TO: All Interested Parties

FROM: Jessica Schultz, Deputy Director, National Weather Service (NWS) Radar Operations Center

SUBJECT: Lowering the Minimum Scan Angle of the KDLH Weather Surveillance Radar - Model 1988 Doppler (WSR-88D) serving Duluth, MN, area JS

DATE: June 5, 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 KDLH WSR-88D serving the Duluth, MN, 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 KDLH WSR-88D is an existing radar facility located at Duluth International Airport in the city of Duluth, St. Louis County, about 6.2 miles northwest of downtown Duluth, MN. The KDLH WSR-88D was commissioned in May 1996 and is one of 159 WSR-88Ds in the nationwide network. The KDLH 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 KDLH WSR-88D from the current minimum of +0.5 deg to +0.2 deg (i.e. 0.3 deg lower than existing) to provide enhanced coverage of the lower portions of the atmosphere. No construction activities or physical modification of the KDLH 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 July 9, 2019. Please submit comments via either email or regular mail to:

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Comments sent by regular mail must be postmarked by July 9, 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
www.sensorenvirollc.com

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 DULUTH, MINNESOTA, 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 Duluth, MN, area. The International Civil Aviation Organization designator for the radar is KDLH and the radar is located at Duluth International Airport in the city of Duluth, St. Louis County, MN, about 6.2 miles northwest of downtown Duluth, MN. The KDLH WSR-88D was commissioned in May 1996 and has been in continuous operation since 1996. It is one of 159 WSR-88Ds in the nationwide network.

The KDLH 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 northeastern Minnesota and northwestern Wisconsin. The KDLH 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 KDLH 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 KDLH 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 KDLH 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 KDLH WSR-88D at a minimum scan angle of +0.2 (i.e., 0.2 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 84.1%. Additionally the height of radar coverage over International Falls, MN, would be reduced from the current 9,100 ft to 7,900 ft above ground level (AGL). The height of coverage over Hayward, WI, would be reduced from 2,600 to 700 ft AGL. These radar coverage improvements 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 KDLH WSR-88D main beam impinging on the ground within 2.7 miles of the WSR-88D. The proposed action would slightly increase radiofrequency (RF) exposure levels in the vicinity of the KDLH 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 KDLH 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	0.602	1.0	1.66	9.58	15.9
Closest Structure, Cellular telephone Tower: 1,400 ft S	0.0041	1.0	244	9.58	2,340
Closest Terrain: 14,300 ft (2.7 miles) NW	0.000069	1.0	14,490	9.58	138,800

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 public 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 562 ft. The KDLH 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 KDLH 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. Four astronomical observatories are located within 150 miles of the KDLH WSR-88D. A minimum scan angle of +0.2 deg would not result in the WSR-88D main beam impinging on any of those observatories.

Lowering the minimum scan angle of the KDLH 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 KDLH WSR-88D to each angle between +0.4 and +0.2 deg in 0.1 degree increments (see Appendix B). Operating the KDLH WSR-88D at alternative minimum scan angles between +0.4 deg and +0.2 deg would result in similar environmental effects as the proposed action. Like the proposed action, significant environmental effects would not result. A minimum scan angle of +0.4 or +0.3 deg would increase the radar's coverage area, but by less than the proposed action (i.e. minimum scan angle of +0.2) deg. Minimum scan angles lower than +0.2 deg would not increase coverage area and would result in increased ground clutter returns.

The no action alternative would result in continued operation of the KDLH 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 July 9, 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 KDLH WSR-88D minimum scan angle after the Final EA report is completed.

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CONTENTS

FIGURES

TABLES

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
KDLH	WSR-88D serving the Duluth, MN, area
m	meter(s)
MBTA	Migratory Bird Treaty Act (of 1918)
MHz	megahertz
mi	mile(s)
MN	Minnesota
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

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 Duluth, MN, area. The radar identifier is KDLH and the radar is located at Duluth International Airport in the city of Duluth, St. Louis County, MN, about 6.2 miles northwest of downtown Duluth, MN. The KDLH WSR-88D is part of the nationwide WSR-88D network. The NWS proposes to operate the KDLH 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 KDLH 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 KDLH 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 KDLH WSR-88D minimum scan angle to +0.2 deg). Potential environmental effects of alternative minimum scan angles between +0.4 deg and +0.2 deg and the no-action alternative (i.e. continued operation of the KDLH 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 KDLH WSR-88D site and vicinity. The scope of this EA is limited to analyzing potential effects from lowering the minimum scan angle of the KDLH 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 KDLH WSR-88D, and do not apply 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 KDLH 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 KDLH WSR-88D serving the Duluth, MN, 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 KDLH WSR-88D minimum scan angle to +0.2 deg; this EA report satisfies that requirement.

3 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

3.1 PROPOSED ACTION

3.1.1 Description of KDLH 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 KDLH WSR-88D, which was commissioned in May 1996 and has been in continuous operations since being commissioned. The KDLH WSR-88D serves the Duluth, MN, area and is operated and maintained by the NWS. The Duluth, MN, Weather Forecast Office (WFO) is the primary recipient of data from the KDLH WSR-88D and serves northeastern Minnesota and northwestern Wisconsin. The KDLH WSR-88D is located is located at Duluth International Airport in the city of Duluth, St. Louis County, MN, about 6.2 miles northwest of downtown Duluth, MN. (see Figure 2). The radar antenna, radome, and steel-lattice tower are standard. Table 1 provides information on the KDLH WSR-88D.

Table 1: Information on the KDLH WSR-88D Serving the Duluth, MN, Area

Elevation, ground surface at tower base (mean sea level, MSL)	1,428 ft
Elevation, center of antenna (MSL)	1,542 ft
Tower Height (m)	30 m (98 ft)
Latitude (WGS84)	46°50’13” N
Longitude (WGS84)	92°12’35” W
Operating Frequency	2,875 megaHertz (MHz)
Spot Blanking or Sector Blanking used	No

Figure 1: Photograph of KDLH WSR-88D serving Duluth, MN, Area

Figure 2: Location of KDLH WSR-88D serving the Duluth, MN, area

0 30 60 miles

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 0.3 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 KDLH 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 84.1% increase in coverage area at 2,000 ft above site level (ASL) to 31.9% increase at 10,000 ft ASL. Figures 5 and 6 show the improvement in radar coverage that would be achieved at 2,000 ft and 10,000 ft ASL, respectively. These improvements in WSR-88D coverage would be beneficial to NWS forecasters and other users of radar data (e.g. emergency response mangers, water managers, transportation officials).

Table 2. Coverage Area for KDLH WSR-88D at Minimum Scan Angle of +0.2 deg

Center of Beam Scan Angle (deg)	Coverage Floor (deg)	Area Covered at 2,000 ft ASL (sq mi)	Area Covered at 10,000 ft ASL (sq mi)
+0.5 (existing)	0.0	10,567	55,386
+0.2 (proposed)	-0.3	19,451 (+84.1%)	73,043 (+31.9%)

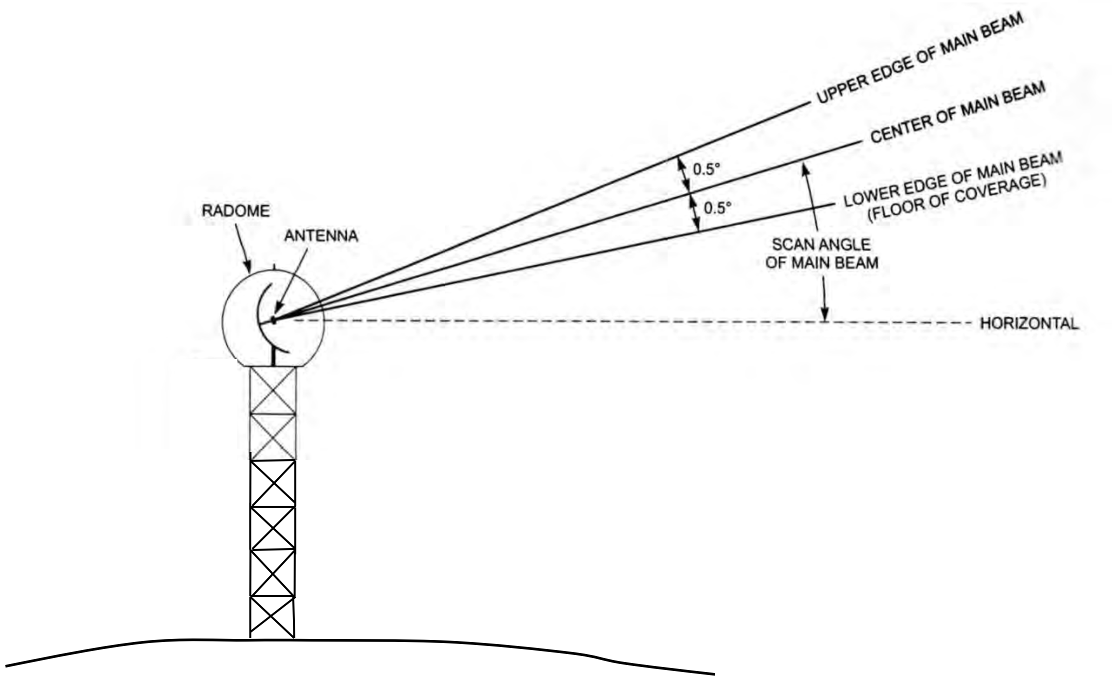

Figure 3: Schematic of WSR-88D Main Beam

(Not to scale, width of main beam exaggerated)

