Friends of Merrymeeting Bay

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12/24/19

Doug Herling, President, CEO
c/o Ken Farber, Senior Counsel
Central Maine Power
83 Edison Dr.
Augusta, ME 04336

Re. Chops Pt. Towers & Crossing, Merrymeeting Bay
Via E-mail to: kenneth.farber@avangrid.com

Doug,

As you no doubt have heard, the new CMP towers at the Chops crossing intrude dramatically on Merrymeeting Bay airspace and viewshed with their excessive and as it turns out, unneeded lighting. We understand too that an active aircraft detection lighting system is being considered as an alternative and this could worsen things further, blanketing the area with radar microwaves, often harmful to people and with evidence of adverse behavioral changes to birds, bats and other wildlife. For a densely populated area, this is a particularly bad idea. Friends of Merrymeeting Bay (FOMB) is adamantly opposed to such a system.

According to federal regulation (14 CFR § 77.17 a. 2.), contrary to popular opinion, these towers even unlit, are not obstructions to air navigation. Fortunately, the simplest solution, turning the lights off, provides the most satisfactory outcome for all parties and at the least cost. We are requesting CMP extinguish the lights and issue a Notice to Airmen (NOTAM) of unlit towers and wire crossing at these coordinates, at least pending resolution of a FAA Marking and Lighting Study which we ask you to apply for. Given the update cycles of FAA paper charts and that these towers are charted, the NOTAM need should expire when the pertinent charts are updated (6 month cycle for VFR Sectionals). Our recommendation is current unlit marking balls be kept in place and only if necessary, additional unlit balls marking the lower wires be installed. Please see below for details.

Thank you,

Ed Friedman, Chair
Friends of Merrymeeting Bay

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1. Friends of Merrymeeting Bay (FOMB) is an environmental non-profit with a member-ship of approximately 450 households. Our mission is to preserve and protect the unique ecosystems of Merrymeeting Bay and we do this through research, advocacy, education and land conservation. We have been here since 1975 and because we are uniquely holistic in our approach, sometimes our activities extend throughout the Gulf of Maine and beyond. www.fomb.org I write this not only on behalf of FOMB but also from the perspective of more than 40 years as an instrument rated private pilot and 12 years as a commercial rotorcraft pilot with an active helicopter business in the Bay area.

2. Merrymeeting Bay is an estuarine freshwater tidal riverine inland delta at the confluence of six rivers including two of Maine's largest, the Kennebec and Androscoggin. Our watershed includes nearly 40% of the state and part of NH and drains via the Chops and Kennebec River about 17 miles to the ocean. The upper Bay runs from the north end of Swan Island to Abbagadasset Pt., the middle Bay from Abbagadasset Pt. to the Chops and the lower Bay from the Chops to Thorne Head. Merrymeeting Bay is listed as an Important Bird Area by the American Bird Conservancy. It is the largest U.S. staging area for migratory waterfowl north of Chesapeake Bay and the second most successful recovery area for bald eagles in the state after Cobscook Bay. The Bay is globally unique and significant not just because of its geography, hydrography and varied bird life but for its populations of rare plants inhabiting the inter-tidal and 12 species of diadromous fish using the Bay for spawning and nursery habitat. It is the only body of water providing this habitat for all the migratory fish species in the Gulf of Maine. There are approximately eight bat species here, a plethora of songbirds and a seasonally consistent population of seals in the vicinity of the Chops crossing.
   http://www.friendsofmerrymeetingbay.org/fombnew/pages/about_bay/about_bay.htm

**3.** Dark Skies. Particularly for our proximity to population centers, Merrymeeting Bay has until erection of the new MPRP towers at Abbagadasset Pt. and the Abbagadasset River, been blessed with a wonderfully dark, peaceful and quiet night sky. Addition of the FAA approved catenary crossing lighting scheme at the Chops has ratcheted up the disturbance beyond belief. Virtually everyone around the Bay considers our airspace violated by the new night lights and adverse effects on wildlife even with blinking rather than steady lights can be profound. For wildlife, the less artificial light, the better; "minimum intensity, maximum off-duration". **(Ex. 1, Manville, USFWS 2007, PDF pg. 11)**

   A wide variety of increasing problems and dissatisfaction with light pollution of the night skies has spawned an International Dark Skies movement. https://www.darksky.org/ . Artificial lights disrupt ecosystems critically altering nighttime environments. According to research scientist Christopher Kyba, for nocturnal animals, "the introduction of

artificial light probably represents the most drastic change human beings have made to their environment."

"Predators use light to hunt, and prey species use darkness as cover," Kyba explains "Near cities, cloudy skies are now hundreds, or even thousands of times brighter than they were 200 years ago. We are only beginning to learn what a drastic effect this has had on nocturnal ecology." https://www.darksky.org/light-pollution/wildlife/

Glare from artificial lights can also impact wetland habitats that are home to amphibians such as frogs and toads, whose nighttime croaking is part of the breeding ritual. Artificial lights disrupt this nocturnal activity, interfering with reproduction and reducing populations.

Birds that migrate or hunt at night navigate by moonlight and starlight. Artificial light can cause them to wander off course and toward the dangerous nighttime landscapes of cities. Every year millions of birds die colliding with needlessly illuminated buildings and towers. Migratory birds depend on cues from properly timed seasonal schedules. Artificial lights can cause them to migrate too early or too late and miss ideal climate conditions for nesting, foraging and other behaviors.

Many insects are drawn to light, but artificial lights can create a fatal attraction and may be a primary driver of massive worldwide insect decline. (Owens 2018) https://onlinelibrary.wiley.com/doi/epdf/10.1002/ece3.4557 Declining insect populations negatively impact all species that rely on insects for food or pollination. Some predators exploit this attraction to their advantage, affecting food webs in unanticipated ways.

Thielens, et al 2018, found insects show a maximum in absorbed radio frequency power at wavelengths that are comparable to their body size. They show a general increase in absorbed radio-frequency power above 6 GHz (until the frequencies where the wavelengths are comparable to their body size), which indicates that if the used power densities do not decrease, but shift (partly) to higher frequencies (*as with radar, emphasis added*), the absorption in the studied insects will increase as well. A shift of 10% of the incident power density to frequencies above 6 GHz would lead to an increase in absorbed power between 3–370%. This could lead to changes in insect behaviour, physiology, and morphology over time due to an increase in body temperatures, from dielectric heating. https://www.nature.com/articles/s41598-018-22271-3 In a dramatic example of how aphids appear responding to radar 14 miles away, Dr. John Nash Ott has this short clip: https://www.youtube.com/watch?v=VKEnAPt4KEQ

4. Area Aviation. The old towers had been on site, (unlit) for more than 80 years according to CMP as quoted in The Times Record on 7/23/19. The Abbbagadasset Pt. and River towers were also unlit until the MPRP project. During this historic period, prior to escalating fuel prices following the 1973 oil crisis, area air traffic was substantially greater than in recent years, particularly with the Brunswick Naval Air Station closure and sale of Merrymeeting field to a developer. Merrymeeting Field (08B) in Bowdoinham began operations in 1945, Wiscasset (KIWI) in 1961 and Brunswick (now KBXM) in 1935 with alternating civil and military use over the years. Merrymeeting, now a private short field with turf runway open to the public is 2.6 nautical miles (NM) from the Chops, Wiscasset 5.1 NM and Brunswick 6.8 NM.

5. FAA Obstruction, Marking and Lighting Advisory Circular. **(Ex. 2, PDF pg. 35)** This 8/17/18 edition of the Advisory Circular (AC) sets forth standards for marking and lighting *obstructions that have been deemed to be* a hazard to air navigation. The FAA

*recommends* the guidelines and standards in this AC for determining the proper way to light and mark obstructions affecting *navigable airspace*.

> **Navigable airspace means airspace** at and above the *minimum flight altitudes* prescribed by or under this chapter, including airspace needed for safe takeoff and landing. **(**49 U.S. Code § 40102. Definitions**)**
>
> **§ 91.119 Minimum safe altitudes**: General
>
> Except when necessary for takeoff or landing, no person may operate an aircraft below the following altitudes:
>
> (a) Anywhere. An altitude allowing, if a power unit fails, an emergency landing without undue hazard to persons or property on the surface.
>
> (b) Over *congested areas*. Over any congested area of a city, town, or settlement, or over any open air assembly of persons, an altitude of 1,000 feet above the highest obstacle within a horizontal radius of 2,000 feet of the aircraft. (*The FAA does not define "congested area." "Rather than publish a definition so pilots can know how to shape their aeronautical behavior, the FAA purposefully doesn't—it comes up with its definition on a case-by-case basis. The FAA says it does that so it can balance the pilot's interests with the need to protect persons and property. In enforcement actions, the FAA has successfully declared that a congested area includes a group of people on an airport ramp, sunbathers on a beach, a small subdivision covering less than a quarter mile, and traffic on an Interstate highway."* *https://pilot-protection-services.aopa.org/news/2016/january/15/congested-area* )
>
> **(c)** Over other than congested areas. An altitude of 500 feet above the surface, except over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500 feet to any person, vessel, vehicle, or structure.
>
> (d) Helicopters, powered parachutes, and weight-shift-control aircraft. If the operation is conducted without hazard to persons or property on the surface -
>
> (1) A helicopter may be operated at less than the minimums prescribed in paragraph (b) or (c) of this section, provided each person operating the helicopter complies with any routes or altitudes specifically prescribed for helicopters by the FAA; and
>
> (2) A powered parachute or weight-shift aircraft may be operated at less than the minimums prescribed in paragraph (c) of this section.

***This AC does not constitute a regulation and, in general, is not mandatory.*** *However, a sponsor proposing any type of construction or alteration of a structure that* ***may*** *affect the National Airspace System (NAS) is required under the provisions of Title 14 Code of Federal Regulations to notify the FAA by completing the Notice of Proposed Construction or Alteration form (FAA Form 7460-1).* These guidelines *may* become mandatory as part of the FAA's determination **(Ex. 3 & 4, PDF pgs. 135, 141)** and *should* (not shall) *be followed on a case-by-case basis, as required.* (Emphasis added).

We interpret this to mean for structures that qualify as obstructions affecting navigable airspace, notification to the FAA via Form 7460-1 is required to ascertain whether or not they *may* be a hazard to air navigation vis a vis marking and lighting, but in general lighting and marking requirements are recommendations, not requirements. An FAA determination of a qualifying obstruction (see 6.) could become mandatory if it is an obstruction *and* if deemed to be an air navigation hazard. But, there is quite a bit of flexibility in those determinations and their "case by case" details. The prerequisite is whether or not a structure meets the obstruction standard. If a structure has, correctly or incorrectly already been subject to an FAA determination under 7460-1, it probably is necessary for a re-filing of 7460-1 to change that status if only to revise notifications to airmen via navigation charts. (4. *Why do I need to request a marking and lighting change? To remain in compliance with Title 14 CFR Part 77 and enable the FAA to ensure the change is captured in the Digital Obstacle File and made available to the flying community*.
https://oeaaa.faa.gov/oeaaa/external/searchAction.jsp?action=malFAQs ).

**§ 77.29 Evaluating aeronautical effect** notes at (b), If you withdraw the proposed construction or alteration or revise it so that it is no longer identified as an obstruction, or if no further aeronautical study is necessary, the FAA may terminate the study

6. FAA Obstruction Standards. (14 CFR § 77.17). Any structure 499' above ground level (AGL) is considered an obstruction. The oft cited 200' threshold for obstacle lighting and marking comes from number (a) 2. of this section but its qualifiers regarding proximity to qualifying airports and subsequent conditions have in the instant case been overlooked.

> (a) An existing object, including a mobile object, is, and a future object would be an obstruction to air navigation if it is of greater height than any of the following heights or surfaces:
>
> **(2)** A height that is 200 feet AGL, or above the established airport elevation, whichever is higher, within 3 nautical miles of the established reference point (*center point*) of an airport, excluding heliports, with its longest runway more than 3,200 feet in actual length, and that height increases in the proportion of 100 feet for each additional nautical mile from the airport up to a maximum of 499 feet.

At 5.1 miles and a runway length of 3,397', Wiscasset (KIWI) is the closest qualifying airport to the Chops. **(Ex. 5, PDF pg. 147)** If the Chops towers were within 3 miles of KIWI, they would be considered an obstacle to air navigation at 200'. Since they are 5 miles from KIWI however, 100' is added for each additional mile up to a maximum of 499'. ***At 5 miles then, to meet the qualifying standard and be possibly deemed an obstruction to air navigation, the towers need to be at least 400' AGL. At 240' AGL, they simply are too short.*** And, *even if* the Advisory Circular standards were mandatory, these towers would not reach the minimum height to qualify as possible obstructions.

The unlit towers themselves do not appear, by definition, obstructions to air navigation. For their distance from KIWI, the closest qualifying airport, they fall substantially below what would be the 400' AGL threshold. Including actual transmission or catenary crossing lines in this evaluation, which is why the towers are present and which are less obviously visible, we look at minimum safe altitudes for air navigation under visual flight rules (VFR) and these depend on a case by case evaluation of whether the area is "congested" or not. If this area is considered congested which it no doubt would be when Chop Pt. School has students, campers or possibly just staff present, then minimum safe altitude is 1,000' over the highest obstacle which would be the 240' tower or 1,240 AGL. The same thing applies on West Chop Pt. because of the subdivision.

Even if the catenary lines were considered to be in an "uncongested area" according to **§ 91.119,** 500' above the surface would be the required minimum safe altitude unless over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500 feet to any person, vessel, vehicle, or structure. Since the waterway measures 790' wide at the Chops **(Ex. 6, PDF pg. 149)**, a float plane flying up the middle would only have 400' on either side to shore and from the channel center to the closest Chop Pt School structure (a cabin) would still not be 500'. Offset to the west an aircraft could attain the necessary setback from Chop Pt. School but would come too close to the tower on West Chop Pt. and if not careful, some of the homes there. For fixed wing aircraft, a flight through the Chops below 500' AGL would not be in navigable airspace.

The only aircraft exempted from the minimum safe altitude requirements are helicopters, powered parachutes and weight-shift controlled aircraft. ("Flying Neighborly" has been a program of HAI, Helicopter Association International since 1982. Their recommendation is when avoidance is not possible, pilots flying VFR flights over noise-sensitive areas should make every effort to fly at not less than 2,000 feet above the surface, weather permitting, even though flight at a lower level may be consistent with the provisions of FAR 91.79, Minimum Safe Altitudes."
https://www.portlandoregon.gov/transportation/article/701922 The Fly Neighborly Guide is one most helicopter pilots are familiar with and of course every licensed pilot knows to check charts and NOTAMS before flying into an unknown area where towers may be present. Pilots are also taught when confronted with transmission towers, to fly over them rather than risk hitting an unseen fine wire between them.

7. Alternatives. All of which probably require the filing of Form 7460-1 with the FAA.

7A. Active Aircraft Detection Lighting Systems (AADLS). Recognizing the Dark Sky issues discussed in Section 3 above, revised FAA Obstruction, Marking & Lighting Advisories now offer ADLS as an alternative to recommended lighting guidelines. Unfortunately, these systems, as approved by the FAA, use *active* radar to distinguish aircraft in the vicinity of structures, whether wind farms or transmission towers.

**Pros:** Full-time lighting of structures is avoided.

**Cons:** High costs, particularly at scales less than for large multi-structure scale deployments like wind farms. Adverse health and behavioral effects to people and wildlife. In 2011, the International Agency for Research on Cancer/World Health Organization (IARC/WHO) classified radiofrequency radiation (RFR) in frequencies from 30 KHz-300 GHz as a Group 2B possible human carcinogen.
https://www.iarc.fr/wp-content/uploads/2018/07/pr208_E.pdf RFR has been shown to cause carcinogenic and non-carcinogenic effects. Having worked on environmental issues for 50 years, I consider RFR proliferation to be the most important toxics issue of our time if only because of its ubiquitous nature. Others, like Bandara & Carpenter, (2018) **(Ex. 7, PDF pg. 151)** also believe the planetary aspect of exposure warrants immediate further attention.

The IARC cancer classification includes all sources of RFR. The exposure from mobile phone base stations, Wi-Fi access points, smart phones and meters, laptops, radar and tablets can be long-term, sometimes around the clock, both at home, work and at school. For children this risk may be accentuated because of a cumulative effect during a long lifetime use. Developing and immature cells can also be more sensitive to exposure to RF radiation.

Since 2011 further research has been done in this field and the "gold standard" 10 year-$30 million National Toxicology Program (NTP is part of the National Institutes of Health) stands out, finding "*clear evidence*" of heart tumors in male rats, "*some evidence*" of brain tumors in male rats , "*some evidence*" of adrenal tumors in male rats. The study also found significant increases in DNA damage to the frontal cortex of the brain in RFR exposed male mice, the blood cells of female mice, and the hippocampus of male rats.
https://ntp.niehs.nih.gov/whatwestudy/topics/cellphones/index.html?utm_source=direct&utm_medium=prod&utm_campaign=ntpgolinks&utm_term=cellphone

Since the NTP study and independent confirmation in a similar study by the Ramazzini Institute in Italy https://www.ncbi.nlm.nih.gov/pubmed/29530389 , many scientists have been calling for a reevaluation of the WHO classification, (Miller, et al 2019 https://www.frontiersin.org/articles/10.3389/fpubh.2019.00223/full ) to Group 2A-probable or Group 1-known human carcinogen. (Belpomme, et al., 2018 https://ecfsapi.fcc.gov/file/12103008105187/nonionizing%20radiation%20international%20perspective%20Belpomme%20Hardell%20Carpenter%202018.pdf)

Cancers can have long latency periods, often 30 years before detection. In contrast, non-cancer effects from RFR exposure can occur very rapidly from minutes to days with very debilitating effects. As an AADLS is considered at the Chops, it is critical to understand proximity to radar is where electromagnetic sensitivity first became commonly known. Microwave generating equipment first became prevalent during World War II with the development of radar. Soviet bloc countries reported that individuals exposed to microwaves frequently developed headaches, fatigue, loss of appetite, sleepiness, difficulty in concentration, poor memory, emotional instability, and labile cardiovascular function, and established stringent exposure standards.

For a variety of reasons these reports were discounted in Western countries, where the prevailing belief was that there could be no adverse health effects of electromagnetic fields (EMFs) that were not mediated by tissue heating. The reported Soviet effects were at lower intensities than those that cause heating. However, there were several accidental exposures of radar operators in Western countries that resulted in persistent symptoms similar to those described above.

The Soviets irradiated the US Embassy in Moscow with microwaves during the period 1953-1975, and while no convincing evidence of elevated cancer rates was reported, there were reports of "microwave illness". Officials passed these complaints off as being due to anxiety, not effects of the microwave exposure. There is increasing evidence that the "microwave syndrome" or "electro-hypersensitivity" (EHS) is a real disease that is caused by exposure to EMFs, especially those in the microwave range.

The reported incidence of the syndrome is increasing along with increasing exposure to EMFs from electricity, WiFi, mobile phones and towers, smart meters and many other wireless devices. Why some individuals are more sensitive is unclear. While most individuals who report having EHS do not have a specific history of an acute exposure, excessive exposure to EMFs, even for a brief period of time, can induce the syndrome. **(Ex. 8, Carpenter 2015, PDF pg. 155)**.

Adverse effects of RFR are not limited to people but affect wildlife as well. Testimony by The Environmental Heath Trust (www.ehtrust.org) regarding proposed expansion of cell coverage in Teton National Park does an excellent job at providing many top-quality references to wildlife effects. **(Ex. 9, Davis, 2018, PDF pg. 162)**. Research specific to radar effects on bats includes Nicholls, (2009)

https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0006246&type=printable and on birds Sheridan (2015) https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=2728&context=icwdm_usdanwrc

As bad as the tower lights are, an Active ADLS is far worse because of the health risks and again, no active deterrent is needed. Exposure to electromagnetic fields is considered high risk by major insurers like Loyd's of London. In request for clarification on this policy language: *General Insurance Exclusions: 31) directly or indirectly arising out of, resulting from or contributed to by electromagnetic fields, electromagnetic radiation, electromagnetism, radio waves or noise*., this response was received on Feb. 18, 2015 from CFC Underwriting LTD, London, UK agent for Lloyd's: "'The Electromagnetic Fields Exclusion (Exclusion 32) is **a General Insurance Exclusion and is applied across the market as standard. The purpose of the exclusion is to exclude cover for illnesses caused by continuous long-term non-ionising radiation exposure i.e. through mobile phone usage."** https://nowhere.news/index.php/2018/10/27/lloyds-refuses-liability-coverage-for-emf-radiation-exposure-mobile-phones/ FOMB is vehemently opposed to AADLS.

7B. Passive Aircraft Detection Lighting Systems (PADLS). Passive radar detection using only receivers, takes opportunistic advantage of commercial broadcasting in the vicinity to discern aircraft, noting the differences using multiple receivers, when those broadcast signals are penetrated by the target and then determining location. (Griffiths, 2017) https://in.bgu.ac.il/en/engn/ece/radar/Radar2017/Documents/Prof.%20Hugh%20Griffiths%20-%20Passive%20Radar%20-%20From%20Inception%20to%20Maturity.pdf (Limnaios, 2019) https://www.researchgate.net/publication/332119662_Passive_Radars_and_their_use_in_the_Modern_Battlefield ; (Hensoldt, 2019) https://www.hensoldt.net/fileadmin/hensoldt/Solutions/Air/Surveillance_Reconnaissance/0570_18_TwInvis_Passive_Radar_datasheet_E_preview.pdf

**Pros:** No emissions, no electro-magnetic pollution, lower cost than AADLS, flexible in deployment, excellent at tracking low flying small aircraft, no FCC licensing issues. (Dirkshof, 2018) https://www.dirkshof.de/fileadmin/Dateien/Passivradar_Infos/Parasol_06_2018_E.pdf

**Cons:** Thus far, the only commercially available PADLS is called PARASOL, designed by Fraunhofer and manufactured in conjunction with Dirkshof, a wind farm firm in Germany. https://www.fhr.fraunhofer.de/en/press-media/press-releases/PARASOL-receives-accreditation-from-german-air-traffic-control.html It has been approved by German Air Traffic Control for ADLS throughout the country where Germans have protested strongly about red nighttime warning lights (required for towers over 300m) and electromagnetic radiation from AADLS. In email correspondence with Fraunhofer about the Chops project as a possible demonstration site, they did some research and found North American commercial broadcasting occurs at somewhat different modulations than in Europe and so their technology is not transferable out of the box. Fraunhofer is interested in researching our markets but is concentrating closer to home at the moment.

While PADLS's are acceptable to FOMB, like lights or AADLS, they are not needed.

7C. Lights off - Notice to Airmen (NOTAM). https://www.faa.gov/documentLibrary/media/Order/7930.2S_Notices_to_Airmen_(NOTAM).pdf

**Pros:** A NOTAM for unlit towers at Chops crossing can be actuated with a simple phone call to 1-877-487-6867. This is sort of the opposite of CMP's "Flip a switch and we're there" advertisements. Modern updates to the NOTAM system can be read about here: https://www.faa.gov/about/initiatives/notam/. Lights off are better for wildlife, residents, dark skies, zero cost [once FAA process is complete) and because of smart grid, lights remain easily functional for emergency use on request [i.e. For SAR in immediate area], Turning the lights off provides excellent PR for CMP and because it's the simplest and cheapest solution to a problem that actually exists (vs. TRC's "off the shelf solution" to a problem that did not exist), it truly creates a win/win for all parties.

**Con:** Turning the lights off is considered an alteration and in accordance with 14 CFR Part 77.9, if you propose "any of the following types of construction or alteration, you must file a 7460-1 notice with the FAA at least 45 days prior to beginning construction or alteration that exceeds an imaginary surface extending outward and upward at any of the following slopes:…OR any construction or alteration exceeding 200 feet above ground level, regardless of location." It is unclear to me if this is considered synonymous with or the initiation of a Marking & Lighting Study request suggested by Dave Maddox who signed off on the original Determination of No Hazard to Air Navigation. In a phone call, Dave also emphasized to me that the FAA was flexible in working with the "sponsor" (CMP) and that neighborhood input can play a role in their decision

8. Recommendation:

a. Call in interim NOTAM for unlit towers at Chops at least pending Marking and Lighting Study and or acceptance of alteration proposal.
b. Please turn lights off within 14 days.

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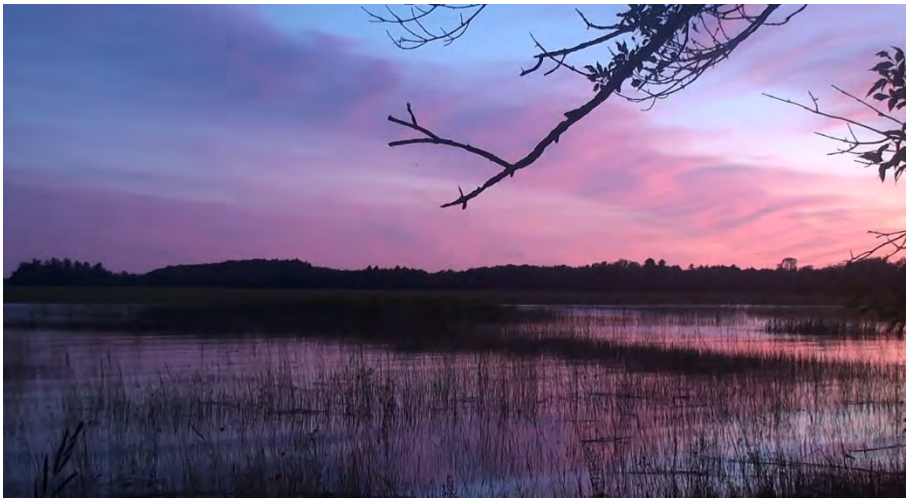
Basis for alteration-

1. Guidelines are recommendations unless they *may* become mandatory on a case by case basis based on determination
2. Towers not obstacles by virtue of height and distance from KIWI
3. Catenary wires not obstacles to fixed wing aircraft by virtue of minimum safe altitudes and proximity to structures and people.
4. Virtually no air traffic, 80 year history no lights at catenary crossing
5. Nobody flies that low at night
6. Community opposed to lights
7. Significant wildlife corridor area-adverse impacts of lights
8. Active ADLS-harmful EMR emissions

# Exhibits



No lights

New Dusk (actually red)

New Night (actually bright red)

# Exhibit 1

Ex. 1

# *U.S. Fish & Wildlife Service Concerns Over Potential Radiation Impacts of Cellular Communication Towers on Migratory Birds and Other Wildlife – Research Opportunities*

**Albert M. Manville, II, Ph.D.**
**Senior Wildlife Biologist**
**Division of Migratory Bird Management, USFWS**
**4401 N. Fairfax Dr. MBSP-4107**
**Arlington, VA 22203**
**(o) 703/358-1963**
**Albert_Manville@fws.gov**

**May 10, 2007, "Congressional Staff Briefing on the Environmental and Human Health Effects of Radiofrequency (RF) Radiation," House Capitol 5, Washington, DC**

# Issues to Be Briefly Addressed:

- Trust responsibilities and avian population status.
- Temporal and spatial use of airspace.
- Documented impacts of communication towers on migratory birds.
- Recent European research discoveries regarding towers and radiation impacts to resident and migrating birds, other fauna (esp. bees).
- Proposal for communication tower research on wildlife in the U.S.
- Next steps.

# *Federal Trust Responsibilities*

- **USFWS entrusted by Congress, and required by statutes and regulations, to manage and protect migratory birds (and other fauna [ESA]) under authority of:**
  - **Migratory Bird Treaty Act,**
  - **Bald and Golden Eagle Protection Act, and**
  - **Endangered Species Act.**

# Avian Population Status

- Status U.S. bird populations of concern. 1995, USFWS listed 124 "nongame species of management concern." Represents early warning system since possible next step is designating birds as "candidates" under Endangered Species Act – scenario we'd prefer to avoid.

- 2002, USFWS published "birds of conservation concern," as mandated by law. Number bird populations in trouble increased from 124 to 131 species – not good news. In addition, 77 endangered and 15 threatened birds included under ESA – numbers continue to increase.

- Recapping, 836 species, > 223 in trouble. In addition, Service essentially lacks data on status 1/3 N. Am. bird populations. Management challenge!

# *Temporal and Spatial Use of Airspace*

- **Air as a habitat is a new concept, including for USFWS.**
- **Service's goal: do *no* harm.**
- **<u>Challenge</u>: All signs indicate continuing massive expansion cellular communication, DTV, emergency broadcast, paging, other electronic communications in U.S. Currently FCC's *Antenna Registry* database contains nearly 100,000 listed providers/licensees. Likely underestimates true number.**
- **Tower growth continues exponentially.**

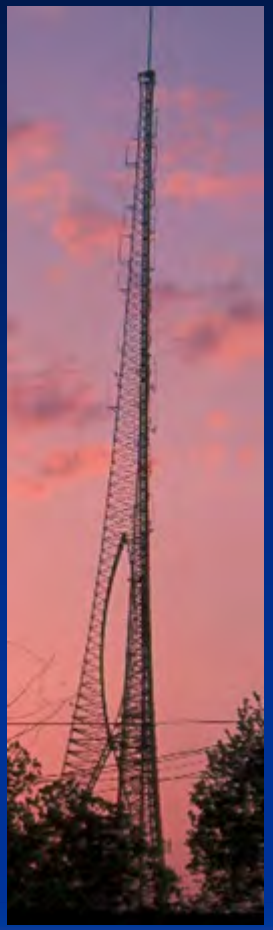
# Potential Impacts Communication Towers on Wildlife

- **Direct effects of individual towers and antenna "farms."**
  - Bird and bat strike mortality.
  - Direct habitat loss/modification.
  - Interior forest, grassland habitat loss.
  - Habitat fragmentation, increase in edge.
  - Increase in nest parasitism and predation.
  - Water quality impacts.

**Indirect effects.**

- Reduced nesting/breeding density.
- Loss population vigor and overall density.
- Habitat and site abandonment, increased isolation b/w patches.
- Loss of refugia.
- Effects on predator/prey relationships.
- Attraction to modified habitats.
- Effects on behavior including stress, interruption, modification.
- Disturbance, avoidance, displacement, habitat unsuitability.

**Cumulative effects.**



A. Manville,
~750 ft. AGL
Catholic Un.
lattice tower

# Issues of Concern to the Service: *Direct Mortality*

- Bird-tower collision mortality been documented problem in U.S. since least 1948 (Aronoff 1949). USFWS (D. Banks 1979) estimated avian-tower mortality at 1.25 million birds/yr. based on assessment 505 tall towers 1975.

- DMBM became involved Feb. 1998 single night kill up to 10,000 Lapland Longspurs, others, Kansas at 3 towers and power generating station.

- Evans (1998) reassessed Banks' mortality estimate based on increased numbers tall towers, estimating 2-4 million bird deaths/yr.

- Manville (2001a) estimated annual mortality at 4-5 million bird deaths/yr., but Manville (2001b) later cited 4-5 million figure as "conservative," indicating that mortality could range high as 40-50 million. Only cumulative impacts analysis determine "true" magnitude problem.

# *Direct Mortality,* cont. 2

- 2003 FCC issued Notice of Inquiry, "Effects Communication Towers on Migratory Birds." USFWS provided detailed comments Nov. 2003, and reply comments Feb. and March 2005.
- Nov. 2006, FCC issued Notice Proposed Rulemaking, "Effects Communication Towers on Migratory Birds," on WT Docket 03-187. Service provided detailed comments Feb. 2, '07.
- We focused on lighting (admittedly radiation issue), recommending minimum intensity, max. off-duration white strobe lighting, provisionally recommending min. intensity red-strobe and/or red flashing incandescent blinking red beacons, and other issues. Did NOT discuss other radiation issues in providing rulemaking recommendations to FCC.

# *Concerns with Tower-emitted Radiation*

- **While focus of this briefing is pointed toward radiation impacts on human health – *e.g.,* rising levels documented "cancer clusters" – USFWS growing concerned about potential impacts of tower radiation on resident and migrating birds and bats, listed species under our jurisdiction, and other potentially impacted living resources including bees.**

- **~ 2002 at briefing similar to this one, T. Litovitz (Catholic Univ., pers. comm.) raised troubling concerns about impact low-level, non-thermal radiation from standard 915 MHz cell phone frequency impacting domestic chicken embryos (data from DeCarlo *et al.* 2002). Deformities, including some deaths under hypoxic conditions noted.**

A. Manville

# *Radiation,* cont. 2

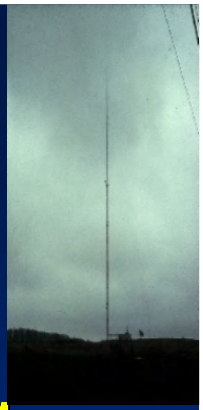
A. Manville

- Meanwhile, A. Balmori (2003) provided USFWS preliminary research from Valladolid, Spain, showing strong negative correlations b/w levels of tower-emitted microwave radiation and bird breeding, nesting, and roosting in vicinity electromagnetic fields.

- In House Sparrow, White Stork, Rock Dove, Magpie, Collared Dove, and other species, (1) nest and site abandonment, (2) plumage deterioration, (3) locomotion problems, and (4) even death were reported among those species found close to cellular phone antennas.

- No such symptoms noted prior to construction cell phone towers. Manville (2005) published these preliminary results, raising initial concerns in U.S.

# *Radiation*, cont. 3



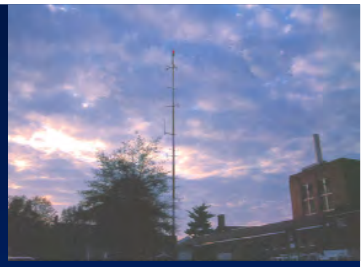
W. Evans

- Balmori has since published his findings on aforementioned species (2003), and on White Storks (2004, 2005) since this species appeared heavily impacted by tower radiation during 2002-2004 nesting seasons.

- Since Balmori research, seen additional avian studies in Europe. *E.g.*, Everaert and Bauwens (2007) found strong negative correlations b/w amount radiation presence (both 900 and 1800 MHz frequencies) and presence male House Sparrows – fewer House Sparrow males seen in areas w/ high electric field strength values.

- Preliminary Conclusion: long-term exposure to higher radiation is affecting abundance or behavior of wild House Sparrows.

# *Radiation,* cont. 4



A. Manville

- New problem recently documented relating to domestic honeybees and possible effects EMF radiation. Colony Collapse Disorder (CCD) been recently documented 60% U.S. West Coast apiaries and 70% on East Coast.

- CCD also being documented in Greece, Italy, Germany, Portugal, Spain and Switzerland (Harst *et al.* 2006, pilot study by Lean and Shawcross 2007). One theory: radiation from mobile phone antennas interfering with bees' navigation systems.

- Have anecdotal reports from at least 1 bee keeper in Vermont of possible cause-and-effect relationship to bee die off at his hives. Among other factors, what role is EMF playing, if any?

# What's Needed?

- In 2006, Service's New England Field Office suggested to Chairman, Connecticut Siting Council, that as stipulation of tower siting permit to Nextel that they fund research effort at control and experimental study sites in Massachusetts to assess radiation. Siting Council declined Service's request.

- Sites in W. Massachusetts provide unique opportunity – along with needed replication at similar sites in Midwest and West – to test impacts radiation on breeding birds, resident bats, and other vertebrate and invertebrate species (including bees).

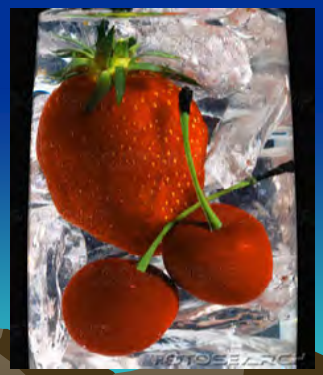
A. Manville

# *What's Needed?* – Control Site

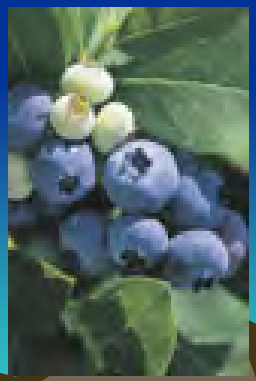
- **Berry farmer in W. Mass. picks berries at 2 sites. At the site with no cell towers, the farmer deters birds using "scarecrows" and other means to minimize damage to ripening fruit – relatively effective against birds.**

- **Wildlife presence normal – *i.e.*, abundant breeding/resident and migrating birds, resident bats, small and large mammals, invertebrates including bees, etc. -- including signs feeding on berries.**

Corbiss Photos



Corbiss Photos



Comstock Photos


Mary Ellen Hart

# *What's Needed?* – Experimental Site

- **However, at other site w/ cell tower adjacent to berry patch, wildlife signs (tracks, scat, feathers) and animal presence noticeably absent.**

- **No berry damage noted at cell site, near total absence sign that birds, other animals feeding on berries. Berries over-ripening on bushes, and dropped berries not gleaned turkey, fox, other wildlife.**

- **Both locations have similar vegetation and edge habitats.**

- **Based on research conducted in Europe, raises troubling concerns – and important need to replicate what been conducted so far in Europe.**

Corbiss Photos

Olconotech Photos

Corbiss Photos

# *What's Needed,* cont.? -- 2

- **Because this issue is so potentially significant, need *not only* conduct experiments in East (not only at this site but various others), also in Midwest and West.**
- **Birds and bats are nature's 'pest control agents' -- bats can eat their body weight in insects/night, and birds eat untold quantities weed seeds and noxious insects.**
- **Birds, bats, and bees are critical pollinators – involved in > $18 billion/yr. global food and forest products industry pollination.**
- **Birds alone fuel ~ $28 B/yr. bird watching industry in U.S (1 in 4 Americans partake).**

# *What's Needed,* cont.? -- 3

- **1/3 all our fruits and vegetables would *not* exist w/out pollinators visiting flowers.**

- **Pollinators play fundamental role in food security. As pollinator numbers decline, price groceries goes up.**

  - ***E.g.,* value pollination to alfalfa seed growers Canadian prairies estimated 35% annual crop production (Blawat and Fingler 1994).**

  - **"Despite its apparent lack of marquee appeal, a decline in pollinator populations is one form of global change that actually has credible potential to alter the shape and structure of terrestrial ecosystems" (M. Berenbaum, Chair, ND Corn Growers Assoc.).**

# *What's Needed,* cont.? -- 4

- **Birds and bats already under assault from communication tower collision mortality – some impacts possibly having effect at population level. Birds, bats, bees, other wildlife also under assault from other anthropocentric challenges:**
  - **Other tall structures (*e,g.*, buildings, power lines, wind turbines, etc.);**
  - **Habitat loss, disturbance, and fragmentation;**
  - **Invasive species competition;**
  - **Toxicants, contaminants, pesticides, and spills;**
  - **Global climate change;**
  - **Other impacts.**

# *What's Needed,* cont.? -- 5

- We may already be impacting breeding bird, bee and other resident -- not to mention migrating -- wildlife populations from radiation and don't yet know it. Issue is, in part, about *cumulative impacts:*
  - What are significance of impacts cumulatively from all communication towers?
  - Overall effects habitat loss, displacement, barrier effects, and collision mortality.
  - Cumulative effects all anthropocentric structures.
  - Are impacts additive to natural mortality?

# *Research Needs*

- **Need to critically review research protocols for studying radiation impacts to birds and bees in Europe. Can they be used in U.S.? Are experimental designs tight enough that we can tease out variables at play to remove extraneous and confounding variables? Can studies be replicated in U.S. at various locations?**

- **Will need behavioral assessments birds and bees, likely manipulation experiments, possibly multiple studies/site (to address impacts to birds, bats, and bees – possibly all different).**

- **Research MUST be conducted in as independent, scientifically credible, unbiased way as possible. Need researchers performing studies who have no vested interest in communications technology, industry, or related connections.**

## *Research Needs*, cont. -- 2

- DMBM (Washington Office) would be interested helping lead research effort. Research may best be conducted by independent consultants and/or academicians w/ whom Service works, performed in collaboration w/ USGS/BRD scientists w/ background in communication tower, radiation issues, ornithology and entomology.

- Service has "Pollinator Campaign" (housed in Division Contaminants) which also should play role in studies, especially dealing w/ bees. Service's Field Offices, Migratory Bird offices, others also need be involved.

# *Next Steps*

- **Publish research results in credible, refereed scientific journals.**
- **Call meeting Communication Tower Working Group to release research findings and recommendations to multi-stakeholder group (DMBM/Manville chairs CTWG).**
- **Work w/ FCC, EPA, Congress, others to update science, address issues, and avoid/minimize impacts.**

# In Summary…

- **The Service favors:**
  - **conservation of wildlife in the public trust;**
  - **development of communication equipment that is bird and bat friendly; and**
  - **use of informed decisions based on adequate environmental assessment and sound science.**

**Thank you**

# Exhibit 2

U.S. Department
of Transportation
**Federal Aviation Administration**

# Advisory Circular

**Subject:** Obstuction Marking and Lighting

**Date:** 08/17/18 **AC No.** 70/7460-1L
**Initiated By:** AJV-15 **Change:** 2

1. **Purpose.** This Advisory Circular (AC) sets forth standards for marking and lighting obstructions that have been deemed to be a hazard to air navigation. The change number and date of the change material are located at the top of the page. Advisory Circular 70/7460-1L is effective September 6, 2018.

2. **Principal Changes.**
   a. Page 5-2. Addition of Paragraph 2. In response to the *Safety Risk Assessment of Light Emitting Diode (LED) Lighting in Aircraft Operations* report, which summarizes the results of a safety risk assessment on the use of LED lighting technology across the National Airspace System (NAS), the FAA has published specifications for LED-based red obstruction lights. This paragraph cross-references the new lighting specification and associated Engineering Brief.

   b. **Reporting Requirements**. Updated All Figures in Appendix A, Pages A-1 to A-30.

3. **Application.**
   The FAA recommends the guidelines and standards in this AC for determining the proper way to light and mark obstructions affecting navigable airspace. This AC does not constitute a regulation and, in general, is not mandatory. However, a sponsor proposing any type of construction or alteration of a structure that may affect the National Airspace System (NAS) is required under the provisions of Title 14 Code of Federal Regulations to notify the FAA by completing the Notice of Proposed Construction or Alteration form (FAA Form 7460-1). These guidelines may become mandatory as part of the FAA's determination and should be followed on a case-by-case basis, as required.

4. **Comments or Suggestions.**
   Direct comments or suggestions regarding this AC to:
   Manager, Obstruction Evaluation Group
   Federal Aviation Administration
   ATTN: AJV-15
   800 Independence Avenue, S.W.
   Washington, DC 20591

**Page Control Chart**

| | Dated | Insert Pages | Dated |
|---|---|---|---|
| 5-2 | 10/08/16 | 5-2 | 09/06/18 |
| A-1 to A-30 | 10/08/16 | A-1 to A-30 | 09/06/18 |

Maurice Hoffman
Director, Airspace Services
Mission Support Services

U.S. Department
of Transportation
**Federal Aviation Administration**

# Advisory Circular

**Subject:** Obstruction Marking and Lighting **Date:** 10/8/2016 **AC No.** 70/7460-1L
**Initiated By:** AJV-15 **Change:** 1

1. **Purpose.** This Advisory Circular (AC) sets forth standards for marking and lighting obstructions that have been deemed to be a hazard to air navigation. The change number and date of the change material are located at the top of the page.

