# Application to North Dakota Public Service Commission for Certificate of Site Compatibility

**Basin Electric Power Cooperative**

**Pioneer Generation Station Phase III Project**

**November 2014**

# Application to North Dakota Public Service Commission for Certificate of Site Compatibility

**prepared for**

**Basin Electric Power Cooperative**
**Pioneer Generation Station Phase III Project**
**Williams County, North Dakota**

**November 2014**

**prepared by**

**Burns & McDonnell Engineering Company, Inc.**
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# DEFINITIONS AND ACRONYMS

| **Term or Acronym** | **Definition** |
|---|---|
| 4SLB | Four-stroke, lean-burn |
| AADT | Average Annual Daily Traffic |
| AC | Alternating current |
| ACS | American Community Survey |
| AEO | Annual Energy Outlook |
| ALTW | Alliant West |
| AVS | Antelope Valley Station |
| Basin Electric | Basin Electric Power Cooperative |
| BEA | Bureau of Economic Analysis of U.S. Department of Commerce |
| BGEPA | Bald and Golden Eagle Protection Act |
| BLM | Bureau of Land Management |
| BMP | Best Management Practice |
| Btu | British thermal units |
| CAA | Clean Air Act |
| CadnaA | Computer Aided Noise Abatement |
| CBM | Coal bed methane |
| Certificate | Certificate of Site Compatibility |
| CFC | Cooperative Finance Corporation |
| CO | Carbon monoxide |
| Corn Belt | Corn Belt Power Cooperative |
| CROD | Contracted Rates of Delivery |
| CT | Combustion turbine |
| dB | decibel |

| **Term or Acronym** | **Definition** |
|---|---|
| dBA | A-weighted decibel |
| DC | Direct current |
| DOE | U.S. Department of Energy |
| DSM | Demand-Side Management |
| EIA | Energy Information Administration |
| EIS | Environmental Impact Statement |
| EMF | Electromagnetic field |
| EPA | Environmental Protection Agency |
| ESA | Endangered Species Act |
| FAPRI | Food and Agricultural Policy Research Institute |
| FIRM | Flood Insurance Rate Map |
| ft | foot/feet |
| G&T | Generation and transmission |
| GDP-IPD | Gross Domestic Product-Implicit Price Deflator |
| GE | General Electric |
| GHG | Greenhouse gas |
| $H_2SO_4$ | Sulfuric acid |
| HCPD | Heartland Consumers Power District |
| hp | Horsepower |
| Hz | Hertz |
| ICNIRP | International Commission on Non-Ionizing Radiation Protection |
| IHS | IHS Energy |
| IPaC | Information, Planning, and Conservation System |
| IRS | Internal Revenue Service |
| ISO | International Organization for Standardization |

| **Term or Acronym** | **Definition** |
|---|---|
| IS | Integrated System |
| kV | kilovolt |
| kV/m | Kilovolts per meter |
| kVA | kilovolt-Ampere |
| kW | Kilowatt |
| $L_{dn}$ | Day-night sound level |
| $L_{eq}$ | Average sound level |
| $L_p$ | Sound pressure level |
| LCS | Lonesome Creek Station |
| LPG | Liquefied propane gas |
| LRS | Laramie River Station |
| $L_w$ | Sound power level |
| $L_x$ | Exceedance sound level (statistical sound level) |
| MAC | Metcalf Archaeological Consultants, Inc. |
| MATS | Mercury and Air Toxics Standards |
| MEC | MidAmerican Energy Company |
| mG | milligaus |
| Minnkota | Minnkota Power Cooperative |
| MISO | Midcontinent Independent System Operator |
| MLRA | Major Land Resource Area |
| MMBtu | Million British thermal units |
| MMBtu/hr | Million British thermal units per hour |
| mph | Miles per hour |
| MSA | Metropolitan statistical area |
| MW | Megawatt |

