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Document Summary: An enumeration of incumbent protection requirements and other encumbrances that impact CBRS spectrum.

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The information in this document is presented for informational purposes only. The reader uses this information “as is” and at their own risk. While the authors have endeavored to compile as complete and accurate of an assessment of incumbent protections and other CBRS encumbrances as possible, the authors make no warranty of any kind, express or implied, statutory, or otherwise, including warranties of fitness for a particular use, or noninfringement, with regard to the information presented here; and to the maximum permitted under applicable law, the authors will have no liability in connection with the information presented herein. Furthermore, the nature of incumbent operations and other encumbrances, and their impact on CBRS operations, can change over time. The reader should not rely solely on this document for making strategic decisions with regard to CBRS, and instead should rely primarily on their own advisors, consultants, and experts in making decisions with regard to CBRS.

Executive Summary

Operations in the CBRS band require protection of incumbents and consideration for other potential encumbrances as a function of geography, frequency, power, and/or time. The following two tables summarize the types of protections that must be respected, and the geographic extent over which those protections apply.

The details of the protections and encumbrance are very complex, hence the need for a document of substantial length to explain them. The reader should refer to the rest of the document to understand the more detailed aspects of the protections, and should consult with a SAS Administrator or other expert source for additional information.

Table 1: Incumbents and Other Entities Protected from CBRS Interference

Operation	Description	CBRS frequency range impacted	Source of information
Federal government	Military shipborne radar	Generally 3550-3650 MHz; OOB protections below 3550 MHz in some harbor areas can impact entire 3550-3700 MHz band	NTIA
	Military ground-based radars	3550-3700 MHz depending on site; OOB protections below 3550 MHz for some sites	
In-band fixed-satellite service earth stations (inband FSS)	FSS receive-only earth stations in some or all of 3600-3700 MHz protected from CBRS in-band and blocking emissions	Greatest potential impact in all or parts of 3600-3700 MHz; smaller impact below 3600 MHz.	FCC
Adjacent band fixed-satellite service earth stations (TT&C FSS)	FSS receive-only earth stations above 3700 MHz used for TT&C, protected from CBRS OOB and blocking emissions	3550-3700 MHz in immediate vicinity of a protected TT&C earth station	
Grandfathered Wireless Protection Zones (GWPZ)	Legacy Part 90 wireless broadband operations that will sunset between 2020 and 2023	All or parts of 3650-3700 MHz	FCC
PAL Protection Areas (PPAs)	PAL operations are protected from co-channel interference in those portions of their PAL license area where the PAL has deployed CBSDs	All or parts of 3550-3650 MHz	SAS Administrators
ESC sensors	Protection of sensors that detect federal government operations	3550-3650 MHz, with additional protections from OOB CBRS operations from Cat A CBSDs in 3650-3660	ESC Operators and/or SAS Administrators

		MHz and Cat B CBSDs in 3650-3680 MHz.	
Quiet Zones/Coordination Zones	Defined areas around contiguous US, Alaska, Hawaii, and Puerto Rico P in which radio operations must meet protection or coordination requirements	3550-3700 MHz	FCC
Canada/Mexico protection	CBRS required to respect international coordination agreements with Canada (in force now), and Mexico (no agreement currently exists)	3615-3620 MHz and 3650-3700 MHz	FCC

Table 2: Distance over which Protections are Considered in Making CBRS Spectrum Grants

Protection Type	**Maximum Distance CBSDs Must be Considered**	
	Category A	**Category B**
DPA	Up to 150 km depending on DPA	>450 km, depending on DPA
Inband FSS	150 km for passband interference; 40 km for blocking	
Adjacent band FSS	40 km for passband interference and blocking	
GWPZ	40 km	
PAL Protection Area	40 km	
ESC sensor	40 km	80 km
Table Mountain	3.8 km	38 - 80 km, depending on CBSD bandwidth
FCC field offices	2.4 km	4.8 km
PRCZ	Islands of Puerto Rico, Desecheo, Mona, Vieques and Culebra	
NRQZ	Bounded by NAD-83 meridians of longitude at 78d 29m 59.0s W and 80d 29m 59.2s W and latitudes of 37d 30m 0.4s N and 39d 15m 0.4s N, and encloses a land area of approximately 13,000 square miles	

Canadian border	8 km (CBSD antenna pointing generally away from Canadian border) 56 km (CBSD antenna pointing generally toward Canadian border)
Canadian FSS	150 km from 45.94444444, -74.53277778

CBRS Incumbent Protections and Encumbrances Overview

1 Overview

This document provides an overview of the incumbent operations that are protected from interference due to PAL and GAA operations in the CBRS band, and how to find more information to gauge their impact on CBRS operations.

This document is informational only, and is not intended to replace expert guidance. Readers are encouraged to contact SAS Administrators and others with detailed domain knowledge. Do not rely solely on the information in this document.

There are three types of incumbents that require protections from CBRS based on FCC rules:

- Federal government
- Fixed-satellite service (FSS) receive-only earth stations
- Grandfathered Wireless Protection Zones (GWPZs). These are legacy Part 90 broadband services that will sunset over time.

In addition to required incumbent protections, the following operations are also protected from CBRS interference by FCC rules:

- CBRS Priority Access License (PAL) Protection Areas (PPAs)
- Radio quiet zones and coordination zones
- Internationally-agreed protections near the borders with Canada and Mexico

Finally, the following operations are protected by virtue of government-mandated certification requirements for Environmental Sensing Capability (ESC) networks:

- ESC sensors

This document provides a description of each type of protected operation, their general impact on CBRS operations, and where to obtain additional information on each.

2 Federal Government Incumbents

2.1 Summary

- The military operates radars in and below the CBRS band that must be protected from interference caused by CBRS
- Dynamic Protection Areas (DPAs) are defined areas in which the military may be operating systems that require protection

    - DPA neighborhoods are defined areas around the DPAs in which CBSDs must be considered in the calculation of aggregate interference to the DPA. It does not mean that all CBSDs within the neighborhood will be affected
    - DPAs are defined for coastal waters, some harbors, ports, and ship transit areas, and some inland areas
    - DPAs can be either areas or points
    - E-DPAs are DPAs whose activity is monitored by an ESC. If a DPA is not fully covered by ESC sensors at all possible frequencies of operation, then the entire DPA must be considered always activated at any frequency for which it is unmonitored
    - P-DPAs are DPAs whose activity is informed to the SASs by the DoD, using a calendar-like portal
    - GB-DPAs are DPAs that protect ground-based radars
    - Some DPAs, such as GB-DPAs, must be assumed to be always activated
- For some military incumbent operations areas, exclusion zones have been defined in which no CBRS operations over specified frequency ranges are allowed at any time (see figure A16).

2.2 Description of Federal Government Incumbent Activity

The U.S. military operates radars in and near the CBRS band that require protection from CBRS interference. Those operations include the following:

1. Shipborne radars that operate off the coast, or within certain harbor areas, that are protected from co-channel CBRS operations in the 3550-3650 MHz band. In some harbor areas, they are also protected from out-of-band (OOB) CBRS emissions below 3550 MHz.

2. Land-based radars at specific locations that are protected from co-channel CBRS operations in some or all of the 3550-3700 MHz band. At some sites, land-based radars are protected from OOB CBRS emissions below 3550 MHz.

The military operations are protected through the concept of Dynamic Protection Areas (DPAs) and their associated neighborhoods, or by exclusion zones. Those concepts are explained below.

2.3 Dynamic Protection Areas (DPAs)

DPAs are defined areas in which (or points at which) military radar systems may operate and must be protected from CBRS emissions. The areas or points are defined by the DoD in conjunction with NTIA, and published on the NTIA website in the form of KML files. DPAs are defined for shipborne and ground-based radar operation areas that require protection. An

example of DPAs defined for shipborne radar operations ("coastal DPAs") is shown in Fig. A-1 in Annex A. Each coastal DPA is defined to be large enough so as not to pinpoint the location of shipborne radar operations, while small enough so as to be covered by a reasonable number of ESC sensors and so as not to impact an overly large number of CBSDs when activity is detected.

In addition to its geographic definition, each DPA includes a frequency range in which the radar operations may occur. All points within the DPA must be protected from interference in the defined range of operation, either by co-channel or OOB CBRS emissions. In practice, a grid of protection points within the DPA is defined, and in some cases only a subset of the points is sufficient for the interference calculation, depending on the geometry of the DPA and the nature of its location, such as open water.

The protection criteria and other important data about each DPA are included in the KML files, as discussed below.

2.4 DPA Neighborhoods

For each DPA, a neighborhood distance has been defined such that any CBSD within that distance of the DPA must be considered in aggregate interference calculations when there is a need to protect that DPA in a frequency range that overlaps the range in which the CBSD is operating (for co-channel protections), or if the DPA requires OOB protections (for OOB CBRS emissions). An example of DPA neighborhoods is shown in Figure A-6 in Annex A.

Due to the difference in max allowed EIRP, different neighborhood distances may exist for Category A CBSDs vs Category B CBSDs. Although OOB emission limits are the same for Category A and Category B CBSDs, different OOB DPA neighborhood distances may be defined for each, or DPAs may require protection from Cagegory B OOB emissions but not Category A OOB emissions. Therefore, four neighborhood distances are defined for each DPA:

- Category A co-channel neighborhood distance
- Category B co-channel neighborhood distance
- Category A out-of-band emissions neighborhood distance
- Category B out-of-band emissions neighborhood distance

As the names suggest, all Category A CBSDs that operate in the same frequency range as the DPA and that are within the Category A neighborhood distance must be considered; and similarly all Category B CBSDs that are within the Category B neighborhood distance, and which operate in the same frequency range as the DPA, must be considered. Category A CBSDs that are within the Category A out-of-band emission neighborhood distance and that operate outside the frequency range of the DPA must be considered with regard to the impact of their out-of-band emissions on operations in the DPA. Lastly, any Category B CBSD that is within the Category B out-of-band emission neighborhood distance must be considered with regard to its potential contribution of out-of-band interference into the DPA. Some DPAs do not require protection from CBRS out-of-band emissions.

DPA neighborhood distances can be quite large, depending on the nature of coastal geography. For example, the Category B co-channel neighborhood distance can exceed 450 km on the east coast in areas with geography that slopes gently toward the coastline. Conversely, the Cat B neighborhood distance can be considerably smaller (less than 150 km) on the west coast in areas with mountainous coastlines that block signal transmission.

2.5 Federal Incumbent Activity Impact on CBSDs: Move List

It is important to note that *a CBSD within a DPA neighborhood is not necessarily impacted when radar activity occurs within the DPA*. Whether a given CBSD is impacted or not depends on its frequency of operation and its predicted contribution to the interference. Each CBSD in the neighborhood is ranked by its predicted interference contribution to the DPA, from largest to smallest. Starting from the top of the list (called a "move list"), those CBSDs with the greatest contribution to interference will have their grant suspended or terminated on the frequency range that the DPA requires protection, until the aggregate interference from the remaining set of CBSDs in the list is under the required protection threshold. In practice, this means that the EIRP in the direction of the DPA and the predicted propagation loss from the CBSD to the DPA are the key factors in determining whether a specific CBSD is impacted. CBSDs with a large propagation loss to the DPA (for example, distant CBSDs) and CBSDs with low EIRP in the direction of the DPA (i.e., lower power and/or antenna pointed away from the DPA) are less likely to be impacted than CBSDs very close to the DPA and/or with their antennas pointed such that high EIRP is present in the direction of the DPA.

2.6 No Consideration for Impact of Government Radar on CBRS

There are no considerations for the impact of government radar operations on CBRS in the DPA or DPA neighborhood concept. The neighborhoods are defined solely for the purpose of protecting government operations from interference caused by CBRS. There are no considerations for interference caused *to* CBRS from government radar operations. In practice, if a CBSD is not predicted to cause interference to a government radar, it is unlikely that the radar will cause interference to the CBSD.

2.7 DPA Activation: How a SAS Learns about Federal Incumbent Operations in a DPA

Federal government operations are generally dynamic, in that, for example, shipborne or ground-based radar operations only occur at certain times and on certain frequencies. With some exceptions, CBRS must protect government operations only where, when, and on the frequency at which the systems are operating. There are three methods used to determine these parameters:

- **ESC**. ESC sensors are deployed to cover specific DPAs. The ESC system will determine when operations are occurring in a specific DPA, and at what frequency or frequency range. The DPA is considered to be "active" on that frequency range. The ESC then provides this information to any SAS that is subscribing to that ESC network. Activity in coastal DPAs, and some inland DPAs, is detected by ESC. DPAs that are ESC-activated are referred to as "E-DPAs," meaning ESC-activated DPAs.

- **Informing Incumbent Portal**. The federal government may schedule operations in certain inland DPAs, in given frequency ranges, by way of a portal, similar to an online

calendar. SASs automatically connect to the portal on a regular basis and protect any DPAs during scheduled activities. Such DPAs are referred to as "P-DPAs," meaning portal-activated DPAs. The portal data are only for the use of the government incumbents and SASs and are not public.

- **Always-on DPAs**. Some DPAs are neither ESC- nor portal-activated, and must be assumed to be always-on throughout their defined frequency range of operation.

- **Exclusion zones**. The military defines certain exclusion zones around some sites in which CBRS operations in certain frequency ranges are never allowed.

2.8 Finding Information on DPAs

NTIA in conjunction with the FCC and DoD publishes KML files that contain information on all DPAs and exclusion zones and their protection requirements. The KML files are publicly available on the NTIA website. The following files are relevant:

- **e-dpas.kml**: The list of ESC-activated DPAs. There are 105 ESC-activated DPAs in total, of which 94 cover 3550-3650 MHz and are monitored by ESCs. Eleven of the DPAs, mostly port and harbor areas, operate down to 3500 MHz, and that portion of their operations that is below 3550 MHz is protected from OOB emissions from CBRS and is assumed to be always activated.

- **p-dpas.kml**: The list of portal-activated DPAs. The sites require co-channel protections in the 3550-3650 MHz range, and also OOB protection in the range 3500-3550 MHz. However, unlike a few ESC-activated DPAs that require OOB protections that are always on (because ESCs do not detect out-of-band), the OOB protections for P-DPAs are only required when OOB operations are scheduled through the portal.

- **gb-dpas.kml**: A list of ground-based radar sites that operate below 3550 MHz, that are protected from CBRS OOB emissions. However, because of the nature of the interplay of CBRS OOB emission masks combined with the receive filter of the radars, industry and government jointly decided to implement protections as if these sites were co-channel with CBRS, but with much higher CBRS channel-by-channel interference criteria that take the CBRS emissions masks and radar receive filters into account. The DPAs are always on.

- **exz.kml**: Exclusion zones in which CBRS operations over specified frequency ranges are forbidden at all times. There are three exclusion zones of 80 km radius around inland radar sites at Pascagoula MS, Pensacola FL, and St. Inigoes MD, in which operations in the 3650-3700 MHz band are prohibited. Operations in 3550-3650 MHz are forbidden at the Nevada Test and Training Range.

The files can be opened directly in Google Earth (for example) to view the contents on a map, or they may be opened with a standard text editor to view the contents directly. In the E-DPA and P-DPA files, the following protection-related data are contained in the files for each DPA:

- DPA name

- Geographic description (either point or polygon)
- The frequency range of operations in which the DPA must be protected
- The protection criterion
- The reference height in meters above ground level at which the protection criterion must be met at all points in the DPA
- The beamwidth and range of pointing azimuth of the receive antenna for the protected system, to be used in determining compliance with the protection criterion
- DPA neighborhood distances for Category A and B, and for in-band and OOB protection (four total values)

The KML files may be updated by NTIA, in conjunction with FCC and DoD, at any time. SASs must implement protections as defined in the latest versions of the files.

3 Inband FSS Incumbents

3.1 Grandfathered Earth Stations that Qualify for Interference Protection

Although the conventional satellite C-band does not extend below 3700 MHz, some earth stations in the U.S. operate in the extended C-band, and may be registered to operate at frequencies as low as 3600 MHz, thereby overlapping with as much as 100 MHz of the CBRS band, potentially including both GAA and PAL. The FCC rules require that CBRS protect certain grandfathered earth stations that operate in the extended C-band. Only those earth stations that have already qualified for grandfathered status are protected. Earth stations that have not been deemed to qualify for grandfathered status may operate below 3700 MHz but are not entitled to protection from CBRS operations. No new grandfathered earth stations will be designated.

In the past, the FCC published a list of grandfathered earth stations. This list was for the purpose of establishing those earth stations that qualified for grandfathered protection from Part 90 wireless broadband systems operating in the 3650-3700 MHz band. Any grandfathered earth stations requesting protection from CBRS must separately register their earth station in a new FCC database designed for this purpose. Only grandfathered earth station sites (i.e., earth station sites that were in the original Part 90 list) are eligible to register for CBRS protections.

See Annex B for maps for FSS sites that are eligible for grandfathered protections, and maps of the subset of those sites that have registered for protections from CBRS as of March 2020.

3.2 Inband FSS Protection Methods

There are two methods to protect FSS. The method used depends on the frequency range and license status of any Part 90 devices within 150 km of the FSS, as described in the table below.

- **Exclusion Zone**. No CBRS operations allowed within 150 km of the coordinates of the grandfathered FSS site, unless alternate arrangements have been made with the FSS operator. This method applies only to 3650-3700 MHz.

- **Protection Zone**. The FSS earth station is protected from aggregate interference from CBRS devices within 150 km of the earth station coordinates.

The table below summarizes which method is used:

Table 3: FSS Protection Methods

Frequency Range	Condition	Protection Method
3600-3650 MHz	N/A	Protection Zone
3650-3700 MHz	At least one unexpired Part 90 device exists within 150 km of the grandfathered earth station coordinates	Exclusion Zone
	No unexpired Part 90 device exists within 150 km of the grandfathered earth station coordinates	Protection Zone

Note that the last Part 90 licenses expire in January 2023, so some FSS exclusion zones could exist as late as that time unless alternate arrangements are made with FSS operators.

