 5
Results of the tree measurements at the 30 random points.

												Effect codes												
												1	2	3	4	5	6	7	8	9	10	11	12	13
N°	Scientific name	X	Y	Side antenna measurement µW/m²	Opposite side measurement µW/m²	Number of Phone Mast 1	Distance a 1	Number of Phone Mast 2	Distance a 2	Number of Phone Mast 3	Distance a 3	Damage only on one side	Sparse leaves or needles (crown transparency)	Brown leaves (start at leaf margins)	Colour change of leaves prematurely	leaves fall prematurely	Dead branches (Peak branches dried).	Tip of the main guide dried	Irregular growth	Not grow in eight	Color change of needles	Dead parts were trimmed down	damage on different sides	no damage
1	*Salix viminalis*	634095	5532455	10	10	63	241,1	58	754,9	60	786,7													+
2	*Thuja occidentalis*	634760	5532680	500	120	60	119,6	63	524,2	59	763		+				+	+			+		+	
3	*Abies alba*	634030	5530490	2200	900	36	201,2	37	418,8	31	447,7		+				+			+	+		+	
4	*Acer campestre*	634545	5530739	890	320	56	326,5	31	649,4	57	657,5	+	+				+							
5	*Acer platanoides*	634557	5530005	4600	1100	31	284,9	30	322,2	62	668,1	+	+	+		+						+		
6	*Picea abies*	635311	5530644	1900	210	9	185,6	8	894,8	30	900									+	+			
7	*Thuja occidentalis*	635635	5529879	10	10	8	252,5	38	621,9	9	702,6													+
8	*Acer platanoides*	635693	5529848	2600	310	8	210,9	38	625,5	21	707,1	+	+			+	+					+		
9	*Cornus sanguinea*	636415	5530248	40	30	27	559,3	8	614,5	25	750,8													+
10	*Acer pseudoplatanus*	637525	5530896	50	50	5	270,5	40	298,1	4	366,7													+
11	*Syringa*	638111	5531436	10	10	39	344,8	40	595,7	18	885,1													+
12	*Acer platanoides 'Globorum'*	637928	5530541	30	30	18	295,5	55	436,8	4	683,7													+
13	*Acer platanoides*	637159	5529361	20	15	28	181,7	46	330,8	43	671,3													+
14	*Quercus rubra*	638342	5528994	1480	570	50	549,7	43	600,8	45	907,4		+			+	+					+	+	
15	*Thuja occidentalis*	638359	5528569	25	20	50	275,5	45	653,6	12	866,2													+
16	*Tilia sp*	637412	5527922	460	320	51	93,6	10	122,5	12	293,8											+		
17	*Quercus robur*	637363	5527807	45	33	10	120	51	137,3	12	389,4													+
18	*Larix decidua*	637804	5527628	4400	3170	53	125,8	51	396,4	12	408,5		+				+		+				+	
19	*Acer pseudoplatanus*	637919	5527135	760	120	53	418,2	15	530,9	51	849,1	+	+			+	+	+				+		
20	*Acer negundo*	637329	5526888	190	30	23	865,1	53	879,8	51	990,7	+										+		
21	*Quercus robur*	637115	5527423	46	26	23	382	10	511,2	51	578,5													+
22	*Thuja occidentalis*	637315	5526260	40	13	64	1367	23	1390	53	1421	+									+			
23	*Salix matsudana 'Tortuosa'*	635403	5525413	15	12	64	848,8	24	1229	65	1297													+
24	*Populus tremula*	635410	5525828	15	9	64	596,8	65	882,5	24	897													+
25	*Salix matsudana 'Tortuosa'*	634981	5526161	41	23	24	369,8	65	665,7	6	777,7													+
26	*Prunus sp.*	634829	5526050	28	21	24	431,4	65	845,7	6	931,9													+
27	*Picea pungens*	634791	5526809	470	340	24	329	6	405,3	1	563,6		+				+		+				+	
28	*Cornus sanguinea*	635164	5527863	15	15	52	288,9	26	454,4	47	460,7													+
29	*Cornus sanguinea*	634905	5528779	20	20	42	65,12	41	242	26	695,1													+
30	*Acer negundo*	634202	5529092	8	8	42	792,6	41	859	62	886,9													+

significant or non-significant respectively differences between the measurements of the two sides are seen (Fig. 6). A post hoc Bonferroni comparisons test showed significant differences between the measurements from the exposed side of damaged trees and all other groups in the random points group (Table 8).

Of the 120 trees, those with lower mean distance to the three closest antennas have usually higher values of radiation (Fig. 7). However, screening is common in cities due to a large amount of buildings, thus some trees that are close to antennas show lower radiation values than expected. This means that radiation measurements at points close to antennas are variable (high and low) while trees farther from antennas always have low values.

A dossier with documentation gathered over the years and the examples of tree damages is presented in: http://kompetenzinitiative.net/KIT/KIT/baeume-in-bamberg/

4. Discussion

In the present study it was useful, that tree damages in the vicinity of phone masts in Bamberg and Hallstadt had been documented starting 2006. We found a high level of damage to trees in the vicinity of phone masts. The damage encountered in these trees is not attributable to harmful organisms, such as diseases, pests or other environmental factors. These would impact upon the entire tree, whereas damage to trees in the present study was only found on parts of the tree and only on one side (unilateral). Therefore, these factors cannot explain the damage documented here. Generally in all trees of this study, damage is higher in areas of high radiation and occurs on the side where the nearest phone mast is located (Table 4 and Fig. 3). Moreover, areas with more antennas have more levels of radiation and damaged trees are found most often in these high electromagnetic polluted areas. These results showed that side differences in damage corresponded to side differences in measured values of power flux density. This paper look at the effects on trees, but also provides information on how electromagnetic radiation is distributed in a city (interpolation map and Fig. 7).

In this study deciduous and coniferous trees were examined under the real radiofrequency field conditions around phone masts in Bamberg and Hallstadt. From most phone masts a broad band of frequencies with different modulations and pulse frequencies and fluctuating power densities is emitted (GSM 900, GSM 1800, UMTS, LTE, TETRA). Different signals may have different effects due to their physical parameters (Belyaev, 2010; IARC, 2013). We do not discriminate between these different signals and cannot answer the question which part of the

Table 6
Results of the tree measurements in the 30 points with low radiation.

												Effect codes												
												1	2	3	4	5	6	7	8	9	10	11	12	13
Nº	Scientific name	X	Y	Side antenna measurement µW/m²	Opposite side measurement µW/m²	Number of Phone Mast 1	Distance a 1	Number of Phone Mast 2	Distance a 2	Number of Phone Mast 3	Distance a 3	Damage only on one side	Sparse leaves or needles (crown transparency)	Brown leaves (start at leaf margins)	Colour change of leaves prematurely	leaves fall prematurely	Dead branches (Peak branches dried).	Tip of the main guide dried	Irregular growth	Not grow in eight	Color change of needles	Dead parts were trimmed down	damage on different sides	no damage
1	*Acer platanoides*	636741	5529855	26	20	25	636,3	33	784,1	35	798,8													+
2	*Carpinus betulus*	634853	5529041	10	8	42	234,5	62	476,4	41	500,1													+
3	*Carpinus betulus*	638311	5528439	12	10	50	229,7	45	563,5	12	750													+
4	*Carpinus betulus*	636753	5529880	8	8	25	609,6	33	811,5	28	823,5													+
5	*Carpinus betulus*	637817	5527130	15	12	53	432,1	15	633	51	806,6													+
6	*Carpinus betulus*	634931	5526731	15	15	24	286	6	310,3	65	428,6													+
7	*Tilia sp.*	636500	5529673	8	8	35	511,4	34	528,3	33	570,3													+
8	*Tilia sp.*	636824	5529794	17	9	25	635,7	28	713,1	33	755,3													+
9	*Quercus robur*	636455	5526130	9	8	64	497,5	65	1240	17	1425													+
10	*Quercus robur 'Fastigiata'*	636178	5528932	10	10	34	282,2	35	306,5	21	332													+
11	*Aesculus hippocastanum*	636828	5529780	10	10	25	645,5	28	699	33	744,2													+
12	*Aesculus carnea*	636463	5529709	12	12	35	526,1	34	551,4	33	608,6													+
13	*Robinia pseudoacacia*	635507	5528534	15	15	14	136,6	13	201,5	26	299,2													+
14	*Robinia pseudoacacia*	634720	5532783	8	8	60	216,7	63	559,3	59	868,7													+
15	*Acer campestre*	635697	5528689	40	30	14	136,5	22	155,8	11	246,8													+
16	*Acer campestre*	636486	5526116	6	6	64	526,2	65	1273	23	1437													+
17	*Juglans regia*	635744	5528667	20	15	22	119	14	145,7	11	202,8													+
18	*Platanus hispanica*	635496	5528529	17	15	14	148,4	13	204,1	26	289,9													+
19	*Prunus avium*	637958	5530874	10	8	18	412,4	40	502,6	39	551,4													+
20	*Prunus sp.*	636079	5528463	10	10	11	237,5	16	269,7	54	312,7													+
21	*Taxus baccata*	638407	5528502	5	5	50	316	45	673,6	12	864,8													+
22	*Taxus baccata*	638222	5531032	10	10	18	474	39	578,6	40	673,1													+
23	*Thuja occidentalis*	636518	5529853	9	9	8	648,4	35	680	34	705													+
24	*Thuja occidentalis*	635318	5528784	20	15	42	371,5	14	389,4	13	514,8													+
25	*Picea pungens*	636512	5529735	17	17	35	571,4	34	590,8	33	632													+
26	*Juniperus communis*	636549	5529756	8	8	35	607,8	34	623,4	33	653,7													+
27	*Cornus sanguinea*	638167	5529098	8	6	43	397,2	50	597,9	45	899,8													+
28	*Sambucus nigra*	635529	5525601	5	5	64	625,2	65	1121	24	1146													+
29	*Corylus avellana*	636422	5526181	5	3	64	476,4	65	1187	17	1371													+
30	*Corylus avellana*	636625	5529834	6	6	35	714	34	725,2	25	732,3													+

radiation has caused the damage. Nevertheless broad bands of frequencies, modulation, pulse frequencies, interferences and other physical characteristics may play an important role, since in some cases, damage already appears at low intensities. This can be a shortcoming of the study.

The aim of the present study was to find out whether there is a causal relationship between the unilateral tree damages, which had been observed since 2006, and the RF-EMF emitted from phone masts and a preliminary observation to find out whether various species react differently to RF exposure.

The selection of the 60 unilaterally damaged trees was limited by the fact that we could do measurements only up to a height of 6 m. Trees with damages above the height of 6 m could not be included.

Many factors can affect the health of trees: Air and soil pollutants, heat, frost, drought, as well as composition, compaction and sealing of the soil, road salts, root injury due to construction work, diseases and pests. Most of these factors do not affect a tree only on one side over a period of >5 years. Industrial air pollutants could eventually cause unilateral damage in direction to an industrial emitter. But the observed unilateral damages appeared in all directions and were not oriented to the incineration plant or other industrial plants. Root injury due to construction work can produce damage on one side of a tree, but 24 of the 60 selected trees were situated in gardens, parks or on the cemetery where they could not be affected by construction damages.

From the damaged side there was always visual contact to one or more phone mast (s). In each case measurements of the power flux density on the damaged side which was facing a phone mast and on the opposite side without (or with less) damage were carried out and the difference between the measured values on both sides was significant (Fig. 5), as well as between the exposed side of damaged trees and all other groups. In all 60 trees the gradient of damage corresponded to a gradient of measured values. The attenuation of the RF-EMF within the treetop offers an explanation: a part of the RF-EMF is absorbed by leaves or needles and another part is reflected, scattered and diffracted.

In the randomely selected group of 30 trees, 17 trees were situated on places with low radiation. These 17 trees showed no damages, the measured values were below 50 µW/m^2 (0.137 V/m) and there was no difference between opposite sides as in the low radiation group. On the other hand, 13 trees grew in the radiation field of one or more phone mast (s). These trees showed unilateral damage or damage on different sides. The measured values at damaged trees showed differences between both sides as in the previous group above.

In the group of 30 trees in areas with low radiation (radio shadow of hills, buildings or trees and without visual contact to phone masts)

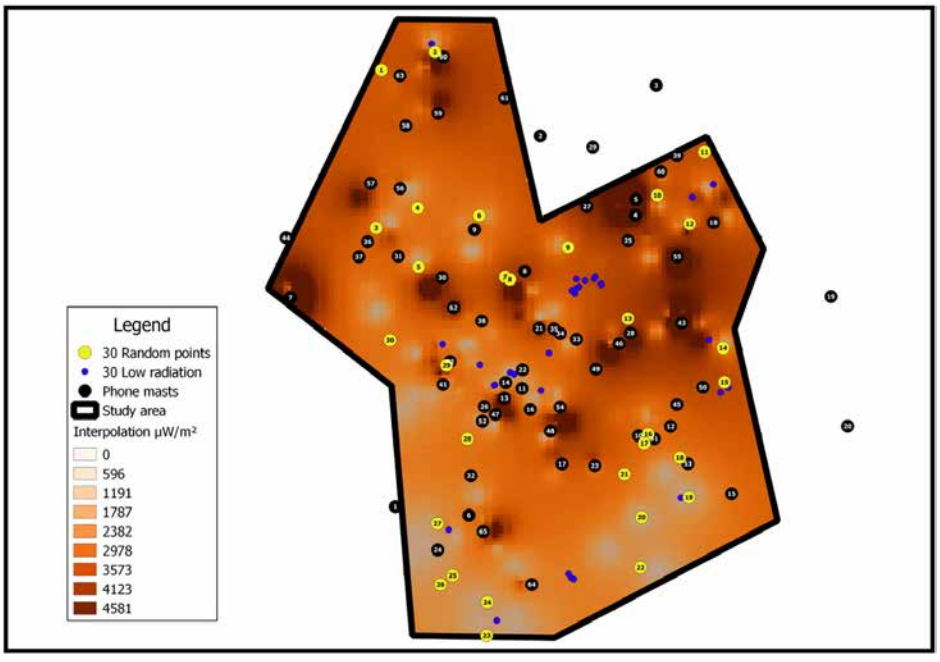


Fig. 4. Map showing the 30 trees at random points and the 30 trees in areas of low radiation (both with code numbers) over the interpolation electromagnetic map of the 144 measurement points. Phone masts (with code numbers) are also represented.

there were no unilateral damages. The measured values were below 50 μW/m^2 (0.137 V/m) and there was no difference between opposite sides. These results in the three groups point to a connection between unilateral tree damage and RF exposure.

In the electromagnetic field of all mobile phone base stations visited numerous tree damages were observed. The damage occurred in temporal relation with the putting into operation of new mobile phone base stations. Woody plants of all species are affected (deciduous and coniferous trees as well as shrubs).

In the five most represented species (n ≥ 4) among the 60 damaged trees (*Acer platanoides*, *Carpinus betulus*, *Tilia* sp., *Taxus baccata* and *Thuja occidentalis*), most trees showed damage only on one side (Damage code 1, Tables 2 and 4). Most of these trees were characterized with sparse leaves or needles (crown transparency) (Damage code 2, Tables 2 and 4). In many of the trees with the one-sided damage, the leaves turned prematurely yellow or brown in June – this always began at the leaf margins (Damage code 3, Tables 2 and 4). In many trees leaves fall prematurely (Damage code 5, Tables 2 and 4) or had dead branches (Peak branches dried) (Damage code 6, Tables 2 and 4). Some trees stopped growing in height while, in others, the main guide died (see Tables 2 and 4).

The differences in susceptibility of different species could be related to radiofrequency energy absorption properties of the trees (e.g., dielectric property). Perhaps this study cannot answer questions about these differences, however it is quite possible that differences are related to the electrical conductivity, related also with the density of the wood (species of fast or slow growth) and particularly with the percentage of water in the tissues. Poplars and aspen that grow near rivers and water bodies in Spain seem to be particularly sensitive to the effects of radiation. But the waves reflection in the water could also influence.

The results presented here lead us to conclude that damage found in the selected trees is caused by electromagnetic radiation from phone

Table 7
Repeated measures ANOVA analysis and Bonferroni post hoc comparisons ($p < 0.01$ values with *) in the three types of trees (damaged, random, and low radiation). Measurement Side 1/2 correspond to the maximum/minumum value of radiation respectively for the opposite sides of each tree.