2. **Effective Date.** This change is effective October 8, 2016.

3. **Explanation of Changes.**
   a. Page 2-2. Paragraph 2.4.3 Note 2 stated NOTAMS were automatically deleted from the system after 15 days and the sponsor was responsible for calling outage reporting to extend the outage date or to report a return to service date. This paragraph has been deleted. Tower owners now have the option to select the amount of time their NOTAMS remain active.

   b. Page A-1. Appendix A, Specifications for Obstruction Lighting Equipment Classification, Table A-1 FAA-Approved Obstruction Lighting Fixtures indicated:
      L-885 – *Low Intensity Flashing* – RED
      It has been changed to L-885 Flashing Obstruction Light (60 FPM) – RED

   c. Entire publication. Additional editorial/format changes were made where necessary. Revision bars were not used because of the insignificant nature of these changes.

Gary A. Norek
Director, Airspace Services

U.S. Department
of Transportation
**Federal Aviation**
**Administration**

# Advisory Circular

**Subject:** Obstruction Marking and Lighting **Date:** 12/04/15 **AC No:** 70/7460-IL
**Initiated By:** AJV-15

1. **Purpose.**
This Advisory Circular (AC) sets forth standards for marking and lighting obstructions that have been deemed to be a hazard to navigable airspace.

2. Advisory Circular 70/7460-1L is effective immediately. However, flashing L-810 lighting has a delayed effective date and becomes mandatory on September 15, 2016.

3. **Cancellation.**
Advisory Circular 70/7460-1K, Obstruction Lighting and Marking, dated February 1, 2007, is cancelled.

4. **Principal Changes.**
The principal changes in this AC are:

1. The height of a structure identified as an obstruction has been lowered from 500 feet above ground level (AGL) to 499 feet above ground level, by amendment to Title 14 Code of Federal Regulations (14 CFR) Part 77, *Safe, Efficient Use, and Preservation of the Navigable Airspace* (75 Federal Register 42303, July 21, 2010). Accordingly, all structures that are above 499 feet AGL are considered obstructions and the Federal Aviation Administration (FAA) will study them to determine their effect on the navigable airspace. This will ensure that all usable airspace at and above 500 feet AGL is addressed during an aeronautical study and that this airspace is protected from obstructions that may create a hazard to air navigation.
2. Standards for voluntary marking of meteorological evaluation towers (METs), less than 200 feet above ground level (AGL), has been added to provide recommendations towards increasing conspicuity of these structures, particularly

for low-level agricultural flight operations. These standards include those for lighting and marking of the tower and associated guy wires.

3. A new Chapter 14, Aircraft Detection Lighting Systems, has been added to provide performance standards for these types of systems.
4. New lighting and marking standards are provided to reduce impact on migratory bird populations.
5. Medium-intensity white and medium-intensity dual obstruction light are now authorized on towers up to and including 700 feet AGL.
6. Editorial changes have been made.

5. **Related Reading Material.**

1. Advisory Circular 150/5345-43, Specification of Obstruction Marking and Lighting.
2. 14 CFR Part 77, Safe, Efficient Use and Preservation of the Navigable Airspace.

6. **Application.**

The FAA recommends the guidelines and standards in this AC for determining the proper way to light and mark obstructions affecting navigable airspace. This AC does not constitute a regulation and, in general, is not mandatory. However, a sponsor proposing any type of construction or alteration of a structure that may affect the National Airspace System (NAS) is required under the provisions of Title 14 Code of Federal Regulations to notify the FAA by completing the Notice of Proposed Construction or Alteration form (FAA Form 7460-1). These guidelines may become mandatory as part of the FAA's determination and should be followed on a case-by-case basis, as required.

7. **Comments or Suggestions.**

Direct comments or suggestions regarding this AC to:

Manager, Obstruction Evaluation Group
Federal Aviation Administration
ATTN: AJV-15
800 Independence Avenue, S.W.
Washington, DC 20591

Jodi S. McCarthy
Director, Airspace Services

## CONTENTS

# CHAPTER 1. ADMINISTRATIVE AND GENERAL PROCEDURES

## 1.1 Reporting Requirements.

A sponsor proposing any type of construction or alteration of a structure that may affect the NAS as required under the provisions of Title 14 Code of Federal Regulations (CFR) Part 77, Construction or alteration requiring notice, is to notify the Federal Aviation Administration (FAA) by completing the Notice of Proposed Construction or Alteration form (FAA Form 7460-1). This form should be filed electronically at https://oeaaa.faa.gov.

## 1.2 Preconstruction Notice.

The notice must be submitted:

1. At least 45 days prior to the date of proposed construction or alteration is to begin.

2. On or before the date an application for a construction permit is filed with the Federal Communications Commission (FCC). (The FCC advises its applicants to file with the FAA well in advance of the 45-day period to expedite FCC processing.)

## 1.3 FAA Acknowledgement.

The FAA will acknowledge, in writing, each FAA Form 7460-1 notice received.

## 1.4 Supplemental Notice Requirement.

1. If required, the FAA will include a statement requiring the filing of FAA Form 7460-2, Notice of Actual Construction or Alteration, on the determination. All FAA Forms 7460-2 should be filed electronically at http://oeaaa.faa.gov.

2. FAA Form 7460-2 Part 1 is to be completed and sent to the FAA at least 10 days prior to starting the actual construction or alteration of a structure. Part 2 shall be submitted within 5 days after the structure has reached its greatest height. The form should be filed electronically at http://oeaaa.faa.gov.

3. In addition, a supplemental notice shall be submitted upon abandonment of construction.

4. Letters are acceptable in cases where the construction/alteration is temporary or a proposal is abandoned. This notification process gives the FAA the necessary time to change effected procedures and/or minimum flight altitudes and to otherwise alert airmen of the structure's presence.

   **Note:** Notification, as required in the determination, is critical to aviation safety.

## 1.5 Modifications and Deviations.

Requests for modification or deviation from the standards outlined in this AC must be submitted to the FAA Obstruction Evaluation Group (OEG). The sponsor is responsible for adhering to approved marking and/or lighting limitations, and/or recommendations given, and should notify the FAA and FCC (for those structures regulated by the FCC) prior to removal of marking and/or lighting. A request received after a determination is issued may require a new study and could result in a new determination.

1. Modification Examples. Modifications will be based on whether they impact aviation safety. Examples of modifications are as follows:

   a. Marking and/or Lighting Only a Portion of an Object. The object may be located with respect to other objects or terrain that only a portion of it needs to be marked or lighted.

   b. No Marking and/or Lighting. The object may be located with respect to other objects or terrain, removed from the general flow of air traffic, or may be so conspicuous by its shape, size or color that marking or lighting would serve no useful purpose.

   c. Voluntary Marking and/or Lighting. The object may be located with respect to other objects or terrain that the sponsor feels increased conspicuity would better serve aviation safety. Sponsors who desire to voluntarily mark and/or light their structure should do so in accordance with this AC.

   d. Marking or Lighting an Object in Accordance with the Standards for an Object of Greater Height or Size. The object may present such an extraordinary hazard potential that higher standards may be recommended for increased conspicuity to ensure aviation safety.

2. Deviations. The assigned Obstruction Evaluation Specialist will conduct an aeronautical study of the proposed deviation(s) and forward their recommendation to FAA Headquarters, OEG Manager, in Washington, DC, for final approval. Examples of deviations that may be considered:

   a. Colors of objects.

   b. Dimensions of color bands or rectangles.

   c. Colors/types of lights.

   d. Basic signals and intensity of lighting.

   e. Night/day lighting combinations.

   f. Flash rate.

3. The FAA strongly recommends that owners become familiar with the different types of lighting systems and to specifically request the type of lighting system desired when submitting FAA Form 7460-1. Information on these systems is given in Table A-1 in Appendix A. While the FAA will make every effort to accommodate the structure sponsor's request, sponsors should also request information from system manufacturers to determine which system best meets their needs based on purpose, installation, and maintenance costs.

## 1.6 Additional Notification.

Any change to the submitted information on which the FAA has based its determination, including modification, deviation, or optional upgrade to white lighting on structures, may require notice to the FCC prior to making the change for proper authorization and annotations of obstruction marking and lighting. These structures may be subject to inspection and enforcement of marking and lighting requirements by the FCC. FCC Forms and Bulletins can be obtained from the FCC's National Call Center at 1-888-CALL-FCC (1-888-225-5322) or online at https://www.fcc.gov.edgekey.net/licensing-databases/forms. Upon completion of the actual change, complete the "Add Supplemental Notice (7460-2 Form)" at the http://oeaaa.faa.gov website. You may also mail the FAA Form 7460-2 to:

FAA Aeronautical Information Services
1305 E W Hwy
Silver Spring, MD 20910
1-800-626-3677

# CHAPTER 2. GENERAL

## 2.1 Structures to be Marked and Lighted.

Any temporary or permanent structure, including all appurtenances, that exceeds an overall height of 200 feet (61 m) above ground level (AGL) or exceeds any obstruction standard contained in 14 CFR Part 77 should be marked and/or lighted. However, an FAA aeronautical study may reveal that the absence of marking and/or lighting will not impair aviation safety. Conversely, the object may present such an extraordinary hazard potential that higher standards may be recommended for increased conspicuity to ensure aviation safety. In general, commercial outside lighting should not be used in lieu of FAA-recommended marking and/or lighting. Recommendations on marking and/or lighting structures can vary, depending on terrain features, weather patterns, geographic location, and in the case of wind turbines, the number of structures and overall design layout. The FAA may also recommend marking and/or lighting a structure that does not exceed 200 (61 m) feet AGL or 14 CFR Part 77 standards because of its particular location. The marking and lighting configurations are illustrated in Appendix A, Figures A-1 through A-27.

## 2.2 Guyed Structures.

The guys of a 2,000-foot (610-m) skeletal tower are anchored between 1,600 feet (488 m) and 2,000 feet (610 m) from the base of the structure. This places a portion of the guys 1,500 feet (458 m) from the tower at a height of between 125 feet (38 m) and 500 feet (153 m) AGL. Title 14 CFR Part 91, Section 119, requires pilots, when operating over other than congested areas, to remain at least 500 feet (153 m) from man-made structures. Therefore, the tower must be cleared by 2,000 feet (610 m) horizontally to avoid all guy wires. Properly maintained marking and lighting are important for increased conspicuity because the guys of a structure are difficult to see until the aircraft is dangerously close.

## 2.3 Marking and Lighting Equipment.

Considerable effort and research was expended to determine the minimum marking and lighting systems or quality of materials that will produce an acceptable level of aviation safety. The FAA will recommend only those marking and lighting systems that meet established technical standards. While additional lights may be desirable to identify an obstruction to air navigation and may, on occasion, be recommended, the FAA will recommend minimum standards in the interest of safety, economy, and related concerns. Therefore, to provide an adequate level of safety, obstruction lighting systems should be installed, operated, and maintained in accordance with the recommended standards herein. Table A-1 in Appendix A contains descriptions of each FAA-approved obstruction lighting fixture that is referred to in this AC.

## 2.4 Light Failure Notification.

2.4.1 Sponsors should consider that conspicuity is achieved only when all recommended lights are working. Partial equipment outages decrease the margin of safety. Any outage should be corrected as soon as possible. Failure of steady-burning side or intermediate lights should be corrected as soon as possible, but notification is not required.

2.4.2 Any failure or malfunction that lasts more than thirty (30) minutes and affects a top light or flashing obstruction light, regardless of its position, should be reported immediately by calling Outage Reporting and Notice to Airmen (NOTAM) 877-487-6867, or for Alaska 800-478-3576, so a NOTAM can be issued. Lights that are voluntary (not required by an FAA determination) do not require a NOTAM. For structures that are regulated by the FCC, the FCC advises that noncompliance with notification procedures could subject the sponsor to penalties or monetary forfeitures.

2.4.3 The following information should be specified for outage reporting:

1. Name of persons or organizations reporting the light failures, including any title, address, and telephone number.
2. The type of structure.
3. Location of structure (including latitude and longitude, if known, prominent structures, landmarks, etc.).
4. Height of structure AGL/above mean sea level (AMSL) if known.
5. A return to service date.
6. FCC Antenna Structure Registration Number (for structures that are regulated by the FCC).

**Note:** When the primary lamp in a double obstruction light fails, and the secondary lamp comes on, no report is required.

## 2.5 Notification of Restoration.

As soon as normal operation is restored, notify outage reporting. For structures that are regulated by the FCC, the FCC advises that noncompliance with notification procedures could subject the sponsor to penalties or monetary forfeitures.

## 2.6 Federal Communications Commission (FCC) Requirement.

The use of a high-intensity flashing white lighting system on structures located in residential neighborhoods (as defined by applicable zoning laws) trigger requirements for FCC licenses and an environmental assessment.

## 2.7 Voluntary Marking of Meteorological Evaluation Towers (METs) Less Than 200 Feet (61 m) AGL.

### 2.7.1 Recommendation.

The FAA recommends voluntary marking of METs less than 200 feet (61 m) AGL in accordance with marking guidance contained in this advisory circular (AC). Historically, this guidance has not been applied. However, the FAA recognizes the need to address safety impacts to low-level agricultural flight operations, and it believes that voluntarily marking METs less than 200 feet (61 m) AGL in remote and rural areas enhance the conspicuity of these structures.

### 2.7.2 Painting.

METs should be painted in accordance to the criteria contained in Chapter 3, paragraphs 3.1 through 3.4, specifically, with alternate bands of aviation orange and white paint. In addition, paragraph 3.5 states that all markings should be replaced when faded or otherwise deteriorated.

### 2.7.3 High-Visibility Sleeves.

It is recommended that several high-visibility sleeves be installed on the MET's outer guy wires. One high-visibility sleeve should be installed on each guy wire, as close to the anchor point as possible, but at a, height well above the crop or vegetation canopy. A second sleeve should be installed on the same outer guy wires midway between the location of the lower sleeve and the upper attachment point of the guy wire to the MET.

### 2.7.4 Spherical Markers.

It is also recommended that high-visibility aviation orange spherical marker (or cable) balls be attached to the guy wires. Spherical markers should be installed and displayed in accordance to Chapter 3, paragraph 3.5. The FAA, however, recognizes various weather conditions and manufacturing placement standards may affect the placement and use of high-visibility sleeves and/or spherical markers. Thus, some flexibility is allowed when determining sleeve length and marker placement on METs.

## 2.8 Obstruction Height Definition Changed to 499 Feet AGL.

Because of changes made to 14 CFR Part 77, *Safe, Efficient Use, and Preservation of the Navigable Airspace*, on July 21, 2010, the height of a structure (identified as an obstruction) was lowered to 499 feet AGL from 500 feet AGL. Consequently, all structures that are above 499 feet AGL will be designated as obstructions. The FAA will conduct an aeronautical study to determine the effect on navigable airspace. This will ensure all usable airspace at and above 500 feet AGL is addressed during the study and the airspace is safe for air navigation.

# CHAPTER 3. MARKING GUIDELINES

## 3.1 Purpose.

This chapter provides recommended guidelines to make certain structures conspicuous to pilots during daylight hours. One way to achieve this conspicuity is to paint and/or mark these structures. Recommendations on marking structures can vary, depending on terrain features, weather patterns, geographic location, and the number of structures. Specific marking guidelines for wind turbines are contained in Chapter 13.

## 3.2 Paint Colors.

Alternate sections of aviation orange and white paint should be used as the contrast in colors provides maximum visibility of an obstruction. Specific paint standards are contained in Chapter 12.

## 3.3 Paint Standards.

To be effective, the paint used should meet specific color requirements when freshly applied to a structure. Because all outdoor paints deteriorate with time, and it is not practical to give a maintenance schedule for all climates, surfaces should be repainted when the color changes noticeably or its effectiveness is reduced by scaling, oxidation, chipping, or layers of contamination. The subsequent standards should be followed.

### 3.3.1 Materials and Application.

The FAA recommends that quality paint and materials be selected to maximize years of service. The paint should be appropriate for the surfaces to be painted, including any previous coatings, and suitable for the environmental conditions. Surface preparation and paint application should follow the manufacturer's recommendations.

> **Note:** In-Service Aviation Orange Color Tolerance Charts are available from private suppliers for determining when repainting is required. The color should be sampled on the upper half of the structure, since weathering is greater there.

### 3.3.2 Surfaces not Requiring Paint.

Ladders, decks, and walkways of steel towers and similar structures do not need to be painted if a smooth surface presents a potential hazard to maintenance personnel. Painting may also be omitted from precision or critical surfaces if the paint would have an adverse effect on the transmission or radiation characteristics of a signal. However, the structure's overall marking effect should not be reduced.

### 3.3.3 Skeletal Structures.

Complete all marking/painting prior to or immediately upon completion of construction. This applies to catenary support structures, radio and television towers, and similar

skeletal structures. To be effective, paint should be applied to all inner and outer surfaces of the framework.

3.4 **Paint Patterns.**

Various types of paint patterns are used to mark structures. The pattern is determined by the size and shape of the structure. The following patterns are recommended.

3.4.1 Solid Pattern.

Obstacles should be painted aviation orange if the structure's horizontal and vertical dimensions do not exceed 10.5 feet (3.2 m).

3.4.2 Checkerboard Pattern.

Alternating rectangles of aviation orange and white are normally displayed on the following structures:

1. Water, gas, and grain storage tanks.
2. Buildings, as required.
3. Large structures exceeding 10.5 feet (3.2 m) across, having a horizontal dimension that is equal to or greater than the vertical dimension.

3.4.3 Size of Patterns.

The sides of the checkerboard pattern should measure not less than 5 feet (1.5 m) or more than 20 feet (6 m) and should be as nearly square as possible. However, if it is impractical because of the size or shape of a structure, the sides of the patterns may be less than 5 feet (1.5 m). When possible, the corner surfaces should be painted aviation orange. (See Figures A-15 and A-16 in Appendix A.)

3.4.4 Alternate Bands.

Alternate bands of aviation orange and white are normally displayed on the following structures:

1. Communication towers and catenary support structures.
2. Poles.
3. Smokestacks.
4. Skeletal framework of storage tanks and similar structures.
5. Structures that appear narrow from a side view are 10.5 feet (3.2 m) or more across, and the horizontal dimension is less than the vertical dimension.

6. Coaxial cable, conduits, and other cables attached to the face of a tower.

3.4.5 Color Band Characteristics.

Bands for structures of any height should be:

1. Equal in width, provided each band is not less than 1 1/2 feet (0.5 m) or more than 100 feet (31 m) wide.

2. Perpendicular to the vertical axis with the bands at the top and bottom painted orange.

3. An odd number of bands on the structure.

4. Approximately one-seventh the height, if the structure is equal to or less than 700 feet (214 m) AGL. For each additional 200 feet (61 m) or fraction thereof, add one (1) additional orange and one (1) additional white band. Table 3-1 shows the required band widths based on the height of the structure.

5. Equal and in proportion to the structure's AGL height.

**Table 3-1. Structure Height to Bandwidth Ratio**

| **If a structure is:** | | **Then Band Width:** |
|---|---|---|
| **Greater Than** | **Equal to or Less Than** | **Band Width** |
| 10.5 feet (3.2 m) | 700 feet (214 m) | 1/7 of height |
| 700 feet (214 m) | 900 feet (275 m) | 1/9 of height |
| 900 feet (275 m) | 1,100 feet (336 m) | 1/11of height |
| 1,100 feet (336 m) | 1,300 feet (397 m) | 1/13 of height |

3.4.6 Structures With a Cover or Roof.

If the structure has a cover or roof, the highest orange band should be continued to cover the entire top of the structure. (See Figures A-15 and A-16 in Appendix A.)

3.4.7 Skeletal Structures Atop Buildings.

If a flagpole, skeletal structure, or similar object is erected on top of a building, the combined height of the object and building will determine whether marking is recommended. However, only the height of the object filed with the FAA determines the width of the color bands.

3.4.8 Partial Marking.

If marking is recommended for only a portion of a structure because the structure is shielded by other objects or terrain, the width of the bands should be determined by the overall height of the structure. A minimum of three bands should be displayed on the upper portion of the structure.

3.4.9 Teardrop Pattern.

Spherical water storage tanks with a single, circular standpipe support may be marked in a teardrop-striped pattern. The tank should show alternate stripes of aviation orange and white. The stripes should extend from the top center of the tank to its supporting standpipe. The width of the stripes should be equal, and the width of each stripe at the greatest girth of the tank should not be less than 5 feet (1.5 m) nor more than 15 feet (4.6 m). (See Figure A-17 in Appendix A.)

3.4.10 Community Names.

If it is desirable to paint the name of the community on the side of a tank, the stripe pattern may be broken to serve this purpose. This open area should have a maximum height of 3 feet (0.9 m). (See Figure A-17 in Appendix A.)

3.4.11 Exceptions.

Structural designs not conducive to standard markings may be marked as follows:

1. If it is not practical to paint the roof of a structure in a checkerboard pattern, it may be painted solid orange.
2. If a spherical structure is not suitable for an exact checkerboard pattern, the shape of the rectangles may be modified to fit the shape of the surface.
3. Storage tanks not suitable for a checkerboard pattern may have alternating bands of aviation orange and white or a limited checkerboard pattern applied to the upper one-third of the structure.
4. The skeletal framework of certain water, gas, and grain storage tanks may be excluded from the checkerboard pattern.

## 3.5 **Unlighted Markers.**

Unlighted markers are used to identify structures and to make them more conspicuous when it is impractical to paint them. Unlighted markers may also be used in addition to aviation orange and white paint when additional conspicuity is necessary for aviation safety. Unlighted markers should be displayed in conspicuous positions on or adjacent to the structures so as to retain the general definition of the structure. They should be recognizable in clear, daytime visibility from a distance of at least 4,000 feet (1,219 m) and in all directions from which aircraft are likely to approach. Unlighted markers should be distinctively shaped, i.e., spherical or cylindrical, so that they are not mistaken for items that are used to convey other information. They should be replaced when faded or otherwise deteriorated.

3.5.1 Spherical Markers.

Spherical markers are used to identify overhead wires and catenary transmission lines that are less than 69 kV. Markers may be of another shape, i.e., cylindrical, provided the projected area of such markers is not less than that presented by a spherical marker.

1. Size and Color.

   The diameter of the markers used on extensive catenary wires (catenary wires that cross canyons, lakes, rivers, etc.) should not be less than 36 inches (91 cm). Smaller 20-inch (51-cm) spheres are permitted on less extensive catenary wires or on power lines below 50 feet (15 m) AGL and within 1,500 feet (458 m) of an airport runway end. Each marker should be a solid color, specifically aviation orange, white, or yellow.

2. Installations.

   a. Spacing. Unlighted markers should be spaced equally along the wire at approximately 200-foot (61-m) intervals, or fraction thereof. There should be less space between markers in critical areas near runway ends [i.e., 30 feet to 50 feet (10 m to 15 m)]. They should be displayed on the highest wire or by another means at the same height as the highest wire. Where there is more than one wire at the highest point, the markers may be installed alternately along each wire if the distance between adjacent markers meets the spacing standard of 200 feet or less. This method distributes the weight and wind-loading factors. (See Figure A-1 in Appendix A.)

   b. Pattern. An alternating color scheme provides the most conspicuity against all backgrounds. Unlighted markers should be installed by alternating solid-colored markers of aviation orange, white, and yellow. Normally, an orange marker is placed at each end of a line and the spacing is adjusted [not to exceed 200 feet (61 m)] to accommodate the rest of the markers. When less than four markers are used, they should all be aviation orange. (See Figure A-1 in Appendix A.)

   c. Wire Sag. Wire Sag, or droop, will occur due to temperature, wire weight, wind, etc. Twenty-five (25) feet (7.62 m) is the maximum allowable distance between the highest wire installed with marker balls and the highest wire without marker balls, and shall not violate the sag requirements of the transmission line design.

   d. Adjacent Lines. Catenary crossings with multiple transmission lines require appropriate markers when the adjacent catenary structure's outside lines are greater than 200 feet (61 m) away from the center of the primary structure. (See Figure A-2 in Appendix A.) If the outside lines of the adjacent catenary structure are within 200 feet (61 m) or less from the center of the primary structure, markers are not required on the adjacent lines. (See Figure A-3 in Appendix A.)

3.5.2 Flag Markers.

Flags are used to mark certain structures or objects when it is technically impractical to use spherical markers or paint. Some examples are temporary construction equipment, cranes, derricks, oil and other drilling rigs. Catenaries should use spherical markers.

1. Minimum Size. Each side of the flag marker should be at least 2 feet (0.6 m) in length.

2. Color Patterns. Flags should be colored as follows:

   a. Solid. Aviation orange.

b. Orange and White. Arrange two triangular sections, one aviation orange and the other white to form a rectangle.

c. Checkerboard. Flags 3 feet (0.9 m) or larger should be a checkerboard pattern of aviation orange and white squares, each 1 foot (0.3 m) plus or minus 10 percent.

3. Shape. Flags should be rectangular in shape and have stiffeners to keep them from drooping in calm wind.

4. Display. Flag markers should be displayed around, on top, or along the highest edge of the obstruction. When flags are used to mark extensive or closely grouped obstructions, they should be displayed approximately 50 feet (15 m) apart. The flag stakes should be strong enough to support the flags and be higher than the surrounding ground, structures, and/or objects of natural growth.

## 3.6 Unusual Complexities.

The FAA may also recommend appropriate marking in an area in which grouped obstructions present a common obstruction to air navigation.

## 3.7 Omission or Alternatives to Marking.

The alternatives listed below require FAA review and concurrence.

### 3.7.1 High-Intensity Flashing White Lighting Systems.

High-intensity flashing white lighting systems are more effective than aviation orange and white paint and therefore can be recommended instead of paint marking. This is particularly true under certain ambient light conditions involving the position of the sun relative to the direction of flight. When high-intensity lighting systems are operated during daytime and twilight, other methods of marking may be omitted. When operated 24 hours a day, other methods of marking and lighting may be omitted.

### 3.7.2 Medium-Intensity Flashing White Lighting Systems.

When medium-intensity flashing white lighting systems are operated during daytime and twilight on structures 700 feet (213 m) AGL or less, other methods of marking may be omitted.

**Note:** Sponsors must ensure that alternatives to marking are coordinated with the FCC for structures under its jurisdiction prior to making the change.

# CHAPTER 4. LIGHTING GUIDELINE

## 4.1 Purpose.

This chapter describes the various obstruction lighting systems used to identify structures that have been determined to require added conspicuity. The lighting standards in this AC are the minimum necessary for aviation safety. Recommendations on lighting structures can vary, depending on terrain features, weather patterns, geographic location, and number of structures. Specific lighting guidelines for wind turbines are contained in Chapter 13.

## 4.2 Standards.

The standards outlined in this AC are based on using light units that meet specified intensities, beam patterns, color, and flash rates as stated in AC 150/5345-43, *Specification for Obstruction Lighting Equipment*. These standards may be obtained from: www.faa.gov/airports/resources/advisory_circulars/

## 4.3 Lighting Systems.

Obstruction lighting may be displayed on structures as follows:

1. Aviation Red Obstruction Lights. Use flashing lights and/or steady-burning lights during nighttime. Tower structures are typically marked with flashing red lights. Buildings and smaller obstructions located near airports should be marked with steady-burning red lights. (See Chapter 5).

2. Medium-Intensity Flashing White Obstruction Lights. Medium-intensity flashing white obstruction lights may be used during daytime and twilight with automatically selected reduced intensity for nighttime operation. When this system is used on structures 700 feet (213 m) AGL or less, other methods of marking and lighting the structure may be omitted. Aviation orange and white paint is always required for daytime marking on structures exceeding 700 feet (213 m) AGL. This system is not normally recommended on structures 200 feet (61 m) AGL or less.

3. High-Intensity Flashing White Obstruction Lights. High-intensity flashing white obstruction lights may be used during daytime with automatically selected reduced intensities for twilight and nighttime operations. When this system is used, other methods of marking and lighting the structure may be omitted. This system should not be used on structures 700 feet (213 m) AGL or less, unless an FAA aeronautical study shows otherwise.

   **Note:** All flashing lights on a structure should flash simultaneously except for catenary support structures, which have a distinct flashing sequence between the levels of lights (see paragraph 4.4).

4. Dual Lighting. This system consists of red lights for nighttime and high- or medium-intensity flashing white obstruction lights for daytime and twilight. When

a dual lighting system incorporates medium-intensity flashing white lights on structures 700 feet (213 m) AGL or less or high-intensity flashing white lights on structures greater than 700 feet (213 m) AGL, other methods of marking the structure may be omitted.

5. Obstruction Lights During Construction. As the height of the structure exceeds each level at which permanent obstruction lights would be recommended, two or more lights of the type specified in the determination should be installed at that level. Temporary high or medium-intensity flashing white lights, as recommended in the determination, should be operated 24 hours a day until all permanent lights are in operation. In either case, two or more lights should be installed on the uppermost part of the structure any time it exceeds the height of the temporary construction equipment. They may be turned off for periods when they could interfere with construction personnel. If practical, permanent obstruction lights should be installed and operated at each level as construction progresses. The lights should be positioned to ensure that a pilot has an unobstructed view of at least one light at each level.

6. Obstruction Lights in Urban Areas. When a structure is located in an urban area where there are numerous other white lights (e.g., streetlights) red obstruction lights with painting or a medium-intensity dual system is recommended. Medium-intensity lighting is not normally recommended on structures less than 200 feet (61 m).

7. Temporary Construction Equipment Lighting. Since there is such a variance in construction cranes, derricks and other drilling rigs, each case should be considered individually. Lights should be installed according to the standards given in Chapters 5, 6, 7, or 8, as they would apply to permanent structures.

## 4.4 Lighted Spherical Markers.

4.4.1 Lighted markers are available for increased night conspicuity of high-voltage (69 kV or greater) transmission line catenary wires. These markers should be used on transmission line catenary wires near airports, heliports, across rivers, canyons, lakes, etc. The lighted markers should be manufacturer-certified as recognizable from a minimum distance of 4,000 feet (1,219 m) under nighttime conditions, minimum Visual Flight Rule (VFR) conditions or having a minimum intensity of at least 32.5 candelas. The lighting unit should emit a steady-burning, red light.

4.4.2 Lighted markers should be installed on the highest energized line. If the lighted markers are installed on a line other than the highest catenary, then markers specified in Chapter 3 paragraph 3.5 should be used in addition to the lighted markers. The maximum distance between the line energizing the lighted markers and the highest catenary above the lighted marker should be no more than 25 feet (7.62 m) and shall not violate the sag requirements of the transmission line design.

4.4.3 Lighted markers should be distinctively shaped, (i.e., spherical or cylindrical) so they are not mistaken for items that are used to convey other information. They should be visible in all directions from which aircraft are likely to approach. The area in the immediate vicinity of the supporting structure's base should be clear of all items and/or objects of natural growth that could interfere with the line-of-sight between a pilot and the structure's lights (See Figure A-4 in Appendix A). When a catenary wire crossing requires three or more supporting structures, the inner structures should be equipped with enough light units per level to provide full coverage from which aircraft are likely to approach.

## 4.5 Inspection, Repair, and Maintenance.

To ensure the proper candela output for fixtures with incandescent lamps, the voltage provided to the lamp filament should not vary more than plus or minus three percent of the lamp's rated voltage. The input voltage should be measured at the closest disconnecting means to the lamp fixture with the lamp operating during the hours of normal operation. (For strobes, the input voltage of the power supplies should be within 10 percent of rated voltage.) Lamps should be replaced after being in operation for approximately 75 percent of their rated life or immediately upon failure. Flashtubes in a light unit should be replaced immediately upon failure, when the peak effective intensity falls below specification limits or when the fixture begins skipping flashes, or at the manufacturer's recommended intervals. Due to the effects of harsh environments, light fixture lenses should be visually inspected every 24 months, or when the light fixture fails, for ultraviolet (UV) damage, cracks, crazing, dirt buildup, etc., to ensure the certified light output has not deteriorated. (See Chapter 2 paragraph 2.4 for reporting requirements in case of failure.) Lenses that have cracks, UV damage, crazing, or excessive dirt buildup should be cleaned or replaced.

## 4.6 Nonstandard Lights.

Moored balloons, chimneys, church steeples, and similar obstructions may be floodlighted by fixed search light projectors installed at three or more equidistant points around the base of each obstruction. The searchlight projectors should provide an average illumination of at least 15 foot-candles (161.45 lux) over the top one-third of the obstruction.

## 4.7 Placement Factors.

The height of the structure AGL determines the number of light levels. The light levels may be adjusted slightly, but not to exceed 10 feet (3 m) when necessary to accommodate guy wires and personnel who replace or repair light fixtures. Except for catenary wire support structures, the following factors should be considered when determining the placement of obstruction lights on a structure.

1. Red Obstruction Lighting Systems. The structure's overall height, including all appurtenances, such as rods, antennas, and obstruction lights, determines the number of light levels.

2. Medium-Intensity Flashing White Obstruction Lighting Systems. The structure's overall height, including all appurtenances such as rods, antennas, and obstruction lights, determines the number of light levels.

3. High-Intensity Flashing White Obstruction Lighting Systems. The main structure's overall height, excluding all appurtenances, such as rods, antennas, and obstruction lights, determines the number of light levels.

4. Dual Obstruction Lighting Systems. The structure's overall height, including all appurtenances, such as rods, antennas, and obstruction lights, is used to determine the number of light levels for a medium-intensity white obstruction light/red obstruction dual lighting system. The structure's overall height, excluding all appurtenances, is used to determine the number of light levels for a high-intensity white obstruction light/red obstruction dual lighting system.

5. Adjacent Structures. The elevation of the tops of adjacent buildings in congested areas may be used as the equivalent of ground level to determine the correct number of light levels required.

6. Shielded Lights. If an adjacent structure or object blocks the visibility of an obstruction light, the light's horizontal placement should be adjusted or additional lights should be mounted on that object to retain or contribute to the definition of the obstruction.

7. Nesting of Lights. Care should be taken to ensure that obstruction lights do not become blocked or "nested" as new antennas, hardware, or appurtenances are added to the top of a structure. If new equipment is added that blocks the obstruction light's visibility, the light fixtures must be relocated and/or raised so that it is not blocked by the new equipment. For example, when new larger cellular antenna panels are fitted to older towers, the obstruction light will need to be raised so that it is not blocked by the larger antenna panels. The widest structure, appurtenance, lightning rod, or antenna that can be placed in front of an obstruction light (excluding the L-810 light) without significantly blocking the obstruction light's visibility should be no wider than 7/8 of an inch. Due to their smaller size, L-810 lights should not be blocked by any structure.

## 4.8 Monitoring Obstruction Lights.

Obstruction lighting systems should be closely monitored by visual or automatic means. It is extremely important to visually inspect obstruction lighting in all operating intensities at least once every 24 hours on systems without automatic monitoring. In the event a structure is not readily accessible for visual observation, a properly maintained automatic monitor should be used. This monitor should be designed to register the malfunction of any light on the obstruction regardless of its position or color. When using remote monitoring devices, the system's communication and operational status should be confirmed at least once every 24 hours. The monitor (aural or visual) should be located in an area generally occupied by the responsible personnel. In some cases,

this may require a remote monitor in an attended location. For each structure, a log should be maintained in which the lighting system's daily operations status is recorded. Light fixture lenses should be replaced if serious cracks, hazing, dirt buildup, etc., has occurred.

4.9 **Ice Shields.**

Where icing is likely to occur, metal grates or similar protective ice shields should be installed directly over each light unit to prevent falling ice or accumulation from damaging the light units. The light should be mounted in a manner to ensure an unobstructed view of at least one light by a pilot approaching from any direction.

4.10 **Light Shields.**

In general, light shields are not permitted because of the adverse effects they have on the obstruction light fixture's photometrics. In addition, these shields can promote undesired snow accumulation, bird nesting, and wind loading.

4.11 **Distraction.**

When obstruction lights are in proximity to a navigable waterway, they may distract vessel operators. To avoid interference with marine navigation, coordinate with the Office of Navigation Systems, United States (U.S.) Coast Guard before installing the lighting system. The contact information for the U.S. Coast Guard is:

Commandant (CG-NAV-1)
U.S. Coast Guard
2703 Martin Luther King Jr. Ave SE STOP 7418
Washington, DC 20593-7418
202-372-1546

# CHAPTER 5. RED OBSTRUCTION LIGHT SYSTEM

## 5.1 Purpose.

Red obstruction lights are used to increase conspicuity during nighttime. Daytime and twilight marking is required. Recommendations on lighting structures can vary, depending on terrain features, weather patterns, geographic location, and number of structures. Specific lighting guidelines for wind turbines are contained in Chapter 13.

## 5.2 Standards.

The red obstruction light system is composed of flashing omnidirectional lights (L-864) and/or steady-burning or flashing (L-810) lights. When one or more levels are comprised of flashing lights, the lights should flash simultaneously. The number of light levels needed is shown in Figure A-6 in Appendix A.

Note: In response to a Safety Risk Assessment of LED Lighting in Aircraft Operations, the FAA has established IR specifications for LED-based red obstruction lights. Specifications are contained in Airport Engineering Brief 98, *Infrared Specifications for Aviation Obstruction Light Compatibility with Night Vision Goggles (NVGs)*, published December 18, 2017, and AC 150/5345-43H, *Specification for Obstruction Lighting Equipment*, dated September 28, 2016.

1. Single Obstruction Light. A single red obstruction light (L-810) may be used when more than one obstruction light is required either vertically or horizontally, or when maintenance is needed, and can be installed within a reasonable time.

    a. Top Level. A single steady-burning light (L-810) may be used to identify low structures, such as airport instrument landing system buildings, as well as long horizontal structures, such as perimeter fences and building roof outlines.

    b. Intermediate Level. Single flashing or steady-burning lights (as appropriate for size and type of structure) may be used on skeletal and solid structures when more than one level of lights is installed, and there are two or more single lights per level.

2. Double Obstruction Light. A double steady-burning (L-810) light should be installed when used as a top light, at each end of a row of single obstruction lights, and in areas or locations where the failure of a single unit could cause an obstruction to be totally unlighted.

    a. Top Level. Structures 150 feet (46 m) AGL or less should have one or more double steady-burning lights installed at the highest point and operating simultaneously.

b. Intermediate Level. Double flashing or steady-burning lights (as appropriate for size and type of structure) should be installed at intermediate levels when a malfunction of a single light could create an unsafe condition and in remote areas where maintenance cannot be performed within a reasonable time. Both units may operate simultaneously, or a transfer relay may be used to switch to a spare unit should the active system fail.

c. Lowest Level. The lowest level of light units may be installed at a higher elevation than normal on a structure if the surrounding terrain, trees, or adjacent building(s) would obscure the lights. In certain instances, as determined by the FAA, the lowest level of lights may be eliminated.

## 5.3 Control Device.

Red obstruction lights should be operated by an acceptable control device (e.g., photocell, timer, etc.) adjusted so the lights will be turned on when the northern sky illuminance reaching a vertical surface falls below a level of 60 foot-candles (645.8 lux) but before reaching a level of 35 foot-candles (376.7 lux). The control device should turn the lights off when the northern sky illuminance rises to a level of not more than 60 foot-candles (645.8 lux). The lights may also remain on continuously. The sensing device should, if practical, face the northern sky in the Northern Hemisphere. (See AC 150/5345-43.)

## 5.4 Poles, Towers, and Similar Skeletal Structures.

The following standards apply to radio and television towers, supporting structures for overhead transmission lines, and similar structures.

1. Top-Mounted Obstruction Light.

   a. Structures 150 Feet (46 m) AGL or Less. Two or more steady-burning red (L-810) lights should be installed in a manner to ensure an unobstructed view of one or more lights by a pilot.

   b. Structures Exceeding 150 Feet (46 m) AGL. At least one red flashing (L-864) light should be installed in a manner to ensure an unobstructed view of one or more lights by a pilot.

   c. Appurtenances 40 Feet (12 m) or Less. If a rod, antenna, or other appurtenance 40 feet (12 m) or less in height is incapable of supporting a red flashing light, then it may be placed at the base of the appurtenance. If the mounting location does not allow an unobstructed view of the light by a pilot, then additional lights should be added.

   d. Appurtenances Exceeding 40 Feet (12 m). If a rod, antenna, or other appurtenance exceeding 40 feet (12 m) in height is incapable of supporting a red flashing light, a supporting mast with one or more lights should be installed adjacent to the appurtenance. Adjacent installations should not exceed the

appurtenance's height and be within 40 feet (12 m) of the tip to allow the pilot an unobstructed view of at least one light. If the rod, antenna, or other appurtenance is 7/8 inch wide or more, at least two lights must be installed on the supporting mast to provide the necessary unobstructed view.

2. Mounting Intermediate Levels. The number of light levels is determined by the height of the structure, including all appurtenances, as shown in Figure A-6 in Appendix A. The number of lights on each level is determined by the shape and height of the structure. These lights should be mounted to ensure an unobstructed view of at least one light by a pilot.

   a. Steady-Burning Lights (L-810).

      i. Structures 150 Feet (46 m) AGL or Less. Two or more steady-burning (L-810) lights should be installed diagonally or on diametrically opposite positions.

      ii. Structures Exceeding 150 Feet (46 m) AGL. These structures do not require steady-burning (L-810) lights.

   b. Flashing Lights (L-810). For structures exceeding 151 feet (46 m) but not more than 350 feet (107 m) at intermediate levels, two or more flashing (L-810) lights should be mounted outside at diagonally opposite positions of intermediate levels. These lights should be configured to flash simultaneously with the L-864 flashing light on the top of the structure at a rate of 30 flashes per minute (fpm) (± 3 fpm).

   c. Flashing Lights (L-864).

      i. Structures 350 Feet (107 m) AGL or Less. These structures do not require flashing (L-864) lights at intermediate levels.

      ii. Structures Exceeding 350 Feet (107 m) AGL. At intermediate levels, as shown in Figure A-6 in Appendix A, two (L-864) lights should be mounted outside at diagonally opposite positions.

## 5.5 Chimneys, Flare Stacks, and Similar Solid Structures.

### 5.5.1 Number of Light Units.

The number of units recommended depends on the diameter of the structure at the top. The number of lights recommended below is the minimum.

1. Structures 20 Feet (6 m) or Less in Diameter. Three light units per level (see Figure A-20 in Appendix A).

2. Structures Exceeding 20 Feet (6 m) but not More Than 100 Feet (31 m) in Diameter. Four light units per level (see Figure A-20 in Appendix A).

3. Structures Exceeding 100 Feet (31 m) but not More Than 200 Feet (61 m) in Diameter. Six light units per level (see Figure A-21 in Appendix A).

4. Structures Exceeding 200 Feet (61 m) in Diameter. Eight light units per level.

5.5.2 Top-Mounted Obstruction Lights.

1. Structures 150 Feet (46 m) AGL or Less. L-810 lights should be installed horizontally at regular intervals at or near the top.