3.3 Inband FSS Protection Criteria

Under the protection zone method, inband FSS is protected from aggregate passband and blocking interference as described in the FCC's rules (47 CFR 96.17). See that rule section for details.

- All co-channel CBSDs out to 150 km must be included in the aggregate passband interference calculation.

- All CBSDs (regardless of frequency) out to 40 km must be included in the aggregate blocking interference calculation.

3.4 Special Considerations

There is no deadline for registering a grandfathered-eligible FSS site in the new FCC registration database, therefore even if a site is not currently registered for protection from CBRS, it could register for such protections at any time in the future, as long as its coincident (or within 10 miles) of a site previously deemed eligible for grandfathered protections.[1] This could cause 150-km exclusion zones or coordination zones to pop up suddenly.

[1] There is some ambiguity regarding whether a site is still eligible for gandfathered protections in the future if all earth stations associated with that site have expired prior to a new registration at or near the same site. SAS Administrators are seeking clarification from the FCC.

4 Adjacent Band TT&C FSS Incumbents

4.1 Adjacent Band FSS Sites that Qualify for Protection

FSS receive-only earth stations operating in the 3700-4200 MHz band and that are used for Telemetry, Telecommand, and Control (TT&C) of satellites are protected from aggregate interference caused by CBRS in the adjacent band. TT&C FSS earth station operators must register their earth stations in the FCC's new registration database to be protected.

4.2 Adjacent Band FSS Protection Criteria

Adjacent band TT&C FSS is protected from aggregate passband interference due to CBRS OOB emissions, and from blocking interference due to CBRS, as described in the FCC's rules (47 CFR 96.17). All CBSDs within 40 km of a TT&C FSS site must be included in the aggregate interference calculation.

4.3 Special Considerations

There are no deadlines for registering a TT&C FSS site, so protection zones can pop up at any time. However, the impact to CBRS operations from either OOB or blocking protections is relatively small. Although there are some 18,000 registered C-band earth stations in the 3700-4200 MHz band, very few (about a dozen sites) have registered as TT&C sites as of March 2020.

See Annex C for maps of currently-registered TT&C sites.

5 Grandfathered Wireless Protection Zones

Prior to the opening of the CBRS band, there were a large number of Part 90 Subpart Z (Wireless Broadband Service) systems deployed in the 3650-3700 MHz band, under a lightly licensed scheme (see 47 CFR 90Z). Wireless Internet Service Providers (WISPs), utilities, and others have taken advantage of this band for broadband systems, SCADA operations, and other applications. The operators receive a nationwide license, then register in the FCC's ULS database individual devices such as base stations, hubs, customer premise equipment (CPE), and other devices. Low power devices less than 1 W, such as mobile devices, do not require registration in the ULS. Before deployment, the operator must coordinate their planned operations with other operators in the area to mitigate the potential for interference.

5.1 GWBLs and GWPZs

Moving forward, Part 90Z licensees are referred to as Grandfathered Wireless Broadband Licensees (GWBLs), although this term has come to be associated with the individual devices that licensees have registered in the ULS. In this discussion, the term GWBLs will refer to the individual devices. These devices are important because their expiration dates are used to determine when the 150 km exclusion zone around inband FSS sites expire (see the section on inband FSS protection).

The FCC is allowing Part 90 devices to continue to operate in the band until the operator's license expires, which can be as late as January 2023. However, operations are not protected from interference caused by CBRS unless the operator defines individual areas (either a point/radius or a point/radius/azimuth range, like a pie slice) in which their systems are operating. These areas are called Grandfathered Wireless Protection Zones (GWPZs). GWPZs are defined such that, for example, the base station is the central point, and the radius is large enough to encompass all of the CPEs that use that base station for broadband service. The FCC opened a filing window in 2017 for Part 90Z operators to define GWPZs to protect their operations.

Note that not all GWBLs (i.e., individual registered devices) are associated with a GWPZ. Some licensees did not register GWPZs encompassing all (or any) of their operations, and therefore some (or all) of their devices are not explicitly protected from interference caused by CBRS. There are approximately 90,000 GWBLs in the ULS database, and approximately 8,000 GWPZs that are registered. GWPZs are not registered in ULS, but are instead available in a separate database maintained by the FCC. The GWPZs are protected over their filed frequency range of operation, which is usually either 25 MHz wide (3650-3675 MHz or 3675-3700 MHz) or covers the entire 3650-3700 MHz band.

5.2 GWPZ Sunset

Part 90Z operations in GWPZs are protected from co-channel CBRS emissions until a sunset period defined by the FCC, based on when the licensee was originally licensed vis-a-vis when they were aware (by FCC releases) of the plan to transition the 3650-3700 MHz band to CBRS. As a result, many GWPZs were scheduled to sunset in April 2020, but some will sunset after that date, as late as January 2023. In March 2020, the FCC granted a waiver that allowed GWPZs expiring prior to October 17, 2020, to remain protected until October 17, 2020. The waiver order suspended acceptance and processing of new site registrations for all part 90 wireless broadband licensees in the 3650-3700 MHz band effective with applications received on or after March 18th, 2020.

5.3 GWPZ Protection Criteria

The SAS must protect GWPZs to an aggregate co-channel interference level of -80 dBm/10 MHz. A hybrid ITM/eHATA propagation model described in WInnForum specification TS-0112 is used by the SAS to model aggregate interference into the GWPZs. Unfortunately, the eHATA portion of this model utilizes a minimum CBSD antenna height of 20 m above ground level, which tends to significantly over-estimate the interference impacts of CBSDs with antenna heights well below 20 m (which is expected to be a large subset of deployed CBSDs). A 15 dB building penetration loss is used for indoor CBSDs in the SAS interference computations.

5.4 GWBLs and FSS Exclusion Zone Expiration

The FCC's rules stipulate that CBRS is excluded in the band 3650-3700 MHz for a distance of 150 km from an inband FSS site so long as a single unexpired GWBL exists within that 150-km zone, unless alternative coordination arrangements are made with the FSS operator. Because GWBLs may expire as late as January 2023, this rule can have significant impact on CBRS near some inband FSS sites until then, absent alternative agreements with the FSS operator.

6 PAL Protection Areas

PALs are not considered incumbents, however by the three-tier nature of CBRS, they are protected from interference caused by GAA and by other PALs and therefore can impact CBRS operations in their surrounding area.

PALs are only protected in areas in which their CBSDs are actually operating. PALs are not protected in those parts of their license area in which they are not operating. However, PAL licensees can deploy CBSDs at any time, and are granted protections where CBSDs are deployed immediately (subject to the 24-hour cadence of data exchanges among SASs).

PALs are only protected from co-channel interference. They are not protected from interference from CBRS operations on frequencies outside the PAL licensed frequency range.

A PAL license, which is a 10 MHz channel within the 3550 to 3650 MHz band, is available to a PAL owner throughout the licensed county. A PAL owner can either choose to deploy CBSDs and claim a PPA or lease a portion of the county for the lessee to claim their own PPA.

6.1 PAL Protection Area (PPA)

A licensee establishes a PAL Protection Area (PPA) for a CBSD or group of CBSDs operating under a PAL license. The PPA is based on the predicted -96 dBm/10 MHz service contour of the CBSD(s) or a substantially similar methodology used by the operator. At all points within the PPA, SASs protect the PALs from aggregate co-channel interference to a level of -80 dBm/10 MHz, as received by an isotropic (0 dBi) antenna at a height of 1.5 m above ground level. All co-channel CBSDs within 40 km of a particular point in the PPA must be included in the aggregate interference calculation.

6.2 Obtaining Information about Spectrum Occupied by PPAs

Specific locations of CBSDs authorized by SASs, including CBSDs operating as PAL and the descriptions of PPAs, are not publicly available. Potential CBRS users should inquire with a SAS Administrator for information regarding current spectrum availability, including the impact of PPAs.

7 ESC Sensors

ESC Operators deploy sensors around the coastline of the U.S. for the purpose of detecting federal incumbent radar activity. These sensors operate in the 3550-3650 MHz portion of the CBRS band. Because the sensors have to listen for potentially weak signals from distant radars,

they must be protected from interference caused by nearby CBSDs. This protection can impact the availability of spectrum across all PAL channels, and some GAA frequencies, in the area.

7.1 ESC Sensor Protection Criterion

The interference criterion is an aggregate mean interference level of -109 dBm/MHz at the input of the sensor, taking into account the sensor's effective antenna pattern. All Category A CBSDs out to a distance of 40 km from the ESC sensor, and all Category B CBSDs out to a distance of 80 km, must be included in the aggregate interference calculation.

To account for ESC sensor filter roll-off, Category A CBSDs up to 3660 MHz and Category B CBSDs up to 3680 MHz are included in the calculation, and are treated as co-channel to the ESC sensor after assuming a filter response as specified in R2-SGN-25 of TS-0112. CBSDs above these frequencies are not included in the interference calculation.

7.2 Obtaining Information about ESC Sensor Occupancy

Specific locations of ESC sensors are not publicly available. Potential CBRS users should inquire with a SAS Administrator for information regarding current spectrum availability, including the impact of ESC sensors.

8 Quiet Zones and Coordination Zones

The FCC's rules require protection of certain quiet zones and coordination zones, which exist to support radio science and government monitoring stations, among other purposes. Such zones are defined in 47 CFR 1.924 of the FCC's rules.

In total, there are 17 quiet or coordination zones that impact the 150-MHz CBRS band as defined in 47 CFR 1.924. Three quiet zones consist of the National Radio Astronomy Observatory (NRAO) site at Green Bank, WV, the Department of Commerce research laboratories at Table Mountain in Boulder, CO, and the Arecibo Observatory in PR. The rest of the quiet zones are the 14 FCC protected field offices across the US.

8.1 The National Radio Quiet Zone

The NRQZ exists to protect the Green Bank Observatory in Green Bank, WV, and a nearby military monitoring site. The NRQZ is approximately 33,000 km2 in area and impacts significant parts of WV, as well as portions of VA and MD. Currently, SASs do not authorize any CBSD emissions inside the NRQZ, pending methods to implement NRQZ coordination.

8.2 The Puerto Rico Coordination Zone

The PRCZ exists to protect the Arecibo Observatory from interference. The zone includes the entire island of Puerto Rico and nearby islands. The PRCZ requires notification/coordination with Arecibo Observatory prior to commencement of operations.

8.3 FCC Field Offices

The FCC operates 14 protected field offices around the U.S. for which interference to their monitoring activities caused by CBRS must be considered. The coordinates of protected field offices are in 47 CFR 0.121. Interference protection for these sites has been implemented by forbidding Category A CBSDs within 2.4 km, and Category B CBSDs within 4.8 km, of the listed coordinates.

8.4 Table Mountain Radio Receiving Zone

The Department of Commerce operates a radio research facility on Table Mountain, outside of Boulder, CO. The facility is protected from radio interference caused by CBRS and other services. CBRS protections are implemented by requiring that a CBRS user present a SAS with evidence of coordination with the Table Mountain facility prior to a SAS providing a spectrum grant if the CBSD is within the following distance of Table Mountain:

Table 4: Table Mountain (Colorado) Coordination Distances

CBSD Category	Total CBSD Operating Bandwidth (BW)	Coordination Distance (km)
A	Any bandwidth	3.8
B	BW ≤ 10 MHz	38
	10 MHz < BW ≤ 20 MHz	54
	20 MHz < BW ≤ 30 MHz	64
	BW > 30 MHz	80

In the absence of evidence of coordination, SASs will not authorize spectrum grants within these coordination distances.

The reference point for the distance calculation is 40.130660 N, 105.244596 W, as established in R2-SGN-18 of WInnForum standard TS-0112. Note that these coordinates are slightly different than those defined in 47 CFR 1.924(b)(1). The interference criterion is a predicted signal strength, using median ITM pathloss, across the entire signal bandwidth, of no more than -88.4 dBm as received by an isotropic antenna located at a height of 9 m above ground level at the specified reference point.

9 Canada/Mexico Protections

CBRS is required to respect international coordination agreements with Canada and Mexico.

9.1 Mexico

Currently, there are no agreements in place with Mexico that cover CBRS frequencies.

9.2 Canada

The U.S. has a coordination agreement with Canada (Arrangement R) that was created to cover Part 90 wireless broadband systems operating in 3650-3700 MHz, but which has been applied to CBRS in the same frequency range as well. In addition, Arrangement R protects one Canadian FSS earth station facility in the 3615-3620 MHz range. The earth station is in Quebec, northwest of Montreal, and is approximately 85 km from the closest point on the U.S. border.

The method to implement protections under Arrangement R are detailed in R2-SGN-19 of the WInnForum TS-0112 standard. The reader should refer to R2-SGN-19 for more information, but generally speaking, a SAS must determine if the emissions from a CBSD will meet a specified interference protection threshold at the border. The SAS must do such a calculation for all CBSDs within 8 km of the border if the CBSD's antenna points generally away from the border; and within 56 km of the border if the CBSD's antenna points generally towards the border.

All CBSDs operating in the 3615-3620 MHz range that are within 150 km of the Canadian earth station described in Arrangement R must meet the same aggregate interference limit as is used for protections of in-band U.S. earth stations.

10 Annex A: Maps Related to Federal Government Incumbent Activity

The following pages show maps related to federal government Dynamic Protection Areas and exclusion zones. Because some maps contain detail that is difficult to reproduce in a small number of maps, the reader should download the referenced KML files and view them in an appropriate utility, such as Google Earth, to examine the data in detail.

Important notes:

- The maps are shown for informational purposes only and should not be relied upon for planning CBRS strategy or deployments
- Refer to the section on federal incumbent protections for more information
- DPAs have currently been defined only for the contiguous U.S., Alaska, Hawaii, Puerto Rico, U.S. Virgin Islands, and Guam
- All federal incumbent data can change with time
- Contact a SAS Administrator for the most up-to-date information

10.1 Map of E-DPAs for Contiguous U.S.

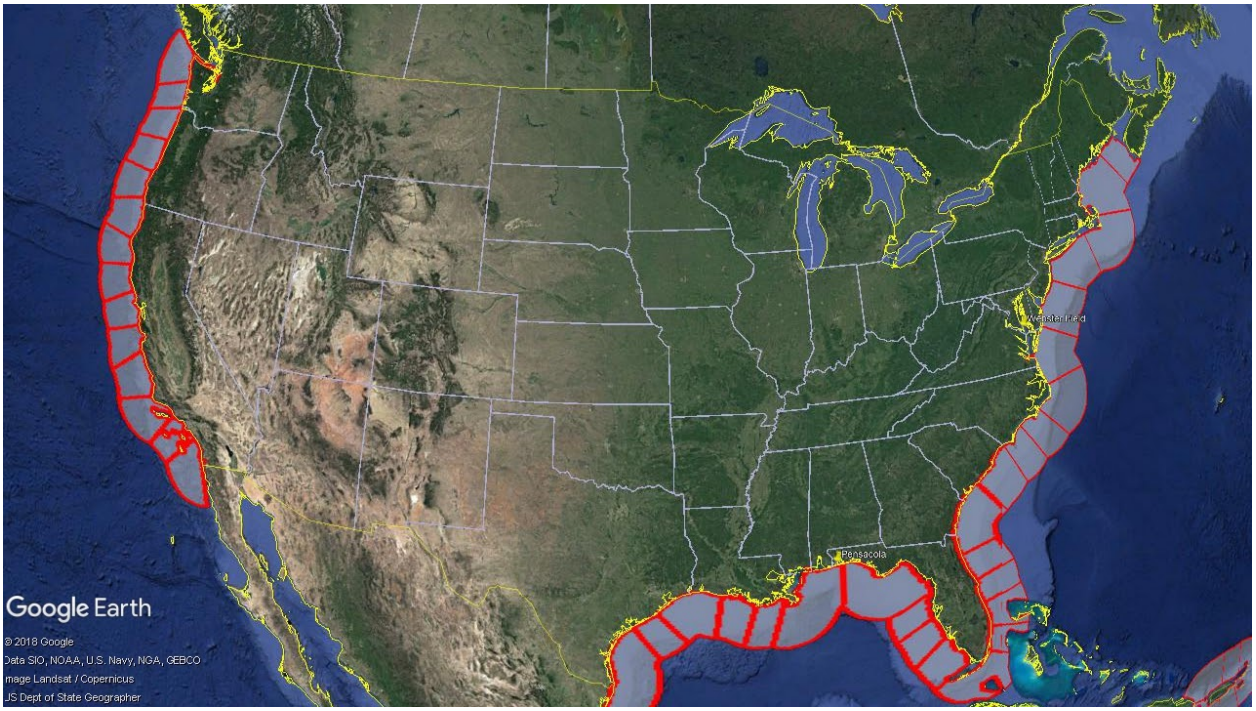

Figure A- 1 ESC-monitored Dynamic Protection Areas (DPAs) (i.e., E-DPAs) for the contiguous U.S. Source: e-dpas.kml (NTIA).

