

TO: All Interested Parties
FROM: Jessica Schultz, Deputy Director, National Weather Service (NWS) Radar Operations Center
SUBJECT: Lowering the Minimum Scan Angle of the KFSX Weather Surveillance Radar - Model 1988 Doppler (WSR-88D) serving Flagstaff, AZ, area
DATE: July 1, 2019

In accordance with provisions of the National Environmental Policy Act of 1969, the National Weather Service (NWS) prepared a Draft Environmental Assessment (EA) analyzing the potential environmental effects of lowering the minimum scan angle of the KFSX WSR-88D serving the Flagstaff, AZ, area. The Draft Environmental Assessment is available for public review and comment. The Draft EA may be obtained at:

<https://www.roc.noaa.gov/WSR88D/SafetyandEnv/EAReports.aspx>

The KFSX WSR-88D is an existing radar facility on Blue Ridge in Coconino National Forest, Coconino County, AZ. The radar is located about 48 miles southeast of downtown Flagstaff, AZ. The KFSX WSR-88D was commissioned in May 1996 and is one of 159 WSR-88Ds in the nationwide network. The KFSX WSR-88D antenna transmits a narrow focused main beam with a width of 1 degree. In normal operation, the radar antenna rotates horizontally to cover all directions (i.e. azimuths). The radar antenna also varies the scan angle at which it points with respect to the horizon. Currently, the WSR-88D operates at a minimum of scan angle of +0.5 degrees (deg) above the horizon. NWS proposes to reduce the minimum scan angle of the KFSX WSR-88D from the current minimum of +0.5 deg to -0.2 deg (i.e. 0.7 deg lower than existing) to provide enhanced coverage of the lower portions of the atmosphere. No construction activities or physical modification of the KFSX WSR-88D would be required to implement the proposed action; the only change would be to the radar's operating software.

NWS will accept written comments on the Draft EA until August 5, 2019. Please submit comments via either email or regular mail to:

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Comments sent by regular mail must be postmarked by August 5, 2019. After the end of the Draft EA review period, NWS will prepare a Final EA containing responses to all comments. NWS will not make any decision on implementing the proposed action until completion of the environmental review. Thank you for your interest in this important project.

SENSOR ENVIRONMENTAL LLC
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Draft Environmental Assessment Report • June 2019

ENVIRONMENTAL ASSESSMENT (EA)
LOWERING THE MINIMUM SCAN ANGLE OF THE WEATHER
SURVEILLANCE RADAR - MODEL 1988, DOPPLER (WSR-88D)
SERVING THE FLAGSTAFF, ARIZONA, AREA

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EXECUTIVE SUMMARY

The National Weather Service (NWS) owns and operates the existing Weather Surveillance Radar, Model 1988 Doppler (WSR-88D) serving the Flagstaff, AZ, area. The International Civil Aviation Organization designator for the radar is KFSX and the radar is located within Coconino National Forest in Coconino County, AZ, about 48 miles southeast of downtown Flagstaff, SC. The KFSX WSR-88D was commissioned in June 1996 and has been in continuous operation since 1996. It is one of 159 WSR-88Ds in the nationwide network.

The KFSX WSR-88D is an S-band Doppler, dual polarized weather radar, which NWS uses to collect meteorological data to support weather forecasts and severe weather warnings for central and northeastern Arizona. The KFSX WSR-88D antenna transmits a narrow focused main beam with a width of 1 degree. In normal operation, the WSR-88D antenna rotates horizontally to cover all directions (i.e. azimuths). The radar antenna also varies the scan angle at which it points with respect to the horizon. The scan angle is measured along the axis of the main beam and can be changed in 0.1 deg increments. Currently, the KFSX WSR-88D operates at a minimum of scan angle of +0.5 degrees (deg) above the horizon. NWS proposes to reduce the minimum scan angle of the KFSX WSR-88D from the current minimum of +0.5 deg to -0.2 deg (the proposed action). Lowering the minimum scan angle would provide enhanced coverage of the lower portions of the atmosphere. No construction activities or physical modification of the KFSX WSR-88D would be required to implement the proposed action; the only change would be to the radar's operating software.

In April 1993, NWS prepared a National Environmental Policy Act (NEPA) document titled, *Supplemental Environmental Assessment (SEA) of the Effects of Electromagnetic Radiation from the WSR-88D Radar*. That document analyzed operating the WSR-88D at a minimum scan angle of +0.5 degree (deg). This Draft EA builds on that prior study by examining the possible effects of operating the KFSX WSR-88D at a minimum scan angle of -0.2 (i.e., 0.7 deg lower than the minimum scan angle examined in the April 1993 SEA). Operating this radar at a lower scan angle would increase the area of radar coverage, providing additional data on atmospheric conditions to NWS forecasters and other data users. The area covered at 2,000 ft above site level (ASL) would increase by 174.6%, which would be very beneficial to NWS forecasters and others parties (e.g. public safety agencies and emergency responders) using the radar information.

The lower minimum scan angle would not result in the KFSX WSR-88D main beam impinging on the ground or structures within 1.7 miles of the WSR-88D site. The proposed action would slightly increase radiofrequency (RF) exposure levels in the vicinity of the KFSX WSR-88D. As shown in Table S-1, during normal operation of the radar with rotating antenna, RF exposure would comply with the safety standards developed by the Institute of Electrical and Electronic Engineers (IEEE) and the adopted by the American National Standards Institute (ANSI) for the general public and workers. Federal Communications Commission (FCC) and Occupational safety and Health Administration (OSHA) safety levels would also be met at all locations.

Table S-1: RF Power Density within Main Beam of KFSX WSR-88D at Minimum Scan Angle of -0.2 deg Compared to ANSI/IEEE Safety Standards

| Location / Distance from Radar | Time-Averaged Power Density (mW/cm ²) | ANSI/IEEE General Public RF Safety Standard | | ANSI/IEEE Occupational RF Safety Standard | |
|---|---|---|------------------|---|------------------|
| | | Safety Standard (mW/cm ²) | Factor Below Std | Safety Standard (mW/cm ²) | Factor Below Std |
| Surface of Radome | 0.599 | 1.0 | 1.67 | 9.63 | 16 |
| 1 mile | 0.00029 | 1.0 | 3,450 | 9.63 | 33,200 |
| Closest illuminated ground (8,800 ft ESE) | 0.00011 | 1.0 | 9,090 | 9.63 | 87,500 |
| 5 miles | 0.000012 | 1.0 | 83,300 | 9.63 | 802,500 |

During infrequent stationary antenna operation, RF exposure levels within the WSR-88D main beam would exceed ANSI/IEEE and FCC safety levels for exposure of the general within 1,740 ft of the WSR-88D antenna. FCC occupational safety levels would be exceeded within 780 ft and ANSI/IEEE occupational safety levels within 560 ft. The KFSX WSR-88D operating at -0.2 deg would not impinge on the ground surface or any structures within those distance and risks to human health would not result.

Because the KFSX WSR-88D operates in a frequency band dedicated to government radiolocation services and the main beam would not impinge on the ground surface in the radar vicinity, the proposed action would not cause radio interference with television, radio, cellular telephone, personal communications devices (PCDs), electro-explosive devices, fuel handling, or active implantable medical devices.

WSR-88D RF emissions have the potential to cause electromagnetic interference (EMI) with sensitive equipment used at astronomical observatories. Six astronomical observatories are located within 150 miles of the KFSX WSR-88D. A minimum scan angle of -0.2 deg would not result in the WSR-88D main beam impinging on any of those six observatories.

Lowering the minimum scan angle of the KFSX WSR-88D would not require physical changes to the radar, vegetation removal, or ground disturbance. The proposed action would not result in significant effects in the following subject areas:

- Land Use and Coastal Zone Management
- Geology, Soils, and Seismic Hazards
- Drainage and Water Quality
- Transportation
- Air Quality

- Flood Hazards
- Wetlands
- Biological Resources / Protected Species
- Cultural and Historic Resources
- Environmental Justice Socioeconomic Impacts
- Farmlands
- Energy Consumption
- Visual Quality/ Light Emissions
- Solid and Hazardous Waste
- Wild and Scenic Rivers

NWS evaluated the benefits and potential impacts of lowering the minimum center of beam scan angle of the KFSX WSR-88D to each angle between +0.4 and -0.2 deg in 0.1 degree increments (see Appendix B). Operating the KFSX WSR-88D at alternative minimum scan angles between +0.4 deg and -0.1 deg would result in similar environmental effects as the proposed action. Like the proposed action, significant environmental effects would not result.

The no action alternative would result in continued operation of the KFSX WSR-88D at the existing minimum scan angle of +0.5 deg. The improvements in radar coverage resulting from the proposed project would not be achieved. The no-action alternative would not change RF exposure levels from existing. Under both the proposed action and the no action alternative, RF exposure during normal WSR-88D operations would conform to safety standards established by ANSI/IEEE, OSHA, and FCC. Similar to the proposed action, the no-action alternative would not cause significant effects to the natural or man-made environment.

The NWS will distribute the Draft EA to interested members of the public and government agencies for review and comment. Comments on the Draft EA will be accepted by NWS during a minimum 30-day comment period which will end on August 5, 2019. The NWS will provide official responses to all pertinent comments received during the Draft EA comment period in a Final EA report. The NWS will make a decision whether to implement the proposed lowering of the KFSX WSR-88D minimum scan angle after the Final EA report is completed.

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ABBREVIATIONS

| | |
|--------------------|--|
| AGL | above ground level |
| AAMI | Association for Advancement of Medical Instrumentation |
| ANSI | American National Standards Institute |
| ASL | above site level |
| deg | degree(s) |
| DoA | Department of Agriculture |
| EA | Environmental Assessment |
| E.O. | Executive Order |
| EED | electro-explosive device |
| EMI | electromagnetic interference |
| EPA | Environmental Protection Agency |
| ESA | Endangered Species Act |
| FCC | Federal Communications Commission |
| FEMA | Federal Emergency Management Agency |
| FONSI | Finding of No Significant Impact |
| ft | foot, feet |
| HERO | Hazards of Electromagnetic Radiation to Ordnance |
| IEEE | Institute of Electrical and Electronics Engineers |
| JSPO | Joint System Program Office |
| KFSX | WSR-88D serving the Flagstaff, AZ, area |
| m | meter(s) |
| MBTA | Migratory Bird Treaty Act (of 1918) |
| MHz | megahertz |
| mi | mile(s) |
| MPE | maximum permissible exposure |
| MSL | mean sea level |
| mW/cm ² | milliwatts per square centimeter |
| NAO | NOAA Administrative Order |
| NEPA | National Environmental Policy Act |
| NEXRAD | Next Generation Weather Radar (also known as WSR-88D) |

| | |
|---------|--|
| NOAA | National Oceanic and Atmospheric Administration |
| NRCS | Natural Resources Conservation Service |
| NTIA | National Telecommunications and Information Agency |
| NWS | National Weather Service |
| PEIS | Programmatic Environmental Impact Statement |
| RF | radiofrequency |
| SEA | Supplemental Environmental Assessment |
| SHPO | State Historic Preservation Office |
| sq mi | square mile(s) |
| std | standard |
| U.S. | United States |
| USAF | U.S. Air Force |
| USFWS | U.S. Fish and Wildlife Service |
| USGS | U.S. Geological Survey |
| WSR-88D | Weather Surveillance Radar – 1988, Doppler |

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1 BACKGROUND AND SCOPE OF REPORT

1.1 BACKGROUND

The National Weather Service (NWS) operates a nationwide network of weather radars that provide critical real-time information on atmospheric conditions to weather forecasters. Additional similar weather radars located in Alaska, Hawaii and Puerto Rico are operated by the Department of Transportation Federal Aviation Administration (FAA). The Department of Defense Air Weather Service also operates weather radars located at United States (U.S.) military installations in the U.S. and abroad. The weather radars operated by these three agencies are part of 159 WSR-88Ds in the nationwide network.

The network radars operated by NWS are named Weather Surveillance Radar-Model 1988 Doppler (WSR-88D) after the year they were first put into service and their capabilities to use Doppler shift measurements to determine wind velocities. They are also known as Next Generation Weather Radars (NEXRADs) or Weather Service Radars. Like all active radars, the WSR-88D transmits a radio signal, which reflects off targets and returns to the radar. The radar measures the strength of the return signal, its direction of return, and the time between transmission and return, which allows determination of the targets characteristics. Because the WSR-88D has the potential to cause electromagnetic effects on the environment, NWS carefully considered these effects and strives to prevent effects, or when effects cannot be avoided, mitigate the significance of those effects. To that end, the NEXRAD Joint System Program Office (JSPO) prepared environmental reports evaluating potential electromagnetic effects of the WSR-88D during planning and implementation of the WSR-88D network. In 1984, the JSPO issued the first environmental document which considered electromagnetic effects (among other effects). That report is titled: *Next Generation Weather Radar Programmatic Environmental Impact Statement (PEIS), Report R400-PE201* [NWS, 1984]. In 1993, JSPO issued a supplemental report updating the analysis contained in the 1984 PEIS to account for changes since 1984 in electromagnetic standards and guidelines and developments in radar design and operational modes. The supplemental report is titled *Final Supplemental Environmental Assessment (SEA) of the Effects of Electromagnetic Radiation from the WSR-88D Radar* [NEXRAD JSPO, 1993]. The 1993 SEA analyzed the potential electromagnetic effects of operating the WSR-88D at a minimum scan angle of +0.5 degree (deg) above horizontal, measured at the center of the WSR-88D main beam. The minimum scan angle of +0.5 deg represented the lowest scan angle used operation of the WSR-88Ds at that time.

The National Weather Service (NWS) owns and operates the WSR-88D serving the Flagstaff, AZ, area. The radar identifier is KFSX and the radar is located in Coconino National Forest, about 48 miles southeast of downtown Flagstaff and 72 miles east of Prescott, AZ. The KFSX WSR-88D is part of the nationwide WSR-88D network. The NWS proposes to operate the

KFSX WSR-88D at a minimum scan angle of -0.2 deg, which is lower than the current minimum scan angle of +0.5 deg above the horizon. Operating the KFSX WSR-88D at this lower scan angle was not analyzed in the 1993 SEA.

The National Oceanic and Atmospheric Administration (NOAA), the parent agency of NWS, require analysis of the potential environmental consequences of proposed actions to comply with the National Environmental Policy Act (NEPA). Procedures to be followed are set forth in NOAA Administrative Order (NAO) 216-6A (NOAA, 2016). Because NWS's proposed action of operating the KFSX WSR-88D at a minimum scan angle below +0.5 deg has the potential to cause environmental effects, there is a need to analyze potential environmental consequences, determine their significance, and develop measures to mitigate adverse impacts if necessary.

1.2 SCOPE OF REPORT

This Draft EA report analyzes the potential effects on persons and activities in the vicinity that could result from implementing the proposed action (i.e. lowering the KFSX WSR-88D minimum scan angle to -0.2 deg). Potential environmental effects of alternative minimum scan angles between +0.4 deg and -0.1 deg and the no-action alternative (i.e. continued operation of the KFSX WSR-88D at the current minimum scan angle of +0.5 deg) are also considered for comparison purposes. As part of that analysis, the findings of the 1993 SEA have been updated to account for changes in safety standards and guidelines that have been occurred since 1993 and site -specific conditions at the KFSX WSR-88D site and vicinity. The scope of this EA is limited to analyzing potential effects from lowering the minimum scan angle of the KFSX WSR-88D. Because the types of electromagnetic effects that may result and their significance depends on local conditions, including uses and topography of the local area, the analysis and findings in this EA are specific to the KFSX WSR-88D, and are not applicable to other WSR-88Ds or the WSR-88D network as a whole.

2 PURPOSE AND NEED

The NWS is the nation's premiere meteorological forecasting organization. The agency's official mission is as follows:

“The National Weather Service (NWS) provides weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy. NWS data and products form a national information database and infrastructure which can be used by other governmental agencies, the private sector, the public, and the global community [NWS, 2009]”.

The nationwide network of 159 WSR-88Ds plays a crucial role in meeting the NWS mission. Data from the WSR-88Ds is used by the NWS to improve the accuracy of forecasts, watches, and warnings. As an example, the WSR-88D generates precipitation estimates allowing prediction of river flooding in hydrological basins of the area. The NWS then disseminates advance flood warnings to local and state public safety, emergency managers, and the public, allowing them to take appropriate actions to minimize hazards to life and property. Because the meteorological phenomena of greatest interest occurs with a few thousand feet (ft) of the ground surface, radar coverage of lower portions of the atmosphere is of great value to forecasters.

However, the elevation above the ground at which the WSR-88D can collect atmospheric data rises with distance from the radar due to earth curvature and the upward tilt of the radar beam, which is currently +0.5 deg or greater. The proposed action of lowering the WSR-88D minimum scan angle to -0.2 deg would expand the geographic area with radar coverage below 10,000 ft AGL, a substantial benefit to forecasters and other users of WSR-88D data. This EA report describes the improvements in radar coverage that would result if the NWS operates the KFSX WSR-88D serving the Flagstaff, AZ, area at a minimum scan angle of -0.2 deg and the environmental effects that may result.

The National Oceanic and Atmospheric Administration (NOAA) is the parent agency of the NWS. NOAA requirements for complying with the National Environmental Policy Act (NEPA) are contained in NOAA Administrative Order (NAO) 216-6A, *Compliance with the National Environmental Policy Act, Executive Orders 12114, Environmental Effects Abroad of Major Federal Actions; 11988 and 13690, Floodplain Management; and 11990 Protection of Wetlands* (NOAA, 2016)], and the Companion Manual for NOAA Administrative Order 216-6A; Policies and Procedures for Compliance with the National Environmental Policy Act and Related Authorities (NOAA, 2017). NWS is subject to those requirements. Appendix E of the NOAA Companion Manual specifies the proper level of NEPA review for actions proposed by NOAA components and lists types of actions that are categorically excluded from the need to prepare a NEPA analysis document (e.g., an EA or environmental impact statement [EIS]). Categorical Exclusion G6, which addresses NEXRAD Radar Coverage, states that “Actions that change the

NEXRAD radar coverage patterns that do not lower the lowest scan angle and do not result in direct scanning of previously non-scanned terrain by the NEXRAD main beam” are categorically excluded from NEPA (NOAA, 2017). The proposed action would not meet these specifications and does not qualify for categorical exclusion treatment. Therefore, NEPA analysis is required for the proposed lowering of the KFSX WSR-88D minimum scan angle to -0.2 deg; this EA report satisfies that requirement.

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3 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

3.1 PROPOSED ACTION

3.1.1 Description of KFSX WSR-88D

The NWS of the Department of Commerce, Air Force of the Department of Defense, and FAA of the Department of Transportation operate a nationwide network of Doppler meteorological radars, known as NEXRAD or WSR-88D. The WSR-88D collects data on weather conditions and provides critical inputs to forecasters. The network is composed of 159 radars, most of which were installed in the late 1980s and 1990s. Each radar includes a roughly 28-ft diameter dish antenna mounted on a steel lattice tower of varying height (depending on local conditions), and shelters housing electronic equipment, a standby power generator and fuel tank, and a transitional power maintenance system. The dish antenna rotates 360 deg and is covered by a fiberglass radome to protect it from the elements.