2. Structures Exceeding 150 Feet (46 m) AGL. At least three L-864 lights should be installed.

3. Chimneys, Cooling Towers, and Flare Stacks. Lights may be displayed as low as 20 feet (6-m) below the top (see Figure A-13 in Appendix A) to avoid the obscuring effect of deposits and heat generally emitted by this type of structure. It is important that these lights are readily accessible for cleaning and lamp replacement. It is understood that with flare stacks, as well as any other structures associated with the petrol-chemical industry, normal lighting requirements may not be necessary. This could be due to the location of the flare stack/structure within a large, well-lighted, petrol-chemical plant, or the fact that the flare, or working lights surrounding the flare stack/structure, is as conspicuous as obstruction lights.

5.5.3 Mounting Intermediate Levels.

The number of light levels is determined by the height of the structure including all appurtenances. For cooling towers 600 feet (183 m) AGL or less, intermediate light levels are not necessary. Structures between 150 feet and 350 feet AGL or less should have a second level of steady-burning red light units installed approximately at the midpoint of the structure and in a vertical line with the top level of lights. Structures exceeding 350 feet (107 m) AGL should have a second level of flashing light units.

1. Steady-Burning (L-810) Lights. The recommended number of light levels is shown in Figure A-15 in Appendix A. At least three lights should be installed on each level.

2. Flashing (L-864) Lights. The recommended number of light levels is shown in Figure A-6 in Appendix A. At least three lights should be installed on each level.

   a. Structures 350 Feet (107 m) AGL or Less. These structures do not need intermediate levels of flashing lights.

   b. Structures Exceeding 350 Feet (107 m) AGL. At least three flashing (L-864) lights should be installed on each level in a manner, allowing an unobstructed view of at least one light.

5.6 **Group of Obstructions.**

When individual objects, except wind turbines, within a group of obstructions are not the same height and are spaced a maximum of 150 feet (46 m) apart, the prominent objects within the group should be lighted in accordance with the standards for individual obstructions of a corresponding height. If the outer structure is shorter than the prominent object, the outer structure should be lighted in accordance with the standards for individual obstructions of a corresponding height. Light units should be placed to ensure that the light is visible to a pilot approaching from any direction. In addition, at least one flashing light should be installed at the top of a prominent center obstruction or on a special tower located near the center of the group. For the purpose of marking and lighting obstructions other than wind turbines, a group of obstructions is considered to be three (3) or more structures.

## 5.7 Alternate Method of Displaying Obstruction Lights.

The FAA may recommend that lights be placed on poles equal to the height of the obstruction and installed on or adjacent to the structure instead of installing lights on the obstruction.

## 5.8 Prominent Buildings, Bridges, and Similar Extensive Obstructions.

When objects within a group of obstructions are approximately the same overall height above the surface and are located a maximum of 150 feet (46 m) apart, the group of obstructions may be considered an extensive obstruction. Light units should be installed on the same horizontal plane at the highest portion, or edge, of the prominent obstructions. Light units should be placed to ensure the light is visible to a pilot approaching from any direction. If the structure is a bridge and is over navigable water, the sponsor must obtain prior approval of the lighting installation from the Commander of the District Office of the U.S. Coast Guard to avoid interference with marine navigation. Steady-burning lights should be displayed to indicate the extent of the obstruction, as follows:

1. Structures 150 Feet (46 m) or Less in Any Horizontal Direction. If the structure/bridge/extensive obstruction is 150 feet (46 m) or less horizontally, at least one steady-burning light (L-810) should be displayed on the highest point at each end of the obstruction's major axis. If this is impractical because of the overall shape, display a double obstruction light in the center of the highest point.

2. Structures Exceeding 150 Feet (46 m) in at Least One Horizontal Direction. If the structure/bridge/extensive obstruction exceeds 150 feet (46 m) horizontally, at least one steady-burning light should be displayed for each 150 feet (46 m), or fraction thereof, of the overall length of the major axis. At least one of these lights should be displayed on the highest point at each end of the obstruction. Additional lights should be displayed at approximately equal intervals, not to exceed 150 feet (46 m) on the highest points along the edge between the end lights. If an obstruction is located near a landing area and two or more edges are the same height, the edge nearest the landing area should be lighted.

3. Structures Exceeding 150 Feet (46 m) AGL. Steady-burning red obstruction lights should be installed on the highest point at each end. At intermediate levels, steady-burning red lights should be displayed for each 150 feet (46 m), or fraction thereof. The vertical position of these lights should be equidistant between the top lights and the ground level, as the shape and type of obstruction will permit. A steady-burning red light should be displayed at each outside corner on each level with the remaining lights evenly spaced between the corner lights.

4. Exceptions. Flashing red lights (L-864) may be used instead of steady-burning lights if early or special warning is necessary. These lights should be displayed on the highest points of an extensive obstruction at intervals not exceeding 3,000 feet (915 m). At least three lights should be displayed on one side of the extensive obstruction to indicate a line of lights. (See Figure A-22 in Appendix A.)

5. Ice Shields. See paragraph 4.9.

## CHAPTER 6. MEDIUM-INTENSITY FLASHING WHITE OBSTRUCTION LIGHT SYSTEMS

### 6.1 Purpose.

Medium-intensity flashing white (L-865) obstruction lights may provide conspicuity both day and night. Recommendations on lighting structures can vary, depending on terrain features, weather patterns, geographic location, and number of structures.

### 6.2 Standards.

6.2.1 The medium-intensity flashing white light system is normally composed of flashing omnidirectional lights. Medium-intensity flashing white obstruction lights may be used during daytime and twilight with automatically selected, reduced intensity for nighttime operation. When this system is used on structures 700 feet (213 m) AGL or less, other methods of marking and lighting the structure may be omitted. (Aviation orange and white paint is always required for daytime marking on structures exceeding 700 feet (213 m) AGL. This system is not normally recommended on structures 200 feet (61 m) AGL or less. The number of light levels needed is shown in Figure A-7 in Appendix A.

6.2.2 Using a 24-hour, medium-intensity, flashing white light system in urban/populated areas is not normally recommended due to their tendency to blend with the background lighting in these areas at night. This makes it extremely difficult for some types of aviation operations, i.e., medical-evacuation (medevac) and police helicopters to see these structures. Using this type of system in urban and rural areas often results in complaints. In addition, this system is not recommended on structures within 3 nautical miles (NM) of an airport.

### 6.3 Radio and Television Towers and Similar Skeletal Structures.

6.3.1 Mounting Lights.

The number of levels recommended depends on the height of the structure, including antennas and similar appurtenances.

1. Top Levels. One or more lights should be installed at the highest point to provide 360-degree coverage, ensuring an unobstructed view by a pilot approaching from any direction.

2. Appurtenances 40 Feet (12 m) or Less. If a rod, antenna, or other appurtenance 40 feet (12 m) or less in height is incapable of supporting the medium-intensity flashing white light, then it may be placed at the base of the appurtenance. If the mounting location does not allow an unobstructed view of the medium-intensity flashing white light by a pilot approaching from any direction, then additional lights should be added.

3. Appurtenances Exceeding 40 Feet (12 m). If a rod, antenna, or other appurtenance exceeds 40 feet (12 m) above the tip of the main structure, a medium-intensity

flashing white light should be placed within 40 feet (12 m) from the top of the appurtenance. If the appurtenance (such as a whip antenna) is incapable of supporting the light, one or more lights should be mounted on a pole adjacent to the appurtenance. Adjacent installations should not exceed the height of the appurtenance and be within 40 feet (12 m) of the tip to allow the pilot an unobstructed view of at least one light. If the rod, antenna, or other appurtenance is 7/8 of an inch wide or more, at least two lights must be installed on the supporting mast to provide the necessary unobstructed view.

6.3.2 Intermediate Levels.

At intermediate levels, two or more lights (L-865) should be mounted outside at diagonally or diametrically opposite positions of intermediate levels. The lowest light level should not be less than 200 feet (61 m) AGL.

6.3.3 Lowest Levels.

The lowest level of light units may be installed at a higher elevation than normal on a structure if the surrounding terrain, trees, or adjacent building(s) would obscure the lights. In certain instances, as determined by the FAA, the lowest level of lights may be eliminated.

6.3.4 Structures 700 Feet (213 m) AGL or Less.

When medium-intensity flashing white lights are used during nighttime and twilight only, marking is required for daytime. When operated 24 hours a day, other methods of marking and lighting are not required.

6.3.5 Structures Exceeding 700 Feet (213 m) AGL.

The lights should be used during nighttime and twilight and may be used 24 hours a day. Marking is always required for daytime.

6.3.6 Ice Shields.

See paragraph 4.9.

6.4 **Control Device.**

The light intensity is controlled by a device (photocell) that changes the light's intensity when the ambient light changes. The system should automatically change intensity steps when, in the Northern Hemisphere, the northern sky illumination reaching a north-facing vertical surface is as follows:

1. Twilight-to-Night. This should not occur before the illumination drops below 5 foot-candles (53.8 lux) but should occur before it drops below 2 foot-candles (21.5 lux).

2. Night-to-Day. The intensity changes listed in subparagraph 6.4 1 above should be reversed when changing from the night-to-day mode.

6.5 **Chimneys, Flare Stacks, and Similar Solid Structures.**

The number of light units recommended depends on the diameter of the structure at the top. Normally, the top level is on the highest point of a structure. However, the top level of chimney lights may be installed as low as 20 feet (6 m) below the top to minimize deposit build-up due to emissions. (See Figure A-13 in Appendix A.) The number of lights recommended below is the minimum, as shown in Figure A-20 in Appendix A.

1. Structures 20 Feet (6 m) or Less in Diameter. Three light units per level. (See Figure A-20 in Appendix A.)

2. Structures Exceeding 20 Feet (6 m) but not More Than 100 Feet (31 m) in Diameter. Four light units per level. (See Figure A-20 in Appendix A.)

3. Structures Exceeding 100 Feet (31 m) but not More Than 200 Feet (61 m) in Diameter. Six light units per level. (See Figure A-21 in Appendix A.)

4. Structures Exceeding 200 Feet (61 m) in Diameter. Eight light units per level.

6.6 **Group of Obstructions.**

When individual objects within a group of obstructions are not the same height and are spaced a maximum of 150 feet (46 m) apart, the prominent objects within the group should be lighted in accordance with the standards for individual obstructions of a corresponding height. If the outer structure is shorter than the prominent object, the outer structure should be lighted in accordance with the standards for individual obstructions of a corresponding height. Light units should be placed to ensure that the light is visible to a pilot approaching from any direction. In addition, at least one medium-intensity flashing white light should be installed at the top of a prominent center obstruction or on a special tower located near the center of the group.

6.7 **Special Cases.**

When lighting systems are installed on structures located near highways, waterways, airport approach areas, etc., caution should be exercised to ensure that the lights do not distract or otherwise cause a hazard to motorists, vessel operators, or pilots on an approach to an airport. In these cases, shielding may be necessary. This shielding should not derogate the lighting system's intended purpose.

6.8 **Prominent Buildings and Similar Extensive Obstructions.**

When objects within a group of obstructions are approximately the same overall height above the surface and are located a maximum of 150 feet (46 m) apart, the group of obstructions may be considered an extensive obstruction. Light units should be

installed on the same horizontal plane at the highest portion, or edge, of the prominent obstructions. Light units should be placed to ensure that the light is visible to a pilot approaching from any direction. Lights should be displayed to indicate the extent of the obstruction as follows:

1. Structures 150 Feet (46 m) or Less in Any Horizontal Direction. If the structure/extensive obstruction is 150 feet (46 m) or less horizontally, at least one light should be displayed on the highest point at each end of the obstruction's major axis. If this is impractical because of the overall shape, display a double obstruction light in the center of the highest point.

2. Structures Exceeding 150 Feet (46 m) in at Least One Horizontal Direction. If the structure/extensive obstruction exceeds 150 feet (46 m) horizontally, at least one light should be displayed for each 150 feet (46 m), or fraction thereof, of the overall length of the major axis. At least one of these lights should be displayed on the highest point at each end of the obstruction. Additional lights should be displayed at approximately equal intervals not to exceed 150 feet (46 m) on the highest points along the edge between the end lights. If an obstruction is located near a landing area and two or more edges are the same height, the edge nearest the landing area should be lighted.

3. Structures Exceeding 150 Feet (46 m) AGL. Lights should be installed on the highest point at each end. At intermediate levels, lights should be displayed for each 150 feet (46 m), or fraction thereof. The vertical position of these lights should be equidistant between the top lights and the ground level as the shape and type of obstruction will permit. One such light should be displayed at each outside corner on each level with the remaining lights evenly spaced between the corner lights.

## CHAPTER 7. HIGH-INTENSITY FLASHING WHITE OBSTRUCTION LIGHT SYSTEMS

### 7.1 Purpose.

High-intensity (L-856) flashing white obstruction lights provides the highest degree of conspicuity both day and night. Recommendations on lighting structures can vary, depending on terrain features, weather patterns, geographic location, and number of structures.

### 7.2 Standards.

High-intensity flashing white obstruction lights should be used during daytime with automatically selected, reduced intensities for twilight and nighttime operations. When high-intensity white obstruction lights are operated 24 hours a day, other methods of marking and lighting may be omitted. This system should not be recommended on structures 700 feet (213 m) AGL or less unless an FAA aeronautical study shows otherwise. The number of light levels needed is shown in Figures A-8 and A-9 in Appendix A.

### 7.3 Control Device.

7.3.1 Light intensity is controlled by a device (photocell) that changes the light's intensity when the ambient light changes. Using a 24-hour, high-intensity flashing white light system in urban/populated areas is not normally recommended due to their tendency to merge with background lighting in these areas at night. This makes it extremely difficult for some types of aviation operations (i.e., medevac) and police helicopters to see these structures. Using this type of system in urban and rural areas often results in complaints.

7.3.2 The system should automatically change intensity steps when, in the Northern Hemisphere, the northern sky illuminance reaching a north-facing vertical surface is as follows:

1. Day-to-Twilight. This should not occur before the illumination drops to 60 foot-candles (645.8 lux) but should occur before it drops below 35 foot-candles (376.7 lux). The illuminance-sensing device should, if practical, face the northern sky in the Northern Hemisphere.

2. Twilight-to-Night. This should not occur before the illumination drops below 5 foot-candles (53.8 lux) but should occur before it drops below 2 foot-candles (21.5 lux).

3. Night-to-Day. The intensity changes listed in subparagraphs 7.3.2 1 and 7.3.2.2 above should be reversed when changing from the night-to-day mode.

### 7.4 Units per Level.

One or more light units are needed to obtain the desired horizontal coverage. The number of light units recommended per level (except for the supporting structures of catenary wires and buildings) depends upon the average outside diameter of the specific structure and the horizontal beam width of the light fixture. Light units should be installed to ensure an unobstructed view of the system by a pilot approaching from **any** direction. The number of lights recommended below is the minimum.

1. Structures 20 Feet (6 m) or Less in Diameter**.** Three light units per level.

2. Structures Exceeding 20 Feet (6 m) but not More Than 100 Feet (31 m) in Diameter. Four light units per level.

3. Structures Exceeding 100 Feet (31 m) in Diameter. Six light units per level.

## 7.5 Installation Guidance.

On most obstruction high-intensity light fixtures, the effective peak intensity of the light beam can be adjusted from 0 to 8 degrees above the horizon. Standard installation should place the top light at 0 degrees to the horizontal and all other light units installed in accordance with Table 7-1.

**Table 7-1. Light Unit Elevation Above the Horizontal**

| Height of Light Unit Above Terrain | Degrees of Elevation Above the Horizontal |
|---|---|
| Exceeding 500 feet AGL | 0 |
| Above 400 feet to 500 feet AGL | 1 |
| Above 300 feet to 400 feet AGL | 2 |
| 300 feet AGL or less | 3 |

1. Vertical Aiming. When terrain, nearby residential areas, or other situations dictate, the light beam may be further elevated above the horizontal. The main beam of light at the lowest level should not strike the ground closer than 3 statute miles (5 km) from the structure. If additional adjustments are necessary, the lights may be individually adjusted upward, in 1-degree increments, starting at the bottom.

Excessive elevation may reduce its conspicuity by raising the beam above a collision course flight path.

2. Special Cases. When lighting systems are installed on structures located near highways, waterways, airport approach areas, etc., caution should be exercised to ensure that the lights do not distract or otherwise cause a hazard to motorists, vessel operators, or pilots on an approach to an airport. In these cases, shielding or adjusting the aim of the vertical or horizontal light may be necessary. This adjustment should not derogate the lighting system's intended purpose. Such adjustments may require an additional review, as described in Chapter 1 paragraph 1.5.

3. Relocation or Omission of Light Units. Light units should not be installed in such a manner that the light pattern/output is disrupted by the structure.

   a. Lowest Level. The lowest level of light units may be installed at a higher elevation than normal on a structure if the surrounding terrain, trees, or adjacent building(s) would obscure the lights. In certain instances, as determined by the FAA, the lowest level of lights may be eliminated.

   b. Two Adjacent Structures. When two structures are within 500 feet (153 m) of each other and the light units are installed at the same levels, the sides of the structures facing each other do not need be lighted. (See Figures A-18 and A-19.) However, all lights on both structures must flash simultaneously, except for adjacent catenary support structures. Vertical placement of the lights should be adjusted to either or both structures' intermediate levels to place the lights on the same horizontal plane. If one structure is higher than the other, a complete level(s) of lights should be installed on the higher structure that extends above the top of the lower structure. If the structures are of such heights that the levels of lights cannot be placed in identical horizontal planes, then the light units should be placed so that the center of the horizontal beam patterns do not face toward the adjacent structure. For example, structures situated north and south of each other should have the light units on both structures installed on a northwest/southeast and northeast/southwest orientation.

   c. Three or More Adjacent Structures. The treatment of a cluster of structures as an individual or a complex of structures will be determined by the FAA, taking into consideration the location, heights, and spacing of other structures.

## 7.6 Antenna or Similar Appurtenance Light.

When a structure lighted by a high-intensity, flashing white light system is topped with an antenna or similar appurtenance exceeding 40 feet (12 m) in height, a medium-intensity flashing white light (L-865) should be placed within 40 feet (12 m) from the tip of the appurtenance. This light should operate 24 hours a day and flash simultaneously with the rest of the lighting system. The location of the appurtenance

light is shown in Figure A-9 in Appendix A. Structures with an appurtenance 40 feet (12 m) or less in height should be lit in accordance with Figure A-8.

7.7 **Chimneys, Flare Stacks, and Similar Solid Structures.**

The number of light levels depends on the height of the structure, excluding appurtenances. Three or more lights should be installed on each level to ensure an unobstructed view by the pilot. Normally, the top level is on the highest point of a structure. However, the top level of chimney lights may be installed as low as 20 feet (6 m) below the top to minimize deposit buildup due to emissions.

7.8 **Radio and Television Towers and Similar Skeletal Structures.**

1. Mounting Lights. The number of levels recommended depends on the height of the structure, including antennas and similar appurtenances. At least three lights should be installed on each level and mounted to ensure that the effective intensity of the full horizontal beam coverage is not impaired by the structural members.

2. Top Level. One level of lights should be installed at the highest point of the structure. If the highest point is a rod or antenna incapable of supporting a lighting system, then the top level of lights should be installed at the highest portion of the main skeletal structure. If guy wires come together at the top, it may be necessary to install this level of lights as low as 10 feet (3 m) below the top. If the rod or antenna exceeds 40 feet (12 m) above the main structure, a medium-intensity, flashing white light (L-865) should be mounted on the highest point. (See Figure A-9 in Appendix A.) If the appurtenance (such as a whip antenna) is incapable of supporting a medium-intensity light, one or more lights should be installed on a pole adjacent to the appurtenance. The adjacent installation should not exceed the height of the appurtenance and be within 40 feet (12 m) of the top, allowing a pilot an unobstructed view of at least one light. If the rod, antenna, or other appurtenance is 7/8 of an inch wide or more, at least two lights must be installed on the supporting mast to provide the necessary unobstructed view.

3. Ice Shields. See paragraph 4.9.

7.9 **Hyperbolic Cooling Towers.**

Light units should be installed to ensure an unobstructed view of at least two lights by a pilot approaching from any direction.

1. Number of Light Units. The number of units recommended depends on the diameter of the structure at the top, as shown in Figure A-21 in Appendix A. The number of lights recommended below is the minimum.

   a. Structures 20 Feet (6 m) or Less in Diameter. Three light units per level.

   b. Structures Exceeding 20 Feet (6 m) but not More Than 100 Feet (31 m) in Diameter. Four light units per level.

c. Structures Exceeding 100 Feet (31 m) but not More Than 200 Feet (61 m) Diameter. Six light units per level.

d. Structures Exceeding 200 Feet (61 m) in Diameter. Eight light units per level.

2. Structures Exceeding 600 Feet (183 m) AGL. Structures exceeding 600 feet (183 m) AGL should have a second level of light units installed approximately at the midpoint of the structure and in a vertical line with the top level of lights.

## 7.10 Prominent Buildings and Similar Extensive Obstructions.

When objects within a group of obstructions are approximately the same overall height above the surface and are located not more than 150 feet (46 m) apart, the group of obstructions may be considered an extensive obstruction. Light units should be installed on the same horizontal plane at the highest portion, or edge, of the prominent obstructions. Light units should be placed to ensure that the light is visible to a pilot approaching from **any** direction. These lights may require shielding, such as louvers, to ensure minimum adverse impact on local communities. Use extreme caution when using high-intensity flashing white lights.

1. If the obstruction is 200 feet (61 m) or less in either horizontal dimension, three or more light units should be installed at the highest portion of the structure to ensure that at least one light is visible to a pilot approaching from any direction. Light units may be mounted on a single pedestal at or near the center of the obstruction. If the light units are placed more than 10 feet (3 m) from the center point of the structure, use a minimum of four light units.

2. If the obstruction exceeds 200 feet (61 m) in one horizontal dimension, but is 200 feet (61 m) or less in the other, two light units should be placed on each of the shorter sides. These light units may be installed either adjacent to each other at the midpoint of the obstruction's edge or at (near) each corner, with the light unit aimed to provide 180 degrees of coverage at each edge. One or more light units should be installed along the overall length of the major axis. These lights should be installed at approximately equal intervals, not to exceed a distance of 100 feet (31 m) from the corners or from each other.

3. If the obstruction exceeds 200 feet (61 m) in both horizontal dimensions, the light units should be equally spaced along the overall perimeter of the obstruction at intervals of 100 feet (31 m), or fraction thereof.

# CHAPTER 8. DUAL LIGHTING WITH RED/MEDIUM-INTENSITY FLASHING WHITE LIGHT SYSTEMS

## 8.1 Purpose.

This dual lighting system includes red lights (L-864) for nighttime and medium-intensity, flashing white lights (L-865) for daytime and twilight use. This lighting system may be used in lieu of operating a medium-intensity flashing white lighting system at night. There may be some populated areas where nighttime use of medium-intensity light systems may cause significant environmental concerns. Using the dual lighting system should reduce/mitigate those concerns. Recommendations on lighting structures can vary, depending on terrain features, weather patterns, geographic location, and number of structures.

## 8.2 Installation.

The light units should be installed as specified in Chapters 4, 5, and 6. The number of light levels needed is dependent on the height of the obstruction, as shown in Figure A-10 in Appendix A.

## 8.3 Operation.

Light systems should be operated as specified in Chapter 3. Both systems should not be operated at the same time; however, there should be no more than a 2-second delay when changing from one system to the other. Outage of the uppermost red light shall cause the white obstruction light system to activate and operate in its specified "night" step intensity.

## 8.4 Control Device.

The light system is controlled by a device (photocell) that changes the light's intensity when the ambient light changes. The system should automatically change steps when, in the Northern Hemisphere, the northern sky illuminance reaching a north-facing vertical surface is as follows:

1. Twilight-to-Night. This should not occur before the illumination drops below 5 foot-candles (53.8 lux) but should occur before it drops below 2 foot-candles (21.5 lux).

2. Night-to-Day. The intensity changes listed in subparagraph 8.4 1 above should be reversed when changing from the night-to-day mode.

## 8.5 Antenna or Similar Appurtenance Light.

When a structure equipped with a dual lighting system is topped with an antenna or similar appurtenance exceeding 40 feet (12 m) in height, a medium-intensity flashing white (L-865) and a flashing red light (L-864) should be placed within 40 feet (12 m) from the tip of the appurtenance. The white light should operate during daytime and

twilight and the red light during nighttime. These lights should flash simultaneously with the rest of the lighting system.

8.6 **Omission of Marking.**

When medium-intensity white obstruction lights are operated on structures 700 feet (213 m) AGL or less during daytime and twilight, other methods of marking may be omitted.

# CHAPTER 9. DUAL LIGHTING WITH RED/HIGH-INTENSITY FLASHING WHITE LIGHT SYSTEMS

## 9.1 Purpose.

This dual lighting system includes red lights (L-864) for nighttime and high-intensity flashing white lights (L-856) for daytime and twilight use. This lighting system may be used in lieu of operating a flashing white lighting system at night. There may be some populated areas where nighttime use of high-intensity lights may cause significant environmental concerns and complaints. Using the dual lighting system should reduce/mitigate those concerns. Recommendations on lighting structures can vary, depending on terrain features, weather patterns, geographic location, and number of structures.

## 9.2 Installation.

The light units should be installed as specified in Chapters 4, 5, and 7. The number of light levels needed is shown in Figures A-11 and A-12 in Appendix A.

## 9.3 Operation.

Lighting systems should be operated as specified in Chapters 4, 5, and 7. These systems should not be operated at simultaneously; however, there should be no more than a 2-second delay when changing from one system to the other. Outage of the uppermost red light shall cause the white obstruction lighting system to activate and operate in its specified "night" step intensity.

## 9.4 Control Device.

9.4.1 The light intensity is controlled by a device (photocell) that changes the light intensity when the ambient light changes.

9.4.2 The system should automatically change intensity steps when, in the Northern Hemisphere, the northern sky illuminance reaching a north-facing vertical surface is as follows:

1. Day-to-Twilight. This should not occur before the illumination drops to 60 foot-candles (645.8 lux) but should occur before it drops below 35 foot-candles (376.7 lux). The illuminance-sensing device should, if practical, face the northern sky in the Northern Hemisphere.

2. Twilight-to-Night. This should not occur before the illumination drops below 5 foot-candles (53.8 lux) but should occur before it drops below 2 foot-candles (21.5 lux).

3. Night-to-Day. The intensity changes listed in subparagraph 9.4.2 1 and 9.4.2.2 above should be reversed when changing from the night to day mode.

9.5 **Antenna or Similar Appurtenance Light.**

When a structure using this dual lighting system is topped with an antenna or similar appurtenance exceeding 40 feet (12 m) in height, a medium-intensity flashing white light (L-865) and a red flashing light (L-864) should be placed within 40 feet (12 m) from the tip of the appurtenance. (See Figure A-11 in Appendix A.) The white light should operate during daytime and twilight and the red light during nighttime. Structures with an appurtenance 40 feet (12 m) or less in height should be lit in accordance with Figure A-12 in Appendix A.

9.6 **Omission of Marking.**

When high-intensity white obstruction lights are operated during daytime and twilight, other methods of marking may be omitted.

# CHAPTER 10. MARKING AND LIGHTING OF CATENARY AND CATENARY SUPPORT STRUCTURES

## 10.1 Purpose.

This chapter provides guidelines for marking and lighting catenary and catenary support structures. For the purpose of marking and lighting, catenary is defined as suspended wires (or lines) kept at a defined mechanical tension by supporting structures. These wires may be either energized or non-energized and are used for transmission, distribution, or for other purposes, as defined. The recommended marking and lighting of both the structures and wires provides day and night conspicuity and assists pilots in identifying and avoiding catenary wires and associated support structures.

## 10.2 Catenary Marking Standards.

Catenary wires should be marked with lighted or unlighted marker balls to make the wires more visible to pilots approaching the hazard. High-voltage (69 kV or greater) transmission lines are typically mounted on large catenary support structures and should be fitted with lighted markers to provide sufficient conspicuity in both day and nighttime conditions. Transmission lines that are less than 69 kV are typically mounted on smaller catenary support structures and should be fitted with unlighted markers that provide daytime conspicuity.

### 10.2.1 Catenary Markers.

Lighted markers provide increased nighttime conspicuity of high-voltage (69 kV or greater) transmission line catenary wires. However, since lighted markers require a minimum line load to operate, it should be noted that the lights may not be operational under certain transmission system conditions, such as power outages or line maintenance. These lighted markers should be used on transmission line catenary wires near airports, heliports, across rivers, canyons, lakes, areas of known risk to aviation, etc. The lighted markers should be manufacturer-certified as (1) recognizable from a minimum distance of 4,000 feet (1,219 m) under nighttime conditions, (2) minimum VFR conditions, or (3) have a minimum intensity of at least 32.5 candelas. The lighting unit should emit a steady-burning red light. Lighted markers should be used on the highest energized line. If the lighted markers are installed on a line other than the highest catenary wire, then the unlighted markers specified in Chapter 3 paragraph 3.5 should be used in addition to the lighted markers. The maximum sag distance between the line energizing the lighted markers and the highest catenary wire above the lighted markers should be no more than 25 feet (7.6 m), and it should not violate the sag requirements of the transmission line design. (See Figure A-5 in Appendix A.) Markers should be distinctively shaped, i.e., spherical or cylindrical, so that they are not mistaken for items used to convey other information. They should be visible to a pilot approaching from any direction. The area in the immediate vicinity of the supporting structure's base should be clear of all items and/or objects of natural growth that could interfere with the line-of-sight between a pilot and the structure's markers.

10.2.1.1 Size and Color.

The diameter of the markers (lighted and unlighted) used on extensive catenary wires that cross canyons, lakes, rivers, etc., should not be less than 36 inches (91 cm). Preferred 20-inch (51-cm) markers, or smaller 12-inch (30.48-cm) markers, are permitted on less extensive catenary wires or on power lines below 50 feet (15 m) above the ground and within 1,500 feet (458 m) of an airport runway end. Each lighted marker should be a solid color; specifically aviation orange, white, or yellow. For transmission lines that are configured in a "double-bundled" arrangement and would typically require the larger 36-inch markers, the next smaller size marker may be used to prevent the marker from rubbing against the parallel transmission line.

10.2.1.2 Installation.

1. Spacing. Lighted markers should be spaced equally along the wire at intervals of approximately 200 feet (61 m), or a fraction thereof. Intervals between markers should be less in critical areas near runway ends, i.e., 30 feet to 50 feet (10 m to 15 m). If the lighted markers are installed on a line other than the highest catenary wire, then unlighted markers specified in Chapter 3 paragraph 3.5 should be used in addition to the lighted markers. The maximum distance between the line energizing the lighted markers and the highest catenary wire above the line with the lighted markers can be no more than 25 feet (7.62 m), so long as the requirement does not violate the transmission line design's droop requirement. The lighted markers may be installed alternately along each wire if the distance between adjacent markers meets the 200-foot (61m) spacing standard. This method allows the weight and wind loading factors to be distributed. (See Figure A-5 in Appendix A.)

2. Pattern. An alternating color scheme provides the most conspicuity against all backgrounds. Lighted and unlighted markers should be installed by alternating solid-colored markers of aviation orange, white, and yellow. Normally, an orange marker is placed at each end of a line and the spacing is adjusted [not to exceed 200 feet (61 m)] to accommodate the rest of the markers. When less than four markers are used, they should all be aviation orange. (See Figure A-5 in Appendix A).

3. Wire Sag. Wire sag or droop will occur due to temperature, wire weight, wind, etc. Twenty-five (25) feet (7.62 m) is the maximum allowable distance between the highest wire installed with marker balls and the highest wire without marker balls, and it should not violate the transmission line design's sag requirements. (See Figure A-5 in Appendix A.)

4. Adjacent Lines. Catenary crossings with multiple transmission lines require appropriate markers when the adjacent catenary structure's outside lines are greater than 200 ft (61 m) away from the center of the primary structure. (See Figure A-2 in Appendix A.) If the outside lines of the adjacent catenary structure are within 200 ft (61m) or less from the center of the primary structure, markers are not required on the adjacent lines. (See Figure A-3 in Appendix A.)

## 10.3 Catenary Lighting Standards.

When using medium-intensity flashing white (L-866), high-intensity flashing white (L-857), dual medium-intensity (L-866/L-885), or dual high-intensity (L-857/L-885) lighting systems operated 24 hours a day, other marking of the support structure is not necessary.

1. Levels. A system of three levels of sequentially flashing light units should be installed on each supporting structure or adjacent terrain. One level should be installed at the top of the structure, one at the height of the lowest point in the catenary wire, and one level approximately midway between the other two light levels. In general, the middle level should be at least 50 feet (15 m) from the other two levels. The middle light unit may be omitted when the distance between the top and the bottom light levels is less than 100 feet (30 m).

    a. Top Levels. One or more lights should be installed at the top of the structure to provide 360-degree coverage, ensuring an unobstructed view. If the installation presents a potential danger to maintenance personnel or inhibits lightning protection, the top level of lights may be mounted as low as 20 feet (6 m) below the highest point of the structure.

    b. Horizontal Coverage. The light units at the middle and bottom levels should be installed to provide a minimum of 180-degree coverage, centered perpendicularly to the flyway. When a catenary crossing is situated near a bend in a river, canyon, etc., or is not perpendicular to the flyway, the horizontal beam should be directed to provide the most effective light coverage to warn pilots approaching from either direction of the catenary wires.

    c. Variation. The vertical and horizontal arrangements of the lights may be subject to the structural limits of the towers and/or adjacent terrain. A tolerance of 20 percent from uniform spacing of the bottom and middle light is allowed. If the base of the supporting structure(s) is higher than the lowest point in the catenary, such as a canyon crossing, one or more lights should be installed on the adjacent terrain at the level of the lowest point in the span. These lights should be installed on the structure or terrain at the height of the lowest point in the catenary. (See Figure A-4 in Appendix A).

2. Flash Sequence and Duration. The flash sequence for catenary wire support structures should be middle, top, and bottom with all lights on the same level

flashing simultaneously. This pattern of flashes is designed to present a unique signal that pilots should interpret as a warning that catenary wires are in the vicinity of the lights. The time intervals for the sequence and duration of the flash pattern are outlined in FAA AC 150/5345-43, Specification for Obstruction Lighting Equipment. If Light-Emitting Diode (LED) obstruction light fixtures are used to light catenary wires, a slower flash rate of 40 fpm is allowed to enable each light fixture to make a well-defined flash so that the middle-top-bottom flash pattern will be easily recognized. Field experience has shown that LED fixtures flashing at 60 fpm, as specified in AC 150/5345-43, do not have enough time to turn off in between flash cycles, and appear as if they are steady-burning. Slowing the flash rate to 40 fpm promotes a cleaner, crisper presentation for the pilot to recognize. In the event there are only two levels of lights, the lights should simply alternate at the same flash rate/duration as if there were three lights.

3. Synchronization. Although not required, it is preferred that the corresponding light levels on associated supporting towers of a catenary crossing flash simultaneously.

4. Structures 700 feet (213 m) AGL or Less. When medium-intensity white lights (L-866) are operated 24 hours a day or when a dual red/medium-intensity light system (L-866 daytime and twilight/L-885 nighttime) is used, marking can be omitted. When using a medium-intensity white light (L-866) or a flashing red light (L-885) during twilight or nighttime only, paint should be used for daytime marking.

5. Structures Exceeding 700 Feet (213 m) AGL. When high-intensity white lights (L-857) are operated 24 hours a day or when a dual red/high-intensity system (L-857 daytime and twilight/L-885 nighttime) is used, marking can be omitted. This system should not be used on structures 700 feet (153 m) or less unless an FAA aeronautical study shows otherwise. When a flashing red obstruction light (L-885), a medium-intensity (L-866) flashing white lighting system, or a high-intensity white lighting system (L-857) is used for nighttime and twilight only, paint should be used for daytime marking.

## 10.4 **Control Device.**

The light intensity is controlled by a device (photocell) that changes the intensity when the ambient light changes. The lighting system should automatically change intensity steps when, in the Northern Hemisphere, the northern sky illuminance reaching a north-facing vertical surface is as follows:

1. Day-to-Twilight (L-857 System). This should not occur before the illumination drops to 60 foot-candles (645.8 lux) but should occur before it drops below 35 foot-candles (376.7 lux). The illuminance-sensing device should, if practical, face the northern sky in the Northern Hemisphere.

2. Twilight-to-Night (L-857 System). This should not occur before the illumination drops below 5 foot-candles (53.8 lux) but should occur before it drops below 2 foot-candles (21.5 lux).

3. Night-to-Day. The intensity changes listed in subparagraph 10.4.1 and 10.4.2 above should be reversed when changing from the night-to-day mode.

4. Day-to-Night (L-866 or L-885/L-866). This should not occur before the illumination drops below 5 foot-candles (563.8 lux) but should occur before it drops below 2 foot-candles (21.5 lux).

5. Night-to-Day. The intensity changes listed in subparagraph10.4.4 above should be reversed when changing from the night-to-day mode.

6. Red Obstruction (L-885). The red lights should not turn on until the illumination drops below 60 foot-candles (645.8 lux) but should occur before reaching a level of 35 foot-candles (367.7 lux). Lights should not turn off before the illumination rises above 35 foot-candles (367.7 lux) but should occur before reaching 60 foot-candles (645.8 lux).

10.5 **Area Surrounding Catenary Wire Support Structures.**

The area in the immediate vicinity of the supporting structure's base should be clear of all items and/or objects of natural growth that could interfere with the line-of-sight between a pilot and the structure's lights.

10.6 **Three or More Catenary Wire Support Structures.**

Where a catenary wire crossing requires three or more supporting structures, the inner structures should be equipped with enough light units per level to provide full 360-degree coverage across rivers, canyons, lakes, areas of known risk to aviation, etc.

10.7 **Adjacent Catenary Structures.**

Where an adjacent catenary wire crossing requires three or more supporting structures, the inner structures should be equipped with enough light units per level to provide full 360-degree coverage across rivers, canyons, lakes, areas of known risk to aviation, etc.

## CHAPTER 11. MARKING AND LIGHTING MOORED BALLOONS AND KITES

11.1 **Purpose.**

The purpose of marking and lighting moored balloons, kites, and their cables or mooring lines is to indicate the presence and general definition of these objects to pilots when approaching from **any** direction.

11.2 **Standards.**

These marking and lighting standards pertain to all moored balloons and kites that require marking and lighting under 14 CFR Part 101.

11.3 **Marking.**

Flag markers should be used on mooring lines to warn pilots of their presence during daylight hours.

1. Display. Markers should be displayed at no more than 50-foot (15-m) intervals and should be visible for at least 1 statute mile.

2. Shape. Markers should be rectangular in shape and not less than 2 feet (0.6 m) on a side. Stiffeners should be used in the borders to expose a large area and to prevent drooping in calm wind or wrapping around the cable.

3. Color Patterns. One of the following color patterns should be used:

   a. Solid Color. Aviation orange.

   b. Orange and White. Two triangular sections, one of aviation orange and the other white, combined to form a rectangle.

   c. Refer to paragraph 12.2 Paint Standard.

11.4 **Purpose.**

Flashing obstruction lights should be used on moored balloons or kites and their mooring lines to warn pilots of their presence during the hours between sunset and sunrise and during periods of reduced visibility. These lights may be operated 24 hours a day.

1. Systems. Flashing red (L-864) or white lights (L-865) may be used to light moored balloons or kites. High-intensity lights (L-856) are not recommended.

2. Display. Flashing lights should be displayed on the top, nose section, tail section, and on the tether cable approximately 15 feet (4.6 m) below the craft to define the extremes of size and shape. Additional lights should be equally spaced along the cable's overall length for each 350 feet (107 m), or fraction thereof.

3. Exceptions. When the requirements of this paragraph cannot be met, floodlights may be used.

## 11.5 **Operational Characteristics.**

The light intensity is controlled by a device (photocell) that changes the intensity when the ambient light changes. The system should automatically turn the lights on and change intensities as ambient light conditions change. The reverse order should apply in changing from nighttime-to-daytime operation. The lights should flash simultaneously.

## CHAPTER 12. MARKING AND LIGHTING EQUIPMENT AND INFORMATION

12.1 **Purpose.**

This chapter lists documents relating to obstruction marking and lighting systems and where they may be obtained.

12.2 **Paint Standard.**

12.2.1 Paint and aviation colors/gloss, referred to in this AC, with the exception of wind turbines, should conform to Federal Standard FED-STD-595. Wind turbines shall meet the standards in Chapter 13 paragraph 13.4 of this AC.

12.2.2 Approved colors shall be formulated without using lead, zinc chromate, or other heavy metals to match international aviation orange, white, and yellow, as listed in Table 12-1. All coatings shall be manufactured and labeled to meet Federal Environmental Protection Act Volatile Organic Compound(s) guidelines, including the National Volatile Organic Compound Emission Standards for architectural coatings.

1. Exterior Acrylic Waterborne Paint. Coatings should be ready-mixed, 100 percent acrylic, exterior latex formulated for application directly to galvanized surfaces. Ferrous iron and steel or nongalvanized surfaces shall be primed with a manufacturer-recommended primer compatible with the finish coat.

2. Exterior Solvent-Borne Alkyd-Based Paint. Coatings should be ready-mixed, alkyd-based, exterior enamel for application directly to nongalvanized surfaces, such as ferrous iron and steel. Galvanized surfaces shall be primed with a manufacturer-recommended primer compatible with the finish coat.

**Table 12-1. Federal Standard FED-STD-595**

| Color | Number |
|---|---|
| Orange | 12197 |
| White | 17875 |
| Yellow | 13538 |

## 12.3 Availability of Specifications.

Federal specifications describing the technical characteristics of various paints and their application techniques may be obtained from:

GSA - Specification Branch
301 7th Street NW
Room 6109
Washington, DC 20407
Telephone: (202) 619-8925

URL: https://gsafas.secure.force.com

## 12.4 Lights and Associated Equipment.

The lighting equipment referred to in this AC should conform to the latest edition of one of the following specifications, as applicable:

1. Obstruction Lighting Equipment.

   a. AC 150/5345-43, *FAA Specification for Obstruction Lighting Equipment*.

   b. Military Specifications MIL-L-6273, *Light, Navigational, Beacon, Obstacle or Code, Type G-1*.

   c. Military Specifications MIL-L-7830, *Light Assembly, Markers, Aircraft Obstruction*.

2. Certified Equipment.

   a. AC 150/5345-53, *Airport Lighting Certification Program*, lists the manufacturers that have demonstrated compliance with the specification requirements of AC 150/5345-43.

   b. Other manufacturers' equipment may be used provided the equipment meets the specification requirements of AC 150/5345-43.

3. Airport Lighting Installation and Maintenance.

   AC 150/5340-30, *Design and Installation Details for Airport Visual Aids*.

4. Vehicles.

   a. AC 150/5210-5, *Painting, Marking, and Lighting of Vehicles Used on an Airport*, contains provisions for marking vehicles principally used on airports.

   b. FAA Facilities**.** Obstruction marking for FAA facilities shall conform to FAA Drawing Number D-5480, referenced in FAA Standard FAA-STD-003, *Paint Systems for Structures*.