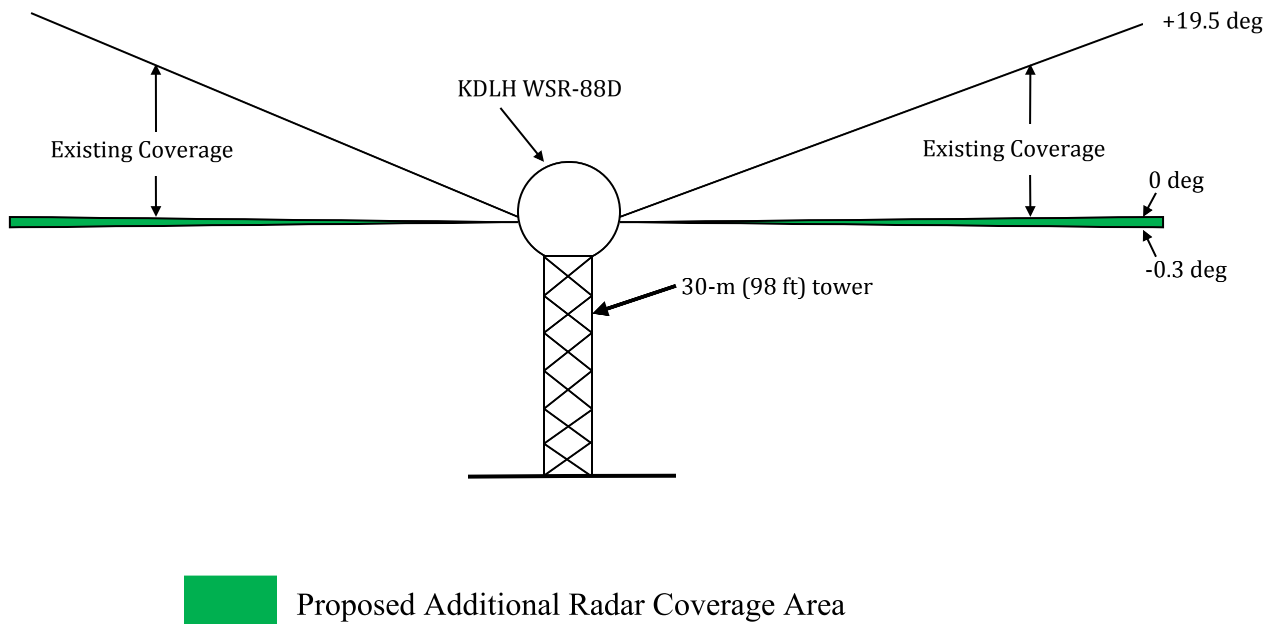

Figure 4: Drawing Showing Proposed Additional Radar Coverage

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

Figure 6: Existing and Proposed KDLH WSR-88D Coverage at 10,000 ft above Site Level

International Falls, MN, about 132 miles north-northwest of the KDLH WSR-88D, is an area of concern for NWS. The proposed action would reduce the minimum height of radar coverage (i.e. radar coverage floor) over International Falls from 9,100 ft to 7,900 ft AGL. Northwestern Wisconsin, represented by Hayward, WI is another area of concern. Hayward, WI, is about 67 miles southeast of the KDLH WSR-88D. The proposed action would reduce the minimum height of radar coverage (i.e. radar coverage floor) over Hayward from 2,600 ft to 700 ft AGL. These reductions in coverage floor height would aid NWS meteorologists by improving their ability to accurately detect and measure low atmosphere weather features and phenomena (e.g. severe storms, tornadoes).

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 KDLH WSR-88D serving the Duluth, MN, 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 +0.2 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 the 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 KDLH WSR-88D transmits a radio signal at a frequency of 2,875 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 KDLH 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 KDLH WSR-88D operating frequency is and 2,875 MHz. The IEEE/ANSI safety standards for those frequencies are 1.0 mW/cm^2 for the general public (averaged over 30 minutes) and 9.58 mW/cm^2 for workers (averaged over 6 minutes). 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 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). The FCC RF exposure standard for occupational exposure is somewhat lower that the ANSI/IEEE safety level: 5.0 mW/cm^2 (averaged over 6 minutes).

RF Exposure Levels

The KDLH WSR-88D is mounted on a 30 m tall steel-lattice tower. Ground elevation is 1,428 ft MSL. The center of the antenna is at 1,542 ft MSL and the lower edge of the antenna is 100 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 not impinge on the ground surface or structures within 2.7 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 KDLH 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.

Table 3: RF Power Density within KDLH WSR-88D Main Beam 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	0.602	1.0	1.66	9.58	15.9
Closest Structure, Cellular telephone Tower: 1,400 ft S	0.0041	1.0	244	9.58	2,340
Closest Terrain: 14,300 ft (2.7 miles) NW	0.000069	1.0	14,490	9.58	138,800

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 public 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 562 ft. The only structure tall enough to be within the WSR-88D main beam within those distances is a cellular telephone tower 1,400 ft to the south. RF levels at the upper portion of that tower would exceed safety standards for exposure of the general public but would comply with occupational safety standards. While workers may access the upper part of the tower, the general public would not be expected to access the upper part of that tower. Thus, only occupational RF exposure would be expected, and RF exposure levels would comply with occupational safety standards.

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 KDLH WSR-88D would continue to operate at 2,875 MHz, outside the frequency range where induced currents or electro-simulation 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

4.2.1 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. Lowering the minimum scan angle to +0.2 deg would not result in the main beam impinging on the ground surface within 2.7 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, dissembled, 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:

$$D = (781)\,(f)^{-1}(\text{average power x antenna gain})^{½}$$

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

$$D = (781)\,(2{,}875)^{-1}\,(475{,}000\text{ W} \times 0.0021 \times 35{,}500)^{½}\text{ ft}$$

$$D = 1{,}616\text{ ft}$$

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

$$D = (2{,}873)\,(f)^{-1}(\text{average power x antenna gain})^{½}$$

$$D = (2{,}873)\,(2{,}875)^{-1}\,(475{,}000\text{ W} \times 0.0021 \times 35{,}500)^{½}\text{ ft}$$

$$D = 5{,}947\text{ ft}$$

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 KDLH WSR-88D main beam would not illuminate the ground within either 1,616 or 5,947 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 2,875 MHz, the field strength is 3 A/m. This is converted to power density (S) in units of W/m^2 by assuming free air impedance of 377 ohms:

$$S = 377\,|3|^2 \quad W/m^2$$

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

To convert to mW/cm^2, we multiply the numerator by 1,000 mW/W and the divisor by 10,000 cm^2/ m^2 which gives a value of 339.3 mW/cm^2. The peak pulse power of the WSR-88D is given by the following formula (see Appendix A):

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

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 KDLH WSR-88D would not illuminate the ground within 2,060 ft of the radar. The cellular telephone tower to the south of the KDLH WSR-88D is within 2,060 ft. However, workers on that tower would be trained in RF safety and use of proper personal protective equipment; thus hazards should not 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 KDLH WSR-88D would comply with the FCC safety standards. Exposure of persons wearing implantable medical devices to the KDLH 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 four astronomical observatories located within 150 miles of the KDLH WSR-88D. The elevation of the KDLH 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 -0.3 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 four observatories. No adverse effects on astronomical observatories would result.

TABLE 4: ASTRONOMICAL OBSERVATORIES WITHIN 150 MILES OF THE KDLH WSR-88D

Observatory	Location	Distance and Direction	Would WSR-88D Main Beam at +0.2 deg Impinge?
Joseph J. Cantby	Afton, MN	136 mi SSW	No
Eisenhower	Hopkins, MN	144 mi S	No
O'Brien (University of Minnesota)	Marine-on-St. Croix, MN	118 mi S	No
Macalester University	St. Paul, MN	139 mi S	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.

Table 5: RF Effects of KDLH WSR-88D on Equipment and Activities

Equipment / Activity	Applicable Standard	Setback Distance	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	5,947 ft	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	Exposure to WSR-88D Main Beam	n/a	n/a	Very Low

4.3 LAND USE AND COASTAL ZONE MANAGEMENT

Minnesota is a coastal state with a Coastal Zone Management Program administered by the Minnesota Department of Natural Resources. The KDLH WSR-88D is located in the Lake Superior coastal management zone (NOAA Office of Coastal Management, 2019; Minnesota Department of Natural Resources, 2019). The proposed action would not impact natural resources, generate air or water pollutants, or affect visual quality of the area. The proposed action would not adversely affect the coastal management zone.

The KDLH WSR-88D is located at Duluth International Airport and nearby land uses are aviation and commercial. The nearest structures are detached houses and apartments located 1,100 ft southwest of the WSR-88D. The proposed action would not change land uses at the KDLH WSR-88D site or vicinity and would not adversely affect nearby land uses.