	SS	Degr. of	MS	F	p
Intercept	62663309	1	62663309	25.81460	0.000001*
Type of tree	52931692	2	26465846	10.90280	0.000046*
Error	284010086	117	2427437		
R1	33197069	1	33197069	18.28694	0.000039*
R1*Type of tree	44608664	2	22304332	12.28656	0.000014*
Error	212395158	117	1815343		

	Type of tree	R1	{1}	{2}	{3}	{4}	{5}	{6}
1	Damaged	Measurement Side1		0.000000*	0.001829*	0.000001*	0.000000*	0.000000*
2	Damaged	Measurement Side2	0.000000*		1.000000	1.000000	1.000000	1.000000
3	Random	Measurement Side1	0.001829*	1.000000		1.000000	1.000000	1.000000
4	Random	Measurement Side2	0.000001*	1.000000	1.000000		1.000000	1.000000
5	Low radiation	Measurement Side1	0.000000*	1.000000	1.000000	1.000000		1.000000
6	Low radiation	Measurement Side2	0.000000*	1.000000	1.000000	1.000000	1.000000	

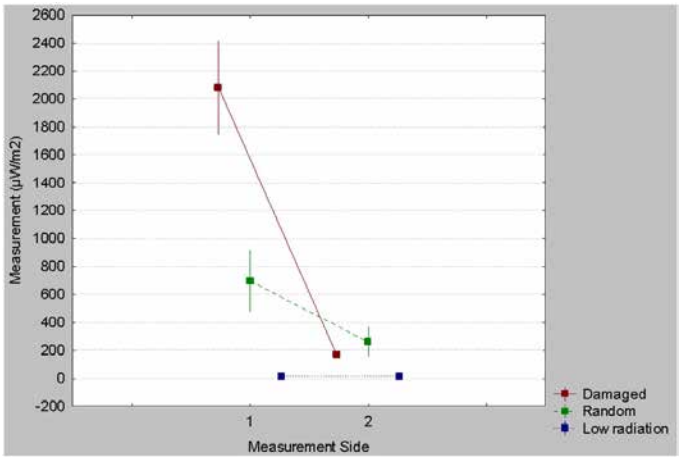


Fig. 5. Differences between measurements in both sides for the three different tree groups: damaged, random, and low radiation. Measurement Side 1/2 correspond to the maximum/minumum value of radiation respectively for the opposite sides of each tree. The bars represent means ± standard errors. The central point represents the mean and the straight line ± 0.95*SE.

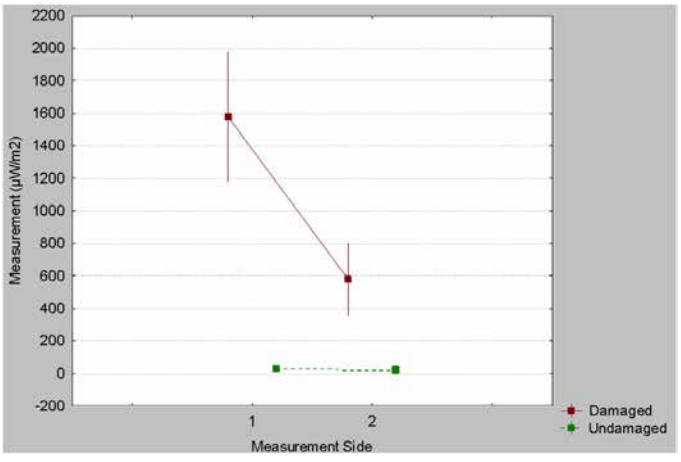


Fig. 6. Differences between measurements in both sides for the damaged and undamaged trees within the random trees group. Measurement side 1/2 correspond to the maximum/minumum value of radiation respectively for the opposite sides of each tree. The bars represent means ± standard errors. The central point represents the mean and the straight line ± 0.95*SE.

masts, as we proposed in previous studies (Balmori, 2004; Waldmann-Selsam, 2007; Waldmann-Selsam and Eger, 2013; Balmori, 2014). Interested parties are able to locate the damaged trees found in this work in Bamberg and Hallstadt with their UTM coordinates. However, trees with code numbers 20, 38 and 48 (Table 4) have been cut down and removed.

Research on the effects of radiation from phone masts is advancing rapidly. In February 2011 the first symposium on the effects of electromagnetic radiation on trees took place in Baarn, Netherlands (Schorpp, 2011 - http://www.boomaantastingen.nl/), where similar effects and results to those found in the current paper were presented.

Although there are some related experiments that show no effect of long-term exposure (3,5 years), 2450-MHz (continous wave) and power flux densities from 0.007 to 300 W/m^2 on crown transparency, height growth and photosynthesis of young spruce and beech trees (Schmutz et al., 1996), this result may not be transferred to modulated 2450-MHz or to other pulsed and modulated frequencies. In addiction, an increasing number of studies have highlighted biological responses and modifications at the molecular and whole plant level after exposure to high frequency electromagnetic fields (Vian et al., 2016). Plants can perceive and respond to various kinds of electromagnetic radiation over a wide range of frequencies. Moreover, a low electric field intensity (5 V/m) was sufficient to evoke morphological responses (Grémiaux et al., 2016). Electromagnetic radiation impacts at physiological and ecological levels (Cammaerts and Johansson, 2015), and evokes a multitude of responses in plants. The effects of high frequency electromagnetic fields can also take place at the subcellular level: it can alter the activity of several enzymes, including those of reactive oxygen species (ROS) metabolism, a well-known marker of plant responses to various kinds of environmental factors; it evokes the expression of specific genes previously implicated in plant responses to wounding (gene expression modifications), and modifies the growth of the whole plants (Vian et al., 2016). It could be hypothesized that membrane potential variations in response to electromagnetic radiation exposure may initiate electrical waves of depolarization (AP and/or VP) that could initiate immediate or delayed growth responses (Grémiaux et al., 2016). It has been proposed that electromagnetic fields act similarly in plants and in animals, with the probable activation of calcium channels via their voltage sensor (Pall, 2016).

Electromagnetic radiation (1800 MHz) interferes with carbohydrate metabolism and inhibits the growth of *Zea mays* (Kumar et al., 2015). Furthermore, cell phone electromagnetic radiation inhibits root growth of the mung bean (*Vigna radiata*) by inducing ROS-generated oxidative stress despite increased activities of antioxidant enzymes (Sharma et al., 2009). Germination rate and embryonic stem length of *Triticum aestivum* was also affected by cell phone radiation (Hussein and El-Maghraby, 2014). After soybeans were exposed to weak microwave radiation from the GSM 900 mobile phone and base station, growth of

Table 8
Repeated measures ANOVA analysis and Bonferroni post hoc comparisons ($p < 0.01$ values with *) in the random trees group. Measurement Side 1/2 correspond to the maximum/minumum value of radiation respectively for the opposite sides of each tree.

	SS	Degr. of	MS	F	p
Intercept	17829607	1	17829607	16.60985	0.000343*
13 code	16391606	1	16391606	15.27023	0.000538*
Error	30056202	28	1073436		
R1	3701923	1	3701923	16.73250	0.000329*
R1*13 code	3627579	1	3627579	16.39647	0.000368*
Error	6194761	28	221241		

	13 code	R1	{1}	{2}	{3}	{4}
1	Undamaged	Measurement Side 1		1.000000	0.002129*	0.416303
2	Undamaged	Measurement Side 2	1.000000		0.000034*	0.927155
3	Damaged	Measurement Side 1	0.002129*	0.000034*		0.000055*
4	Damaged	Measurement Side 2	0.416303	0.927155	0.000055*	

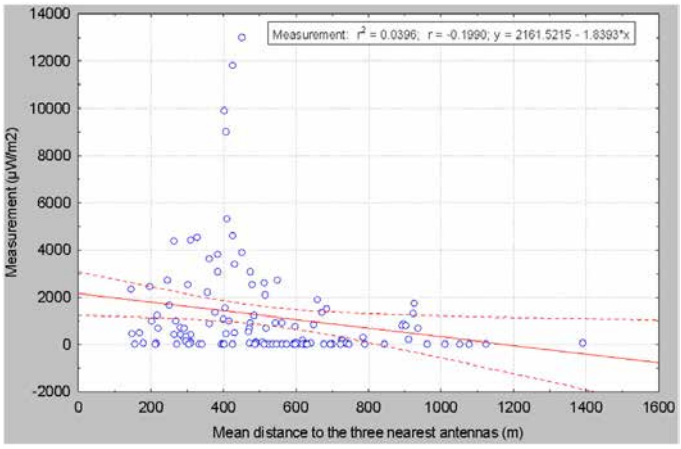


Fig. 7. Scatterplot showing the correlation between measurements from each of the 120 trees and the mean distance to the three nearest antennas. Dashed lines represent the 0.95 confidence interval.

epicotyl and hypocotyl was reduced, whereas the outgrowth of roots was stimulated. These findings indicate that the observed effects were significantly dependent on field strength as well as amplitude modulation of the applied field (Halgamuge et al., 2015). Phone mast radiation also affects common cress (*Lepidium sativum*) seed germination (Cammaerts and Johansson, 2015). In *Arabidopsis thaliana*, the long term exposure to non ionizing radiation causes a reduction in the number of chloroplasts as well as the decrease of stroma thylakoids and the photosynthetic pigments (Stefi et al., 2016). Finally, low-intensity exposure to radiofrequency fields can induce mitotic aberrations in root meristematic cells of *Allium cepa*; the observed effects were markedly dependent on the frequencies applied as well as on field strength and modulation (Tkalec et al., 2009).

In general, polarization from man-made electromagnetic radiation appears to have a greater bioactive effect than natural radiation, and significantly increases the probability for initiation of biological or health effects (Panagopoulos et al., 2015).

Tree damages as in Bamberg and Hallstadt were documented by the authors in several countries: Spain (Valladolid, Salamanca, Madrid, Palencia, León), Germany (Munich, Nürnberg, Erlangen, Bayreuth, Neuburg/Donau, Garmisch-Partenkirchen, Murnau, Stuttgart, Kassel, Fulda, Göttingen, biosphere reserve Rhön, Tegernsee Valley and in several small towns), Austria (Graz), Belgium (Brussels) and Luxemburg.

Each phone mast can harm many trees and each tree can be affected by several phone masts belonging to the same or different base stations. Damaged trees seem to exist around each antenna and the several million phone masts in the world could potentially be damaging the growth and health of millions of trees. This can occur not only in cities, but also in well-preserved forests, and in natural and national parks, where base stations are being installed without the necessary prior environmental impact studies, due to a lack of knowledge of the problem. For this reason, it is essential for an assessment on the environmental impact of any new base station prior to implementation.

Additionally, phone masts can cause a drop in timber productivity in plantations of pine, poplar, etc., as well as fruits, nuts, etc. Thus, the industry must be required to pay damages to plantation owners. Similarly, as trees are a common social good, the industry should compensate for damaged and dead trees around the world due to radiation. Further, the money spent by municipalities to repair or replace damaged trees should enter into the computation of costs/benefits of this technology. For installation of any new technology, the burden of proof should be to the industry that requires demonstration of safety prior to deployment.

Electromagnetic radiation from telecommunication antennas affected the abundance and composition of wild pollinators in natural habitats and these changes in the composition of pollinator communities associated with electromagnetic smog may have important ecological and economic impacts on the pollination service that could significantly affect the maintenance of wild plant diversity, crop production and human welfare (Lázaro et al., 2016).

Evidence for plant damage due to high frequency electromagnetic radiation was not taken into account in determining the current statutory regulations (the limit values). Once the problem becomes evident, the guidelines of radiation emitted by the antennas should be reviewed. Proper risk assessment of electromagnetic radiation should be undertaken to develop management strategies for reducing this pollution in the natural environment (Kumar et al., 2015).

Moreover, due to the lack of recognition, certain modern projects with interesting ideas for decreasing environmental pollution could have opposite effects than expected. For example, in the Netherlands, the TreeWiFi project (http://treewifi.org/), which aims to motivate people to use bikes and public transport in order to reduce the [NO2] pollution providing free WiFi when air quality improves, could be favoring electromagnetic pollution with even more harmful effects as it has been demonstrated in this manuscript (see also: http://www.greenpeace.org/canada/fr/Blog/le-wi-fi-tuerait-les-ar-bres/blog/33569/).

In addition, the number of sector antennas has increased in Bamberg and this increase appears to be accelerating: 483 sector antennas in 2011 and 779 sector antennas in 2015. Both radiation and damaged trees represent a loss of quality of life for citizens. This study began after finding that patients who claimed to be affected by phone masts, referred to as radiation, live in areas where affected trees and plants are located. Evidence of radiation damage was even found in potted plants inside patient homes (Waldmann-Selsam and Eger, 2013). Thus, this study is certainly complementary to the study by Eger and Jahn (2010) and other research that has shown effects on the health of people by phone masts located in their vicinity (Santini et al., 2002; Eger et al., 2004; Wolf and Wolf, 2004; Abdel-Rassoul et al., 2007; Khurana et al., 2010; Dode et al., 2011; Gómez-Perretta et al., 2013; Shahbazi-Gahrouei et al., 2014; Belyaev et al., 2015).

In the introduction to the International Seminar on "Effects of Electromagnetic Fields on the Living Environment" in 1999 in Ismaning, Germany, organized by WHO, ICNIRP and German Federal Office for Radiation Protection (BfS), M. Repacholi, head of the International EMF Project of the WHO, said: "By comparison, influences of these fields on plants, animals, birds and other living organisms have not been properly examined. Given that any adverse impacts on the environment will ultimately affect human life, it is difficult to understand why more work has not been done. There are many questions that need to be raised: …" and "…it seems that research should focus on the long-term, low-level EMF exposure for which almost no information is available. Specific topics that need to be addressed include: … EMF influences on agricultural plants and trees" (Matthes et al., 2000).

5. Conclusions

In this study we found a high-level damage in trees within the vicinity of phone masts. Preliminary laboratory studies have indicated some deleterious effects of radiofrequency radiation. However, these early warnings have had no success and deployment has been continued without consideration of environmental impact.

We observed trees with unilateral damage in the radiation field of phone masts. We excluded the possibility that root injury due to construction work or air pollutants could have caused the unilateral damage. We found out that from the damaged side there was always visual contact to one or more phone mast (s).

Statistical analyses demonstrated that the electromagnetic radiation from cellphone towers is harmful to trees. Results show that the measurements in the most affected sides of damaged trees (i.e. those that withstand higher radiation levels) are different to all other groups. These results are consistent with the fact that damage inflicted on

trees by cellphone towers usually start on one side, extending to the whole tree over time.

The occurrence of unilateral damage is the most important fact in our study and an important argument for a causal relationship with RF-EMF, as it supplies evidence for non-thermal RF-EMF effects. This constitutes a danger for trees worldwide. The further deployment of phone masts has to be stopped. Scientific research on trees under the real radiofrequency field conditions must continue.

Acknowledgements

The work presented here was carried out without any funding. Francisco Cabrero and José Ignacio Aguirre from the Department of Zoology, University Complutense of Madrid suggested the interpolation points on the map of radiation. This paper is dedicated in memoriam to the great Swedish researcher and courageous man, Örjan Hallberg. Authors have not a conflict of interest to declare.

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generation phones, 4G and 5G, open a vast potential for future research and whether these changes observed due to RFR exposure are reversible or not on withdrawing the exposure is another arena which warrants further research.

ACKNOWLEDGEMENTS

We express our sincere thanks to Dr. Arunchandra Singh, Professor of Anatomy, and faculty members of Anatomy, MGMC and RI, and Mr. M. Chandrasekhar, Technician, for his technical support during the course of the study.

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FINANCIAL OR OTHER COMPETING INTERESTS: None.

Date of Submission: **Jan 02, 2017**
Date of Peer Review: **Mar 27, 2017**
Date of Acceptance: **Jun 08, 2017**
Date of Publishing: **Jul 01, 2017**

Journal of Plant Physiology 171 (2014) 1436–1443

Contents lists available at ScienceDirect

Journal of Plant Physiology

journal homepage: www.elsevier.com/locate/jplph

Physiology

Influence of microwave frequency electromagnetic radiation on terpene emission and content in aromatic plants

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ARTICLE INFO

Article history:
Received 29 April 2014
Received in revised form 17 June 2014
Accepted 19 June 2014
Available online 8 July 2014

Keywords:
Microwave
Abiotic stress
Essential oils
Volatile organic compounds
Aromatic plants

SUMMARY

Influence of environmental stress factors on both crop and wild plants of nutritional value is an important research topic. The past research has focused on rising temperatures, drought, soil salinity and toxicity, but the potential effects of increased environmental contamination by human-generated electromagnetic radiation on plants have little been studied. Here we studied the influence of microwave irradiation at bands corresponding to wireless router (WLAN) and mobile devices (GSM) on leaf anatomy, essential oil content and volatile emissions in *Petroselinum crispum*, *Apium graveolens* and *Anethum graveolens*. Microwave irradiation resulted in thinner cell walls, smaller chloroplasts and mitochondria, and enhanced emissions of volatile compounds, in particular, monoterpenes and green leaf volatiles (GLV). These effects were stronger for WLAN-frequency microwaves. Essential oil content was enhanced by GSM-frequency microwaves, but the effect of WLAN-frequency microwaves was inhibitory. There was a direct relationship between microwave-induced structural and chemical modifications of the three plant species studied. These data collectively demonstrate that human-generated microwave pollution can potentially constitute a stress to the plants.

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Introduction

Aromatic plants represent an important resource for human nutrition, due to their valuable properties, including medicinal benefits (Bonjar, 2004; Wong and Kitts, 2006; Bakkali et al., 2008; Ortan et al., 2009; Cornara et al., 2009). Therefore, understanding their chemical composition and how the properties of aromatic plants are affected by key climate change factors as well as human-generated pollution are research topics of major interest.

The key property of aromatic plants is the presence of essential oils that play important roles in plants acting as direct defenses against pathogen and herbivore attacks (Rhoades, 1977; Lewinsohn et al., 1991; Fugmann et al., 1997; Reddy et al., 2001). The essential oils are very complex natural mixtures that consist of molecules produced through different secondary metabolic pathways, characteristically containing terpenoids, benzenoids and sometimes aliphatic compounds (Bauer et al., 1998; Eggersdorfer et al., 1998; Cheng et al., 2007; Bakkali et al., 2008).