12.5 **Availability.**

The standards and specifications listed above may be obtained from:

1. Military Specifications: Copies of Military standards and specification may be obtained from:

   DAP/DODSSP
   Building 4, Section D.
   700 Robbins Ave.
   Philadelphia, PA 19111-5094
   Tel; (215)697-2179
   FAX: (215)697-1460
   URL: https://acc.dau.mil/DoDSSP

2. FAA Advisory Circulars: Copies of FAA ACs may be obtained online at:

   http://www.faa.gov/airports/resources/advisory_circulars/

# CHAPTER 13. MARKING AND LIGHTING WIND TURBINES

## 13.1 Purpose.

This chapter provides guidelines for the marking and lighting of wind turbine farms. These guidelines are applicable to single wind turbines and wind turbine farms. For the purpose of this AC, wind turbine farms are defined as a wind turbine development that contains more than three turbines. The recommended marking and lighting of these structures is intended to provide day and night conspicuity and to assist pilots in identifying and avoiding these obstacles.

## 13.2 General Standards.

The development of wind turbine farms is a very dynamic process, which changes based on the terrain. Each wind turbine farm is unique. Therefore, it is important that a lighting plan be developed that provides sufficient safety for air traffic. Proximity to airports and VFR routes, extreme terrain where heights may vary widely, and local flight activity should be considered when developing a lighting plan. The following guidelines are recommended for wind turbines.

## 13.3 Wind Turbine Configurations.

Prior to marking and lighting the wind turbine farm, the configuration and the terrain of the wind turbine farm should be determined. The following is a description of the most common configurations.

1. Linear—wind turbine farms in a direct, consecutive configuration, often located along a ridge line, the face of a mountain, or along borders of a mesa or field. The line may be ragged in shape or be periodically broken, and may vary in size from just a few turbines to many turbines forming a line that is several miles long.

2. Cluster—wind turbine farms arranged in circular configuration. A cluster is typically characterized by having a pronounced perimeter, with various turbines placed inside the circle at various, erratic distances throughout the center of the circle.

3. Grid—wind turbine farms arranged in a geographical shape, such as a square or a rectangle, in which the turbines are placed a consistent distance from each other in rows, giving the appearance that they are part of a square pattern.

## 13.4 Marking Standards.

13.4.1 Wind turbines should be painted white or light grey, as these colors have been shown to be the most effective method for providing daytime conspicuity. Wind turbine manufacturers typically use a European color-matching system that is referred to as the RAL Color Standard. Unlike the Federal Specification 595, the RAL system used a four-digit code to identify a specific color of paint. For example, an RAL 9xxx code would represent a color in the white/black range, and an RAL 6xxx code would be in

the grey range. Most wind turbines currently produced are painted light grey, RAL 7035, which is the darkest acceptable off-white paint allowed. The preferred white paint color is pure white, RAL 9010, or an equivalent. Any shade of white between these two RAL specifications is strongly recommended. See Table 13-1.

**Table 13-1. Wind Turbine Paint Standard Colors**

| Color | RAL Number |
|---|---|
| Pure White | 9010 |
| Light Grey (Darkest Acceptable) | 7035 |

13.4.2 In geographic areas that experience lengthy periods of snow cover (i.e., Alaska), and where it is deemed necessary, the mast of the turbine may be painted alternating bands of aviation orange and white to provide additional contrast against the snow. The nacelle and blades of the turbine shall remain solid white or light grey. (See Figure A-24 in Appendix A.)

13.4.3 Blades or blade tips shall not be painted or manufactured in colors to camouflage wind turbines with the surrounding terrain. (See Figure A-25 in Appendix A.)

13.4.4 For turbines that are constructed with lattice-type masts, the mast structure shall be painted with alternating bands of aviation orange and white, in accordance with Chapter 3. The turbine's nacelle and blades shall remain solid white or light grey.

13.5 **Lighting Standards.**

13.5.1 Nighttime wind turbine obstruction lighting should consist of FAA L-864 aviation red flashing, strobe, or pulsed obstruction lights. Studies have shown that red lights provide the most conspicuity to pilots.

13.5.2 In most cases, not all wind turbine units within a wind turbine farm need to be lighted. Obstruction lights should be placed along the perimeter of the wind turbine farm so that there are no unlit separations or gaps more than 1/2 statute mile (sm) (804 m). Wind turbines within a grid or cluster should not have an unlighted separation or gap of more than 1 sm (1.6 km) across the interior of a grid or cluster of turbines. (See Figure A-26 in Appendix A.)

13.5.3 Any array of flashing, strobe, or pulsed obstruction lighting should be synchronized to flash simultaneously (within ±1/20 second (0.05 second) of each other).

13.5.4 Should any lighting fixture or the lighting system synchronization fail, a lighting outage report should be prepared in accordance with Chapter 2 paragraph 2.4.

13.5.5 Light fixtures should be placed as high as possible on the turbine nacelle so they are visible by a pilot approaching from **any** direction. (See Figure A-23 in Appendix A.)

13.5.6 Daytime lighting of wind turbines is not required. See paragraph 13.4 for daytime marking requirements.

13.5.7 When developing lighting plans for wind turbine farms, it is best to use an aerial-view map or diagram of the turbine farm to plan the location of the required lighting. This way, a certain degree of strategy plan can be applied, which, in many instances, results in a minimal number of lights.

13.5.8 For linear turbine configurations, lights should be placed on the turbine positioned at each end of a line or string of turbines. Lights should also be placed along the line of turbines so that there is no more than a 1/2-sm (2,640-foot (805-m)) gap between the lighted turbines. In the event the gap between lights on the last segment of turbines is significantly short, it may be appropriate to move the lights on the turbine string back toward the starting point to present a well-balanced string of lights. High concentrations of lights should be avoided. (See Figure A-26 in Appendix A.)

13.5.9 For cluster turbine configurations, a turbine should be selected as a starting point along the outer perimeter of the cluster. The turbine should be lighted, and a light should be placed on the next turbine along the perimeter of the cluster (clockwise or counterclockwise) so that no more than a 1/2-sm (2,640-foot (805-m)) gap exists. This pattern should be continued around the perimeter of the cluster until the starting point is reached. In the event that the gap between the lights on the last segment of turbines is significantly short, it may be appropriate to move the lights along the perimeter of the cluster back toward the starting point to present a well-balanced perimeter of lights. If the distance across the cluster is greater than 1 sm, additional lights should be placed on other turbines throughout the center of the cluster so that there are no unlighted gaps across the cluster. (See Figure A-26 in Appendix A.) (Example: If the distance across a wind turbine farm is 1.8 sm (2.9 km), a light should be placed on a turbine at approximately every 0.9 sm (1.4 km).

13.5.10 For grid turbine configurations, turbines on the corners of the farm should be lit, and then use the same concept for selecting which turbines should be lit as outlined in paragraph 13.5.9.

13.5.11 Special Considerations.

13.5.11.1 Occasionally, some wind turbines may be located apart from the main group of turbines. If one or two wind turbines protrude from the general limits of the turbine farm, these turbines should be lighted in addition to those identified in the main group.

13.5.11.2 Additional lighting may be necessary on wind turbines located on the interior of a cluster or grid configuration whose height is 100 feet (30 m) or higher than the other wind turbines located within the farm.

13.6 **Wind Turbines Above 499 Feet.**

13.6.1 For wind turbines with a rotor tip height, while at top dead center, greater than 499 feet (153 m) AGL, but less than 699 feet AGL, the turbines should be lighted in accordance with paragraph 13.5. In addition to these requirements, the top of the turbine's nacelle should be equipped with a second L-864 flashing red light. (See Figure A-23 in Appendix A.)

13.6.2 The two obstruction lights should be arranged horizontally, positioned on opposite sides of the nacelle, visible to a pilot approaching from **any** direction, and flash simultaneously. (See Figure A-23 in Appendix A.) This lighting configuration ensures the turbines in this size category are always lighted.

13.6.3 In the event one of the two obstruction lights fails, no light failure notification is required; however, the light should be restored to service as soon as possible.

13.6.4 All turbines within this size category should be illuminated, regardless of their location within a wind turbine farm, and should be configured to flash simultaneously with the other turbines in the same farm. This requirement ensures the pilots operating at 500 feet AGL have sufficient warning that a wind turbine obstruction may be within their flight path.

13.7 **Wind Turbines at or Above 699 Feet (213 m).**

13.7.1 For wind turbines with a rotor tip height, while at top dead center, at or above 699 feet (213 m) AGL, additional lighting is required. All wind turbines of this size, regardless of number or configuration should be lighted.

13.7.2 In addition to the lighting identified in paragraph 13.6, an additional level of lights is required at a point midway between the top of the nacelle and ground level. The location of the additional lights may be adjusted as necessary to allow mounting at a seam within the turbine's mast.

13.7.2.1 The additional level of lights should consist of a minimum of three L-810 flashing red lights configured to flash in unison with the two L-864 red flashing lights located at the top of the nacelle at a rate of 30 fpm (± 3 fpm). The L-810s should be spaced at equal distances around the mast. The light should be installed to ensure a pilot approaching from **any** direction has an

unobstructed view of at least two of the lights. (See Figure A-23 in Appendix A.)

13.7.2.2 For wind turbine structures with a mast diameter greater than 20 feet (6 m), four L-810 red lights should be used.

13.7.2.3 All turbines within this size category should be illuminated, regardless of their location within a turbine farm, and should be configured to flash simultaneously with the other turbines in the same farm. This requirement ensures the pilots operating at 500 feet AGL have sufficient warning that a wind turbine obstruction may be within their flight path.

## 13.8 Lighting of Wind Turbines During Construction Phase.

To ensure proper conspicuity of turbines at night during construction, all turbines should be lighted with temporary lighting once they reach a height of 200 feet (61 m) or greater until the permanent lighting configuration is turned on. As the structure's height continues to increase, the temporary lighting should be relocated to the structure's uppermost height. The temporary lighting may be turned off for short periods if they interfere with construction personnel. If practical, permanent obstruction lights should be installed and operated at each level as construction progresses. An L-810 steady-burning red light shall be used to light the structure during the construction phase, if the permanent L-864 flashing-red lights are not in place. If power is not available, turbines should be lighted with a self-contained, solar-powered, LED, steady-burning red light that meets the photometric requirements of an FAA L-810 lighting system. The lights should be positioned to ensure a pilot has an unobstructed view of at least one light at each level. Using a NOTAM (D) to justify not lighting the turbines until the entire project is completed is prohibited.

## 13.9 Lighting and Marking of Airborne Wind Turbines.

The FAA is currently conducting research to develop special lighting and marking standards for Airborne Wind Turbines. Sponsors should consult with their respective FAA OE Specialists for updated information.

## 13.10 Lighting and Marking of Offshore Wind Turbines.

FAA lighting and marking recommendations apply to structures out to 12 NM from the coast of the United States, which is the extent of the territorial seas. The Bureau of Ocean Energy Management (BOEM), which maintains jurisdiction of land leases beyond the 12 NM, may also require compliance with the marking and/or lighting recommendations identified in this AC.

# CHAPTER 14. AIRCRAFT DETECTION LIGHTING SYSTEMS

## 14.1 Purpose.

Aircraft Detection Lighting Systems (ADLS) are sensor-based systems designed to detect aircraft as they approach an obstruction or group of obstructions; these systems automatically activate the appropriate obstruction lights until they are no longer needed by the aircraft. This technology reduces the impact of nighttime lighting on nearby communities and migratory birds and extends the life expectancy of obstruction lights.

## 14.2 General Standards.

14.2.1 The system should be designed with sufficient sensors to provide complete detection coverage for aircraft that enter a three-dimensional volume of airspace, or coverage area, around the obstruction(s) (see Figure A-27 in Appendix A), as follows:

1. Horizontal detection coverage should provide for obstruction lighting to be activated and illuminated prior to aircraft penetrating the perimeter of the volume, which is a minimum of 3 NM (5.5 km) away from the obstruction or the perimeter of a group of obstructions.

2. Vertical detection coverage should provide for obstruction lighting to be activated and illuminated prior to aircraft penetrating the volume, which extends from the ground up to 1,000 feet (304 m) above the highest part of the obstruction or group of obstructions, for all areas within the 3 NM (5.5 km) perimeter defined in subparagraph 14.2.1 1 above.

3. In some circumstances, it may not be possible to meet the volume area defined above because the terrain may mask the detection signal from acquiring an aircraft target within the 3 NM (5.5 km) perimeter. In these cases, the sponsor should identify these areas in their application to the FAA for further evaluation.

4. In some situations, lighting not controlled by the ADLS may be required when the 3 NM (5.5 km) perimeter is not achievable to ensure pilots have sufficient warning before approaching the obstructions.

14.2.2 The ADLS should activate the obstruction lighting system in sufficient time to allow the lights to illuminate and synchronize to flash simultaneously prior to an aircraft penetrating the volume defined above. The lights should remain on for a specific time period, as follows:

1. For ADLSs capable of continuously monitoring aircraft while they are within the 3 NM/1,000 foot (5.5 km/304 m) volume, the obstruction lights should stay on until the aircraft exits the volume. In the event detection of the aircraft is lost while being continuously monitored within the 3 NM/1,000 foot (5.5 km/304 m) volume, the ADLS should initiate a 30-minute timer and keep the obstruction lights on until the timer expires. This should provide the untracked aircraft sufficient time to exit the area and give the ADLS time to reset.

2. For ADLSs without the capability of monitoring aircraft targets in the 3 nm/1,000 foot (5.5 km/304 m) volume, the obstruction lights should stay on for a preset amount of time, calculated as follows:

   a. For single obstructions: 7 minutes.

   b. For groups of obstructions: (the widest dimension in nautical miles + 6) x 90 seconds equals the number of seconds the light(s) should remain on.

14.2.3 Acceptance of ADLS applications will be on a case-by-case basis and may be modified, adjusted, or denied based on proximity of the obstruction or group of obstructions to airports, low-altitude flight routes, military training areas, or other areas of frequent flight activity. It may be appropriate to keep certain obstructions closest to these known activity areas illuminated during the nighttime hours, while the remainder of the group's obstruction lighting is controlled by the ADLS.

14.2.4 Project sponsors requesting ADLS use should include in their application maps or diagrams indicating the location of the proposed sensors, the range of each sensor, and a visual indication showing how each sensor's detection arc provides the full horizontal and vertical coverage, as required under paragraph 14.2.1. In the event that detection coverage is not 100 percent due to terrain masking, project sponsors should provide multiple maps or diagrams that indicate coverage at the affected altitudes. A sample diagram is shown in Figure A-27 in Appendix A.

14.2.5 Types of ADLS Component or System Failure Events.

1. In the event of an ADLS component or system failure, the ADLS should automatically turn on all the obstruction lighting and operate in accordance with this AC as if it was not controlled by an ADLS. The obstruction lighting must remain in this state until the ADLS and its components are restored.

2. In the event that an ADLS component failure occurs and an individual obstruction light cannot be controlled by the ADLS, but the rest of the ADLS is functional, that particular obstruction light should automatically turn on and operate in accordance with this AC as if it was not controlled by an ADLS, and the remaining obstruction lights can continue to be controlled by the ADLS. The obstruction lighting will remain in this state until the ADLS and its components are restored.

3. Complete light failure should be addressed in accordance with Chapter 2 paragraph 2.4.

14.2.6 The ADLS's communication and operational status shall be checked at least once every 24 hours to ensure both are operational.

14.2.7 The ADLS should be able to detect an aircraft with a cross-sectional area of 1 square meter or more within the volume, as required in subparagraphs 14.2.1 1 and 14.2.1 2.

14.2.8 Each ADLS installation should maintain a log of activity data for a period of no less than the previous 15 days. This data should include, but not be limited to, the date, time, duration of all system activations/deactivations, track of aircraft activity, maintenance issues, system errors, communication and operational issues, lighting outages/issues, etc.

14.2.9 Operational Frequencies.

1. Unlicensed devices (including FCC Part 15) devices cannot be used for this type of system.

2. Any frequency used for the operation of ADLS must be individually licensed through the FCC.

14.3 **Voice/Audio Option.**

14.3.1 ADLS may include an optional voice/audio feature that transmits a low-power, audible warning message to provide pilots additional information on the obstruction they are approaching.

14.3.2 The audible transmission should be in accordance with appropriate FAA and FCC regulations.

14.3.3 The audible transmission should be over an aviation frequency licensed by the FCC and authorized under the Code of Federal Regulations Title 47- Part 87.483 (excluding 121.5 MHz).

**Note:** Using air traffic control frequencies in the 117.975-MHz to 137-MHz frequency band is prohibited for this operation.

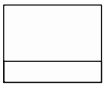
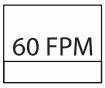
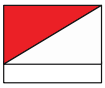
14.3.4 The audible message should consist of three quick tones, followed by a verbal message that describes the type of obstruction the system is protecting. Appropriate terms to be used include tower(s), wind turbine(s), or power line(s).

14.3.5 The audible message should be repeated three times or until the system determines the aircraft is no longer within the audible warning area defined in the following paragraph.

14.3.6 The audible message should be considered as a secondary, final warning and should be activated when an aircraft is within 1/2 NM (926 m) horizontally and 500 feet (152 m) vertically of the obstruction. The use of, or variation to, the audible warning zone may occur, depending on site-specific conditions or obstruction types.

## APPENDIX A: Specifications for Obstruction Lighting Equipment Classification

### Table A-1. FAA-Approved Obstruction Lighting Fixtures

| Type | Symbol | Description |
|---|---|---|
| **L-810** |  | Steady-Burning - RED<br>Single Obstruction Light |
| **L-810** |  | Steady-Burning – RED<br>Double Obstruction Light |
| **L-856** |  | High-Intensity Flashing – WHITE<br>Obstruction Light (40 FPM) |
| **L-857** |  | High-Intensity Flashing – WHITE<br>Catenary Light (60 FPM) |
| **L-864** |  | Medium-Intensity Flashing – RED<br>Obstruction Light (20-40 FPM) |
| **L-865** |  | Medium-Intensity Flashing – WHITE<br>Obstruction Light (40-FPM) |
| **L-866** |  | Medium-Intensity Flashing - WHITE<br>Catenary Light (60-FPM) |
| **L-864/L-865** |  | Medium-Intensity Flashing Dual – RED / WHITE<br>Obstruction Light (20-40 FPM)<br>Obstruction Light (40 FPM) |
| **L-885** |  | Flashing Obstruction Light - RED<br>Obstruction Light (60 FPM) |