4.4 GEOLOGY, SOILS, AND SEISMIC HAZARDS

KDLH WSR-88D site is located on glacial till and moraine of Pleistocene Epoch (10,000 to 2 million years ago). Soil is Hermantown-Conosia-Giese complex, depressional, on 0 to 3% slope 9. The upper soil layer is silt loam and the subsoil is gravelly sandy loam. This soil is somewhat poorly drained with shallow water table at 6 inches of depth. This soil is classified as farmland of statewide importance where in agricultural use. (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 KDLH 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, or seismicity. No mitigation measures are required.

4.5 DRAINAGE AND WATER QUALITY

The KDLH WSR-88D site drains southeastward into Miller Creek which flows for about 6.5 miles and discharges into Lake Superior (USGS, 2016). Lowering the minimum scan angle of the KDLH 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 KDLH WSR-88D is collocated with the Duluth WFO and is accessed via Miller Trunk Highway (U.S. Highway 53) which is a divided four-lane paved public road. The proposed action requires 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 KDLH 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 KDLH 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 KDLH WSR-88D site is mapped by the Federal Emergency Management Agency in Zone C, an area of minimal flood hazards (FEMA, 1980). The proposed action of lowering the minimum 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 palustrine scrub-shrub broad-leaved deciduous wetlands (PSS1D) located 200 ft northeast and east of the WSR-88D site. Those wetlands are continuously saturated (USFWS, 2019a). 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 KDLH WSR-88D is located within the area served by the USFWS Minnesota-Wisconsin Ecological Services Field Office in Bloomington, MN. NWS obtained a protected species list from that office (see Appendix B). Table 6 lists threatened and endangered species listed under the ESA that could potentially occur in the vicinity of the KDLH WSR-88D.

Table 6: Endangered/Threatened Species Potentially Occurring near the KDLH WSR-88D

Species (scientific name)	Type	Status	Is WSR-88D site in Critical Habitat?
Canada lynx (*Lynx canadensis*)	Mammal	Threatened	Yes
Gray wolf (*Canis lupis)*	Mammal	Threatened	No
Northern long-eared bat (*Myotis septentrionalis*)	Bat	Threatened	None designated
Piping plover (*Charadius melodus*)	Bird	Endangered	No
Red knot (*Calidris canutus rufa*)	Bird	Threatened	None designated

Canada lynx (*Lynx canadensis)* is a medium-sized cat with long legs and large paws, which help it hunt in deep snow. It is closely associated with boreal forests (USFWS, 2019b). Large portions of St. Louis County, including the project site and vicinity have been designated as critical habitat for the Canada lynx (see Appendix B). Gray wolf (*Canis lupis)* is a keystone predator that occurs in a wide range of habitats (USFWS, 2019c). USFWS has designated critical habitat for the gray wolf; the WSR-88D site is not located in critical habitat (see Appendix B). The proposed action does not include construction activities and would not result in ground disturbance or vegetation removal. 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 overage 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 nearest ground to be directly illuminated by the lowered WSR-88D main beam would be 14,300 ft to the northwest. At that distance, the WSR-88D main beam would comply with all safety standards for human RF exposure. Exposure to RF energy from the WSR-88D would not be harmful to the Canada lynx, gray wolf or other mammals in the vicinity. The proposed action would not require vegetation removal or other physical changes to the critical habitat for the Canada lynx. The proposed action would not adversely affect the Canada lynx or grey wolf.

Northern long-eared bat (*Myotis septentrionalis*) is a medium-sized bat that occurs across the eastern and north-central U.S. and Canada. White-nosed syndrome, a fungal disease, is the predominant threat to this species (USFWS, 2019d). USFWS has not designated critical habitat for this species (see Appendix B).

Piping plover (*Charadius melodus*) occurs on beaches of the Atlantic Coast and Great Lakes. They nest on coastal beaches, sandflats, foredunes, blowout areas behind dunes, washout areas between dunes (USFWS, 2019e). USFWS has designated critical habitat for the piping plover; the WSR-88D site is not located in critical habitat (see Appendix B).

Red knot is a shorebird with historic range throughout the U.S. east of the Rocky Mountains. Red knots migrate each year up to 9,300 miles between North and South America. The species has been adversely affected by shoreline development, reduced populations of horseshoe crabs on which is feeds, and impacts of wind turbines. Harvests of horseshoe crabs are now managed to provide increased food availability during the critical period when the red knot migrates across the Atlantic coast. The species is also thought to be vulnerable to the effects of climate change (USFWS, 2019f). Critical habitat has not been designated for the red knot (see Appendix B).

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 overage 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 - 3 ft thick at a distance of 900 ft from the WSR-88D and increasing in thickness with distance from the radar. At 1 mile it would be 18 ft thick and at five miles it would be 89 ft thick. 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.

Increased RF exposure levels could result if birds or bats 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 or bat 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 KDLH WSR-88Ds where RF exposure of persons within the WSR-88D main beam could potentially exceed safety levels (see Appendix A). The Minnesota National Register of Historic Places (NRHP) was searched for listings within the APE. No listings for historic places were found within the APE (Minnesota Historical Society, 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 the Minnesota 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 KDLH WSR-88D is located at Duluth International Airport in St. Louis County. The nearest residences are located 1,100 ft southwest of the radar. The proposed action would not generate air or water pollutants or hazardous waste. The project would modify the operation of the KDLH 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 KDLH WSR-88D site is classified as farmland of state wide importance. However, the WSR-88D site and adjoining properties are committed to non-agricultural uses. 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 KDLH 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 KDLH WSR-88D is the St. Croix River on the boundary between Minnesota and Wisconsin about 52 miles south of WSR-88D (National Park Service, 2019). The proposed action would not affect the St. Croix River or any other wild and scenic river. No mitigation is necessary.

5 ALTERNATIVES TO THE PROPOSED ACTION

5.1 MINIMUM SCAN ANGLES BETWEEN +0.4 AND +0.2 DEG

NWS evaluated the benefits and potential impacts of lowering the minimum center of beam scan angle of the KDLH 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 International Falls, MN and northern Wisconsin.

A minimum scan angle of +0.4 or +0.3 deg would increase the radar's coverage area, but by less than the proposed action (i.e. minimum scan angle of +0.2) deg. A minimum scan angle lower than +0.2 deg would not increase coverage area and would have the drawback of increasing ground clutter returns.

Because a minimum scan angle of +0.2 deg would result in significant improvement in radar coverage area while avoiding significant environmental impacts, NWS selected +0.2 deg as the proposed minimum scan angle for the KDLH WSR-88D.

5.2 NO ACTION

The no action alternative consists of continued operation of the KDLH 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

6 FINDING

The proposed action of lowering the scan angle of the KDLH 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 Duluth, MN, WFO service area (northeastern Minnesota an northwestern Wisconsin) 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 Manitakos, 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, Deputy Director of the NWS Radar Operations Center, and Mr. Edward Ciardi, Program Manager, EVP Weather Systems, from the ROC assisted in preparation of this EA. Mr. Michael Stewart, Meteorologist-in-Charge, and staff from the Duluth, MN, WFO, also assisted in preparation of this EA.

8 REFERENCES

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SENSOR ENVIRONMENTAL LLC
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Environmental Assessment Report

ENVIRONMENTAL ASSESSMENT (EA)

LOWERING THE MINIMUM SCAN ANGLES OF THE WEATHER SURVEILLANCE RADAR - MODEL 1988, DOPPLER (WSR-88D) SERVING THE DULUTH, MINNESOTA, AREA

APPENDICES

APPENDIX A

RADIOFREQUENCY RADIATION POWER DENSITY CALCULATIONS

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 angle of +0.5 degrees (deg) (current minimum scan angle) and +0.2 deg (proposed minimum scan angle). 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. Table A-1 shows parameters of the WSR-88D, which have not changed from the 1993 analysis:

Table A-1: WSR-88D Radiofrequency Parameters	
Parameter	**Value**
Operating Frequency	2,700 to 3,000 megahertz (MHz)
Wavelength at center frequency (2,850 MHz)	0.345 ft, 10.5 cm
Maximum radiated 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 KDLH WSR-88D serving the Duluth, MN, area below the +0.5 angle currently in use. 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. VOLUME SCAN PATTERN 31 MODIFIED BY ADDING +0.2 DEG SCANS (KDLH WSR-88D)

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 less than +0.5 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. For the KDLH WSR-88D, the two added scans would be at +0.2 deg (i.e. lower half power point of -0.3 deg). 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 RFR POWER DENSITIES FOR KDLH WSR-88D

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 SEA 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 0.0 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

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

$$U_4 = (0.6024)\ U3$$

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

$$U_4 = 8.132 \times 10^3/R^2 \quad \text{mW/cm}^2$$

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 eradiated energy. The 1993 SEA calculated the average power density of these higher order sidelobes at $4/R^2$ mW/cm^2. 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:

$$U_5 = 8.132 \times 10^3/R^2 + 4/R^2 = 8.136 \times 10^3/R^2 \quad \text{mW/cm}^2$$

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 $Y = 28 \div R \text{ Tan } 2 \text{ deg} + 0.035R$. Since the modified scan pattern of interest includes scans of +0.2. +0.5, and +1.5 degs, the angular range is 1.3 deg, and we recalculate Y as follows:

$$Y = 28 + R\text{Tan }(1.3 \text{ deg}) = 28 + 0.023R$$

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

$$A = 2\pi RY = 176R + 0.14R^2$$

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):

$$U_6 = 2 * 10^6 / (929) (176R + 0.14R^2) = 15{,}378 / (R^2 + 1{,}257\ R)\ \text{mW/cm}^2$$

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 Combined Result

Table A-2 shows the time-averaged RFR power densities that would result at locations directly illuminated by the main beam of the KDLH 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 lower half-power point (i.e. bottom edge) of the main beam occurs and would also slightly increase the time-averaged power densities in both the near and far fields.