Both the composition and content of essential oils has been shown to strongly depend on plant species and environmental conditions (Langlille and MacLean, 1976; Letchamo et al., 1996; Zabaras et al., 2002; Manzan et al., 2003). These aspects are relevant because plants in natural conditions as well as in agricultural fields are exposed to a plethora of abiotic and biotic stresses and the importance of several biological and environmental stresses is expected to increase in the future (Peñuela and Estiarte, 1998; Lobell et al., 2008; Craufurd and Wheeler, 2009; Jacob and Winner, 2009; Niinemets, 2010a,b).

The key abiotic stresses (Lobell et al., 2008; Craufurd and Wheeler, 2009; Jacob and Winner, 2009) of contemporary economical importance for plant growth worldwide are drought, heat, cold (chilling and freezing), high salinity, soil mineral deficiency and toxicity. Furthermore, diffuse environmental pollution, including air and soil pollution constitutes a major problem for agriculture

Abbreviations: VOC, volatile organic compounds; GLV, green leaf volatiles; WLAN, wireless router; GSM, mobile devices; TEM, transmission electron microscopy.

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http://dx.doi.org/10.1016/j.jplph.2014.06.013
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and human health (Gauderman et al., 2004; WHO, 2004; Copaciu et al., 2013; Opriş et al., 2013). It was demonstrated that the blend of volatile organic compounds (VOC) emitted by aromatic plants under stress factors is complex (Rodrigues-Navas et al., 2012). The complexity of volatile emissions in species having specialized storage structures for volatiles results from the circumstance that there may be emissions directly coming from storage and de novo emissions independent of storage (Staudt et al., 1997; Niinemets et al., 2010a,b; Monson et al., 2012; Grote et al., 2013; Li and Sharkey, 2013).

Among the novel potential pollution sources is the enhanced use of mobile phones and wireless devices generating an exponentially increased level of electromagnetic radiation in the microwave range of radiation frequencies (1–100 GHz). There have been some studies on microwave effects on plants showing no significant effects, while others have demonstrated important modifications in plant functioning. Laboratory growth experiments in plants subject to magnetic fields demonstrated that plants were taller and heavier (Martínez et al., 2003). Likewise, germination of *Cicer arietinum* L. seeds and early development were enhanced upon exposure to a moderate magnetic field (Vashisth and Nagarajan, 2008). It has been shown that electromagnetic radiation at broadcast-frequency (0.2–30 MHz) altered the cellular contents of calcium and sulfur, effect associated with the power of radiation (Balmori Martínez, 2003), while in animal cells has been observed that microwaves (frequency of 147 MHz, amplitude-modulated at 16 Hz) can influence the intercellular communication through altering the functioning of the calcium channels (Balmori Martínez, 2003). Exposure to microwaves (frequency of 9.75 GHz and low intensity) of wheat (*Triticum aestivum*) plants has resulted in cytogenetic changes (Pavel et al., 1998; Balmori Martínez, 2003). Studies have also shown alterations in condensed chromatin distribution of meristem cells exposed to low magnetic fields (Belyavskaya, 2001, 2004). In general, these studies collectively suggest that the effects of electromagnetic fields on plants can be variable.

It is, however, unclear what the mechanism of low-energy microwave irradiation effects on plant is. While high energy microwave-radiation can break the chemical bonds (Caldwell et al., 1995; Barnes and Cardoso-Vilhena, 1996), the quantum energy of microwave radiation is low and mainly can have thermal effects, heating up selectively plant structures and possibly also alter the conformation of biomolecules, such as proteins, nucleic acids and membrane lipids. Furthermore, modifications in biomolecular tertiary structure can importantly alter the rate of physiological processes, again implying that microwaves can lead to stress conditions in plants (Takeuchi and Thornber, 1994; Ha et al., 1997; Havaux, 1998). Thus, it is important to gain more conclusive insight into the effects of microwaves on plant performance.

The aim of the present study was to investigate the influence of microwave irradiation on the ultrastructure of leaves, the essential oil content and VOC emission of three aromatic plant species of the Apiaceae family, parsley (*Petroselinum crispum* L.), dill (*Anethum graveolens* L. subsp. *hortorum* Alef.) and celery (*Apium graveolens* L.). The stress application consisted in three weeks microwave irradiation of plants at bands corresponding to wireless router (WLAN) and mobile devices (GSM). As the emissions of stress volatiles such as green leaf volatiles (GLV) and specific terpenes are enhanced upon exposure to different stresses (Heiden et al., 2003; Beauchamp et al., 2005; Copolovici et al., 2011; Niinemets et al., 2013), we hypothesized that microwave irradiation leads to enhanced emission of stress volatiles. In addition, we intend to investigate how microwave irradiation affects the leaf structure, content and composition of essential oils in these aromatic plants of nutritional and medicinal importance.

Materials and methods

Plant material and growth conditions

Plant material including parsley (*Petroselinum crispum* cv. Plain leaved 2) (P), dill (*Anethum graveolens* subsp. *hortorum* cv. Common) (D) and celery (*Apium graveolens* cv. Pascal Giant) (C) were grown in laboratory from seeds obtained from Agrosel (Câmpia Turzii, Romania). Fifteen seeds were sown in 150 mL plastic pots (height × diameter of 8.5 cm × 6.5 cm) filled with commercial garden soil.

Three weeks after seeding, the vessels with plants were placed in three identical anechoic chambers (Surducan et al., 2012) characterized by a degree of isolation of 60 dB at radio-frequency range between the exterior and interior. The fully-closed chambers were maintained under the same conditions of light intensity at 300 μmol m^{-2} s^{-1} provided from four 4 W MR16 LED lamps (every lamp consisting of 26 warm white SMD 5050 LED at 3300 K), temperature (25 °C), CO_2 concentration (385 ± 20 ppmv) and humidity (65%). One chamber was for non-treated control plants, while plants in the other two chambers were subjected to microwave irradiation. The microwave irradiation was performed at bands corresponding to mobile devices (GSM) using a modified AP5200 generator (D-LINK, China), operating in four bands (860–910 MHz frequency range, Pout 29 dBm), and to wireless router (WLAN) using a D-LINK wireless router 802.11 g/2.4 GHz (2.412–2.48 GHz frequency range, Pout 19 dBm). In the irradiation chamber there is one stick antenna placed in the center of the ceiling. The exposure levels where chosen in agreement with the microwave irradiation levels measured in open space for heavily used GSM networks (100 mW/m^2) and for indoor WLAN (70 mW/m^2) communication protocols. The power density to the base of chambers was measured with a spectrum analyzer SPECTRAN HF 4060, AARONIA AG (Germany). Both control and microwave-irradiated plants were watered every 2 days with 10 mL of bidistilled water (bidistillator AcquaMatic model AWC/4D, Hamilton Laboratory Glass Ltd., Kent, UK).

Irradiation was performed during three weeks, after which plants were removed from the chambers for measurements of volatile organic compound (VOC) emission and analyses of leaf structure and essential oil content. All measurements of VOC emission and analyses of leaf structure and essential oil content have been replicated with eight different plants.

Transmission electron microscopy measurements

Samples for transmission electron microscopy (TEM) were contrasted with 2% uranyl acetate in 50% ethanol solution for 2 min and in 0.2% lead citrate in 0.1 M sodium hydroxide solution for 2 min. The samples were dehydrated in ethanol series and embedded in epoxy resin, Epon 812. The samples were cut in an Ultramicrotome, Leica UC6 with a diamond knife and the ultrathin samples (100 nm) were analyzed with a 120 kV TEM Model JEM 1010 (Jeol USA Inc., Peabody, MA, USA). The number of chloroplasts, mitochondria, starch grains in the chloroplasts and nuclei were determined in the palisade mesophyll cells for replicate plants under each treatment.

Essential oil extraction

Samples of fresh plant material of 1 g were frozen in liquid nitrogen, pulverized and essential oils were extracted with 2 mL of 1:1 (v/v) mixture of HPLC-grade diethyl ether and *n*-hexane (Merck, Germany). For extraction, plant material was initially soaked for 10 min with the solvent mixture, and then extracted in an ultrasonic bath (Elmasonic S 15H, 37 kHz) for 30 min at 30 °C. Each extraction was performed using five parallel samples. In all cases, extracts

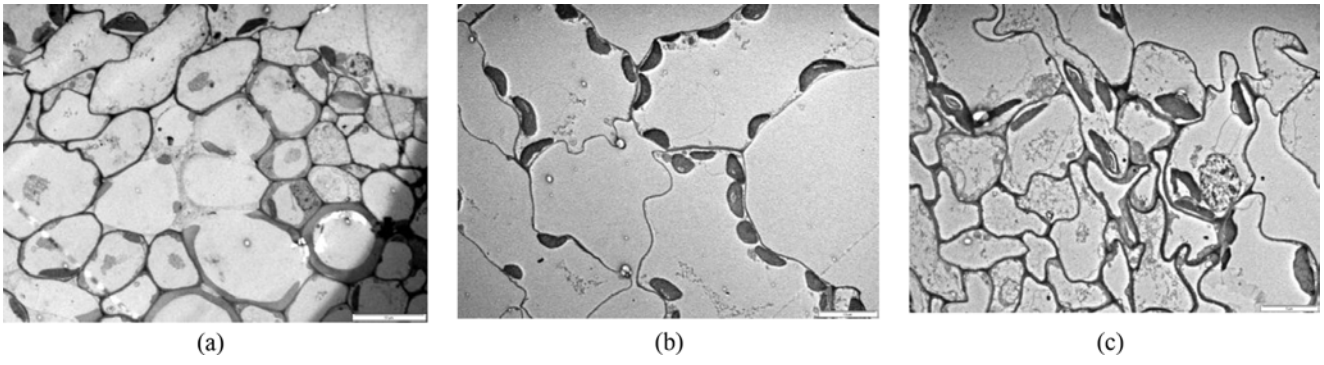


Fig. 1. TEM images of cell walls in leaves of microwave-irradiated and control parsley: (a) Control; (b) GSM irradiated; and (c) WLAN iradiated.

were decanted and filtered through nylon syringe filters (0.45 μm) before use.

Volatile organic compounds (VOC's) sampling and photosynthetic parameters determinations

VOC sampling was performed using a portable gas exchange system GFS-3000 (Waltz GmbH, Effeltrich, Germany). The system has an environment-controlled cuvette with 8 cm^2 window area and multiple leaves were enclosed in the cuvette to fill the whole cuvette window. A volume of 4 L of air exiting the cuvette was sampled in a multibed stainless steel cartridge (8.88 cm × 0.65 cm, Supelco, Bellefonte, PA, USA) filled with Carbopack adsorbents (C 20/40 mesh, C 40/60 mesh, and X 20/40 mesh). The chamber air was sampled at a flow rate of 200 mL min^{-1} for 20 min using a 1003-SKC constant flow sampling pump (SKC Inc., Houston, TX, USA) at room temperature. Background air samples were taken before and after the measurements using the same system without the leaves enclosed in the cuvette. Using the same system, CO_2 and H_2O concentrations have been measured. The rates of net assimilation (A) and stomatal conductance to water vapour (g_s) were calculated per unit enclosed plant leaf area according to von Caemmerer and Farquhar (1981).

Essential oils and VOC analysis

For both essential oils and VOC analysis, a Shimadzu QP2010 Plus gas chromatograph coupled with quadrupole mass spectrometer (GC–MS) (Kyoto, Japan) was used. The conditions for essential oils analysis were as follows: injector temperature was 215 °C, initial oven temperature at 40 °C was held for 1 min; ramped at 5 °C min^{-1} up to 200 °C, held at this temperature for 1 min; ramped at 10 °C min^{-1} up to 220 °C and held for further 5 min. Helium (purity 99.9999%, Elmer Messer Gaas AS, Tallinn, Estonia) was employed as carrier gas with a constant flow rate of 1 mL min^{-1}. The mass spectrometer was operated in electron-impact mode (EI) at 70 eV, in the scan range m/z 30–400, the transfer line temperature was set at 240 °C and ion-source temperature at 150 °C.

For VOC analysis, an automated cartridge desorber Shimadzu TD20 (Kyoto, Japan) was used. The volatiles were analyzed according to the method described in detail in Copolovici et al., 2009.

The essential oils and VOC were identified by comparing the mass spectra of individual compounds with the spectra of GC purity external standards (Sigma–Aldrich, St. Louis, MO, USA) and with the spectra of NIST Library.

Statistical analysis and data handling

For TEM analyses, five replicate measurements, and for essential oils and VOC three replicates with independent samples of plants were available and we report means of the replications ± SE at each treatment. The means were statistically compared with Student ANOVAs followed by post hoc Tukey's tests using ORIGIN 8 (OriginLab Corporation, Northampton, MA, USA). All statistical differences were considered significant at $P < 0.05$.

Results and discussion

Ultrastructural analyses and photosynthetic parameters

Irradiation resulted in both qualitative and quantitative modifications in leaf anatomy. Palisade and spongy-parenchyma cells exhibit slightly wavy walls in leaves of irradiated plants, while in leaves of control plants were straight-walled (Fig. 1).

This indicates alterations in spatial arrangement of cells in leaf lamina cross-section and a moderate decrease of lamina turgidity. In fact, cell wall thickness was reduced by microwave-irradiation, and generally more strongly by the treatment with WLAN-frequency microwaves (Table 1).

Chloroplasts retained their ultrastructure and normal arrangement within cells, but chloroplasts tended to be smaller in irradiated leaves, especially in the case of WLAN frequency microwaves (Table 1). The ratio of starch grain area to chloroplast area was somewhat increased in treatment with GSM-frequency microwaves in *P. crispum* and *A. graveolens*, while it was reduced in WLAN-frequency microwave treatment in *P. crispum* (Table 1). Nevertheless, the differences among the treatments were relatively small, indicating moderate effects of microwave treatments on starch accumulation.

The mitochondrion length generally decreased in microwave-treated plants, especially in the case of plants irradiated with WLAN-frequency microwaves (Table 1). In addition, the number of mitochondrial cristae was also somewhat less, suggesting a certain decrease in their metabolic activity. Nuclei of most cells showed normal structure, however abundance of heterochromatin and presence of wavy contours tended to be greater in microwave-treated plants.

The anatomical modifications were qualitatively similar among species (Table 1). In all species, the treatment with WLAN-frequency microwaves resulted in greater anatomical changes than the treatment with GSM-frequency microwaves (Table 1). However, the microwave-induced changes were the strongest in *Anethum graveolens*, where all treatments differed from each other (Table 1) followed by *P. crispum* and *Apium graveolens*. In this species, chloroplast length did not differ among the treatments and mitochondrion length in GSM-frequency microwaves was not different from that in control plants (Table 1).

These data collectively demonstrate important alterations in foliage ultrastructure by microwave irradiation, and are in agreement with observations in wheat (*T. aestivum*) exhibiting

Table 1
Ultrastructural analysis of the leaves of studied plants. The average values (±SE) are replicates of six independent measurements with different plants.

Treatment	Cell wall thickness (μm)	Chloroplast length (μm)	Chloroplast area (μm^2)	Mitochondrion length (μm)	Ratio of starch grain area to chloroplast area (%)
Petroselinum crispum					
Control	0.300 ± 0.07	6.78 ± 0.12	13.31 ± 0.22	1.00 ± 0.27	8.93 ± 0.13
860–910 MHz	0.250 ± 0.06	6.76 ± 0.28	8.491 ± 0.06	0.90 ± 0.13	9.99 ± 0.12
2.4–2.5 GHz	0.200 ± 0.05	6.50 ± 0.16	7.807 ± 0.11	0.70 ± 0.05	6.01 ± 0.08
Apium graveolens					
Control	0.187 ± 0.01	5.90 ± 0.13	8.43 ± 0.23	1.68 ± 0.13	5.21 ± 0.13
860–910 MHz	0.175 ± 0.01	5.20 ± 0.17	8.08 ± 0.29	1.00 ± 0.25	8.13 ± 0.08
2.4–2.5 GHz	0.175 ± 0.01	4.85 ± 0.31	7.04 ± 0.22	0.80 ± 0.10	0
Anethum graveolens					
Control	0.160 ± 0.01	5.80 ± 0.20	7.68 ± 0.14	1.57 ± 0.08	5.34 ± 0.28
860–910 MHz	0.156 ± 0.01	4.33 ± 0.26	7.06 ± 0.35	0.55 ± 0.13	0
2.4–2.5 GHz	0.136 ± 0.01	3.33 ± 0.26	6.68 ± 0.14	0.25 ± 0.13	0

pronounced cytogenetic changes in response to microwaves (Pavel et al., 1998; Balmori Martínez, 2003). It was shown that under the influence of low-intensity microwaves in the species of *T. aestivum*, as compared to the control plants different types of chromosomal aberrations appeared: delayed chromosomes, micronuclei, inter-chromosomal bridges, chromosomal fragments (Pavel et al., 1998). In meristem cells of *Pisum sativum* L. roots exposed to low-magnetic field were observed ultrastructural changes such as a noticeable accumulation of lipid bodies, development of a lytic compartment (vacuoles, cytosegresomes and paramural bodies), and reduction of phytoferritin in plastids. The most sensitive organelle to low-magnetic field application was mitochondria, whose size and relative volume in cells increased, matrix was electron-transparent, and cristae reduced (Belyavskaya, 2001).