| Term or Acronym | Definition |
|---|---|
| MWEC | Mountrail-Williams Electric Cooperative |
| MWh | Megawatt-hour |
| NAAQS | National Ambient Air Quality Standards |
| NAICS | North American Industrial Classification System |
| NDAAQS | North Dakota Ambient Air Quality Standards |
| NDAC | North Dakota Administrative Code |
| NDCC | North Dakota Century Code |
| NDDH | North Dakota Department of Health |
| NDDOT | North Dakota Department of Transportation |
| NDGS | North Dakota Geological Survey |
| NDPSC | North Dakota Public Service Commission |
| NESC | National Electrical Safety Code |
| NESHAP | National Emission Standards for Hazardous Air Pollutants |
| NIEHS | National Institute of Environmental Health Science |
| NIH | National Institutes of Health |
| NIPCO | Northwest Iowa Power Cooperative |
| $NO_2$ | Nitrogen dioxide |
| NOAA | National Oceanic and Atmospheric Administration |
| $NO_x$ | Nitrogen oxides |
| NPDES | National Pollutant Discharge Elimination System |
| NRHP | National Register of Historic Places |
| NRI | Nationwide Rivers Inventory |
| NSPS | New Source Performance Standards |
| $O_3$ | Ozone |
| OSHA | Occupations Safety and Health Administration |

| **Term or Acronym** | **Definition** |
|---|---|
| PACE | PACE Global Energy Services |
| Pb | Lead |
| PCE-IPD | Personal Consumption Expenditures-Implicit Price Deflator |
| PGS | Pioneer Generation Station |
| PM | Particulate matter |
| $PM_{10}$ | Particulate matter of 10 microns in diameter or smaller |
| $PM_{2.5}$ | Particulate matter of 2.5 microns in diameter or smaller |
| PPA | Power purchase agreement |
| PPI | Producer Price Index |
| PRB | Powder River Basin |
| PRECorp | Powder River Energy Corporation |
| PSD | Prevention of Signification Deterioration |
| REG | Recovered Energy Generation |
| RICE | Reciprocating internal combustion engine |
| RFP | Request for Proposal |
| RMR | Rocky Mountain Region |
| ROD | Record of Decision |
| RUS | Rural Utilities Service of U.S. Department of Agriculture |
| SCCT | Simple-cycle combustion turbine |
| SCR | Selective catalytic reduction |
| SEDS | State Energy Data Price, Consumption, and Expenditures Data |
| $SF_6$ | Sulfur hexafluoride |
| SHPO | State Historic Preservation Officer |
| SICS | Standard Industrial Classification System |
| $SO_2$ | Sulfur dioxide |

| **Term or Acronym** | **Definition** |
|---|---|
| SPCC | Spill Prevention, Control, and Countermeasure |
| SPP | Southwest Power Pool |
| SR | Sensitive noise receptor |
| SWPPP | Stormwater Pollution Prevention Plan |
| tpy | Tons per year |
| ULSD | Ultra-low sulfur diesel |
| UMZ | Upper Missouri Zone |
| URGE | Uniform Rating of Generating Equipment |
| USACE | U.S. Army Corps of Engineers |
| USDA | U.S. Department of Agriculture |
| USGS | U.S. Geological Survey |
| USFWS | U.S. Fish and Wildlife Service |
| V/m | Volts per meter |
| VOC | Volatile organic compound |
| W&P | Woods & Poole Economics, Inc. |
| WAUE | Western Area Power Administration Upper Great Plains Region East |
| Western | Western Area Power Administration |

# 1.0 INTRODUCTION

Basin Electric Power Cooperative (Basin Electric) submits this application for a Certificate of Site Compatibility (Certificate) for the Pioneer Generation Station (PGS) Phase III Project (Project) to the North Dakota Public Service Commission (NDPSC). On March 27, 2013, a Certificate of Site Compatibility (PU-12-509) was issued for PGS Phase II Project.

Basin Electric is a regional wholesale electric generation and transmission cooperative owned and controlled by the 134 member cooperatives it serves. It was created in May 1961 as a result of regional efforts by electric distribution cooperatives. Basin Electric serves approximately 2.8 million customers in 540,000 square miles covering portions of nine states: Colorado, Iowa, Minnesota, Montana, Nebraska, New Mexico, North Dakota, South Dakota, and Wyoming.