10.2 Map of E-DPAs for Alaska

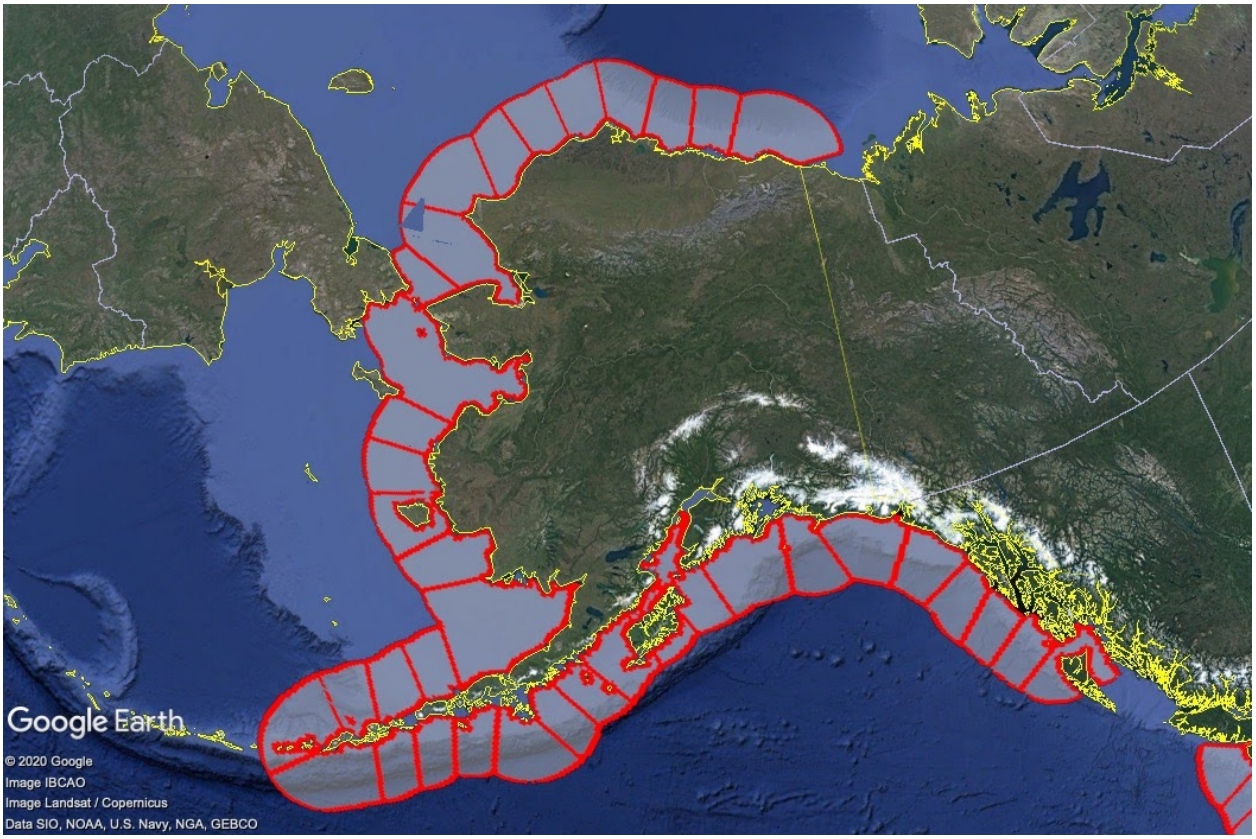

Figure A- 2: E-DPAs for Alaska. Source: e-dpas.kml (NTIA).

10.3 Map of E-DPAs for Hawaii

Figure A- 3 Figure A-3: E-DPAs for Hawaii. Source: e-dpas.kml (NTIA).

10.4 Map of E-DPAs for Puerto Rico and the U.S. Virgin Islands

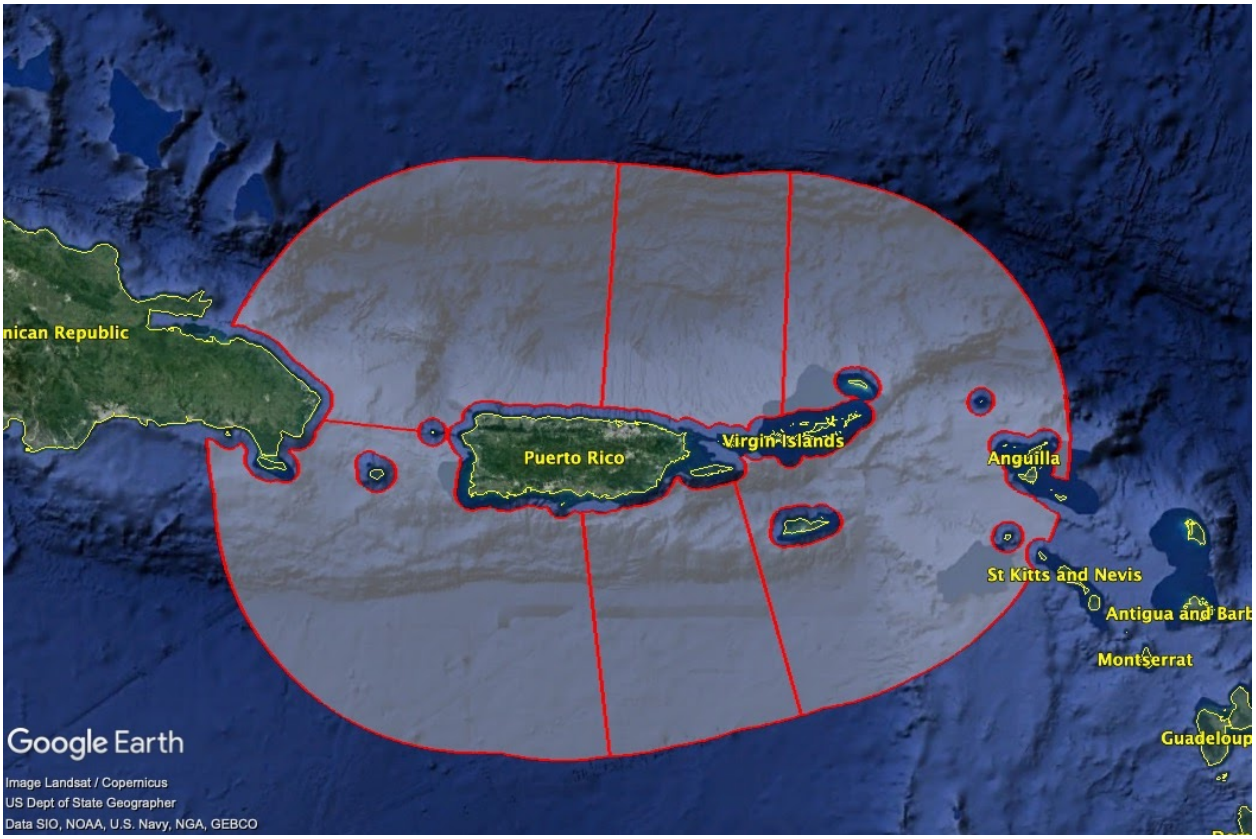

Figure A- 4: E-DPAs for Puerto Rico and the U.S. Virgin Islands. Source: e-dpas.kml (NTIA).

10.5 Map of E-DPAs for Guam

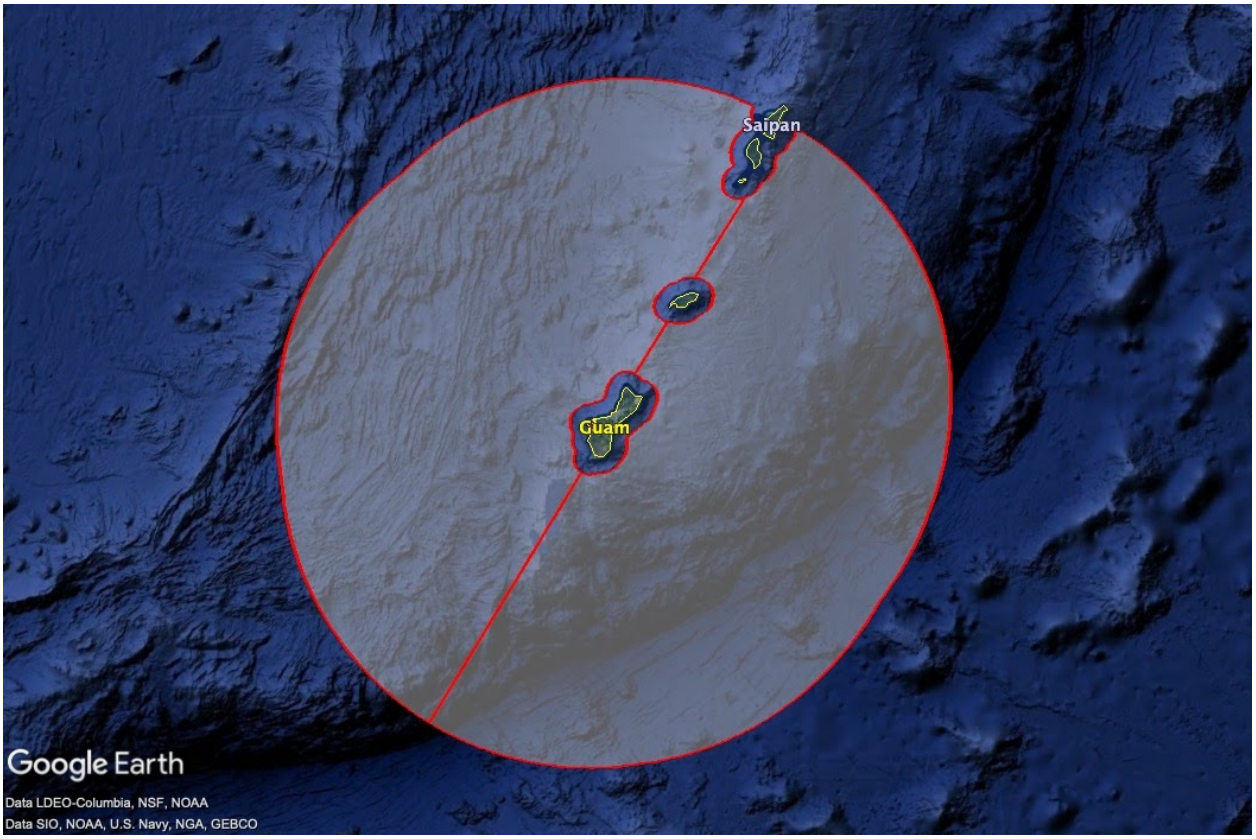

Figure A- 5 E-DPAs for Guam. Source: e-dpas.kml (NTIA).

10.6 Map of Category B E-DPA Neighborhoods for Contiguous U.S.

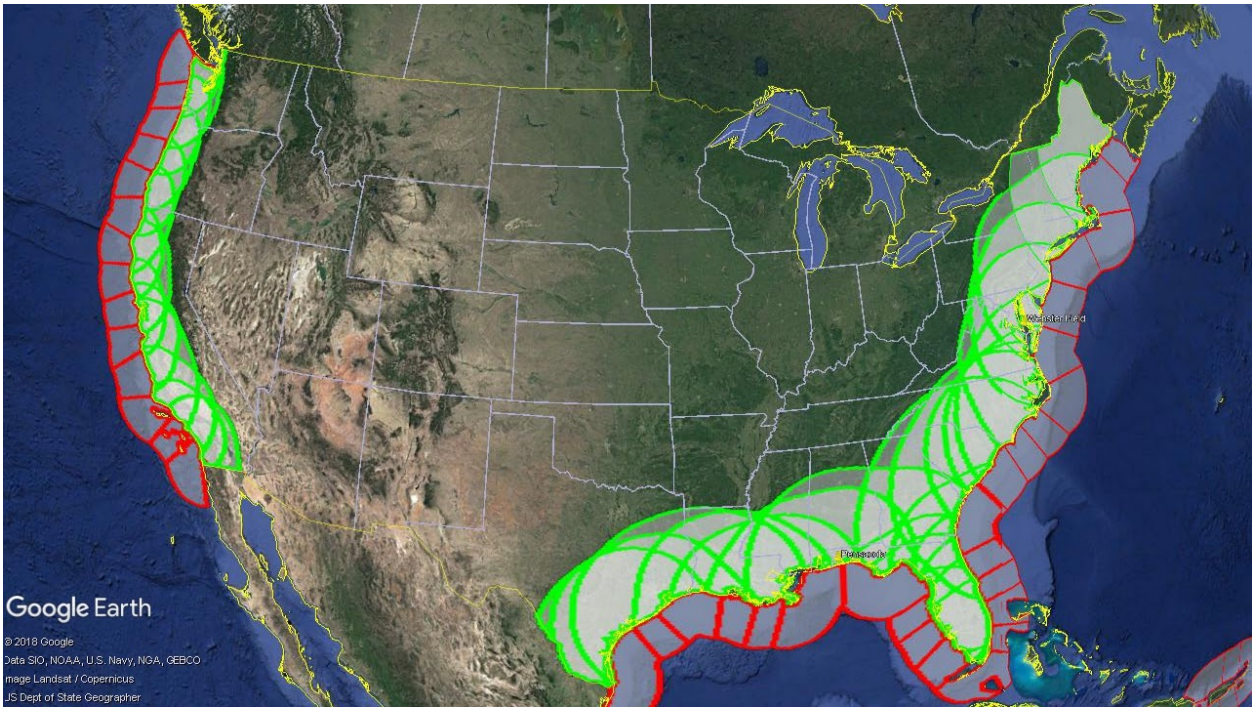

Figure A- 6 : Category B DPA neighborhoods (green areas) for E-DPAs (red) in the contiguous U.S.

10.7 Map of P-DPAs for Contiguous U.S.

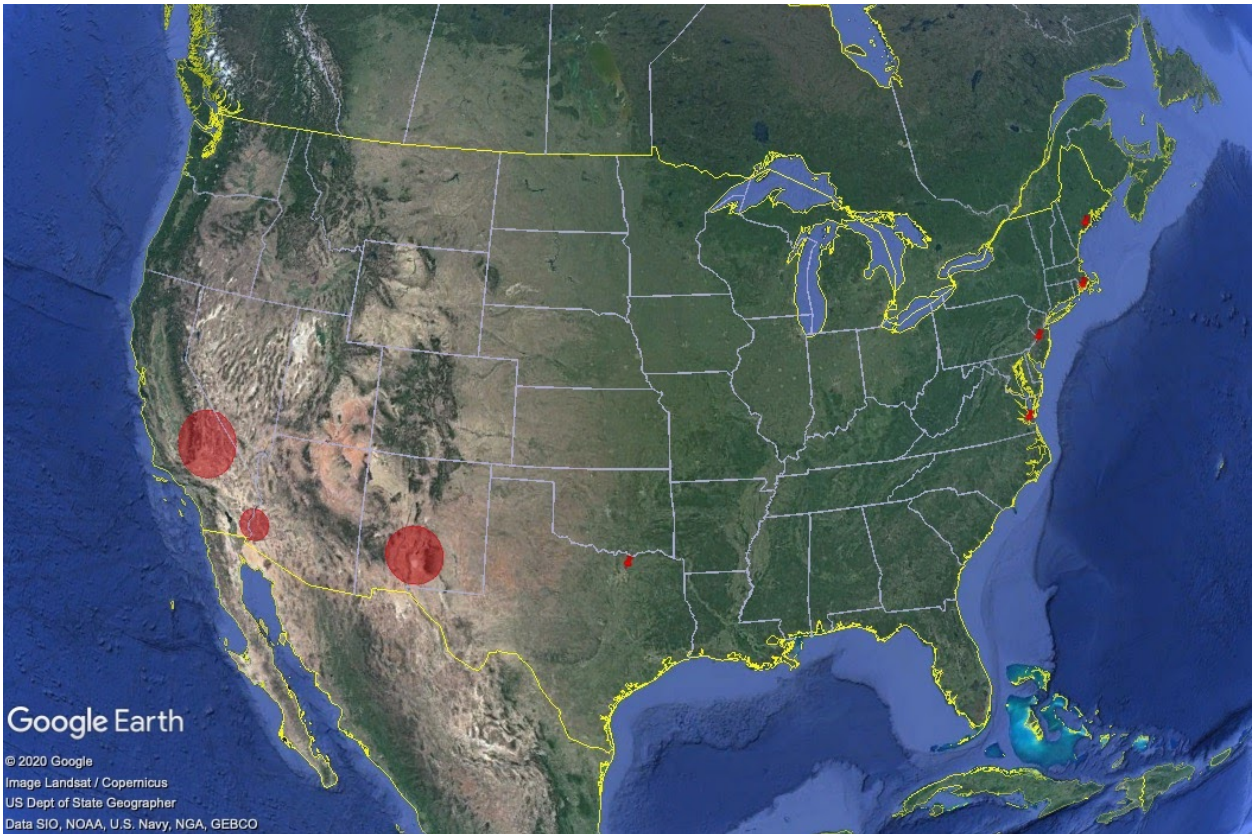

Figure A- 7 : Portal-controlled DPAs (P-DPAs) for the contiguous U.S. Point DPAs are shown by red pushpins, area DPAs are shown as red areas. Source: p-dpas.kml (NTIA).