Photosynthesis parameters (assimilation rates and stomata conductance to water vapor) have been affected by microwaves exposure (Fig. 2). Even more, both parameters are influenced by the strength of the stress.

Overall, reduction in the size of organelles may indicate that photosynthesis and respiratory metabolism was somewhat impaired by microwave treatment (Louwerse and van der Zweerde, 1977; Lichtenthaler, 1981; Griffin et al., 2001; Terashima et al., 2011). On the other hand, reduction in cell wall thickness reduces mesophyll diffusion conductance to chloroplasts thereby potentially compensating for reduced physiological potentials and altered stomatal conductance to water vapor (Terashima et al., 2006; Tosens et al., 2012a,b; Tomás et al., 2013). However, reduced cell wall thickness reduces cellular resistance to low leaf water potentials (Niinemets, 2001). Thus, microwave irradiance may importantly decrease plant drought resistance.

Changes in essential oils content in response to microwave irradiation: general patterns

Many aromatic plants have specialized structures for the storage of volatiles and the composition of essential oils in these storage structures is often complex (Letchamo et al., 1995; Manzan et al., 2003; Rajabi Memari et al., 2013). Our study also observed complex composition of essential oils in the studied species, 10 compounds were detected in *P. crispum*, 11 compounds in *Anethum graveolens* and 7 compounds in *Apium graveolens*. In all species, monoterpenes constituted a significant component of the essential oil (Fig. 3). In addition, several specific benzenoids were also dominating components of the oil: apiol in *P. crispum*, and myristicin and dillapiole in *Anethum graveolens* (Fig. 3). Lipoxygenase pathway compounds were important constituents in essential oil in *P. crispum* and *Apium graveolens* (Fig. 3). In addition, the main volatile compounds in *Apium graveolens* are 3-hexen-1-ol, myrcene, α-ocimene, γ-terpinene (Fig. 3). These results broadly agree with past observations of essential oils produced by these species (Deng et al., 2003; Orav et al., 2003).

Multiple environmental factors have been shown to modify the content of essential oil (Langlille and MacLean, 1976; Gershenzon, 1984; Letchamo et al., 1994; Wannaz et al., 2003; Peñuelas et al.,

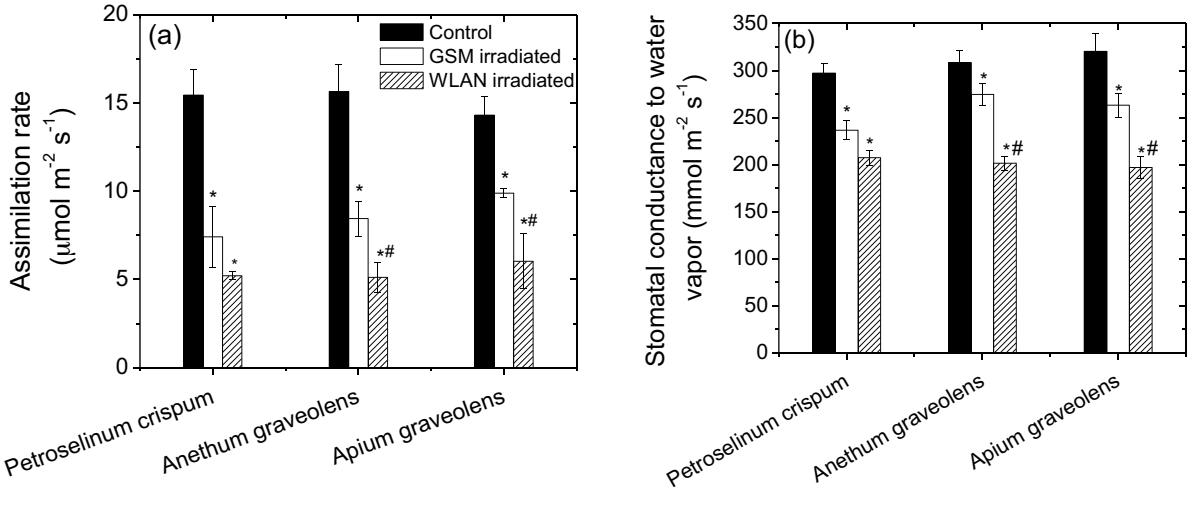


Fig. 2. Changes in net assimilation rate (a) and stomatal conductance to water vapour (b) in 3 aromatic plants in response to microwave stress. The data are expressed per unit projected leaf area. Each data point is the mean (±SE) of 8 independent replicate experiments with a different plant. * and # demonstrate statistically significant differences between the microwave irradiated plants and control plants and between WLAN and GSM irradiated plants respectively ($P < 0.05$).

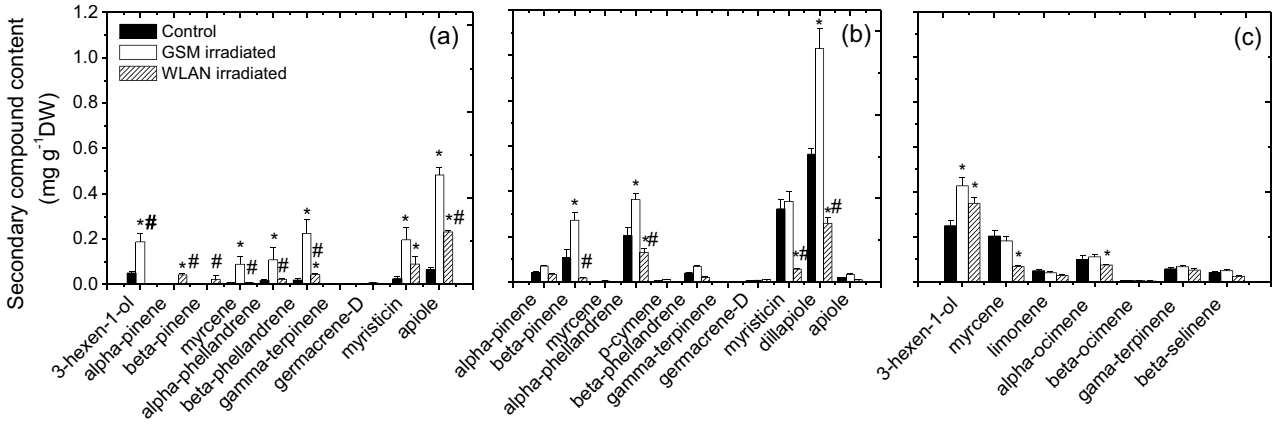


Fig. 3. Changes in terpene content (mg g^{-1} FW) in *Petroselinum crispum* (a), *Anethum graveolens* subsp. *hortorum* (b) and *Apium graveolens* (c) foliage in response to microwave irradiations at bands corresponding to wireless router (WLAN) and mobile devices (GSM). Each data point is the mean (±SE) of three independent replicate experiments with a different plant. * and # demonstrate statistically significant differences between the microwave irradiated plants and control plants and between WLAN and GSM irradiated plants respectively ($P < 0.05$).

2011). Such modifications in essential oil content have been often explained on the basis of hypotheses linking growth, and primary and secondary metabolism (Bryant, 1983; Herms and Mattson, 1992; Peñuela and Estiarte, 1998). According to these hypotheses, when sink activity (growth) rate decreases and carbon dioxide availability is in excess of that naturally occurring in the atmosphere, plants increase the rate of synthesis of secondary metabolites such as essential oils (Bryant, 1983; Herms and Mattson, 1992; Peñuela and Estiarte, 1998). In agreement with this hypothesis, water deficit has been shown to increase the yield of essential oil and affected its relative composition in *P. crispum* (Petropoulos et al., 2008). Analogously, enhanced salinity increased the essential oil yield for *Anethum graveolens* plants under stress (Ghassemi-Golezani et al., 2011).

In our study, microwave irradiation by GSM-frequency microwaves generally increased the essential oil contents (Fig. 3), while the effect of WLAN-frequency microwaves was less clear, varying from positive or negative for different compounds and species (Fig. 3). In a like manner, ozone stress induced two distinct pathways in *P. crispum* (Eckey-Kaltenbach et al., 1994) suggesting that different types and severity of stress can lead to qualitatively different responses. Taken together, these results are in partial agreement with several past observations indicating enhanced production of essential oils under stress and also are in agreement with the evidence of impaired photosynthetic and respiratory metabolism under microwave irradiation (Table 1). However, differently from essential oils, the anatomical modifications were significant under WLAN microwave irradiation (cf. Table 1 and Fig. 1c).

Species and microwave-frequency effects on essential oils

Although the effects were broadly similar among species, important species differences were observed in individual compound responses to GSM- and WLAN-frequency microwaves. Among the three plant species tested in these experiments, the strongest effects of microwave irradiation on essential oils were observed on *Anethum graveolens* plants (Fig. 3).

For individual compounds in *P. crispum*, the microwave irradiation produced by GSM generator statistically increased 3-hexen-1-ol, myrcene, α-phellandrene, β-phellandrene, myristicin and apiole contents. Compared to the reference, the strongest increase in response to GSM-frequency irradiation was observed for apiole (more than seven times greater content, Fig. 3a). The WLAN-frequency microwaves statistically increased the content of α-pinene, β-phellandrene, myristicin and apiol in this species (Fig. 3a).

In *Anethum graveolens* irradiated with GSM microwaves, increased content was observed for β-pinene, α-phellandrene and dillapiole (Fig. 3b). However, WLAN-frequency microwaves reduced α-phellandrene, myristicin and dillapiole content, whereas the greatest reduction was observed for myristicin (approximately to the level 18% of that in reference plants, Fig. 3b).

In *Apium graveolens*, both types of microwaves used in this study increased 3-hexen-1-ol content (Fig. 3c). Irradiation by WLAN-frequency microwaves reduced myrcene (19%) and α-ocimene (21%) contents (Fig. 3c).

Species-differences in environmental responses to stress factors have been demonstrated (El-Keltawi and Croteau, 1986; Mangas et al., 2006) although interspecific studies have been rare. Species ranking according to anatomical modifications was similar to the ranking based on essential oil changes (cf. Table 1 and Fig. 3). The structure of *Apium graveolens* leaves was the least affected by microwave irradiation and the effect on leaf chemistry was also the least in this species.

General patterns in VOC emissions

Our data demonstrate that the emissions observed did reflect a mixture of both storage emission consisting of compounds present in essential oils and de novo emissions. The blend of volatiles was very complex and, in all plant species, the non-stressed plants also emitted monoterpenes and benzenoids present in essential oils, in some cases even compounds not present in essential oils (Fig. 4). The number of compounds detected in the emissions was greater than in the essential oils, and characteristic de novo released stress volatiles were observed (Fig. 4). 16 compounds were detected in the emissions of *P. crispum*, 16 compounds in *Anethum graveolens* and 20 compounds in *Apium graveolens*.

There was evidence of similar enhancement of essential oils and emissions for several monoterpenes, especially for GSM microwave treatments in *P. crispum* and *Anethum graveolens* (cf. Figs. 3 and 4). However, in these species, emissions were more strongly enhanced under WLAN microwave treatment, which appeared to have an inhibitory effect on the content of the same terpenoids, e.g. α-pinene and β-phellandrene (cf. Figs. 3 and 4). Although there was evidence of parallel changes in contents and emissions for some volatiles in species, and for some treatments, this evidence suggests that the storage and de novo emissions cannot be fully teased apart in the current study. Nevertheless, the data suggest that the total

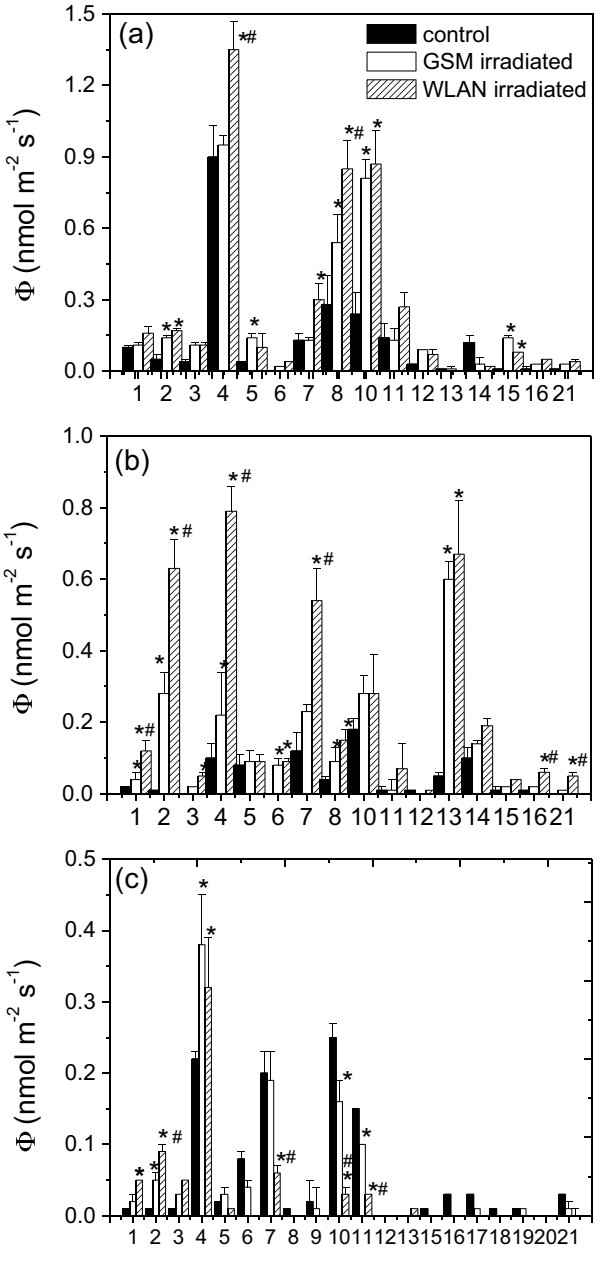


Fig. 4. Alteration of the emission of volatile organic compounds (nmol m^{-2} s^{-1}) from foliage of *Petroselinum crispum* (a), *Anethum graveolens subsp. hortorum* (b) and *Apium graveolens* (c) in response to microwave irradiations at bands corresponding to wireless router (WLAN) and mobile devices (GSM) (presentation of statistical differences as shown in Fig. 2). Each number corresponds to a particular volatile compound as follows: (1) 1-hexanol; (2) (*Z*)-3-hexen-1-ol; (3) (*E*)-2-hexenal; (4) α-pinene; (5) camphene; (6) β-myrcene; (7) β-pinene; (8) α-phellandrene; (9) Δ-3-carene; (10) D-limonene; (11) *para*-cymene; (12) β-phellandrene; (13) (*E*)-β-ocimene; (14) 1,8-cineol; (15) iso-bornyl acetate; (16) longicyclene; (17) caryophyllene oxide; (18) α-selinene; (19) (*Z*)-β-farnesene; (20) α-caryophyllene; (21) geranylacetone. * and # demonstrate statistically significant differences between the microwave irradiated plants and control plants and between WLAN and GSM irradiated plants respectively ($P < 0.05$).

emissions and especially treatment differences reflect to a large degree the microwave-induced de novo synthesized plant volatiles.

Compound-class, species- and treatment-specific differences in volatile emissions

Among the de novo emissions, GLV, also called volatiles of lipoxygenase pathway (LOX volatiles) are released in plants in response to different stresses (Copolovici and Niinemets, 2010; Copolovici et al., 2011, 2012). GLVs are formed in the hydroperoxide lyase pathway of oxylipin metabolism from free octadecanoic fatty acids and consist usually of a mixture of C6 aldehydes and ketones (Matsui, 2006). In our study, all microwave-irradiated plants emitted the following GLVs: (*E*)-2-hexenal, (*Z*)-3-hexenol, 1-hexanol, while the emissions of GLVs were very low at the level of detection limit of our device in control plants (Fig. 4).

In general, in all plant species studied, the emissions of GLV were greater for WLAN-frequency microwaves compared to GSM-frequency microwaves (Fig. 4, $P < 0.001$ for all). These results suggest greater stress in the case of WLAN microwave irradiation, and are in agreement with the more significant changes in anatomy of leaves induced by WLAN microwaves (Table 1). Stronger GLV emissions under more severe stress have been shown for water (Capitani et al., 2009), ozone (Beauchamp et al., 2005), herbivory attack (Allmann and Baldwin, 2010) and temperature (Copolovici et al., 2012) stresses.

The GLV emissions of the *P. crispum* and *Anethum graveolens* were dominated by the 1-hexanol (Fig. 4), while in *Apium graveolens* the main component was (*Z*)-3-hexenol that was also important constituent in the essential oil in this species (Figs. 3 and 4). The total GLV emission from *P. crispum* and *Anethum graveolens* was five times higher than from *Apium graveolens*. As with the essential oil content (Fig. 3), *Apium graveolens* was clearly less sensitive to the microwave fields than *P. crispum* and *Anethum graveolens*.