Figure 1 is a photograph of the KFSX WSR-88D, which was commissioned in May 1996 and has been in continuous operations since being commissioned. The KFSX WSR-88D serves the Flagstaff, AZ, area and is operated and maintained by the NWS. The Flagstaff, AZ, Weather Forecast Office (WFO) is the primary recipient of data from the KFSX WSR-88D and serves central and northeastern AZ. The KFSX WSR-88D is located in Coconino National Forest in Coconino County, about 48 miles southeast of downtown Flagstaff, AZ (see Figure 2). The radar antenna, radome, and steel-lattice tower are standard. Table 1 provides information on the KFSX WSR-88D.

| | |
|---|-----------------------------------|
| Elevation, ground surface at tower base (mean sea level, MSL) | 7,415 ft |
| Elevation, center of antenna (MSL) | 7,512 ft |
| Tower Height (m) | 25 m (82 ft) |
| Latitude (WGS84) | 34°34'27.6" N |
| Longitude (WGS84) | 111°11'54.4" W |
| Operating Frequency (primary/secondary) | 2,890 megaHertz (MHz) / 2,760 MHz |
| Spot Blanking or Sector Blanking used | No |



Figure 1: Photograph of KFSX WSR-88D serving Flagstaff, AZ, Area

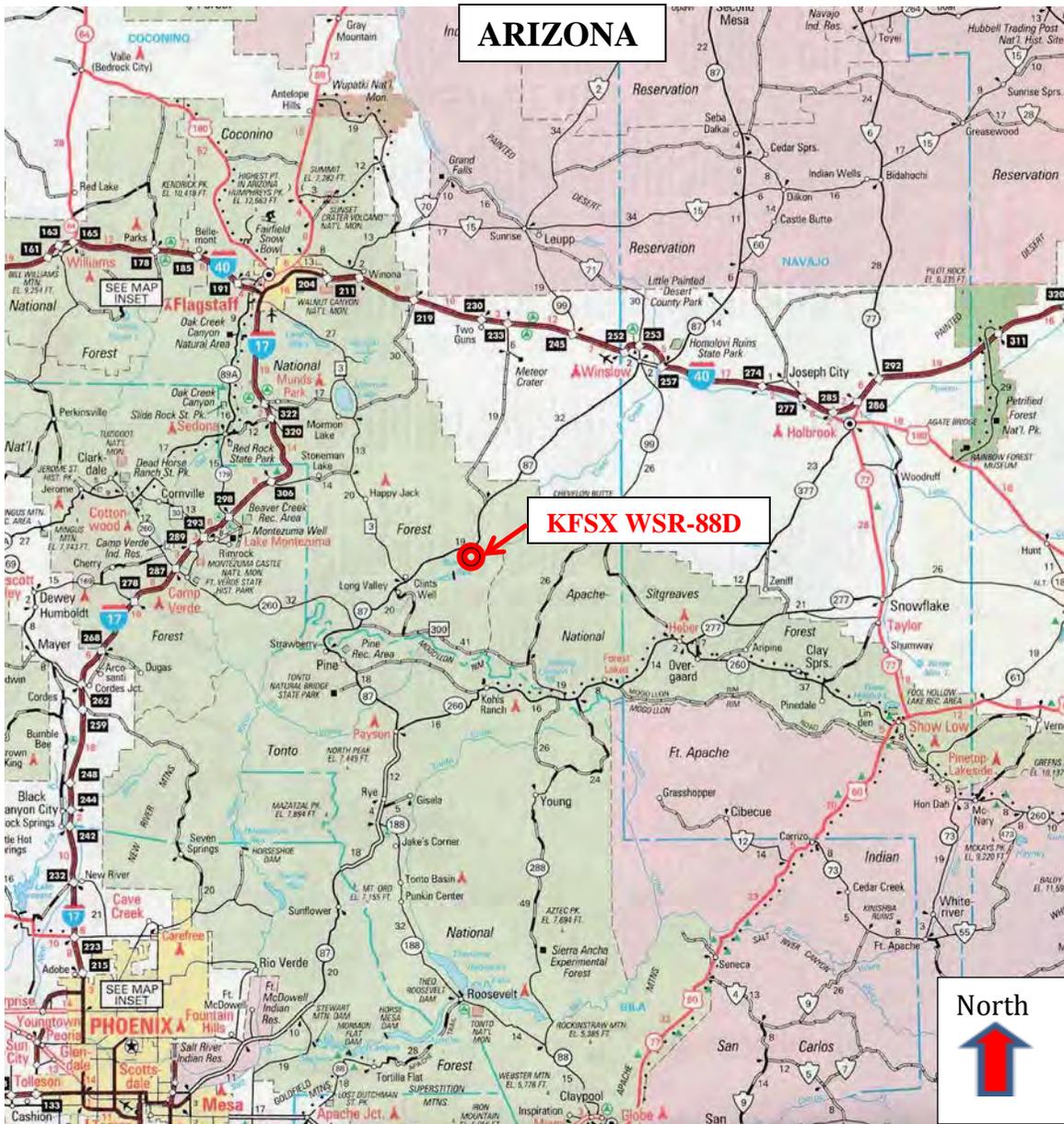


Figure 2: Location of KFSX WSR-88D serving the Flagstaff, AZ, area



3.1.2 Proposed Change in Minimum Scan Angle

The WSR-88D is designed to detect and track weather phenomena within a roughly 230 mi distance of the radar. It accomplishes this task by emitting a narrow main beam from a rotating dish antenna. The antenna rotates continuously around a vertical axis to cover the surrounding area. The main beam scan angle is the number of degrees above or below horizontal at the center of the main beam. The upward tilt of the antenna (and therefore the scan angle of the main beam) can be changed, allowing the radar to scan the sky at angles up to +60.0 deg and down to -1.0 deg; however, in current operation, the maximum scan angle is +19.5 deg and the minimum scan angle is +0.5 deg.

The WSR-88D main beam has a total width of 1 deg in the horizontal and vertical directions (i.e., beam edge is ½ deg from the center of the beam), as shown in Figure 3. The power density of the WSR-88D is greatest at the center of the beam and decreases towards the edge of the beam. At the edge of the main beam, the power density is one half of the center of beam power density. In current operation, the minimum scan angle of the main beam is +0.5 deg (i.e., 0.5 deg above horizontal at the center of the main beam) and the lower edge of the main beam (i.e. lower half-power point) is at 0.0 deg or horizontal. NWS proposes to reduce the minimum center of beam scan angle to -0.2 deg, which is 0.7 deg lower than the current minimum scan angle.

Figure 4 is a schematic drawing showing the change in coverage that would result from lowering the KFSX WSR-88D minimum scan angle. The floor of coverage would decrease slightly, but at a scan angle of -0.2 deg would not impinge on the ground surface in the vicinity of the radar. Because the lowered radar main beam would not be significantly obstructed by nearby terrain, buildings, or trees, the radar would cover portions of the atmosphere which are currently not covered. Table 1 shows the improvement in radar coverage that would be achieved, which ranges from 174.6% increase in coverage area at 2,000 ft above site level (ASL) to 48.8% increase at 10,000 ft ASL. Figures 5, 6, and 7 show the improvement in radar coverage at 2,000 ft, 5,000 ft, and 10,000 ft ASL, respectively.

| Center of Beam Scan Angle (deg) | Coverage Floor (deg) | Area Covered at 2,000 ft ASL (sq mi) | Area Covered at 5,000 ft ASL (sq mi) | Area Covered at 10,000 ft ASL (sq mi) |
|--|-----------------------------|---|---|--|
| +0.5 (existing) | 0.0 | 9,592 | 25,410 | 52,273 |
| -0.2 (proposed) | -0.7 | 26,341 (+174.6%) | 46,216 (+81.9%) | 77,787 (+48.8%) |

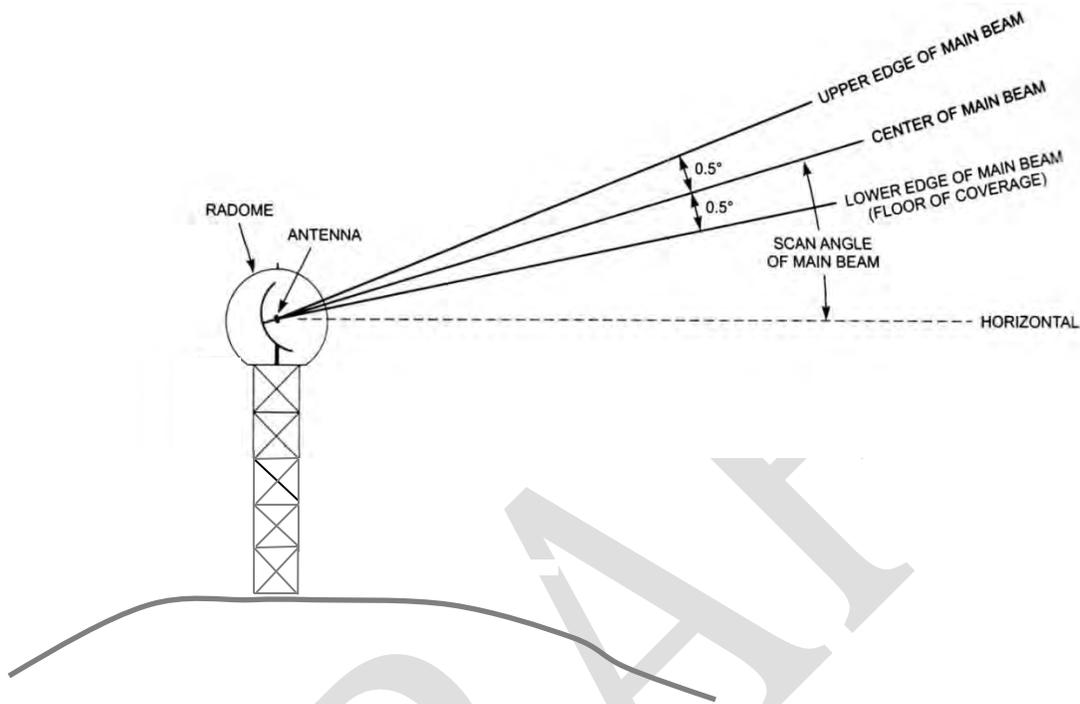


Figure 3: Schematic of WSR-88D Main Beam
(Not to scale, width of main beam exaggerated)

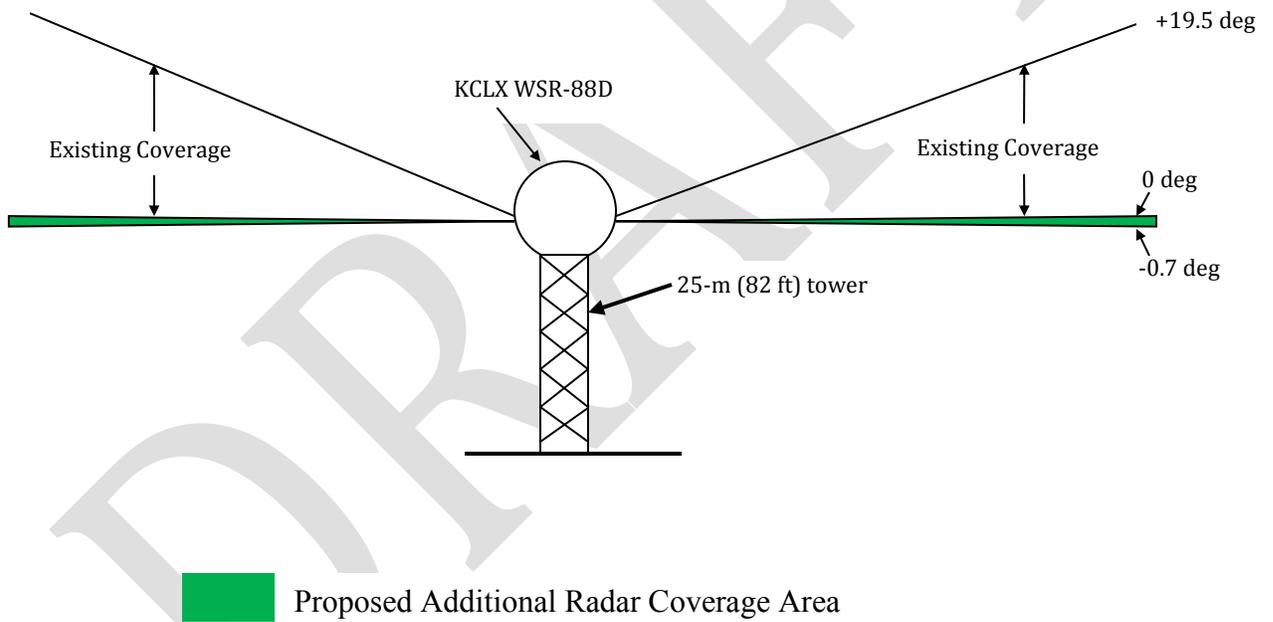


Figure 4: Drawing Showing Proposed Additional Radar Coverage

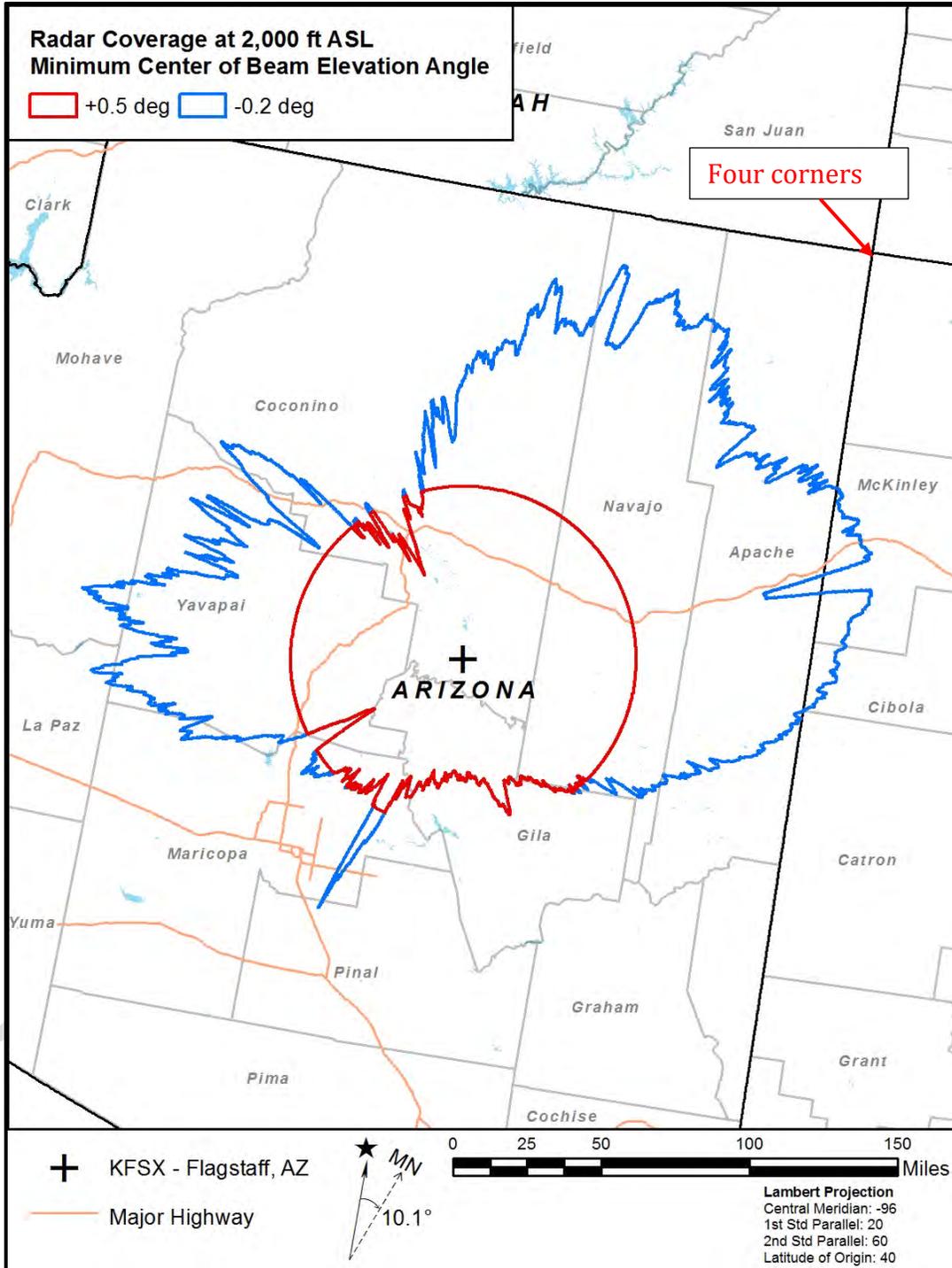


Figure 5: Existing and Proposed KFSX WSR-88D Coverage at 2,000 ft above Site Level

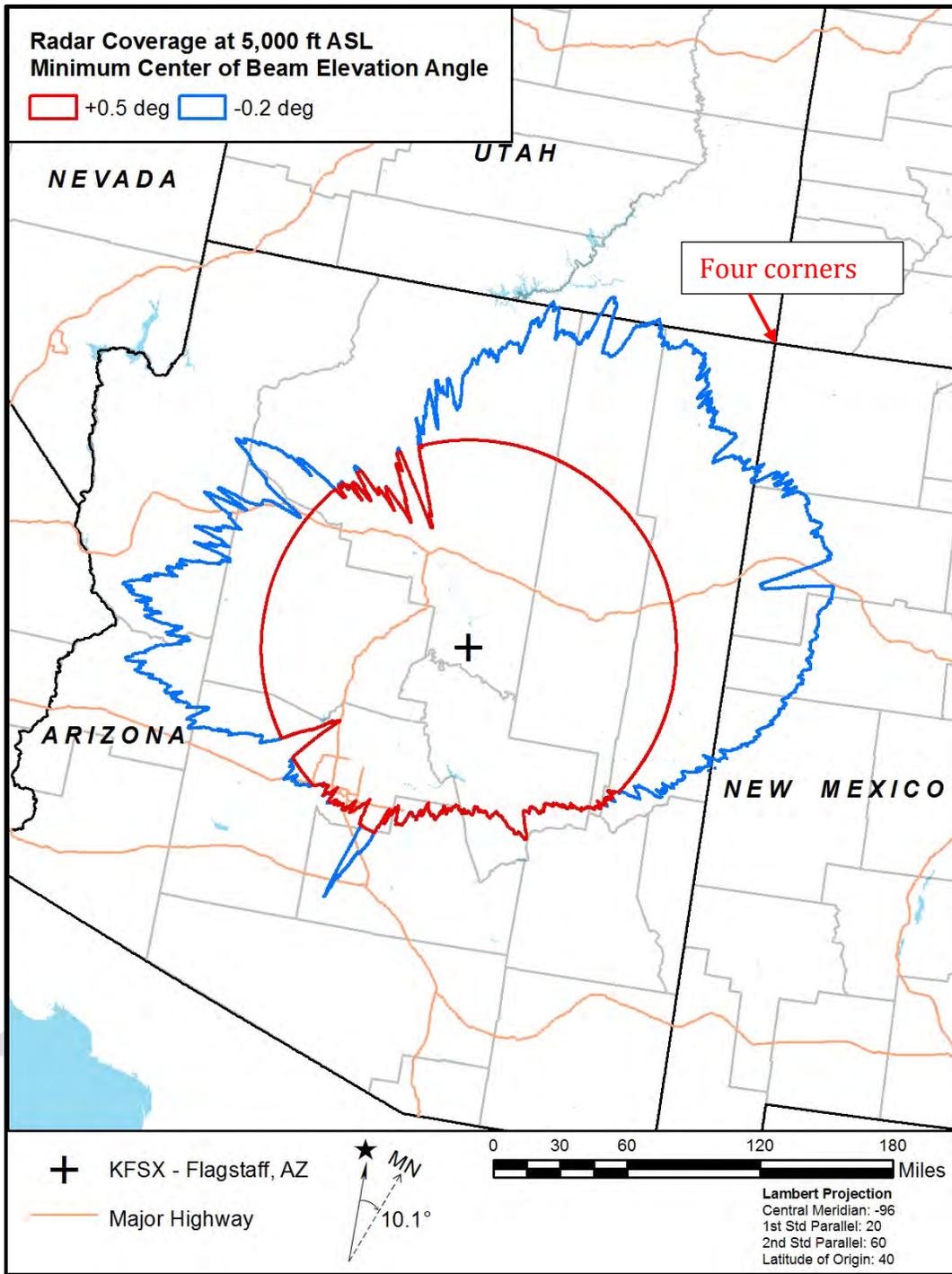


Figure 6: Existing and Proposed KFSX WSR-88D Coverage at 5,000 ft above Site Level