FPM = Flashes Per Minute

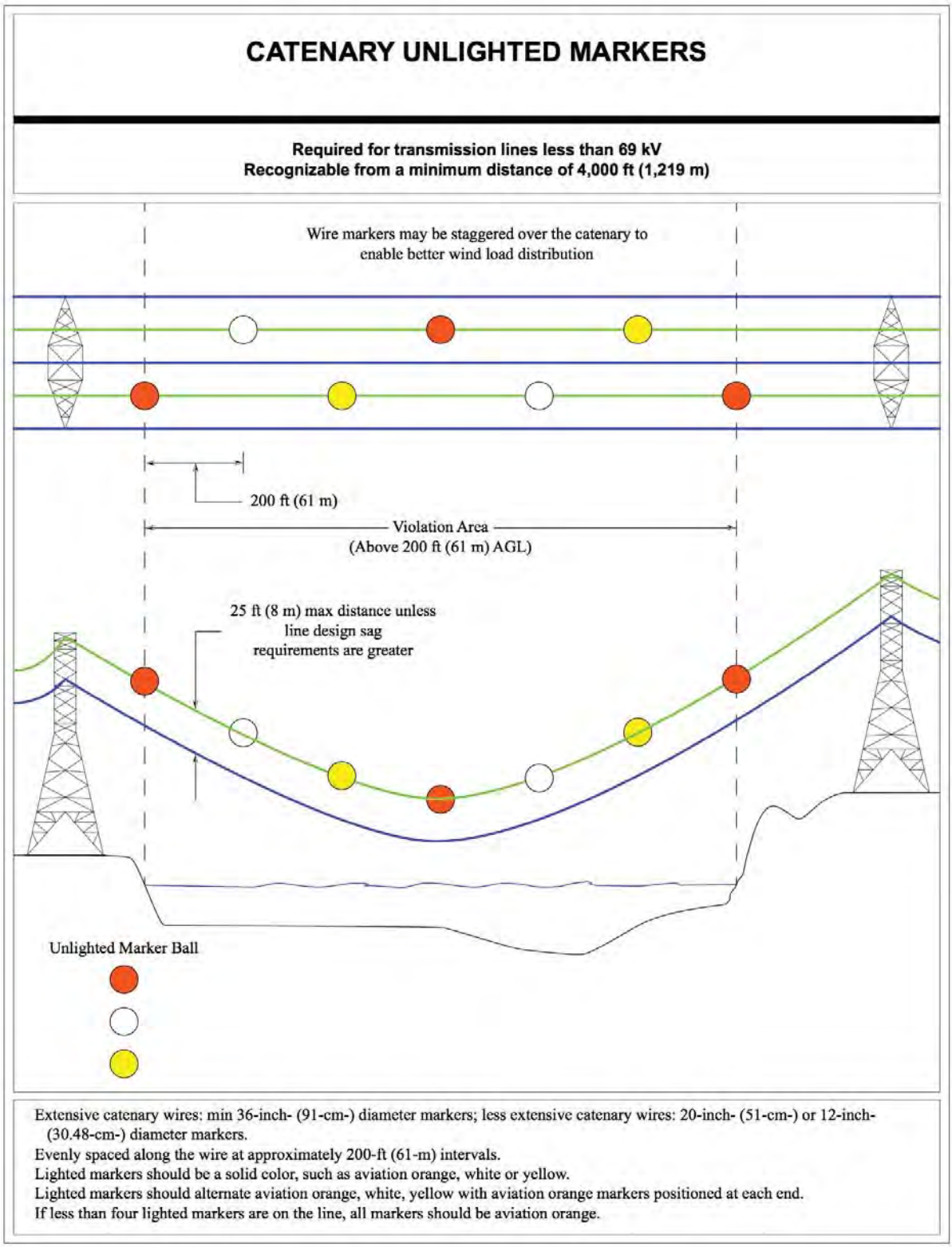



**Figure A-2. Catenary Unlighted Markers**

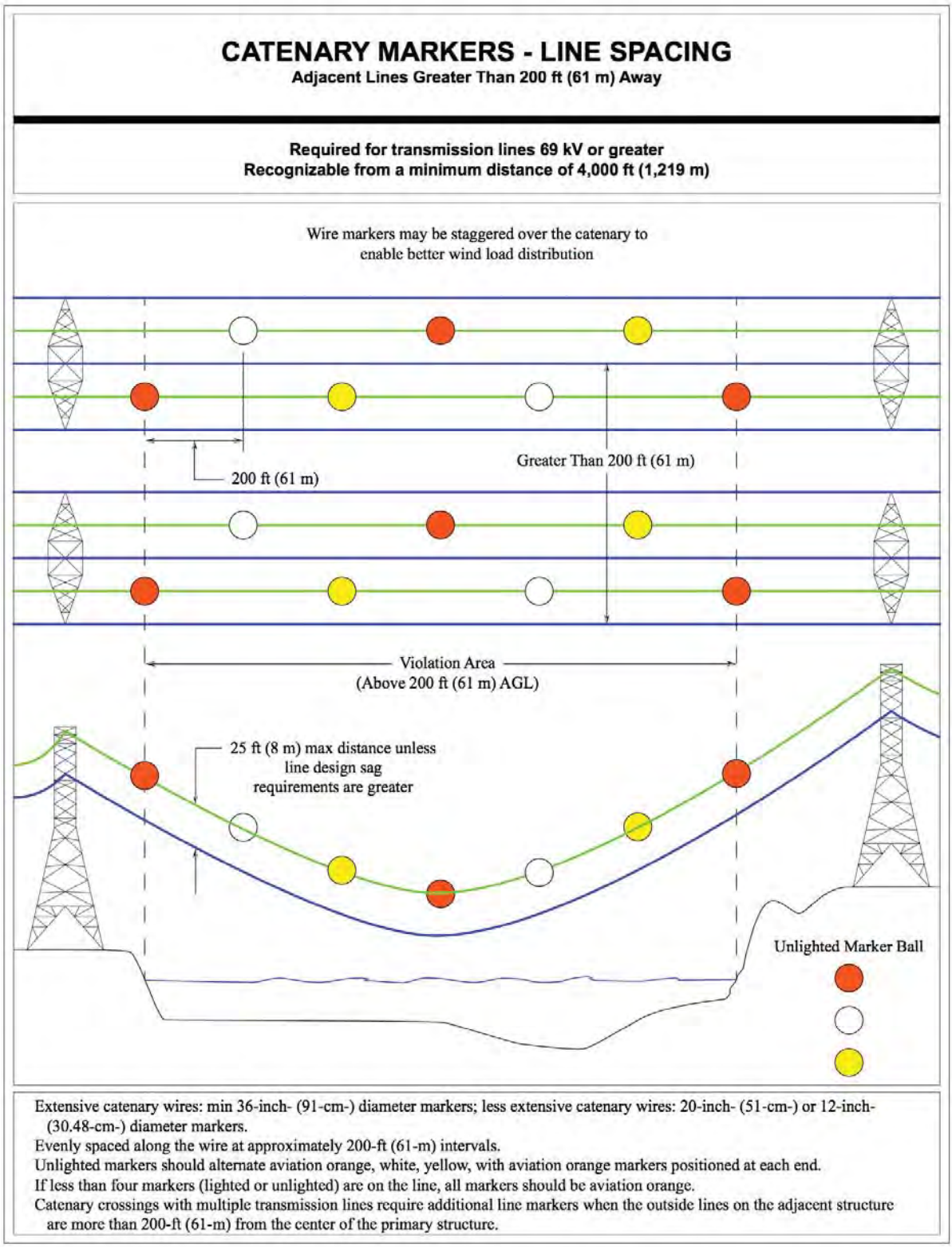



**Figure A-3. Catenary Markers - Line Spacing (Adjacent Lines Greater Than 200 ft (61 m) Away)**

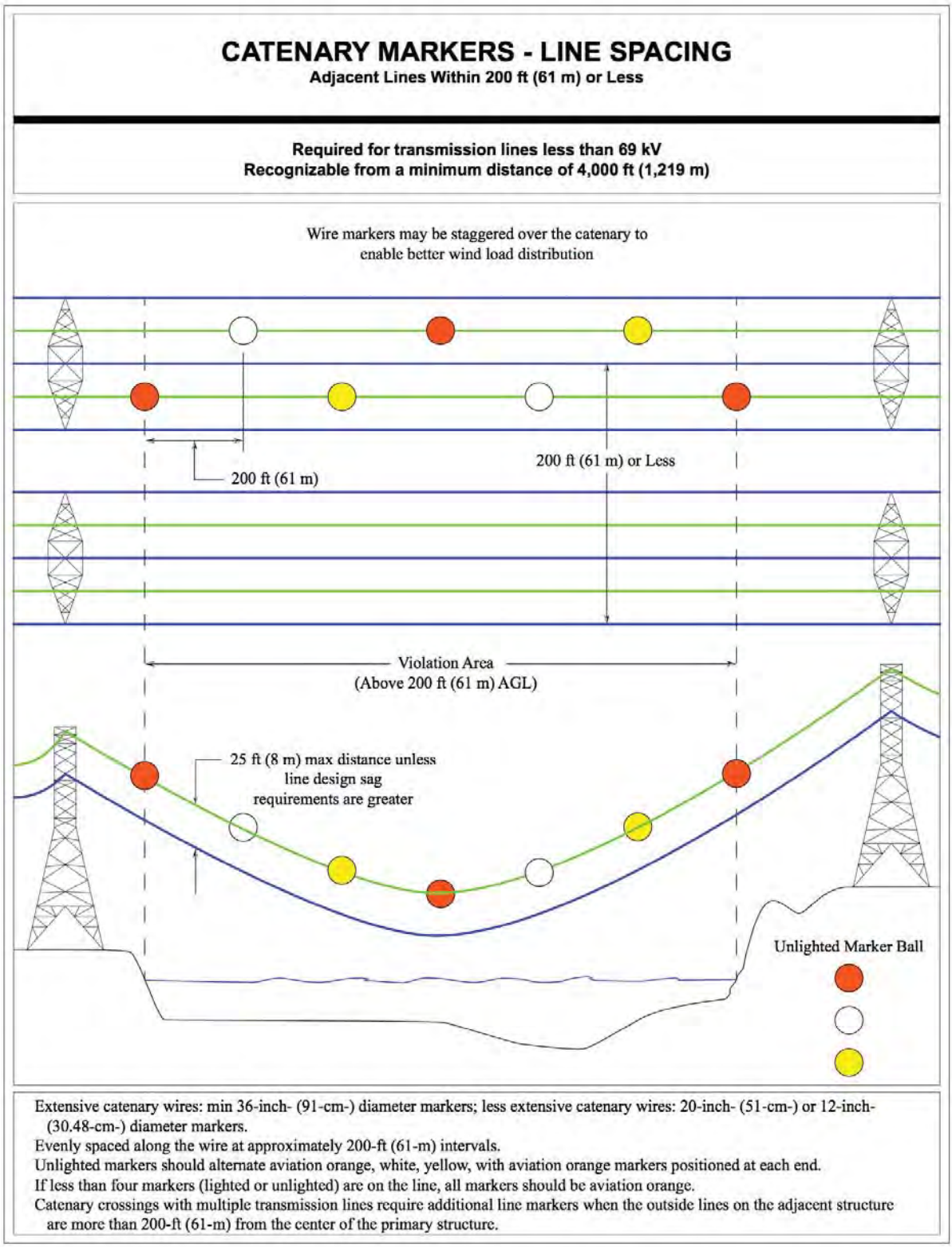



**Figure A-4. Catenary Markers – Line Spacing (Adjacent Lines Within 200 ft (61 m) or Less**

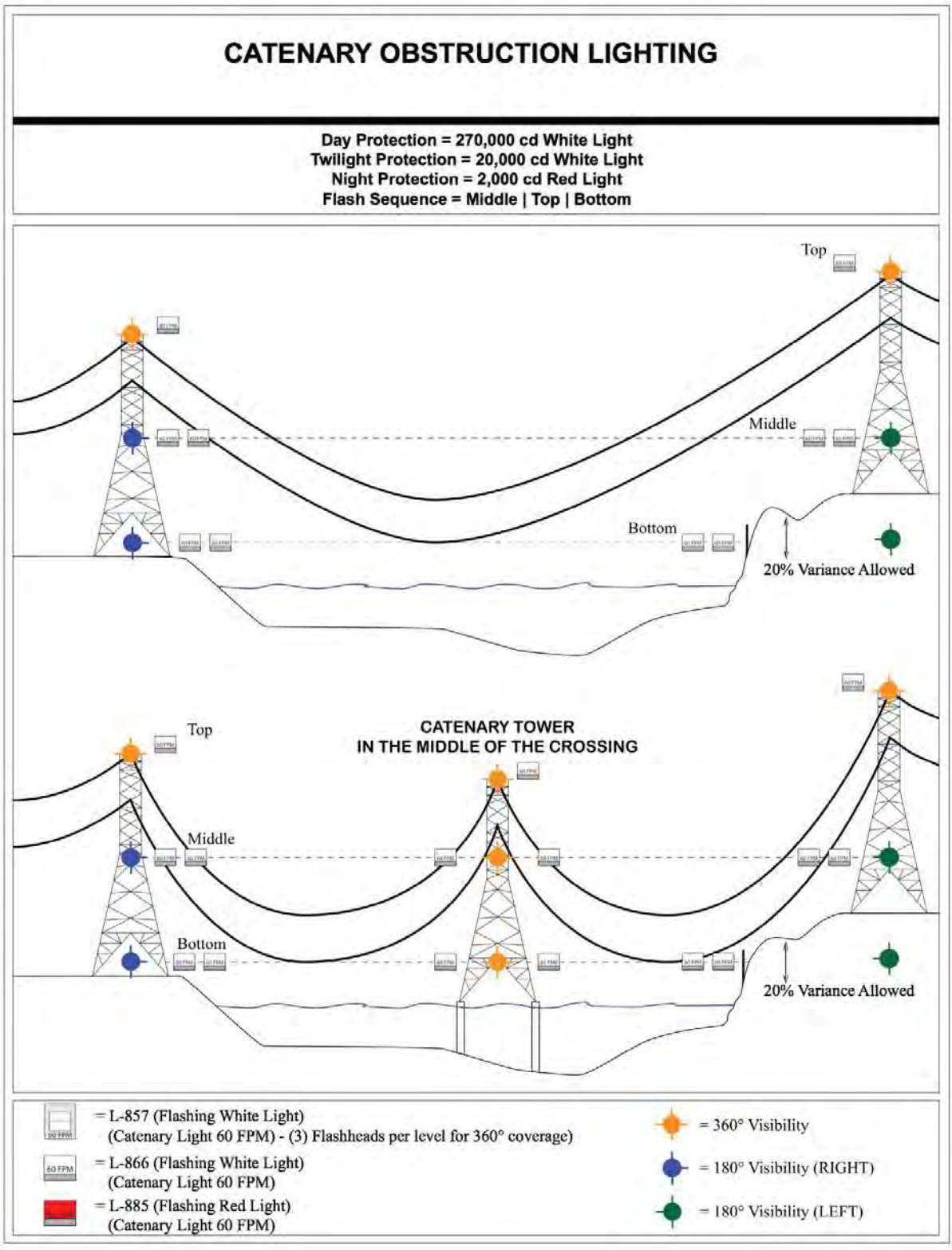



**Figure A-5. Catenary Obstruction Lighting**

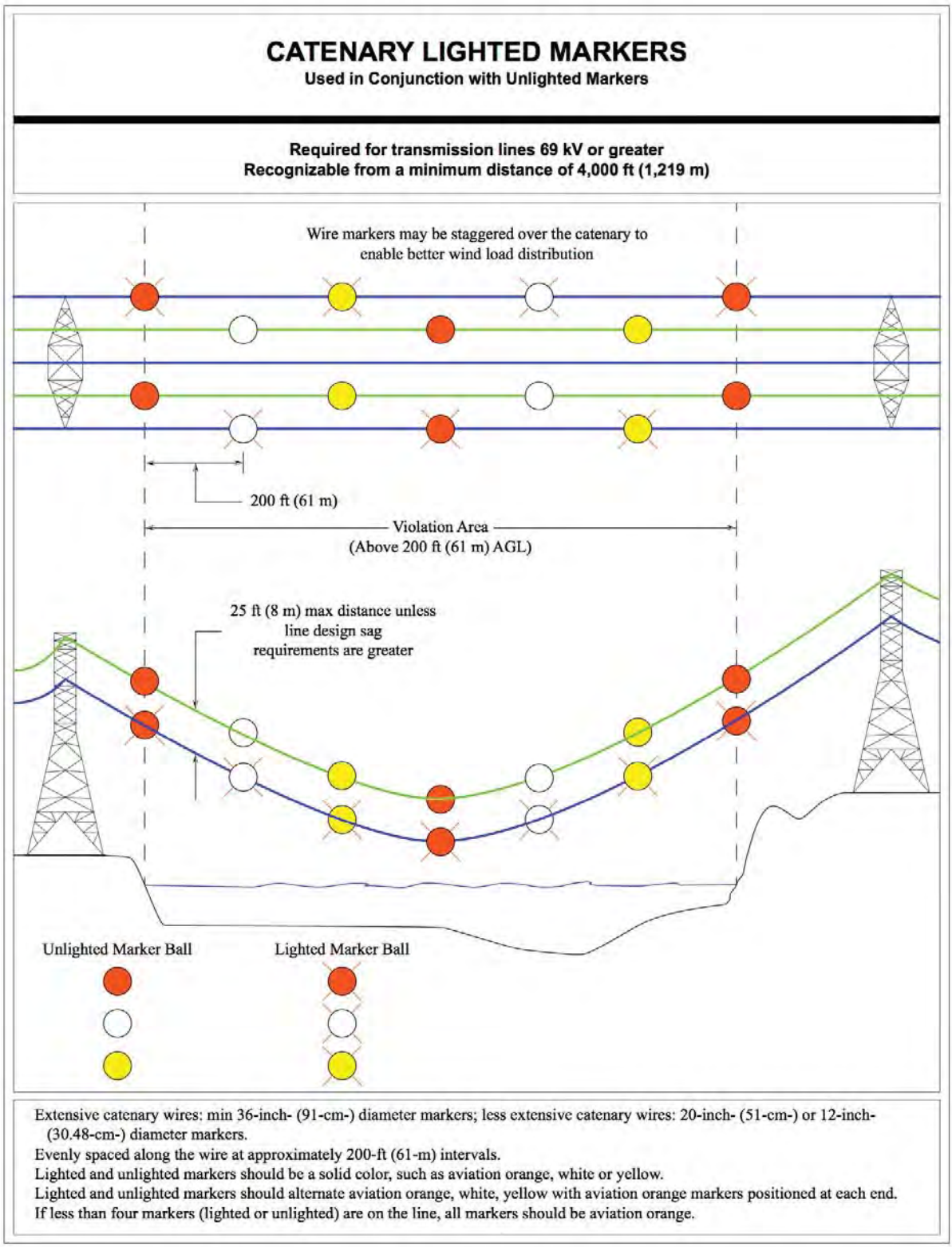



**Figure A-6. Catenary Lighted Markers**

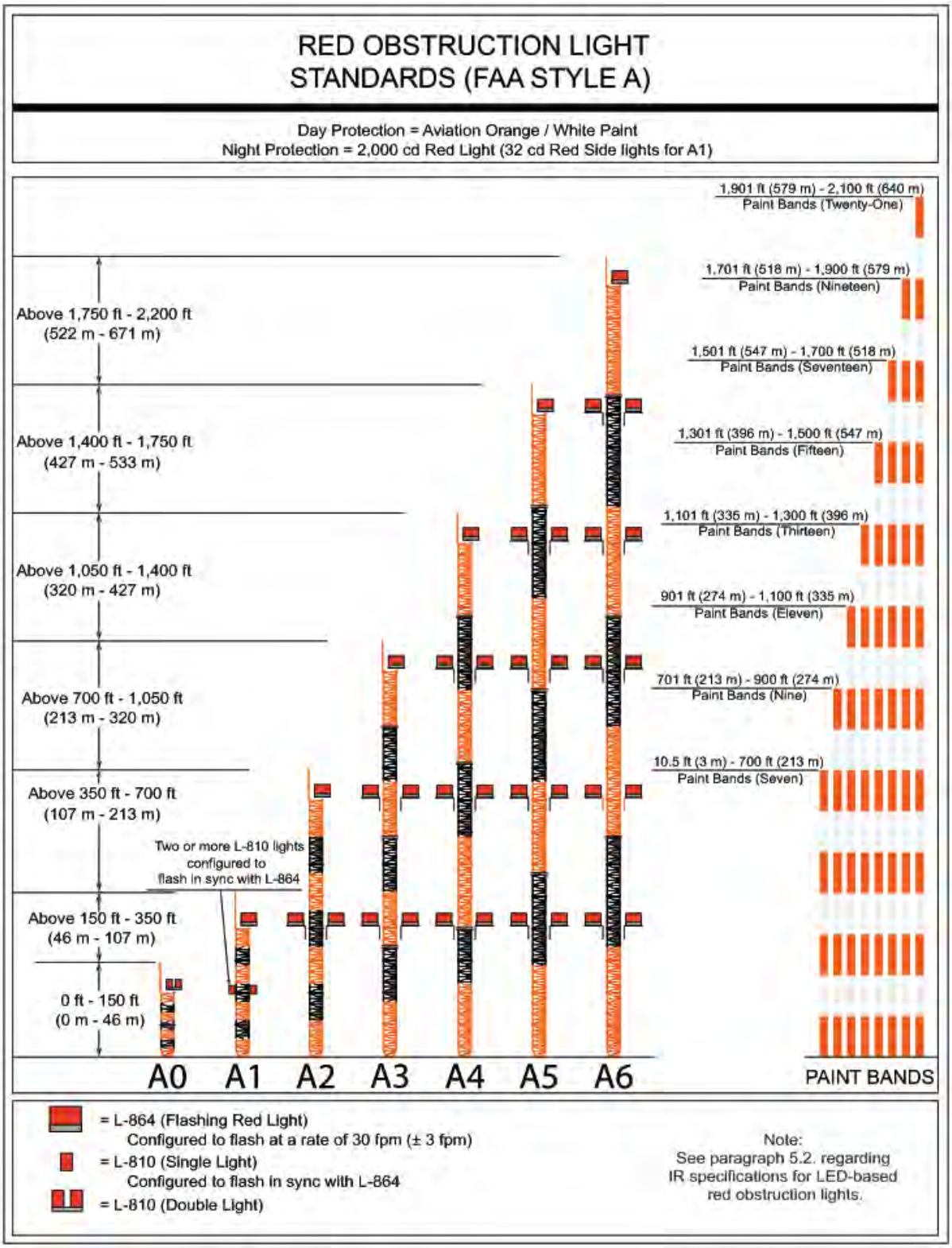



**Figure A-7. Red Obstruction Light Standards**

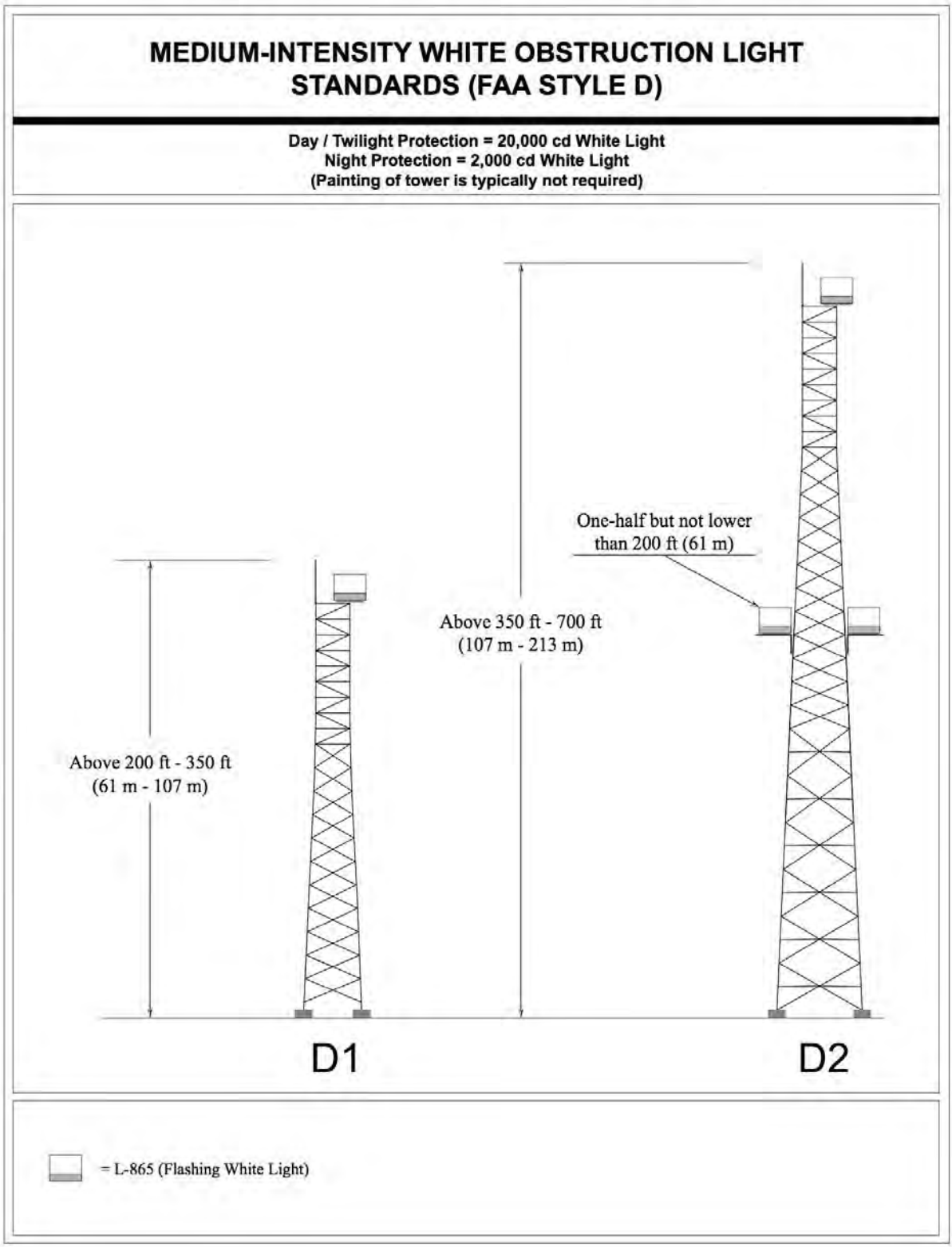



**Figure A-8. Medium-Intensity White Obstruction Light Standards**

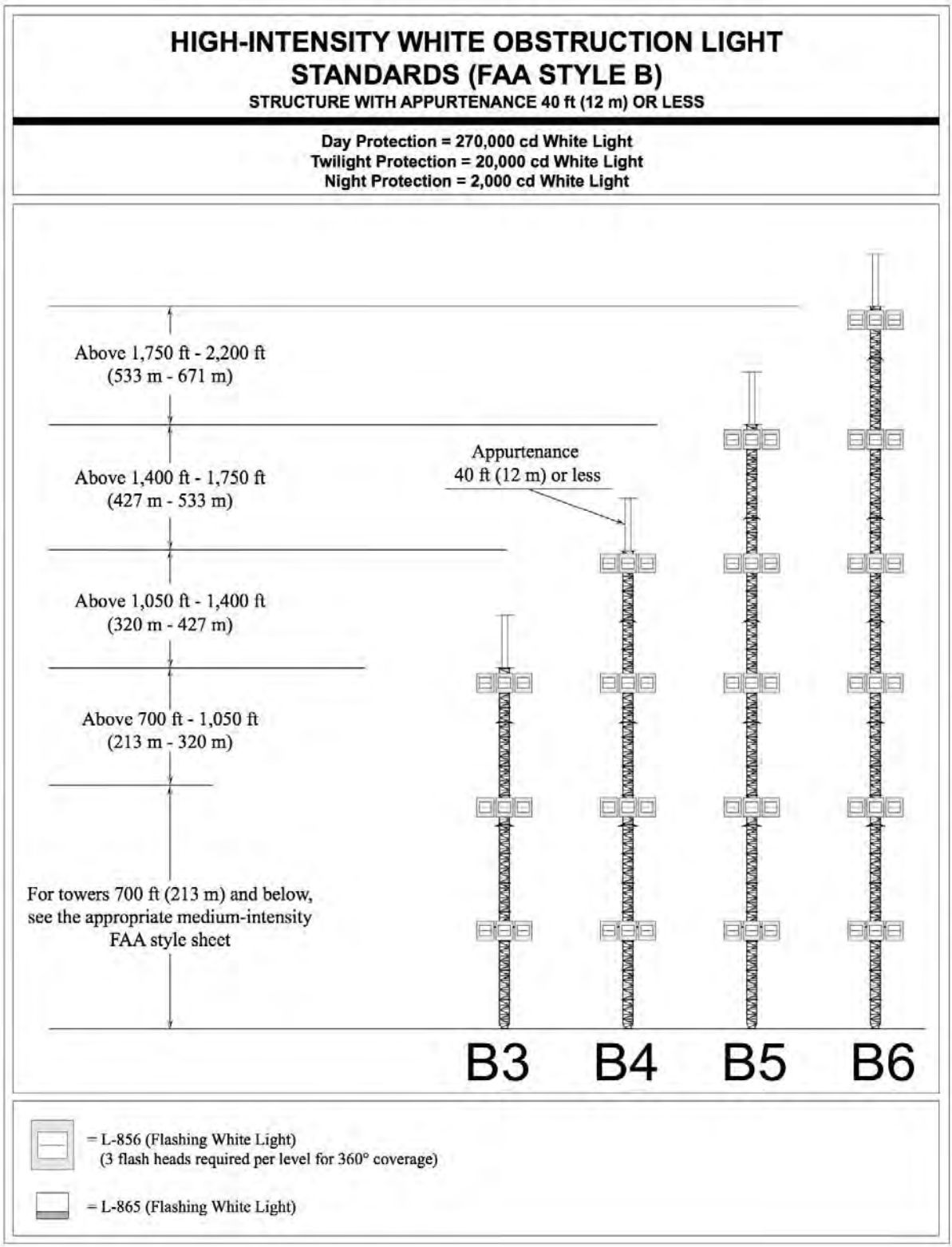



**Figure A-9. High-Intensity White Obstruction Light Standards—Structures With Appurtenance 40 Feet or Less**

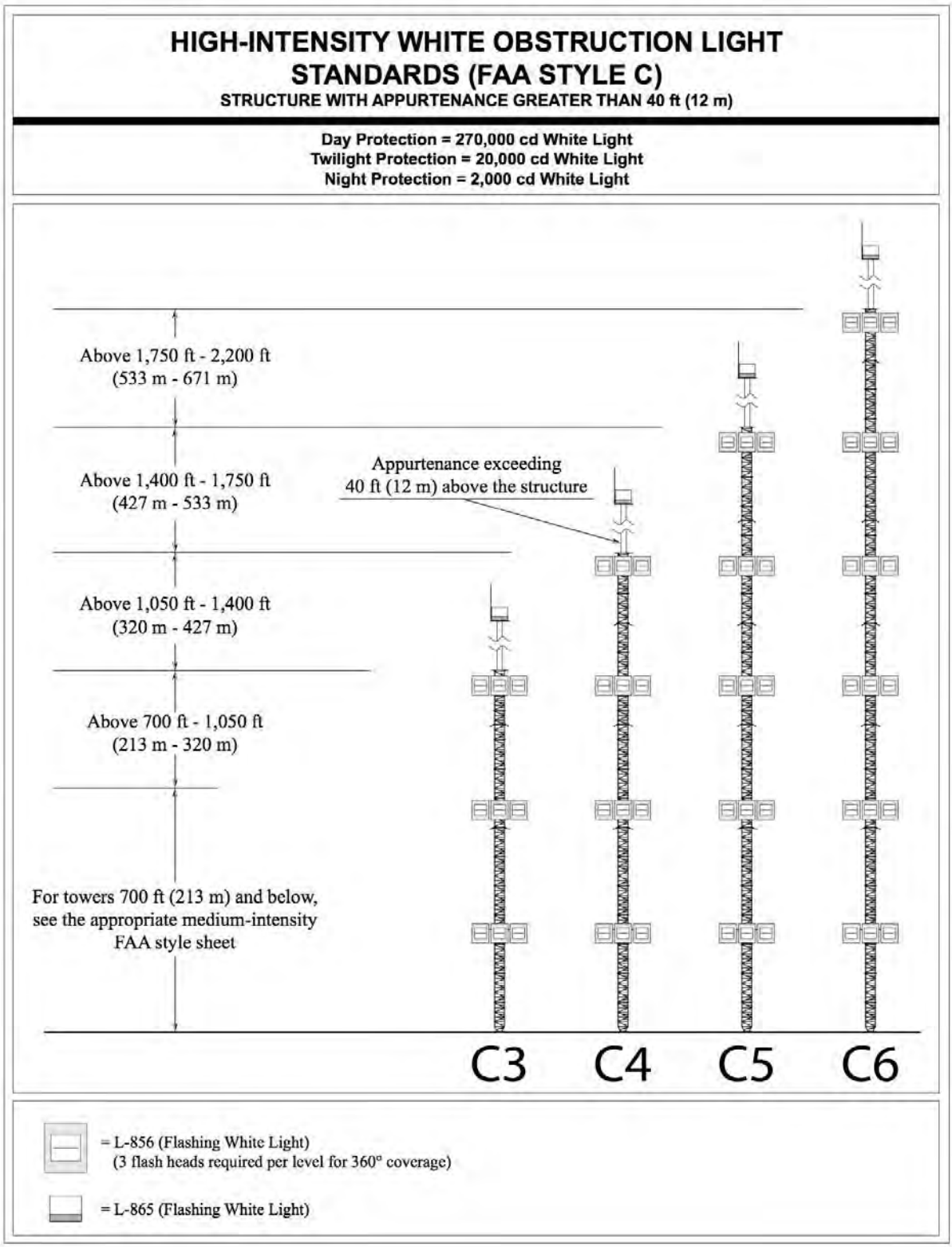



**Figure A-10. High-Intensity Obstruction Lighting Standards—Structures With Appurtenance Over 40 Feet High**

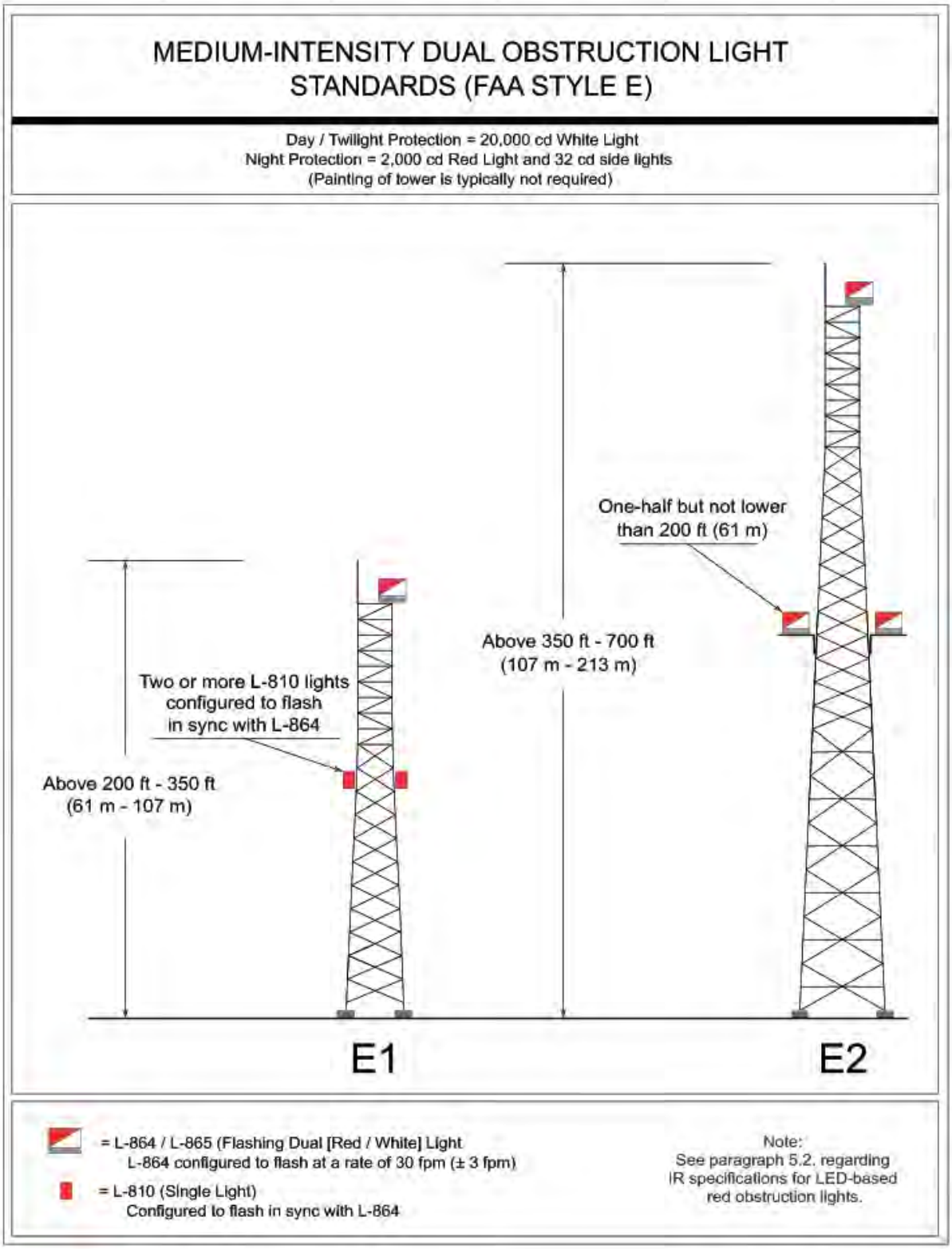



**Figure A-11. Medium-Intensity Dual Obstruction Lighting Standards**

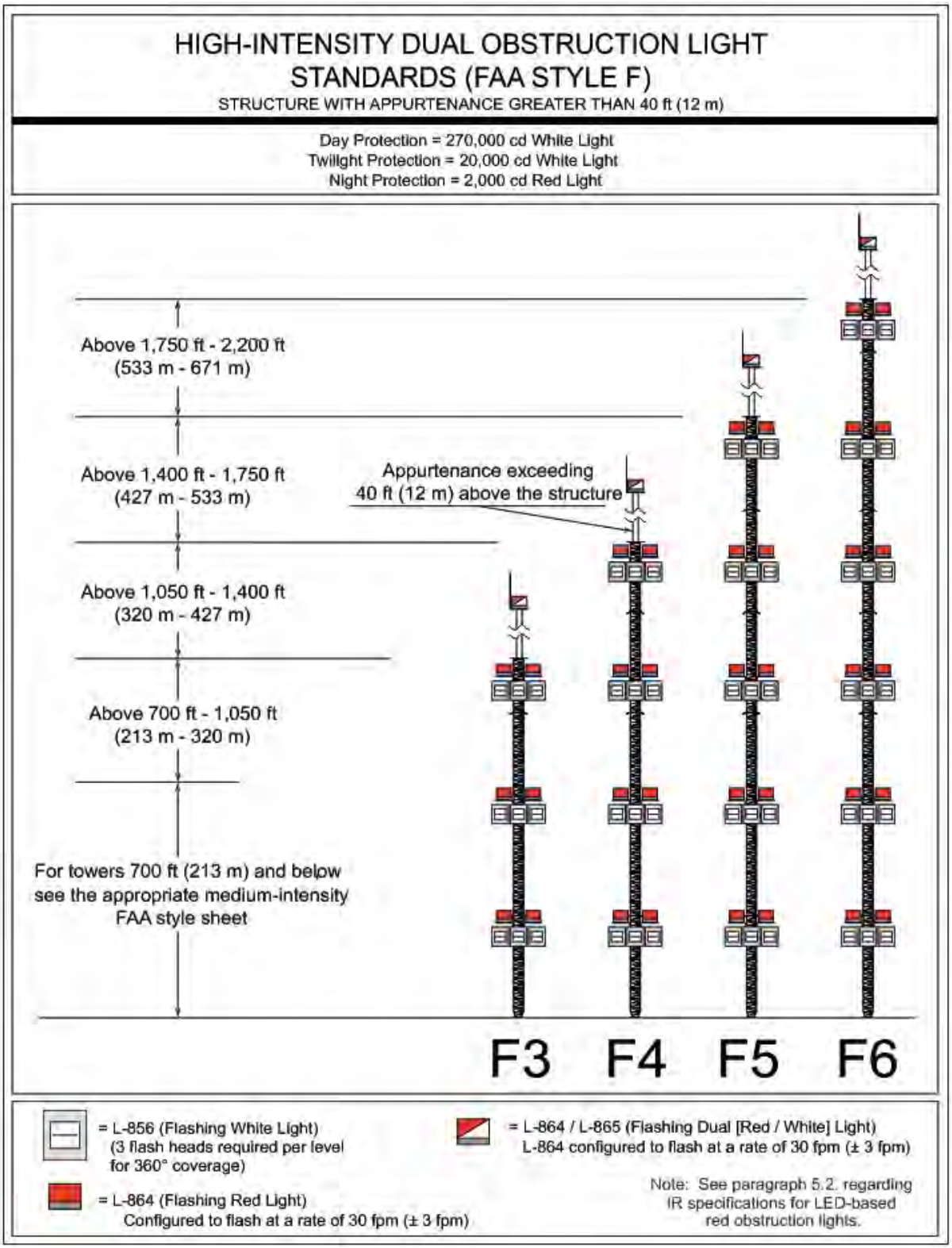



**Figure A-12. High-Intensity Dual Obstruction Lighting Standards—Structures With Appurtenance Over 40 Feet High**

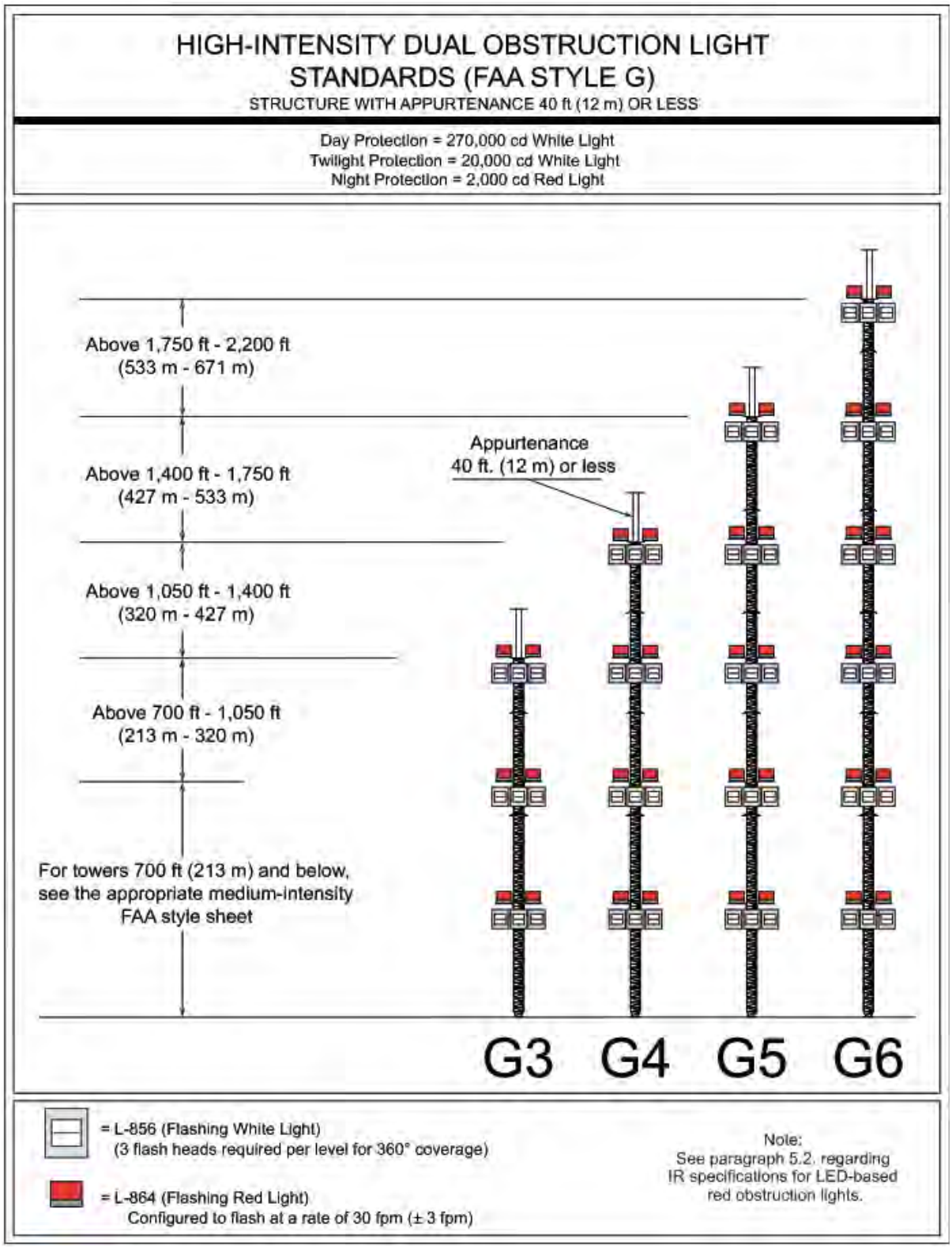



**Figure A-13. High-Intensity Dual Obstruction Lighting Standards—Structures With Appurtenance 40 Feet or Less**

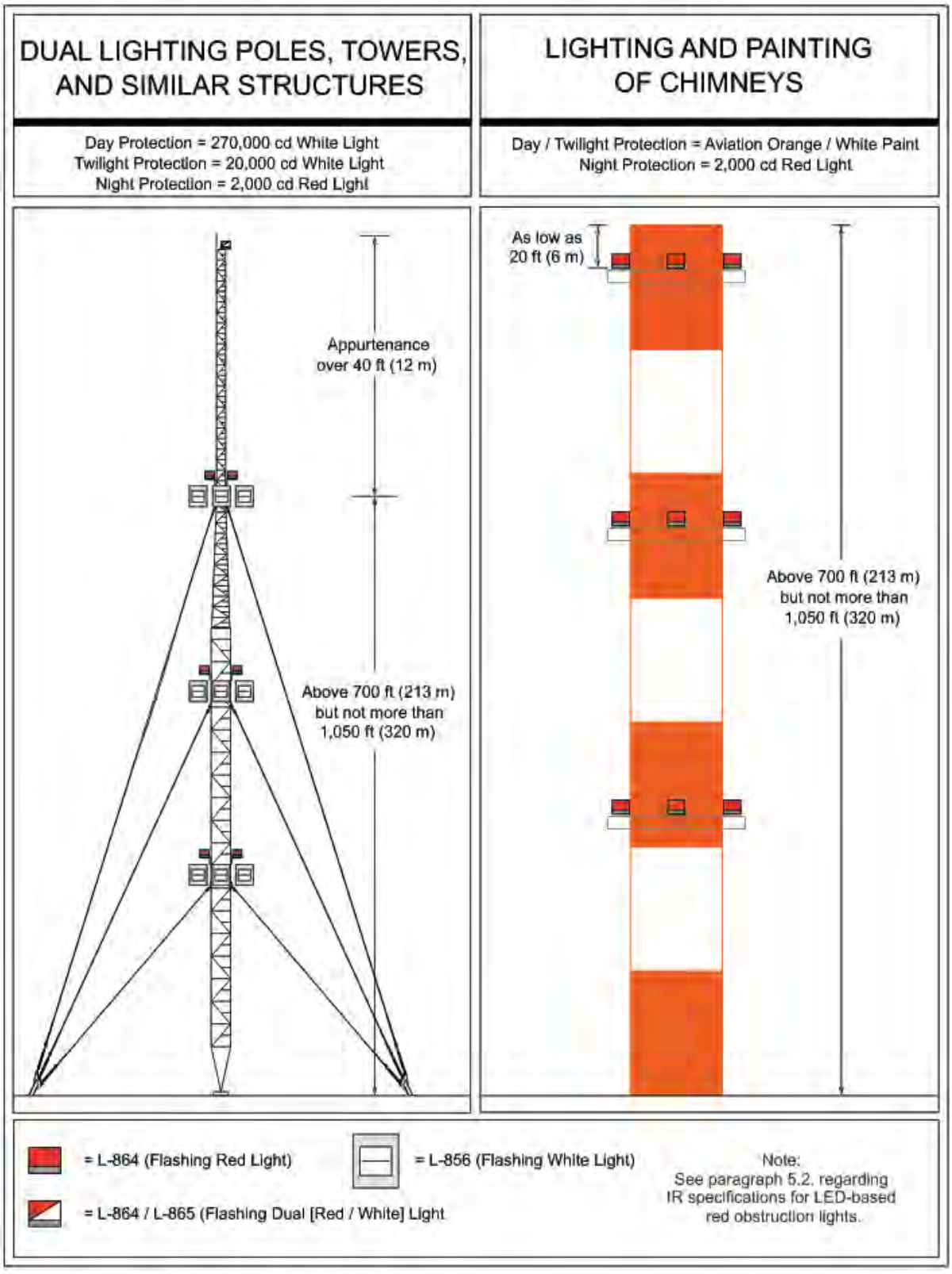



**Figure A-14. Painting and/or Dual Lighting of Chimneys, Poles, Towers, and Similar Structures**

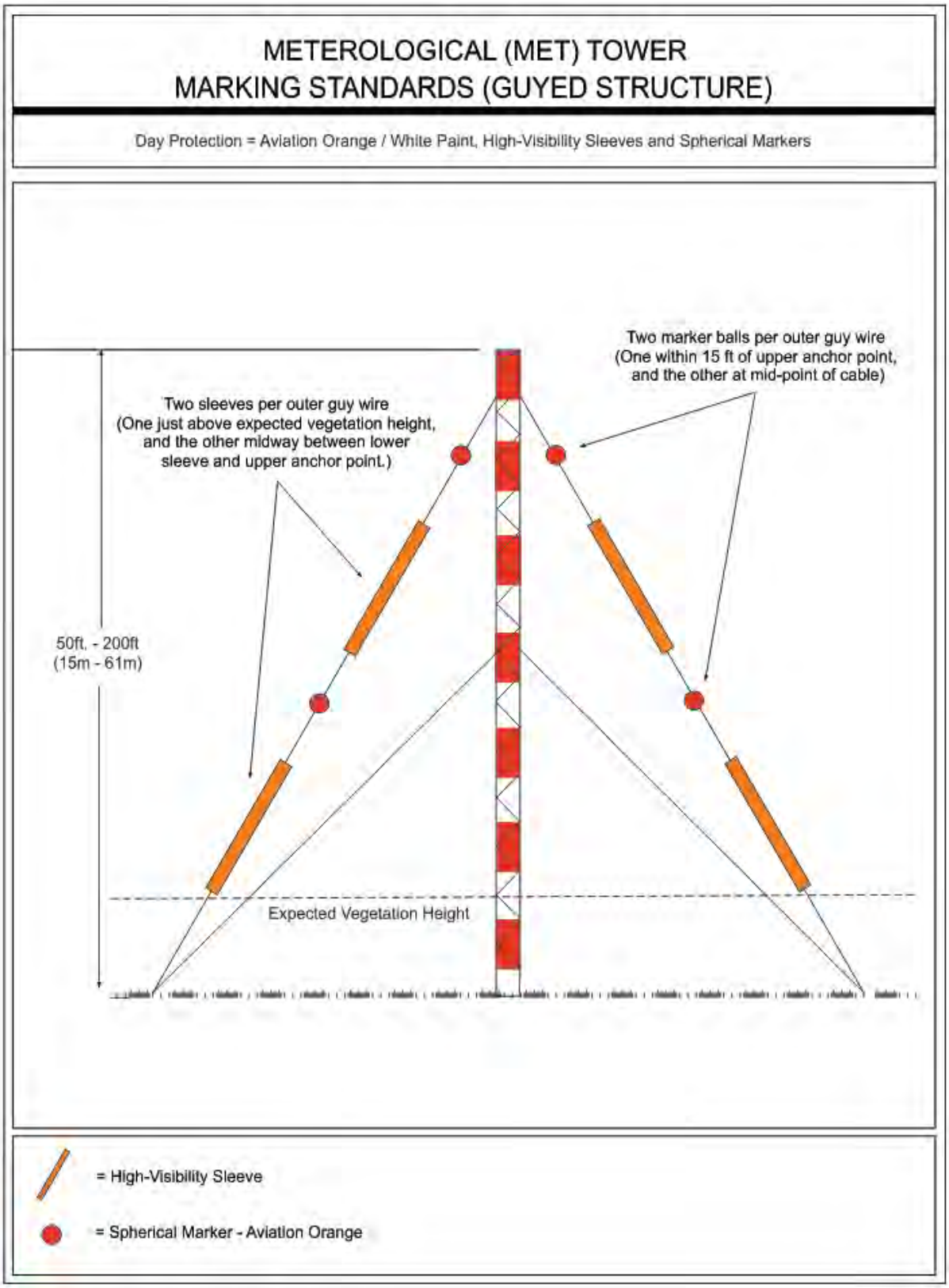



**Figure A-15. Meteorological (MET) Tower Marking Standards (Guyed Structure)**

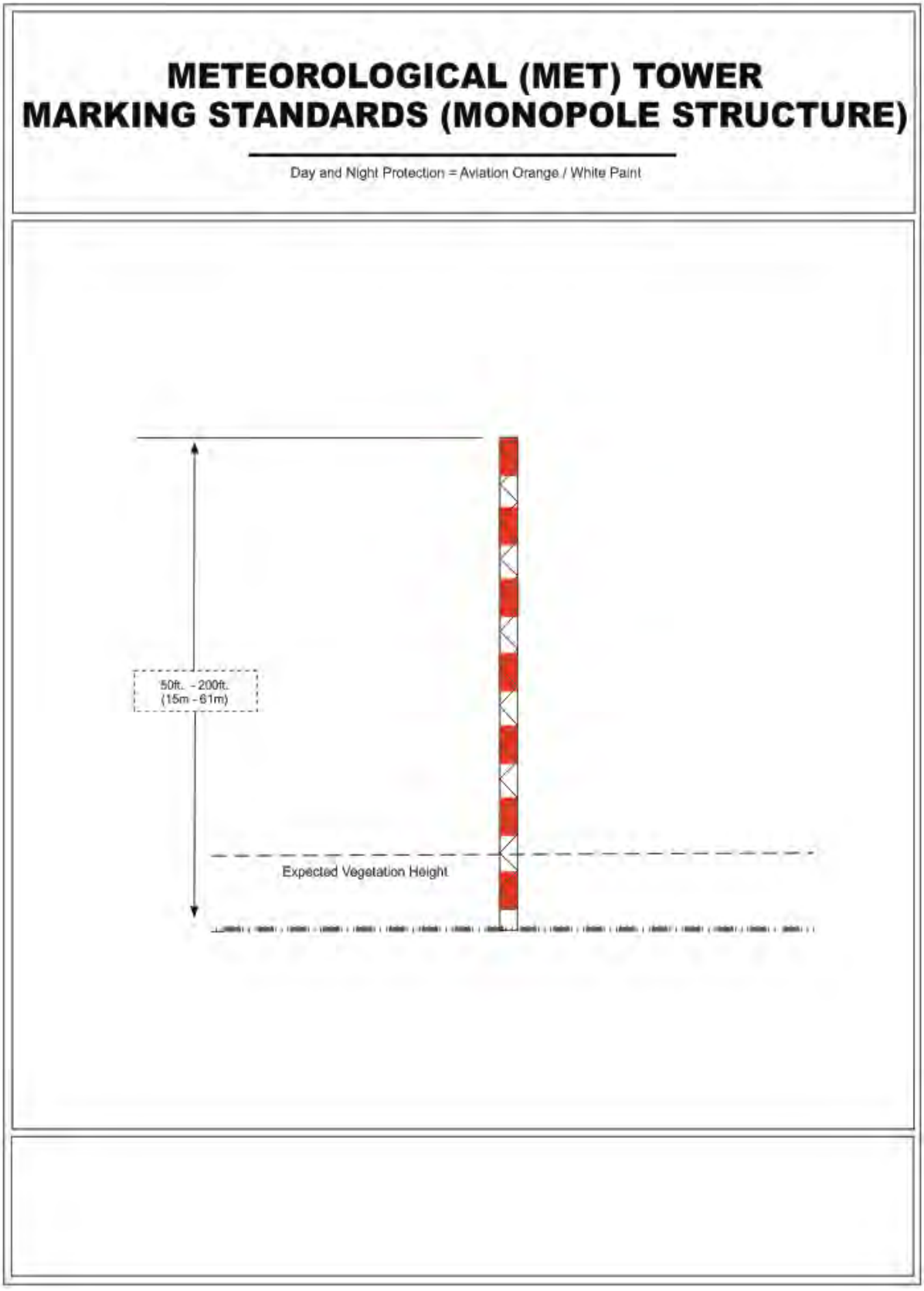



**Figure A-16. Meteorological (MET) Tower Marking Standards (Monopole Structure)**

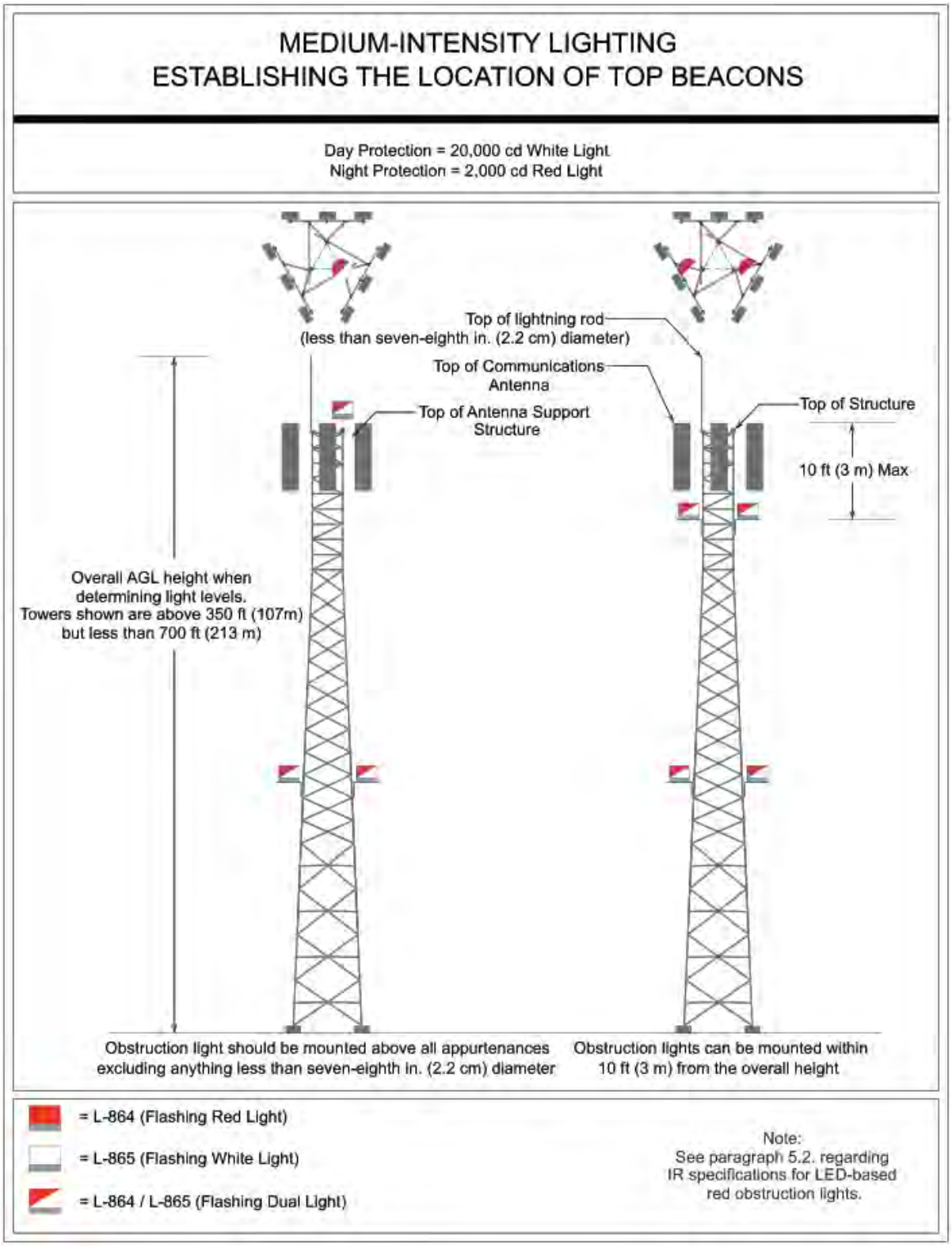