The monoterpenes detected in the emissions were α-pinene, β-pinene, camphene, limonene, 3-carene, *para*-cymene, β-phellandrene, (*E*)-β-ocimene, eucalyptol and bornyl acetate. In *P. crispum*, emission of α-pinene, β-pinene and β-phellandrene were dominant and enhanced by microwave irradiation, especially in the case of WLAN-frequency microwave treatment (Fig. 4a). Treatment effects on monoterpene emissions were similar for *Apium graveolens* and *Anethum graveolens*, but the main components are at some extent different (Fig. 4b and c). Monoterpene emissions from *Anethum graveolens* were dominated by α-pinene, α-phellandrene and limonene, and these emissions were enhanced by microwave irradiation (Fig. 4b). In *Apium graveolens*, the emissions were almost four times lower than in the other species and were dominated by α-pinene, β-pinene and limonene (Fig. 4c). The emission of terpenes was inhibited by microwave irradiation similarly to the content of essential oils (Figs. 3 and 4).

Overall, these emitted monoterpenes are characteristic plant-released compounds and are not specific to stress-induced emissions (Staudt et al., 1997; Kesselmeier and Staudt, 1999; Staudt et al., 2000; Niinemets et al., 2010a,b). However, the emission rates of these typical monoterpenes is also often enhanced in stress conditions (Vuorinen et al., 2004; Blande et al., 2007; Heijari et al., 2008; Copolovici et al., 2011, 2012), implying that induced and constitutive emission are often difficult to separate. Among the characteristic induced monoterpenes (Staudt and Bertin, 1998; Hakola et al., 2001; Noe et al., 2006; Niinemets et al., 2010a,b), emissions of (*E*)-β-ocimene and 1,8-cineole were strongly enhanced by microwave-irradiation in *Anethum graveolens* (Fig. 4). In addition, both *P. crispum* and *Anethum graveolens*, emitted in low amounts longicyclene, a stress induced sesquiterpene, under WLAN-frequency irradiation.

Conclusions

The presented data collectively suggest that microwave irradiation constitute a stress to the plants, resulting in enhanced emissions of GLV, up-regulation of terpenoid emissions and modification in essential oil content and foliage anatomy. Anatomical and emission traits suggested that WLAN-frequency irradiation resulted in more severe stress than GSM-frequency irradiation,

but the effect of WLAN-frequency irradiation on essential oil was inhibitory. There was an agreement between anatomical and chemical traits with anatomically most resistant species *Apium graveolens* being chemically least responsive.

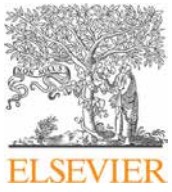
Acknowledgments

This work was supported by grants of the Romanian National Authority for Scientific Research, CNCS-UEFISCDI, projects numbers PN-II-RU-TE-2011-3-0283 and PN-II-RU-TE-2011-3-0022, Estonian Ministry of Science and Education (institutional grant IUT-8-3) and the European Commission through the European Regional Fund (the Center of Excellence in Environmental Adaptation) and the European Research Council (advanced grant 322603, SIP-VOL+). The authors thank to Dr. E. Surducan team (INCDTIM Cluj-Napoca) for all their experimental support with anechoic chambers.

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Ecological Indicators 108 (2020) 105683



Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind



Review

The influence of bioactive mobile telephony radiation at the level of a plant community – Possible mechanisms and indicators of the effects



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ARTICLE INFO

Keywords:
Wireless communication
Mobile phone radiation
Ecosystem
Ecological effect
Species diversity
Species interactions

ABSTRACT

Environmental exposure to radiofrequency electromagnetic fields (RF-EMFs) from mobile telephony has rapidly increased in the last two decades and this trend is expected to continue. The effects of this exposure at plant community level are unknown and difficult to assess in a scientifically appropriate manner. Such an assessment can be scientifically adequate if a studied plant community is completely new and control-impact radiation treatment is used.

In this review we aimed to predict ecological effects and identify indicators of the impact of bioactive RF-EMFs at the mobile telephony frequency range on plant communities. We considered the scenario where a plant community was exposed to radiation generated by a base transmitting station antenna mounted on a nearby mast. This plant community can be represented by mesic meadow, ruderal or arable weed community, or other herbaceous, moderately productive vegetation type. We concentrated primarily on radiation effects that can be recorded for a year since the exposure started. To predict them we used physical theories of radiowave propagation in vegetation and the knowledge on plants physiological responses to RF-EMF. Our indicators can be used for the detection of the impact of RF-EMFs on vegetation in a control-impact experiment.

The identified indicators can be classified into the following groups: (1) canopy parameters; (2) plant characteristics to be measured in the field or laboratory in a number of individuals that represent the populations of selected species; (3) community weighted means/medians (CWMs) of plant traits and strategies; (4) the abundance of other organisms that interact with plants and can influence their fitness or population size. The group of canopy parameters includes mean height, vertical vegetation structure and dry weight of above-ground standing phytomass. Plant characteristics requiring biometric sampling in the field are plant height, the number of fruits and seeds, as well as seed viability. The group of plant traits that are calculated as CWMs covers seed releasing height, seed dispersal mode, SLA, leaf orientation, month of germination and flowering, Ellenberg's light indicator value, and the proportion of individuals in the classes of competitors and stress tolerators according to Grime's CSR strategy scheme. The group of "non-plant" indicators includes primarily the frequency of flower visits by beetles, wasps, hoverflies, and bees that have their nests over ground. To detect ecological responses that occur for the first year since a herbaceous community has been exposed to potentially bioactive RF-EMF, the first two indicators groups should be used.

1. Introduction

The experiments of plant exposure to radiofrequency electromagnetic fields (RF-EMF) have been carried out at least since the 1970s (Tanner and Romero-Sierra, 1974). From 1974 to 2017 over 80 original peer-reviewed studies were published on this topic, and ca. 90% of them showed significant effects on plants such as the inhibition, or more rarely, stimulation of growth, changes in various metabolic activities and alteration of gene expression (Cucurachi et al., 2013; Senavirathna and Asaeda, 2014; Vian et al., 2016; Halgamuge 2017). In some of these studies (Pesnya and Romanovsky 2013; Halgamuge et al., 2015; Waldmann-Selsam et al., 2016) the exposure did not exceed the

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https://doi.org/10.1016/j.ecolind.2019.105683
Received 9 February 2019; Received in revised form 23 August 2019; Accepted 28 August 2019
Available online 14 September 2019
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levels that occur in the vicinity of mobile phone base stations (Mann et al., 2000; Urbinello et al., 2014; Chief Inspectorate of Environmental Protection of Poland, 2018). This means that the biological effects of RF-EMF observed under artificial, experimental conditions may occur also in the environment, at the scale of plant communities or ecosystems. Moreover, the size of these effects is likely to increase in the future, because the level of environmental exposure to RF-EMFs is expected to rise as a consequence of the increasing demand for mobile devices and services, as well as by the release of new high frequency bands for radiocommunication by governments (European Commission, 2016).

Although the literature on the effects of RF-EMF on plants is extensive, not a single field study has assessed the biological response at the level of a plant community or ecosystem, but nearly all the publications describe short-term laboratory studies conducted on single species. This dissonance is particularly striking in view of the fact that alterations in a plant community's structure and composition have long been considered to be well founded, sensitive and universal environmental indicators (de Boer, 1983; Stohlgren, 2006). This substantial literature gap developed possibly due to the practical difficulty to assess the impact of human-made electromagnetic radiation on an existing, multi-species plant community in a scientifically rigorous way (Smith, 2006). Studying this impact using a Control-Impact Design is problematic, as the patches of species-rich vegetation in the natural electromagnetic environment are already rare. This is because normally the zones with low human population density, and the absence of wireless communication infrastructure are characterized by vegetation of simplified ecological structure due to unfavorable climatic conditions and poor soils. In such conditions, the opportunity for studying plant-plant interactions, such as competition, is limited. One may think that vegetation patches isolated from anthropogenic radiation due to geomorphological conditions, i.e. located in valleys, gorges, canyons, etc., can be used as control but they may be functionally connected with other landscape elements (the surrounding vegetation patches), covered by wireless communication networks. Investigating the impact of EMFs on existing vegetation using a Before-After Design is also complicated, because the response of vegetation might be non-specific, which makes it difficult to distinguish the effect of artificial RF-EMF from the long-term effects caused by other environmental factors, which could have acted before the start of the irradiation. Besides, local environmental conditions may overcome or limit the expression of EMF-induced plant responses. Probably the most feasible way to investigate this impact in a scientifically correct way is to restore or create completely new patches of some specific vegetation type and use an experimental, control-impact radiation treatment. These patches should represent vegetation which is native to the area of study and includes many plant species that differ in terms of morphological or physiological features, to record different potential species-specific responses to RF-EMF. The experiment should be set up in an area where the biological impact of man-made radiation sources is negligible. The size and number of the new vegetation patches should ensure the representativeness of the resulting data. Half of each patch should be irradiated with experimental RF radiation from directional, microwave antennas to simulate the exposure under normal environmental conditions. Radiation effects could be assessed by comparisons of vegetation properties between the irradiated and non-irradiated part. In such a study RF-EMF impact can be isolated from other environmental impacts. The recent progress in restoration ecology and ecological engineering enabled ecologists to create species-diverse ecosystems in a relatively short time (Perring et al., 2015; Wainwright et al., 2018). Previous studies have mentioned different experimental ideas for testing RF-EMF effects in ecological communities; Cucurachi et al. (2013) postulated that such research could be carried out after experimental shutting down the communication stations for some period while Malkemper et al. (2018) proposed exposing the populations of wild animals to controlled RF field using coil-collars or coil systems around outdoor enclosures.

In this paper we aim at identifying useful ecological indicators of the effects of the exposure of a plant community to the radiation used by different mobile phone networks in rural or suburban areas. We focus mainly on the frequency range from 0.7 to 1.8 GHz, because this range is utilized by cellular technologies that contribute most to the outdoor exposure in rural and suburban areas (Joseph et al., 2012). To achieve this aim, we used theory that is applied in telecommunication engineering and remote sensing to model radiowave propagation in vegetation bodies. We searched for indicators that can be applied for the detection of the impact of EMF on vegetation in a control-impact *in natura* experiment, but not for environmental monitoring. We hope that this paper will help establish the theoretical basis to design such an experiment. The cited sources of data on plant species traits refer mainly to Central Europe, the region where we have conducted ecological studies. We considered the impact of RF-EMF on moderately productive, multi-species herbaceous community, in which inter-specific competition for light plays a significant role in shaping species composition and the architecture of canopy. By moderate productivity we mean 0.4–0.8 $kg\,m^{-2}$ of dry matter per year (Leuschner and Ellenberg, 2017) which equals to the production of 1.3–2.6 $kg\,m^{-2}$ of standing above-ground phytomass, assuming that gravimetric water content of the phytomass is 0.7 (Jefferson, 1999). This community can be represented by vegetation types such as species-rich mesic meadows, arable weed communities or ruderal communities that are composed of graminoids and forbs (Leuschner and Ellenberg, 2017). Herbaceous communities are particularly suitable to assess the radiation effects because:

1. physiognomy of herbaceous communities allows to determine their composition, foliage-canopy structure, and other characteristics relatively quickly and on small observation plots;
2. herbs undergo periodic shoot reduction and live for a relatively short time, which allows to observe their response to radiation from the development of above-ground tissues and organs to seed production;
3. the information on different canopy parameters is readily available for different herbaceous vegetation types; canopy parameters (vertical distribution of leaf area index, leaf area density, biomass density) are useful for analyzing RF-EMF propagation in vegetation;
4. the creation of herbaceous communities is faster and less complicated when compared to woods; also, the knowledge on the creation of semi-natural grasslands is particularly extensive because they are often restored for nature conservation;
5. some herbaceous communities, such as lowland dry meadows, represent a considerable diversity of plant species and traits, with multi-level, intricate relationships.

We focus our analysis on plant community responses that are most likely to occur during the first year of exposure to RF-EMF from base transmitting station (BTS), when new generation of herbaceous plant species passes the stages of vegetative and generative growth, and completes the stage of seed shedding. Note that the effects of mobile telephony radiation which have been noticed *in natura* in non-cultivated plants, have been reported probably only for trees and not for herbs (Appendix A). This may be because the relatively long life span of trees makes them exposed to radiation for longer periods. The duration of exposure may be as important as radiation power density and energy absorption rate (Belyaev, 2010). Therefore, the experiment suggested here might not detect some long-term effects that could be revealed if it was carried out for several years on woody perennials, such as *Calluna vulgaris*, or other evergreen chamaephytes. Nevertheless, the analysis for periods longer than one year (one growing season for annuals) is much more complicated because it requires including additional factors, such as plant life span, the position of the vegetative perennating buds during the winter (Raunkiaer's classification of plant life forms),

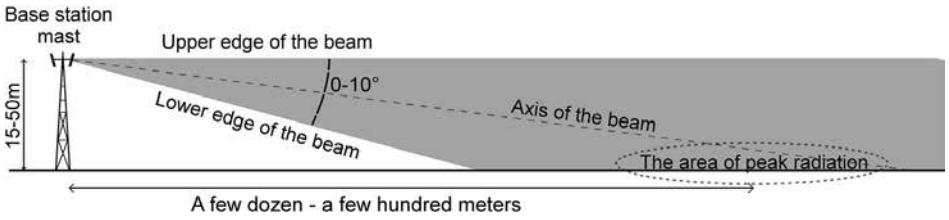


Fig. 1. Schematic diagram showing the shape of the beam formed by a typical directional antenna used with a macrocellular base station.

mode of reproduction, etc. With so many factors to consider, it is risky to make predictions on ecological responses of a plant community.

In this manuscript we will often refer to the radiation exposure level that is above the response threshold, estimated after a detailed analysis of the relevant literature, for plants or other living organisms that interact with plants in the considered vegetation types. For convenience, we use this descriptive term interchangeably with "biologically active" or "bioactive" radiation level.

2. Methods

In order to identify ecological indicators of RF-EMF impact on herbaceous vegetation, we performed an extensive literature review in three different stages in which different literature sources were used. This is reflected in the division of our manuscript into three relevant Sections (3, 4 and 5).

In the first stage (Section 3), we defined exposure conditions and key parameters of bioactive RF-EMF that represent expected real-life irradiation scenarios. We also described expected physiological plant responses to the radiation. Literature on this subject was summarized in Appendix A. In this summary, we excluded papers in which the information on radiation exposure level was not provided or significance of the obtained results was not determined. The defined radiation conditions and the expected specific plant physiological responses provided the framework of our study.

In the second stage (Section 4), we reviewed physical theory that can be applied to determine vertical distribution of RF-EMF in a herbaceous canopy and the absorption of radiation energy by individual plants. We also calculated the attenuation of RF energy that passes through the canopy of a herbaceous community. These calculations, presented in Appendix B, were essential to formulate the conclusions from our study.

In the third stage (Section 5), we used the described physical phenomena and introduced physical laws to predict ecological responses in a herbaceous community to RF-EMF. Based on these predictions, we proposed ecological indicators of RF-EMF impact.

The papers for our review were selected using Google Scholar, EMF-Portal (www.emf-portal.org) and Web of Science Core Collection. We considered only peer-reviewed studies, which were published in journals indexed in the Web of Science database.

3. Theory that underpins our study and provided basis for our predictions of radiation effects in plant communities

Our study is based on specific assumptions regarding conditions of the RF-EMF exposure. We consider these conditions as representative of real-life scenarios. We also expect specific plant physiological responses to the radiation. The following theory provides the framework of our study:

1. *Potential effects of man-made RF-EMFs on vegetation are most likely to occur in the areas surrounding mobile phone base stations.*

The measurements of RF-EMFs carried out in different developed countries show that power flux density in outdoor suburban and rural areas typically does not exceed 10^{-3} W m^{-2}, and the highest values are recorded near mobile phone base stations (Mann et al., 2000; Henderson and Bangay, 2006; Kim and Park, 2010; Urbinello et al., 2014; Chief Inspectorate of Environmental Protection of Poland, 2018). This means that the effects of man-made RF-EMFs on vegetation, if any, should probably be sought first in places of peak radiation around cellular base stations.

2. *Electromagnetic waves that most likely influence species interactions in a plant community, come from one dominant direction and fall at angle of 3–10° to the ground surface*

Transmitters which are utilized in a BTS usually comprise directional antennas that generate a cone-like beam of main radiation (that is wider in horizontal plane than in vertical). The lateral and vertical dimensions of the beam are defined in terms of their half power beam width, i.e. the angle between the points where power is reduced by 50% (3 dB). The beam is tilted slightly downwards so the top edge of the main beam is approximately horizontal, whereas the lower edge is directed up to 10° below horizontal. On the ground, the highest radiation level tend to occur between the point of incidence of the beam axis and the point of incidence of the lower edge of the main beam in the vertical plane (based on a 3 dB reduction of power) (Briggs et al., 2012). Over this distance, the emitted electromagnetic waves arrive at angle ranging from 3° to 10° (Fig. 1). When considering the heights at which antennas are mounted (15–50 m), this implies that the area of peak power flux density can be found a few dozen up to a few hundred meters from the foot of the mast on which antennas are installed (Appendix C). In this area, the electromagnetic signal from the local base station dominates the strength of radiofrequency signals measured, and signals from other environmental radio sources have little additional effect (Mann et al., 2000).