The Basin Electric service area in northwestern North Dakota is experiencing a rapid increase in development as a result of the activities associated with oil and gas extraction from the Bakken shale formation, currently concentrated in McKenzie, Mountrail, and Williams Counties. The development that has already occurred and additional development planned for the future require numerous infrastructure upgrades throughout the region, including an increase in electrical generation capacity and reliability. Through load forecast studies, it has been determined that up to 12 reciprocating internal combustion engines (RICE or gas engines) are needed to serve the needs of northwestern North Dakota by increasing the power generation capacity, increasing voltage support for the electricity transmission system, and enhancing the reliability of the electrical system in the region.

PGS currently consists of three General Electric (GE) LM6000PC natural gas-fired simple-cycle combustion turbines (SCCTs)—Units 1, 2, and 3—each with a nominal generation capacity of 45 megawatts (MW). PGS Unit 1 started commercial operation in September 2013, Unit 2 started commercial operation in February 2014, and Unit 3 started commercial operation in March 2014. The existing PGS is located approximately 15 miles northwest of the City of Williston in Hebron Township in the southeast quarter of Section 20, Township 155 North, Range 103 West; Williams County; North Dakota.

Basin Electric proposes to construct, operate, and maintain up to 12 new RICE or gas engines at the existing PGS. The proposed Project would have the capability of generating up to 111 MW of electricity and would be designed to produce electricity ranging from 3 to 111 MW. The new gas engines would themselves occupy approximately 8.2 acres within the energy conversion facility area, which would include all of the existing 120-acre PGS property. The new RICEs would be installed adjacent to the three existing 45-MW SCCTs located onsite. An approximately 3.7-acre electrical switchyard would also be constructed onsite. The Project is expected to start construction in May 2015 after all the necessary permits have been acquired, with an anticipated commercial operation date of June 2016.

In accordance with the North Dakota Energy Conversion and Transmission Facility Siting Act, Basin Electric has considered exclusion areas, avoidance areas, the selection criteria, and the policy criteria in the design of the PGS. In addition, sufficient generation design and technical information allowed for a thorough evaluation of the reasonableness of the site studied. Basin Electric located and designed the proposed Project to minimize environmental impacts by utilizing an existing generating station site with compatible existing infrastructure (gas supply, water supply, electricity system connections).

Table 1-1 outlines the information required to fulfill the requirements to obtain a Certificate from the NDPSC using the NDPSC's Guidelines and identifying where these requirements are addressed in this application.

**Table 1-1: Certificate of Site Compatibility Completion Checklist**

| State Authority | Description | Section |
|---|---|---|
| **Chapter 49-22** | **NDPSC Guidelines: Energy Conversion and Transmission Facility Siting** | |
| **Section A** | **Description** | **1.0, 3.0** |
| 1. | Type: Describe the type of facility addressed in this application. The description shall include the purpose of the facility and the technology to be employed | 1.1 |
| 2. | Product: Describe the type, source, and final destination of the product to be transmitted by the proposed facility | 1.1.2 |
| 3. | Size and Design | 1.1.1 |
| 4. | Location of any new facility | 1.1.3 |
| 4a. | Provide a description of the size and design of the pipeline facility including, but not limited to, the following: | N/A |
| 5. | Time Schedule: Provide the anticipated time schedule for the accomplishment of the following events: | 1.2 |
| 5a. | Certificate of Site Compatibility | 1.2 |
| 5b. | Site Application | 1.2 |
| 5c. | Site Permit | 1.2 |
| 5d. | Construction start date | 1.2 |
| 5e. | Construction complete | 1.2 |
| 5f. | In-service date | 1.2 |