**Figure A-17. Medium-Intensity Lighting—Establishing the Location of Top Beacons**

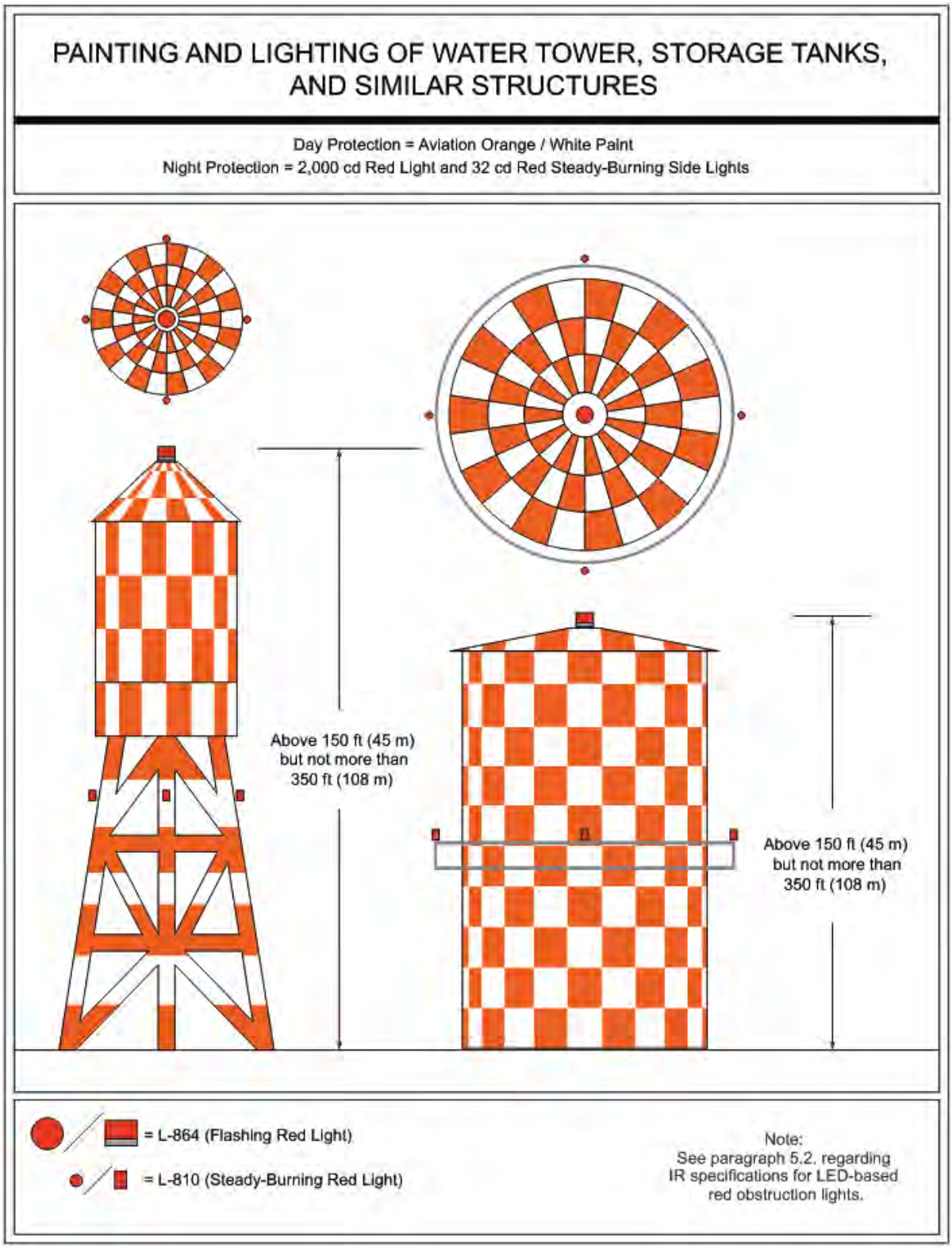



**Figure A-18. Painting and Lighting of Water Towers, Storage Tanks, and Similar Structures**

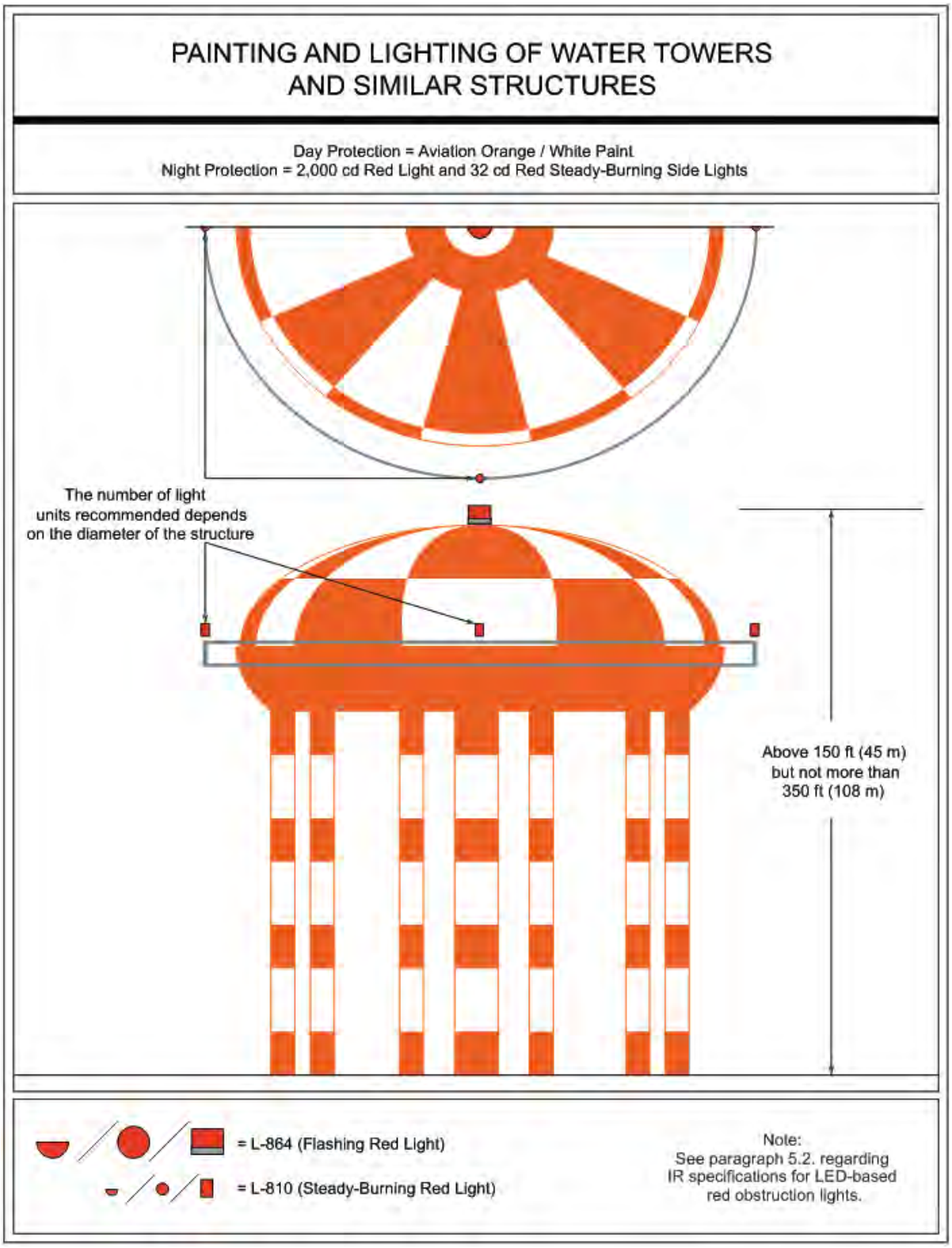



**Figure A-19. Painting and Lighting of Water Towers and Similar Structures**

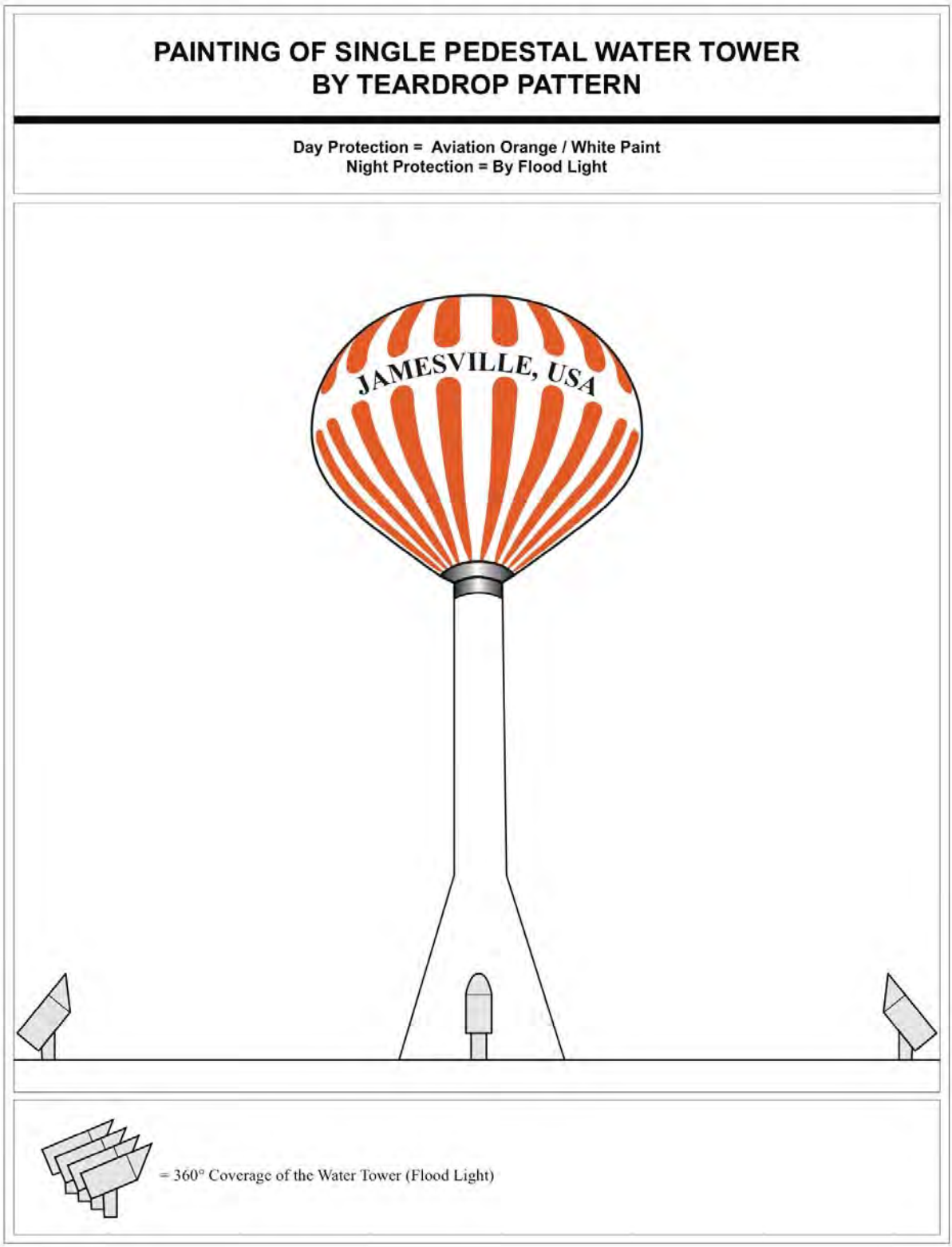



**Figure A-20. Painting a Single Pedestal Water Tower Using the Teardrop Pattern**

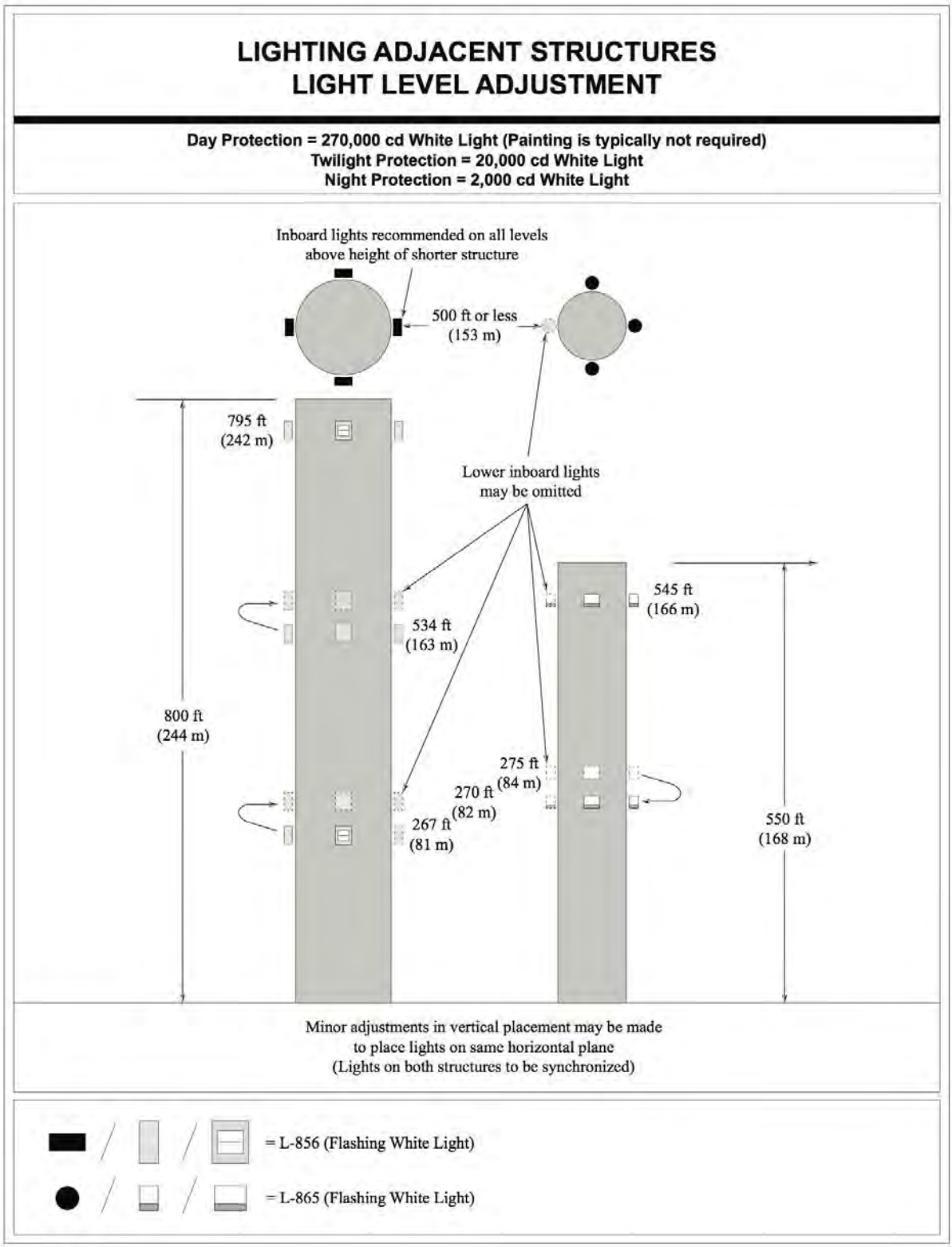



**Figure A-21. Lighting Adjacent Structures—Light Level Adjustment**

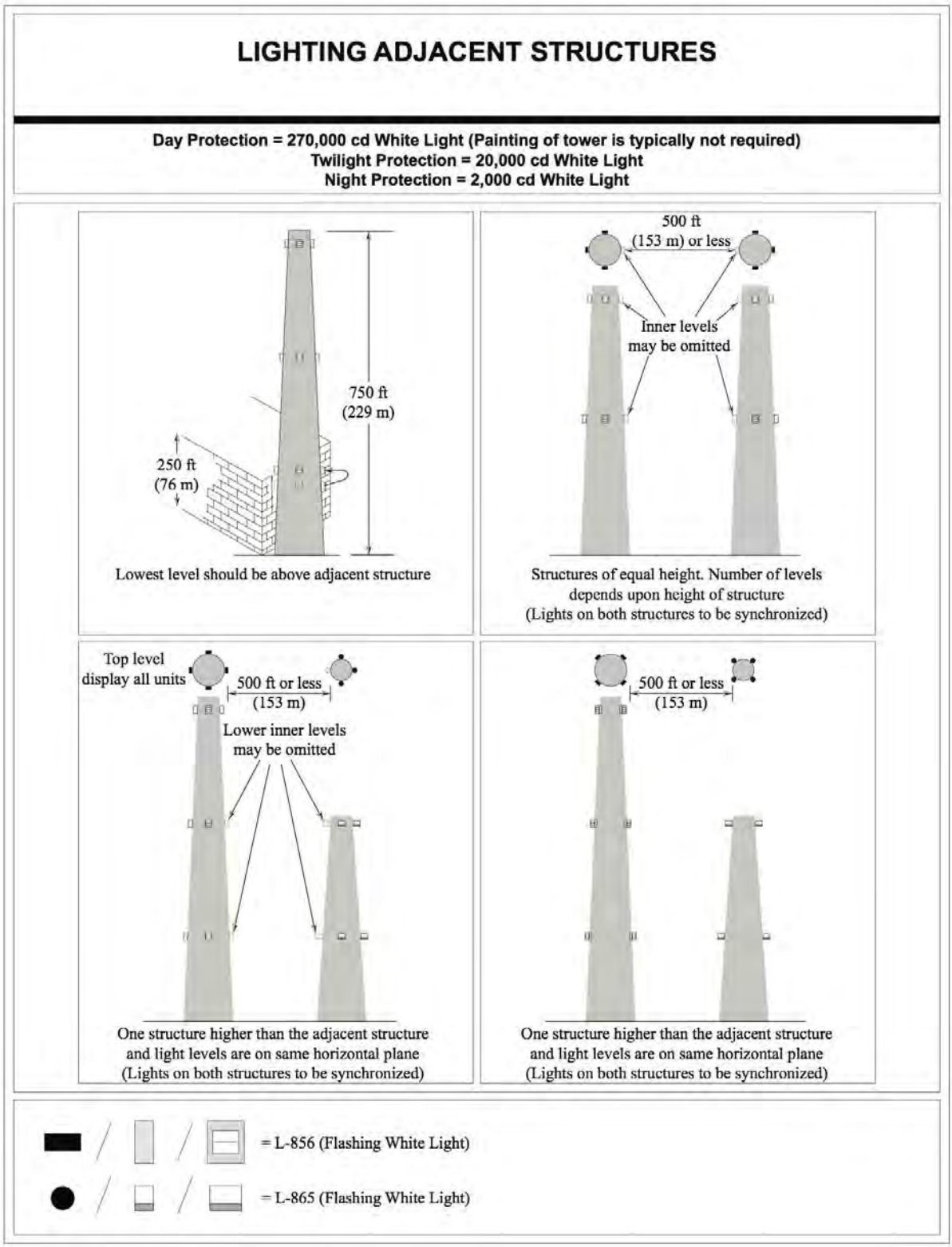



**Figure A-22. Lighting Adjacent Structures**

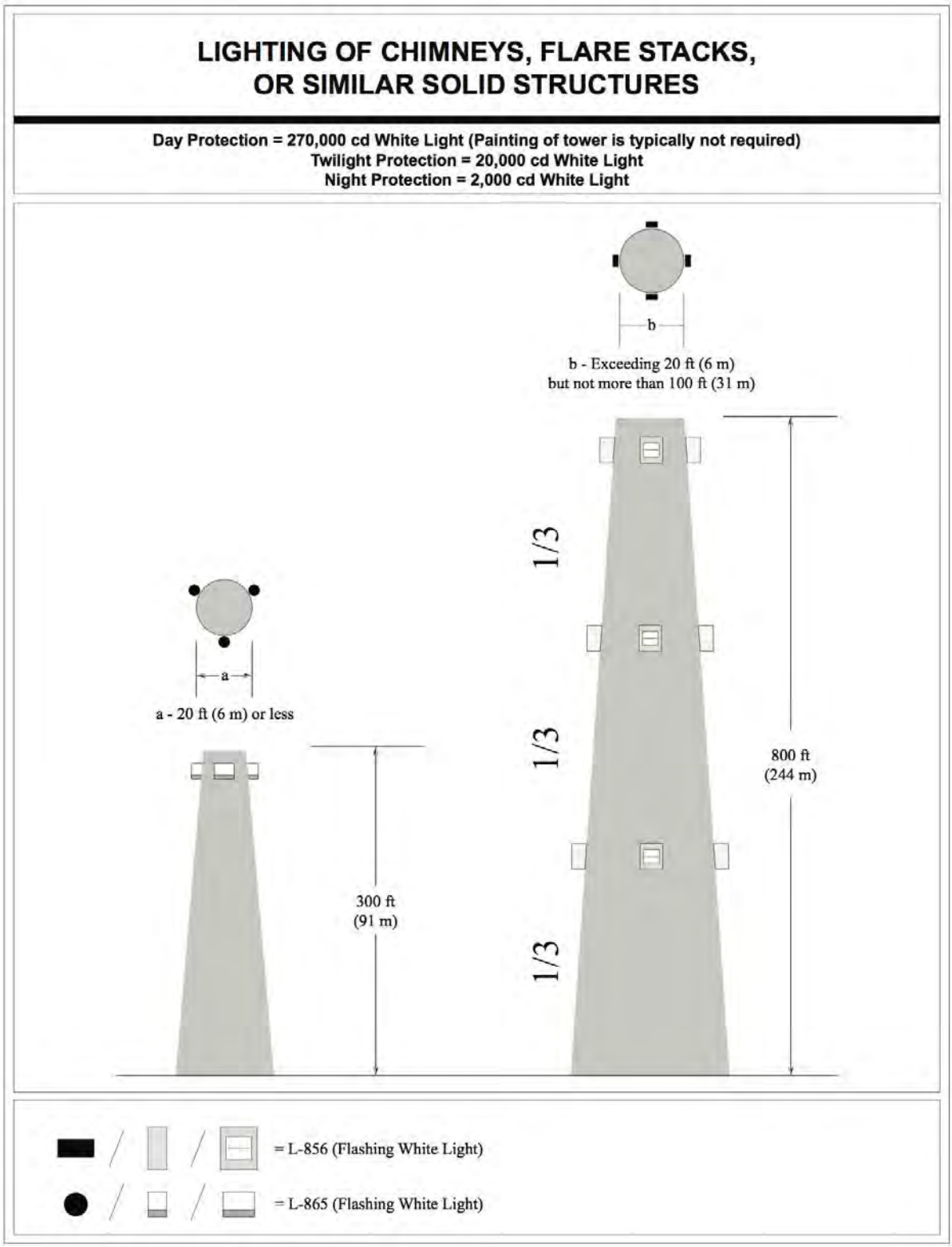



**Figure A-23. Lighting of Chimneys, Flare Stacks, or Similar Solid Structures**

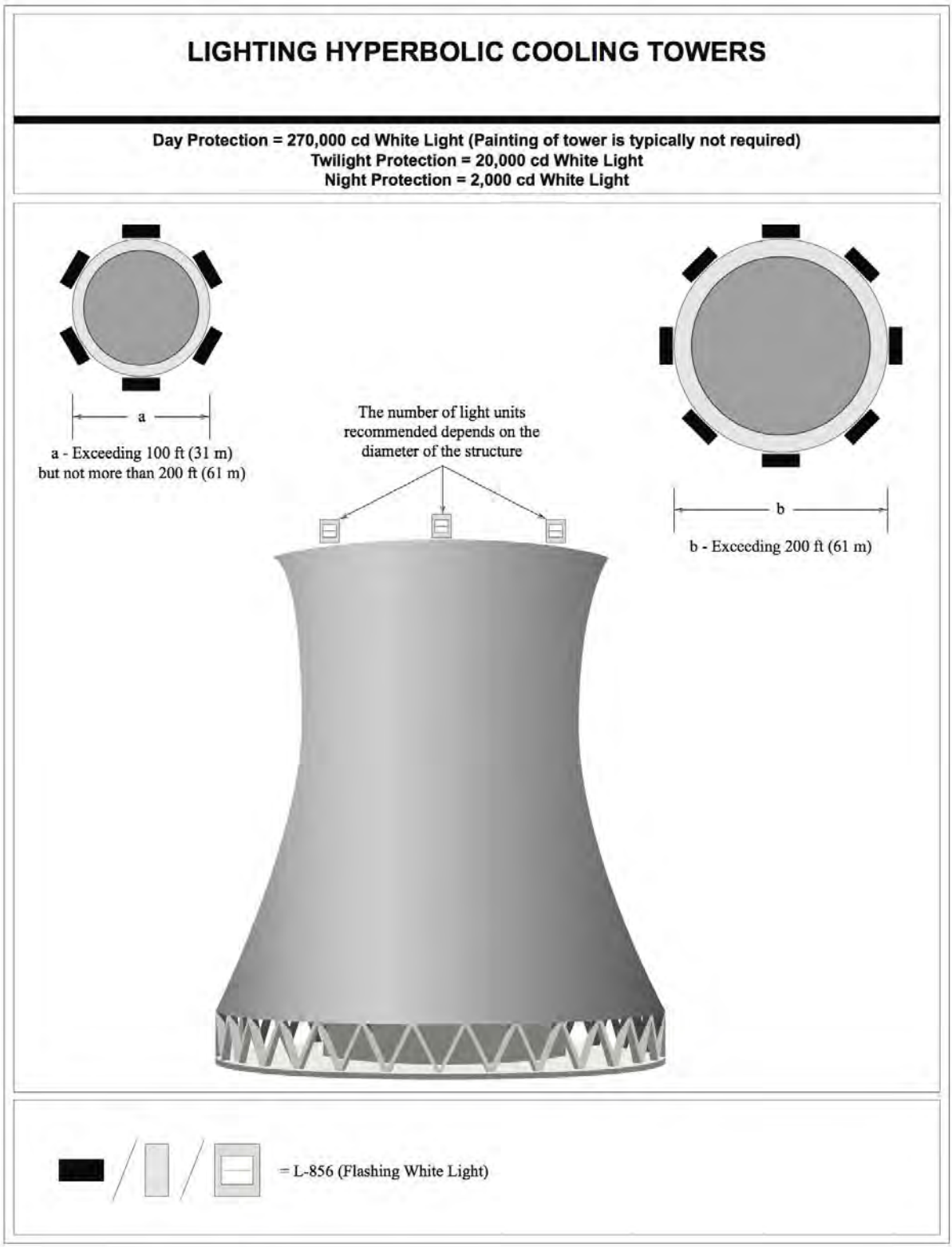



**Figure A-24. Hyperbolic Cooling Tower**

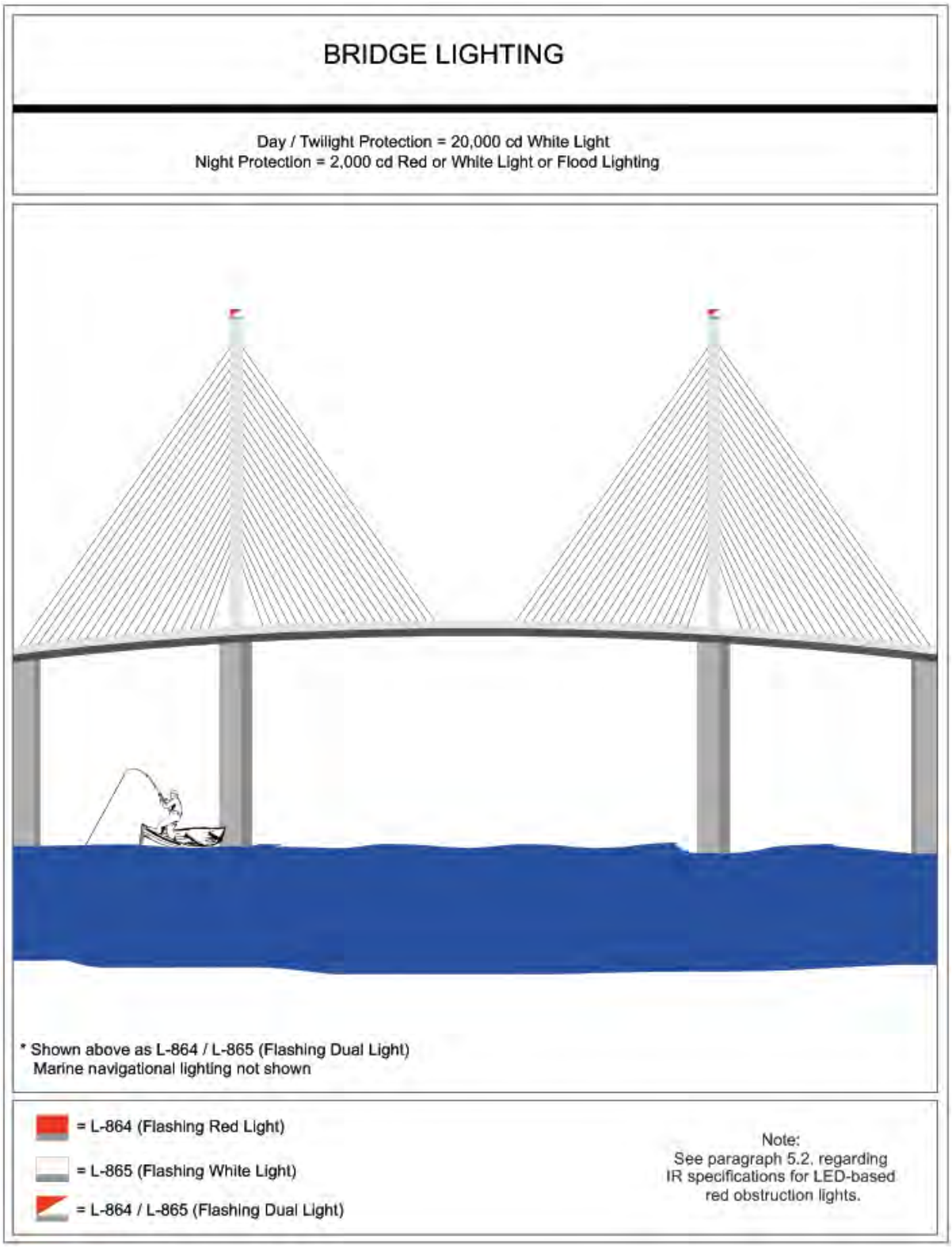



**Figure A-25. Bridge Lighting**

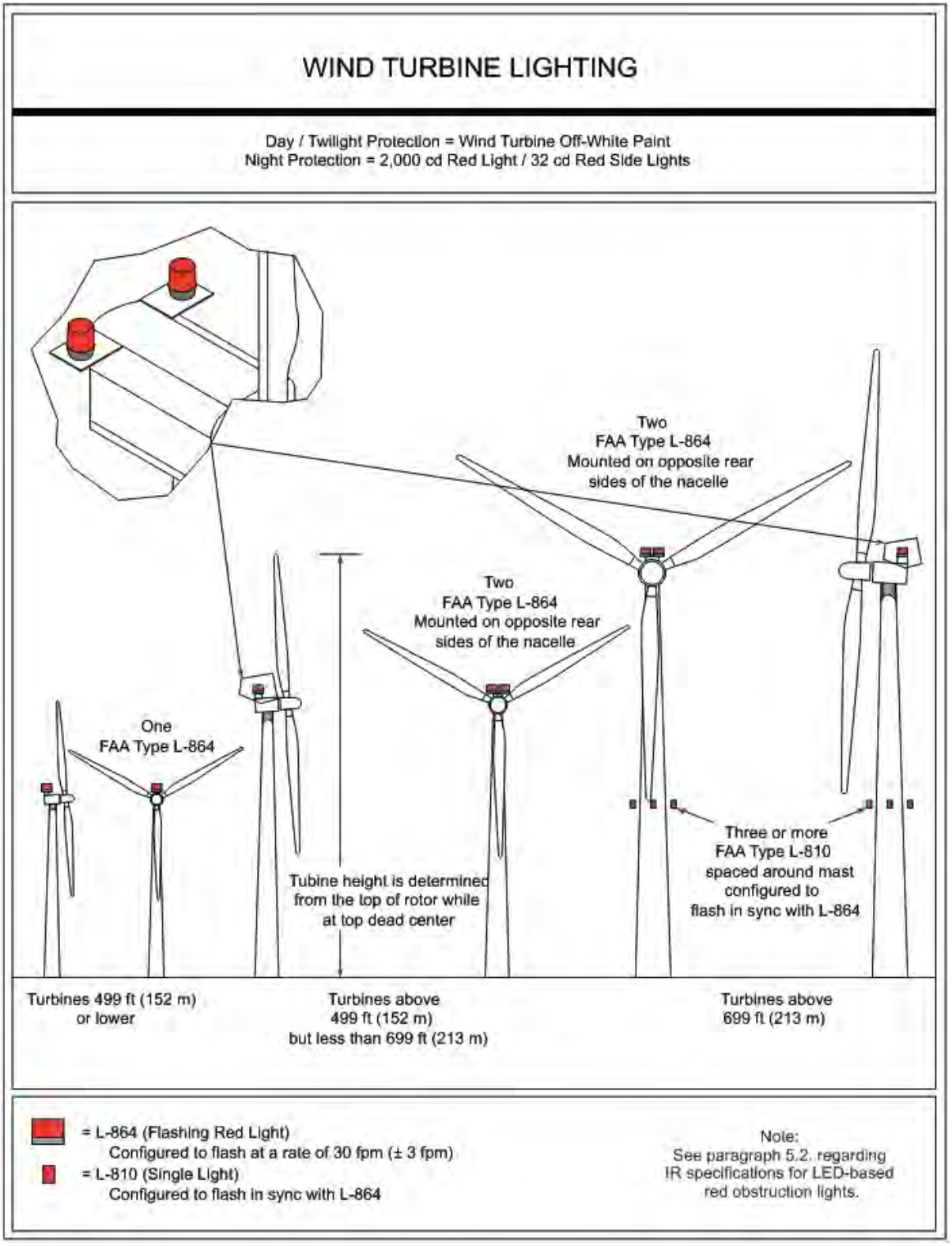



**Figure A-26. Wind Turbine Lighting**

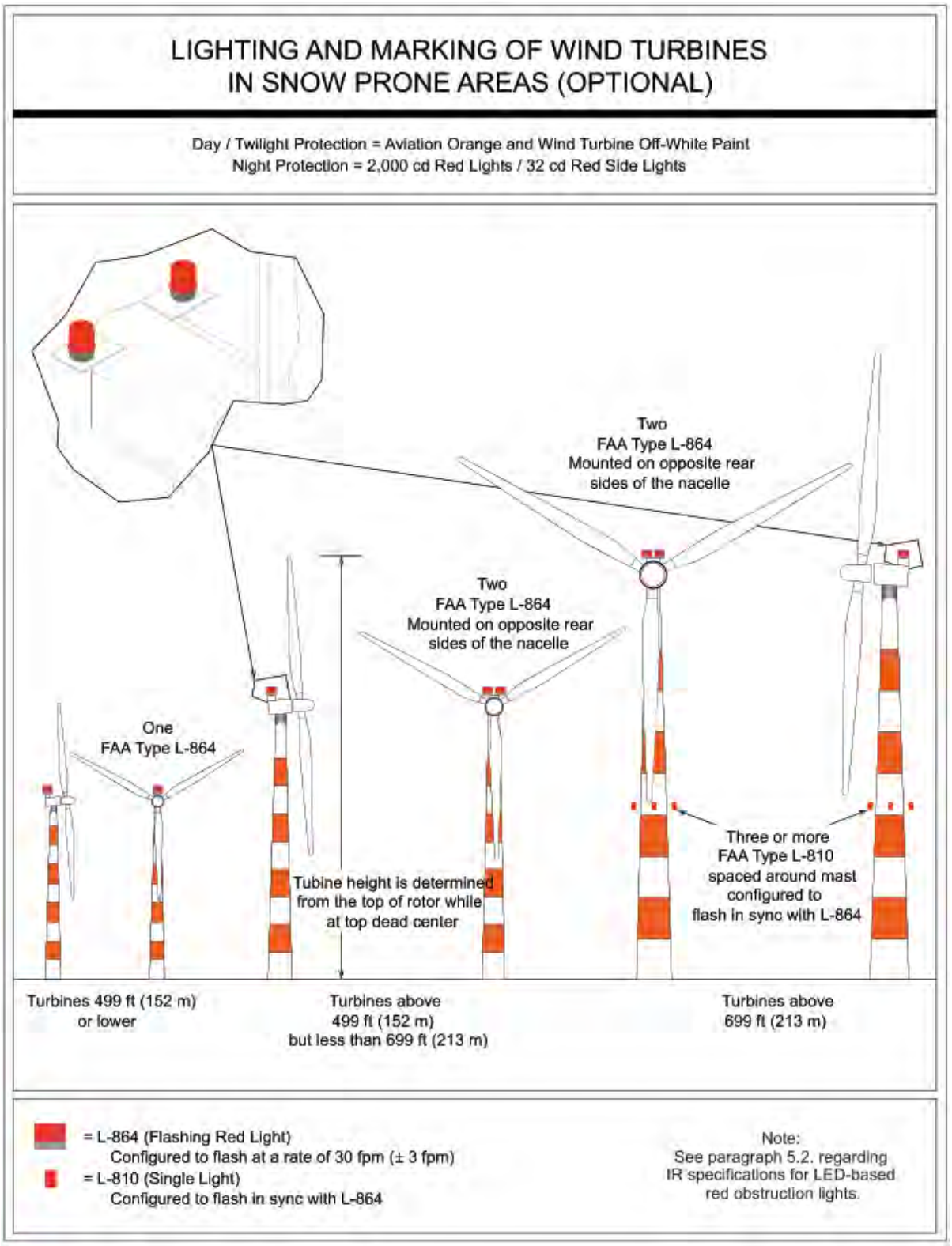



**Figure A-27. Wind Turbine Lighting and Marking in Snow Prone Areas (Optional)**

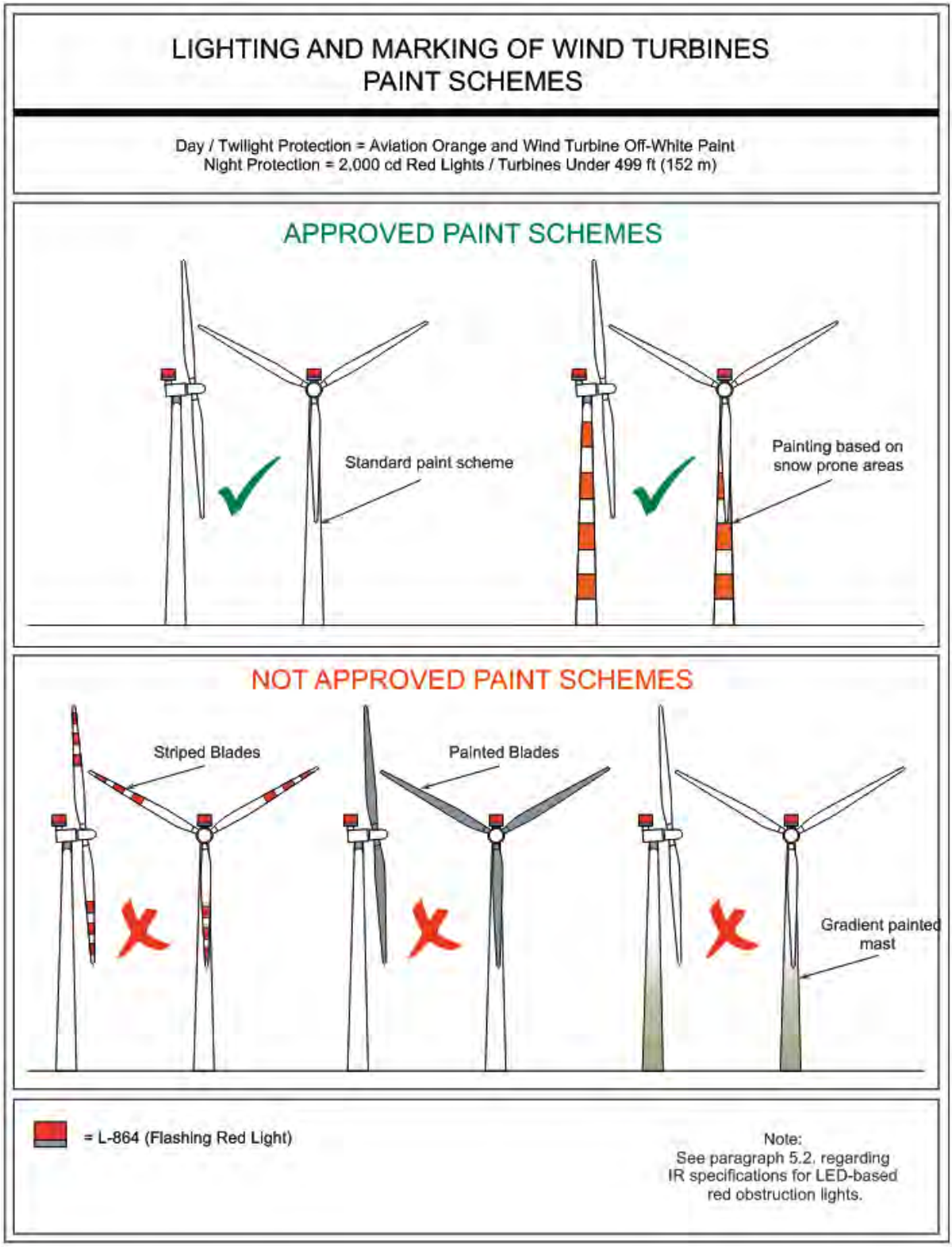



**Figure A-28. Lighting and Marking of Wind Turbines – Paint Schemes**

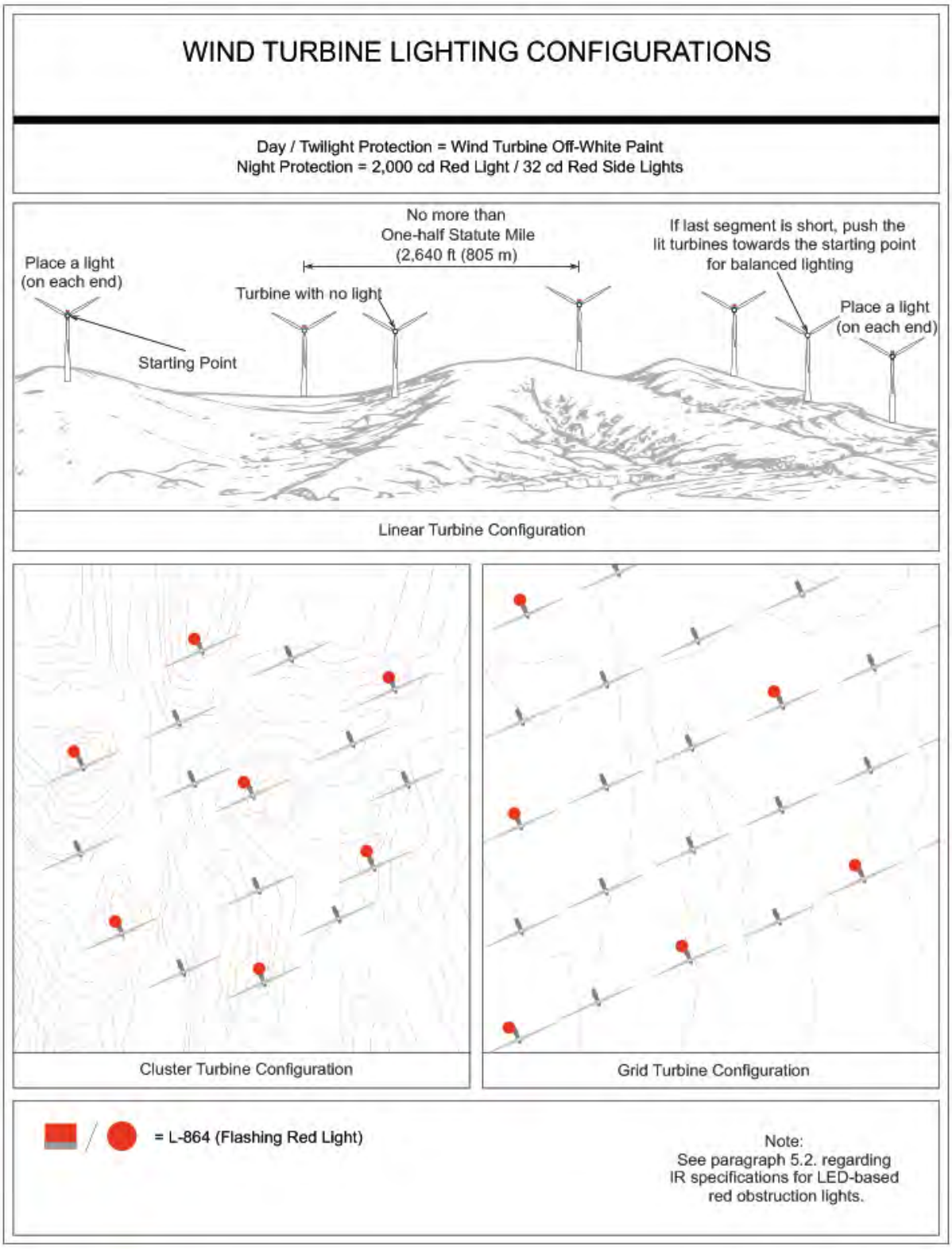



**Figure A-29. Wind Turbine Lighting Configurations**

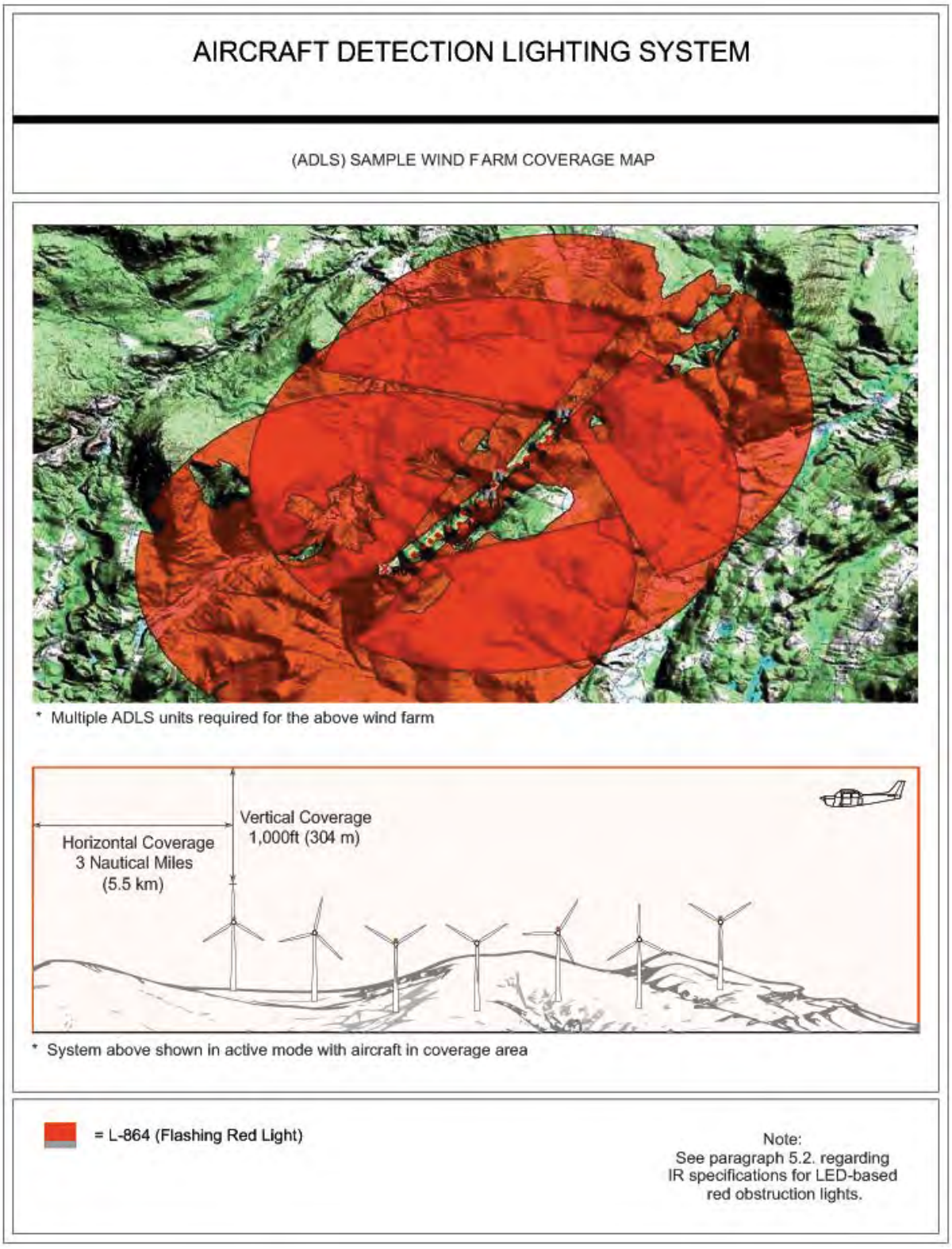



**Figure A-30. Sample of Aircraft Detection Lighting System Coverage Map**

## APPENDIX B: MISCELLANEOUS

B-1 **Rationale for Obstruction Light Intensities**.

Sections 91.117, 91.119 and 91.155 of 14 CFR Part 91, *General Operating and Flight Rules*, prescribe aircraft speed restrictions, minimum safe altitudes, and basic visual flight rules (VFR) weather minimums for governing the operation of aircraft, including helicopters, within the United States.

B-2 **Distance Versus Intensities**.