10.8 Close-up of P-DPAs for Mid-Atlantic Region

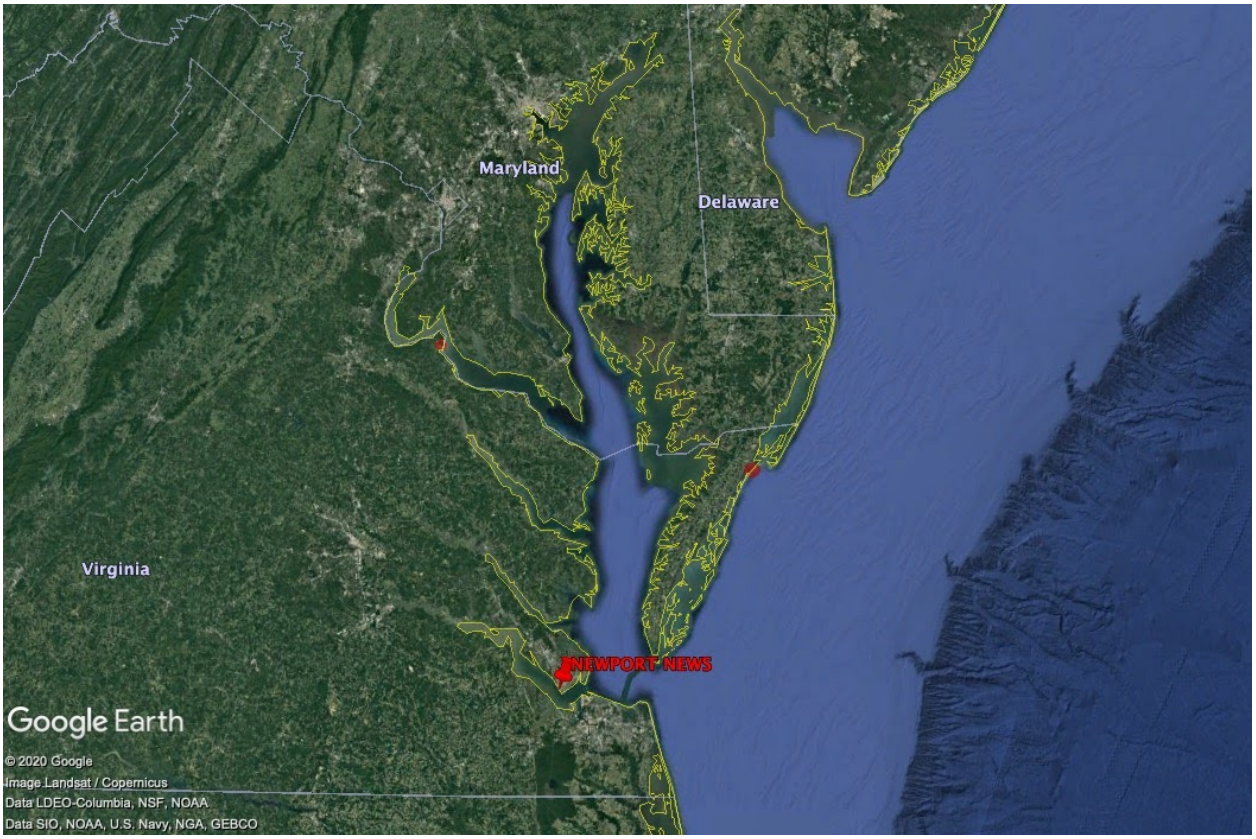

Figure A- 8 : Close-up of P-DPAs in Virginia showing Dahlgren (left center), Wallops Island (below center right), and Newport News (lower center) DPAs. Source: p-dpas.kml (NTIA).

10.9 Map of P-DPA for Hawaii

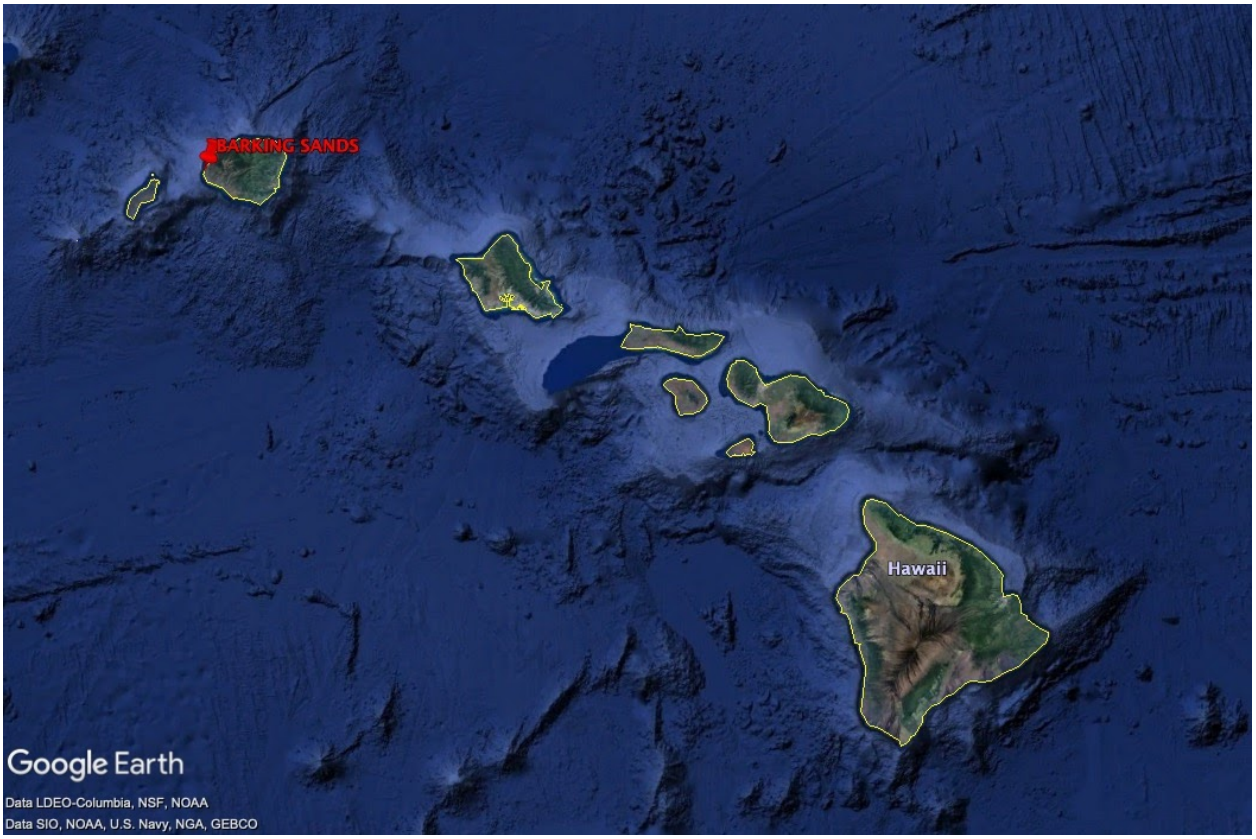

Figure A- 9 : Barking Sands P-DPA in Hawaii. Source: p-dpas.kml (NTIA).

10.10 Category B P-DPA Neighborhoods in the Contiguous U.S.

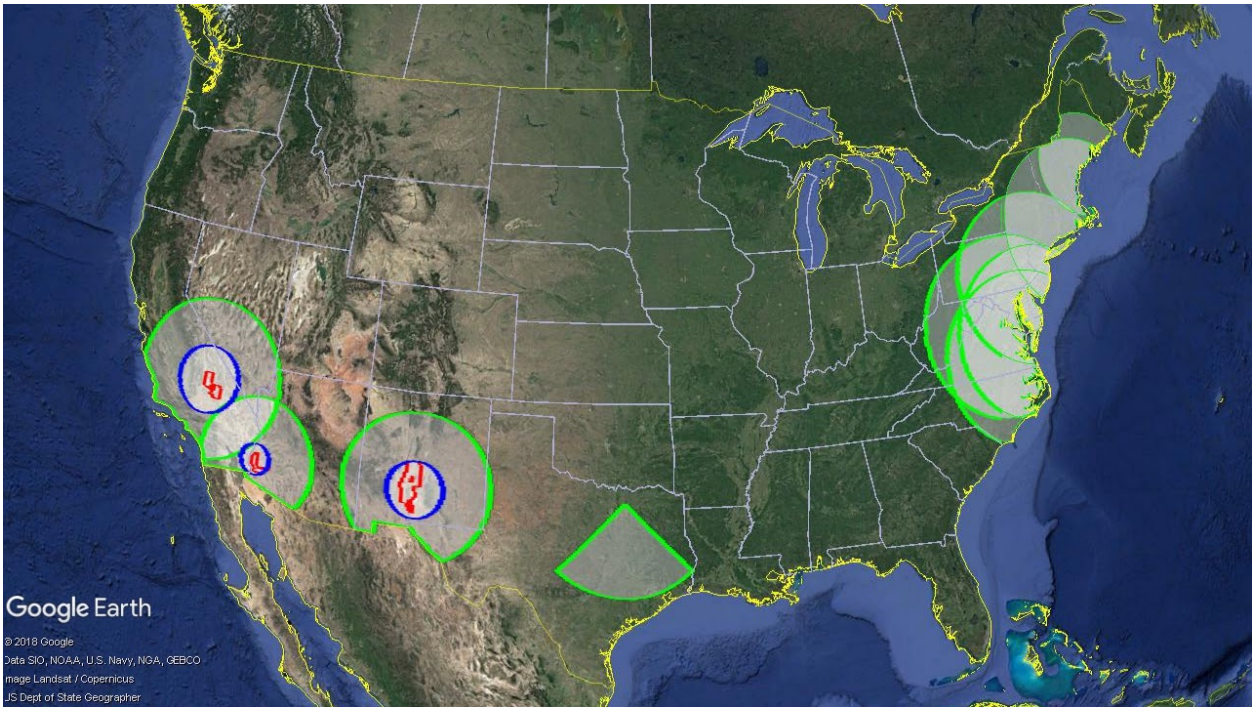

Figure A- 10: Category B neighborhoods surrounding P-DPAs in the contiguous U.S.

10.11 Map of GB-DPAs (southwest U.S.)

Figure A- 11: GB-DPAs in the southwest U.S. (white areas surrounded by red borders). Source: GB-DPAS.kml (NTIA).

10.12 Map of GB-DPAs (Texas/Oklahoma)

Figure A- 12: GB-DPAs in Texas (small area west of Dallas) and Oklahoma. Source: GB-DPAS.kml (NTIA).

10.13 Map of GB-DPAs (North and South Carolina)

Figure A- 13: GB-DPAs in North Carolina and South Carolina (small white area surrounded by red border southwest of Charleston). Source: GB-DPAS.kml (NTIA).

10.14 Map of GB-DPAs (Virginia Beach, VA)

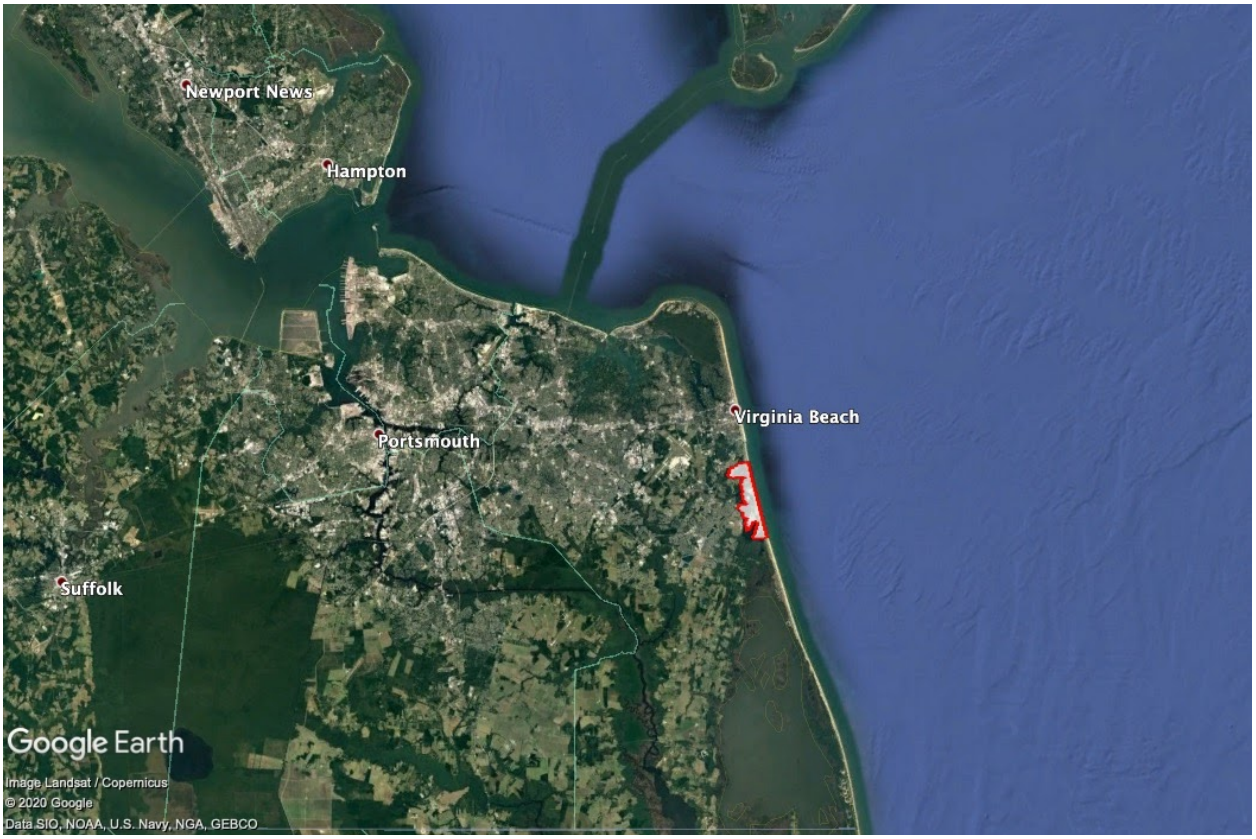

Figure A- 14: GB-DPA in Virginia Beach, VA. Source: GB-DPAS.kml (NTIA).

10.15 Map of GB-DPAs (Pennsylvania)

Figure A- 15: GB-DPA in Pennsylvania. Source: GB-DPAS.kml (NTIA).

10.16 Map of Exclusion Zones

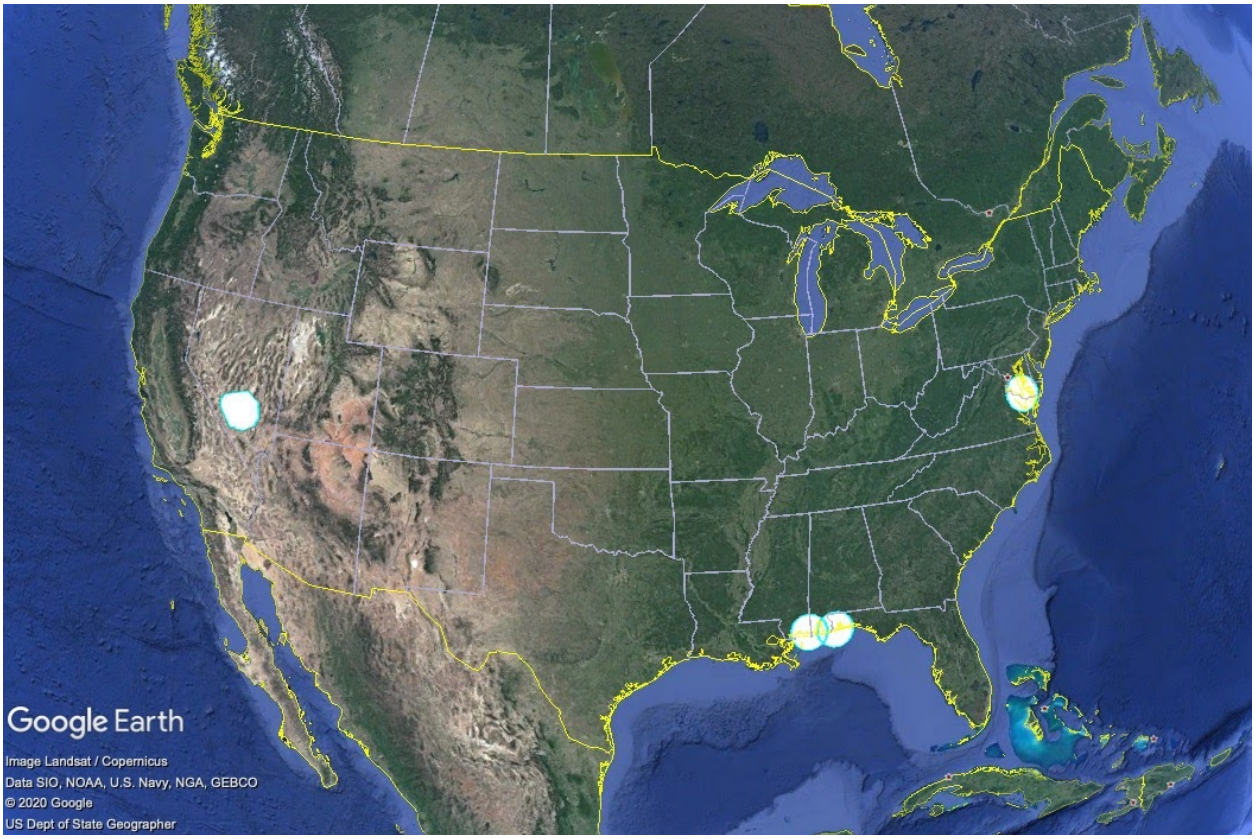

Figure A- 16: Federal exclusion zones. The Nevada Test and Training Range covers 3550-3650 MHz. The other three zones cover 3650-3700 MHz. Source: EXZ.kml (NTIA).

11 Annex B: Maps Related to Inband Fixed-Satellite Service Protections

The following page shows maps of grandfathered inband fixed-satellite service (FSS) sites. The maps are shown for informational purposes only and should not be relied upon for planning CBRS strategy or deployments.