3. *The minimum bioactive exposure level (peak values of the pulsed signal) for plants can be expected typically within the range of 10^{-4}–10^{-2} W m^{-2}*

In order to determine the exposure level which is the threshold of response in plants, we conducted a detailed survey of literature where significant effects of RF-EMF were observed in plants at non-thermal exposure levels (see Appendix A). This literature indicates that the exposure level (time-averaged value) which is the threshold of response in plants can be expected typically within the range of 10^{-4}–10^{-2} W m^{-2}. This level may depend on the mean power level, carrier frequency, and the low frequency amplitude modulation of the electromagnetic signal (Halgamuge et al., 2015). The relationship between power flux density in the non-thermal range and the magnitude of effect is difficult to identify and is probably non-linear. In most studies the intensity of plants reaction increased with the increasing power density (Halgamuge et al., 2015; Waldmann-Selsam et al., 2016). Similar response regardless of the exposure level was observed by Roux et al. (2006). The assumed threshold value is based on limited evidence and mainly on short-term studies, so it should be regarded as tentative until more empirical data is collected.

4. *Polarization of electromagnetic waves, that is typical for RF-EMF generated from cellular antennas, may increase its bioactivity*

In wireless mobile communication systems, electromagnetic waves with linear polarization are often utilized. This polarization is often vertical because vertical antenna polarization has been the standard configuration for cellular BTSs for many years. In modern wireless systems, two orthogonal linear polarization are often used (Weitzen and Wallace, 2002). In radiowave propagation scenario considered in this paper there are no physical obstacles between the BTS and vegetation

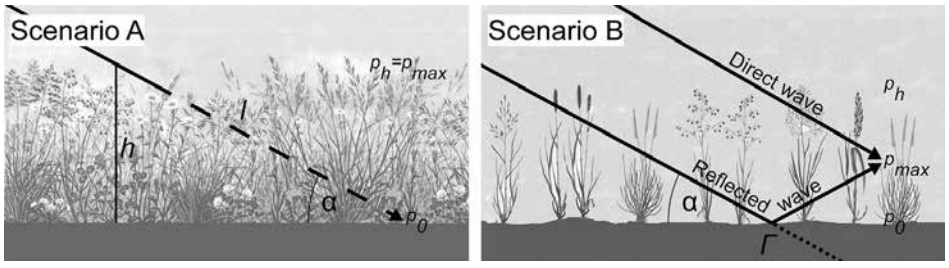


Fig. 2. The propagation of bioactive RF-EMF in the canopy of herbaceous vegetation; in scenario A the canopy is dense so that the radiation is attenuated to the level which does not elicit physiological response in plants; in this scenario, EMF power density is the highest above the canopy; in scenario B bioactive radiation penetrates the entire canopy profile and is reflected off or absorbed by the ground; in this scenario, EMF power density is the highest within the canopy; symbols used: h – mean canopy height; α – radiation incidence angle; l – radiation path length ($l = h/sin\ \alpha$; for $h = 1\ m$ and $\alpha = 3°$, $l = 19.1\ m$); p_0 – power density of the incident radiation at the ground level; p_h – power density of the incident radiation at height h; p_{max} – maximum power density in the canopy; Γ – ground reflection coefficient.

canopy (there is no wave diffraction nor reflection that could alter wave polarization on wave propagation path). Therefore it can be assumed that radiowaves that fall upon the vegetation canopy are also linearly polarized.

It has been hypothesized that polarized RF-EMF have the ability to disrupt the cell's electrochemical balance (Panagopoulos et al., 2015a). Wave polarization and field power density are two parameters that deserve special attention in our study, because these parameters change as radio wave penetrate vegetation canopy (see Section 3).

5. *The ultimate physiological effects of long-term exposure of plants to RF-EMF are adverse and lead to the deterioration of plant condition as well as to the inhibition of growth and development*

Although RF-EMF can both stimulate and inhibit plant germination, development or growth, an inhibitive impact was observed in the overwhelming majority of the studies (Appendix A). Different hypotheses have been developed to explain the mechanisms that underlie this impact (see Appendix D for the review of these hypotheses), but further research is needed in this area. Nevertheless, physiological responses in plants are similar to those triggered by injurious stimulation or environmental stressful conditions, such as drought, heat, cold, high salinity, soil mineral deficiency and toxicity (e.g. Beaubois et al., 2007; Sharma et al., 2009; Singh et al., 2012; Soran et al., 2014). Plant responses were observed not only in the tissues directly exposed but also in distant organs (Beaubois et al., 2007). Some researchers postulate that the stress response of plant and animal cells should be an appropriate biological guideline to evaluate electromagnetic safety and the effects of long term and complex repeated exposures (Blank and Goodman, 2004; Panagopoulos et al., 2015b).

4. Radiofrequency radiation exposure of plants in a herbaceous canopy in the language of physics

4.1. Vertical distribution of potentially bioactive electromagnetic field in a herbaceous canopy

Biologically active radiofrequency radiation can have various effects on a herbaceous community, depending on its intensity in the vegetation canopy. Therefore, it is important to determine vertical distribution of EMF energy in the canopy. In the assumed propagation scenario (Section 2), this distribution is determined mainly by frequency and power density of the radiation falling upon the canopy, the inclination of radiation beam axis, reflection from the ground surface as well as by the properties of the irradiated vegetation canopy. The properties of canopy considered here are its height and the coefficient of wave attenuation (or extinction) in vegetation, γ (dB m^{-1}) (Goldhirsh and Vogel, 1998; Chukhlantsev, 2006). The value of γ depends on the absorption and scattering of radiation in a vegetation medium (Goldhirsh and Vogel, 1998; Chukhlantsev, 2006). It can be calculated using Eq. (1) (Chukhlantsev, 2006):

$$\gamma = \rho \times m_v \times b, \quad (1)$$

where:

ρ – vegetation volume density, i.e. average vegetation mass in the canopy per unit volume (kg m^{-3});
m_v – volumetric moisture content of plants (–);
b – proportionality coefficient (dB kg^{-1} m^2).

Empirical studies showed that at decimeter wavelengths (frequency 1–2 GHz) the value of b is similar for alfalfa, rye, wheat, pea, pasture grasses and other common agricultural crops that represent different plant architectures (broad-leaved forbs vs. narrow-leaved graminoids) (Chukhlantsev, 2006; Appendix B). This indicates that the value of b determined for crop plants can be used also for different types of multispecies herbaceous vegetation, including grasslands as well as ruderal and arable weed communities.

Theoretical calculations and field measurements carried out for the frequency range from 1 to 2 GHz show that the attenuation coefficient ranges from 1.0 to 2.0 dB m^{-1} for the considered herbaceous communities (Chukhlantsev, 2006; Mestre et al., 2010; Olasupo et al., 2016; Appendix B). This means that for slant-path propagation in which the EM wave propagates in canopy on much larger distances than its height, high and dense herbaceous canopies attenuate radiation power density by one or two orders of magnitude before the electromagnetic waves reach the ground surface. This in turn suggests that the exposure of plants to biologically active radiation can occur mainly in the upper and middle parts of herbaceous vegetation profile, whereas the exposure levels near the ground are below plants' response threshold to radiation (Fig. 2, Scenario A). It should be noted, however, that systemic responses routinely occur in plants after local (i.e. partial) stimulation, including exposure to RF-EMF (Beaubois et al., 2007). Consequently, a direct exposure of plant tissue may not be required to achieve biological responses.

Attenuation of microwave radiation in vegetation to the levels below plants' response threshold was observed by Waldmann-Selsam et al. (2016). The authors recorded unilateral damages of tree crowns for approximately 700 deciduous and coniferous trees exposed to radiation from phone masts. On the side facing a phone mast, crowns were characterized by sparse foliage, premature color change of leaves, dead branches and other damages, while on the opposite side of the crowns, these damages were not observed. It can be expected that the radiation from a BTS that passes through high herbaceous canopy is attenuated to a similar degree as in tree crowns. This is because the attenuation coefficients for the crowns of tree species studied by Waldmann-Selsam et al. (2016) are similar to those in herbaceous canopies (they range from 0.7 to 2.0 dB m^{-1} at the frequency of 870 MHz, Goldhirsh and Vogel, 1998). Also the diameters of tree crowns are similar to the lengths of radio paths in herbaceous canopies (Fig. 2, Scenario A; Appendix B).

It should be emphasized that attenuation of RF-EMF in vegetation to the levels below plants' response threshold can occur only if the canopy is high and dense, and the constituent plants are still growing (so that water content in plant tissues remains high). As suggested by our calculations (Appendix B), bioactive radiation from a BTS penetrates the entire canopy down to the ground surface if vegetation is sparse or low (spring) or if plant hydric status is lowered (which occurs in autumn,

when plants have entered into the phase of senescence). Radiowaves that pass through herbaceous canopy are partially absorbed in the upper layer of soil and also partially reflected off its surface. In such case, direct and reflected wave interfere with each other. Depending on their phases they can add their energy (when there is no phase difference) or decrease their energy (where there is 180° phase shift between them). Reflection coefficient Γ (the ratio of reflected wave amplitude to the incident wave) for typical ground is 0.6, so the reflected wave has significantly lower amplitude than the direct wave. Direct and reflected waves that add their energy are expected to increase the total power density near the ground by a factor up to four (but for typical grounds it does not exceed 3.0) (Mann et al., 2000; European Committee for Electrotechnical Standardization, 2017). In such circumstances, maximum EMF power density (p_{max}) can occur in the middle, not upper vegetation layer (Fig. 2, Scenario B). For such a scenario, vertical distribution of power density in the canopy can be estimated using a simplified two-ray model. In this model, the electromagnetic field in each point above the reflecting surface is computed with a direct and reflected wave that are added with respect to their phases (Pérez-Fontán and Mariño Espiñeira, 2008). The height in the canopy, where the combination of these two waves gives rise to an interference pattern with the maximum amplitude, is not constant. It increases with increasing wave length and incident angle α. This height, as well as vertical distribution of EMF energy in general, might also depend on the value of Γ and ρ, the latter being usually varied in the canopy profile. It should be stressed that the amplitude of the reflected wave in the considered case can be considerably reduced compared to the energy of the direct wave. This reduction is the effect of the attenuation by vegetation canopy along the path from its top to the bottom (l in Fig. 2) and the reflection off the ground.

For both scenarios, the radio energy that reaches ground is relatively small. This suggests that biological effects of radiation absorbed in the soil are also small and probably insignificant, but this hypothesis is worth exploring in a specifically designed research.

4.2. Physical plant species characteristics that influence the absorption of radiofrequency energy by individual plants

It is generally accepted that biological effects observed in a plant that is exposed to RF-EMF depend on the power absorbed by the plant during the exposure (Vian et al., 2016). This power is determined using the specific absorption rate (SAR), which is an EMF exposure metric for living tissues (Vian et al., 2016). A key factor that determines SAR for plants is the water content of their tissues (Vian et al., 2016; Waldmann-Selsam et al., 2016). Water content of plants has a dramatic impact on their dielectric properties, which are, by definition, a measure of the polarizability of a material when subjected to an electric field (Trabelsi and Nelson, 2003). Another factor that can greatly influence SAR for plants is their architecture (Vian et al., 2007, 2016), particularly in a community that is irradiated from one dominant direction and the distribution of the radiation energy is not uniform in the community profile (the scenario analyzed here). Based on the theory of radiowave propagation in vegetation (Chukhlantsev, 2006), SAR might be higher for plants that have relatively large total surface area of leaves and arrange their leaf blades perpendicular, rather than parallel, to the radiation beam axis. Also, SAR is likely to be higher for plants that have their foliage located higher than their neighbors.

5. Radiofrequency radiation exposure of plants in a herbaceous canopy in the language of ecology

5.1. Plant species' traits that are most likely to be affected by RF-EMF exposure

5.1.1. Common traitbases as a reference for the identification of ecological indicators

Making predictions on the structure, dominance and diversity of a plant community from plant-level responses is very difficult because plant communities create complex and dynamic systems. To make such predictions easier, ecologists use a functional approach, which consists in reducing the number of species investigated by grouping them into 'functional groups'. Functional groups are distinguished by 'functional traits' of species, i.e. traits which are considered relevant to the response of those species to the environment and/or their effects on ecosystem properties (Violle et al., 2007). The use of functional approach in ecology was largely facilitated by the compilation of species functional traits in databases, such as LEDA, BIOLFLOR, TRY etc. (Klotz et al., 2002; Kleyer et al., 2008; Kattge et al., 2011). Thus, the functional characteristics of a plant community can be often derived from species composition only, without measuring traits of those species in the field. The development of traitbases was associated with the publication of handbooks with protocols for standardized measurements of plant traits (e.g. Pérez-Harguindeguy et al., 2013). We used these traitbases and protocols as a reference to propose ecological indicators from plant biophysical parameters that can influence absorption of radiofrequency radiation (Section 3).

5.1.2. Height at which foliage is developed

If the radiation that illuminates a herbaceous community is attenuated to non-bioactive levels before it reaches the soil surface (Fig. 2, Scenario A), the propagating energy is expected to be absorbed mostly by species that develop high canopy or large tussocks, because these species are not shielded by other plants. Also, tall-statured species are likely to respond to the radiation in a different way than their smaller neighbors because of different microhabitat conditions. In the bottom layer of herbaceous canopies light intensity is greatly reduced, and air humidity can be considerably increased. In the middle layer, air temperature is the highest (Fliervoet and Werger, 1984). Plant height can be easily measured in the field, in the number of individuals that represent the populations of selected species within a plot (Pérez-Harguindeguy et al., 2013). The information on species canopy height has also been collected in traitbases and it is available for most plant species occurring in the temperate zone (Kleyer et al., 2008; Kattge et al., 2011). Plant canopy height is positively associated with plant's ability to compete for light and the capacity for carbon gain (Anten, 2005). However, the fractional allocation of biomass to leaves (another trait which can influence plants response to EMF) generally decreases with height, because height growth involves investments of biomass in support structures (stems, branches and petioles) to maintain mechanical stability (Anten, 2005).

5.1.3. Seed releasing height, seed dispersal mode and seed viability

Relative differences in stature between plant species in a multispecies grassland canopy, and the related absorption of biologically active electromagnetic radiation depend also on the height at which inflorescences and fruiting heads are elevated. This characteristic seems particularly important in the context of the exposure of seeds to RF-EMF, because it can modify the rate and time of their germination (Scialabba and Tamburello, 2002; Jinapang et al., 2010; Pietruszewski, 2011). In many species, seeds contain a very dehydrated embryo which incubates the reserves (exalbuminated seeds). In the other seeds, the reserves remain outside the embryo in specialized tissues (endosperm or perisperm) whose cells are often no longer alive when they are mature. Most of them also have solid integuments that limit oxygen

availability in the seed, which inhibits metabolism. It is thus possible that their particular constitution (very low water content, low oxygen tension) makes these organs insensitive to EMF exposure as long as the imbibition has not occurred. The situation is different in fruits, particularly in fleshy fruits or immature dry fruits where the high water content may facilitate interaction with EMF (Kundu and Gupta, 2014; Kundu et al., 2016). It could be hypothesized that an interaction between electromagnetic fields and fruit would have a negative impact on future seed germination. We are currently unaware of any work that raises this question, but the importance of seeds in the population dynamics of many communities makes this a point that should be the focus of future investigations.

The height at which fruits are developed in plants is greatly determined by seed dispersal mode. Relatively high elevated fruits are typical of plants that disperse their seeds by wind (anemochoric plants). For the other seed dispersal modes (hydro, endozoo-, epizoochory), the elevation of fruits is of lesser importance (van der Pijl, 1982). Seed germination rate and time can be tested in a laboratory (Baskin and Baskin, 2014). The height at which fruits are developed and the potential for wind dispersal can be found in traitbases for most herbs in Europe. In LEDA traitbase seed releasing height for plant species is given (Kleyer et al., 2008) and in the D^3 traitbase anemochory ranking index is specified (Hintze et al., 2013).

Increased irradiation of flowers in plants growing in a herbaceous vegetation raises questions about RF-EMF effects on the viability of pollen (plant microgametophyte). Pollen is a very small structure (2–3 celled) that has haploid genome, which makes it especially sensitive to gene alteration. Some experiments show that pollen germination was affected by EMF, but they were conducted for low frequencies (Dattilo et al., 2005; Betti et al., 2011; Majd et al., 2013). Further research is required to determine if pollen formation (meiosis of mother cells, tetrad set-up, cell wall acquisition) or functioning (elaboration of pollen tube, delivering of sperm cells to the female gametophyte) can be affected by RF-EMFs.

5.1.4. Leaf area and leaf water content

Total surface area of leaves is not widely used in between-species comparisons because it is very time-consuming to determine this parameter for many plant species (Norman and Campbell, 1991). The associated, much more popular species attributes are mean area of a leaf (LA; LA × no. of leaves = total surface area of leaves) (Kleyer et al., 2008), leaf area per shoot biomass (LAR), and leaf mass as a fraction of total mass (LMF) (Wright et al., 2004; Pickup et al., 2005; Pérez-Harguindeguy et al., 2013). Data on species leaf water content is not typically included in traitbases, but it can be easily derived from the information on the content of leaf dry matter (LDMC), the complementary component of a fresh leaf. LDMC is a standard trait in ecological databases (Kleyer et al., 2008; Kattge et al., 2011). The ratio of LA and LDMC yields specific leaf area index (SLA), a characteristic which is considered a principal functional trait of plants (Westoby, 1998). Specific leaf area might be a sensitive indicator in studying the response of plant species to RF-EMF due to the direct dependence on LA and LDMC.