Table B-1 shows the distance the various intensities are visible under 1 and 3 statute miles meteorological visibilities:

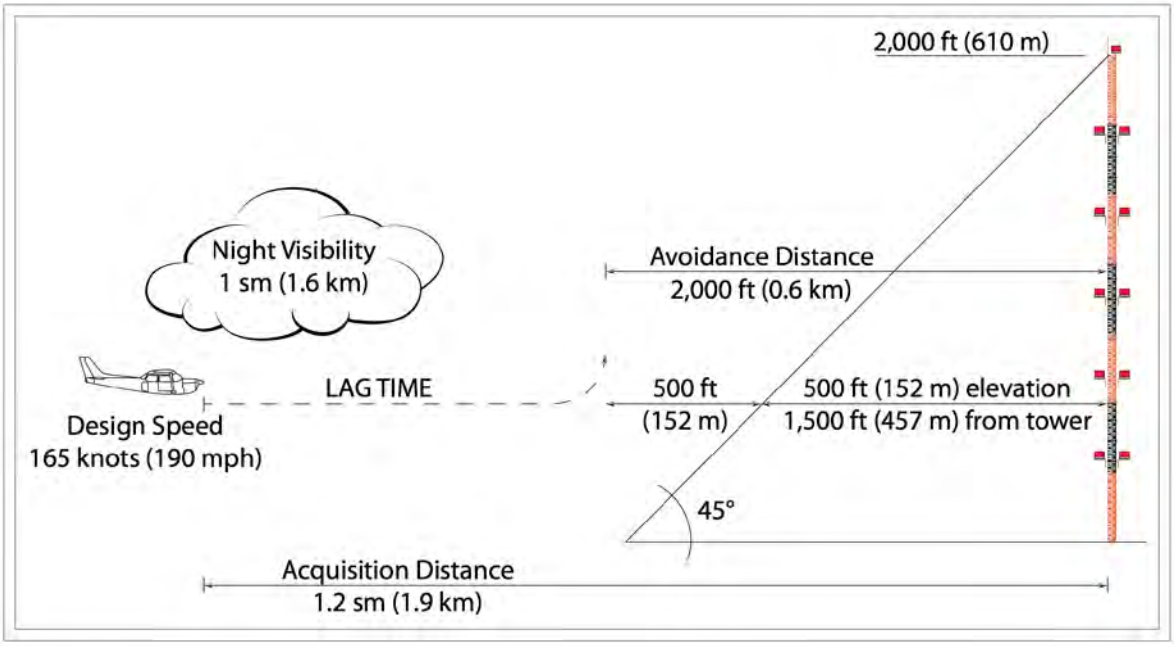
**Table B-1. Distance and Intensity**

| Time Period | Meteorological Visibility Statute Miles | Distance Statute Miles | Intensity Candelas |
|---|---|---|---|
| Night | | 2.9 (4.7 km) | 1,500 (±25%) |
| | 3 (4.8 km) | 3.1 (4.9 km) | 2,000 (±25%) |
| | | 1.4 (2.2 km) | 32 |
| Day | | 1.5 (2.4 km) | 200,000 |
| | 1 (1.6 km) | 1.4 (2.2 km) | 100,000 |
| | | 1.0 (1.6 km) | 20,000 (±25%) |
| Day | | 3.0 (4.8 km) | 200,000 |
| | 3 (4.8 km) | 2.7 (4.3 km) | 100,000 |
| | | 1.8 (2.9 km) | 20,000 (±25%) |
| Twilight | 1 (1.6 km) | 1.0 (1.6 km) to 1.5 (2.4 km) | 20,000 (±25%) |
| Twilight | 3 (4.8 km) | 1.8 (2.9 km) to 4.2 (6.7 km) | 20,000 (±25%) |

**Note:** Distance calculated for north sky illuminance.

B-3 **Conclusion**.

Aircraft pilots travelling at 165 kt (190 mph/306 kph) or less should be able to see obstruction lights in sufficient time to avoid the structure by at least 2,000 feet (610 m) horizontally under all conditions of operation, provided the pilot is operating in accordance with 14 CFR Part 91. Pilots operating 250 kt (288 mph/463 kph) aircraft should be able to see the obstruction lights unless the weather deteriorates to 1 statute mile (1.6 km) visibility at night, during which time period 2,000 candelas enables the light to be seen at 1.2 statute miles (1.9 km). To provide an acquisition distance of 1.5 statute miles, a higher intensity of 20,000 candelas would be required. This light, with 3-statute mile visibility at night, could generate a residential annoyance factor. In addition, aircraft at these speeds can normally be expected to operate under instrument flight rules (IFR) at night when the visibility is 1 statute mile (1.6 km).




**Note:** The 2,000-foot avoidance distance comes from the guy wires of a 2,000-foot structure. The guy wires at a 45-degree angle would be at a distance of 1,500 feet from the structure at a 500-foot elevation. Since the aircraft is to be 500 feet clear of obstacles (the guy wire), the distance of avoidance from the structure is 1,500 + 500 = 2,000 feet. (See Figure B-1.)

**Figure B-1. Illustration of Acquisition Distance Calculation**

B-4 **Definitions**.

B-4.1 Flight Visibility.

The average forward horizontal distance, from the cockpit of an aircraft in flight, at which prominent unlighted objects may be seen and identified by day and prominent lighted objects may be seen and identified by night.

Reference: *Airman's Information Manual Pilot/Controller Glossary*.

B-4.2 Meteorological Visibility.

A term that denotes the greatest distance, expressed in statute miles, that selected objects (visibility markers) or lights of moderate intensity (25 candelas) can be seen and identified under specified conditions of observation.

B-5 **Lighting System Configuration**.

1. Configuration A . Red Obstruction Lighting System.

2. Configuration B. High-Intensity White Obstruction Lights for structures with appurtenance 40 feet or less.

3. Configuration C. High-Intensity White Obstruction Lights for structures with appurtenance greater than 40 feet.

4. Configuration D. Medium-Intensity White Obstruction Lights.

5. Configuration E. Medium-Intensity Dual White and Red Obstruction Lights.

6. Configuration F. High-Intensity Dual Obstruction Lights for structures with appurtenance greater than 40 feet.

7. Configuration G. High-Intensity Dual Obstruction Lights for structures with appurtenance 40 feet or less.

**Example:** "Configuration B 3" denotes a high-intensity lighting system with three levels of light.

# Exhibit 3

Mail Processing Center
Federal Aviation Administration
Southwest Regional Office
Obstruction Evaluation Group
10101 Hillwood Parkway
Fort Worth, TX 76177

Aeronautical Study No.
2018-ANE-1643-OE
Prior Study No.
2016-ANE-707-OE

Ex. 3

Issued Date: 03/12/2018

Benjamin Shepard
Central Maine Power Company
83 Edison Drive
Augusta, ME 04336

**** DETERMINATION OF NO HAZARD TO AIR NAVIGATION ****

The Federal Aviation Administration has conducted an aeronautical study under the provisions of 49 U.S.C., Section 44718 and if applicable Title 14 of the Code of Federal Regulations, part 77, concerning:

| | |
|---|---|
| Structure: | Tower Section 77 & 277 |
| Location: | Woolwich, ME |
| Latitude: | 43-58-59.59N NAD 83 |
| Longitude: | 69-49-41.33W |
| Heights: | 47 feet site elevation (SE) |
| | 240 feet above ground level (AGL) |
| | 287 feet above mean sea level (AMSL) |

This aeronautical study revealed that the structure does not exceed obstruction standards and would not be a hazard to air navigation provided the following condition(s), if any, is(are) met:

As a condition to this Determination, the structure is to be marked/lighted in accordance with FAA Advisory circular 70/7460-1 L Change 1, Obstruction Marking and Lighting, a med-dual system - Chapters 4,8(M-Dual),&12.

Any failure or malfunction that lasts more than thirty (30) minutes and affects a top light or flashing obstruction light, regardless of its position, should be reported immediately to (877) 487-6867 so a Notice to Airmen (NOTAM) can be issued. As soon as the normal operation is restored, notify the same number.

It is required that FAA Form 7460-2, Notice of Actual Construction or Alteration, be e-filed any time the project is abandoned or:

_____ At least 10 days prior to start of construction (7460-2, Part 1)
__X__ Within 5 days after the construction reaches its greatest height (7460-2, Part 2)

**See attachment for additional condition(s) or information.**
This determination expires on 09/12/2019 unless:

(a) the construction is started (not necessarily completed) and FAA Form 7460-2, Notice of Actual Construction or Alteration, is received by this office.
(b) extended, revised, or terminated by the issuing office.

(c) the construction is subject to the licensing authority of the Federal Communications Commission (FCC) and an application for a construction permit has been filed, as required by the FCC, within 6 months of the date of this determination. In such case, the determination expires on the date prescribed by the FCC for completion of construction, or the date the FCC denies the application.

NOTE: REQUEST FOR EXTENSION OF THE EFFECTIVE PERIOD OF THIS DETERMINATION MUST BE E-FILED AT LEAST 15 DAYS PRIOR TO THE EXPIRATION DATE. AFTER RE-EVALUATION OF CURRENT OPERATIONS IN THE AREA OF THE STRUCTURE TO DETERMINE THAT NO SIGNIFICANT AERONAUTICAL CHANGES HAVE OCCURRED, YOUR DETERMINATION MAY BE ELIGIBLE FOR ONE EXTENSION OF THE EFFECTIVE PERIOD.

This determination is based, in part, on the foregoing description which includes specific coordinates, heights, frequency(ies) and power. Any changes in coordinates, heights, and frequencies or use of greater power, except those frequencies specified in the Colo Void Clause Coalition; Antenna System Co-Location; Voluntary Best Practices, effective 21 Nov 2007, will void this determination. Any future construction or alteration, including increase to heights, power, or the addition of other transmitters, requires separate notice to the FAA.This determination includes all previously filed frequencies and power for this structure.

If construction or alteration is dismantled or destroyed, you must submit notice to the FAA within 5 days after the construction or alteration is dismantled or destroyed.

This determination does include temporary construction equipment such as cranes, derricks, etc., which may be used during actual construction of the structure. However, this equipment shall not exceed the overall heights as indicated above. Equipment which has a height greater than the studied structure requires separate notice to the FAA.

This determination concerns the effect of this structure on the safe and efficient use of navigable airspace by aircraft and does not relieve the sponsor of compliance responsibilities relating to any law, ordinance, or regulation of any Federal, State, or local government body.

A copy of this determination will be forwarded to the Federal Communications Commission (FCC) because the structure is subject to their licensing authority.

If we can be of further assistance, please contact our office at (202) 267-4525, or david.maddox@faa.gov. On any future correspondence concerning this matter, please refer to Aeronautical Study Number 2018-ANE-1643-OE.

**Signature Control No: 357417092-359408333** ( DNE )
David Maddox
Specialist

Attachment(s)
Additional Information
Case Description
Map(s)

cc: FCC

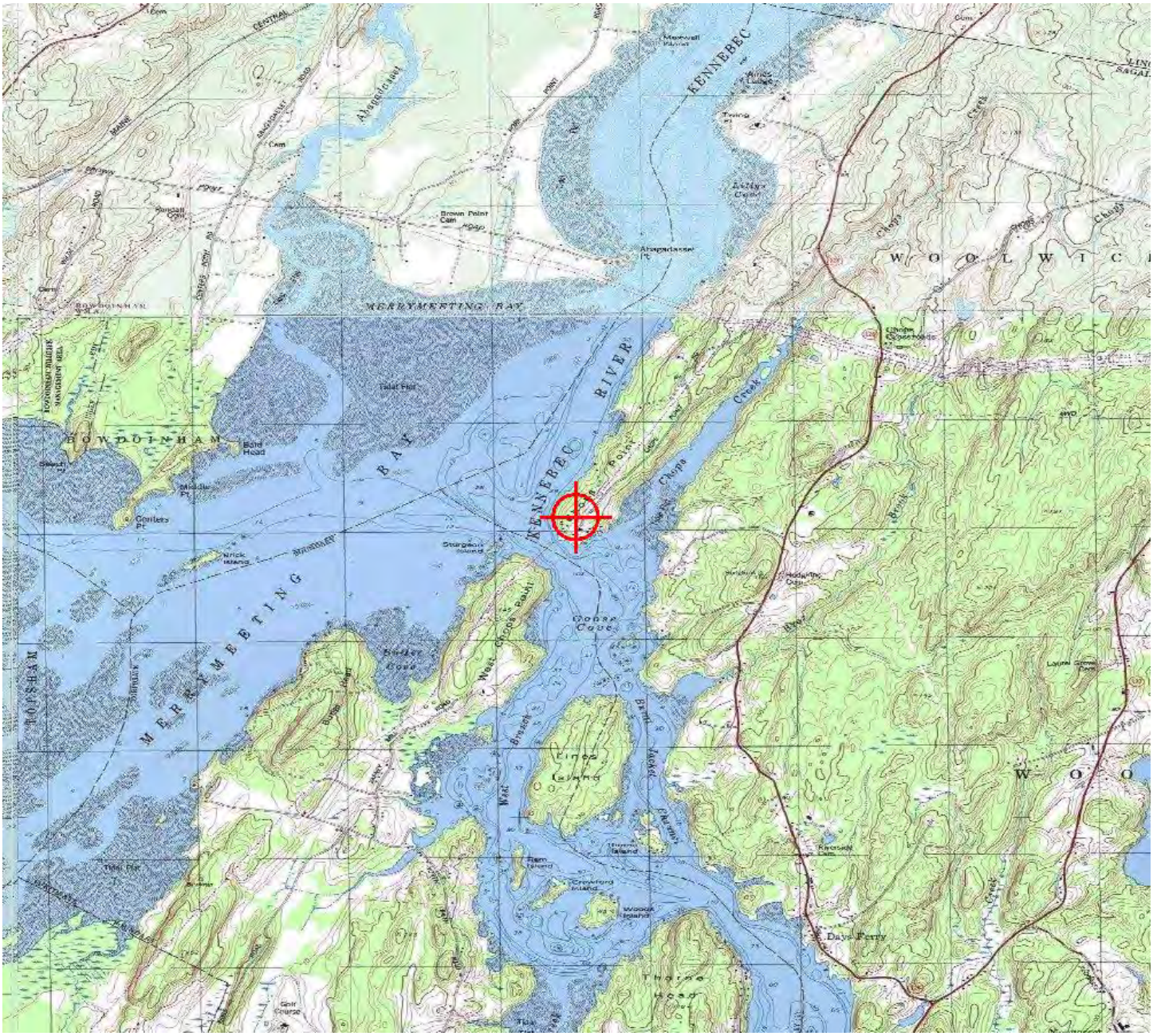
## Additional information for ASN 2018-ANE-1643-OE

In addition to marking and lighting condition above, Spherical markers approved.

## Case Description for ASN 2018-ANE-1643-OE

Replace existing electrical transmission tower, adjacent to the existing tower with a new lattice tower 240' tall.

# TOPO Map for ASN 2018-ANE-1643-OE



# Exhibit 4

Mail Processing Center
Federal Aviation Administration
Southwest Regional Office
Obstruction Evaluation Group
10101 Hillwood Parkway
Fort Worth, TX 76177

Aeronautical Study No.
2018-ANE-1642-OE
Prior Study No.
2016-ANE-708-OE

Ex. 4

Issued Date: 03/12/2018

Benjamin Shepard
Central Maine Power Company
83 Edison Drive
Augusta, ME 04336

**** DETERMINATION OF NO HAZARD TO AIR NAVIGATION ****

The Federal Aviation Administration has conducted an aeronautical study under the provisions of 49 U.S.C., Section 44718 and if applicable Title 14 of the Code of Federal Regulations, part 77, concerning:

| | |
|---|---|
| Structure: | Tower Sections 77 & 207 |
| Location: | Bath, ME |
| Latitude: | 43-58-46.15N NAD 83 |
| Longitude: | 69-49-56.07W |
| Heights: | 47 feet site elevation (SE) |
| | 240 feet above ground level (AGL) |
| | 287 feet above mean sea level (AMSL) |

This aeronautical study revealed that the structure does not exceed obstruction standards and would not be a hazard to air navigation provided the following condition(s), if any, is(are) met:

As a condition to this Determination, the structure is to be marked/lighted in accordance with FAA Advisory circular 70/7460-1 L Change 1, Obstruction Marking and Lighting, a med-dual system - Chapters 4,8(M-Dual),&12.

Any failure or malfunction that lasts more than thirty (30) minutes and affects a top light or flashing obstruction light, regardless of its position, should be reported immediately to (877) 487-6867 so a Notice to Airmen (NOTAM) can be issued. As soon as the normal operation is restored, notify the same number.

It is required that FAA Form 7460-2, Notice of Actual Construction or Alteration, be e-filed any time the project is abandoned or:

_____ At least 10 days prior to start of construction (7460-2, Part 1)
__X__ Within 5 days after the construction reaches its greatest height (7460-2, Part 2)

**See attachment for additional condition(s) or information.**
This determination expires on 09/12/2019 unless:

(a) the construction is started (not necessarily completed) and FAA Form 7460-2, Notice of Actual Construction or Alteration, is received by this office.
(b) extended, revised, or terminated by the issuing office.

(c) the construction is subject to the licensing authority of the Federal Communications Commission (FCC) and an application for a construction permit has been filed, as required by the FCC, within 6 months of the date of this determination. In such case, the determination expires on the date prescribed by the FCC for completion of construction, or the date the FCC denies the application.

NOTE: REQUEST FOR EXTENSION OF THE EFFECTIVE PERIOD OF THIS DETERMINATION MUST BE E-FILED AT LEAST 15 DAYS PRIOR TO THE EXPIRATION DATE. AFTER RE-EVALUATION OF CURRENT OPERATIONS IN THE AREA OF THE STRUCTURE TO DETERMINE THAT NO SIGNIFICANT AERONAUTICAL CHANGES HAVE OCCURRED, YOUR DETERMINATION MAY BE ELIGIBLE FOR ONE EXTENSION OF THE EFFECTIVE PERIOD.

This determination is based, in part, on the foregoing description which includes specific coordinates, heights, frequency(ies) and power. Any changes in coordinates, heights, and frequencies or use of greater power, except those frequencies specified in the Colo Void Clause Coalition; Antenna System Co-Location; Voluntary Best Practices, effective 21 Nov 2007, will void this determination. Any future construction or alteration, including increase to heights, power, or the addition of other transmitters, requires separate notice to the FAA.This determination includes all previously filed frequencies and power for this structure.

If construction or alteration is dismantled or destroyed, you must submit notice to the FAA within 5 days after the construction or alteration is dismantled or destroyed.

This determination does include temporary construction equipment such as cranes, derricks, etc., which may be used during actual construction of the structure. However, this equipment shall not exceed the overall heights as indicated above. Equipment which has a height greater than the studied structure requires separate notice to the FAA.

This determination concerns the effect of this structure on the safe and efficient use of navigable airspace by aircraft and does not relieve the sponsor of compliance responsibilities relating to any law, ordinance, or regulation of any Federal, State, or local government body.

A copy of this determination will be forwarded to the Federal Communications Commission (FCC) because the structure is subject to their licensing authority.

If we can be of further assistance, please contact our office at (202) 267-4525, or david.maddox@faa.gov. On any future correspondence concerning this matter, please refer to Aeronautical Study Number 2018-ANE-1642-OE.

**Signature Control No: 357417091-359354168** ( DNE )
David Maddox
Specialist

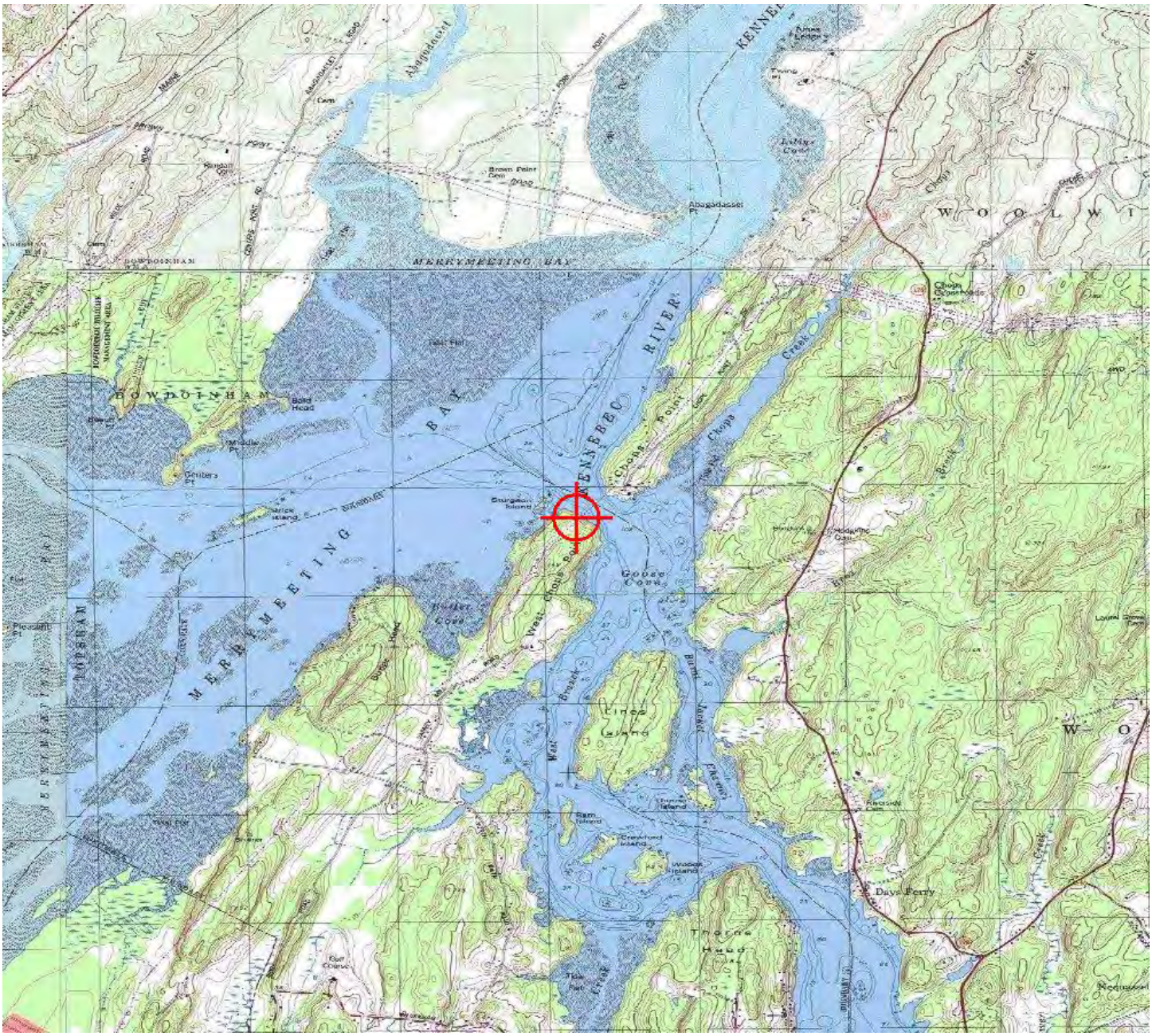
Attachment(s)
Additional Information
Case Description
Map(s)

cc: FCC

In addition to the above marking and lighting condition, use of marker spheres is approved.

Replace existing electrical transmission tower immediately adjacent to existing tower with new tower, 240'

# TOPO Map for ASN 2018-ANE-1642-OE



# Exhibit 5

Distances from Chops towers in nautical miles [NM] to:

08B Merrymeeting Field in Bowdoinham, 2.6 NM
Runway length 1,935'

KIWI Wiscasset 5.1 NM Runway length 3,397'

KBXM Brunswick 6.8 NM Runway length 8,000'

# Exhibit 6

To KIWI: 5.1 NM

Untitled Placemark

Chop Point Camp

Chop Point School

Gym Road

Chops Point Rd

To 08B: 2.6 NM

Chops Width: 789'

Sturgeon Island

Eagle Point Rd

Untitled Placemark

To KBXM: 6.8NM

Templeton Rd





Goose Cove

1996

Imagery Date: 5/4/2018 43°58'49.46" N 69°49'47.63" W elev -1 ft eye alt 5394 ft

# Exhibit 7

# Planetary electromagnetic pollution: it is time to assess its impact

As the Planetary Health Alliance moves forward after a productive second annual meeting, a discussion on the rapid global proliferation of artificial electromagnetic fields would now be apt. The most notable is the blanket of radiofrequency electromagnetic radiation, largely microwave radiation generated for wireless communication and surveillance technologies, as mounting scientific evidence suggests that prolonged exposure to radiofrequency electromagnetic radiation has serious biological and health effects. However, public exposure regulations in most countries continue to be based on the guidelines of the International Commission on Non-Ionizing Radiation Protection[1] and Institute of Electrical and Electronics Engineers,[2] which were established in the 1990s on the belief that only acute thermal effects are hazardous. Prevention of tissue heating by radiofrequency electromagnetic radiation is now proven to be ineffective in preventing biochemical and physiological interference. For example, acute non-thermal exposure has been shown to alter human brain metabolism by NIH scientists,[3] electrical activity in the brain,[4] and systemic immune responses.[5] Chronic exposure has been associated with increased oxidative stress and DNA damage[6,7] and cancer risk.[8] Laboratory studies, including large rodent studies by the US National Toxicology Program[9] and Ramazzini Institute of Italy,[10] confirm these biological and health effects in vivo. As we address the threats to human health from the changing environmental conditions due to human activity,[11] the increasing exposure to artificial electromagnetic radiation needs to be included in this discussion.

Due to the exponential increase in the use of wireless personal communication devices (eg, mobile or cordless phones and WiFi or Bluetooth-enabled devices) and the infrastructure facilitating them, levels of exposure to radiofrequency electromagnetic radiation around the 1 GHz frequency band, which is mostly used for modern wireless communications, have increased from extremely low natural levels by about $10^{18}$ times (figure). Radiofrequency electromagnetic radiation is also used for radar, security scanners, smart meters, and medical equipment (MRI, diathermy, and radiofrequency ablation). It is plausibly the most rapidly increasing anthropogenic environmental exposure since the mid-20th century, and levels will surge considerably again, as technologies like the Internet of Things and 5G add millions more radiofrequency transmitters around us.

Unprecedented human exposure to radiofrequency electromagnetic radiation from conception until death has been occurring in the past two decades. Evidence of its effects on the CNS, including altered neurodevelopment[14] and increased risk of some neurodegenerative diseases,[15] is a major concern considering the steady increase in their incidence. Evidence exists for an association between neurodevelopmental or

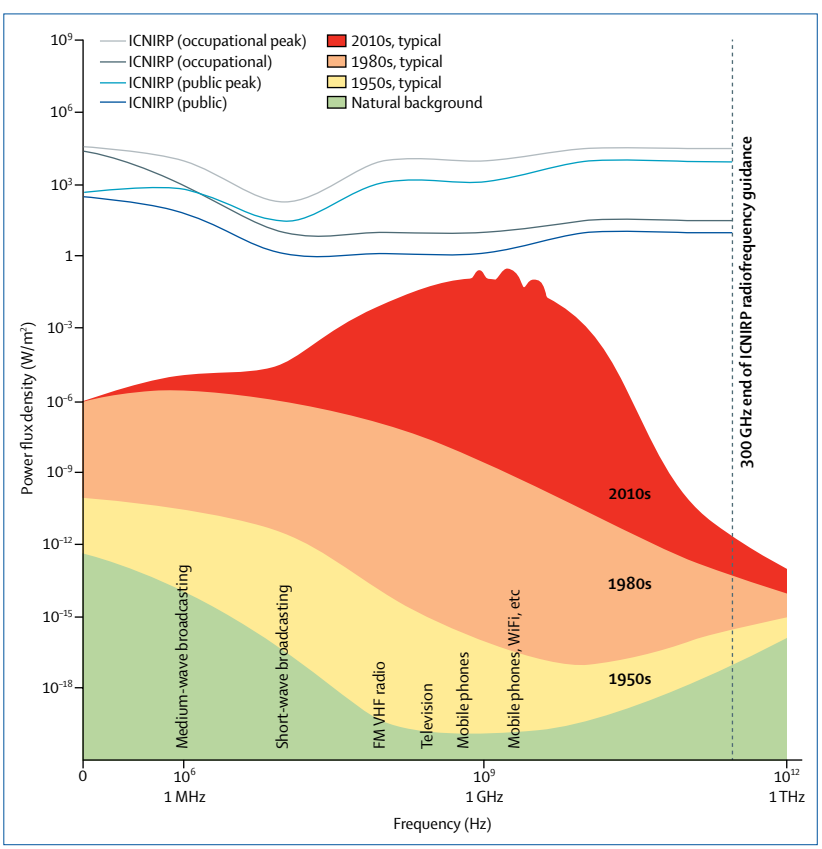



***Figure:*** **Typical maximum daily exposure to radiofrequency electromagnetic radiation from man-made and natural power flux densities in comparison with International Commission on Non-Ionizing Radiation Protection safety guidelines[1]**

Anthropogenic radiofrequency electromagnetic radiation levels are illustrated for different periods in the evolution of wireless communication technologies. These exposure levels are frequently experienced daily by people using various wireless devices. The levels are instantaneous and not time-averaged over 6 minutes as specified by International Commission on Non-Ionizing Radiation Protection for thermal reasons. Figure modified from Philips and Lamburn[12] with permission. Natural levels of radiofrequency electromagnetic radiation were based on the NASA review report CR-166661.[13]

behavioural disorders in children and exposure to wireless devices,[14] and experimental evidence, such as the Yale finding, shows that prenatal exposure could cause structural and functional changes in the brain associated with ADHD-like behaviour.[16] These findings deserve urgent attention.

For the **Oceania Radiofrequency Scientific Advisory Association** see www.orsaa.org

At the Oceania Radiofrequency Scientific Advisory Association, an independent scientific organisation, volunteering scientists have constructed the world's largest categorised online database of peer-reviewed studies on radiofrequency electromagnetic radiation and other man-made electromagnetic fields of lower frequencies. A recent evaluation of 2266 studies (including in-vitro and in-vivo studies in human, animal, and plant experimental systems and population studies) found that most studies (n=1546, 68·2%) have demonstrated significant biological or health effects associated with exposure to anthropogenic electromagnetic fields. We have published our preliminary data on radiofrequency electromagnetic radiation, which shows that 89% (216 of 242) of experimental studies that investigated oxidative stress endpoints showed significant effects.[7] This weight of scientific evidence refutes the prominent claim that the deployment of wireless technologies poses no health risks at the currently permitted non-thermal radiofrequency exposure levels. Instead, the evidence supports the International EMF Scientist Appeal by 244 scientists from 41 countries who have published on the subject in peer-reviewed literature and collectively petitioned the WHO and the UN for immediate measures to reduce public exposure to artificial electromagnetic fields and radiation.

For the **International EMF Scientist Appeal** see www.emfscientist.org

Evidence also exists of the effects of radiofrequency electromagnetic radiation on flora and fauna. For example, the reported global reduction in bees and other insects is plausibly linked to the increased radiofrequency electromagnetic radiation in the environment.[17] Honeybees are among the species that use magnetoreception, which is sensitive to anthropogenic electromagnetic fields, for navigation.

Man-made electromagnetic fields range from extremely low frequency (associated with electricity supplies and electrical appliances) to low, medium, high, and extremely high frequency (mostly associated with wireless communication). The potential effects of these anthropogenic electromagnetic fields on natural electromagnetic fields, such as the Schumann Resonance that controls the weather and climate, have not been properly studied. Similarly, we do not adequately understand the effects of anthropogenic radiofrequency electromagnetic radiation on other natural and man-made atmospheric components or the ionosphere. It has been widely claimed that radiofrequency electromagnetic radiation, being non-ionising radiation, does not possess enough photon energy to cause DNA damage. This has now been proven wrong experimentally.[18,19] Radiofrequency electromagnetic radiation causes DNA damage apparently through oxidative stress,[7] similar to near-UV radiation, which was also long thought to be harmless.

At a time when environmental health scientists tackle serious global issues such as climate change and chemical toxicants in public health, there is an urgent need to address so-called electrosmog. A genuine evidence-based approach to the risk assessment and regulation of anthropogenic electromagnetic fields will help the health of us all, as well as that of our planetary home. Some government health authorities have recently taken steps to reduce public exposure to radiofrequency electromagnetic radiation by regulating use of wireless devices by children and recommending preferential use of wired communication devices in general, but this ought to be a coordinated international effort.

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We declare no competing interests. We thank Alasdair Philips for assistance with the figure and Victor Leach and Steve Weller for assistance with the ORSAA Database, which has enabled our overview of the scientific evidence in this area of research.



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# Exhibit 8

DE GRUYTER Rev Environ Health 2015; 30(4): 217–222

David O. Carpenter*

# The microwave syndrome or electro-hypersensitivity: historical background

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**Abstract:** Microwave generating equipment first became common during World War 2 with the development of radar. Soviet bloc countries reported that individuals exposed to microwaves frequently developed headaches, fatigue, loss of appetite, sleepiness, difficulty in concentration, poor memory, emotional instability, and labile cardiovascular function, and established stringent exposure standards. For a variety of reasons these reports were discounted in Western countries, where the prevailing belief was that there could be no adverse health effects of electromagnetic fields (EMFs) that were not mediated by tissue heating. The reported Soviet effects were at lower intensities than those that cause heating. However, there were several accidental exposures of radar operators in Western countries that resulted in persistent symptoms similar to those described above. The Soviets irradiated the US Embassy in Moscow with microwaves during the period 1953–1975, and while no convincing evidence of elevated cancer rates was reported, there were reports of "microwave illness". Officials passed these complaints off as being due to anxiety, not effects of the microwave exposure. There is increasing evidence that the "microwave syndrome" or "electro-hypersensitivity" (EHS) is a real disease that is caused by exposure to EMFs, especially those in the microwave range. The reported incidence of the syndrome is increasing along with increasing exposure to EMFs from electricity, WiFi, mobile phones and towers, smart meters and many other wireless devices. Why some individuals are more sensitive is unclear. While most individuals who report having EHS do not have a specific history of an acute exposure, excessive exposure to EMFs, even for a brief period of time, can induce the syndrome.

**Keywords:** cognitive dysfunction; electromagnetic fields; headache; insomnia.

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## Introduction

Electro-hypersensitivity (EHS) is a syndrome that may include some or all of the following: excessive fatigue, headache, tinnitus, insomnia, photophobia, a feeling of cognitive dysfunction and impaired memory, irritability, pain at various sites and often cardiovascular abnormalities (1). However, these are all relatively common complaints. All of us have on occasion suffered from headaches and insomnia. Because the symptoms are relatively non-specific, and because the adverse health effects of electromagnetic fields (EMFs) is a contentious issue, and also because primary care physicians have no objective diagnostic algorithms by which to diagnose EHS, patients suffering from EHS are often referred to a psychiatrist. There is, however, a body of evidence, both old and more recent, that indicates that these symptoms are triggered by exposure to EMFs in sensitive individuals. This is the case for exposure to both the extra low electromagnetic fields (ELF) coming from electricity and the radiofrequency (RF) EMFs coming from radar, communication devices, WiFi, smart meters and many other forms of wireless devices.

The symptoms of EHS have a number of commonalities to those of several other syndromes, including chronic fatigue, fibromyalgia, multiple chemical sensitivity, Gulf War Illness and others. These are sometimes collectively identified as "idiopathic environmental intolerance". They have in common symptoms of fatigue, weakness, headaches, difficulty concentrating, multiple aches and pains, difficulty with sleep, and often difficulties with balance and vertigo. While the triggering events vary for each of these syndromes, many people suffer from more than one. A critical question is why some develop these sensitivities while others do not.

There are conflicting estimates on what percent of the population suffers from EHS, with some suggesting that between 5 and 10% of people have the syndrome, and that the incidence is increasing with time (2). However, there are several reports of tests of individuals taken into a laboratory and their responses recorded when they were unaware of whether or not an EMF field was being applied. Some of these studies have not shown that individuals who report that they are electro-sensitive are in

fact able to discern if the EMFs are present or not (3–6). However, these reports are balanced by others that show that at least some individuals do respond with adverse symptoms when exposed to EMFs in a blinded fashion (7, 8). Thus not everyone who believes they are electrosensitive really is, but it is also likely that some have the symptoms of EHS but have not identified the cause. Thus the true incidence of EHS is currently not known.

Table 1 lists the symptoms reported in two studies by individuals who believe that they suffer from EHS. These are self-reported symptoms, and because all occur commonly in the general population they illustrate the difficulty in confirming that the cause is exposure to EMFs.

## Microwave sickness

Soviet and Eastern European standards for exposure to EMFs have long been much more stringent than those in Western countries (11). As shown in Table 2 the Soviet countries' standard for maximal permissible exposure during the workday is 1,000 times lower than that in the US. These lower standards were set based on concern for the "asthenic syndrome", characterized by fatigue, pain, depression, blood pressure lability, fainting, and "apathic ambulic" disorders consisting of hypersomnia, hypokinesis, hypothalamo-pituitary-suprarenal weakness, and inhibition of sexual and digestive reflexes [reviewed by references (12) and (13)]. Memory and general mental function was also described as being impaired. Frey (14) has reviewed other studies by Soviet scientists who report a variety of behavioral and nervous system affects in animals and humans with EMF exposures much below the levels that cause tissue heating.

**Table 1:** Reported symptoms from Röösli et al. (9) and Lamech (10).

| | Röösli et al. (n=429) | Lamech (n=92) |
|---|---|---|
| Insomnia | 58% | 48% |
| Headaches | 41% | 45% |
| Fatigue | 18% | 32% |
| Concentration difficulties | 16% | 30% |
| Nervousness | 19% | 13% |

**Table 2:** US Armed Forces and Soviet standards for maximum permissible exposure to microwaves (10 mW/cm$^2$=0.01 mW/m$^2$) [Data from reference (15)].

| USDOD standard | USSR standard |
|---|---|
| 10 mW/cm$^2$ | 0.01 mW/cm$^2$ over an entire workday<br>No more than 0.1 mW/cm$^2$ for more than 2 h<br>No more than 1.0 mW/cm$^2$ for more than 15–20 min |

The strength of the evidence supporting the lower standards in Soviet and Eastern European countries is difficult to evaluate because most publications lack sufficient experimental details regarding exposure parameters and documentation of experimental results. None-theless these symptoms are very much those that comprise the syndrome of EHS.

During the period 1953–1975 the Soviets irradiated the US Embassy in Moscow with microwaves (2.5–4.0 GHz) at intensities up to 18 μW/cm$^2$ (16, 17). A health study of 1,800 employees who worked at the Moscow embassy and more than 3,000 dependents was performed by AM Lillienfeld from the Johns Hopkins University, as compared to employees at other embassies in Eastern Europe. The study was never published although he summarized some of the results briefly in a review article (18). The study was reported to not show an excess risk of cancer or early death, but did find significantly more depression, irritability, difficulty in concentrating and more memory loss among the exposed Embassy staff, especially in men. While the intensity of symptoms did not correlate well with the intensity of exposure (19), this could reflect differences in individual susceptibility. However, as emphasized by Johnson-Liakouris (20), the health conditions that were reported match those of the microwave sickness syndrome.

Serious questions (21) have been raised about how the results were reported and interpreted. Goldsmith examined the original report as compared to the information that was released by the US State Department, and found that the conclusions of Prof. Lillienfeld had been altered and in some cases deleted, and found that this was at the request of his contracting officer. Goldsmith concluded that there had been a persistent cover-up and deliberate distortions of the conclusions made by the author of the report. Among other findings he concluded that there was an elevated rate of leukemia among the highly exposed group, and that information on some of the cancers was withheld from Dr. Lillienfeld until after the report was submitted. In a later publication Goldsmith (22) reported that there were more lymphocyte chromosomal changes in the Moscow workers as well. Unfortunately we will probably never know the actual results of this study.

This is, however, other evidence that EHS is a real disease. Djordjevic et al. (23) investigated the health status of 322 radar workers all of whom had 5–10 years of occupational exposure to microwave fields. They did not find

significant differences in clinical or laboratory findings, but did report that the radar operators had more subjective complaints than a control group. This was particularly true for headache, fatigue, irritability, sleep disturbances and inhibition of sexual activity. However, the authors concluded that the subjective complaints likely reflected factors other than microwave exposure, however.

Some of the strongest evidence that EHS is a real syndrome comes from cases of acute high intensity exposure to microwaves of healthy people, which resulted in prolonged illness. Williams and Webb (24) reported effects of two airmen exposed to high levels of RF radiation. After an immediate sensation of heat, they later developed nausea, lightheadedness and extreme apprehension with poor appetite and photosensitivity. Forman et al. (25) reported on two men who were accidentally and acutely exposed to microwave radiation. Both exhibited symptoms of headaches, insomnia, irritability and emotional lability even after a 12-month follow-up. Both also developed hypertension several months after exposure. Schilling (26) reported on three men accidentally exposed to 785 MHz RF radiation. All experienced immediate sensations of heating, followed by pain, headache, numbness and parasthesiae, malaise, diarrhea and skin erythema. The first man, age 44, experienced lassitude, lack of stamina, drowsiness and chronic headache. The symptoms gradually improved over 3 years follow-up, but he still had chronic headaches at 3 years. The second man, age 47, also had lassitude, lack of stamina, drowsiness and chronic left sided frontoparietal headache, which was made worse by exposure to sun or heating. The symptoms improved somewhat over 3 years follow-up but the headaches remained. The third man had a lower exposure and his symptoms almost disappeared after 18 months. Schilling (27) reported on six antenna engineers exposed in two separate incidents. All experienced acute headache, parathesias, diarrhea, malaise and lassitude. Four of the men showed no improvement in symptoms after follow-up for 3 or 4 years, with headache, loss of stamina, several malaise and lassitude being the major symptoms.

Reeves (28) reported on 34 US Air Force personnel who were at some point exposed to RF at intensities greater than the permissible exposure limits. Acute symptoms included a sensation of heat, headaches, muscle pain and photophobia. An unspecified number of these subjects exhibited longer lasting symptoms, but these were dismissed as being due to factors other than the exposure. Two-thirds of the subjects were given psychometric testing and found to have "abnormalities including antisocial personality, mild organic brain syndrome, anxiety, tendency toward hypochondriasis and somatization, and in one case, frank malingering in an individual described as being 'emotionally invested in maintaining symptoms for the purpose of meeting emotional needs'". The author concluded that the several subjects who complained of prolonged fatigue, generalized weakness, irritability, decrease memory and concentration and weight changes "seem to reflect a personal 'coping style' of long duration or else manifestation of pre-exposure organic dysfunction, rather than an acute change attributable to RFR overexposure." This general attitude of dismissal of prolonged symptoms in young, otherwise healthy males is indicative of the general response to EHS. Is seems very unlikely that 2/3rd of young, otherwise healthy US Air Force personnel suffer from serious psychiatric disease!

## Does some acute exposure trigger EHS? Case studies

The author has also had opportunity to review the exposure and medical history of several individuals whose history is similar to that of the radar operators. Brief summaries of their exposures and symptoms are given below.

JG was a technical expert at repair of RF generating equipment who prior to an accidental RF exposure was healthy. In 2011 he was called to a site to troubleshoot three radios and antenna cables in a facility where all other RF generation equipment was supposed to be shut down. After 1–2 h of work within the facility he began to feel hot and developed a headache, dizziness and nausea. He left the room and was taken a hospital, where he was found to have mild burns on his face, head and neck. It was subsequently determined that not all of the equipment had been turned off and that he had been exposed to concentrated RF for the whole period of time he was in the room. When seen by a neurologist 1 month later he was found to suffer from headaches, dizziness, photosensitivity, nausea, confusion and difficulty with cognition. His gait was unsteady and he was easily disoriented. He noted that he was more irritable, less spontaneous, had decreased sex drive and memory problems. When he and the author met two and a half years after the exposure he complained of constant headaches, confusion and memory loss, lower back, hip and stomach pain, nausea, weight loss, vertigo and constant anxiety and depression. Thus an acute excessive exposure to RF radiation led to a syndrome of adverse health effects that continued essentially unabated for at least two and a half years, and had all of the characteristics of EHS.