11.1 Map of FSS Sites Eligible to Register for Grandfathered Protections (Contiguous U.S.)

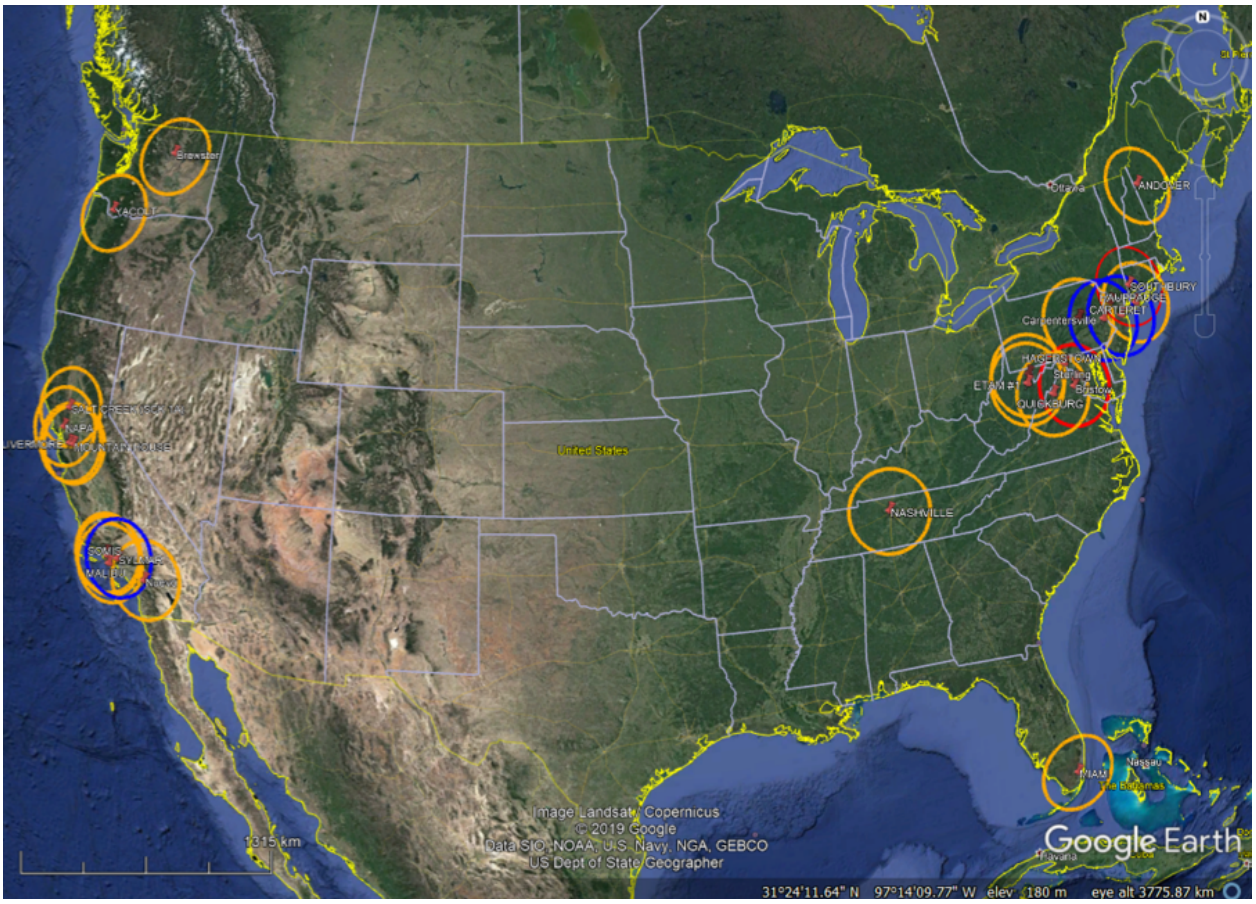

Figure B- 1: The FSS earth station sites that are eligible to register for grandfathered protections from CBRS. Only a subset of such sites have registered for CBRS protections (see next figure). The circles denote 150 km radius of the site coordinates. Source: FCC.

11.2 Map of FSS Sites Eligible to Register for Grandfathered Protections (Hawaii)

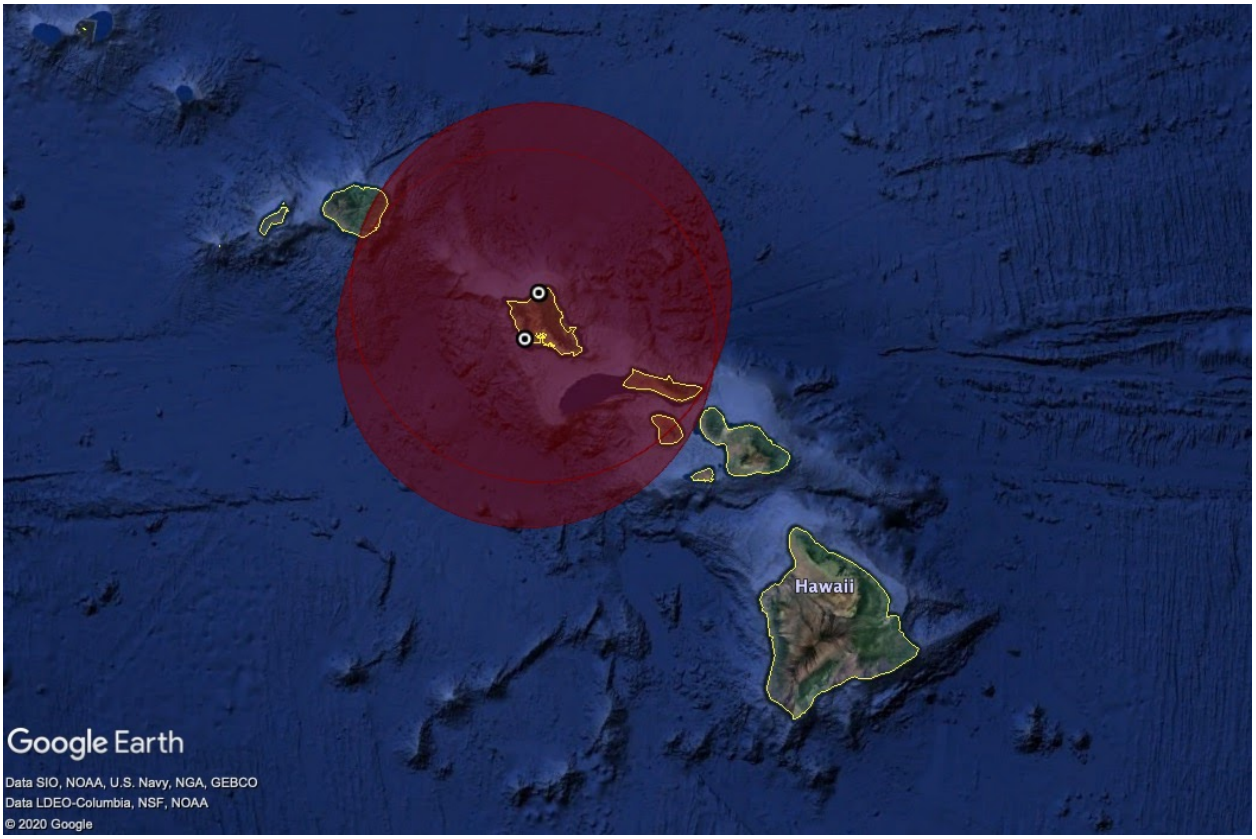

Figure B- 2: The FSS earth station sites (white dots) in Hawaii that are eligible to register for grandfathered protections from CBRS, with 150-km radius circles denoting the exclusion/protection zones.

The northern site operates down to 3625 MHz. The southern site operates down to 3640 MHz. Source: FCC.

11.3 Map of FSS Sites Eligible to Register for Grandfathered Protections (Puerto Rico)

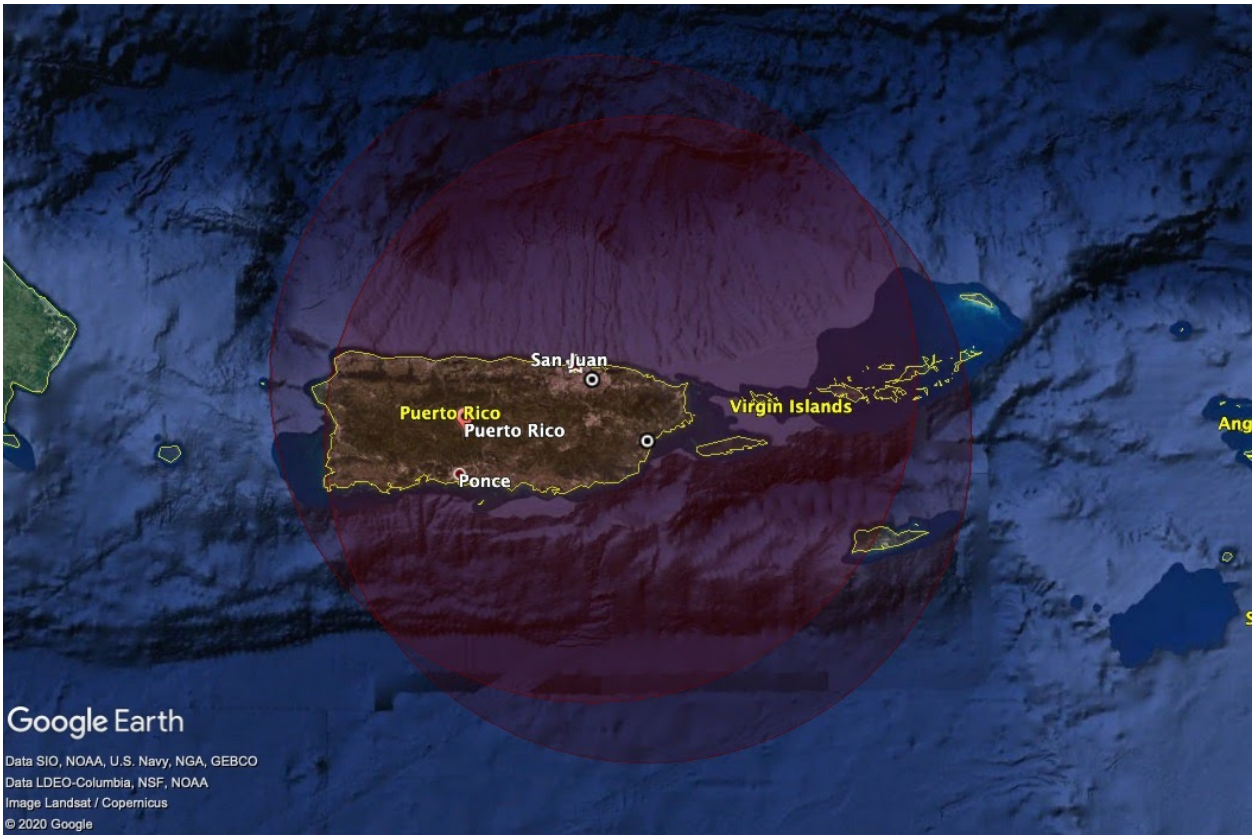

Figure B- 3: The FSS earth station sites (white dots) in Puerto Rico that are eligible to register for grandfathered protections from CBRS, with 150-km radius circles denoting the exclusion/protection zones. Both sites operate down to 3625 MHz.

Source: FCC.

11.4 Map of FSS Site Eligible to Register for Grandfathered Protections (Guam)

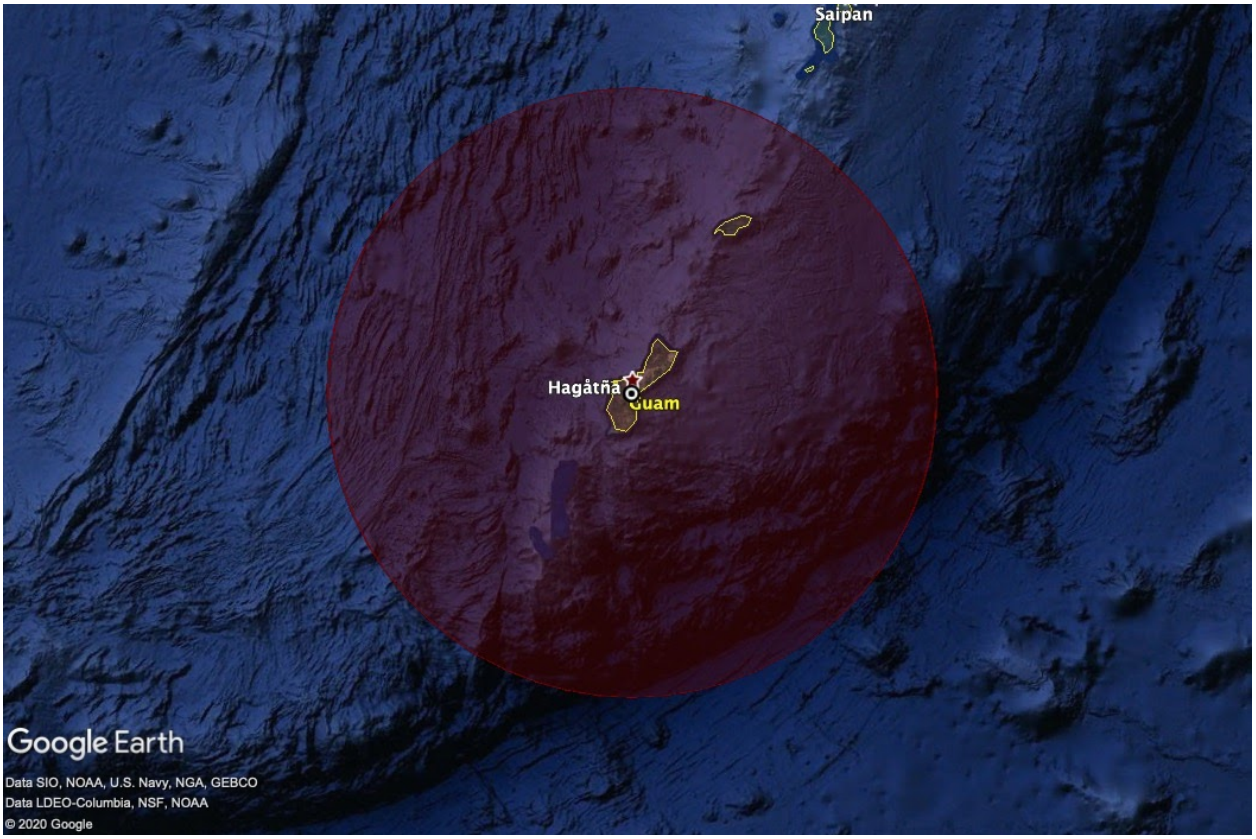

Figure B- 4: The FSS earth station site (white dot) in Guam that is eligible to register for grandfathered protections from CBRS, with a 150-km radius circle denoting the exclusion/protection zone. The site operates down to 3625 MHz.

Source: FCC.

11.5 Map of FSS Sites that have Registered for Grandfathered Protections (Contiguous U.S.)

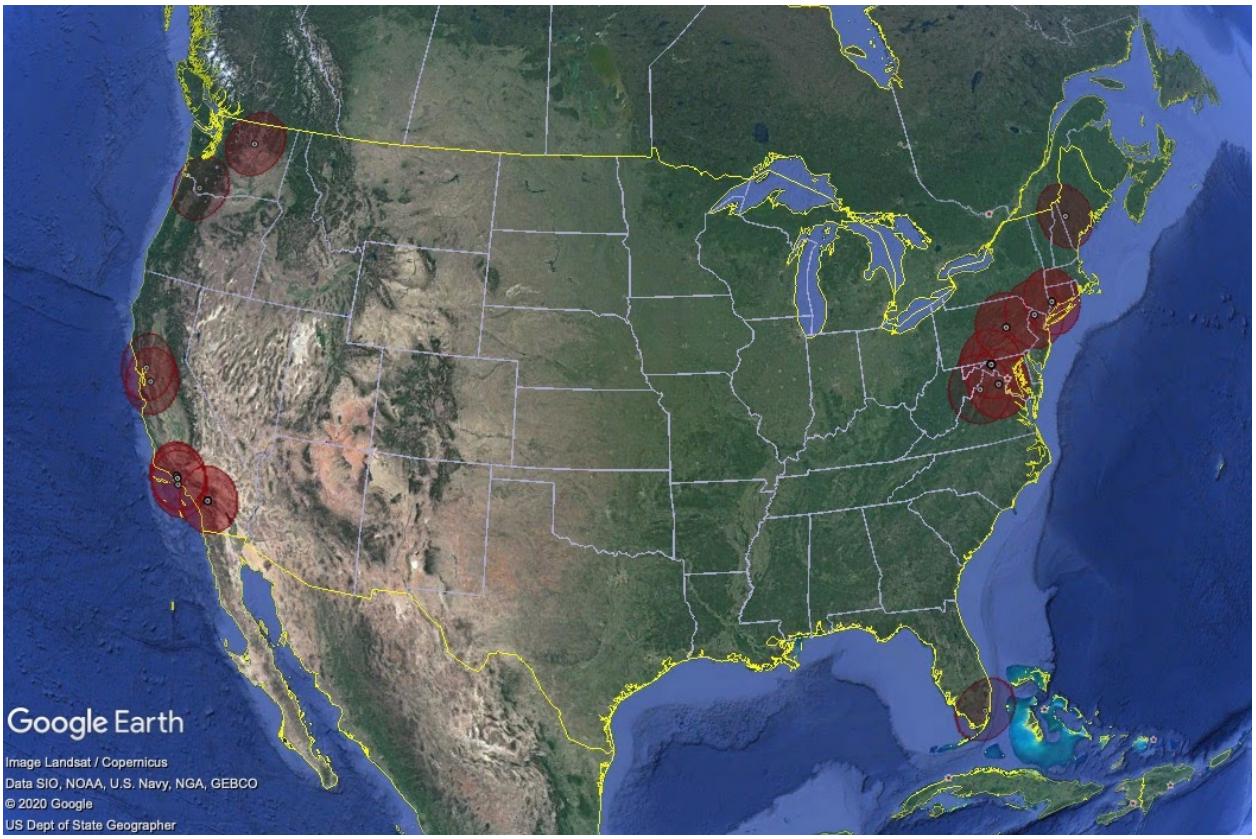

Figure B- 5: The inband FSS sites that are eligible for grandfathered protections and that have registered for protections from CBRS interference as of March 15th, 2020, with 150 km radius zones drawn around them.

Data source: FCC.