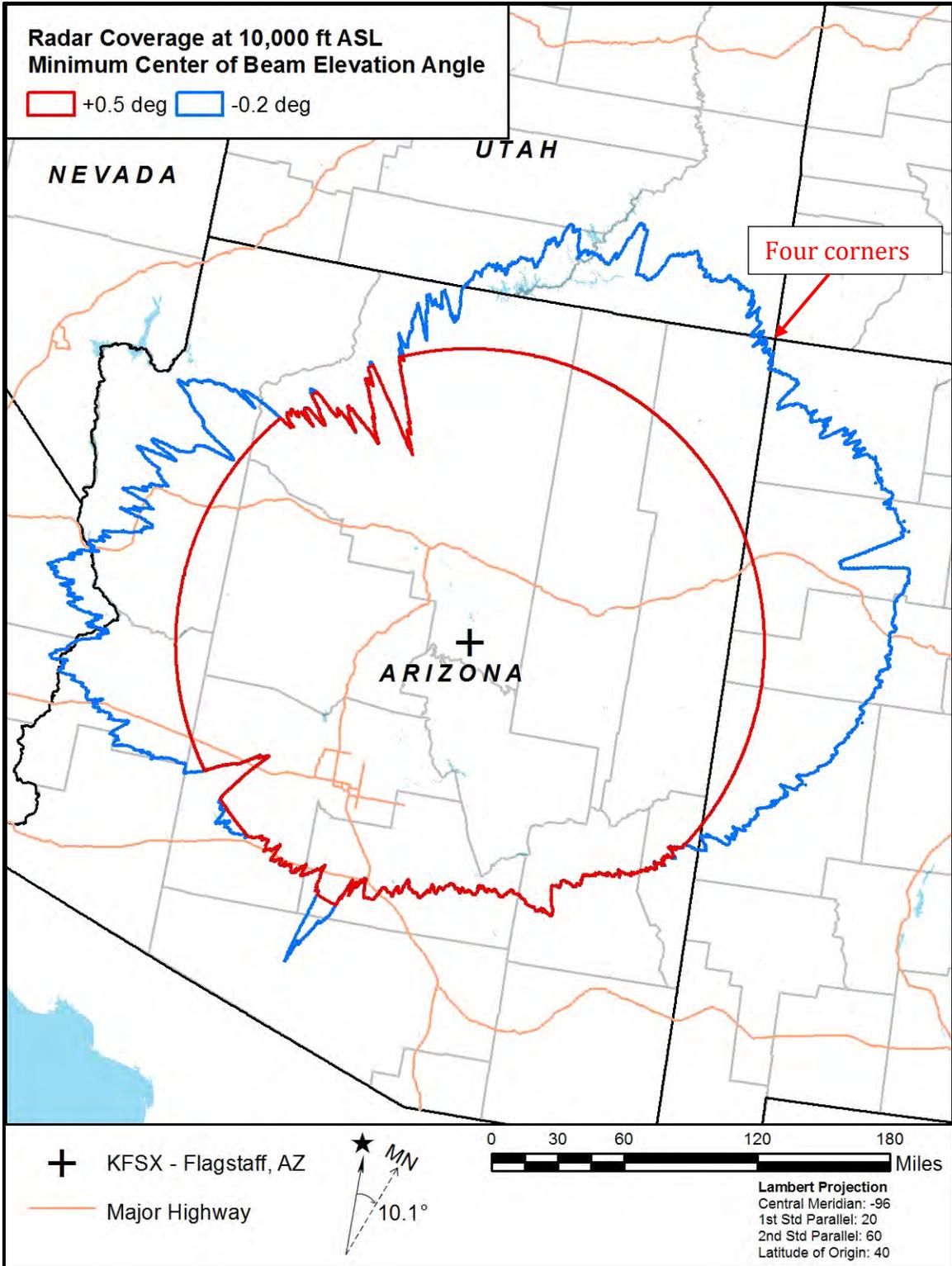


Figure 7: Existing and Proposed KFSX WSR-88D Coverage at 10,000 ft above Site Level

The four corners area (i.e. where AZ, Colorado, New Mexico, and Utah meet) is about 204 miles northeast of the KFSX WSR-88D. The proposed action would reduce the minimum height of radar coverage (i.e. radar coverage floor) over the four corners area from 23,500 ft to 12,200 ft AGL. These improvements in WSR-88D coverage would be beneficial to NWS forecasters and other users of radar data (e.g. emergency response managers, water managers, transportation officials). This reduction in coverage height would aid NWS meteorologists by improving their ability to accurately detect and measure low atmosphere weather features and severe weather.

The existing WSR-88D transmitter and antenna are physically equipped to operate at the proposed minimum scan angle. The only change required to implement the proposed change would be modifications to the software that controls radar operations and processes data collected by the radar. No construction activities or ground disturbance would be required to implement the proposed action. The transmit power of the radar would also be unchanged.

3.2 ALTERNATIVES

NAO 216-6A requires analysis of the no-action alternative in EAs. For purposes of this EA report, the no-action alternative is defined as continuing to operate the KFSX WSR-88D serving the Flagstaff, AZ, area with the current minimum center of main beam scan angle of +0.5 deg. This is the same minimum scan angle used by most other WSR-88Ds in the nationwide network. The no-action alternative and alternative minimum scan angles between +0.4 and -0.1 deg are analyzed in Section 5 of this EA.

4 ENVIRONMENTAL SETTING, CONSEQUENCES, AND MITIGATION

4.1 EXPOSURE OF PERSONS TO RADIOFREQUENCY RADIATION

Safety Standards

The electromagnetic environment at a specific location and time is composed of all the electromagnetic fields from various sources (natural and manmade) that arrive there. The electromagnetic spectrum in an area is a continuously usable resource whose dimensions are amplitude, time, frequency, and space. In areas large enough to permit adequate spatial separation of users, the electromagnetic spectrum can simultaneously accommodate many users if they are sufficiently separated in frequency. The electromagnetic environment at any point can change nearly instantaneously and will vary spatially, even at locations in close proximity; therefore, it is convenient to measure and characterize electromagnetic phenomena using averages over time and space.

Manmade contributions to the electromagnetic environment are both intentional and unintentional. Radio and television broadcasts, cellular telephone transmissions, and radar signals are examples of intentional contributions. Electromagnetic noise generated by power lines, fluorescent lights, and motors of all sorts are examples of unintentional human contributions. The KFSX WSR-88D transmits a radio signal at a frequency of 2,890 MHz, which is within the radiofrequency (RF) or microwave portion of the electromagnetic spectrum. Although microwaves can add heat to objects, they do not contain enough energy to remove electrons from biological tissue, and are a form of non-ionizing radiation. In this regard, microwaves are fundamentally different from ionizing radiations (e.g., X-rays, ultraviolet rays) which occur at higher frequency portions of the electromagnetic spectrum. Ionizing radiation occurs only at frequencies greater than 10^9 MHz. RF or microwave fields are non-ionizing radiation. Due to the fundamental differences between ionizing and non-ionizing radiation, safety standards and guidelines vary greatly for the two types of electromagnetic radiation. In this section only standards for non-ionizing radiation are addressed because KFSX WSR-88D RF emissions are non-ionizing.

The Institute of Electrical and Electronics Engineers (IEEE) developed safety guidelines for human exposure to RFR, and those standards have been adopted by the American National Standards Institute (ANSI) [ANSI/IEEE, 2006]. The ANSI/IEEE safety standard is designed to protect all persons (including infants, elderly persons, and pregnant women) from adverse health effects from exposure to radiofrequency (RF), even if exposure should last over an entire lifetime. These guidelines set safety levels for maximum permissible exposure (MPE) to RF signals, which include a 10- to 50-fold safety margin and are intended to protect all members of the population.

MPEs are specified in power density of the radio signal in milliwatts per square centimeter (mW/cm^2) and vary with operating frequency. Separate MPEs have been established for exposure of the general public and workers and for time-averaged exposure and peak exposure.

Occupational safety standards are higher than those for the general public because workers are trained in RF safety practices and have greater ability to use that knowledge to protect themselves from potentially harmful RF exposure. The KFSX WSR-88D operating frequency is and 2,890 MHz. The IEEE/ANSI safety standard for that frequency is 1.0 mW/cm^2 for the general public (averaged over 30 minutes) and 9.63 mW/cm^2 for workers (averaged over 6 minutes).

The Occupational Health and Safety Administration (OSHA) regulates occupational exposure to RF emissions. The OSH safety standard is similar to the ANSI/IEEE occupational safety standard: 10.0 mW/cm^2 (averaged over 6 minutes) (OSHA, 2015). Federal Communications Commission (FCC) RF exposure standards for RF exposure of the general public are the same as the ANSI/IEEE: 1.0 mW/cm^2 averaged over 30 minutes). The FCC RF exposure standard for occupational exposure is somewhat lower than the ANSI/IEEE safety level: 5.0 mW/cm^2 (averaged over 6 minutes).

RF Exposure Levels

The KFSX WSR-88D is mounted on a 25 m tall steel-lattice tower. Ground elevation is ft 7,415 ft MSL. The center of the antenna is at 7,512 ft MSL and the lower edge of the antenna is at 7,498 ft MSL, which is 83 ft above ground level (AGL). When operating at the current minimum scan angle of +0.5 deg, the lower edge of the beam is at 0.0 deg (i.e. horizontal) and the radar's main beam does not impinge on the ground surface or any structures in proximity to the radar. Operating at the proposed minimum scan angle of -0.2 deg would not change that situation; the main beam would still not impinge on the ground surface or structures within 1.7 miles of the WSR-88D.

Compared to the existing minimum scan angle of +0.5 deg, lowering the minimum scan angle to -0.2 deg would result in a slight increase in RF exposure levels at air space in the vicinity of the radar. Appendix A includes calculations of the existing time-averaged RF exposure levels in the vicinity of the KFSX WSR-88D, and the RF exposure that would result if NWS lowers the minimum scan angle to -0.2 deg. Table 3 summarizes the results from Appendix A. During normal operation of the WSR-88D with a rotating antenna, RF exposure levels at all locations would comply with safety standards for exposure of both workers (i.e. occupational exposure) and the general public.

During infrequent stationary antenna operation, RF exposure levels within the WSR-88D main beam would exceed ANSI/IEEE and FCC safety levels for exposure of the general within 1,740 ft of the WSR-88D antenna. FCC occupational safety levels would be exceeded within 780 ft and ANSI/IEEE occupational safety levels within 560 ft. The KFSX WSR-88D operating at -0.2 deg would not impinge on the ground surface or any structures within those distance and risks to human health would not result.

**Table 3: RF Power Density within KFSX WSR-88D Main Beam
Compared to ANSI/IEEE Safety Standards**

| Distance from Radar | Time-Averaged Power Density (mW/cm ²) | ANSI/IEEE General Public RF Safety Standard | | ANSI/IEEE Occupational RF Safety Standard | |
|---|---|---|------------------|---|------------------|
| | | Safety Standard (mW/cm ²) | Factor Below Std | Safety Standard (mW/cm ²) | Factor Below Std |
| 20 ft* | 0.599 | 1.0 | 1.67 | 9.63 | 16 |
| 1 mile | 0.00029 | 1.0 | 3,450 | 9.63 | 33,200 |
| Closest illuminated ground (8,800 ft ESE) | 0.00011 | 1.0 | 9,090 | 9.63 | 87,500 |
| 5 miles | 0.000012 | 1.0 | 83,300 | 9.63 | 802,500 |

*surface of WSR-88D radome

RF Electro-stimulation

The ANSI/IEEE safety guidelines also cover possible induction of currents within the bodies of persons and the potential for electro-stimulation of persons who make contact with conductive objects in the RFR field. The result is potentially harmful sensation of shock and/or burn. These effects only occur for RF fields at frequencies below 110 MHz (ANSI/IEEE, 2006). The primary operating frequency of the KFSX WSR-88D would be unchanged at 2,890 MHz, outside the frequency range where induced currents or electro-stimulation occur, and would not cause these effects.

Cumulative RF Exposure

As shown in Table 3, the power density of RF transmissions decreases exponentially with distance from the antenna. At all locations in the vicinity, RF emitted by the WSR-88D during normal operation would be at substantially below the safety standard for RF exposure of the general public. It is improbable that radio emissions from an external source would add to the WSR-88D RF emissions during normal operation to cause cumulative RF exposure levels exceeding safety standards.

4.2 RF EXPOSURE OF EQUIPMENT AND ACTIVITIES

4.1.7 Television, Radio, Cellular Telephone, and Personal Communications Devices (PCDs)

High-power radar, such as the WSR-88D, can interfere with operation of radio, television, cellular telephone, and PCDs in close vicinity to the radar antenna. However, these devices operate at different frequencies from the WSR-88D, reducing the potential for radio interference. NTIA regulations reserve the 2,700 to 3,000 MHz band for government radiolocation users (e.g., meteorological and aircraft surveillance radars) [NTIA, 2009]. The WSR-88D operates outside the frequencies used by television and radio broadcasts, cellular telephones, and personal communication devices. NWS has not received any reports of the KFSX WSR-88D interfering with operation of other radio uses (Schultz, 2019). Lowering the minimum scan angle to -0.2 deg would not result in the main beam impinging on the ground surface within 1.7 miles of the radar and the potential for radio interference would be low. No mitigation is necessary.

4.2.2 Electro-explosive Devices (EEDs)

Electro-explosive devices are used to detonate explosives, separate missiles from aircraft, and propel ejection seats from aircraft. Under extreme circumstances, electromagnetic radiation can cause unintended firing of EEDs. Calculations based on a U.S. Air Force (USAF) standard indicate that using electric blasting caps at distances beyond approximately 900 ft from the WSR-88D is a safe practice, even in the main beam of the radar, where the power density of the WSR-88D radio signal is greatest [USAF, 1982]. The U.S. Navy Hazards of Electromagnetic Radiation to Ordnance (HERO) regulations classify ordnance as safe, susceptible, or unsafe and unreliable, based on compliance with MIL-STD 664 (series). HERO safe ordnance is considered safe in all RFR environments. HERO susceptible ordnance may be detonated by RF energy under certain circumstances. HERO unsafe or unreliable ordnance has not been evaluated for compliance with MILSTD 664 or is being assembled, disassembled, or subject to unauthorized conditions, which can increase its sensitivity to RF emissions. Safe separation distances vary for susceptible and unsafe or unreliable ordnance [Naval Sea Systems Command, 2008]. For HERO susceptible ordnance, the safe separation distance (D) in ft is calculated as follows:

$$D = (781) (f)^{-1} (\text{average power} \times \text{antenna gain})^{1/2}$$

Where f is operating frequency in MHz and average power = maximum transmitted power × duty cycle. Inserting these values gives:

$$D = (781) (2,890)^{-1} (475,000 \text{ W} \times 0.0021 \times 35,500)^{1/2} \text{ ft}$$

$$D = 1,608 \text{ ft}$$

For HERO unsafe or unreliable ordnance, the safe separation distance (D) in ft is calculated as follows:

$$D = (2,873) (f)^{-1} (\text{average power} \times \text{antenna gain})^{1/2}$$

$$D = (2,873) (2,890)^{-1} (475,000 \text{ W} \times 0.0021 \times 35,500)^{1/2} \text{ ft}$$

$$D = 5,916 \text{ ft}$$

HERO concerns are only applicable in locations illuminated by the main beam of the radar. When operating at a minimum scan angle of -0.2 deg, the KFSX WSR-88D main beam would not illuminate the ground or structures within 5,916 ft of the radar. The WSR-88D would not be a hazard to EEDs use in the vicinity. No mitigation is necessary.

4.2.4 Fuel Handling

Electromagnetic fields can induce currents in conductive materials and those currents can generate sparks when contacts between conductive materials are made or broken. Sparks can ignite liquid fuels, such as gasoline. This phenomenon is rare, but can result in hazards to human health and property. This potential hazard arises during the transfer of fuel from container to another (e.g., fueling an automobile, boat, or airplane). The U.S. Navy developed a Technical Manual identifying the circumstances where this hazard may occur and providing direction on how to prevent it. The Technical Manual identifies a safe standoff distance based on radar operating characteristics [Naval Sea Systems Command, 2003]. Using formula contained in the Technical Manual, the distance from the WSR-88D at which RFR hazards to fuel may occur is 537 ft. This hazard only exists in areas directly illuminated by the main beam. The WSR-88D main beam operating at a minimum center of antenna scan angle of -0.2 deg would not illuminate the ground or any structures within 537 ft of the radar. The existing fuel tank for the standby generator at the base of the WSR-88D tower would not be illuminated by the WSR-88D main beam and hazards to fuel handling activities would not result. No mitigation is required.

4.2.5 Active Implantable Medical Devices

ANSI and the Association for Advancement of Medical Instrumentation (AAMI) developed the PC69:2007 standard to prevent external electromagnetic sources from causing electromagnetic interference with active implantable medical devices, including cardiac pacemakers and implantable cardiac defibrillators [ANSI/AAMI, 2007]. This standard specifies that cardiac pacemakers and ICDs must be tested by exposing them to a specified magnetic field and that the device must operate without malfunction or harm to the device. The specified field strength varies with frequency. For the WSR-88D operating frequency of 2,855 MHz, the field strength is 3 A/m. This is converted to power density (S) in units of W/m² by assuming free air impedance of 377 ohms:

$$S = 377 |3|^2 \text{ W/m}^2$$

$$S = 3,393 \text{ W/m}^2$$

To convert to mW/cm², we multiply the numerator by 1,000 mW/W and the divisor by 10,000 cm²/m² which gives a value of 339.3 mW/cm². The peak pulse power of the WSR-88D is given by the following formula (see Appendix A):

$$U_1 = 1.44 \times 10^9 / R^2 \text{ mW/cm}^2$$

Inserting $R = 2,060$ ft gives a value of 339.3 mW/cm^2 , which equals the threshold established by PC69:2007 standard. At distances of 2,060 ft or greater, the main beam of the WSR-88D would not adversely affect implantable medical devices. There would also be no hazards to implantable medical devices at locations outside the main beam. Operating at the minimum potential center of beam scan angle of -0.2 deg, the main beam of the KFSX WSR-88D would not illuminate the ground or structures within 2,060 ft of the radar and no hazards would result to persons with implanted devices.