5.1.5. Orientation of leaves

Plants that have vertically inclined leaves are more exposed to the radiation than individuals with horizontally oriented leaves when the incident wave is nearly horizontal. Leaf orientation, which remains constant through the leaf life span, is considered a species-specific trait, and it has been already determined for a few thousand taxa (Kattge et al., 2011). Horizontal or shallow angled leaves allow for greater light interception and potentially greater carbon gain, but they also increase self-shading of individuals, genets or ramets within a species. Therefore, horizontal leaves are common in non-clonal species and the “guerrilla” clonal species, which extensively spread their stolons or rhizomes. Vertical leaves are typical of clonal plants whose ramets are closely spaced and shade one another (“phalanx” growth form, typical of tussock species). In those plants light can be utilized by leaves at lower layers, because it passes between the upper leaves. This way, photosynthetic capacity and carbon gain of the whole clone are maximized (Hikosaka and Hirose, 1997; Anten, 2005).

5.1.6. Time of germination and growth

The absorption of radiofrequency energy and its biological effects may be particularly significant for plant species that develop their foliage early in the growing season, earlier than the neighbors in a multispecies plant community. Plants that germinate and emerge later may be protected from bioactive EMF because they are shielded by their neighbors. The irradiation effects for early-season plants may be important not only because they grow in a sparse canopy created by dead or still dormant shoots of the other species, but also because the irradiated young tissues leaves undergo the phase of fast growth and contain relatively much water. Serious radiation damages in juvenile plants, exposed to weak EMF, were described by Stefi et al. (2016, 2017a,b,c). The exposure of a juvenile plant to bioactive EMF can affect fitness of this plant in the long term. Grémiaux et al. (2016) showed that axillary buds of *Rosa hybrida*, that were exposed to extremely low intensity RF-EMFs, produce shoots that grow slower than shoots produced by non-irradiated plants. This effect was observed a few weeks after the exposure had ended.

5.2. Stage of vegetation growth as an important criterion in selecting the indicators

The effects of each of the above-mentioned traits on the absorption of RF energy by plants change over time. In spring, when the considered plant community is young, sparse and low, electromagnetic waves may penetrate entire vegetation profile and reach the surface layer of soil (see Section 3). At this time, probably the most important factor that determines energy absorption by individual species is month of their germination, seedling emergence and development of above-ground organs. Other traits, important at this early stage of community development, are water content in plants, as well as the area and orientation of leaves.

At the end of spring, thick and dense canopy of plants is developed, and, as a result, the intensity of inter-specific competition for light increases. In these conditions most of the bioactive radiation is likely to be absorbed or scattered in the upper part of the vegetation profile. Therefore, at this time, the absorption of RF energy by individual plant species greatly depends on the characteristics which determine plant's success in the competition for light, particularly on canopy height.

5.3. Plant-plant interactions

There are different forms of plant-plant relationships in mesic grasslands: competition, allelopathy, parasitism, facilitation and mutualism. Among these interactions, competition has always been foremost in the understanding of community structure in herbaceous communities (Gibson, 2009; Grime, 1979). Competitive relations drive differentiation of canopy height, SLA, leaf inclination, and other species traits within a community. They are also commonly considered to determine plant community composition, productivity, dynamics, and diversity in grasslands (Grime, 1979; Briske, 2007). Competition, which may revolve around different environmental resources: water, light, and nutrients, occurs between individuals of different species (interspecific competition) and between individuals of the same species (intraspecific competition). In multispecies herbaceous communities, the exclusion of plant species is most often caused by the competition for light (Hautier et al., 2009), which is associated with the directionality of light supply. Due to this directionality, faster growing or taller species can preempt this resource and shade those beneath. A small advantage in height therefore allows much more of the light to be

intercepted, conferring a disproportionately large competitive advantage. This mode of competition, which is disproportionate to some measure of size, is called 'size-asymmetric' (Vojtech et al., 2007). In contrast, the competition for water and nutrients is often assumed to be size-symmetric, because these resources are supplied omnidirectionally.

The reduction of the fitness of fast growing and tall-statured species under radiowave exposure is expected to cause the decrease in the asymmetry in the competition for light. Theoretically, this should lead to the overall slowdown of the growth of plants and the reduction of relative differences in size between them (Vojtech et al., 2007). We note, however, that these hypothetical effects may prove to have limited significance due to the fact that species of the greatest ability to compete for light, project their leaves horizontally to monopolize this resource, which reduces RF-EMF effects.

Plants can communicate through volatile organic compounds (VOCs) that act both as allelochemicals and as neighbour detection signals (Kegge and Pierik, 2010). The emission of VOCs was recently found to be evoked by EMF exposure (Soran et al., 2014; Lung et al., 2016) but the effects at plant community level have not been evaluated yet. Moreover, there may be functional link between EMF-stimulated VOCs emission and several plant-insect interactions, such as pollination or pathogenicity (see Section 4.6), because VOCs are signal-molecules for these interactions (Heil, 2014).

One might also hypothesize that RF-EMF increases the role of facilitation in structuring plant communities. It is easy to explain it for the scenario in which radiation power density is the highest in the upper layer of the vegetation exposed to bioactive RF-EMF (Fig. 2, Scenario A). In these exposure conditions large or tall-statured species facilitate growth of their smaller neighbors by shielding them from the radiation. Predicting changes of the other forms of plant-plant relationships runs a high risk of drawing erroneous inferences because these relationships are poorly known and their role can be very different across the types of herbaceous vegetation. It is also difficult to identify universal indicators of such effects. The comparison of metabolic profiles between directly exposed plants and their neighbors, more or less protected (masked) could constitute a first method to answer these questions. Indeed, these techniques have progressed significantly in recent years and they are competitive alternatives to more traditional approaches (Arbona et al., 2013). In addition, precise information provided by these analyses makes it possible to search for morphological markers in adequacy with these modifications (i.e. height of plants and diameter of their stems if lignification is increased).

5.4. Plant ecological strategies

Ecological response of a herbaceous community to RF-EMF can be better predicted if considered in relation to plant strategies, i.e. the manners in which species secure carbon profit during vegetative growth and ensure gene transmission into the future (Westoby et al., 2002). Strategies represent multiple functional traits, which are correlated due to evolutionary or biophysical constraints and trade-offs (Reich et al., 2003). When vegetation descriptions are condensed into strategy categories rather than listing each species individually, ecologically important information is retained and instructive patterns and contrasts between communities emerge.

Among many ecological strategy schemes (or models) proposed (see review in Westoby, 1998), the CSR model developed by Grime (1979) is the most widely used now. In Grime's model, three different plant life histories represent a continuum of adaptations and trade-offs to interspecific competition (C), environmental stress (S), or disturbance (R) – for ruderals. Competitors are species that are able to maximize relative growth rate (RGR_{max}), and rapidly make use of abundant above- and below-ground resources. Stress tolerant species are distinguished by low RGR_{max} and the ability to withstand low resource levels and low disturbance. Ruderals are species that can exploit newly created, low-stress, highly or frequently disturbed habitats. The impact of artificial RF radiation, if analyzed from the perspective of Grime's scheme, would be the most negative for competitors, whereas stress-tolerant species would be the least affected. The information on strategy according to Grime for plant species occurring in Europe has been collected in Biolflor traitbase (Klotz et al., 2002).

Another strategy scheme, which is potentially useful for this analysis, is based on species tolerance for shade (realized light niche), expressed in so-called 'light indicator value'. In Central Europe, the most extensively used classification of species with respect to light was created by Ellenberg and Leuschner (2010), who ordered species from those that have their peak occurrence in shaded habitats (low indicator values) to those that typically occur in sparse canopies or develop higher canopy than the neighbors (high indicator values). It may be hypothesized that species with highest indicator value for light are also the most affected by biologically active, man-made RF radiation. However, species with high L-numbers may have also hardy leaves, indicated by low SLA and low LAR, which may reduce the absorption of RF-EMF.

One more scheme of plant strategies, which is relevant to our study, was created by Westoby (1998). In this model the strategy is determined by three traits: canopy height, SLA and seed mass. In our study, canopy height and SLA were also identified as potentially important for the absorption of RF radiation (Section 4). The key role of these traits in distinguishing different strategies of plants confirms that man-made RF-EMF, if biologically active, influences not only selected species, but also general community-level processes.

5.5. Mean height and vertical structure of vegetation canopy

It is possible that RF-EMF can influence not only morphology of individual plants and interactions between them, but also the physiognomy of plant community composed by those plants. This is particularly likely when this community physiognomy is shaped by plants affected by the radiation or when the intensity of competition is decreased under RF-EMF exposure (see Section 5.3). The physiognomy of plant community is often characterized using mean height, vertical structure of canopy and the dry weight of above-ground standing phytomass. These parameters can be sensitive indicators of RF-EMF bioactivity because they can be determined with precise, convenient and standardized methods (Laca and Lemaire, 2000; Stewart et al., 2001; Zehm et al., 2003).

5.6. The interactions between plants and other living organisms

5.6.1. Rationale for the studies on RF-EMF impact on plants mediated by other organisms in herbaceous vegetation

In a herbaceous community, the fitness, reproduction and survival of plants depend on other species groups, such as insects, snails, mammals or fungi. These organisms could also be influenced by RF-EMF at environmental radiation levels (see below). This means that RF-EMFs could affect plant community properties directly, by affecting the irradiated plants, and indirectly, through the impact on organisms that interact with plants. Although there is not enough empirical evidence yet to evaluate to which extent these indirect effects can modify radiation effects in plants, it is certain that animals and other organisms that interact with plants can play key ecological roles in herbaceous communities. Therefore, in the next sections, we review current knowledge on the effects of radiation on them and shortly describe how these RF-EMF indirect effects could be estimated in the proposed experiment.

5.6.2. Plant-insect interactions

Plant-insect interactions are ubiquitous and important for the survival of plants. Several laboratory studies on different insect species have shown negative effects of mobile telephony radiation on their reproductive success (e.g. Panagopoulos and Margaritis, 2010;

Panagopoulos et al., 2010; Sharma and Kumar, 2010). Radiofrequency EMF may also affect visual and olfactory memory (Cammaerts et al., 2012), and locomotion and orientation (Cammaerts et al., 2014; Cammaerts and Johansson 2014) of insects.

Plant-pollinator interactions are one of the most important plant-insect interactions that can be affected by electromagnetic fields in the environment, because losses in the pollinator community may threaten the sexual reproduction of plants and affect the diversity and composition of plant communities. Studies on honeybees have shown that radiation by mobile phone devices can decrease colony strength and oviposition rate (Sharma and Kumar, 2010), induce worker piping, a behavior associated with swarming (Favre, 2011), and reduce hatching of honeybee queens, although not mating success once succeeded the point of pupal development (Odemer and Odemer, 2019). It has also been reported that under electromagnetic radiation, honeybees may encounter difficulties to return to their hives resulting in a massive loss of workers (Sharma and Kumar, 2010). However, still very little is known about the effect of electromagnetic radiation on other insect pollinators in field conditions. Only one study to our knowledge has evaluated the abundance and diversity of pollinators in wild communities in relation to electromagnetic radiation (Lázaro et al., 2016). This study showed that as radiation levels in the environment augmented, the abundance of several pollinator guilds (beetles, wasps and hoverflies) decreased, whereas the abundance of other groups of insects (underground-nesting wild bees and bee flies) increased. Lázaro et al. (2016) hypothesized that larvae developing aboveground (many beetles, wasps, many hoverflies) might be more vulnerable than those developing underground (underground nesting wild bees), because the former may be exposed to higher radiation levels. Pollinators potentially more tolerant to radiation might fill the vacant niches left by less tolerant species and increase their populations. At any rate, radiation-related changes in the composition of wild pollinators in natural habitats might have ecological impacts on the maintenance of wild plant diversity, and therefore, more studies are needed to evaluate potential changes in the pollinator community in relation to RF-EMF.

Herbaceous communities are normally diverse and very attractive to pollinators, and therefore, they are usually associated with a diverse community of pollinators belonging to many different functional groups. These communities might be particularly exposed to radiation in comparison to others, such as forest communities, because they are more open and therefore they can be easier penetrated by electromagnetic waves. Based on available information, under a scenario of increased electromagnetic radiation, it would be expectable to detect honeybee losses and the relative loss of beetles, wasps, and hoverflies in wild pollinator communities. The decrease in the frequency of flower visits by these insects that develop aboveground, could result in lower seed production in the plants that are pollinated by them and, in the long term, it could lead to the decrease of the populations of these plant species, particularly if they are not able to self-pollinate. The identity of main pollinators of different focal plant species as well as the potential decrease in the number of flower visits under RF-EMF exposure could be detected by means of hand-netting transects to observe flower visitors (Dafni, 1992). Fruit and seed production could be estimated by marking flowering branches in the blooming peak of the community and counting fruits and seeds produced by them after the pollination period (Dafni, 1992). If species' capability of self-pollinating is not available in literature, it could be evaluated using bagging experiments that prevent insects from contacting the reproductive parts of the flowers (Dafni, 1992).

Even more unknown are the effects of radiation on other plant-insect interactions that might be important for the survival of plants, such as the interactions with insects for seed dispersal, or antagonistic interactions such as herbivory or granivory. However, some studies indicate that electromagnetic radiation could be used for pest management in cultivars, as it can control their populations by disrupting development of these harmful insects. For instance, radio-frequency radiation affects weight, development and survival in the larval stage of tobacco hornworms, *Manduca sexta* (Schwartz et al., 1985) and causes mortality of the granary weevil, *Sitophilus granarius* (Ponomaryova et al., 2009). As all these studies were carried out in conditions of much higher radiation levels than those found currently in the environment, it is difficult to predict the response of these antagonists. Monitoring the levels of herbivory in leaves and flowers, as well as seed predation in experimental conditions of radiation in comparison to control communities, and estimating their effect on plant reproductive success, will help to understand whether radiation at lower levels also has a negative impact on the antagonist insects of plants and, in turn, indirectly influence plant performance and reproduction.

5.6.3. Interactions between plants and vertebrates

Different groups of vertebrates can interact with plants in a herbaceous community that is exposed to experimental RF-EMF treatment. Among vertebrates that occur in temperate European herbaceous communities and live at least partly aboveground, rodents (*Rodentia*) and shrews (*Soricidae*) have particular ecological importance (Hayward and Phillipson, 1979). Rodents, such as a vole (*Microtus*) or a mouse (*Apodemus*) can impact herbaceous ecosystems mainly through the consumption of plant biomass and selective grazing on more palatable plant species. Shrews are small predators that have a major effect on invertebrate communities in herbaceous vegetation due to their capacity for high population densities and consumption rates (Churchfield et al., 1991). Rodents are likely to be more exposed than shrews to artificial RF-EMFs because they forage above ground level. Shrews, by contrast, are predominantly foragers at ground level or in subterranean burrows (Churchfield et al., 1991). Experimental studies show that when rodents are excluded from grasslands, aboveground plant biomass increases, litter decomposes slower and graminoids invade plant community over 2–3 year time scales (Howe et al., 2006; Moorhead et al., 2017). In bioelectromagnetic research, small rodents comprise an extensively studied group of vertebrates. Despite this, the findings of RF-EMF influence can be described as contradictory and inconclusive if environmental levels of RF radiation are considered (Cucurachi et al., 2013; Malkemper et al., 2018). Negative response of rodents nesting in the area under experimental RF-EMF might be detected by the increase in the abundance of grass species that are most preferred by those rodents. This abundance should be considered in relation to the abundance of other grass species that are less often eaten by rodents but have similar traits that can influence their exposure to RF-EMF (see Section 5).

5.6.4. Other interactions

Biotic interactions that occur in the upper layer of grassland vegetation involve not only plant-plant or plant-insect relationships, but also interactions with endosymbiotic bacteria and fungi, arachnids, snails, slugs, as well as with fungal, bacterial, viral, or mycoplasma pathogens (Haggar et al., 1984). The impact of RF-EMF on these organisms remains largely unknown (Cucurachi et al., 2013). The activity of plant pathogens under RF-EMF exposure can be assessed through observations of phenotypic abnormalities in plants, such as leaf spots, leaf blotch, chlorosis etc. Similarly, the activity of slugs or snails can be determined by the size of holes (feeding damages) in leaves or flowers. Other interactions are more difficult to observe.

6. Conclusions

In this study, we identified several indicators of the impact of bioactive mobile telephony radiation at the level of a plant community. We considered the scenario where a herbaceous plant community was exposed to radiation generated by a BTS antenna mounted on a nearby mast. The identified indicators can be used for the assessment of the impact of RF-EMF on vegetation in a control-impact experiment, but not for environmental monitoring, as when there is not a controlled

experimental set up, the effect of radiation can be confounded with the effects of other environmental factors. Since these indicators represent different types of community parameters and they are determined using different methods, it is useful to classify them into the following groups:

(1) canopy parameters;
(2) plant characteristics that need to be measured in the field in a number of individuals that represent the population of a selected species within a plot;
(3) community weighted means/medians (CWMs) of plant traits and strategies which are derived from species composition and abundance recorded within the study plots that represent an investigated plant community (the information on these traits and strategies, determined for individual species, is available in online databases);
(4) the abundance of other organisms that interact with plants and can influence their fitness or population size; in this group, the abundance of insects that pollinate plants is particularly important.