11.6 Map of FSS Site that has Registered for Grandfathered Protections (Hawaii)

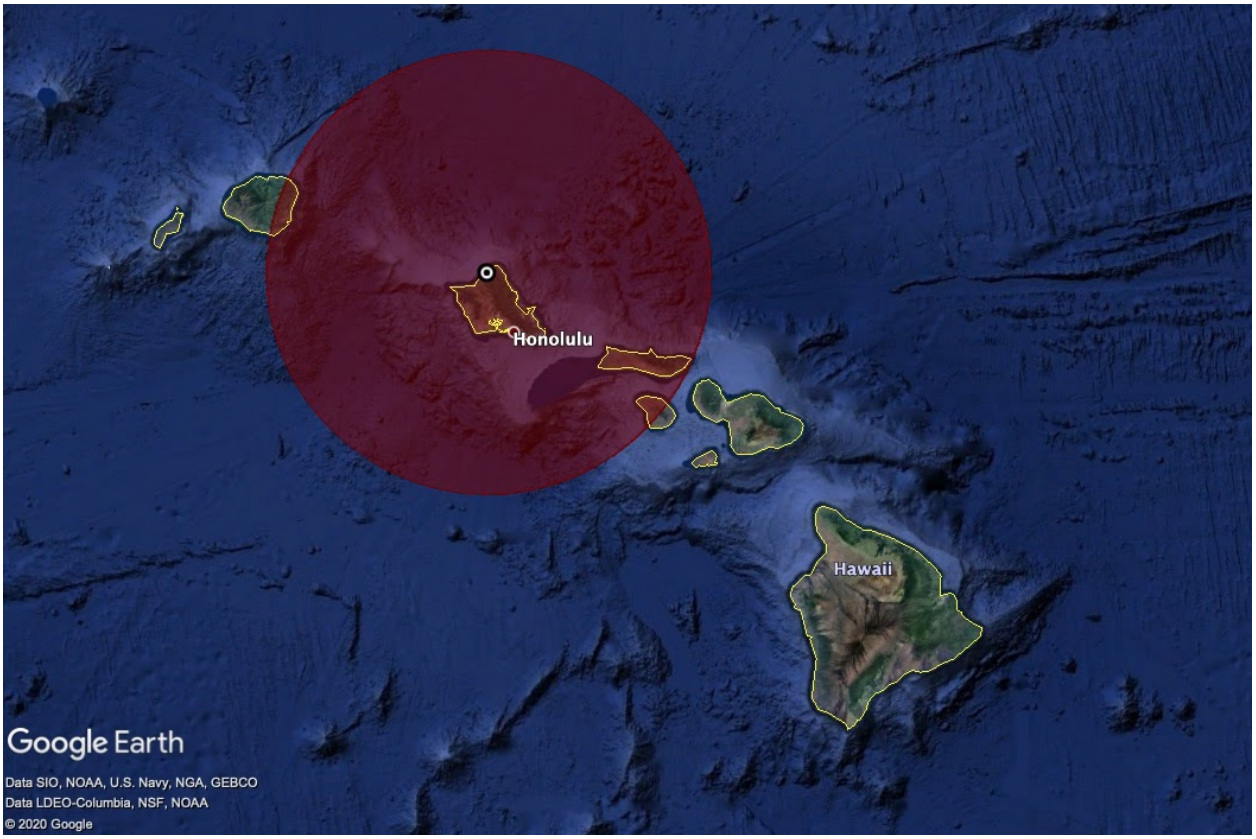

Figure B- 6: The inband FSS site in Hawaii that is eligible for grandfathered protections and that has registered for protections from CBRS interference as of March 15th, 2020, with a 150 km radius zone drawn around it. The site registered for operations down to 3600 MHz.

Data source: FCC.

12 Annex C: Map of Adjacent Band Fixed-Satellite Service TT&C Protections

The following is a snapshot of currently-registered adjacent band FSS TT&C sites. Registrations may change over time. The map is shown for informational purposes only and should not be relied upon for planning CBRS strategy or deployments.

12.1 Map of Currently-Registered Adjacent Band TT&C FSS Earth Station Locations

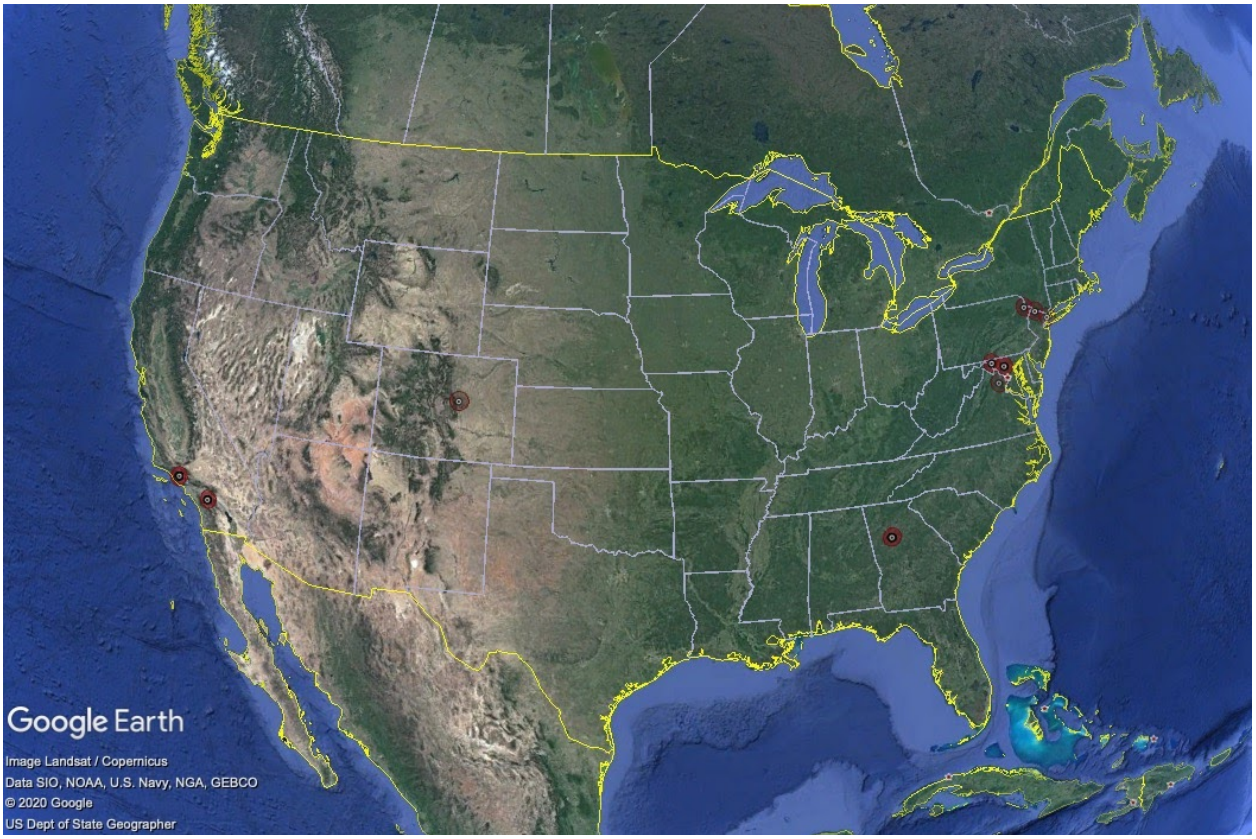

Figure C- 1: Figure C-1: FSS earth station sites in the adjacent 3700-4200 MHz band that operate TT&C and have registered for protections from CBRS interference. Zones of 40 km radius have been drawn around the sites to represent the extent of the area in which the contributions of all CBSDs must be considered. The data are as of March 15th, 2020. Data source: FCC.

12.2 Map of Currently-Registered Adjacent Band TT&C FSS Earth Station Location (HI)

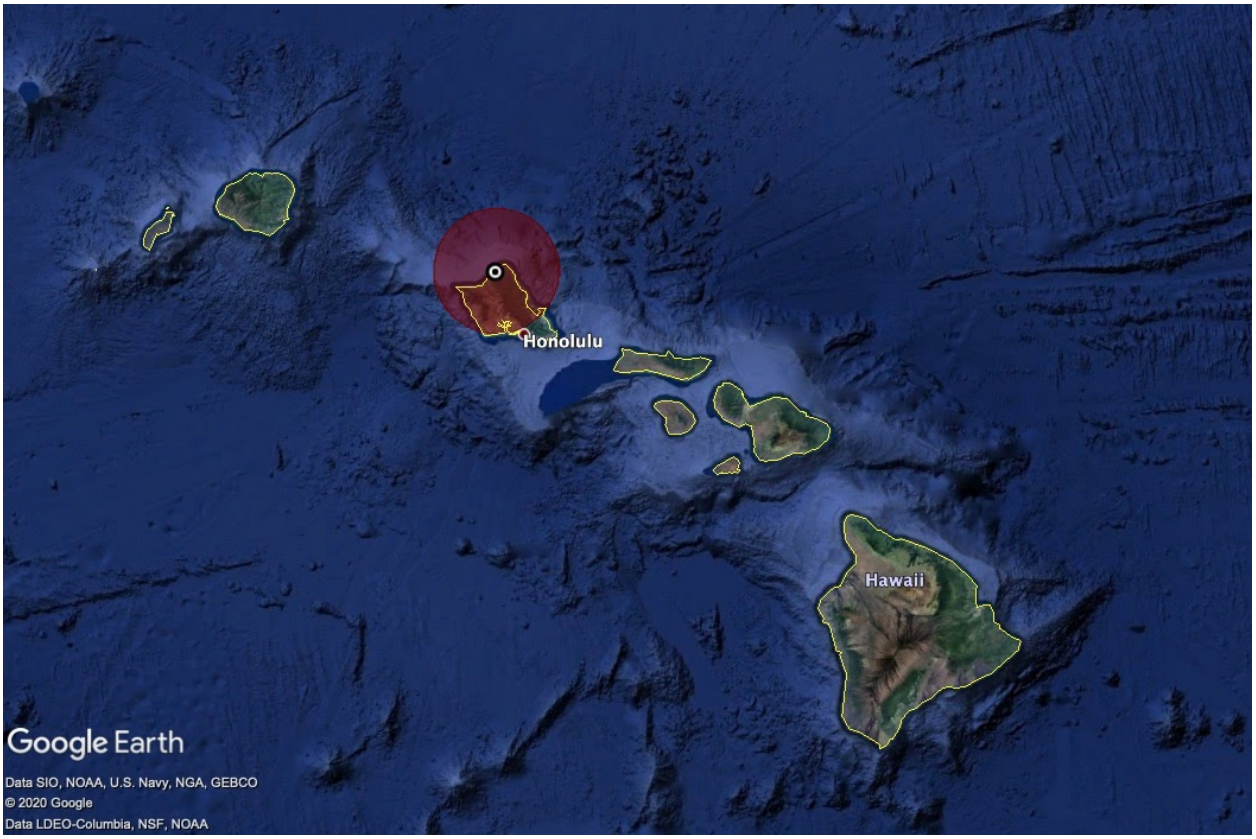

Figure C- 2: FSS earth station site in Hawaii in the adjacent 3700-4200 MHz band that operates TT&C and has registered for protections from CBRS interference. A zone of 40 km radius has been drawn around the site to represent the extent of the area in which the contributions of all CBSDs must be considered. The data are as of March 15th, 2020. Data source: FCC.

13 Annex D: Maps of GWPZs and GWBLs

The following maps show the registered GWPZs and GWBLs. Note that there are currently no GWPZs defined outside of the contiguous U.S., Hawaii, Puerto Rico, and the U.S. Virgin Islands. These maps are for informational purposes only and should not be relied upon for planning CBRS strategy or deployments.

13.1 GWPZ Example 1

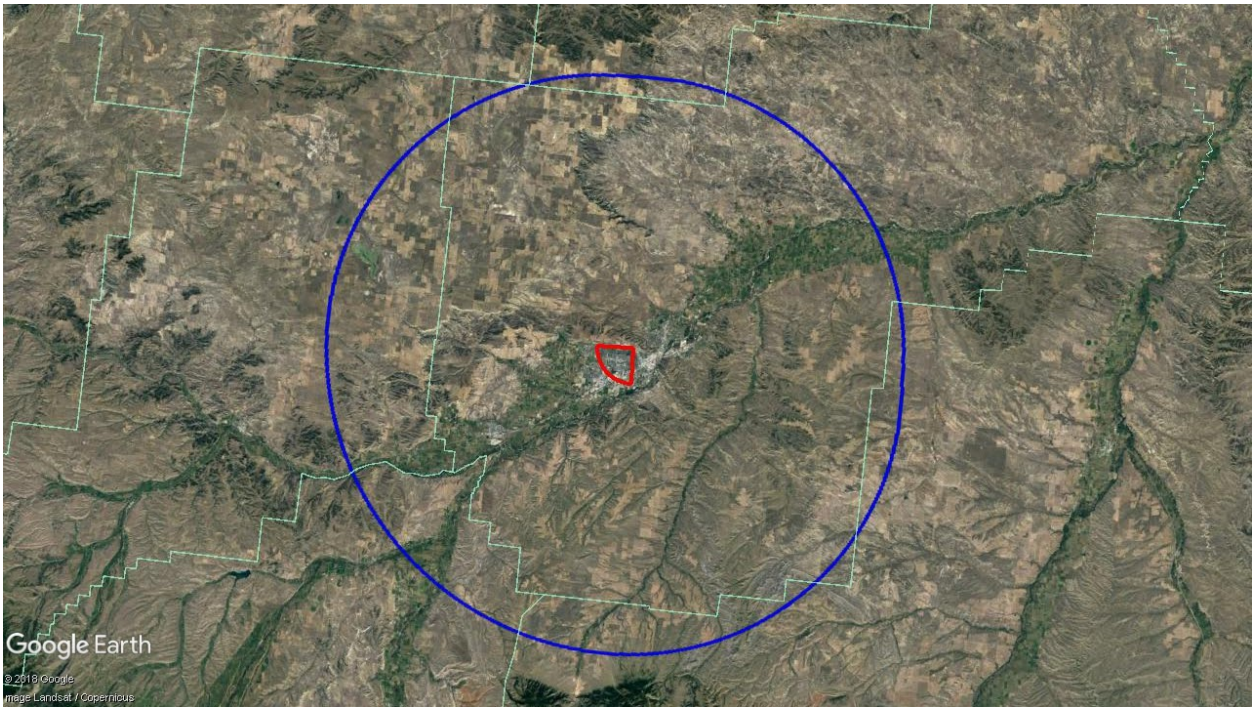

Figure D- 1: One example of a GWPZ. The GWPZ is a red pie-shaped wedge, with a base station at the vertex, in communication with customer devices over a defined range of azimuth and maximum radius. The blue shape is a 40 km zone around the boundaries of the GWPZ in which all CBSDs operating co-channel with the GWPZ must be included in the aggregate interference calculation.

13.2 GWPZ Example 2

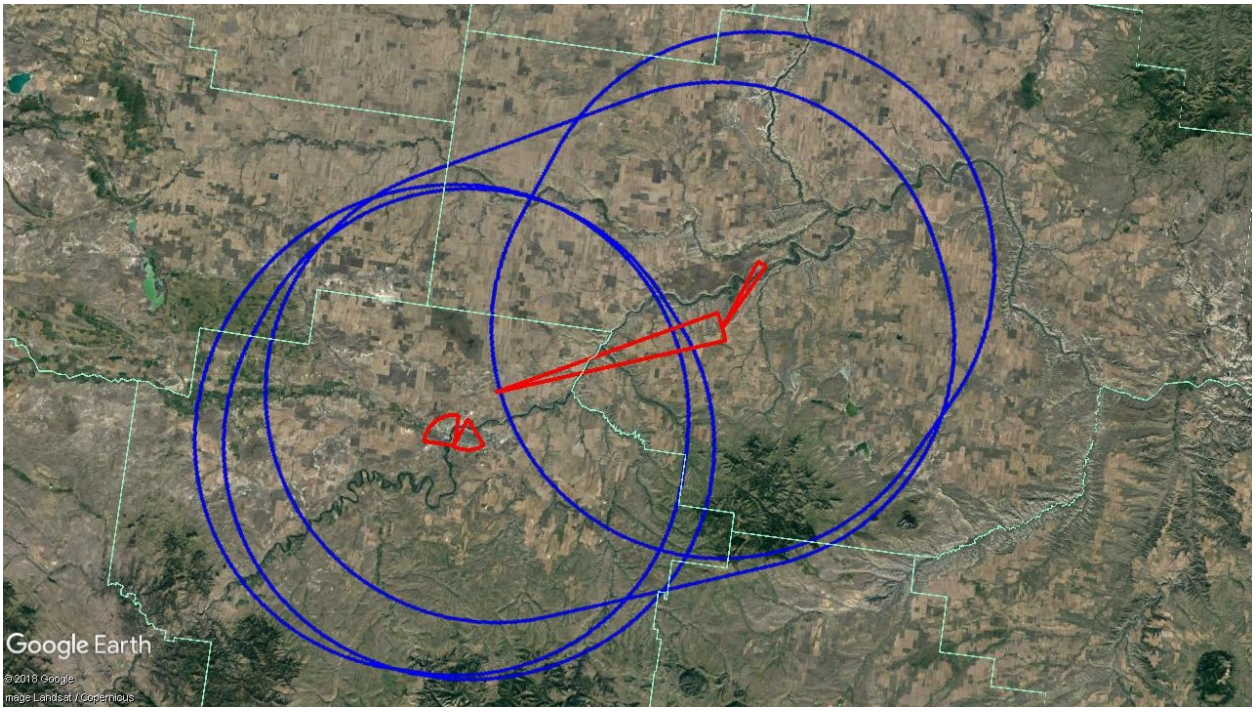

Figure D- 2: Additional examples of GWPZs. The highly elongated GWPZs are point-to-point links. As in the previous example, the blue lines are the 40-km boundaries around the GWPZs in which CBSDs must be included in the aggregate interference calculations.