Table A-2: Comparison of Time-Average RFR Power Densities at Various Distances within the Illuminated Area for KDLH WSR-88D

Distance (ft)	Distance (mi)	Change in Elevation of Lower Half-Power Point (ft)	Original VCP 31 Time-Avg Power Density (mW/cm2)	Modified VCP 31 Time-Avg Power Density (mW/cm^2)
20	0.004	No change	0.598	0.602
900	0.17	-5	0.0072	0.0100
5,280	1	-28	0.00021	0.00029
25,400	5	-133	0.000009	0.000013

4.4 RF Exposure Levels near KDLH WSR-88D

Table A-3 shows the time-averaged RF power densities that would result at locations directly illuminated by the main beam of the KDLH WSR-88D when operating in modified VCP 31. The near field formula U_6 is used within 640 ft of the radar and the far field formula U_5 is used beyond 640 ft. For comparison purposes, corresponding values for the original VCP 31 are also shown. As can be seen from Table A-3, modified scan pattern 31 would slightly increase the level of RF exposure.

Table A-3: Time-Average RFR Power Densities at Terrain and Structures Directly Illuminated by the KDLH WSR-88D Main Beam			
Place or Structure	**Distance (ft) and Direction**	**Original VCP 31 Time-Avg Power Density (mW/cm^2)**	**Modified VCP 31 Time-Avg Power Density (mW/cm^2)**
Closest Terrain	14,300 ft NW	0.000045	0.000069
Closest Structure	Cellular telephone Tower: 1,400 ft S	0.0032	0.0041
Antenna Farm	24,300 ft SE	0.000016	0.000025

NWS may infrequently operate the KDLH 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

$$U_7 = (1.44 \times 10^9/R^2)\ 0.0021 = 3.024 \times 10^6/R^2 \qquad (mW/cm^2)$$

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

ANSI/IEEE and FCC General Public Safety Level (1.0 mW/cm^2): 1,740 ft

FCC Occupational Safety Level (5.0 mW/cm^2): 780 ft

ANSI/IEEE Occupational Safety Level* (9.58 mW/cm^2): 562 ft

*Frequency-dependent safety standard calculated for KDLH operating frequency of 2,875 MHz.

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. email to James Manitakos, Sensor Environmental LLC (February 14, 2018).

APPENDIX B

PROTECTED SPECIES LIST

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Minnesota-Wisconsin Ecological Services Field Office
4101 American Blvd E
Bloomington, MN 55425-1665
Phone: (952) 252-0092 Fax: (952) 646-2873
http://www.fws.gov/midwest/Endangered/section7/s7process/step1.html

In Reply Refer To: March 26, 2019
Consultation Code: 03E19000-2019-SLI-0676
Event Code: 03E19000-2019-E-01678
Project Name: KDLH WSR-88D Lower Scan Angle

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 attached species list identifies any federally threatened, endangered, proposed and candidate species that may occur within the action area the area that is likely to be affected by your proposed project. The list also includes any designated and proposed critical habitat that overlaps with the action area. This list is provided to you as the initial step of the consultation process required under section 7(c) of the Endangered Species Act, also referred to as Section 7 Consultation.

Section 7 of the Endangered Species Act of 1973 requires that actions authorized, funded, or carried out by Federal agencies not jeopardize federally threatened or endangered species or adversely modify designated critical habitat. To fulfill this mandate, Federal agencies (or their designated non-federal representatives) must consult with the Service if they determine their project may affect listed species or critical habitat. Agencies must confer under section 7(a)(4) if any proposed action is likely to jeopardize species proposed for listing as endangered or threatened or likely to adversely modify any proposed critical habitat.

Under 50 CFR 402.12(e) (the regulations that implement Section 7 of the Endangered Species Act) the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally. You may verify the list by visiting the ECOS-IPaC website http://ecos.fws.gov/ipac/ at regular intervals during project planning and implementation and completing the same process you used to receive the attached list. As an alternative, you may contact this Ecological Services Field Office for updates.

Please use the species list provided and visit the U.S. Fish and Wildlife Service's Region 3 Section 7 Technical Assistance website at - http://www.fws.gov/midwest/endangered/section7/

s7process/index.html. This website contains step-by-step instructions that will help you determine if your project will have an adverse effect on listed species or critical habitat and will help lead you through the Section 7 process.

For all **wind energy projects** and **projects that include installing towers that use guy wires or are over 200 feet in height**, please contact this field office directly for assistance, even if no federally listed plants, animals or critical habitat are present within the action area.

Although no longer protected under the Endangered Species Act, be aware that bald eagles (*Haliaeetus leucocephalus*) are protected under the Bald and Golden Eagle Protection Act (16 U.S.C. 668 *et seq.*) and Migratory Bird Treaty Act *(*16 U.S.C. 703 *et seq*), as are golden eagles (*Aquila chrysaetos*). Projects affecting these species may require measures to avoid harming eagles or may require a permit. If your project is near a bald eagle nest or winter roost area, see our Eagle Permits website at http://www.fws.gov/midwest/midwestbird/EaglePermits/index.html. The information available at this website will help you determine if you can avoid impacting eagles or if a permit may be necessary.

We appreciate your concern for threatened and endangered species. Please include the Consultation Tracking Number in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment(s):

- Official Species List
- Migratory Birds

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:

Minnesota-Wisconsin Ecological Services Field Office
4101 American Blvd E
Bloomington, MN 55425-1665
(952) 252-0092

Project Summary

Consultation Code: 03E19000-2019-SLI-0676

Event Code: 03E19000-2019-E-01678

Project Name: KDLH WSR-88D Lower Scan Angle

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/46.83679819905789N92.21015889647953W

Counties: St. Louis, MN

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 Fisheries[1], 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.

Mammals

NAME	STATUS
Canada Lynx *Lynx canadensis* Population: Wherever Found in Contiguous U.S. There is **final** critical habitat for this species. Your location overlaps the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/3652	Threatened
Gray Wolf *Canis lupus* Population: MN There is **final** critical habitat for this species. Your location is outside the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/4488	Threatened
Northern Long-eared Bat *Myotis septentrionalis* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/9045	Threatened

Birds

NAME	STATUS
Piping Plover *Charadrius melodus* Population: [Great Lakes watershed DPS] - Great Lakes, watershed in States of IL, IN, MI, MN, NY, OH, PA, and WI and Canada (Ont.) There is **final** critical habitat for this species. Your location is outside the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/6039	Endangered
Red Knot *Calidris canutus rufa* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/1864	Threatened

Critical habitats

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

NAME	STATUS
Canada Lynx *Lynx canadensis* https://ecos.fws.gov/ecp/species/3652#crithab	Final

Migratory Birds

Certain birds are protected under the Migratory Bird Treaty Act[1] and the Bald and Golden Eagle Protection Act[2].

Any person or organization who plans or conducts activities that may result in impacts to migratory birds, eagles, and their habitats should follow appropriate regulations and consider implementing appropriate conservation measures, as described below.

---

1. The Migratory Birds Treaty Act of 1918.
2. The Bald and Golden Eagle Protection Act of 1940.
3. 50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)

The birds listed below are birds of particular concern either because they occur on the USFWS Birds of Conservation Concern (BCC) list or warrant special attention in your project location. To learn more about the levels of concern for birds on your list and how this list is generated, see the FAQ below. This is not a list of every bird you may find in this location, nor a guarantee that every bird on this list will be found in your project area. To see exact locations of where birders and the general public have sighted birds in and around your project area, visit the E-bird data mapping tool (Tip: enter your location, desired date range and a species on your list). For projects that occur off the Atlantic Coast, additional maps and models detailing the relative occurrence and abundance of bird species on your list are available. Links to additional information about Atlantic Coast birds, and other important information about your migratory bird list, including how to properly interpret and use your migratory bird report, can be found below.

For guidance on when to schedule activities or implement avoidance and minimization measures to reduce impacts to migratory birds on your list, click on the PROBABILITY OF PRESENCE SUMMARY at the top of your list to see when these birds are most likely to be present and breeding in your project area.