The group of canopy parameters includes mean height, vertical vegetation structure and dry weight of above-ground standing phytomass. Plant characteristics requiring biometric sampling in the field that can be suitable to detect the effects of RF-EMF are plant height, the number of fruits per plants, the number of seeds per fruit or seed head as well as seed viability. The group of plant traits that are calculated as CWMs covers seed releasing height, seed dispersal mode, SLA, leaf orientation, month of germination and flowering, and Ellenberg's indicator value for light. It can also be useful to calculate the proportion of individuals in the classes of competitors and stress tolerators according to the CSR strategy scheme (Grime, 1979). The group of "non-plant" indicators includes the frequency of flower visitations by beetles, wasps, hoverflies, and bees that have their nests over ground, and in some cases, also the abundance of invertebrate herbivores and seed predators.

The first two groups of indicators: canopy parameters and plant characteristics that require biometric sampling in the field can be used to detect ecological responses that occur for the first year since a herbaceous community has been exposed to bioactive RF-EMF. Community weighted means/medians of traits are less sensitive when it comes to the detection of short-term ecological responses to RF-EMF. This is because species composition of plant communities might remain largely unchanged throughout one growing season even if environmental conditions are altered.

Acknowledgements

Marek Czerwiński wishes to thank Prof. Stanisław Kozłowski, Department of Grassland and Natural Landscape Sciences, Poznan University of Life Sciences, for his advice and inspiring discussions on the topic of this manuscript.

Funding

Amparo Lázaro was supported by a Ramón y Cajal contract (RYC-2015-19034) from the Spanish Ministry of Economy and Competitiveness.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ecolind.2019.105683.

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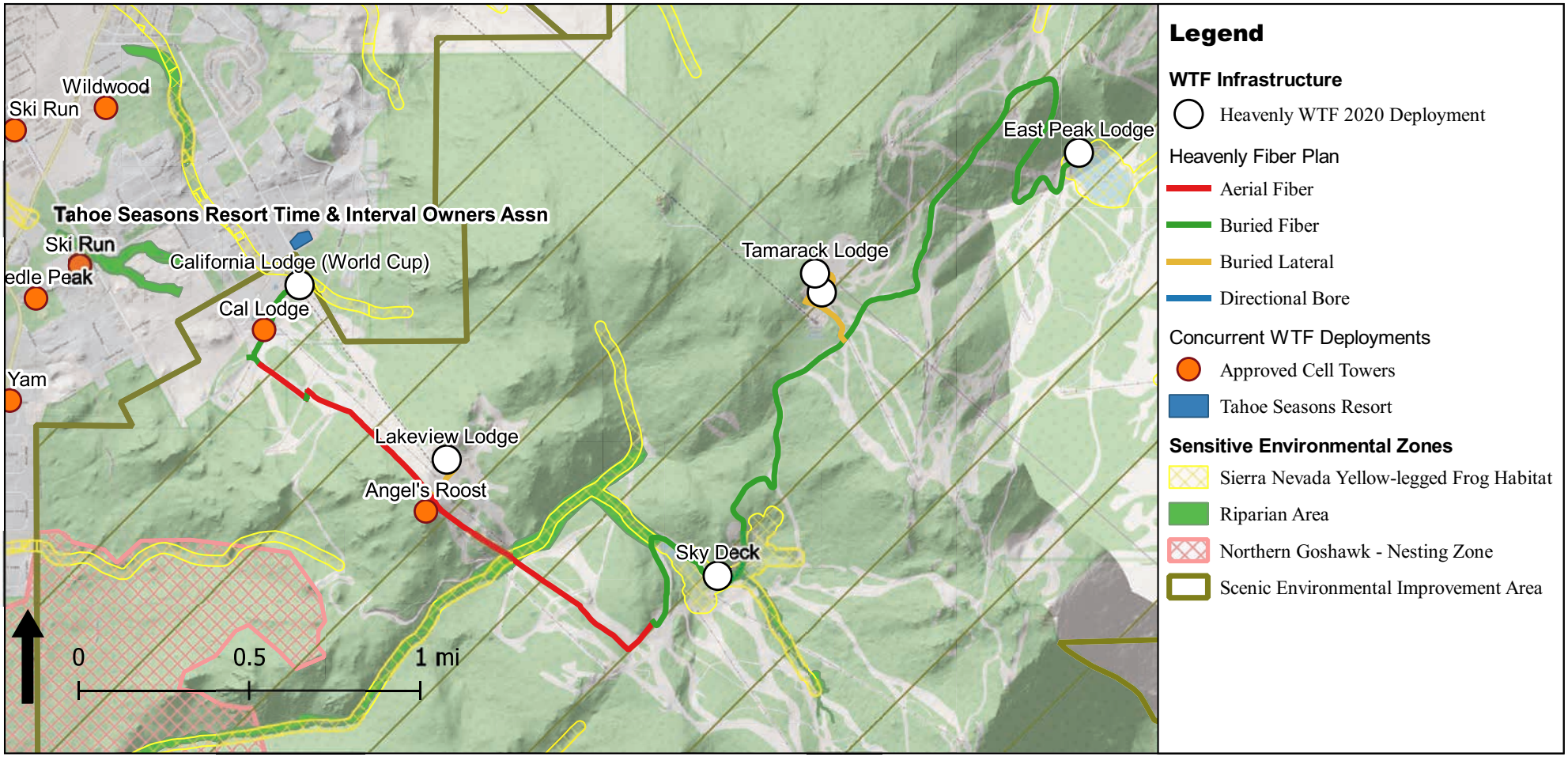
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Verizon's Unfair and Deceptive Business Practice: Concurrent National Forest Deployment

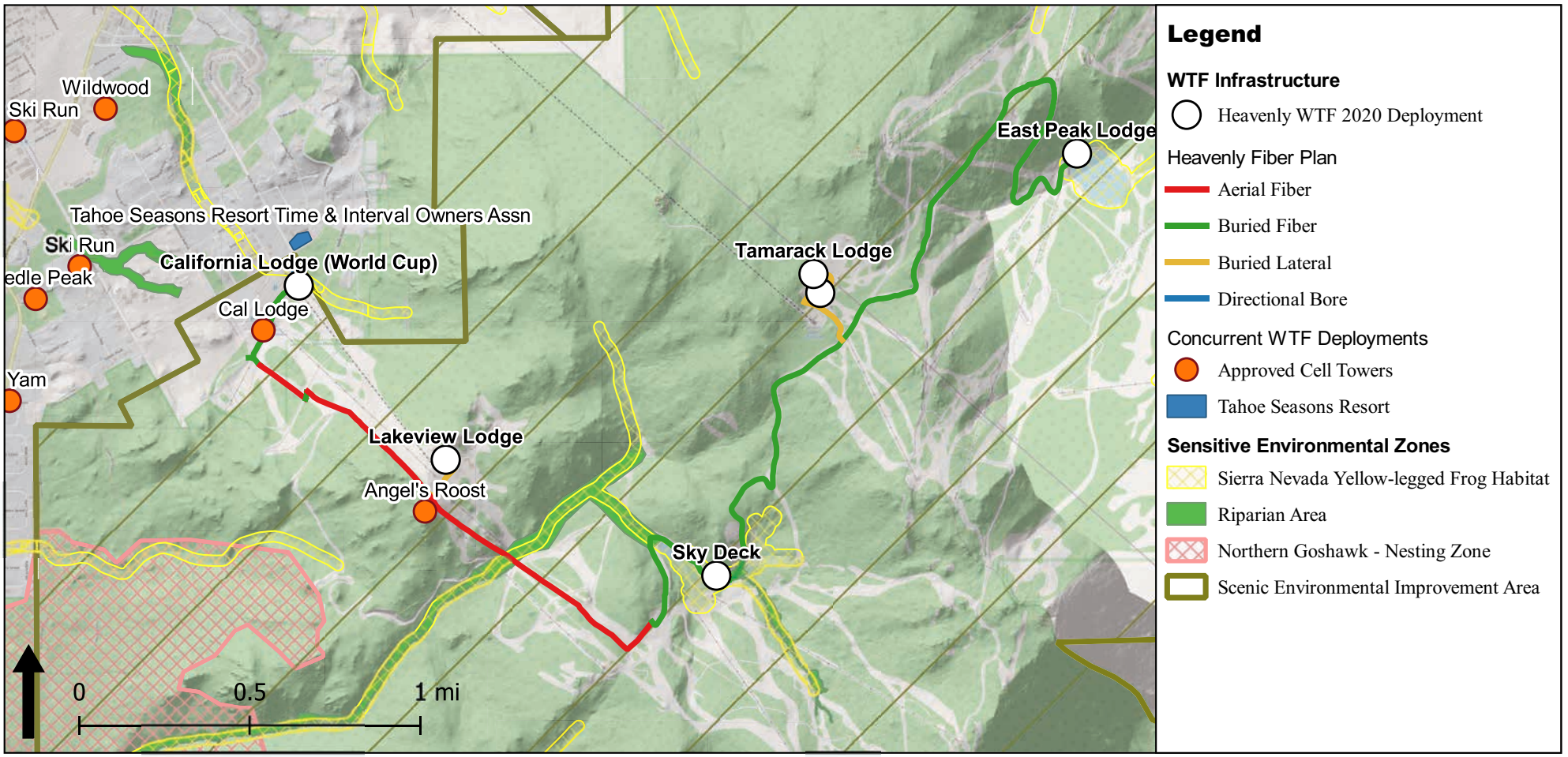


Unfair and Deceptive Business Practices

Verizon and the Tahoe Prosperity Center deceived City of South Lake Tahoe elected leaders, officials, staff, and residents into believing it was too burdensome to deploy towers in the adjacent National Forest lands, while simultaneously using existing special use permits to "fast-track" cell tower deployments and side-step non-discretionalry environmental review of which they had feigned as onerous. This constitutes Unfair and Deceptive Business Practices.

(*See* Business & Professions Code §§ 17200 *et seq.*):

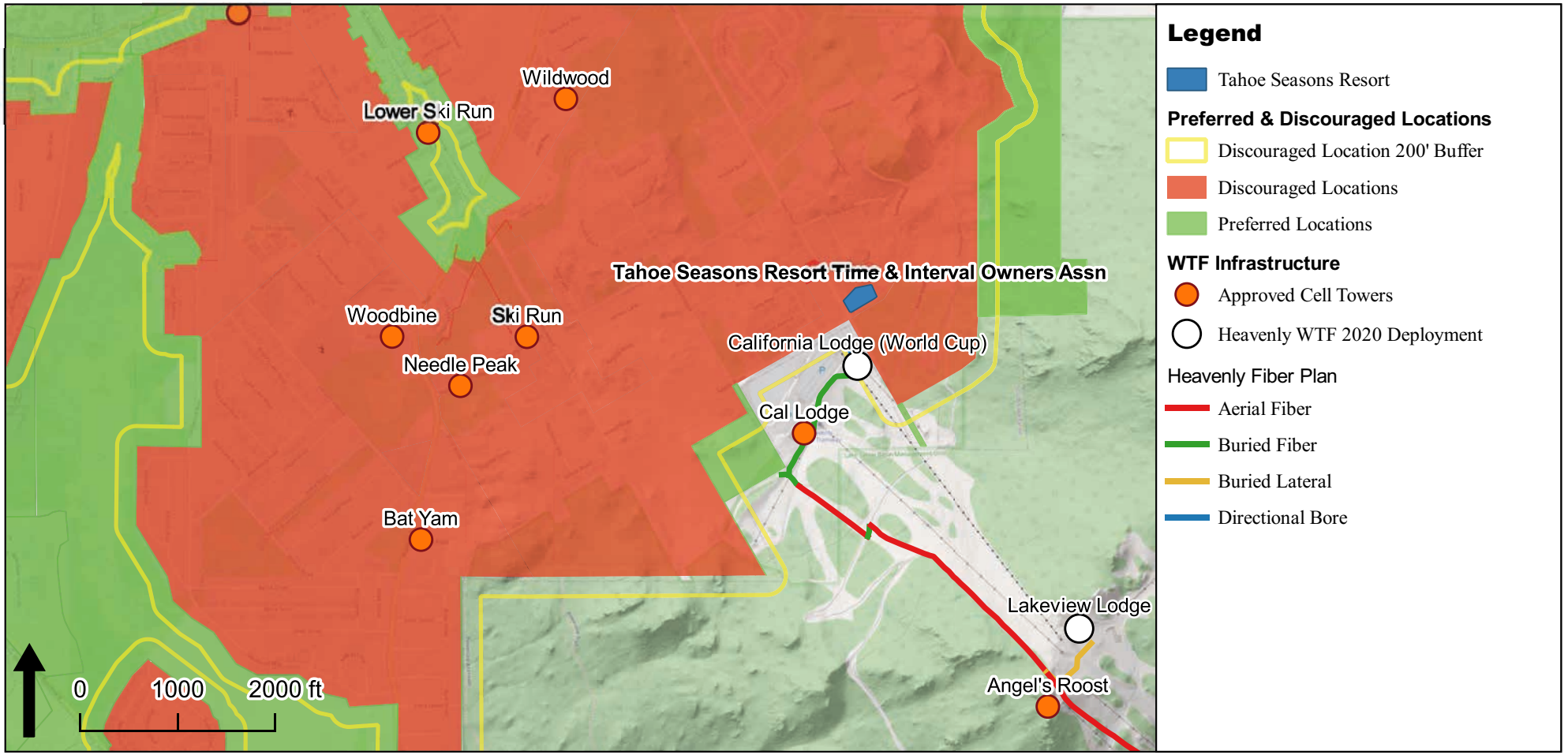
Heavenly Distributed Antenna System Plan: Regulatory Issues



Project May Pose Significant Effect on the Environment

Numerous research studies have found that cell tower radiation causes mortality in frogs and amphibians [*e.g.,* Balmori, Alfonso. (2010). Mobile Phone Mast Effects on Common Frog (*Rana temporaria*) Tadpoles: The City Turned into a Laboratory. *Electromagnetic biology and medicine.* 29. 31-5. DOI: 10.3109/15368371003685363]. A NEPA "categorical exclusion" cannot be issued because there exists substantial evidence that the WTF's may have a significant effect on the environment, particularly an endangered frog and protected birds [36 CFR § 220.6(b)(1)(i),(iii); 50 CFR § 17.11(h); 79 FR 24255; *see also* 16 U.S.C. § 497b; 47 CFR § 1.1307(a)(3); 40 CFR § 1508.8]. The affected area contains substantive habitat for endangered, rare, or threatened species, and could result in significant effects relating to wetlands [50 CFR § 10.13; EO 13186; 16 U.S.C. § 700 et. seq.; *cf.* 14 CCR §§ 15192(d), 15097(c)(2), 15206(b)(4)(A),(b)(5)] or water quality [*cf.* 14 CCR § 15332]. The antennas would expose both nesting and migratory birds—including bald eagles—to radiofrequency radiation in excess of human exposure limits [47 CFR § 1.1310]. The miles of aerial fiber also blight the visual quality of the TRPA designated "Heavenly Valley Ski Resort" Scenic Recreation Environmental Improvement Area. This is an extraordinary Congressionally protected region warranting further analysis and documentation in an EA or an EIS [36 CFR § 220.6(b)(1)(iii); *see also* Public Law 96551; Public Law 96586; EO 13057].

Tahoe Seasons Resort WTF Special Use Permit: City Ordinance Issues



Proposed Macro Cell Facility Does not Conform to WTF Ordinance

The proposed Tahoe Seasons WTF upon parcel "028-231-001" is entirely within a discouraged location—being located within both "PAS 085-LAKEVIEW HEIGHTS" as well as a TRPA "residential regional land use" (https://www.cityofslt.us/DocumentCenter/View/61). It would be egregiously located within 110 feet of multiple structures both approved and utilized for residential use, which is the precise issue the new city ordinance was meant to prevent (SLTCC § 6.75.090.C.1)(expressly discouraging such facilities within 200 feet from a structure approved for residential use OR any parcel with a General Plan Land Use Designation as Residential). The legislative intent that this parcel be discouraged is further expressed clearly in the multiple "discouraged vs. preferred location maps" presented to the city council and the public (*e.g.,* 4/14/2020 City Council Meeting "Item 17 Presentation.pptx"). Moreover, the WTF will be located approximately 1,000 feet from two separate encouraged locations within city limits, and 100 feet from Heavenly Valley Limited Partnership parcel "030-370-004" located outside city limits—in county jurisdiction—and already receiving multiple co-locatable WTF's (TRPA File #'s ERSP2019-0375 & ERSP2019-0375-01).

The approval authority may approve wireless communication facility applications only when the approval authority makes a finding that the proposed wireless facility is in a preferred location; or the proposed wireless facility is in a discouraged location and the applicant has demonstrated through a meaningful comparative analysis that no more preferred location or support structure would be technically feasible and potentially available (SLTCC § 6.75.080.A.1). The applicant clearly demonstrated no such analysis, and therefore this application must be rejected. Notwithstanding, when an application involves a new facility in a discouraged location, the approval authority shall consider whether any alternative site within a preferred location would be technically feasible and potentially available (SLTCC § 6.75.090.C). As *prima facie* evidence of such alternative feasibility, the Tahoe Seasons site is within suitable proximity to multiple co-locatable WTF's on the Heavenly parcel, in addition to three preferred location areas. Meaningful comparative analysis must be required and based upon material information including alternate system designs, signal measurement tests, drive tests, photo simulations from injurious vantage points, and documented application attempts to place proposed facility within other jurisdictions.