13.3 Map of GWPZs and 40-km Coordination Zones in the Contiguous U.S.

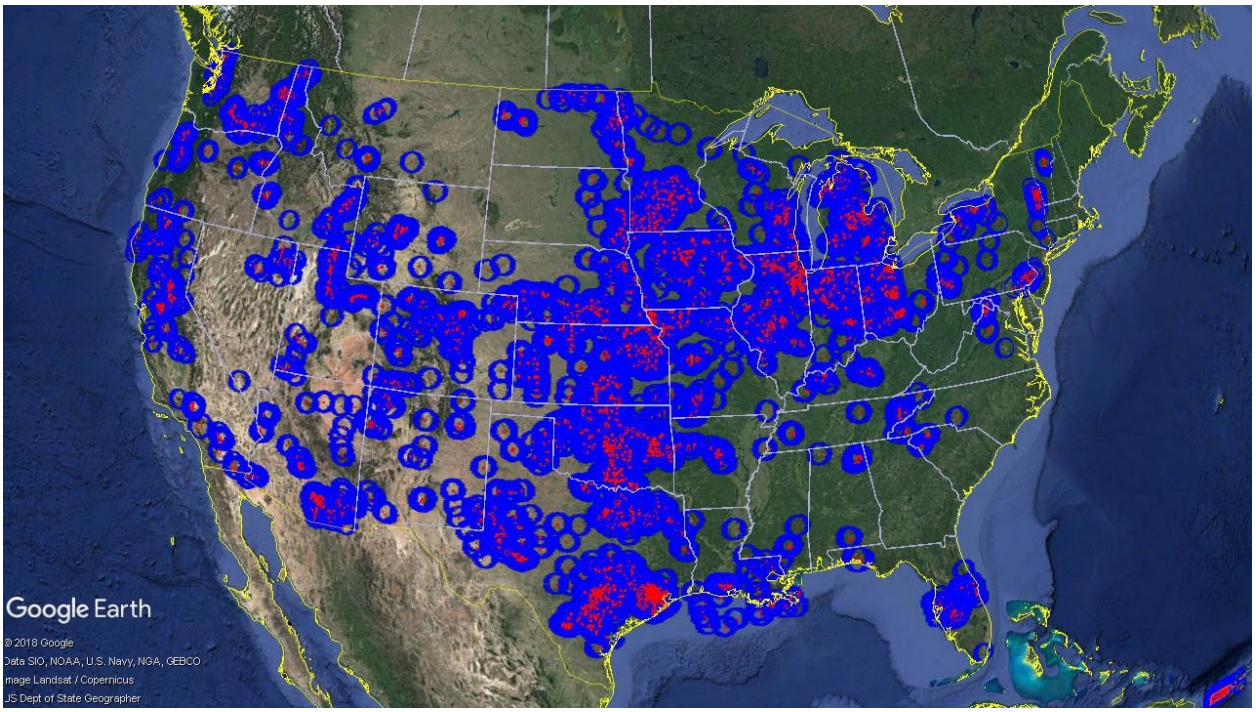

Figure D- 3: GWPZs (red) and 40 km coordination zones (blue) in the contiguous U.S. Many of these GWPZs will begin sunsetting in 2020 and will continue until the last ones sunset in January 2023.

13.4 Map of GWPZ and 40-km Coordination Zone in Hawaii

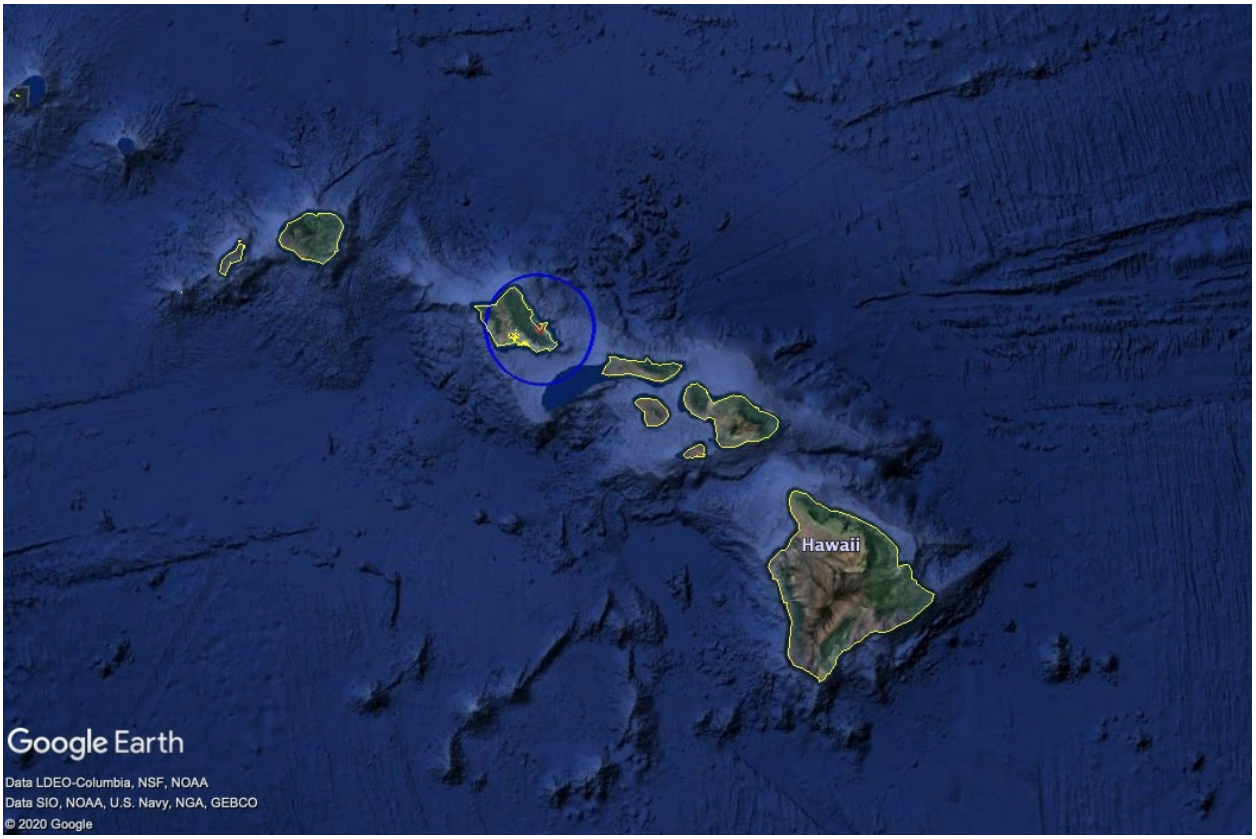

Figure D- 4: A GWPZ and 40-km coordination zone in Hawaii.

13.5 Map of GWPZs and 40-km Coordination Zones in Puerto Rico and the USVI

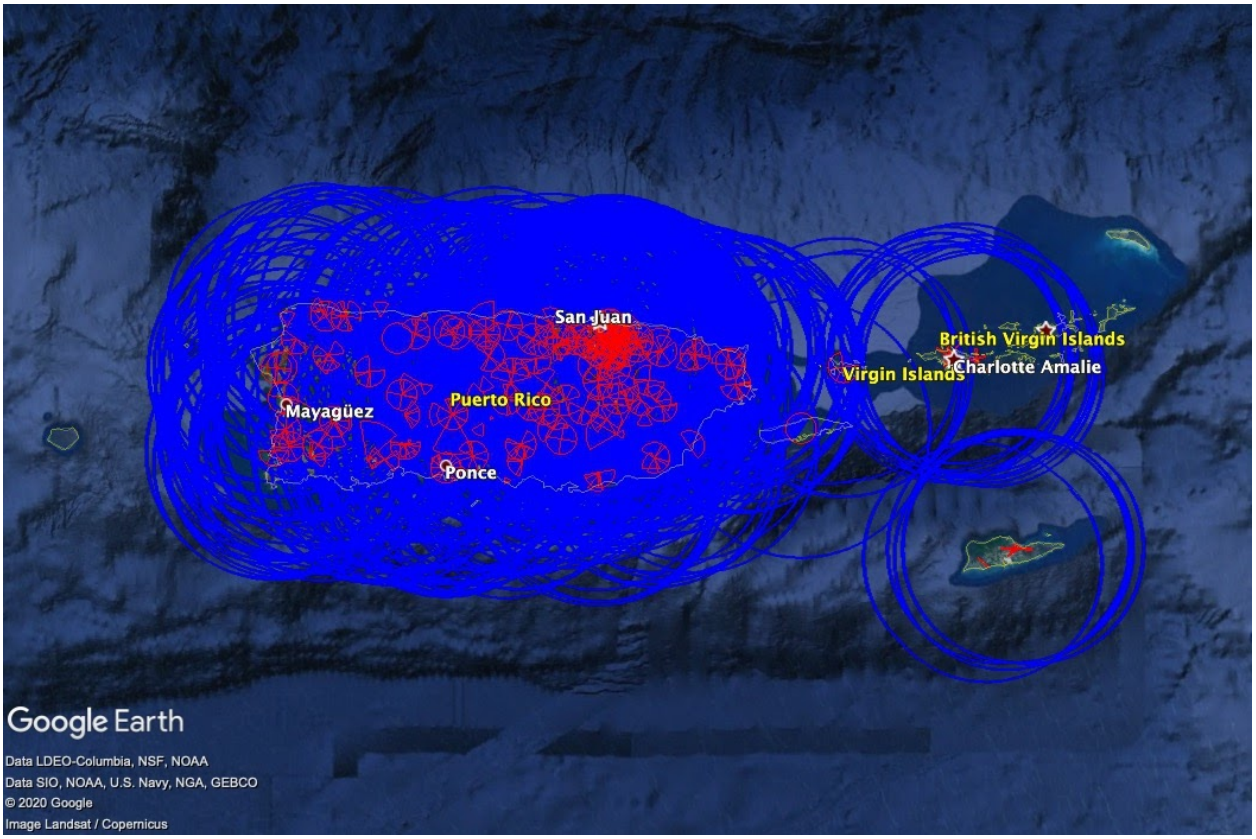

Figure D- 5: GWPZs and 40-km coordination zones in Puerto Rico and the U.S. Virgin Islands.

13.6 Map of GWBLs in the Contiguous U.S.

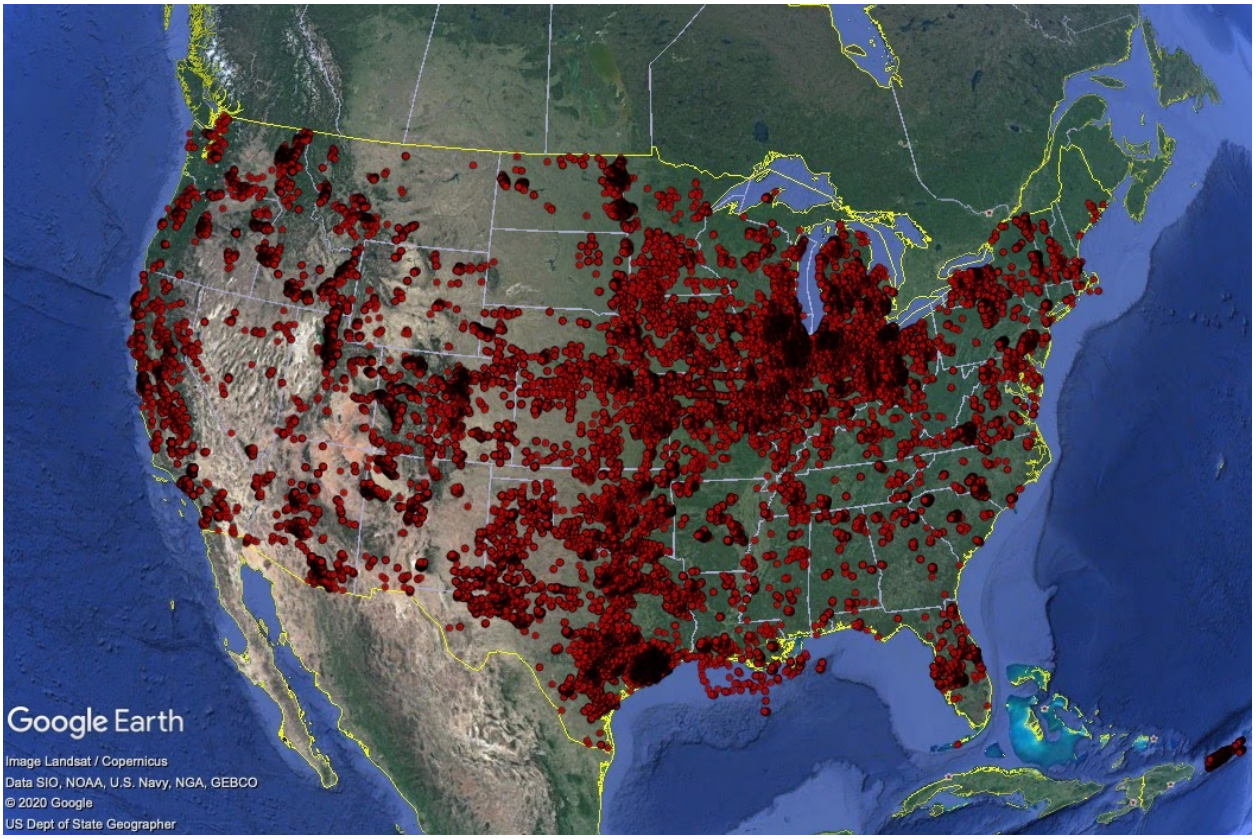

Figure D- 6: Individually registered Part 90Z devices ("GWBLs") in the contiguous U.S. Source: FCC ULS as of March 15th, 2020.

13.7 Map of GWBLs in Alaska

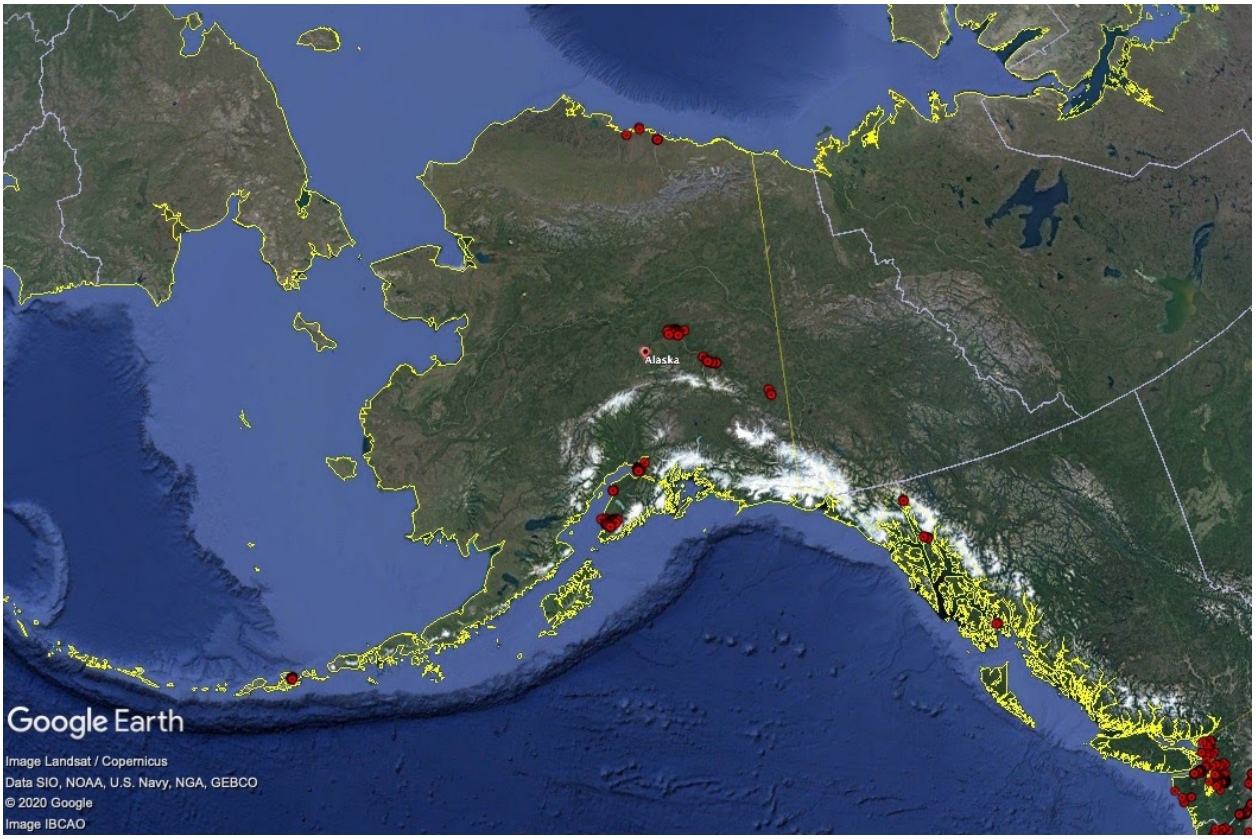

Figure D- 7: Individually-registered Part 90Z devices ("GWBLs") in Alaska. None of these have been registered as GWPZs. Source: FCC ULS as of March 15th, 2020.