NAME	BREEDING SEASON
American Bittern *Botaurus lentiginosus* This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA https://ecos.fws.gov/ecp/species/6582	Breeds Apr 1 to Aug 31
Bald Eagle *Haliaeetus leucocephalus* This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities. https://ecos.fws.gov/ecp/species/1626	Breeds Dec 1 to Aug 31

NAME	BREEDING SEASON
Black-billed Cuckoo *Coccyzus erythropthalmus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9399	Breeds May 15 to Oct 10
Bobolink *Dolichonyx oryzivorus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds May 20 to Jul 31
Canada Warbler *Cardellina canadensis* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds May 20 to Aug 10
Cape May Warbler *Setophaga tigrina* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds Jun 1 to Jul 31
Connecticut Warbler *Oporornis agilis* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds Jun 15 to Aug 10
Dunlin *Calidris alpina arcticola* This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA	Breeds elsewhere
Evening Grosbeak *Coccothraustes vespertinus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds May 15 to Aug 10
Golden Eagle *Aquila chrysaetos* This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities. https://ecos.fws.gov/ecp/species/1680	Breeds Jan 1 to Aug 31
Golden-winged Warbler *Vermivora chrysoptera* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/8745	Breeds May 1 to Jul 20
Harris's Sparrow *Zonotrichia querula* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds elsewhere

NAME	BREEDING SEASON
Lesser Yellowlegs *Tringa flavipes* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9679	Breeds elsewhere
Long-eared Owl *asio otus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/3631	Breeds Mar 1 to Jul 15
Marbled Godwit *Limosa fedoa* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9481	Breeds elsewhere
Olive-sided Flycatcher *Contopus cooperi* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/3914	Breeds May 20 to Aug 31
Red-headed Woodpecker *Melanerpes erythrocephalus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds May 10 to Sep 10
Ruddy Turnstone *Arenaria interpres morinella* This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA	Breeds elsewhere
Rusty Blackbird *Euphagus carolinus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds May 10 to Jul 20
Semipalmated Sandpiper *Calidris pusilla* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds elsewhere
Whimbrel *Numenius phaeopus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9483	Breeds elsewhere
Wood Thrush *Hylocichla mustelina* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds May 10 to Aug 31

Probability Of Presence Summary

The graphs below provide our best understanding of when birds of concern are most likely to be present in your project area. This information can be used to tailor and schedule your project activities to avoid or minimize impacts to birds. Please make sure you read and understand the FAQ "Proper Interpretation and Use of Your Migratory Bird Report" before using or attempting to interpret this report.

Probability of Presence (■)

Each green bar represents the bird's relative probability of presence in the 10km grid cell(s) your project overlaps during a particular week of the year. (A year is represented as 12 4-week months.) A taller bar indicates a higher probability of species presence. The survey effort (see below) can be used to establish a level of confidence in the presence score. One can have higher confidence in the presence score if the corresponding survey effort is also high.

How is the probability of presence score calculated? The calculation is done in three steps:

1. The probability of presence for each week is calculated as the number of survey events in the week where the species was detected divided by the total number of survey events for that week. For example, if in week 12 there were 20 survey events and the Spotted Towhee was found in 5 of them, the probability of presence of the Spotted Towhee in week 12 is 0.25.
2. To properly present the pattern of presence across the year, the relative probability of presence is calculated. This is the probability of presence divided by the maximum probability of presence across all weeks. For example, imagine the probability of presence in week 20 for the Spotted Towhee is 0.05, and that the probability of presence at week 12 (0.25) is the maximum of any week of the year. The relative probability of presence on week 12 is 0.25/0.25 = 1; at week 20 it is 0.05/0.25 = 0.2.
3. The relative probability of presence calculated in the previous step undergoes a statistical conversion so that all possible values fall between 0 and 10, inclusive. This is the probability of presence score.

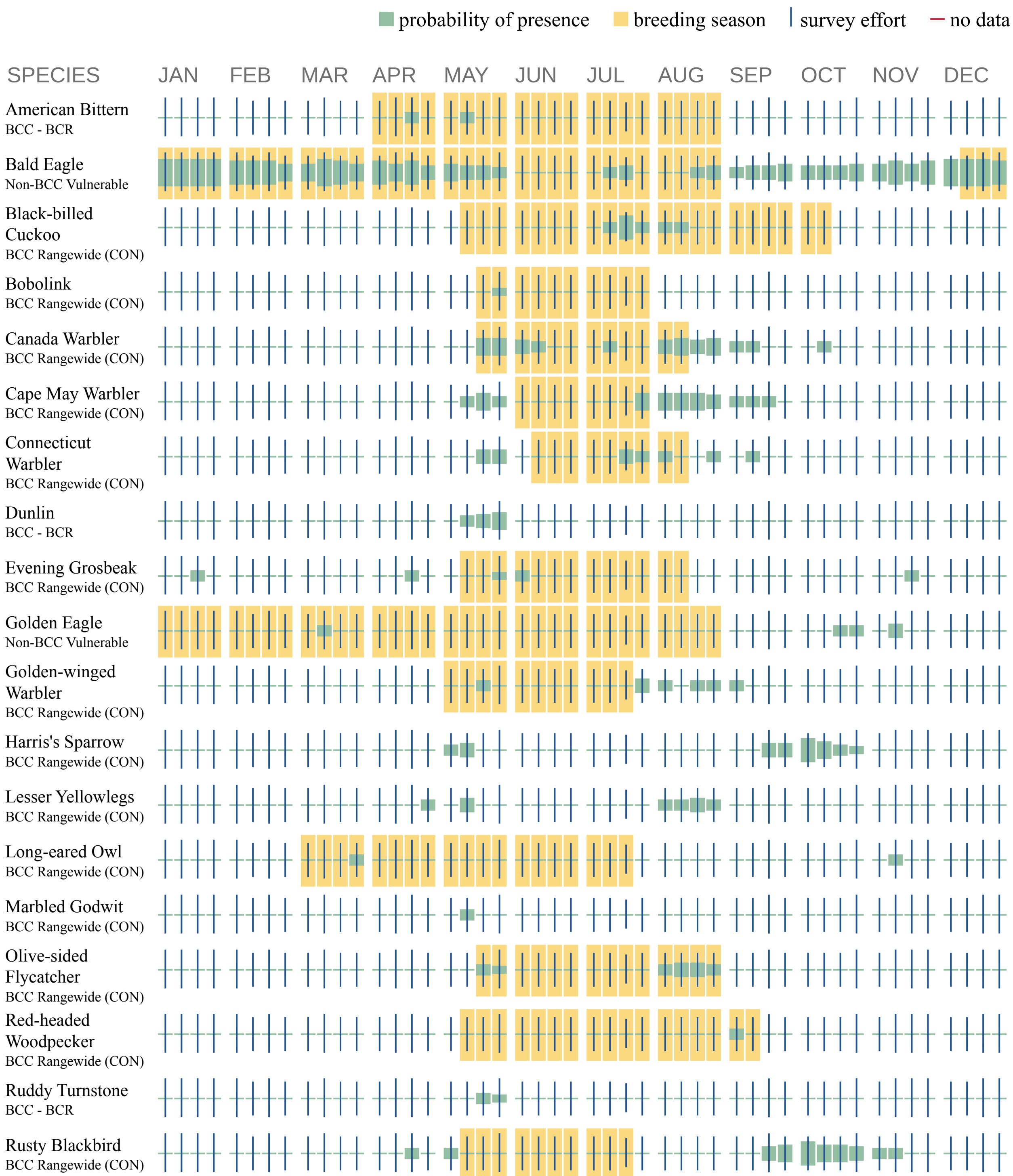
Breeding Season (■)
Yellow bars denote a very liberal estimate of the time-frame inside which the bird breeds across its entire range. If there are no yellow bars shown for a bird, it does not breed in your project area.

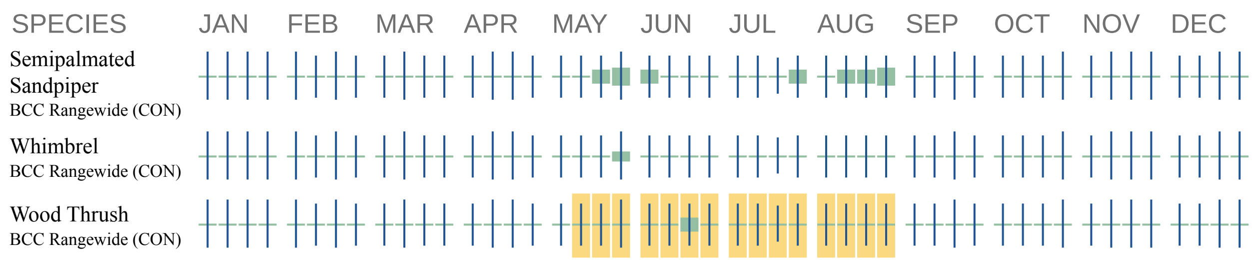
Survey Effort (|)
Vertical black lines superimposed on probability of presence bars indicate the number of surveys performed for that species in the 10km grid cell(s) your project area overlaps. The number of surveys is expressed as a range, for example, 33 to 64 surveys.

No Data (–)
A week is marked as having no data if there were no survey events for that week.

Survey Timeframe

Surveys from only the last 10 years are used in order to ensure delivery of currently relevant information. The exception to this is areas off the Atlantic coast, where bird returns are based on all years of available data, since data in these areas is currently much more sparse.