JJ is a 41-year-old man who also was healthy prior to a near electrocution event while working at home. Upon contacting a live wire he froze, lost consciousness for about 30 s, but did not suffer from cardiac problems. He went to the hospital with a very bad headache, but was not found to have other abnormalities. Subsequently he was fatigued, had severe photophobia and very severe headaches, which he had never had before. Four year later he has constant dizziness, frequent headaches, vertigo, and nausea, and the symptoms are greatly increased when he is in the presence of EMFs, particularly RF. Again it appears that an acute exposure caused an increased sensitivity to EMFs which has not gone away over a period of several years. However, in this case the acute exposure was to electric current from the household electricity, including extremely lower frequency EMFs.

DL served multiple tours in the US Army in Afghanistan and Iraq as a gunner in a vehicle that used equipment to detect cell phone-detonated improvised explosive devices (IEDs). These electronic counter measures (ECMs) are vehicle-mounted high-power microwave systems that put out a wide range of frequencies at high wattage. He reported that these devices were put into the field rather quickly without any real studies conducted as to the long term effects on health. Gunners were directly exposed to the ECMs, and when they were running he could actually hear a buzzing sound inside the head phones he wore for internal vehicle communications. Upon returning home he suffered constant headaches, difficulty thinking clearly, nausea and tinnitus. He was treated for post-traumatic stress syndrome, but believes these symptoms arose because of the RF exposure. It is interesting and relevant that Westhoff et al. (29) recently published a report of six soldiers in two separate incidents who experienced nausea and headache during an ECM mission in southwest Asia. Their symptoms were dismissed by the military authorities who concluded "the symptoms could not be linked with exposure to the HPM (high-power microwave) systems in any manner 'consistent with current scientific literature'".

A different DL, age 34, worked in information technology but developed insomnia and headaches. He discovered the cause was a DECT cordless phone, which caused tinges in his vision and severe headaches. These symptoms disappeared within 12 h after the DECT phone was turned off. Shortly after that he noticed intolerance to his laptop, and then over a period of 6 months developed difficulties in concentration. He noticed heart palpitations when he was close to the cordless phone base or laptop. This evolved within a recent period of being intolerant of his neighbor's WiFi, but again he got relief when it was turned off. He is currently in good health as long as he stays away from sources of RF.

JJ, a civil engineer, and his wife live in California. Both were in excellent health. They went on vacation, and when they returned found that they both suffered from intense headaches, heart palpitations, tinnitus and insomnia while in their home, with relief when they left their home. Without their knowledge while they were away a rack of wireless smart meters had been installed directly below their bedroom. It took 4 months to get the utility to remove the smart meters, but by that time both had become electro-hypersensitive. This resulted in splitting headaches if using a cell phone, and it was painful to be in a WiFi environment or use a computer. The symptoms have not diminished over time if either is in an RF environment.

## Discussion

EMFs are almost never simple sine waves. Powerline EMFs also have many higher frequency RF components, transients, harmonics and resonance frequencies (30–33). Furthermore most RF EMFs are pulse-modulated and often on carrier waves (34). Some applications of RF EMFs, such as in smart meters, use atypical short pulses of RF of very high intensity but very brief duration of individual pulses.

Recent years have seen a marked increase in overall exposure to EMFs. Urbinello et al. (35) monitored RF exposures in several European cities and found that in 1 year there were increases of between 20.1 and 57.1%, with much of the increase coming from mobile phone base stations and public transport. In many countries "smart" meters are being placed on homes, apartments and business establishments which report electricity usage to the utility using RF EMFs. And the use of RF to monitor electrical usage is scheduled to increase significantly. As the "smart (or perhaps not-so-smart) grid" develops, each household application will have a Zigbee RF generator in every kitchen and laundry room appliance, with each appliance sending RF signals to the smart meter, which will send RF signals to the utility. This will significantly increase RF levels inside homes, adding to the WiFi and other existing sources.

The report by Lamech (10) raises the possibility that excessive exposure to RF, perhaps to some specific characteristic of the RF waveforms associated with smart meters, triggers the development of EHS. As stated in this paper "….since the beginning of installation of wireless smart meters in the state of Victoria, people from various regional and metropolitan areas, of all ages and during all

seasons have started to report symptoms from exposure to the meters' radiofrequency fields…, only 8% of cases stated that they had suffered from EHS prior to exposure to smart meters, which suggests that when it comes to wireless meters, the threshold for symptom development appears to be significantly lower compared to that for other wireless devices".

There has always been uncertainty over which characteristics of EMFs are most important with regard to human health effects. Because the mechanisms whereby these various adverse health outcomes arise are still not well understood, it is important to ask the question of which components pose the greatest risk, whether or not we are confident of the answer. Frey (36, 37) first suggested that peak power density was more important than average power density. Litovitz et al. (38) concluded that 60 Hz EMFs and RF EMFs do very much the same things, and later studies suggested that the low frequency, modulatory component of RF was particularly important (39). Others have implicated on-off transients, "dirty electricity" and other characteristics of the fields than the steady 50 or 60 Hz fields.

The typical exposure from a smart meter is less than that of use of a cell phone held to the head [see Table 1 in reference (40)], and like that from other sources of RF does decline rapidly with distance from the smart meter. However, the smart meter RF radiation is significantly different from many other forms of RF, in that it consists of brief but very high intensity pulses. Thus, whereas the average exposure over time is not excessive it appears possible that the high intensity pulses are responsible for the development of EHS. Brief intense pulses have been described as "dirty electricity" by Milham and Morgan (33), who suggest that many of the reported adverse effects of EMFs are due to these brief events, rather than the sine wave forms. Since brief transients are founds among all forms of EMFs, including power line frequencies, these events may be the more important variable.

## Conclusion

The weight of evidence indicates that EHS is a real syndrome induced by exposure to either ELF or RF EMF. In some cases it results from a brief, high intensity exposure, whereas in others it appears to reflect ambient exposures, especially those of increasing intensity and perhaps of certain waveforms. Whether from acute high intensity exposure or ambient background exposure from cell towers, mobile phones, smart meters and other devices, it is clear that not everyone develops EHS, for reasons not well understood. Certainly more research is needed to understand exactly which of the components of EMF exposures pose the greatest danger to human health, and what biological mechanisms are responsible. But the important conclusion is that there is something about EMFs of various forms that do pose direct hazards to human health.

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# Exhibit 9

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David Vela, Superintendent
Grand Teton National Park
John D. Rockefeller, Jr. Memorial Parkway

Re: Telecommunications Infrastructure Plan EA

Dear Mr. Vela & National Park Staff,

Environmental Health Trust (EHT) is a nonprofit Think Tank and policy organization dedicated to identifying and reducing environmental health hazards. EHT provides independent scientific research and advice on controllable environmental hazards to local, state and national governments. Today, we write to advise you of scientific grounds for major health and environmental concerns about the proposal for the installation of wireless telecommunications facilities and associated infrastructure at nine developed areas in the park and to express our grave concerns about this planned expansion of mobile communications in Grand Teton National Park. You may recall your discussions last year with me about the need to limit exposures to wildlife and fauna from wireless radiation that took place when we met as part of the City Kids final ascent of the Grand.

We fully recognize there is a need for communication for emergency purposes. We further recognize that the Park plays a unique role in our country and in our lives by providing a wilderness that is apart from the normal hectic life that many Americans lead today. We are deeply concerned that by expanding wireless communications this proposal will irrevocably impair the wilderness experience and that there are wired solutions that would be far less damaging.

The transmissions to and from these proposed microwave wireless installations will be emissions that are an environmental pollutant known to cause cancer (in both experimental animals and humans) and other adverse health and environmental effects (e.g., on birds, bees, trees) according to internationally recognized authoritative research, including studies conducted by the U.S. National Toxicology Program, which is the nation's premiere testing program.

In light of the scientific documentation showing harmful effects, EHT writes today to advise regarding technical scientific information on impacts to human health, wildlife and the environment, explaining why more than 240 expert scientists are calling for immediate reductions in exposures to microwave wireless radiation.

**Documented Impacts to Wildlife and the Environment**

We would like to make you aware that there is growing literature showing the adverse impacts of microwave radiation on animal and bird behavior and physiology, as well as plants and trees. As the Natural Resources Defense Council and the Public Employees for Environmental Responsibility have argued, an environmental impact

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assessment should be performed before building these networks. Peer-reviewed research links EMF emissions to myriad adverse environmental and health effects. Environmental effects include disruptions to reproduction, development, orientation, and migration of animals,[1], and damage to plants and crops.[2]

Albert Manville, former U.S. Fish and Wildlife Service agency lead on avian-structural impacts, wrote "A BRIEFING MEMORANDUM: What We Know, Can Infer, and Don't Yet Know about Impacts from Thermal and Non-thermal Non-ionizing Radiation to Birds and Other Wildlife" [3] documenting the body of research and concluding:

> "There is an increasing body of published laboratory research that finds DNA damage at low intensity exposures — well below levels of thermal heating — which may be comparable to far field exposures from cell antennas. This body of work would apply to all species, including migratory birds, since DNA is DNA, whether single-strand or double helix. The first study to find such effects was conducted by H. Lai and N.P. Singh in 1995 (Lai and Singh 1995). Their work has since been replicated (e.g., Lai and Singh 1996, as well as in hundreds of other more recent published studies), performed in at least 14 laboratories worldwide. The take-home message: low level transmission of EMF from cell towers and other sources probably causes DNA damage. The laboratory research findings strongly infer this relationship. Since DNA is the primary building block and genetic "map" for the very growth, production, replication and survival of all living organisms, deleterious effects can be critical."

**Please note the following published research studies.**

- "A review of the ecological effects of RF-EMF" 2013 review of 113 published studies found in 65% of the studies (50% of the animal studies and about 75% of the plant studies) RF-EMF had a significant effect on birds, insects, other vertebrates, other organisms and plants (Cucurachi 2013). The review paper cites development and reproduction in birds and insects as the most strongly affected endpoints.[4]

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[1] See, e.g., Kimmel, Stefan, et al. "Electromagnetic radiation: influences on honeybees (Apis mellifera)." *IIAS-InterSymp Conference*, 2007 (finding that 39.7% of the non-irradiated bees had returned to their hives compared to only 7.3% of the irradiated bees); Cucurachi, C., et al. "A review of the ecological effects of radiofrequency electromagnetic fields (RF-EMF)." *Environment International*, vol. 51, 2013, pp. 116–40; "Briefing Paper on the Need for Research into the Cumulative Impacts of Communication Towers on Migratory Birds and Other Wildlife in the United States." *Division of Migratory Bird Management (DMBM)*, U.S. Fish & Wildlife Service, 2009; Balmori, A. "Mobile phone mast effects on common frog (Rana temporaria) tadpoles." *Electromagnetic Biology and Medicine*, vol. 29, no. 1-2, 2010, pp. 31-5; Harkless, Ryan, Muntather Al-Quraishi and Mary C. Vagula. "Radiation hazards of radio frequency waves on the early embryonic development of Zebrafish." *SPIE Proceedings*, vol. 9112, 2014.

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- A 2012 Review "Impacts of radio-frequency electromagnetic field (RF-EMF) from cell phone towers and wireless devices on biosystem and ecosystem – A Review" on 919 research papers found 593 showed impacts, 180 showed no impacts, and 196 were inconclusive studies."[5]
- Studies on bees have found behavioral effects (Kumar 2011[6], Favre 2011[7]), disrupted navigation Goldsworthy 2009[8], Sainudeen 2011[9], Kimmel et al. 2007[10]), decreasing egg-laying rate (Sharma and Kumar, 2010[11]) and reduced colony strength after RF exposures (Sharma and Kumar, 2010, Harst et al. 2006[12]).
- A study focusing on RF from cellular antennas found increased sperm abnormalities in mice exposed to RF from GSM antennas (Otitoloju 2010).[13]
- "Exposure of Insects to Radio-Frequency Electromagnetic Fields from 2 to 120 GHz" published in Scientific Reports is the first study to investigate how insects (including the Western honeybee) absorb the higher frequencies (2 GHz to 120 GHz) to be used in the 4G/5G rollout. The scientific simulations showed increases in absorbed power between 3% to 370% when the insects were exposed to the frequencies. Researchers concluded, "This could lead to changes in insect behavior, physiology, and morphology over time…."[14]
- Researchers published a study on frogs in Electromagnetic Biology and Medicine exposing eggs and tadpoles to electromagnetic radiation from cell phone antennas for two months, from the egg phase until an advanced phase of tadpole and found low coordination of movements, an asynchronous growth, resulting in both big and small tadpoles, and a high mortality rate. The authors conclude, "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."[15]

We also want to bring your attention to the growing body of literature showing the impacts on trees and plants. Here again, experimental literature has found that rhizomes, nitrification and other critical processes to plant growth and health are affected by cell phone like radiation under controlled conditions. There have been over one hundred studies that have shown this and most recently a field study[16] that showed under controlled conditions, trees that are

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closer to cell phone towers start to die more readily; and this can be seen if one looks at the branches of the trees closest to the antennae of the cell phone tower with the fake tree at the Stilson parking lot off Hwy 390.

**Please note these published studies:**

- A field monitoring study spanning 9 years involving over 100 trees (Waldmann-Selsam 2016)[17] found trees sustained significantly more damage on the side of the tree facing the antenna, leaving the entire tree system prone to degradation over time. Documentation of tree damage from base stations is made visible in the Report "Tree Damage Caused by Mobile phone base stations" (Breunig, 2017).[18]
- A study on Aspen trees near Lyons, Colorado entitled "Adverse Influence of Radio Frequency Background on Trembling Aspen Seedlings " published in the *International Journal of Forestry* found adverse effects on growth rate and fall anthocyanin production concluding that, "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."[19]
- An analysis of 45 peer-reviewed scientific publications (1996-2016) on changes in plants due to the non-thermal RF-EMF effects from mobile phone radiation entitled "Weak radiofrequency radiation exposure from mobile phone radiation on plants concludes, "Our analysis demonstrates that the data from a substantial amount of the studies on RF-EMFs from mobile phones show physiological and/or morphological effects (89.9%, $p < 0.001$). Additionally, our analysis of the results from these reported studies demonstrates that the maize, roselle, pea, fenugreek, duckweeds, tomato, onions and mungbean plants seem to be very sensitive to RF-EMFs. Our findings also suggest that plants seem to be more responsive to certain frequencies…"[20]

**Electromagnetic Fields Alter Animal and Insect Orientation**

*Science of the Total Environment* published environmental scientist Alforso Balmori's "Anthropogenic radiofrequency electromagnetic fields as an emerging threat to wildlife orientation," which states, "Current evidence indicates that exposure at levels that are found in the environment (in urban areas and near base stations) may particularly alter the receptor organs to orient in the magnetic field of the earth. These results could have important implications for migratory birds and insects, especially in urban areas, but could also apply to birds and insects in

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Radiofrequency radiation injures trees around mobile phone base stations, Science of The Total Environment, Volume 572, 2016, Pages 554-569, ISSN 0048-9697, doi.org/10.1016/j.scitotenv.2016.08.045.

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natural and protected areas where there are powerful base station emitters of radiofrequencies. Therefore, more research on the effects of electromagnetic radiation in nature is needed to investigate this emerging threat." [21]

Multiple research studies have documented how animals magnetoreception can be disrupted by external electromagnetic fields from mice[22] to cows to dogs to birds.[23] Electromagnetic exposure is especially disruptive to migratory birds.[24] Electromagnetic fields have been shown to disrupt the magnetic compass orientation used by birds to navigate.[25,26] Researchers have suggested this disruption of magnetoreception is due to cryptochrome photoreceptors that allow birds to use built-in receptors as a biological compass.

In 2012 the government of India's Ministry of the Environment and Forest issued a report on the potential impacts of communication towers on wildlife, citing hundreds of research studies that found adverse effects. Recommendations from the Ministry include, "Introduce a law for protection of urban flora and fauna from emerging threats like ERM/EMF as conservation issues in urban areas are different from forested or wildlife habitats."[27]

A 2017 report to UNESCO[28] by botanist Mark Broomhall details the association between increasing amounts of electromagnetic radiation from cellular antennas on the Mt. Nardi tower complex and species disappearance and exodus from the Mt. Nardi area of the Nightcap National Park World Heritage Area during a 15-year period (2000-2015). He estimates "in both volume and species that from 70 to 90 % of the wildlife has become rare or has disappeared from the Nightcap National Park within a radius of the Mt. Nardi tower complex. This statement can be summarised with concrete data: 3 bat species once common have become rare or gone, 11 threatened and endangered bird species are gone, 11 migratory bird species are gone, 86 bird species are demonstrating unnatural behaviours, 66 once common bird species are now rare or gone." The Report concludes, "With these short explanations of events we can appreciate that the effects of this technology and its application on Mt. Nardi over the last fifteen years, affect not only the top of the life chain species but they are devastating the fabric of the continuity of the World Heritage, causing genetic deterioration in an insidious, massive and ever escalating scale. To truly understand what these studies reveal is to stare into the abyss."

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It is very important that in considering antenna placement, there be a full environmental assessment on migratory animal patterns (from the smallest to the largest) and not simply on birds and mammals like the pronghorn but also on impacts to amphibians and insects.

**Wireless Radiation is Known to Harm Humans and Wildlife**

Human health effects include impaired reproduction, increased incidence of brain cancer, DNA breaks, oxidative stress and immune dysfunction, altered brain development, sleep changes, hyperactivity, and memory and cognitive problems.[29] Since the WHO/IARC classified EMF as a Group 2B Possible Carcinogen in 2011, the peer-reviewed research connecting wireless exposure to cancer has significantly strengthened and several scientists have published documentation that the weight of current peer-reviewed evidence supports the conclusion that radiofrequency radiation should be regarded as a human carcinogen.[30,31,32]

- The 10 year $30 million National Institute of Environmental Health Sciences National Toxicology Program's (NTP) Studies of the Toxicology and Carcinogenicity of Cell Phone Radiation[33,34] found that RFR was associated with "clear evidence" of cancer due to the increased malignant schwannomas found in RFR-exposed male rats. The brain (glioma) cancers and tumors in the adrenal glands were also considered evidence of an association with cancer. In addition, exposed animals had significantly more DNA damage, heart damage, and low birth weight.
- The Ramazzini Institute published its findings[35] that animals exposed to very low-level RFR developed the same types of cancers as reported by the NTP.
- Long-term research on humans who have used cell phones has found increased tumors—schwannomas and glioblastomas—the same cell type as found in the NTP and Ramazzini Institute studies. Persons who started using cell phones under age 20 had the highest risk.[36]
- A 2015 Jacobs University study (replicating a 2010 study) found that weak cell phone signals significantly promote the growth of tumors in mice and that combining a toxic chemical exposure with RF more than doubled the tumor response.[37,38]

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[29] For more information on acute health symptoms, see, e.g., Martin Pall, Microwave Frequency Electromagnetic Fields (EMFs) Produce Widespread Neuropsychiatric Effects Including Depression, 75 *J. Chemical Neuroanatomy* 43-51 (Sept. 2016); Response of residents living in the vicinity of a cellular phone base station in France ; Electromagnetic Fields: A Hazard to Your Health?, Healthy Children.

[30] Adams, Jessica A., et al. "Effect of mobile telephones on sperm quality: a systematic review and meta-analysis." *Environment International,* 70, 2014, pp. 106-112.

[31] Deshmukh, P.S., et al. "Cognitive impairment and neurogenotoxic effects in rats exposed to low-intensity microwave radiation." *International Journal of Toxicology*, vol. 34, no. 3, 2015, pp. 284-90.

[32] Aldad, T.S., et al. "Fetal Radiofrequency Radiation Exposure From 800-1900 MHz-Rated Cellular Telephones Affects Neurodevelopment and Behavior in Mice." *Scientific Reports,* vol. 2, no. 312, 2012.

[33] National Toxicology Program, Cell Phone Radio Frequency Radiation

[34] High exposure to radio frequency radiation associated with cancer in male rats

[35] L. Falcioni, L. Bua, E. Tibaldi, M. Lauriola, L. De Angelis, F. Gnudi, D. Mandrioli, M. Manservigi, F. Manservisi, I. Manzoli, I. Menghetti, R. Montella, S. Panzacchi, D. Sgargi, V. Strollo, A. Vornoli, F. Belpoggi, Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radiofrequency field representative of a 1.8 GHz GSM base station environmental emission, *Environmental Research*, Volume 165, 2018, Pages 496-503, ISSN 0013-9351, doi.org/10.1016/j.envres.2018.01.037.

[36] https://www.pathophysiologyjournal.com/article/S0928-4680(14)00064-9/fulltext

[37] Lerchl, Alexander, et al. "Tumor promotion by exposure to radiofrequency electromagnetic fields below exposure limits for humans." *Biochemical and Biophysical Research Communications,* vol. 459, no. 4, 2015, pp. 585-90.

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- "5G wireless telecommunications expansion: Public health and environmental implications," is a research review published in Environmental Research, which documents the range of adverse effects reported in the published literature from cancer to bacteria growth changes to DNA damage and concludes that "a moratorium on the deployment of 5G is warranted" and "the addition of this added high-frequency 5G radiation to an already complex mix of lower frequencies, will contribute to a negative public health outcome both from both physical and mental health perspectives."[39]
- A study published in Electromagnetic Biology and Medicine, "Impact of radiofrequency radiation on DNA damage and antioxidants in peripheral blood lymphocytes of humans residing in the vicinity of mobile phone base station," compared people living close and far from a cell antennas and found that people living closer to cellular antennas had higher radiation levels in the homes and several significant changes in their blood predictive of cancer development."[40]
- A 2019 study of students in schools near cell towers found their higher RF exposure was associated with impacts on motor skills, memory and attention (Meo 2019).[41] Examples of other effects linked to cell towers in research studies include neuropsychiatric problems[42], elevated diabetes[43], headaches[44], sleep problems[45] and genetic damage[46]. Such research continues to accumulate after the 2010 landmark review study on 56 studies that reported biological effects found at very low intensities, including impacts on reproduction, permeability of the blood-brain barrier, behavior, cellular and metabolic changes, and increases in cancer risk (Lai and Levitt 2010).[47]
- Published research has found impacts from wireless radiation exposure to reproduction and brain development in addition to a myriad of other adverse effects.[48,49,50,51] Although renowned institutions, such

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[38] Tillmann, Thomas, et al. "Indication of cocarcinogenic potential of chronic UMTS-modulated radiofrequency exposure in an ethylnitrosourea mouse model." *International Journal of Radiation Biology,* vol. 86, no. 7, 2010, pp. 529-41.

[39] https://doi.org/10.1016/j.envres.2018.01.016

[40] Zothansiama & Zosangzuali, Mary & Lalramdinpuii, Miriam & Jagetia, Ganesh & Siama, Zothan. (2017). Impact of radiofrequency radiation on DNA damage and antioxidants in peripheral blood lymphocytes of humans residing in the vicinity of mobile phone base stations. Electromagnetic Biology and Medicine. 36. 1-11. 10.1080/15368378.2017.1350584.

[41] Meo, S. A., Almahmoud, M., Alsultan, Q., Alotaibi, N., Alnajashi, I., & Hajjar, W. M. (2019). Mobile Phone Base Station Tower Settings Adjacent to School Buildings: Impact on Students' Cognitive Health. *American Journal of Men's Health*. doi.org/10.1177/1557988318816914.

[42] G. Abdel-Rassoul, O. Abou El-Fateh, M. Abou Salem, A. Michael, F. Farahat, M. El-Batanouny, E. Salem, Neurobehavioral effects among inhabitants around mobile phone base stations, NeuroToxicology, Volume 28, Issue 2, 2007, Pages 434-440, ISSN 0161-813X, doi.org/10.1016/j.neuro.2006.07.012.

[43] SA, Meo & Alsubaie, Yazeed & Almubarak, Zaid & Almutawa, Hisham & AlQasem, Yazeed & Hasanato, Rana. (2015). Association of Exposure to Radio-Frequency Electromagnetic Field Radiation (RF-EMFR) Generated by Mobile Phone Base Stations with Glycated Hemoglobin (HbA1c) and Risk of Type 2 Diabetes Mellitus. International Journal of Environmental Research and Public Health. 12. 14519-14528;. 10.3390/ijerph121114519.

[44] Hutter, H. P., Moshammer, H., Wallner, P., & Kundi, M. (2006). Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations. *Occupational and environmental medicine*, *63*(5), 307–313. doi:10.1136/oem.2005.020784.

[45] R. Santini, P. Santini, J.M. Danze, P. Le Ruz, M. Seigne, Enquête sur la santé de riverains de stations relais de téléphonie mobile: I/Incidences de la distance et du sexe, Pathologie Biologie, Volume 50, Issue 6, 2002, Pages 369-373, ISSN 0369-8114, doi.org/10.1016/S0369-8114(02)00311-5.

[46] Gursatej Gandhi, Gurpreet Kaur & Uzma Nisar (2015) A cross-sectional case control study on genetic damage in individuals residing in the vicinity of a mobile phone base station, Electromagnetic Biology and Medicine, 34:4,344-354, DOI: 10.3109/15368378.2014.933349.

[47] B. Blake Levitt and Henry Lai, Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays, Environ. Rev. Downloaded from www.nrcresearchpress.com by 172.58.41.200 on 04/10/19

[48] Adams, Jessica A., et al. "Effect of mobile telephones on sperm quality: a systematic review and meta-analysis." *Environment International,* 70, 2014, pp. 106-112.

as the Cleveland Clinic, advise men to keep phones and wireless devices away from their reproductive organs, the public remains largely unaware.

Once the towers are erected they will be upgraded over time with new antennas and soon 5G technology. 5G would use today's wireless frequencies while adding new, higher frequencies to transmit data at faster speeds. These higher frequency millimeter waves uniquely penetrate the eyes and skin,[52,20,21,22] and have been shown to accelerate bacterial and viral cell growth.[53] Millimeter waves were originally developed as a military weapon to create the sensation that the skin is burning.[54] Currently accepted standards are not sophisticated enough to measure effects on sweat glands or quantify the risks of cumulative exposure.[55,56]Any future applications of these technologies must consider the biological effect of cumulative exposures to these frequencies.

**Radiofrequency radiation exposure is increasing at a rapid pace.**

A 2018 article published in *The Lancet Planetary Health* points to unprecedented increasing RF exposures, and the abstract concludes, "due to the exponential increase in the use of wireless personal communication devices (eg, mobile or cordless phones and WiFi or Bluetooth-enabled devices) and the infrastructure facilitating them, levels of exposure to radiofrequency electromagnetic radiation around the 1 GHz frequency band, which is mostly used for modern wireless communications, have increased from extremely low natural levels by about 1018 times…"(Bandara and Carpenter 2018).[57]

Another key finding from Zothansiama 2017 was that homes closer to antennas had measurably higher radiation levels—adding to the documentation that antennas increase RF levels. An Australian study also found that children in kindergartens with nearby antenna installations had nearly three-and-a-half times higher RF exposures than children with installations further away (more than 300 meters (Bhatt 2016).[58]

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[49] Deshmukh, P.S., et al. "Cognitive impairment and neurogenotoxic effects in rats exposed to low-intensity microwave radiation." *International Journal of Toxicology*, vol. 34, no. 3, 2015, pp. 284-90.
[50] Aldad, T.S., et al. "Fetal Radiofrequency Radiation Exposure From 800-1900 MHz-Rated Cellular Telephones Affects Neurodevelopment and Behavior in Mice." *Scientific Reports,* vol. 2, no. 312, 2012.
[51] Sonmez, O.F., et al. "Purkinje cell number decreases in the adult female rat cerebellum following exposure to 900 MHz electromagnetic field." *Brain Research,* vol. 1356, 2010, pp. 95-101.
[52] A lecture by Paul Ben-Ishai, PhD at the Israel Institute for Advanced Studies on this finding can be found on the 2017 IIAS Conference website. Feldman, Yuri and Paul Ben-Ishai. "Potential Risks to Human Health Originating from Future Sub-MM Communication Systems." *Conference on Wireless and Health*, 2017.
[53] Cindy L. Russell, 5G Wireless Telecommunications Expansion: Public Health and Environmental Implications, 165 Envt'l Res. 484 (2018).
[54] For information on Active Denial Systems, see, e.g., Vehicle-Mounted Active Denial System (V-MADS) ; Active Denial System FAQs.
[55] A lecture by Paul Ben-Ishai, PhD at the Israel Institute for Advanced Studies on this finding can be found on the 2017 IIAS Conference website. Feldman, Yuri and Paul Ben-Ishai. "Potential Risks to Human Health Originating from Future Sub-MM Communication Systems." *Conference on Wireless and Health*, 2017.
[56] Hayut, Itai, Paul Ben Ishai, Aharon J. Agranat and Yuri Feldman. "Circular polarization induced by the three-dimensional chiral structure of human sweat ducts." *Physical Review E*, vol. 89, no. 042715, 2014.
[57] Priyanka Bandara, David O Carpenter, Planetary electromagnetic pollution: it is time to assess its impact, *The Lancet Planetary Health*, Volume 2, Issue 12, 2018, Pages e512-e514,ISSN 2542-5196, doi.org/10.1016/S2542-5196(18)30221-3.
[58] Bhatt, C. R., Redmayne, M., Billah, B., Abramson, M. J., & Benke, G. (2016). Radiofrequency-electromagnetic field exposures in kindergarten children. *Journal Of Exposure Science And Environmental Epidemiology*, *27*, 497. Retrieved from https://doi.org/10.1038/jes.2016.55.

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A 2018 multi-country study that measured RF in several countries found that cell phone tower radiation is the dominant contributor to RF exposure in most outdoor areas exposure in urban areas was higher and that exposure has drastically increased. As an example, the measurements the researchers took in Los Angeles, USA was 70 times higher than the US EPA estimate 40 years ago.[59]

**FCC limits are non-protective**

FCC limits are based only on thermal heating and do not account for biological impacts at levels far lower than FCC limits. The Department of Interior wrote a 2014 letter on the impact of cell towers on migratory birds documenting several studies that found adverse effects and concludes that "The electromagnetic radiation standards used by the Federal Communications Commission (FCC) continue to be based on thermal heating, a criterion now nearly 30 years out of date and inapplicable today."[60]

In the United States, RFR radiation regulatory limits were set by the FCC more than two decades ago in 1996. However, the FCC limits are not safety standards. Although the EPA was actively researching this issue and tasked to develop proper safety limits,[61,62] the EPA was abruptly defunded in 1996 and the FCC adopted guidelines developed by industry-connected non-independent groups (ANSI/IEEE C95.1-1992, NCRP's 1986 Report)[63] Experts from U.S. government agencies (including the EPA and NIOSH) have repeatedly documented issues concerning the inadequacy of these limits but their letters have gone unanswered.[64,65] The EPA has clarified that the FCC limits do not protect against effects from long-term low-level exposures.[66] In 2008, the National Academy of Sciences released a Report on research needs that included recommending research on the impacts to brain development and exposures to children and pregnant women.[67]

In 2012, the Government Accountability Office issued a Report calling for RFR standards to be updated with current research recommending that the FCC formally reassess the current RF energy exposure limit, including its effects on

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[59] Sanjay Sagar, Seid M. Adem, Benjamin Struchen, Sarah P. Loughran, Michael E. Brunjes, Lisa Arangua, Mohamed Aqiel Dalvie, Rodney J. Croft, Michael Jerrett, Joel M. Moskowitz, Tony Kuo, Martin Röösli, Comparison of radiofrequency electromagnetic field exposure levels in different everyday microenvironments in an international context, Environment International, Volume 114, 2018, Pages 297-306, ISSN 0160-4120, doi.org/10.1016/j.envint.2018.02.036.

[60] W.R.Taylor, February 7, 2014, United States Department of the Interior, Letter In Reply Refer To: (ER 14/0001) (ER 14/0004).

[61] A lecture by Paul Ben-Ishai, PhD at the Israel Institute for Advanced Studies on this finding can be found on the 2017 IIAS Conference website. Feldman, Yuri and Paul Ben-Ishai. "Potential Risks to Human Health Originating from Future Sub-MM Communication Systems." *Conference on Wireless and Health*, 2017.

[62] Hayut, Itai, Paul Ben Ishai, Aharon J. Agranat and Yuri Feldman. "Circular polarization induced by the three-dimensional chiral structure of human sweat ducts." *Physical Review E*, vol. 89, no. 042715, 2014.

[63] https://www.fcc.gov/general/fcc-policy-human-exposure#block-menu-block-4

[64] A lecture by Paul Ben-Ishai, PhD at the Israel Institute for Advanced Studies on this finding can be found on the 2017 IIAS Conference website. Feldman, Yuri and Paul Ben-Ishai. "Potential Risks to Human Health Originating from Future Sub-MM Communication Systems." *Conference on Wireless and Health*, 2017.

[65] Hayut, Itai, Paul Ben Ishai, Aharon J. Agranat and Yuri Feldman. "Circular polarization induced by the three-dimensional chiral structure of human sweat ducts." *Physical Review E*, vol. 89, no. 042715, 2014.

[66] https://ehtrust.org/wp-content/uploads/4c0f61dc30c3d6bb27d90f53a57c616e.pdf

[67] Consensus Study Report, Identification of Research Needs Relating to Potential Biological or Adverse Health Effects of Wireless Communication Devices, 2008.

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human health, the costs, and benefits associated with keeping the current limit, and the opinions of relevant health and safety agencies, and change the limit if determined appropriate. In response to the 2012 GAO Report, the FCC opened proceedings (ET Docket No. 13-84 Reassessment of FCC Radiofrequency Exposure Limits and ET Docket No. 03-137 Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields) to explore whether it should modify its radiofrequency exposure standards. The FCC also noted, "we specifically seek comment as to whether our current limits are appropriate as they relate to device use by children." To date, the FCC has failed to act. Over 900 comments have been filed since the FCC opened these dockets these dockets, but no US health agency has submitted any opinion or scientific documentation to either docket.

Due to the FCC's inaction, the GAO has updated the status[68] as "Closed - Not Implemented" with these comments: "despite many years of consideration, FCC still has no specific plans to take any actions that would satisfy our recommendations. Accordingly, we are closing the recommendations as not implemented."

**Children are more vulnerable.**

Children's skulls are thinner, their heads are smaller, and the radiation penetrates deeper into their brain. Research has found that a child's head's absorption can be over two times greater, and absorption of the skull's bone marrow can be ten times greater, than adults.[69,70] The American Academy of Pediatrics, which is the largest organization of U.S. pediatricians, has repeatedly written to the U.S. government documenting children's vulnerabilities and recommends reducing children's and pregnant women's exposure.[71]

The California Department of Health, the Connecticut Department of Health, many international health organizations and medical associations, and more than 20 governments are recommending wireless exposure reduction, especially for children.[72]

Several countries have allowable public exposure limits lower than ICNIRP levels with limits that are even more protective for kindergartens, schools and hospitals. In addition, some governments' regulatory actions include banning cell phones or removing Wi-Fi and cell towers in or near schools.[73] For example:

- Belgium and France have banned the sale of cell phones designed for young children and made it illegal to market cell phones to children less than 14 years of age.

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[68] Exposure and Testing Requirements for Mobile Phones Should Be Reassessed GAO-12-771: Published: Jul 24, 2012. Publicly Released: Aug 7, 2012.

[69] A lecture by Paul Ben-Ishai, PhD at the Israel Institute for Advanced Studies on this finding can be found on the 2017 IIAS Conference website. Feldman, Yuri and Paul Ben-Ishai. "Potential Risks to Human Health Originating from Future Sub-MM Communication Systems." *Conference on Wireless and Health*, 2017.

[70] Hayut, Itai, Paul Ben Ishai, Aharon J. Agranat and Yuri Feldman. "Circular polarization induced by the three-dimensional chiral structure of human sweat ducts." *Physical Review E*, vol. 89, no. 042715, 2014.

[71] https://ehtrust.org/wp-content/uploads/American-Academy-of-Pediatrics-Letters-.pdf

[72] For more on international policy actions, see our online briefing. "International Policy Briefing: Cautionary Policy on Radiofrequency Radiation Actions by Governments, Health Authorities and Schools Worldwide." Environmental Health Trust, 2017.

[73] See Database of Worldwide Policies on Cell Phones, Wireless and Health, Environmental Health Trust.

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- France has banned cell phones in elementary and middle schools, and playgrounds.[74]
- The Supreme Court of India upheld the High Court of the State of Rajasthan's decision to remove all cell towers from the vicinity of schools, hospitals and playgrounds because this radiation is "hazardous" and causes cancer, brain tumour, digestive disorder and tachycardia.[75]
- The Environment Minister of Italy has decreed to reduce as much as possible indoor exposure to both ELF-EMF and RF-EMF.
- Cyprus has banned Wi-Fi from kindergartens and elementary classrooms.
- In Chile, the 2012 "Antenna Law" prohibits cell antennas/towers in "sensitive areas" such as "educational institutions, nurseries, kindergartens, hospitals, clinics, nursing homes or other institutions of similar nature."[76]

Children will have a lifetime of exposure to wireless radiation; in order to protect their healthy future, public health authorities must limit this exposure as much as possible.

Moreover, recent cell phone radiation tests released by the French government found that nine out of ten cell phones exceed regulatory limits for radiofrequency radiation when tested in body contact positions (simulating a phone in pants pocket, bra or resting on chest). Despite this documentation, U.S. radiation limits have still not been revised. To this date, there has been no public record of an independent systematic review of the research by any U.S. health agency in order to set proper safety standards. The current outdated regulations are inadequate to protect public health.

Since 1997, insurance companies have refused to insure wireless companies and "electromagnetic field exclusions" in insurance policies are an industry standard. EMFs are deemed as "high-risk" in insurance white papers, and EMFs are defined as a "pollutant" by many insurance companies alongside smoke, chemicals, and asbestos. Some companies will only cover liability from EMFs under additional "Pollution Liability" policy enhancement coverage. Some policies not only exclude damages from EMFs but also exclude paying for the defense of "*any supervision, instruction, recommendation, warning or advice given or which should have been given in connection with bodily injury, property damage, abatement and/or mitigation etc.*"

Wireless companies warn their shareholders—in mandated annual 10k filings—that they may incur financial losses from lawsuits related to EMF radiation emissions of their products. For example:

- AT&T states, *"We may incur significant expenses defending such suits or government charges and may be required to pay amounts or otherwise change our operations in ways that could materially adversely affect our operations or financial results."*
- Crown Castle's 2016 10-K ANNUAL REPORT states, *"If radio frequency emissions from wireless handsets or equipment on our wireless infrastructure are demonstrated to cause negative health effects, potential future claims could adversely affect our operations, costs or revenues. The potential connection between radio frequency emissions and certain negative health effects, including some forms of cancer, has*

[74] « Plus de téléphones portables dans les écoles et collèges à la rentrée 2018 », annonce Jean-Michel Blanquer, Le Monde (Dec. 10, 2017).
[75] Abhinav Sharma, Rajasthan HC orders relocation of mobile towers from schools, hospitals, Economic Times (Nov. 28, 2012).
[76] New communications antenna law in Chile, 20 Communications Law: Newsletter of the International Bar Association Legal Practice Division 14-16 (2013).

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*been the subject of substantial study by the scientific community in recent years. We cannot guarantee that claims relating to radio frequency emissions will not arise in the future or that the results of such studies will not be adverse to us...If a connection between radio frequency emissions and possible negative health effects were established, our operations, costs, or revenues may be materially and adversely affected. We currently do not maintain any significant insurance with respect to these matters."*

Most wireless companies—from AT&T to Nokia to T Mobile to Verizon Wireless—have issued similar warnings to their shareholders.[77]

Will the visiting public to the National Parks also be warned of the risk?

**Scientists Worldwide: Reduce Exposure**

An increasing number of experts around the world are calling for reduced exposure—due to the unprecedented threat to public health and the environment—to stop the installation of radiation-emitting equipment placed within meters of homes, playgrounds, and schools.

- In 2015, the International EMF Scientist Appeal, now signed by over 225 scientists from 41 nations, urging the development of more protective guidelines for EMF (including RF-EMF), encouraging precautionary measures, and calling for education of the public about health risks, particularly risks to children and fetal development, was submitted to the Secretary-General of the United Nations, the Director-General of the World Health Organization, and U.N. Member Nations.[78]
- In June 2017, EMF Scientists submitted Comments to the U.S. FCC, asking the FCC to critically consider the potential impact of the 5th generation wireless infrastructure on the health and safety of the U.S. population before proceeding to deploy this infrastructure.
- In September 2017, I joined over 180 experts from 35 countries who sent a declaration to the European Union calling for a moratorium on 5G until hazards have been fully investigated by independent scientists, citing potential neurological impacts, infertility, and cancer.[79]

The tobacco and asbestos crises demonstrate that failing to act on public health hazards when they arise can lead to irreversible damage later. EHT thus strongly opposes building out 5G infrastructure—which would place thousands of new sources of microwave radiation emissions in close proximity to workers, families, and local wildlife—at least until more testing has been conducted.

**Cell Towers Create Additional Safety Hazards**

Another area of concern with the proposed expansion of the wireless infrastructure is fires. Cell towers are known to catch fire such as the 150-foot tower in Washington that experienced an electrical malfunction at a lighted beacon on top of the tower which caught an Osprey's nest on fire. Many birds, particularly raptors, choose to nest on or near cell towers because of the heat they provide, the clear view, and high vantage point that they favor for their nesting

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[77] Corporate Company Investor Warnings In Annual Reports 10k Filings Cell Phone Radiation Risks
[78] Blank, M., et al. "International Appeal: Scientists call for protection from non-ionizing electromagnetic field exposure." *European Journal of Oncology,* vol. 20, no. 3/4, 2015, pp. 180-2.
[79] "Appeal to the European Union: Scientists warn of potential serious health effects of 5G." 13 September 2017.

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sites. There are many more examples of these towers catching fire, such as a 125-foot tower in Maryland. A church in South Africa that housed antennas caught fire this month, and news reports state authorities are investigating if it was a short circuit from the equipment that started the fire.

Towers have also been known to attract lightning strikes. The higher the tower the higher the probability that lightning will strike the tower, presenting another type of fire hazard.[80]

We at the Environmental Health Trust urge you, as stewards of our national parks and along with your mission, "The **National Park Service** preserves unimpaired the **natural** and cultural resources and values of the **national park** system for the enjoyment, education, and inspiration of this and future generations," to seek out the research and information about the health effects on both humans and the flora and fauna of the parks in order to protect and preserve. Taking all information into consideration you are also following the National Park Service's own statement, "by caring for the parks and conveying the park ethic, we care for ourselves and act on behalf of the future. The larger purpose of this mission is to build a citizenry that is committed to conserving its heritage and its home on earth."[81]

Respectfully submitted,

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Fellow, American College of Epidemiology
Visiting Prof. Hebrew Univ. Hadassah Medical Center & Ondokuz Mayis Univ. Medical School
Associate Editor, Frontiers in Radiation and Health

[80] Witman, S. (2017), Antenna towers attract additional lightning strikes, *Eos, 98,* doi.org/10.1029/2017EO074341. Published on 26 May 2017.
[81] NPS Entering the 21st Century, Changes in Mission, Changes in the Future, 2016.