Theoretically, persons in aircraft flying within 2,060 ft of the radar could be exposed to RF levels above the device susceptibility threshold set by ANSI/AAMI, but the likelihood of significant harm is extremely low. For persons in aircraft, the airframe would attenuate the RF level and the duration of exposure would be far less than the averaging time (6 to 30 minutes) specified in the RF safety standards, reducing the amount of RF exposure. Additionally, device susceptibility threshold in the PC69:2007 standard is based on coupling of the RFR directly into the device leads (which is the test protocol); the WSR-88D signal would be incident upon the surface of the body and would decrease considerably in strength at the location of the device leads within the body. Third, even in the unlikely event that the WSR-88D RFR couples into the device at levels above the susceptibility threshold, the device would revert to safe mode of operation that would prevent significant harm to the wearer or damage to the device [ANSI/AAMI, 2007].

FCC regulations at 47 CFR Part 95.1221 require that MedRadio medical implant devices and medical body-worn transmitters be able to withstand exposure to RF at the MPEs specified in FCC regulations at 47 CFR 1.1310 (FCC, 2017). As described in Section 4.1 above, RF exposure levels in the vicinity of the KFSX WSR-88D would comply with the FCC safety standards. Exposure of persons wearing implantable medical devices to the KFSX WSR-88D radio emissions would not result in adverse effects.

4.2.6 Astronomical Observatories

The WSR-88D can cause harmful electromagnetic interference (EMI) with charge-couple devices (CCDs) which electronically record data collected by astronomical telescopes (NEXRAD JSPO 1993). The potential for harmful EMI would arise if the WSR-88D's main beam would directly impinge on an astronomical observatory during low angle scanning. Table 4 lists six astronomical observatories located within 150 miles of the KFSX WSR-88D. The elevation of the KFSX WSR-88D main beam at each observatory was calculated based on a minimum center of beam scan angle of -0.2 deg (i.e. lower half-power point of -0.2 deg) and factors in earth curvature, beam spreading, and terrain blockage. Lowering the minimum scan angle of the WSR-88D to -0.2 deg would not result in the main beam impinging on any of the six observatories. No adverse effects on astronomical observatories would result.

| Observatory | Location | Distance and Direction | Would WSR-88D Main Beam at -0.2 deg Impinge? |
|-----------------------|-----------------|-------------------------------|---|
| Apache-Sitgreaves | Overgaard, AZ | 39 mi east-southeast | No |
| Mt. Graham | Safford, AZ | 149 mi south-southeast | No |
| Lowell | Flagstaff, AZ | 41 mi north-northwest | No |
| Mt. Lemmon Sky Center | Tucson, AZ | 150 mi south | No |
| Emory Riddle Prescott | Prescott, AZ | 71 miles west | No |
| U.S. Naval | Flagstaff, AZ | 52 mi northwest | No |

Summary of RF Exposure Effects

Table 5 summarizes impacts to potentially RF-sensitive equipment and activities. The potential for the proposed action to cause radio interference with other radio users would be very low.

| Equipment / Activity | Applicable Standard | Setback Distance (ft) | Would Main Beam Impinge on Ground Within Setback Distance? | Potential for Significant Effects |
|---|--|------------------------------|---|--|
| Television, Radio, and Cellular Telephone, and Personal Communications Devices (PCDs) | NTIA Frequency Allocations | n/a | n/a | Very Low |
| EEDs | U.S. Navy HERO | 5,916 | No | Very Low |
| Fuel Handling | U.S. Navy Hazards to Personnel, Fuel, and Other Flammable Material | 537 | No | Very Low |
| Active Implantable Medical Devices | AAMI PC69:2007, FCC 47 CFR Part 95.1221 | 2,060 | No | Very Low |
| Astronomical Observatories | WSR-88D main beam impinges | n/a | n/a | Very Low |

4.3 LAND USE AND COASTAL ZONE MANAGEMENT

Arizona is not a coastal state and does not have a Coastal Zone Management Program. The KFSX WSR-88D is located at in a rural forested portion of Coconino National Forest in Coconino County, AZ, which is administered by the U.S. Forest service (USFS). Land uses in the vicinity consist of dispersed recreational activities within the national forest. The nearest uses are the Rock Crossing and Blue Ridge campgrounds, about 1.6 mile south and northeast of the WSR-88D, respectively. The USFS Mogollon Rim District Office is about 4 miles to the north (USFS, 2013). The proposed action would not change land uses at the KFSX WSR-88D site or vicinity and would not adversely affect nearby land uses.

4.4 GEOLOGY, SOILS, AND SEISMIC HAZARDS

KFSX WSR-88D site is situated on an elevated plateau composed of Paleozoic Era sedimentary and volcanic layers. Bedrock is composed of volcanics, limestone, sandstone, and shale of the Kaibab, Coconino, Toroweap, and Hermit formations (American Association of Petroleum Geologists, 1990). Soil at the site consists of Brollier very stony clay loam on 0 to 10% slopes. This soil is well drained and the depth to the water table is more than 80 inches. Depth to bedrock is 24 to 34 inches. This soil is not classified as prime farmland. (Soil Survey Staff, Natural Resources Conservation Service, U.S. Department of Agriculture, 2019).

The risk of an earthquake is low. U.S. Geological Survey (USGS) estimates the potential for an earthquake strong enough to cause minor damage or greater at less than 1% per year (USGS, 2019).

Lowering the minimum scan angle of the KFSX WSR-88D would not require physical changes to the radar or result in ground disturbance. The proposed action would have no effect on geology, soils, farmland, or seismicity. No mitigation measures are required.

4.5 DRAINAGE AND WATER QUALITY

The KFSX WSR-88D site drains northward to Moqui Draw, which is a tributary of East Clear Creek, Little Colorado River, and the Colorado River (USGS, 1965 and 1960). Lowering the minimum scan angle of the KFSX WSR-88D would not result in ground disturbance. The proposed action would not affect the amount of impervious surface area at the radar site, the rate of storm runoff flowing from the site during or after precipitation events, or generate water pollutants. The proposed action would have no effect on drainage or water quality. No mitigation measures are required.

4.6 TRANSPORTATION

The KFSX WSR-88D is accessible via Arizona State Highway 87, which is a paved two-lane rural highway, and Forest Roads 751 and 751B, which are unpaved. The proposed action would require modification of the WSR-88D software to be able to scan at angles below +0.5 deg. To implement the change in scan angle, NWS technicians and engineers would travel to the KFSX WSR-88D site to perform initial testing and ensure that the modified software is operating

properly. Travel to the site would be minimal and would not result in significant congestion on local roads. Transportation effects would not be significant. No mitigation measures are required.

4.7 AIR QUALITY

The KFSX WSR-88D is equipped with a standby generator that is used if primary power is interrupted and also periodically for testing. The proposed action would not change the power consumption of the WSR-88D or affect the hours of operation of the standby generator, and no change in air emissions would result. A Clean Air Act Federal Conformity Determination is not required. No mitigation measures are required.

4.8 FLOOD HAZARDS

Executive Order (E.O.) 11988, *Floodplain Management*, requires the Federal Government to avoid adverse impacts to the 100-year or base floodplain (that is, the area subject to a 1 percent annual chance of flooding), unless there is no practicable alternative [President, 1977a]. The KFSX WSR-88D site is at the crest of Blue Ridge and is not within a 100-year floodplain as mapped by the Federal Emergency Management Agency (Coconino County, 2019). The proposed action of lowering the minimum scan angle of the KFSX WSR-88D to -0.2 deg would not affect floodplains or flood hazards. No mitigation measures are required.

4.9 WETLANDS

E.O. 11990, *Protection of Wetlands*, requires the Federal Government avoid funding or implementing projects which would adversely impact wetlands unless there is no practicable alternative [President, 1977b]. Based on National Wetland Inventory maps prepared by the U.S. Fish and Wildlife Service (USFWS), the WSR-88D site does not contain federal jurisdictional wetlands. The nearest wetlands are man-made excavations that temporarily collect water and contain palustrine, unconsolidated shore wetlands (PUSAx) located 1,300 ft south and 1,800 ft east of the WSR-88D. The nearest drainage is tributary of Moqui Draw located 2,700 ft east-northeast of the WSR-88D. That drainage contains riverine intermittent streambed, seasonally flooded wetlands (R4SBC). The proposed action would not involve ground disturbance and would not affect federal jurisdictional wetlands; no mitigation is required.

4.10 BIOLOGICAL RESOURCES / PROTECTED SPECIES

The USFWS administers the Endangered Species Act (ESA) and Migratory Bird Treaty Act. The KFSX WSR-88D is located within the area served by the USFWS Arizona Ecological Services Field Office in Phoenix, AZ and a protected species list was obtained from that office (see Attachment B). Table 6 lists threatened and endangered species listed under the ESA that could potentially occur in Coconino County, AZ. The protected species include two birds, one reptile, one amphibian, and one fish. The KFSX WSR-88D is within critical habitat for the Mexican spotted owl.

| Species (scientific name) | Type | Status | Is WSR-88D site in Critical Habitat? |
|--|-------------|---------------|---|
| Mexican spotted owl (<i>Strix occidentalis lucida</i>) | Bird | Threatened | Yes |
| Yellow billed cuckoo (<i>Coccyzus ameicanus</i>) | Bird | Threatened | No |
| Northern Mexican garter snake (<i>Thamnophis eques megalops</i>) | Reptile | Threatened | No |
| Chiricahua leopard frog (<i>Rana chriricahuensis</i>) | Amphibian | Threatened | No |
| Little Colorado spinedance (<i>Lepidomeda vittata</i>) | Fish | Threatened | No |

Mexican spotted owls inhabit conifer, pine-oak, and riparian forests with multi-layered uneven-aged tree structure (USFWS, 2019a). The conifer forest surrounding the KFSX WSR-88D site could serve as habitat for Mexican spotted owls although the trees are of relatively uniform age. The proposed action would not require ground disturbance or removal/pruning of trees. It would not disturb Mexican spotted owl habitat and would not affect Mexican spotted owls.

Yellow-billed cuckoo is a fairly large, long, and slim bird that forages in deciduous forests for caterpillars. In the western U.S. they inhabit cottonwood-dominated forest along major rivers (USFWS, 2019b). Suitable habitat is not present at or near the KFSX WSR-88D site.

Northern Mexican garter snakes inhabit riparian areas, including wetlands, stock tanks, riparian corridors along large rivers and the adjacent woodlands, and deciduous riparian forests (USFWS, 2019c). Suitable habitat is not present at or near the KFSX WSR-88D site.

Chiricahua leopard frogs consist of two populations. The northern population occurs in the Mogollon Rim area of Central Arizona. They inhabit springs, pools, cattle tanks, lakes, reservoirs, streams, and rivers (USFWS, 2019d). (USFWS, 2019e). Little Colorado spinedance is a small minnow-like fish that inhabits streams of central and northern Arizona (USFWS, 2019e). Neither of these species would be expected to occur at or near the KFSX WSR-88D as aquatic habitat is not present.

The proposed action would not include construction activities and would not result in ground disturbance or vegetation removal. No physical changes to suitable habitat for any of the listed species would result. Lowering the minimum scan angle to -0.2 deg from the current +0.5 deg would result in a thin sliver of the atmosphere, which is currently below the main beam coverage area, being exposed to the main beam of the WSR-88D (see Figure 4). The portion of this

atmosphere above the newly exposed sliver of atmosphere is currently within the main beam and RF exposure levels would not change. The sliver of the atmosphere where new main beam coverage would result in increased RF exposure levels would be very small in close proximity to the WSR-88D -11 ft thick at a distance of 900 ft from the WSR-88D and increasing in thickness with distance from the radar. Migratory birds or bats flying within the newly covered sliver of the atmosphere would be exposed to RF emissions from the WSR-88D. The RF levels in the sliver of airspace would be no greater than in RF levels in the existing covered airspace, which occurs just above the newly exposed air space. At a distances of several miles or greater where the volume of newly covered airspace would be substantial, RF levels would be very low. At a distance of 900 ft, RF exposure levels would be 100 times less than safety standards for human exposure. Based on the extremely low RF levels at distance from the WSR-88D, RF exposure of listed migratory birds flying within the newly covered airspace would not be harmful.

Elevated RF exposure could result if birds fly in a path that keeps it within the WSR-88D main beam for extended periods of time. However, during normal operation the WSR-88D main beam is continuously moving. At a distance of 1,000 ft the WSR-88D main beam is moving at an effective speed of about 89 miles per hour and it is very unlikely that a bird could fly within the WSR-88D main beam for any length of time.

The proposed action would not result in significant impacts to protected species, critical habitat, or migratory birds. No mitigation measures are required.

4.11 CULTURAL AND HISTORIC RESOURCES

Section 106 of the National Historic Preservation Act of 1966 (as amended) requires that federal agencies consider the effects of their actions on historic places and, if effects may result, provide the State Historic Preservation Officer (SHPO) with an opportunity to comment on their actions. Section 106 regulations are set forth in 36 CFR Part 800, *Protection of Historic Properties* (Advisory Council on Historic Preservation, 2010).

Because the proposed action would not involve ground disturbance, no impacts to archaeological or paleontological resources would result. The proposed action's area of potential effect (APE) is defined as area within 1,740 ft of the KFSX WSR-88Ds where RF exposure of persons within the WSR-88D main beam could potentially exceed safety levels (see Table 4). The AZSITE website was searched to identify places listed on the National Register of Historic Places (NRHP) or the Arizona Register of Historic Places (ARHP) within the APE. The search area included sections 19, 20, 29, and 39 of Township 14 north, Range 11 east, which encompasses the APE. No listings for cultural or historic sites were found within the APE (AZSITE, 2019). Under Section 106 Regulations 36 CFR Section 800.2 (a)(1), *Protection of Historic Properties*, if the proposed action doesn't have the potential to affect historic properties, NWS "has no further obligations under section 106" and consultation with Arizona SHPO regarding possible impacts on historic properties is not required [Advisory Council on Historic Preservation, 2010].

4.12 ENVIRONMENTAL JUSTICE AND SOCIOECONOMIC IMPACTS

E.O. 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations*, requires federal agencies to identify and address, as appropriate, disproportionately high and adverse environmental or human health effects on minority populations and low income populations (President, 1994).

The KFSX WSR-88D is located in Coconino National Forest and no residences or campgrounds occur within 1.5 miles of the KFSX WSR-88D. The proposed action would not generate air or water pollutants or hazardous waste. The project would modify the operation of the KFSX WSR-88D by reducing the minimum scan angle from +0.5 deg to -0.2 deg. The lowered WSR-88D main beam would not impinge on the ground in proximity to the radar and would comply with safety standards for human exposure to RF energy and setbacks for activities (e.g. fuel handling and EED use) that are potentially sensitive to RF exposure. No disproportionately high and adverse effects would result to any persons, including minority or low income populations. No mitigation is required.

4.13 FARMLANDS

The Farmland Protection Policy Act sets forth federal policies to prevent the unnecessary conversion of agricultural land to non-agricultural use. NRCS regulations at 7 CFR Part 658, *Farmland Protection Policy Act*, are designed to implement those policies. Completion of Form AD-1006 and submission to the U.S. Department of Agriculture (DoA) is required if a federal agency proposes to convert land designated as prime farmland, farmland of statewide importance, or unique farmland to non-agricultural use. Soil at the KFSX WSR-88D site is not classified as prime farmland. The proposed action would not convert farmland to non-farm use. No mitigation is necessary.

4.14 ENERGY CONSUMPTION

The proposed action would not change electric use by the WSR-88D and would have no effect on energy consumption. No mitigation is necessary.

4.15 VISUAL QUALITY/ LIGHT EMISSIONS

The proposed action would not change the appearance of the KFSX WSR-88D or result in new emissions of visible light. The proposed action would have no effect on visual quality. No mitigation is necessary.

4.16 SOLID AND HAZARDOUS WASTE

The proposed action would result in no changes to solid or hazardous waste generation. No mitigation is necessary.

4.17 WILD AND SCENIC RIVERS

The Wild and Scenic Rivers Act of 1968 protects free-flowing rivers of the U.S. These rivers are protected under the Act by prohibiting water resource projects from adversely impacting values of the river: protecting outstanding scenic, geologic, fish and wildlife, historic, cultural, or recreational values; maintaining water quality; and implementing river management plans for these specific rivers. The wild and scenic river closest to the KFSX WSR-88D is Fossil Creek, located 20 miles to the southwest (National Park Service, 2019). The proposed action would not affect the Fossil Creek or any other wild and scenic river. No mitigation is necessary.

DRAFT

5 ALTERNATIVES TO THE PROPOSED ACTION

5.1 MINIMUM SCAN ANGLES BETWEEN +0.4 AND -0.1 DEG

NWS evaluated the benefits and potential impacts of lowering the minimum center of beam scan angle of the KFSX WSR-88D to each angle between +0.4 and -0.2 deg in 0.1 degree increments (see Appendix B). That analysis found that the proposed action of lowering the minimum scan angle to -0.2 deg would result in the significant feasible improvement in radar coverage area and reduce the height of radar coverage over the four corners area.

A minimum scan angle between +0.4 and -0.1 deg would increase the radar's coverage area, but by less than the proposed action (i.e. minimum scan angle of -0.2) deg. Because a minimum scan angle of -0.2 deg would result in the greatest improvement in radar coverage without causing significant environmental effects, NWS rejected alternatives of operating the KFSX WSR-88D at alternative minimum scan angles between +0.4 and -0.1 deg.

5.2 NO ACTION

The no action alternative consists of continued operation of the KFSX WSR-88D at the existing minimum scan angle of +0.5 deg. The improvements in radar coverage summarized in Section 3 would not be achieved and the project objectives would not be met.

The proposed action would result in increased RF exposure compared to existing WSR-88D operations as described in section 4.1; the no-action alternative would not change RF exposure levels from existing. Under both the proposed action and the no action alternative, RF exposure during normal WSR-88D operations would conform to safety standards established by ANSI/IEEE, OSHA, and FCC.

Similar to the proposed action, the no-action alternative would not result in adverse effects in the following topic areas:

- Land Use and Coastal Zone Management
- Geology, Soils, and Seismic Hazards
- Drainage and Water Quality
- Transportation
- Air Quality
- Flood Hazards
- Wetlands
- Biological Resources / Protected Species
- Cultural and Historic Resources
- Environmental Justice and Socioeconomic Impacts
- Farmlands
- Energy Consumption
- Visual Quality/ Light Emissions
- Solid and Hazardous Waste

- Wild and Scenic Rivers

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6 FINDING

The proposed action of lowering the scan angle of the KFSX WSR-88D from the current minimum of +0.5 deg to -0.2 deg would not result in significant changes in the quality of the human environment. Lowering the minimum scan angle would also not add to the environmental effects of past, present, and reasonably foreseeable future actions to cause cumulatively significant effects

The proposed action would improve the quality of meteorological radar data available to NWS forecasters and others users of the data. This may indirectly benefit the residents and businesses of the Flagstaff, AZ, WFO service area (central and northeastern Arizona) by improving the accuracy of forecast and severe weather alerts, which could result in environmental benefits if weather dependent economic activities (e.g., agriculture, construction, outdoor recreation, transportation, water management) become more efficient or safer as a result of improved weather services. The resulting environmental benefits are difficult to quantify, but are unlikely to be significant.

Implementation of the proposed action would not have the potential to cause significant changes in the environmental. A Finding of No Significant Impact is warranted for the proposed action.