Additional information can be found using the following links:

- Birds of Conservation Concern http://www.fws.gov/birds/management/managed-species/birds-of-conservation-concern.php
- Measures for avoiding and minimizing impacts to birds http://www.fws.gov/birds/management/project-assessment-tools-and-guidance/conservation-measures.php
- Nationwide conservation measures for birds http://www.fws.gov/migratorybirds/pdf/management/nationwidestandardconservationmeasures.pdf

Migratory Birds FAQ

Tell me more about conservation measures I can implement to avoid or minimize impacts to migratory birds.

Nationwide Conservation Measures describes measures that can help avoid and minimize impacts to all birds at any location year round. Implementation of these measures is particularly important when birds are most likely to occur in the project area. When birds may be breeding in the area, identifying the locations of any active nests and avoiding their destruction is a very helpful impact minimization measure. To see when birds are most likely to occur and be breeding in your project area, view the Probability of Presence Summary. Additional measures and/or permits may be advisable depending on the type of activity you are conducting and the type of infrastructure or bird species present on your project site.

What does IPaC use to generate the migratory birds potentially occurring in my specified location?

The Migratory Bird Resource List is comprised of USFWS Birds of Conservation Concern (BCC) and other species that may warrant special attention in your project location.

The migratory bird list generated for your project is derived from data provided by the Avian Knowledge Network (AKN). The AKN data is based on a growing collection of survey, banding, and citizen science datasets and is queried and filtered to return a list of those birds reported as occurring in the 10km grid cell(s) which your project intersects, and that have been identified as warranting special attention because they are a BCC species in that area, an eagle (Eagle Act requirements may apply), or a species that has a particular vulnerability to offshore activities or development.

Again, the Migratory Bird Resource list includes only a subset of birds that may occur in your project area. It is not representative of all birds that may occur in your project area. To get a list of all birds potentially present in your project area, please visit the E-bird Explore Data Tool.

What does IPaC use to generate the probability of presence graphs for the migratory birds potentially occurring in my specified location?
The probability of presence graphs associated with your migratory bird list are based on data provided by the Avian Knowledge Network (AKN). This data is derived from a growing collection of survey, banding, and citizen science datasets .

Probability of presence data is continuously being updated as new and better information becomes available. To learn more about how the probability of presence graphs are produced and how to interpret them, go the Probability of Presence Summary and then click on the "Tell me about these graphs" link.

How do I know if a bird is breeding, wintering, migrating or present year-round in my project area?
To see what part of a particular bird's range your project area falls within (i.e. breeding, wintering, migrating or year-round), you may refer to the following resources: The Cornell Lab of Ornithology All About Birds Bird Guide, or (if you are unsuccessful in locating the bird of interest there), the Cornell Lab of Ornithology Neotropical Birds guide. If a bird on your migratory bird species list has a breeding season associated with it, if that bird does occur in your project area, there may be nests present at some point within the timeframe specified. If "Breeds elsewhere" is indicated, then the bird likely does not breed in your project area.

What are the levels of concern for migratory birds?
Migratory birds delivered through IPaC fall into the following distinct categories of concern:

1. "BCC Rangewide" birds are Birds of Conservation Concern (BCC) that are of concern throughout their range anywhere within the USA (including Hawaii, the Pacific Islands, Puerto Rico, and the Virgin Islands);
2. "BCC - BCR" birds are BCCs that are of concern only in particular Bird Conservation Regions (BCRs) in the continental USA; and
3. "Non-BCC - Vulnerable" birds are not BCC species in your project area, but appear on your list either because of the Eagle Act requirements (for eagles) or (for non-eagles) potential susceptibilities in offshore areas from certain types of development or activities (e.g. offshore energy development or longline fishing).

Although it is important to try to avoid and minimize impacts to all birds, efforts should be made, in particular, to avoid and minimize impacts to the birds on this list, especially eagles and BCC species of rangewide concern. For more information on conservation measures you can implement to help avoid and minimize migratory bird impacts and requirements for eagles, please see the FAQs for these topics.

Details about birds that are potentially affected by offshore projects

For additional details about the relative occurrence and abundance of both individual bird species and groups of bird species within your project area off the Atlantic Coast, please visit the Northeast Ocean Data Portal. The Portal also offers data and information about other taxa besides birds that may be helpful to you in your project review. Alternately, you may download the bird model results files underlying the portal maps through the NOAA NCCOS Integrative Statistical Modeling and Predictive Mapping of Marine Bird Distributions and Abundance on the Atlantic Outer Continental Shelf project webpage.

Bird tracking data can also provide additional details about occurrence and habitat use throughout the year, including migration. Models relying on survey data may not include this information. For additional information on marine bird tracking data, see the Diving Bird Study and the nanotag studies or contact Caleb Spiegel or Pam Loring.

What if I have eagles on my list?
If your project has the potential to disturb or kill eagles, you may need to obtain a permit to avoid violating the Eagle Act should such impacts occur.

Proper Interpretation and Use of Your Migratory Bird Report
The migratory bird list generated is not a list of all birds in your project area, only a subset of birds of priority concern. To learn more about how your list is generated, and see options for identifying what other birds may be in your project area, please see the FAQ “What does IPaC use to generate the migratory birds potentially occurring in my specified location”. Please be aware this report provides the “probability of presence” of birds within the 10 km grid cell(s) that overlap your project; not your exact project footprint. On the graphs provided, please also look carefully at the survey effort (indicated by the black vertical bar) and for the existence of the “no data” indicator (a red horizontal bar). A high survey effort is the key component. If the survey effort is high, then the probability of presence score can be viewed as more dependable. In contrast, a low survey effort bar or no data bar means a lack of data and, therefore, a lack of certainty about presence of the species. This list is not perfect; it is simply a starting point for identifying what birds of concern have the potential to be in your project area, when they might be there, and if they might be breeding (which means nests might be present). The list helps you know what to look for to confirm presence, and helps guide you in knowing when to implement conservation measures to avoid or minimize potential impacts from your project activities, should presence be confirmed. To learn more about conservation measures, visit the FAQ “Tell me about conservation measures I can implement to avoid or minimize impacts to migratory birds” at the bottom of your migratory bird trust resources page.

APPENDIX C

TECHNICAL MEMORANDUM / TRIP REPORT

TECHNICAL MEMORANDUM

TO: Edward Ciardi, Program Manager, EVP Weather Systems, Centuria Corporation	**FROM:** James Manitakos, CEO, Sensor Environmental LLC
CC: Jessica Schultz, Deputy Director, Radar Operations Center, 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 Duluth, MN, Area
DATE: April 23, 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 Duluth, MN, area. Information on this radar is shown in Table 1. This 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 Duluth, MN, AREA	
Location	Co-located with Weather Forecast Office (WFO) at Duluth International Airport, Duluth, MN
International Civil Aviation Organization designator	KDLH
Elevation, ground surface at tower base (mean sea level, MSL)	1,428 ft
Elevation, center of antenna (MSL)	1,542 ft
Tower Height (m)	30 m (98 ft)
Latitude (WGS84)	46° 50’ 13” N
Longitude (WGS84)	-92° 12’ 35” W
WFO	5027 Miller Trunk Highway Duluth, MN 55811-1442
Meteorologist-in-Charge (MIC)	Michael Stewart Email: michael.stewart@noaa.gov Tel. 218-729-6697
Operating Frequency	2,875 megaHertz (MHz)
Spot Blanking or Sector Blanking used	No

NWS currently operates the KDLH 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 KDLH 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 -0.3 deg.

2. INVESTIGATIONS PERFORMED

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

1. We visited the KDLH WSR-88D and met with NWS staff from the Duluth, MN, 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 25-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 KDLH WSR-88D that would be directly illuminated by the main beam at each lower scan angle under consideration by NWS.

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 KDLH 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 elevation of KDLH WSR-88D coverage. Table 2 shows coverage areas at 2,000 ft above site level (ASL) for KDLH WSR-88D for the range of minimum scan angles under consideration by NWS.

TABLE 2: KDLH 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	10,567	n/a
2,000	+0.4	-0.1	14,071	+33.2%
2,000	+0.3	-0.2	17,268	+63.4%
2,000	+ 0.2	-0.3	19,451	+84.1%

KDLH WSR-88D is located at Duluth International Airport in Duluth, MN. When operating at the current minimum center of beam minimum scan angle of +0.5 deg, the KDLH WSR-88D is not subject to terrain blockage (see Attachment B). At a minimum scan angle of +0.4 deg, coverage would increase in all directions. To the north (azimuths 335 through 50, where 0 = true north, 90 = east, 180 = south, 270 = west) rising terrain would partially block the main beam. At a minimum scan angle of +0.3 deg, rising terrain to the west through northeast (azimuth 250 through 70) would partially block the main beam. At a minimum scan angle of +0.2 deg, the main beam would be wholly or partially blocked in all directions; however, some improvement in radar coverage would occur to the east through southwest (azimuths 70 through 245). A minimum scan angle below +0.2 deg would not further increase radar coverage. Operating the KDLH at the proposed minimum scan angle of +0.2 would increase radar coverage in all directions, and the greatest increase would occur to the east, southeast, south, and southwest. Compared to the existing minimum scan angle of +0.5 deg, the total area covered at 2,000 ft ASL would increase by 84.1%.