13.8 Map of GWBLs in Hawaii

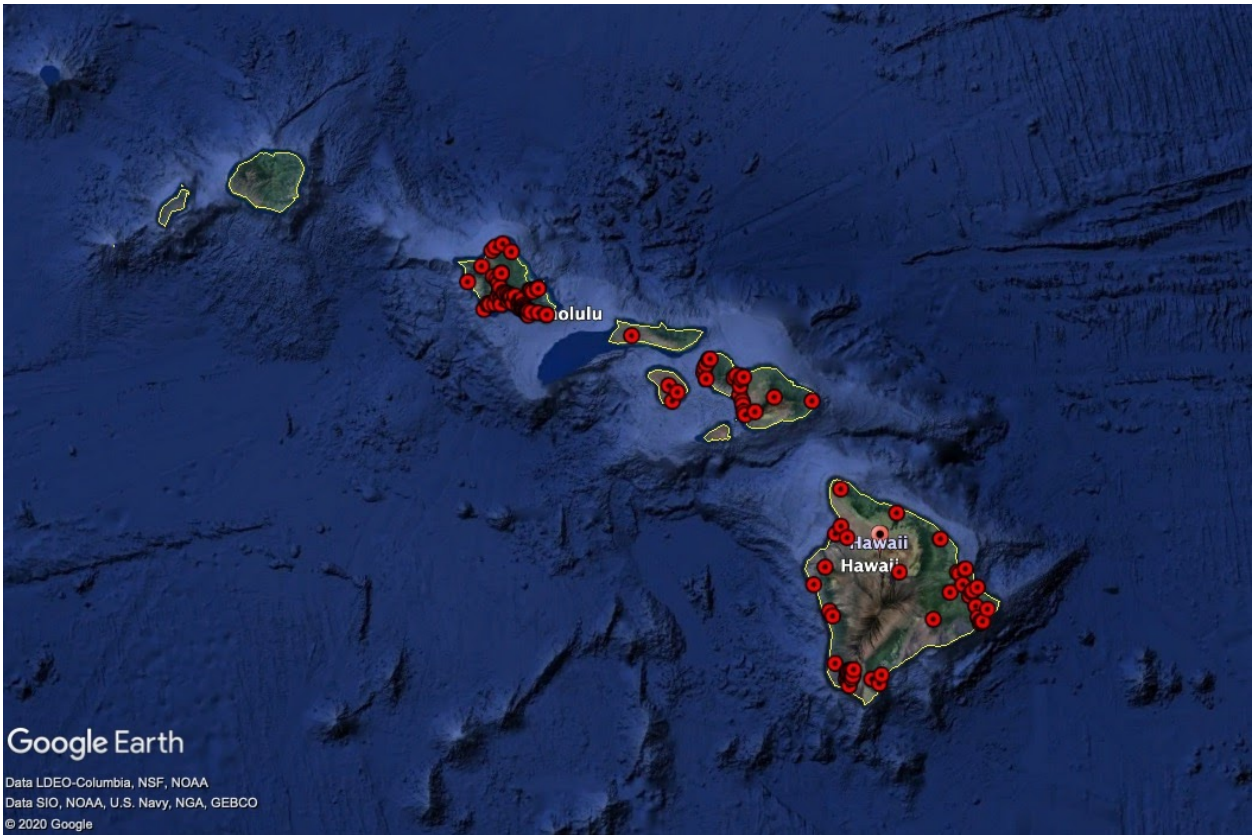

Figure D- 8: Individually-registered Part 90Z devices ("GWBLs") in Hawaii. Source: FCC ULS as of March 15th, 2020.

13.9 Map of GWBLs in Puerto Rico and USVI

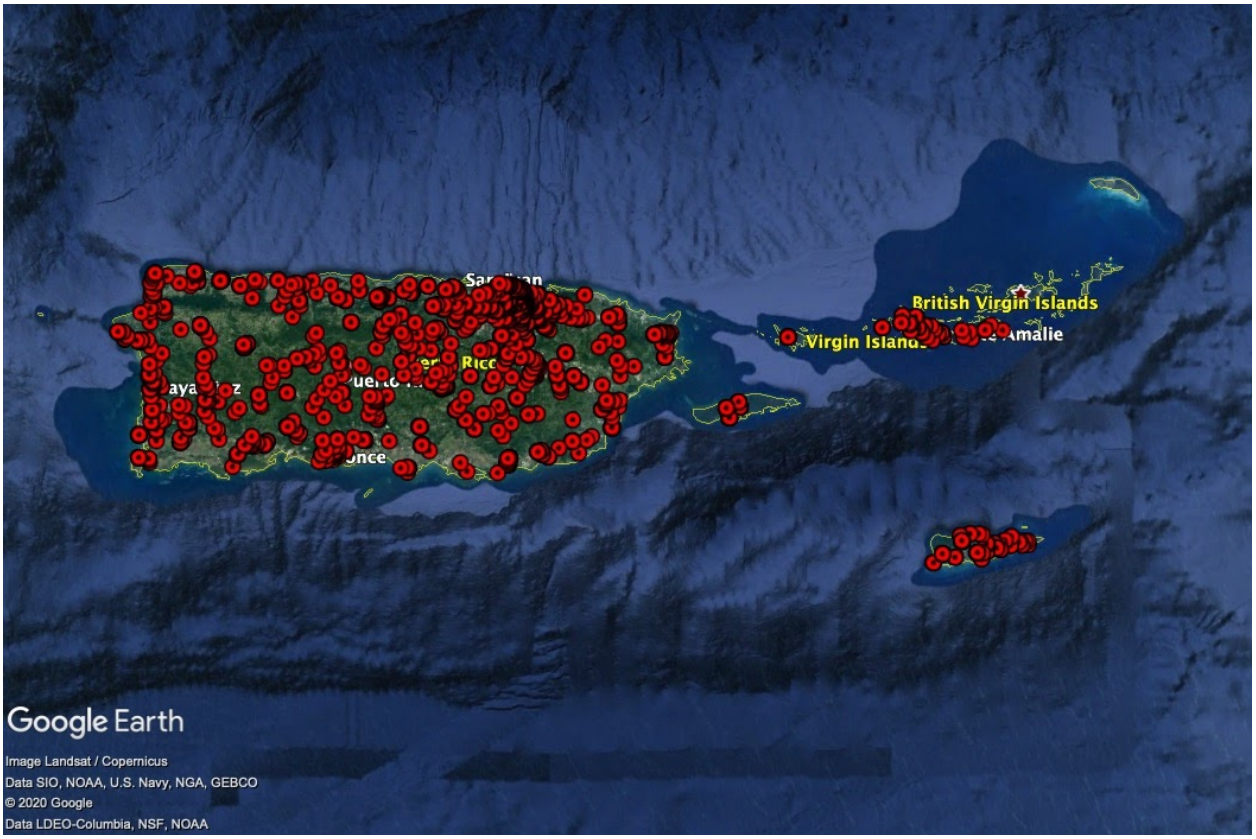

Figure D- 9: Individually-registered Part 90Z devices ("GWBLs") in Puerto Rico and the USVI. Source: FCC ULS as of March 15th, 2020.

14 Annex E: Maps of Quiet Zones and Coordination Zones

The following maps show the areas impacted by Quiet Zone and Coordination Zone rules. These maps are for informational purposes only and should not be relied upon for planning CBRS strategy or deployments.

14.1 Map of the National Radio Quiet Zone

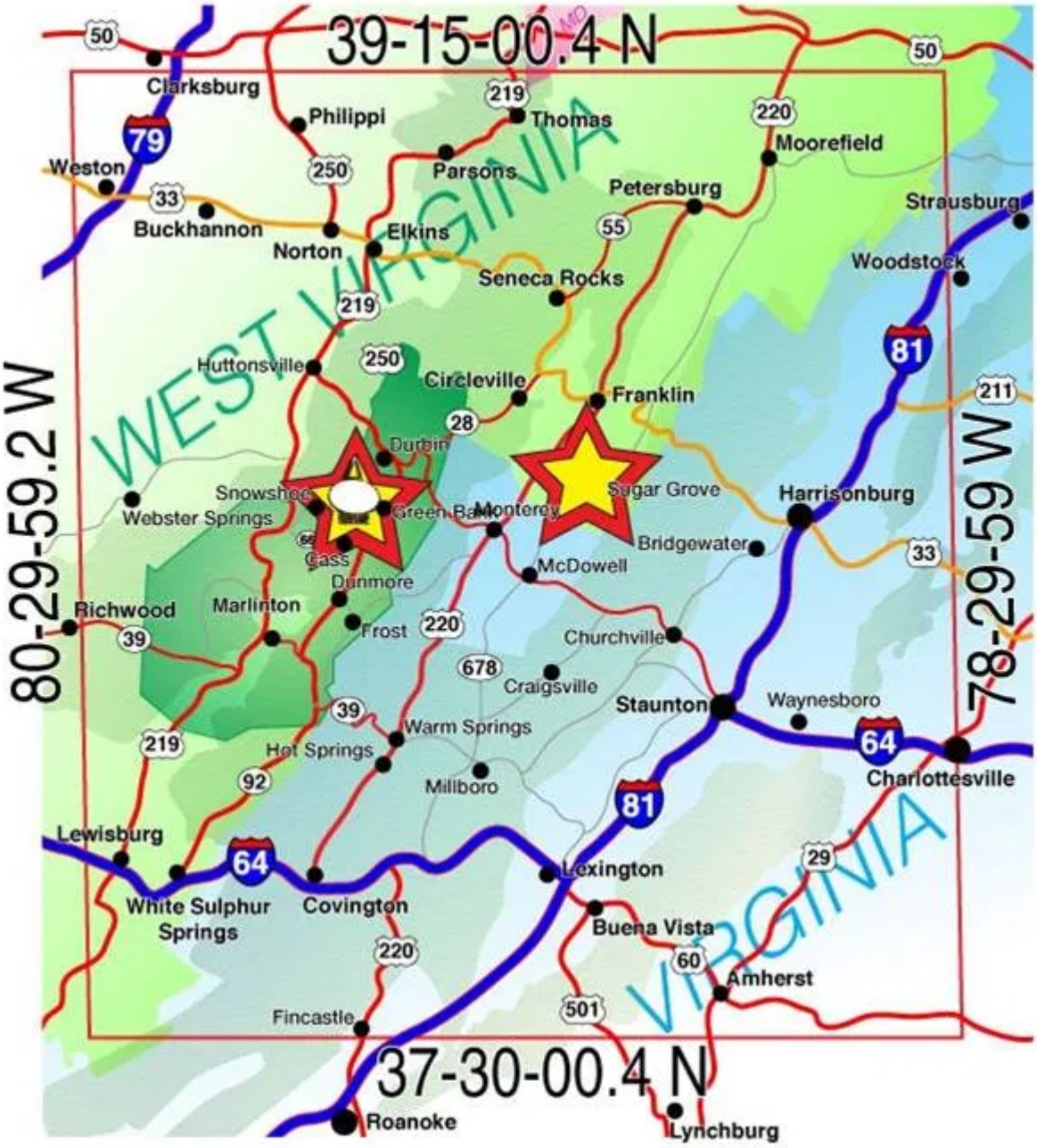

Figure E- 1: The National Radio Quiet Zone in West Virginia (green/yellow), with additional coverage in Virginia (blue) and Maryland (pink). Source: Green Bank Observatory.

14.2 Map of the Table Mountain Radio Receiving Zone Maximum Coordination Distance

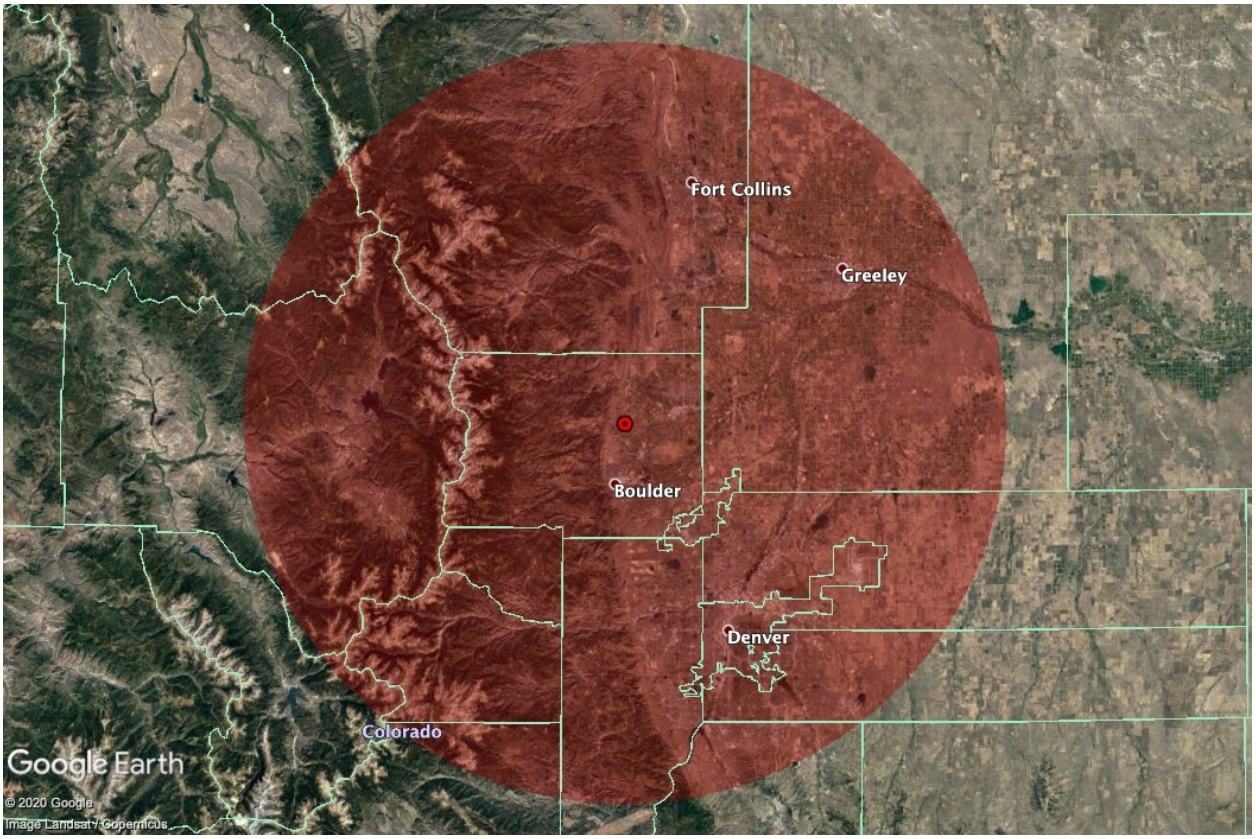

Figure E- 2: Maximum extent (80 km) of the coordination area surrounding the Table Mountain Radio Receiving Zone near Boulder, CO.

14.3 Map of the Protected FCC Field Offices (Contiguous U.S.)

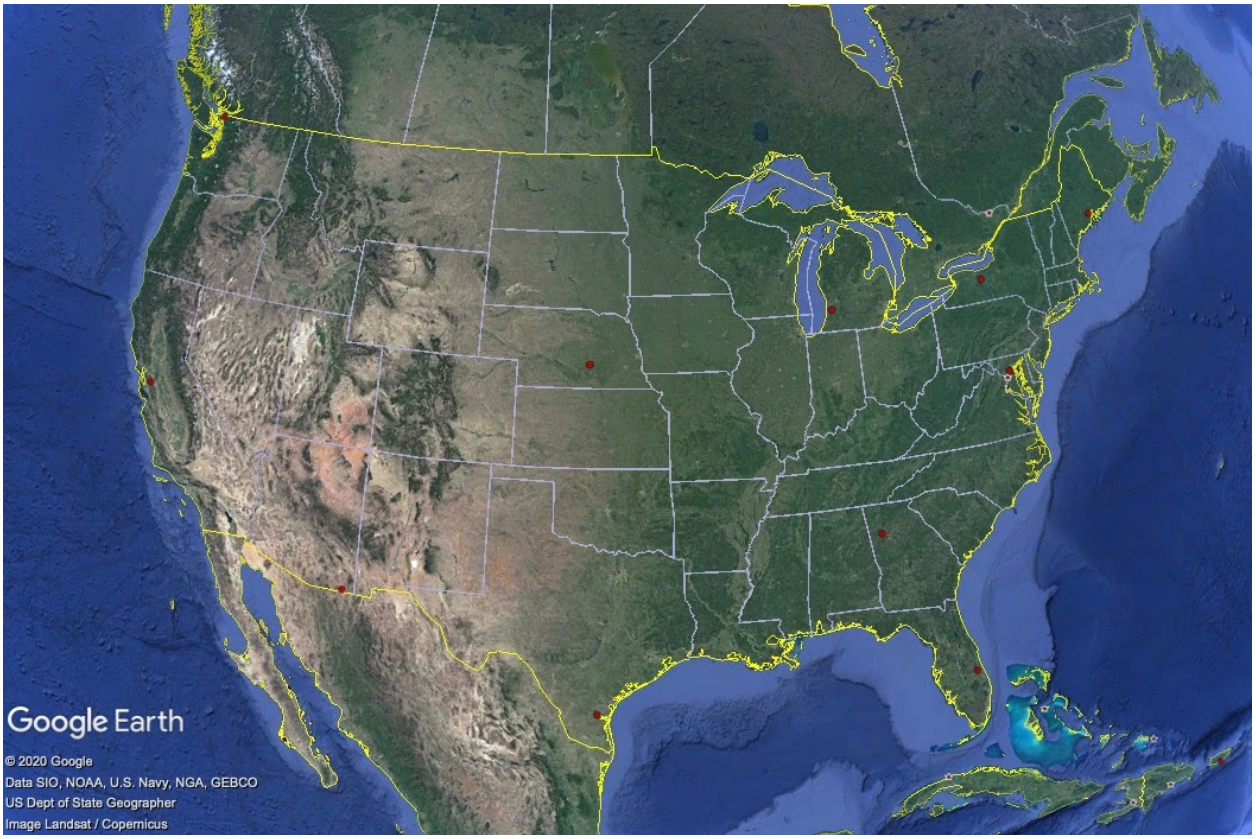

Figure E- 3: Protected FCC field offices in the U.S. (red dots). The extent of the coordination zones (2.4 km for Category A or 4.8 km for Category B) is smaller than the dots.

14.4 Map of the Protected FCC Field Office (Alaska)

Figure E- 4: Protected FCC field office near Anchorage, Alaska (larger red dot). The extent of the coordination zones (2.4 km for Category A or 4.8 km for Category B) is smaller than the dot.

14.5 Map of the Protected FCC Field Office (Hawaii)

Figure E- 5: Protected FCC field office near Honolulu, Hawaii (larger red dot). The extent of the coordination zones (2.4 km for Category A or 4.8 km for Category B) is smaller than the dot.

14.6 Map of the Protected FCC Field Office (Puerto Rico)

Figure E- 6: Protected FCC field office in Puerto Rico (larger red dot). The extent of the coordination zones (2.4 km for Category A or 4.8 km for Category B) is smaller than the dot.