7 DOCUMENT PREPARERS

This Draft EA was prepared by Sensor Environmental LLC under contract to Centuria Corporation. Centuria Corporation provides support to the NWS Radar Operations Center (ROC) in Norman, OK.

Mr. James Manidakos, CEO, served as Sensor's Project Manager. Alion Science and Technology Corporation prepared radar coverage maps and calculated coverage areas under subcontract to Sensor. Mr. Andre Tarpinian, Radio Frequency Engineer, served as Alion's Project Manager. Ms. Jessica Schultz, NWS Radar Focal Point, and Mr. Edward Ciardi, Program Manager, EVP Weather Systems, from the ROC assisted in preparation of this EA. Mr. Brian Klimowski, Meteorologist-in-Charge, and staff from the Flagstaff, AZ, WFO, also assisted in preparation of this EA.

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8 REFERENCES

- Advisory Council on Historic Protection. *Protection of Historic Properties*, “Participants in the Section 106 Process.” 36 CFR Section 800.2 (July 1, 2010).
- American Association of Petroleum Geologists. *Geological Highway Map, Southern rocky Mountain Region, Utah, Colorado, New Mexico, and Arizona*. (1990).
- ANSI/AAMI. *American National Standard, Active Implantable Medical Devices – Electromagnetic compatibility – EMC test protocols for cardiac pacemakers and implantable cardioverter defibrillators*, ANSI/AAMI PC69:2007 (2007).
- ANSI/IEEE. *IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz*, IEEE Std. C95.1-2005, (April 19, 2006).
- AZSITE. *Arizona’s Cultural Resource Inventory*. (accessed June 15, 2019).
- EPA. *National Primary and Secondary Ambient Air Quality Standards*, 40 CFR Part 50 (2011).
- FCC. Title 47 Code of Federal Regulations Part 1.1310 *Radiofrequency Radiation Exposure Limits* and Part 95.1221 *Medical Device Radiocommunication Service, RF Exposure*, <https://www.law.cornell.edu/cfr/text/47/1.1310> (accessed May 6, 2017).
- ESRI. *Coconino County 100 Year Flood Zones*. <https://www.arcgis.com/home/webmap/viewer.html?webmap=2fba0520d1fb4b099993b6819ef07962> (Accessed June 15, 2019).
- National Park Service, National Wild and Scenic Rivers System. <https://www.rivers.gov/>. (accessed June 15, 2019).
- Naval Sea Systems Command. *Technical Manual, Electromagnetic Radiation Hazards (U), (Hazards to Personnel, Fuel, and Other Flammable Material) (U)*, NAVSEA OP 3565/NAVAIR 16-1-529, Volume 1, Sixth Revision (February 1, 2003).
- Naval Sea Systems Command. *Technical Manual, Electromagnetic Radiation Hazards (U), (Hazards to Ordnance) (U)*, NAVSEA OP 3565/NAVAIR 16-1-529, Volume 2, Seventeenth Revision, (September 11, 2008).
- NEXRAD JSPO. *Final Supplemental Environmental Assessment (SEA) of the Effects of Electromagnetic Radiation from the WSR-88D Radar* (April 1993).
- NOAA NAO 216-6A: *Compliance with the National Environmental Policy Act , Executive Orders 12114, Environmental Effects Abroad of Major Federal Actions ; 11988 and 13690, Floodplain Management; and 11990 Protection of Wetlands*. (April 22, 2016).
- NOAA. *Policies and Procedures for Compliance with the National Environmental Policy Act and Related Authorities*. Companion Manual for NOAA Administrative Order 216-6A (January 13, 2017).

- NOAA Office of Costal Management. *Coastal Management Program*. <https://coast.noaa.gov/czm/mystate/> (accessed June 15, 2019).
- NRCS. *Farmland Protection Policy Act*, 9 CFR Part 658 (January 1, 2010).
- NTIA. *Manual of Regulations and Procedures for Federal Radio Frequency Management* (revised September 2009).
- NWS. *Next Generation Weather Radar Programmatic Environmental Impact Statement (PEIS), Report R400-PE201* (1984).
- NWS. *Mission of the NWS*, <http://www.wrh.noaa.gov/psr/general/mission/index.php> (Accessed October 26, 2009).
- President. *Floodplain Management*, Executive Order 11988, 42 *Federal Register* 26951 (May 24, 1977a).
- President. *Protection of Wetlands*, Executive Order 11990, 42 *Federal Register* 26961 (May 24, 1977b).
- President. *Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations*, Executive Order 12898, 59 *Federal Register* 7629 (February 11, 1994).
- Schultz, Jessica. Radar Focal Point, NWS Radar Operations Center. email to jmanitakos@sensorenvirollc.com (January 28, 2019).
- Soil Survey Staff, NRCS, U.S. Department of Agriculture. *Web Soil Survey*. <https://websoilsurvey.nrcs.usda.gov> (accessed June 15, 2019).
- USFS, *Coconino National Forest Map*. 2013.
- USFWS. *National Wetlands Inventory*. <https://www.fws.gov/wetlands/data/mapper.html> (Accessed June 15, 2019).
- USFWS. Species Profile for Mexican Spotted owl. <https://ecos.fws.gov/ecp/species/8196>. (accessed June 15, 2019a).
- USFWS. *Species Profile for Yellow Billed Cuckoo*. <https://ecos.fws.gov/ecp/species/3911>. (accessed June 15, 2019b).
- USFWS. *Species Profile for Northern Mexican Garter Snake*. <https://ecos.fws.gov/ecp0/profile/speciesProfile?slId=7655> (accessed June 15, 2019c).
- USFWS. *Species Profile for Chiricahua Leopard Frog*. <https://ecos.fws.gov/ecp0/profile/speciesProfile?slId=1516> (accessed June 15, 2019d).
- USFWS. *Species Profile for Little Colorado Spinedance*. <https://ecos.fws.gov/ecp/species/1516>. (accessed June 15, 2019e).

USGS. *Blue Ridge Reservoir, Arizona, Coconino County*. 7.5 Minute Series topographic quadrangle (1965).

USGS. *Holbrook, Arizona*. 1:250,000 topographic map (1960).

USGS, *Short-term Induced Seismicity Models, 2018 One-year Model*. <https://earthquake.usgs.gov/hazards/induced/index.php#2018> (accessed June 15, 2019).

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9 EA DISTRIBUTION

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SENSOR ENVIRONMENTAL LLC
www.sensorenirollc.com

Environmental Assessment Report

**ENVIRONMENTAL ASSESSMENT (EA)
LOWERING THE MINIMUM SCAN ANGLE OF THE WEATHER
SURVEILLANCE RADAR - MODEL 1988, DOPPLER (WSR-88D)
SERVING THE FLAGSTAFF, ARIZONA, AREA**

APPENDICES

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APPENDIX A

RADIOFREQUENCY RADIATION POWER DENSITY CALCULATIONS

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1. OBJECTIVE

This appendix quantifies the power densities of the radiofrequency radiation (RFR) emitted by the Weather Surveillance Radar, Model 1988 Doppler (WSR-88D) during operations that include minimum scan angles of +0.5 to +0.4 degrees (deg). The calculated power densities will be used to analyze the potential for effects to result from exposure of humans, equipment, and activities to the WSR-88D radio signal, and the significance of any identified potential effects.

2. METHODOLOGY

This memorandum builds upon the analysis included in the 1993 *Supplemental Environmental Assessment (SEA) of the Effects of Electromagnetic Radiation from the WSR-88D Radar* [NEXRAD Joint System program Office, 1993]. The 1993 analysis analyzed the potential electromagnetic effects of the WSR-88D signal when the radar operates at a minimum center of beam scan angle of +0.5 deg. This memorandum builds on that analysis by considering operation at a lower minimum scan angle of -0.2 deg. The parameters of the WSR-88D are shown in Table A-1 and are not changed from the 1993 analysis:

| Parameter | Value |
|---|----------------------------------|
| Operating Frequency | 2,890 megahertz (MHz), 2,760 MHz |
| Wavelength at center frequency (2,850 MHz) | 0.345 ft, 10.5 cm |
| Maximum pulse power | 475 kiloWatts (kW) |
| Maximum duty cycle | 0.21% |
| Antenna diameter | 28 ft, 853 cm |
| Antenna gain | 35,500:1, 45.5 dB |
| Beam width to half-power points | 1.0 deg |
| First sidelobe relative power density, maximum | 0.00325, -25 dB |
| Other sidelobe maximum power density, relative to main beam | 0.0004, -34 dB |

The NWS proposes to modify the minimum center of beam scan angle used during operation of the KFSX WSR-88D below the +0.5 angle currently used. This would not require changes to the antenna, other hardware which composes the WSR-88D, or the radiated pulse power of the WSR-88D. However, incorporating scans at angles below +0.5 deg could affect the amount of RFR exposure experienced by persons, equipment, and activities at or near ground level in the vicinity of the radar. This memorandum quantifies that change.

3. MODIFIED VOLUME SCAN PATTERN 31

The WSR-88D uses a number of complex volume scan patterns to maximize the quality and usefulness of the meteorological data it collects. The 1993 report analyzed volume scan pattern 31, which results in the highest levels of ground-level RFR exposure. Volume Scan Pattern (VCP) 31 consists of eight 360 deg rotations of the antenna at various scan angles. NWS

proposed to add two additional antenna rotations at a scan angle between +0.5 and 0.0 deg to this scan pattern to increase the range at which the radar can detect and track meteorological phenomena, especially at low elevations within the atmosphere. This memorandum assumes that the two added scans would be at -0.2 deg (i.e. lower half power point of -0.7 deg), the lowest scan angles under consideration by NWS. Adding two -0.2 degree scans would result in the greatest possible increase in ground level RFR exposure. The modified VCP 31 would be as follows:

- Two complete rotations at -0.2 deg
- Two complete rotations at +0.5 deg
- Two complete rotations at +1.5 deg
- Two complete rotations at +2.5 deg
- One complete rotation at +3.5 deg
- One complete rotation at +4.5 deg

The complete pattern would include 10 rotations of the antenna at a speed of 0.8 revolutions per minute (rpm), the pattern would take about 12 minutes and 22 seconds to complete [Turner, 2011].

4. CALCULATION OF RF POWER DENSITIES

Appendix A of the 1993 SEA includes detailed calculations of the RFR power density and exposure levels resulting from volume scan pattern 31. The proposed scan change would not affect the distance of the transition from the near field to the far field, calculated at 640 to 800 ft in section A.3 of the 1993 Appendix A.

4.1 Far Field

The values of U_1 , U_2 , and U_3 would be unchanged from the values derived in 1993 Appendix A. The maximum pulse power density within the main beam (U_1) is given by the formula:

$$U_1 = 1.44 \times 10^9 / R^2 \text{ milliWatts per square centimeter (mW/cm}^2\text{)}$$

where R is the distance from the antenna in ft. The maximum pulse power density at locations greater than 6 deg off the main beam axis (i.e. outside the area illuminated by the main beam and first five sidelobes) is U_2 (unchanged from 1993 Appendix A), given below:

$$U_2 = 5.76 \times 10^5 / R^2 \text{ mW/cm}^2$$

The RF human exposure standards are based on time-averaged RF exposure for six minutes (occupational exposure) or 30 minutes (general public exposure) [American National Standards Institute/Institute of Electrical and Electronic Engineers, 2005]. We use six minutes as the averaging time as a worst-case analysis. The time-averaged power density for the main beam rotating continuously at +0.5 deg, considering the contributions from both the main beam and the first five sidelobes is given by U_3 (unchanged from 1993 Appendix A), below:

$$U_3 = 1.35 \times 10^4 / R^2 \text{ mW/cm}^2$$

At this point the analysis must consider the proposed modifications to VCP 31. The modified VCP 31 would have two additional -0.2 deg scans. Within our six minute averaging time, these two added scans would replace the RFR contribution from one +1.5 deg and one +2.5 deg scan. As described in the 1993 appendix, U_4 sums the RFR contributions at center of antenna level from each of the scans performed during the six minute period of interest. The coefficients for the -0.2 deg scans are 2.4/6 reflecting the proportion of the 6 minutes and 1.0 because the center of beam will essentially be at antenna level (i.e. -0.2 deg which equates to 2.8 ft, or one-tenth of the beam width at the far field transition distance of 800 ft). The corresponding coefficients for the two +0.5 deg scans within the six minutes are 2.4/6 and 0.5, and for the one +1.5 deg scan within the six minutes are 1.2/6 and 0.012. The modified U_4 calculation is given below

$$U_4 = [(2.4/6) (1.0) + (2.4/6) (0.5) + (1.2/6) (0.012)] U_3$$

$$U_4 = (0.602)U_3$$

Inserting the U_3 value of $1.35 \times 10^4/R^2$ milliwatts/cm² (mw/ cm²), yields:

$$U_4 = 8.13 \times 10^3/R^2 \text{ mW/cm}^2$$

U_4 is the 6-minute time-averaged power density at locations in the far field directly illuminated by the main beam and at the same elevation as the WSR-88D antenna, considering the RFR contributed from the main beam and the first five sidelobes. According to the WSR-88D specification, sidelobes of higher order than the first five will contain less than 5% of the radiated energy. The 1993 SEA calculated the average power density of these higher order sidelobes at $4/R^2$ mW/cm². We add this to U_4 to obtain U_5 , the total time-averaged power density at an elevation even with the center of antenna elevation and distances greater than 800 ft from the antenna:

$$U_5 = 8.13 \times 10^3/R^2 + 4/R^2 = 8.134 \times 10^3/R^2 \text{ mW/cm}^2$$

4.2 Near Field

Appendix A of the 1993 SEA calculates the height Y of the mathematical cylinder illuminated by all scans during the six-minute period using the formula $Y = 28 \div R \tan 2 \text{ deg} + 0.035R$. Since the modified scan pattern of interest includes scans of -0.2, +0.5, and +1.5 degs, the angular range is 1.7 deg, and we recalculate Y as follows:

$$Y = 28 + R \times \tan (1.7 \text{ deg}) = 28 + 0.03R$$

The circumference of the illumination cylinder is $2\pi RY$ and the total area A is

$$A = 2\pi RY = 176R + 0.19R^2$$

The average power radiated is less than or equal to 1 kW, and the average power over the cylindrical surface cannot exceed this value divided by the area. At the mid-height of the

cylinder, the local power density will exceed the average value by a factor of 2 (unchanged from the 1993 analysis). We introduce this factor, multiply by 10^6 to convert from kW to mW, and divide by 929 to convert from sq ft to square centimeters (sq cm):

$$U_6 = 2 * 10^6 / (929) (176R + 0.19R^2) = 11,331 / (R^2 + 926 R) \text{ mW/cm}^2$$

U_6 is the time-averaged RFR exposure within the area illuminated by the WSR-88D main beam up to distances of 640 ft where the beam begins to spread.

4.3 RF Exposure Levels near KFSX WSR-88D

Table A-2 shows the time-averaged RF power densities that would result at locations directly illuminated by the main beam of the KFSX WSR-88D when operating in modified VCP 31. The near field is within 640 ft of the radar and the U_6 formula is used to calculate these near field values. At greater distances, the far field formula for U_5 is used. For comparison purposes, corresponding values for the original VCP 31 are also shown. As can be seen from Table A-1, use of modified scan pattern 31 would lower the elevation at which the main beam occurs and would also slightly increase the time-averaged power densities in both the near and far fields.

| Place | Distance (ft) | Original VCP 31 Lowest Elev (ft MSL) | Original VCP 31 Time-Avg Power Density (mW/cm ²) | Modified VCP 31 Lowest Elev (ft MSL) | Modified VCP 31 Time-Avg Power Density (mW/cm ²) |
|----------------------------|---------------|--------------------------------------|--|--------------------------------------|--|
| Surface of Radome | 20 | 7,498* | 0.598 | n/a | 0.599 |
| Base of WSR-88D tower | 0 | 7,415 | 0.005 | 7,415 | 0.007 |
| 1 mile | 5,280 | 7,497 | 0.00021 | 7,435 | 0.00029 |
| Closest Illuminated Ground | 8,800 ft ESE | 7,496 | 0.000075 | 7,391 | 0.00011 |
| 5 miles | 26,400 | 7,486 | 0.0000083 | 7,188 | 0.000012 |

*Elevation of bottom edge of KFSX WSR-88D antenna

NWS may infrequently operate the KFSX WSR-88D with a stationary antenna, resulting in the main beam being continuously pointed at the same location for a period of time. The RF exposure level within the main beam can be calculated using equation U_1 multiplied by the radar duty cycle

$$U_7 = (1.44 \times 10^9 / R^2) 0.0021 = 3.024 \times 10^6 / R^2 \quad (\text{mW/cm}^2)$$

When operating in stationary antenna mode, the KFSX WSR-88D would exceed the ANSI/IEEE safety levels within the following distances:

ANSI/IEEE and FCC General Public Safety Level (1.0 mW/cm²): 1,740 ft

FCC Occupational Safety Level (5.0 mW/cm²): 780 ft

ANSI/IEEE Occupational Safety Level (9.63 mW/cm²): 560 ft

5. REFERENCES

American National Standards Institute / Institute of Electrical and Electronic Engineers (ANSI/IEEE). *IEEE Standard for Safety Levels with respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz*. IEEE Std C95.1-2005 (April 19, 2006).

Next Generation Weather Radar Joint System Program Office (JSPO), *Final Supplemental Environmental Assessment (SEA) of the Effects of Electromagnetic Radiation from the WSR-88D Radar* (April 1993).

Edward Ciardi, Program Manager, EVP weather Systems, Centuria Corporation. emails to James Manidakos, Sensor Environmental LLC, (February 14, 2018).

APPENDIX B

PROTECTED SPECIES LIST



United States Department of the Interior



FISH AND WILDLIFE SERVICE

Arizona Ecological Services Field Office
9828 North 31st Ave

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Phoenix, AZ 85051-2517

Phone: (602) 242-0210 Fax: (602) 242-2513

<http://www.fws.gov/southwest/es/arizona/>

http://www.fws.gov/southwest/es/EndangeredSpecies_Main.html

In Reply Refer To:

March 26, 2019

Consultation Code: 02EAAZ00-2019-SLI-0442

Event Code: 02EAAZ00-2019-E-01029

Project Name: KFSX WSR-88D Lower Scan

Subject: List of threatened and endangered species that may occur in your proposed project location, and/or may be affected by your proposed project

To Whom It May Concern:

The Fish and Wildlife Service (Service) is providing this list under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.). The list you have generated identifies threatened, endangered, proposed, and candidate species, and designated and proposed critical habitat, that may occur within one or more delineated United States Geological Survey 7.5 minute quadrangles with which your project polygon intersects. Each quadrangle covers, at minimum, 49 square miles. In some cases, a species does not currently occur within a quadrangle but occurs nearby and could be affected by a project. Please refer to the species information links found at:

http://www.fws.gov/southwest/es/arizona/Docs_Species.htm

<http://www.fws.gov/southwest/es/arizona/Documents/MiscDocs/AZSpeciesReference.pdf> .