Two areas of interest are International Falls in Koochiching County, MN and northern Wisconsin, represented by Hayward in Sawyer County, WI. Existing minimum coverage altitude over those cities and the coverage with a +0.2 deg scan are shown in Table 3.

TABLE 3: KDLH WSR-88D Coverage Floor at Two Areas of Interest				
Area	Distance (mi)	Azimuth	Coverage Floor at +0.5 deg scan (ft above ground level ([AGL])	Coverage Floor at +0.2 deg scan (ft AGL)
International Falls, MN	132	335	9,100	7,900
Hayward, WI	67	145	2,600	700

Higher terrain in the Mesabi Range between the KDLH WSR-88D and International Falls would block scan angles lower than +0.4 deg. The reduction in coverage floor over International Falls would be from the current radar floor altitude of 9,100 ft AGL to 7,900 ft AGL. In the direction of Hayward the +0.2 scan would be mostly unobstructed by terrain and the radar coverage floor would decrease from the current 2,600 ft AGL to 700 ft AGL. This analysis is based on 4/3 earth curvature to account for refraction of the radar beam within the atmosphere. Radar beam ducting can be expected during portions of the year due to the presence of a marine layer caused by Lake Superior, and could cause coverage altitudes over northern Wisconsin to vary considerably from this projection.

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 electro-explosive devices (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.

<table>
<tr><th colspan="4">TABLE 4: Safe Setback Distances For Human Exposure And Potentially Sensitive Activities Directly Illuminated By The WSR-88D Main Beam</th></tr>
<tr><th>Activity</th><th colspan="2">Safe Setback Distance (ft)</th><th>Source</th></tr>
<tr><td rowspan="2">Human Exposure (general public)</td><td>Rotating Antenna</td><td>20</td><td rowspan="4">American National Standards Institute/Institute of Electrical and Electronic Engineers (ANSI/IEEE)</td></tr>
<tr><td>Stationary Antenna</td><td>1,740</td></tr>
<tr><td rowspan="2">Human Exposure (occupational)</td><td>Rotating Antenna</td><td>20</td></tr>
<tr><td>Stationary Antenna</td><td>560</td></tr>
<tr><td>Implantable Medical devices</td><td colspan="2">2,060</td><td>ANSI/Association for the Advancement of Medical Instrumentation (AAMI)</td></tr>
<tr><td>EEDs</td><td colspan="2">6,030</td><td>U.S. Air Force</td></tr>
<tr><td>Fuel Handling</td><td colspan="2">537</td><td>Naval Sea Systems Command</td></tr>
</table>

5. DIRECTLY ILLUMINATED TERRAIN AND STRUCTURES

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 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 deg. At a scan angle of +0.2 deg, the KDLH main beam would impinge on the ground 2.7 miles (14,300 ft) northwest of the radar. Attachment C shows the terrain that would be directly illuminated by the WSR-88D main beam at a minimum scan angle of +0.2 deg. That distance is farther than all safety setback distances from the WSR-88D. The only nearby structure that raises above the horizon is a cellular telephone located 1,400 ft south of the KDLH WSR-88D (See Photograph 4C in Attachment A). The WSR-88D main beam impinges on that tower during current operations and would continue to do so if the WSR-88D minimum scan angle was lowered. It is unlikely that the general public would be on the upper portion that tower. Workers may access the upper portion of the tower for maintenance or repair purposes, but even during stationary antenna operation, power density the WSR-88D main beam would not exceed occupational safety standards. No hazards to persons or potentially sensitive activities would result from lowering the minimum scan angle of the KDLH WSR-88D to +0.2 deg.

A number of communications towers are located at an antenna farm 4.6 to 5.6 miles southeast of the KDLH WSR-88D (see Photograph 4B in Attachment A). These towers rise above the horizon at azimuths 125 to 130 deg. The WSR-88D main beam currently impinges on the upper portions of these towers and would continue to do so if minimum scan angle was lowered to +0.2 deg. Those towers are farther from the WSR-88D than all safety setback distances and no hazards to persons or potentially RF-sensitive activities would result

WFO staff has reported intermittent blockage or interference with the WSR-88D main beam at azimuths 123 to 125 deg. The closest towers to those azimuths are two KQDS television towers at azimuth 125 deg (Federal communication commission [FCC] Antenna Structure Registration Numbers 1023509 and 1203847). Those towers reach elevations of 1,777 ft MSL and 2,025 ft MSL, respectively (FCC, 2019). The elevation at those towers of the lower half-power point of the WSR-88D main beam under current operations is about 1,550 ft MSL, and would be reduced to elevation 1,410 at a scan angle of +0.2 deg.

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. Table 5 lists astronomical observatories located within 150 miles of the KDLH WSR-88D and provide distances and azimuths to the observatories from the WSR-88D based on true north. Portions of Wisconsin and the province of Ontario are within 150 miles of the KDLH WSR-88D, but there are no astronomical observatories in those two jurisdictions within 150 miles. The table also shows whether or not the WSR-88D main beam at scan angles of +0.5 deg to +0.2 deg would impinge on each observatory. Impingement would not result if terrain or structural blockage is present between the observatory and WSR-88D or if the elevation of the lower half-power point of the main beam at the observatory location would be higher than the observatory elevation.

TABLE 5: ASTRONOMICAL OBSERVATORIES WITHIN 150 MILES OF THE KDLH WSR-88D

Observatory	Location	Distance from WSR-88D / azimuth	Observatory elevation (ft MSL)	KDLH WSR-88D main beam impinges at 0.5 deg or below?
Joseph J. Cantby	Afton, MN	136 mi / 204 deg	850	No at +0.5 to +0.2 deg
Eisenhower	Hopkins, MN	144 mi / 190 deg	1,000	No at +0.5 to +0.2 deg
O’Brien (University of Minnesota)	Marine-on-St. Croix, MN	118 mi / 193 deg	1,035	No at +0.5 to +0.2 deg
Macalester University	St. Paul, MN	139 mi, 196 deg	1,030	No at +0.5 to +0.2 deg

Lowering the minimum scan angle of the KDLH WSR-88D down to +0.2 deg would not result in the main beam impinging on astronomical observatories.

7. RECOMMENDATION

Lowering the minimum scan angle of the KDLH WSR-88D serving the Duluth, MN, area to +0.2 deg would increase coverage area at 2,000 ft above site level by 84.1% and would not result in adverse effects to person or activities or astronomical observatories. Therefore, a minimum scan angle of +0.2 deg is recommended for the KDLH 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 Manitakos, 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

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ATTACHMENT A

TRIP REPORT, KDLH WSR-88D

TRIP REPORT

Traveler: James Manitakos, Sensor Environmental LLC

Destination: Duluth, MN, Weather Forecast Offices (WFO) and Weather Surveillance Radar, Model 1988 Doppler (WSR-88D)

Dates: April 14 -16, 2019

Purpose: Field Inspection of KDLH WSR-88D serving Duluth, MN, area

Summary: April 14, 2018: Mr. Manitakos flew from San Jose, CA to Duluth, MN.

April 15, 2019: Mr. Manitakos met at the Duluth WFO with Science and Operations Officer Dan Miller and Electronics Technician David Leach. Mr. Manitakos went over the radar coverage plots for KDLH WSR-88D. WFO staff expressed interest in potential improvements in radar coverage over the following areas of interest: Mesabi Range area to the northwest of the WSR-88D, International Falls, MN, and northwestern Wisconsin. They also showed radar plots showing a strong reflection at azimuths 123 to 125 that they believe results from radio interference caused by communications tower(s) located about 5.2 miles from the WSR-88D. WFO staff drove Mr. Manitakos to the area of communications towers for a visual inspection of the towers (see Photographs 1 and 2). Mr. Manitakos then proceeded to the KDLH WSR-88D and took a photograph of the WSR-88D (Photograph 3) and panoramic photographs (Photograph 4) from the 25-m level of the KDLH WSR-88D, which is about 30 ft below the center of the WSR-88D antenna. In the evening, Mr. Manitakos was scheduled to return to San Jose but weather delayed the flight from Duluth to Minneapolis and he missed his connecting flight in Minneapolis. Delta Airlines rebooked him on the next available flight, which was the following morning. He stayed in Minneapolis for the night.