The purpose of the Act is to provide a means whereby threatened and endangered species and the habitats upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 et seq.), Federal agencies are required to utilize their authorities to carry out programs for the conservation of Federal trust resources and to consult with us if their projects may affect federally listed species and/or designated critical habitat. A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2)(c)). For projects other than major construction activities, we recommend preparing a biological evaluation similar to a Biological Assessment to determine whether the project may

affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If the Federal action agency determines that listed species or critical habitat may be affected by a federally funded, permitted or authorized activity, the agency must consult with us pursuant to 50 CFR 402. Note that a "may affect" determination includes effects that may not be adverse and that may be beneficial, insignificant, or discountable. You should request consultation with us even if only one individual or habitat segment may be affected. The effects analysis should include the entire action area, which often extends well outside the project boundary or "footprint." For example, projects that involve streams and river systems should consider downstream effects. If the Federal action agency determines that the action may jeopardize a proposed species or adversely modify proposed critical habitat, the agency must enter into a section 7 conference. The agency may choose to confer with us on an action that may affect proposed species or critical habitat.

Candidate species are those for which there is sufficient information to support a proposal for listing. Although candidate species have no legal protection under the Act, we recommend considering them in the planning process in the event they become proposed or listed prior to project completion. More information on the regulations (50 CFR 402) and procedures for section 7 consultation, including the role of permit or license applicants, can be found in our Endangered Species Consultation Handbook at:

<http://www.fws.gov/endangered/esa-library/pdf/TOC-GLOS.PDF>.

We also advise you to consider species protected under the Migratory Bird Treaty Act (MBTA) (16 U.S.C. 703-712) and the Bald and Golden Eagle Protection Act (Eagle Act) (16 U.S.C. 668 et seq.). The MBTA prohibits the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests, except when authorized by the Service. The Eagle Act prohibits anyone, without a permit, from taking (including disturbing) eagles, and their parts, nests, or eggs. Currently 1026 species of birds are protected by the MBTA, including species such as the western burrowing owl (*Athene cunicularia hypugea*). Protected western burrowing owls are often found in urban areas and may use their nest/burrows year-round; destruction of the burrow may result in the unpermitted take of the owl or their eggs.

If a bald eagle (or golden eagle) nest occurs in or near the proposed project area, you should evaluate your project to determine whether it is likely to disturb or harm eagles. The National Bald Eagle Management Guidelines provide recommendations to minimize potential project impacts to bald eagles:

<https://www.fws.gov/migratorybirds/pdf/management/nationalbaldeaglenanagementguidelines.pdf>

<https://www.fws.gov/birds/management/managed-species/eagle-management.php>.

The Division of Migratory Birds (505/248-7882) administers and issues permits under the MBTA and Eagle Act, while our office can provide guidance and Technical Assistance. For more information regarding the MBTA, BGEPA, and permitting processes, please visit the following: <https://www.fws.gov/birds/policies-and-regulations/incidental-take.php>. Guidance for minimizing impacts to migratory birds for communication tower projects (e.g. cellular, digital

television, radio, and emergency broadcast) can be found at:

<https://www.fws.gov/birds/bird-enthusiasts/threats-to-birds/collisions/communication-towers.php>.

Activities that involve streams (including intermittent streams) and/or wetlands are regulated by the U.S. Army Corps of Engineers (Corps). We recommend that you contact the Corps to determine their interest in proposed projects in these areas. For activities within a National Wildlife Refuge, we recommend that you contact refuge staff for specific information about refuge resources.

If your action is on tribal land or has implications for off-reservation tribal interests, we encourage you to contact the tribe(s) and the Bureau of Indian Affairs (BIA) to discuss potential tribal concerns, and to invite any affected tribe and the BIA to participate in the section 7 consultation. In keeping with our tribal trust responsibility, we will notify tribes that may be affected by proposed actions when section 7 consultation is initiated.

We also recommend you seek additional information and coordinate your project with the Arizona Game and Fish Department. Information on known species detections, special status species, and Arizona species of greatest conservation need, such as the western burrowing owl and the Sonoran desert tortoise (*Gopherus morafkai*) can be found by using their Online Environmental Review Tool, administered through the Heritage Data Management System and Project Evaluation Program <https://www.azgfd.com/Wildlife/HeritageFund/>.

For additional communications regarding this project, please refer to the consultation Tracking Number in the header of this letter. We appreciate your concern for threatened and endangered species. If we may be of further assistance, please contact our following offices for projects in these areas:

Northern Arizona: Flagstaff Office 928/556-2001

Central Arizona: Phoenix office 602/242-0210

Southern Arizona: Tucson Office 520/670-6144

Sincerely,

/s/ Steven L. Spangle Field Supervisor

Attachment

Attachment(s):

- Official Species List
-

Official Species List

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

Arizona Ecological Services Field Office

9828 North 31st Ave

#c3

Phoenix, AZ 85051-2517

(602) 242-0210

Project Summary

Consultation Code: 02EAAZ00-2019-SLI-0442

Event Code: 02EAAZ00-2019-E-01029

Project Name: KFSX WSR-88D Lower Scan

Project Type: COMMUNICATIONS TOWER

Project Description: Lowering the minimum scan angle of the NWS radar

Project Location:

Approximate location of the project can be viewed in Google Maps: <https://www.google.com/maps/place/34.574471479830265N111.19844173320747W>



Counties: Coconino, AZ

Endangered Species Act Species

There is a total of 5 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries¹, as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

-
1. [NOAA Fisheries](#), also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

Birds

| NAME | STATUS |
|--|------------|
| Mexican Spotted Owl <i>Strix occidentalis lucida</i> There is final critical habitat for this species. Your location overlaps the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/8196 Species survey guidelines: https://ecos.fws.gov/ipac/guideline/survey/population/129/office/22410.pdf | Threatened |
| Yellow-billed Cuckoo <i>Coccyzus americanus</i> Population: Western U.S. DPS There is proposed critical habitat for this species. Your location is outside the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/3911 | Threatened |

Reptiles

| NAME | STATUS |
|---|------------|
| Northern Mexican Gartersnake <i>Thamnophis eques megalops</i> There is proposed critical habitat for this species. Your location is outside the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/7655 | Threatened |

Amphibians

| NAME | STATUS |
|---|------------|
| Chiricahua Leopard Frog <i>Rana chiricahuensis</i> There is final critical habitat for this species. Your location is outside the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/1516 | Threatened |

Fishes

| NAME | STATUS |
|--|------------|
| Little Colorado Spinedace <i>Lepidomeda vittata</i> There is final critical habitat for this species. Your location is outside the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/6640 | Threatened |

Critical habitats

There is 1 critical habitat wholly or partially within your project area under this office's jurisdiction.

| NAME | STATUS |
|---|--------|
| Mexican Spotted Owl <i>Strix occidentalis lucida</i> https://ecos.fws.gov/ecp/species/8196#crithab | Final |

APPENDIX C

TECHNICAL MEMORANDUM / TRIP REPORT

TECHNICAL MEMORANDUM

| | |
|---|---|
| TO: Edward Ciardi, Program Manager, EVP Weather Systems, Centuria Corporation | FROM: James Manidakos, CEO, Sensor Environmental LLC |
| CC: Jessica Schultz, Radar Focal Point, National Weather Service Andre Tarpinian, Senior RF Engineer, Alion Science and Technology Corp. | SUBJECT: Analysis of Lower Scan Angles For Weather Surveillance Radar, Model 1988 Doppler (WSR-88D) Serving Flagstaff, AZ, Area |
| DATE: May 16, 2019 | |

1. BACKGROUND AND NEED

The National Weather Service (NWS) proposes to reduce the minimum vertical Scan angles used during normal operation of the WSR-88D serving Flagstaff, AZ, area. Information on this radar is shown in Table 1. The KFSX WSR-88D is located at the crest of Blue Ridge in Coconino National Forest, about 48 miles southeast of downtown Flagstaff, AZ and about 72 miles east of Prescott, AZ. The KFSX WSR-88D was commissioned in May 1996 and has been in operation at its current location since then.

| TABLE 1: INFORMATION ON WSR-88D SERVING THE FLAGSTAFF, AZ, AREA | |
|--|--|
| Location | Blue Ridge, Coconino National Forest, Coconino County, AZ |
| International Civil Aviation Organization designator | KFSX |
| Elevation, ground surface at tower base (mean sea level, MSL) | 7,415 ft |
| Elevation, center of antenna (MSL) | 7,512 ft |
| Tower Height (m) | 25 m (82 ft) |
| Latitude (WGS84) | 34° 34' 27.6" N |
| Longitude (WGS84) | 111° 11' 54.4" W |
| Weather Forecast Office (WFO) | P.O. Box 16057 Bellemont, AZ 86015 |
| Meteorologist-in-Charge (MIC) | Brian Klimowski Email: brian.klimowski@noaa.gov Tel. (928)556-9161 |
| Operating Frequency | 2,890 megaHertz (MHz), 2,760 MHz |
| Spot Blanking or Sector Blanking used | No |

NWS currently operates the KFSX WSR-88D at a minimum center-of-beam scan angle of +0.5 degree (deg). The WSR-88D main beam has a width of 1 deg to the half power points. Half of the beam (i.e., 0.5 deg) is below the axis, resulting in an essentially horizontal floor for existing radar coverage. As a result, the WSR-88D cannot provide radar coverage of the atmosphere below the elevation of the WSR-88D antenna. At considerable distance from the radar, earth curvature increases the height above the ground surface of the uncovered area. To increase the amount of radar coverage provided by the KFSX WSR-88D, NWS proposes to operate the radar with a center-of-beam Scan angle as low -0.2 deg, which would result in the lower half power point of the main beam at -0.7 deg.

2. INVESTIGATIONS PERFORMED

To analyze the benefits and potential impacts of lowering the Scan angle of the KFSX WSR-88D, Sensor Environmental LLC and our subcontractor Alion Science and Technology Corporation performed the following tasks:

1. We visited the KFSX WSR-88D with NWS staff from the Flagstaff, AZ, Weather Forecast Office (WFO) to ascertain site conditions and activities in the vicinity (see Attachment A, Trip Report).
2. We obtained 360-degree calibrated panoramic photograph taken at 20-m level of the WSR-88D tower, which is about 30 ft lower than the center of antenna height.
3. We prepared maps showing the extent of WSR-88D coverage at 2,000 ft above site level for each (center of beam) Scan angle from the current minimum of +0.5 degree to -0.2 degree.
4. We identified areas of terrain and potentially sensitive activities in proximity to the KFSX WSR-88D that would be directly illuminated by the main beam at each lower Scan angle under consideration by NWS.
5. We calculated the change in height of KFSX WSR-88D radar coverage above ground level for the Four Corners area of interest.

3. WSR-88D COVERAGE

The Project team used Alion Integrated Target Acquisition System (ITAS) terrain-based computer model with GIS-based interface to project the terrain-dependent radar coverage for the KFSX WSR-88D at 2,000 ft above site level (ASL). The radar coverages shown in Attachment B are based on Digital Terrain Elevation Data (DTED) Level 2 topographic data and 4/3 earth radius to account for atmospheric refraction of the WSR-88D main beam. The lower half-power point of the unobstructed WSR-88D main beam is considered the minimum height of WSR-88D coverage. Table 2 shows coverage areas at 2,000 ft above site level (ASL) for KFSX WSR-88D for the range of minimum Scan angles under consideration by NWS.

| TABLE 2: KFSX WSR-88D Radar Coverage Areas for Minimum Scan Angles | | | | |
|---|--|-------------------------------------|---|--|
| Coverage Altitude (ft ASL) | Minimum Center of Beam Scan Angle (deg) | Lower Half-power Point (deg) | Area in Lambert Projection (sq mi) | Change from Existing Minimum Scan Angle |
| 2,000 | +0.5 (existing) | 0.0 | 9,592 | n/a |
| 2,000 | +0.4 | -0.1 | 11,931 | +24.4% |
| 2,000 | +0.3 | -0.2 | 14,733 | +53.6% |
| 2,000 | +0.2 | -0.3 | 17,837 | +86.0% |
| 2,000 | +0.1 | -0.4 | 21,002 | +119.0% |
| 2,000 | 0.0 | -0.5 | 23,811 | +148.2% |
| 2,000 | -0.1 | -0.6 | 25,703 | +168.0% |
| 2,000 | -0.2 | -0.7 | 26,341 | +174.6% |

KFSX WSR-88D is located at the crest of Blue Ridge at over 7,400 ft MSL. The radar site is in Coconino National Forest in Coconino County, CO, about 48 miles southeast of downtown Flagstaff, AZ. When operating at the current minimum center of beam minimum Scan angle of +0.5 deg, the KFSX WSR-88D is subject to terrain blockage to the southeast, south, southwest, and northwest (see Attachment B). At minimum scan angles below +0.5 deg, terrain blockage would prevent increased radar coverage in those directions. However, radar coverage would increase in other directions (i.e., west, north, northeast, and east). Coverage to the north, northeast, and east would increase with each lower scan angle down -0.2 deg. Coverage to the west would increase with each lower scan angle down to -0.1 deg.

The Four Corners area (where Colorado, New Mexico, Arizona, and Utah meet) is of special interest with respect to the potential for improved radar coverage. The Four Corners area is about 204 miles northeast of the KFSX WSR-88D at azimuth 38 (where 0 = true north, 90 = east, 180 = south, and 270 = west). Four Corners area is at elevation 4,870 ft MSL. Table 3 shows the existing height of the center of the WSR-88D beam and the radar coverage floor over the Four Corners area at the current minimum scan angle of +0.5 deg and lower scan angles. Lowering the minimum Scan angle of the KFSX WSR-88D to -0.1 deg would reduce the radar coverage floor (i.e. lower half-power point of main beam) over the Four Corners area from the current 23,500 ft above ground level (AGL) to 12,200 ft AGL. Terrain blockage between the KFSX WSR-88D and the Four Corners area would prevent reduction in coverage floor altitude for scan angles lower than -0.1 deg.

| WSR-88D | Minimum Center of Beam Scan Angle (deg) | Center of Beam Altitude (ft AGL)* | Radar Coverage Floor (ft AGL)* |
|----------------|--|--|---------------------------------------|
| KFSX | +0.5 (existing) | 32,900 | 23,500 |
| | +0.4 | 31,000 | 21,600 |
| | +0.3 | 29,100 | 19,700 |
| | +0.2 | 27,200 | 17,800 |
| | +0.1 | 25,300 | 15,900 |
| | +0.0 | 23,500 | 14,100 |
| | -0.1, -0.2 | 21,600 | 12,200 |

*rounded to nearest 100 ft

4. HUMAN EXPOSURE AND POTENTIALLY RF-SENSITIVE ACTIVITIES

Exposure to the WSR-88D main beam could represent a hazard to persons and certain sensitive activities. Table 4 presents the safe setback distances from the WSR-88D for human exposure, implantable medical devices, fuel handling, and EEDs (Sensor Environmental LLC, 2011). Safety standards for implantable medical devices, fuel handling, and EEDs are based on instantaneous exposure. Safety Standards for human exposure are based on time-averaged exposure; therefore exposure during both rotating antenna and stationary-antenna operation are considered.

| Activity | Safe Setback Distance (ft) | | Source |
|-----------------------------|-----------------------------------|-------|---|
| Human Exposure | Rotating Antenna | 20 | American National Standards Institute/Institute of Electrical and Electronic Engineers (ANSI/IEEE) and International Council for Non-Ionizing Radiation Protection (ICNIRP) |
| | Stationary Antenna | 1,740 | |
| Implantable Medical devices | 2,060 | | ANSI/Association for the Advancement of Medical Instrumentation (AAMI) |
| EEDs | 6,030 | | U.S. Air Force |
| Fuel Handling | 537 | | Naval Sea Systems Command |

5. DIRECTLY ILLUMINATED TERRAIN

Exposure to radiofrequency (RF) radiation can potentially be harmful to humans and RF-sensitive activities. The safe setback distances from the WSR-88D for human exposure, implantable medical devices, fuel handling, and electro-explosive devices (EEDs), are given in section 4 of this memorandum. The greatest safe setback distance for human exposure or any of these activities is 6,030 ft for exposure of EEDs, which include blasting caps, some types of ordnance, and equipment used in aviation systems (e.g. ejection seats and separation systems for air-launched missiles).

There would be no directly illuminated terrain within 3 miles at scan angles of +0.5 deg, 0+0.4 deg, or +0.3. Attachment C shows terrain within 3 miles of the KFSX WSR-88D that would be directly illuminated by the WSR-88D main beam at a lower center of beam Scan angle of +0.2 deg or lower. At a scan angle of +0.2 deg or lower, the KFSX WSR-88D main beam would impinge on the ground about 2.1 miles (11,200 ft) to the east-southeast. The area of affected ground would increase with each lower scan angle and a minimum scan angle of -0.2 deg, would result in the main beam impinging on the ground to the east-southeast at about 1.7 miles (8,800 ft). Other than the area to east-southeast, no other terrain within 3 miles would be affected by a minimum scan angle of +0.2 deg. The nearest directly illuminated ground would be farther than all safety setback distances from the WSR-88D. No hazards to persons or potentially sensitive activities would result from lowering the minimum scan angle down to -0.2 deg.

Photographs 2A through 2D in attachment A are panoramic photographs taken from the 20-m level of the KFSX WSR-88D tower and show a 360 deg view of the horizon. No structures in the vicinity rise above the horizon and lowering the KFSX WSR-88D minimum scan angle would not result in the WSR-88D main beam impinging on structures within safe setback distances. No RF-exposure hazards would result to persons or potentially RF-sensitive activities.

6. ASTRONOMICAL OBSERVATORIES

The WSR-88D can potentially cause harmful electromagnetic interference (EMI) with charge-couple devices (CCDs) which electronically record data collected by astronomical telescopes (NEXRAD JSPO), 1993). Due to the sensitivity of astronomical equipment which is designed to detect very faint signals from space, this equipment is vulnerable to EMI. The potential for harmful EMI would arise if the WSR-88D main beam would directly impinge on an astronomical observatory during low angle scanning. Six astronomical observatories are located within 150 miles of the KFSX WSR-88D. Table 5 shows the potential for the KFSX to impinge on each of the six observatories and factors in earth curvature, 4/3 earth radius to account for atmospheric refraction, and terrain blockage if present between the WSR-88D and the observatory. At a minimum scan angle between +0.5 and -0.2 deg, the KFSX WSR-88D main beam would not impinge on any of the six observatories.

| TABLE 5: ASTRONOMICAL OBSERVATORIES WITHIN 150 MILES OF THE KFSX WSR-88D | | | | |
|---|-----------------|--|---------------------------------------|---|
| Observatory | Location | Distance from WSR-88D / azimuth | Observatory elevation (ft MSL) | Would KFSX WSR-88D main beam impinge? |
| Apache-Sitgreaves | Overgaard, AZ | 39 mi / 105 deg | 6,600 | No at +0.5 to +0.2: Main beam elevation > 7,200 ft MSL No at +0.1 deg or lower: terrain blockage |
| Mt. Graham | Safford, AZ | 149 mi / 150 deg | 10,520 | No at +0.5 to -0.2 deg: terrain blockage |
| Lowell | Flagstaff, AZ | 41 mi / 331 deg | 7,280 | No at +0.5 to -0.2 deg: terrain blockage |
| Mt. Lemmon sky Center | Tucson, AZ | 150 mi / 172 deg | 9,200 | No at +0.5 to -0.2 deg: terrain blockage |
| Emory-Riddle Prescott | Prescott, AZ | 71 mi / 272 deg | 6,070 | No at +0.5 to +0.0: Main beam elevation > 6,760 ft MSL No at -0.1 deg or lower: terrain blockage |
| U.S. Naval | Flagstaff, AZ | 52 mi / 325 deg | 7,620 | No at +0.5 to -0.2 deg: terrain blockage |

7. RECOMMENDATION

Lowering the minimum scan angle of the KFSX WSR-88D to -0.2 deg would increase coverage are at 2,000 ft above site level by 174.6% and would not result in adverse effects to person or activities or astronomical observatories. Compared to current WSR-88D coverage, the minimum height of radar coverage over the Four Corners area would be reduced from the current 23,500 ft to 12,200 ft AGL. Therefore, a minimum Scan angle of -0.2 deg is recommended for the KFSX WSR-88D.