Weather: 45° F, Overcast

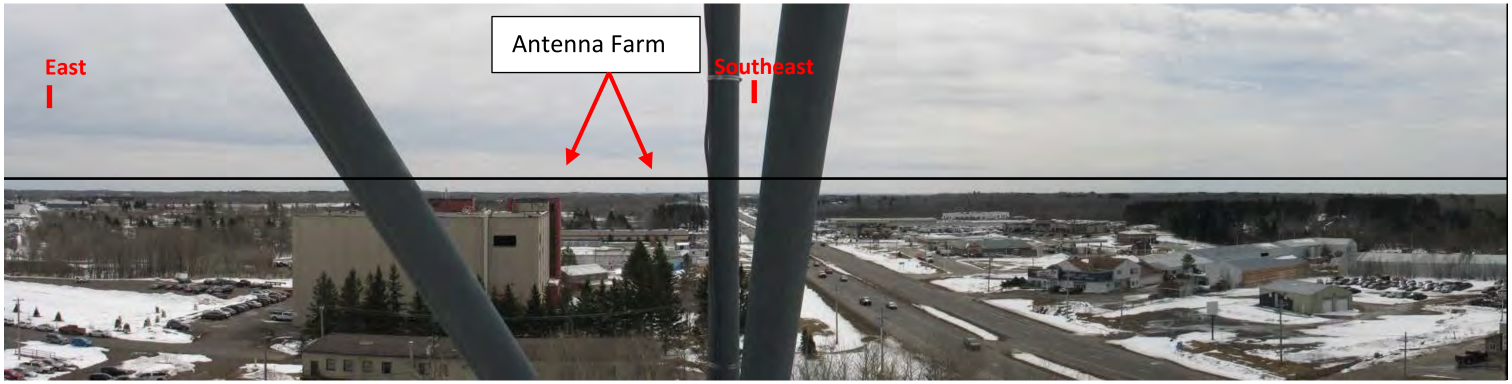
April 16, 2019: In morning, Mr. Manitakos flew back to San Jose, CA.

Photograph 1: Communications towers located 5.2 miles southeast of the KDLH WSR-88D viewed from First United Methodist Church (intersection of Highway 194 and Rice Lake Drive)

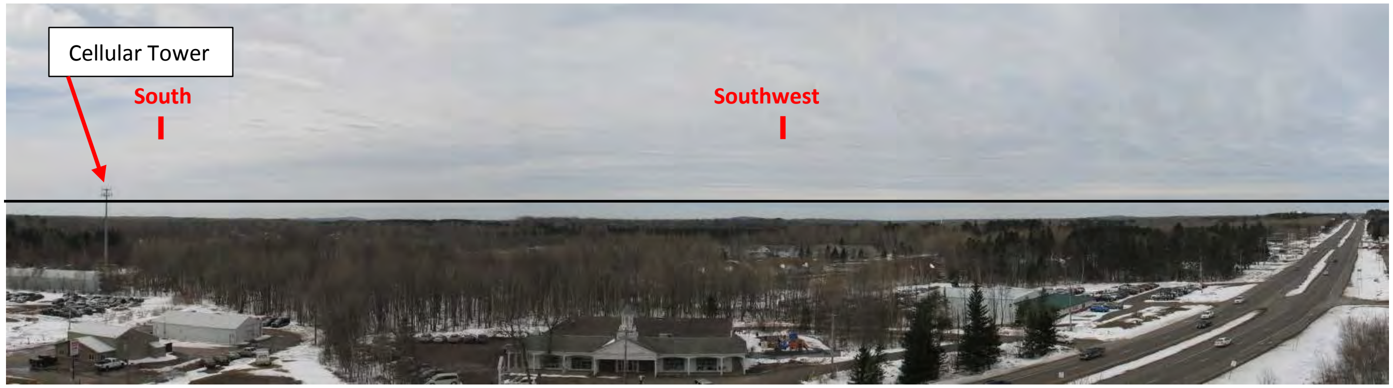
Photograph 2: Communications towers southeast of the KDLH WSR-88D viewed from Superior Hiking Trail at Duluth Harbor

Photograph 3: KDLH WSR-88D serving Duluth, MN, area viewed from the southwest

Photograph 4A: Panoramic photograph from KDLH WSR-88D tower [— 0 deg]



Photograph 4B: Panoramic photograph from KDLH WSR-88D tower [— 0 deg]



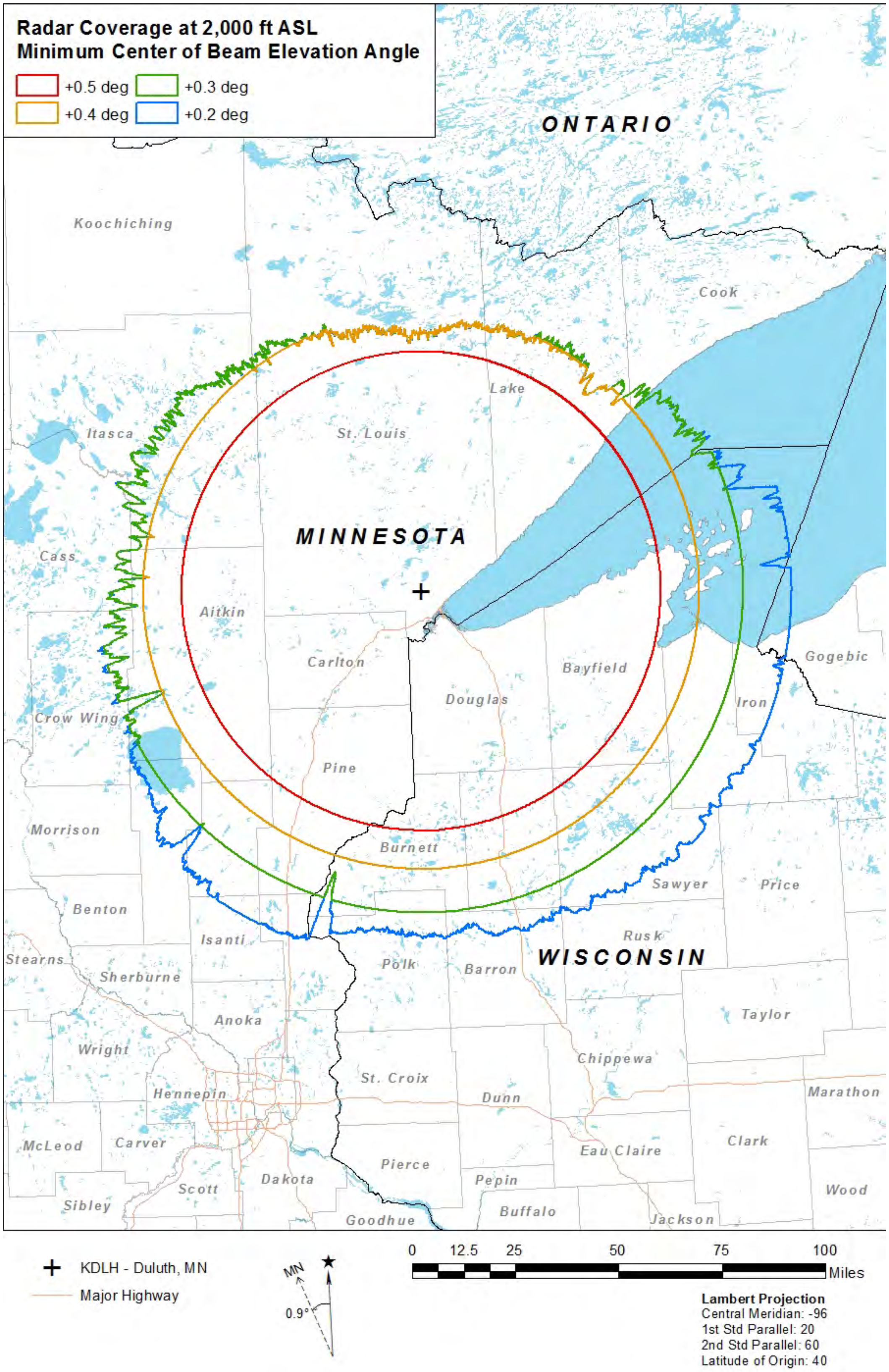
Photograph 4C: Panoramic photograph from KDLH WSR-88D tower [—— 0 deg]

Photograph 4D: Panoramic photograph from KDLH WSR-88D tower [—— 0 deg]

ATTACHMENT B

KDLH WSR-88D COVERAGE MAP

MINIMUM SCAN ANGLES +0.5 deg to -0.2 deg


Radar Coverage at 2,000 ft ASL
Minimum Center of Beam Elevation Angle
+0.5 deg
+0.3 deg
+0.4 deg
+0.2 deg
ONTARIO
MINNESOTA
WISCONSIN
Koochiching
Cook
Lake
St. Louis
Itasca
Cass
Aitkin
Carlton
Crow Wing
Pine
Douglas
Bayfield
Gogebic
Iron
Morrison
Burnett
Sawyer
Price
Benton
Isanti
Rusk
Stearns
Sherburne
Polk
Barron
Taylor
Anoka
Wright
Chippewa
St. Croix
Hennepin
Dunn
Marathon
McLeod
Carver
Eau Claire
Clark
Pierce
Dakota
Scott
Pepin
Wood
Sibley
Buffalo
Goodhue
Jackson
KDLH - Duluth, MN
Major Highway
MN
0.9°
0
12.5
25
50
75
100
Miles
Lambert Projection
Central Meridian: -96
1st Std Parallel: 20
2nd Std Parallel: 60
Latitude of Origin: 40

ATTACHMENT C

KDLH WSR-88D NEARBY DIRECTLY ILLUMINATED TERRAIN

AT SCAN ANGLES OF +0.2 deg


Terrain Illuminated by WSR-88D
Minimum Center of Beam Elevation Angle
+0.2 deg
KDLH - Duluth, MN
MN
0.9°
0
0.25
0.5
1
1.5
Miles