8. MEMORANDUM AUTHORS

This memorandum was prepared by Sensor Environmental LLC under contract to Centuria Corporation, which is a support contractor to the National Weather Radar Operations Center. Mr. James Manidakos, CEO, served as Sensor’s Project Manager. Alion Science and Technology Corporation prepared radar coverage maps and calculated coverage areas under subcontract to Sensor. Mr. Andre Tarpinian, Radio Frequency Engineer, served as Alion’s Project Manager.

9. REFERENCES

- American National Standards Institute/Institute of Electrical and Electronic Engineers (ANSI/IEEE). *IEEE Standard for Safety Levels with respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz*. IEEE Std C95.1-2005 (April 19, 2006).
- ANSI/AAMI. *American National Standard, Active Implantable Medical Devices – Electromagnetic compatibility – EMC test protocols for cardiac pacemakers and implantable cardioverter defibrillators*, ANSI/AAMI PC69:2007 (2007).
- Go Astronomy, www.go-astronomy.com/observatories.htm, accessed January 29, 2019.
- ICNIRP. “ICNIRP Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz).” Published in *Health Physics Society*, **1998**, 74(4), pp. 494-522.
- ICNIRP. Statement on the “Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz).” Published in *Health Physics Society*, 2009, 97(3), pp. 257-258.
- Naval Sea Systems Command. *Technical Manual, Electromagnetic Radiation Hazards (U), (Hazards to Personnel, Fuel, and Other Flammable Material) (U)*, NAVSEA OP 3565/NAVAIR 16-1-529, Volume 1, Sixth Revision (February 1, 2003).
- Naval Sea Systems Command. *Technical Manual, Electromagnetic Radiation Hazards (U), (Hazards to Ordnance) (U)*, NAVSEA OP 3565/NAVAIR 16-1-529, Volume 2, Seventeenth Revision, (September 11, 2008).
- NEXRAD JSPO. *Final Supplemental Environmental Assessment (SEA) of the Effects of Electromagnetic Radiation from the WSR-88D Radar* (April 1993).
- NTIA. *Manual of Regulations and Procedures for Federal Radio Frequency Management*. May 2014.
- Schultz, Jessica, NWS Radar Focal Point, email to James Manidakos, Sensor Environmental LLC. January 28, 2019.
- Sensor Environmental LLC, Supplemental Environmental Assessment (EA) of the Electromagnetic Effects of Operating Weather Service Radar – 1988 Doppler (WSR-88D) to Serve Coastal Washington at Scan Angles Below +0.5 Degree. Prepared for National Weather Service/Centuria Corporation, September 2011.
- U.S. Air Force. *Explosive Safety Standards*. U.S. Air Force Regulation 127-100(c1). July 27, 1982.
- U.S. Geological Survey. *Blue Ridge Reservoir, Arizona – Coconino County. 7.5 Minute Series (Topographic)*. 1:24,000 scale (1965).
- U.S. Geological Survey. *Holbrook, AZ Topographic Map*. 1:250,000 scale (1960).

ATTACHMENT A
TRIP REPORT, KFSX WSR-88D

TRIP REPORT

Traveler: James Manidakos, Sensor Environmental LLC

Destination: KFSX Weather Surveillance Radar, Model 1988 Doppler (WSR-88D) serving the Flagstaff, AZ, area

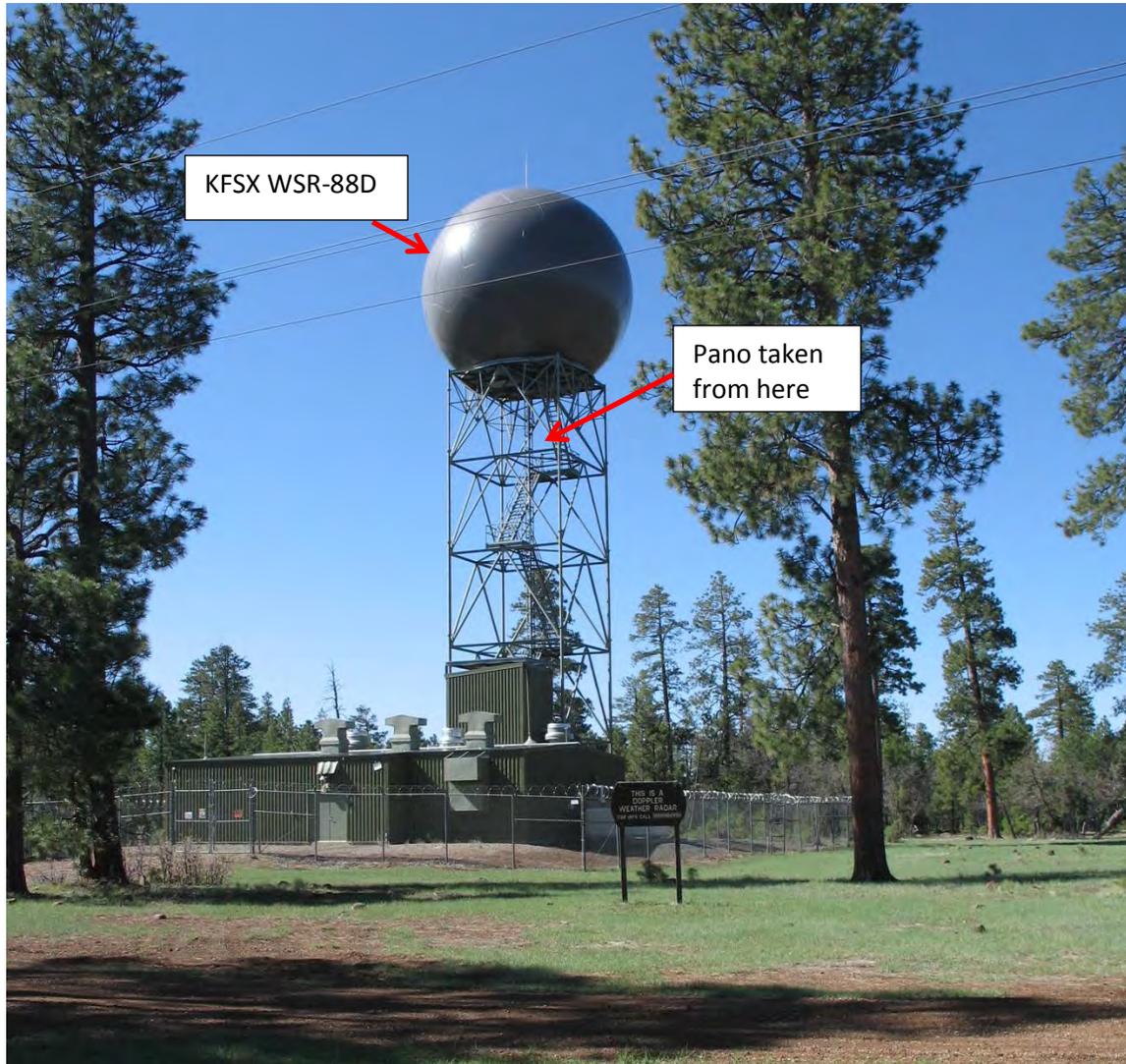
Dates: May 12 -13, 2019

Purpose: Conduct a field inspection of radar and vicinity and obtain 360-degree panoramic photographs from the 20-m level of KFSX WSR-88D tower.

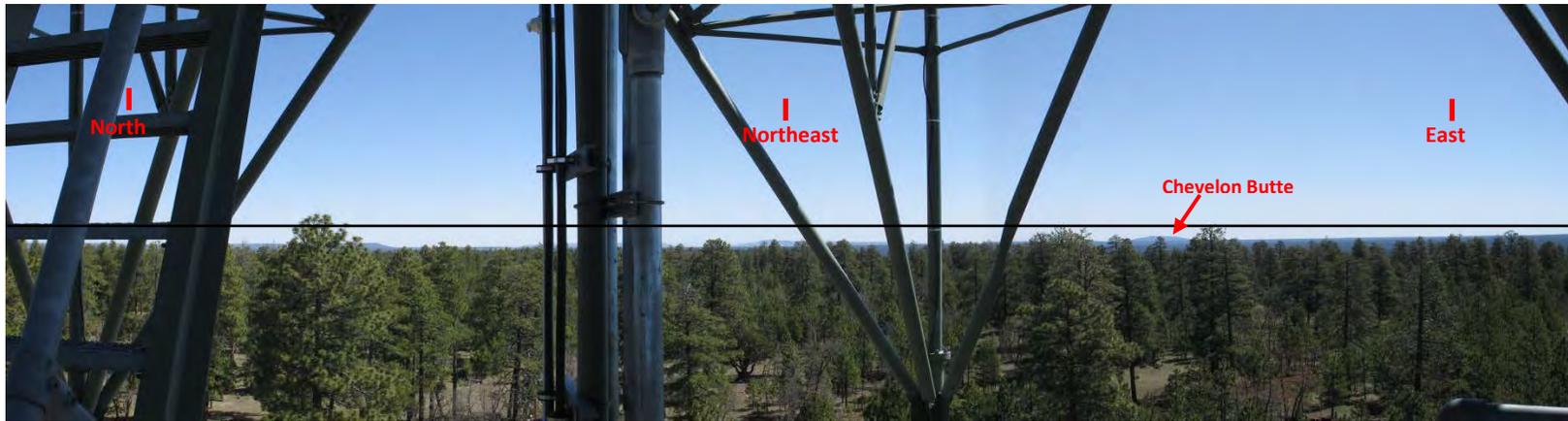
Summary: May 12, 2019: Mr. Manidakos flew from San Jose, CA, to Phoenix, AZ and drove to Payson, AZ.

May 13, 2019: Mr. Manidakos met at the KFSX WSR-88D with Electronics Systems Analyst Michael Moroney. Mr. Manidakos then took a photograph of the KFSX WSR-88D (Photograph 1) and panoramic photographs (Photograph 2) from the 20-m level of the KFSX WSR-88D, which is about 30 ft below the center of the WSR-88D antenna. In the evening, Mr. Manidakos drove back to Phoenix and flew to San Jose, CA.

Weather: 65° F, Sunny



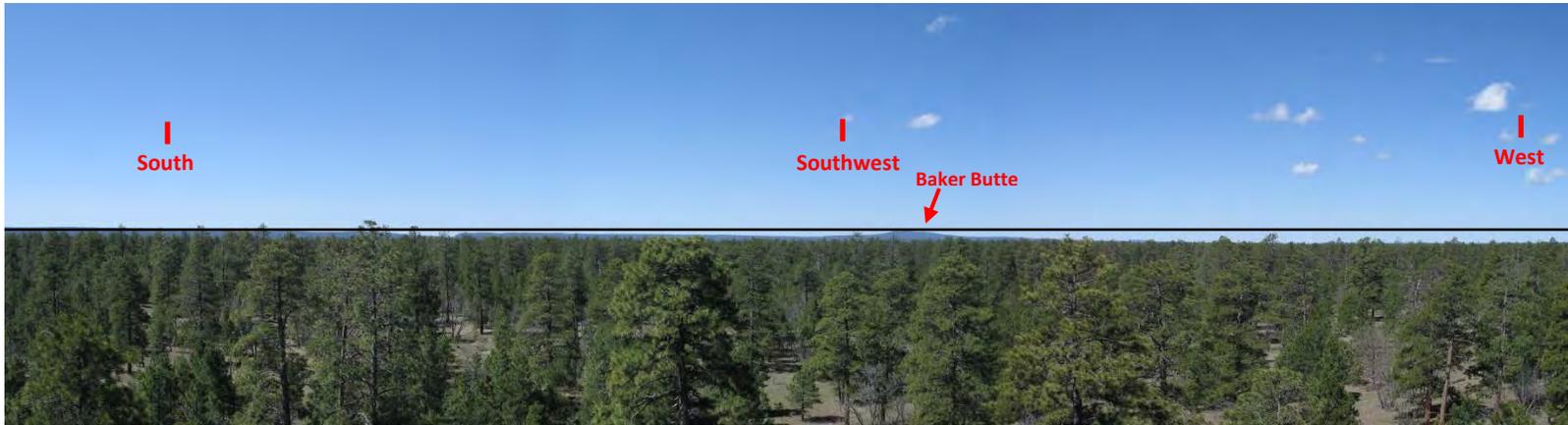
Photograph 1: KFSX WSR-88D serving Flagstaff, AZ, area viewed from northwest



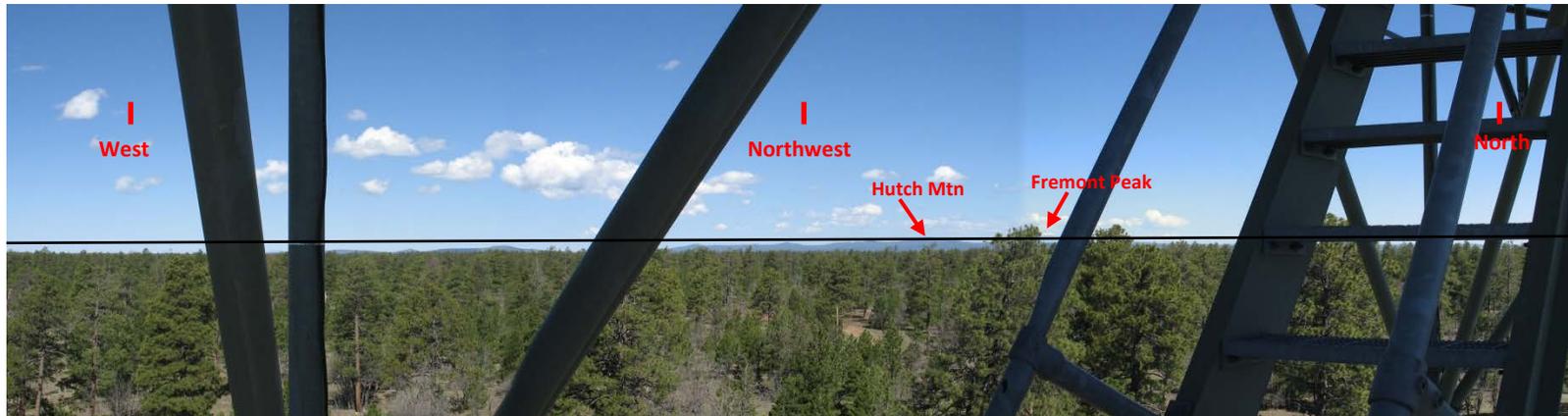
Photograph 2A: Panoramic photograph from KFSX WSR-88D tower [— 0 deg]



Photograph 2B: Panoramic photograph from KFSX WSR-88D tower [— 0 deg]



Photograph 2C: Panoramic photograph from KFSX WSR-88D tower [— 0 deg]

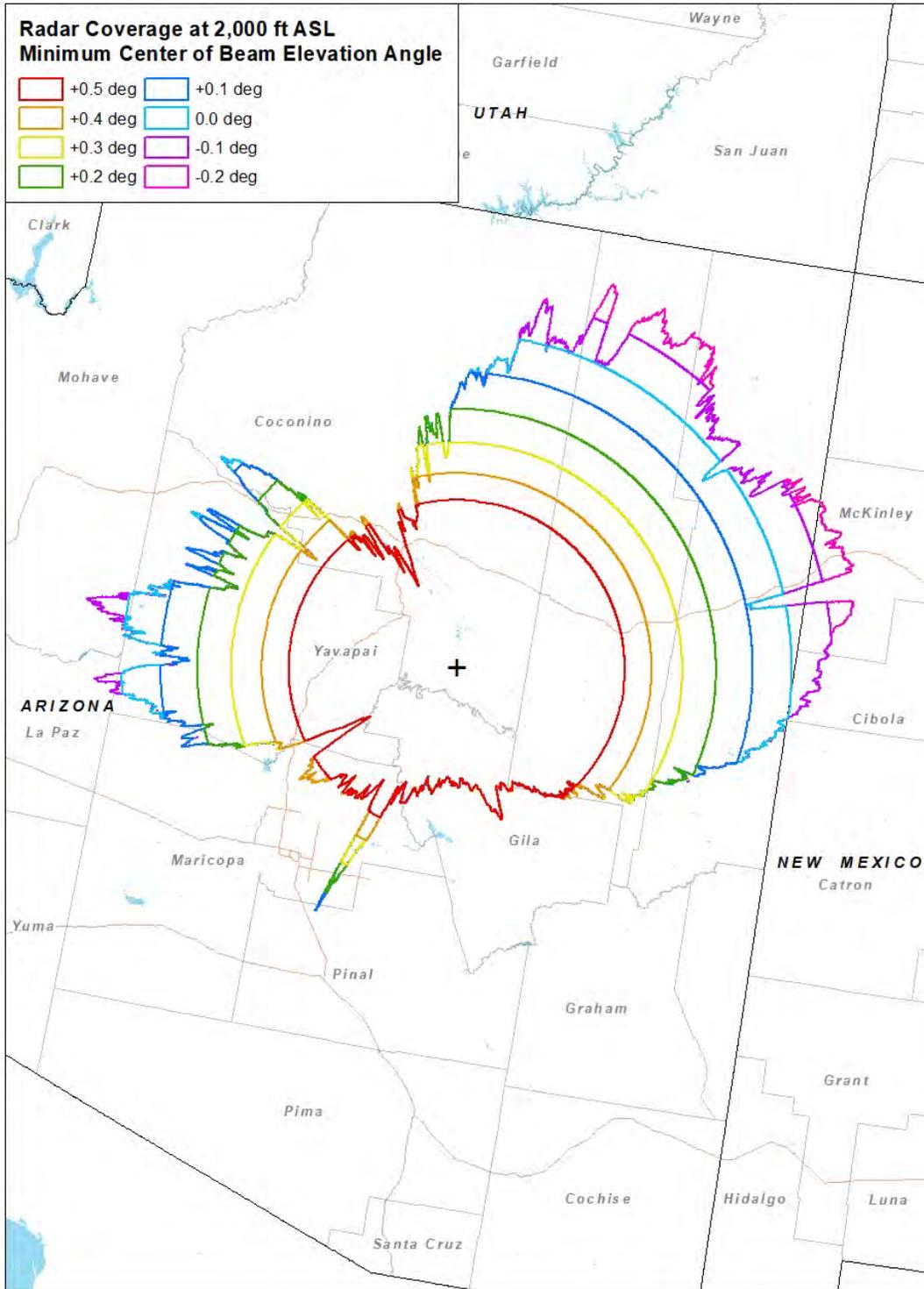


Photograph 2D: Panoramic photograph from KFSX WSR-88D tower [— 0 deg]

ATTACHMENT B

KFSX WSR-88D COVERAGE MAP

MINIMUM SCAN ANGLES +0.5 deg to -0.2 deg



+ KFSX - Flagstaff, AZ
 — Major Highway

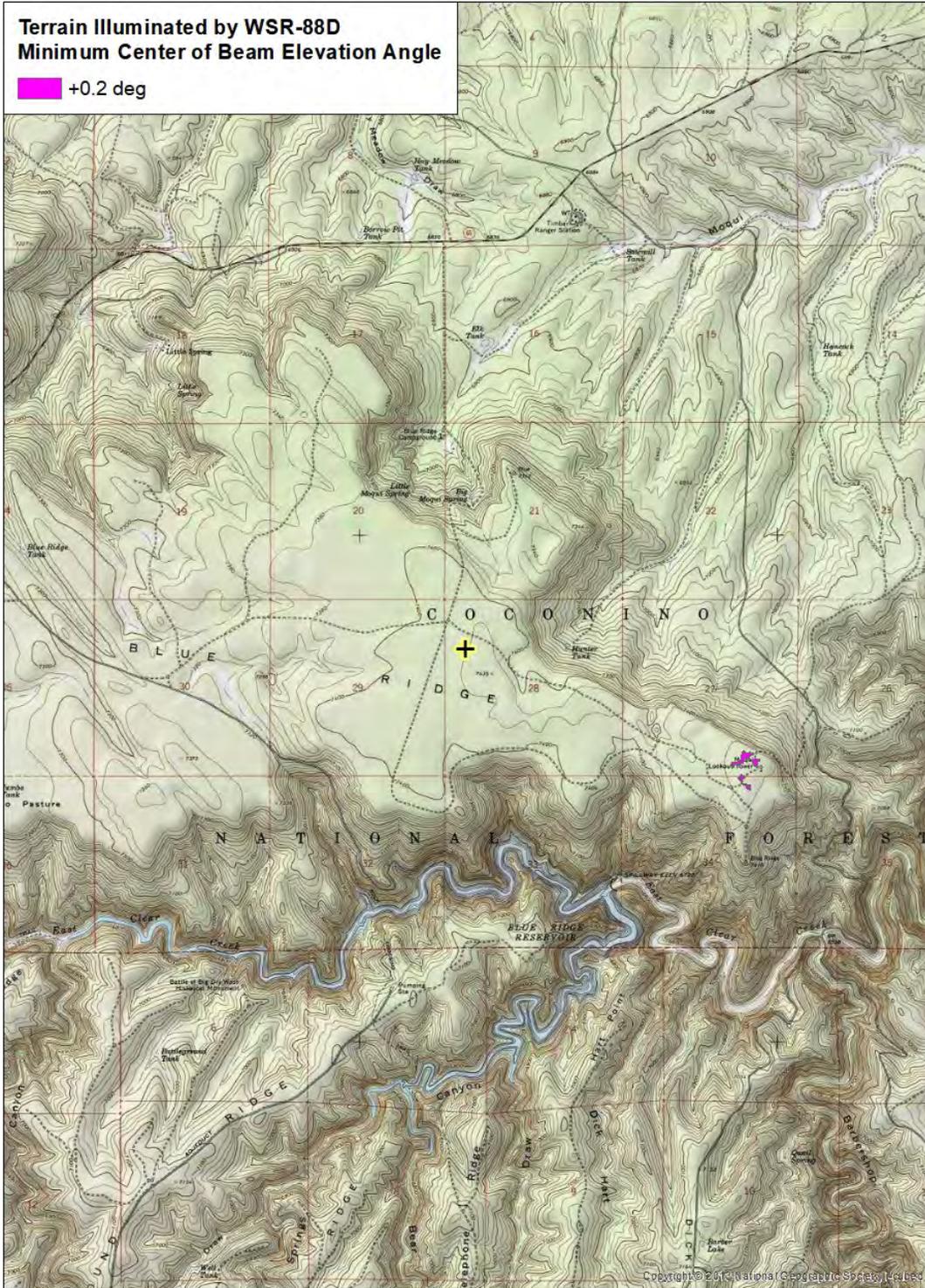


Lambert Projection
 Central Meridian: -96
 1st Std Parallel: 20
 2nd Std Parallel: 60
 Latitude of Origin: 40

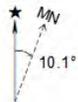
ATTACHMENT C

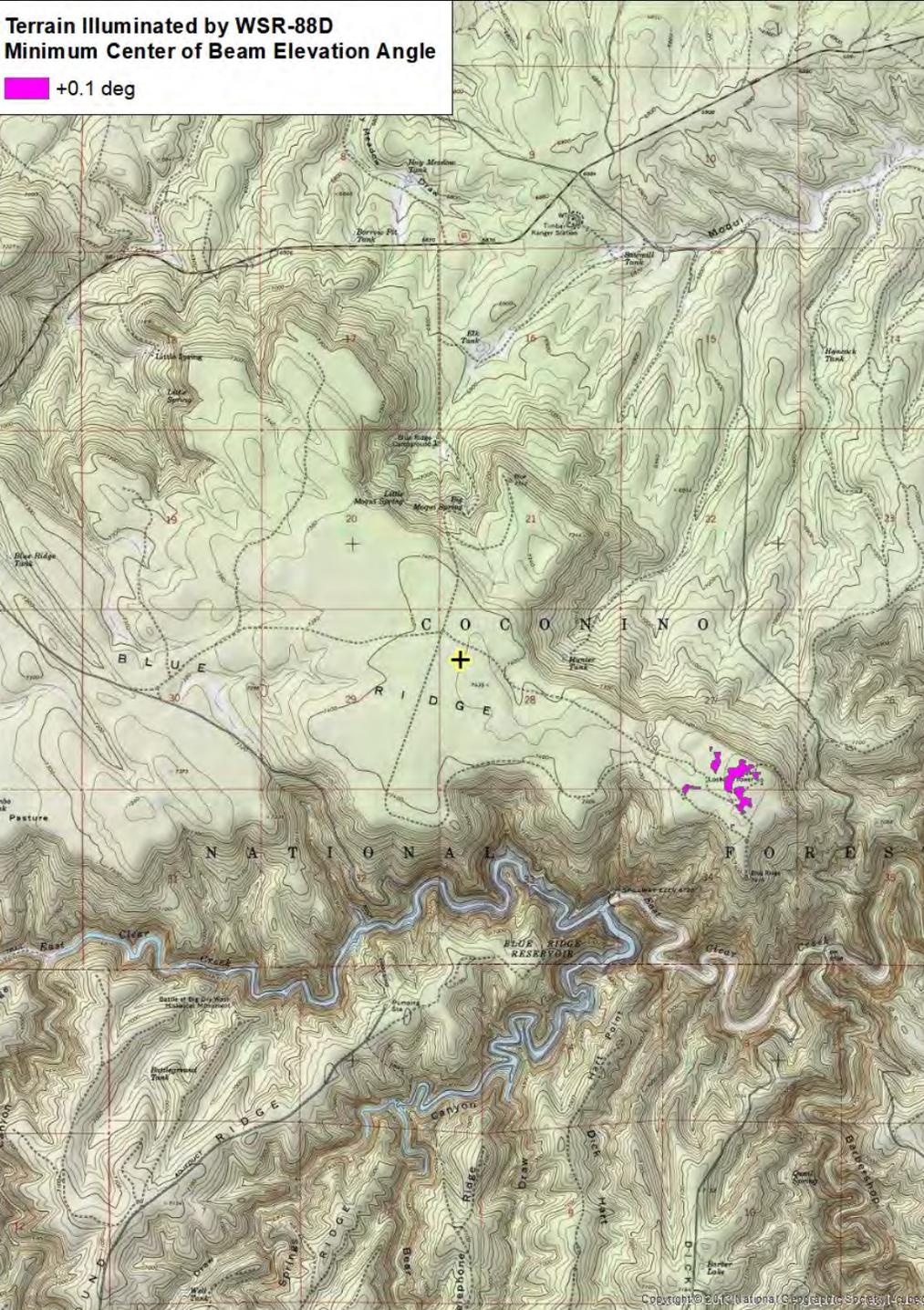
KFSX WSR-88D NEARBY DIRECTLY ILLUMINATED TERRAIN

AT SCAN ANGLES OF +0.5 to -0.2 deg

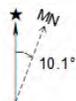


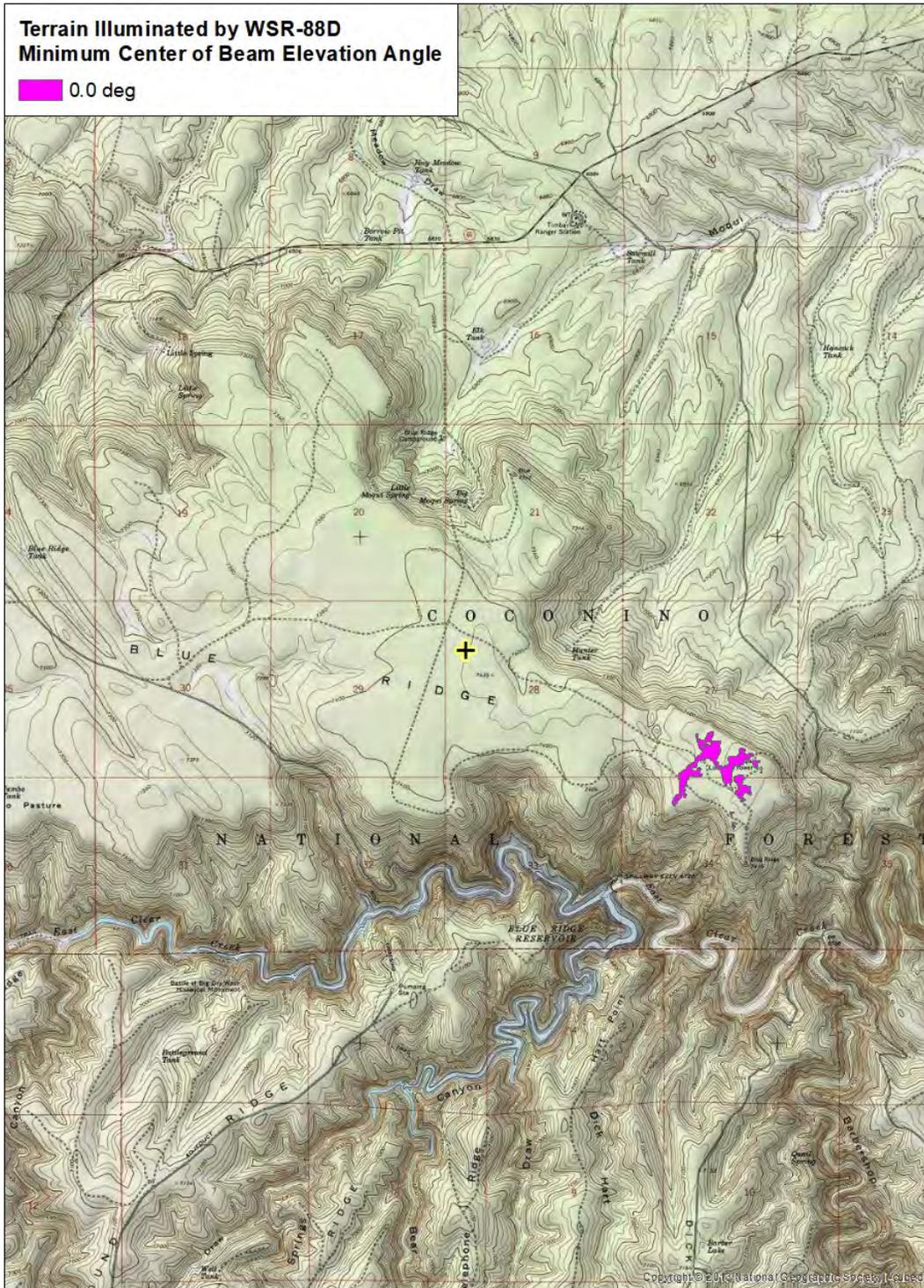
 KFSX - Flagstaff, AZ

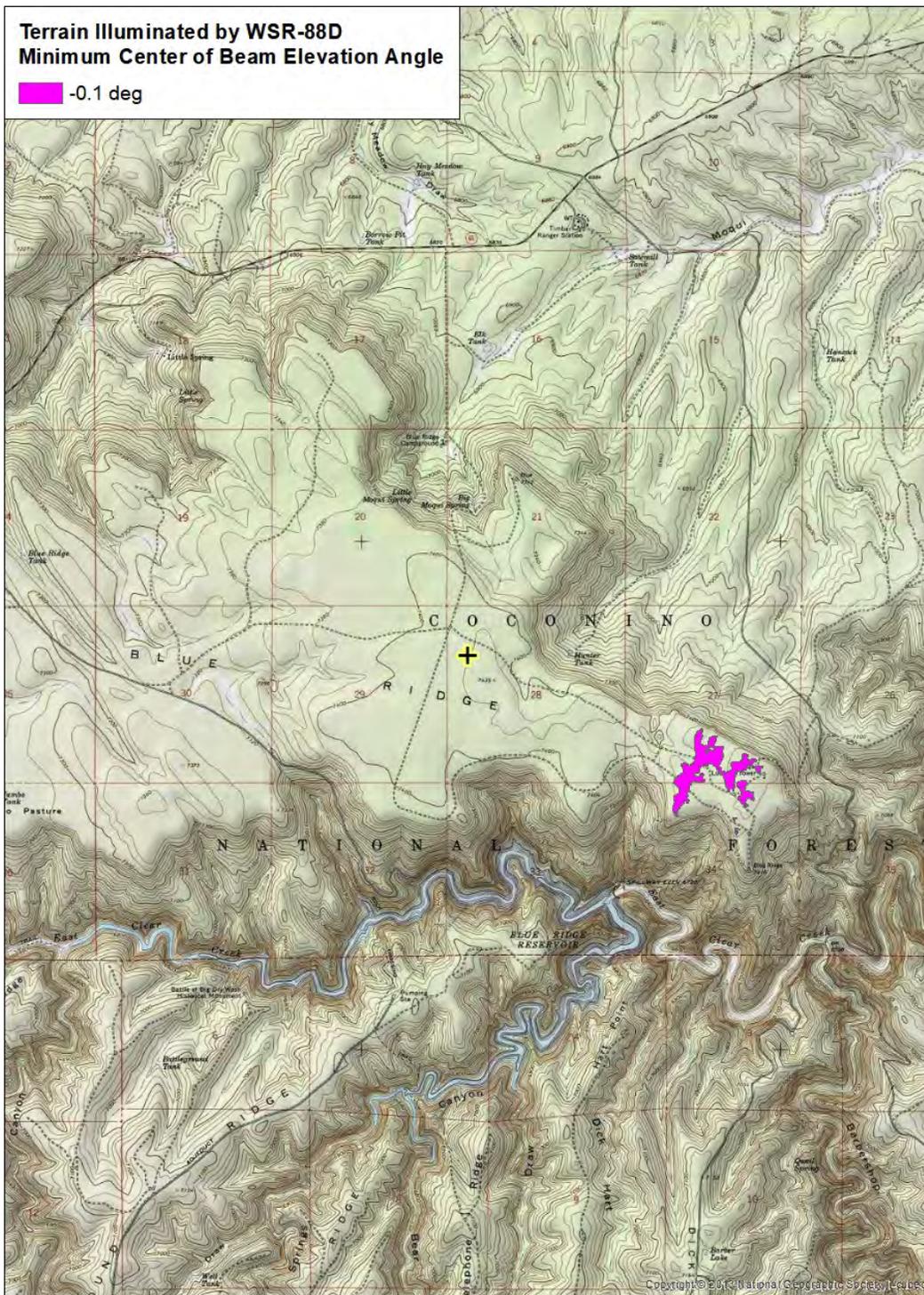




 KFSX - Flagstaff, AZ

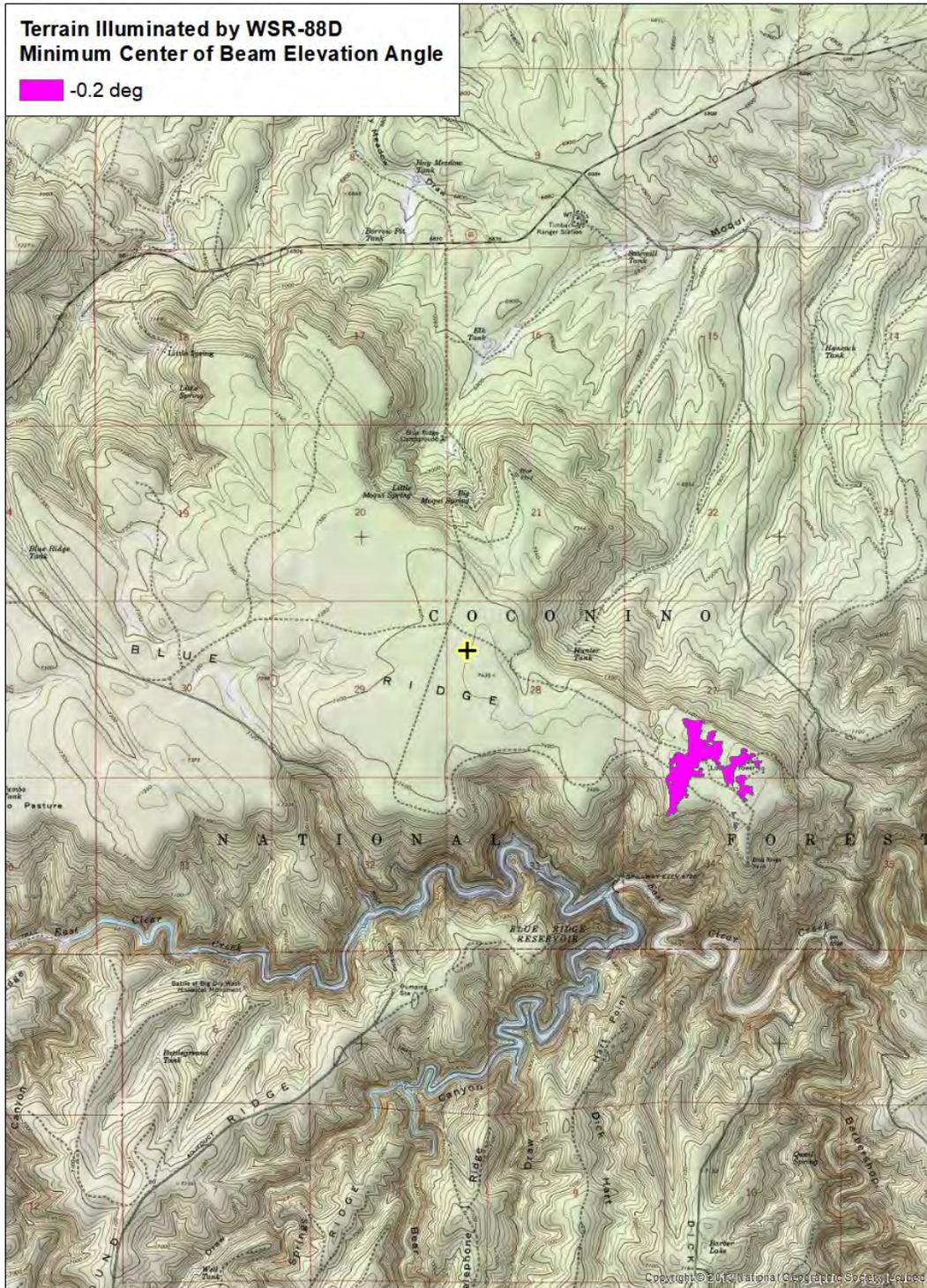






 KFSX - Flagstaff, AZ





 KFSX - Flagstaff, AZ