| State Authority | Description | Section |
|---|---|---|
| **Section B** | **Studies** | |
| | Provide a copy of any evaluative studies or assessments of the environmental impact of the proposed facility submitted to any federal, regional, state or local agency | Appendices |
| **Section C** | **Need for Facility** | **1.3** |
| 1. | An analysis of the need for the proposed facility based on present and projected demand for the product to be transmitted by the facility, including the most recent system studies supporting the analysis of the need. | 1.3 |
| 2. | A description of any feasible alternative methods of serving the need. | 1.3.8 |
| 3. | A statement justifying any deviations from the most recent Ten-Year Plan which the proposed facility may present. | 1.3.9 |
| **Section D** | **Location** | |
| 1. | Identify and map the criteria that led to the proposed site location within the study area. | Figures |
| 2. | Discuss the relative value of each criteria and how the proposed corridor location was selected giving consideration to all criteria. | 2.0 |
| 3. | The criteria to be evaluated shall include at a minimum all of the following which are within the study area: | |
| 3a. | Exclusion areas | 2.1, Table 2-1 |
| 3b. | Avoidance areas | 2.2, Table 2-2 |
| 3c. | Selection criteria | 2.3, Table 2-3 |
| 3d. | Policy criteria | 2.4, Table 2-4 |
| 3e. | Design and construction limitations | 2.5 |
| 3f. | Economic considerations | 2.6 |
| 5. | Discuss the general mitigative measures that would be taken to minimize adverse impacts | 4.19 |
| 6. | List the qualifications of the people in the various disciplines that contributed to the corridor location study | 9.0 |
| 7. | Maps | Figures |

| State Authority | Description | Section |
|---|---|---|
| 7a. | Map the criteria within the site area. Several different criteria may be shown on each map, depending on the map scale and the density and nature of the criteria. Minimum map scale shall be ½ inch = 1 mile. All maps shall be at the same scale unless otherwise specified. | |
| 7b. | Furnish one set of Mylar maps, separate from the application, of the same scale as the criteria maps and showing the same basic features as the criteria maps, including the study area, but not the proposed facility location. | |
| **Chapter 49-22-09** | **Factors to be considered in evaluating applications and designation of sites, corridors, and routes.** | **7.0** |
| 1. | Available research and investigations relating to the effects of the location, construction, and operation of the proposed facility on public health and welfare, natural resources, and the environment. | 4.0, 7.1, & Appendices |
| 2. | The effects of new energy conversion and transmission technologies and systems designed to minimize adverse environmental effects. | 7.2 |
| 3. | The potential for beneficial uses of waste energy from a proposed energy conversion facility | 7.3 |
| 4. | Adverse direct and indirect environmental effects which cannot be avoided should the proposed site or route be designated. | 7.4 |
| 5. | Alternatives to the proposed site, corridor, or route which are developed during the hearing process and which minimize adverse effects. | N/A |
| 6. | Irreversible and irretrievable commitments of natural resources should the proposed site. | 7.5 |
| 7. | The direct and indirect economic impacts of the proposed facility | 7.6 |
| 8. | Existing plans of the state, local government, and private entities for other developments at or in the vicinity of the proposed site | 7.7 |
| 9. | The effect of the proposed site on existing scenic areas, historic sites and structures, and paleontological or archaeological sites | 7.8 |
| 10. | The effect of the proposed site on areas which are unique because of biological wealth or because they are habitats for rare and endangered species | 7.9, 7.10 |
| 11. | Problems raised by federal agencies, other state agencies, and local entities | 7.11 |

Table 1-2 below outlines the information required in the NDPSC Guidelines dated November 1979 for a Site Compatibility Permit.

**Table 1-2: Site Permit Completion Checklist**

| State Authority | Description | Section |
|---|---|---|

| State Authority | Description | Section |
|---|---|---|
| **Chapter 49-22-08** | **NDPSC Guidelines: Energy Conversion and Transmission Facility Siting** | |
| **Section A** | **Description** | **1.0, 3.0** |
| 1. | Type: Describe the type of transmission facility proposed. | 1.1.1 |
| 2. | Product: Describe the product or products to be transmitted. | 1.1.2 |
| 3. | Size and Design: Provide a general description of the proposed size and design, and any alternate size or design, which was considered. Provide one (1) copy of the design data report, separate from the application, for the proposed facility and any associated facilities. | 1.1.1 |
| 4. | Time Schedule: Provide the anticipated time schedule for the accomplishment of major events including, at a minimum, the following: | 1.2 |
| 4a. | Site Permit | 1.2 |
| 4b. | Construction start date | 1.2 |
| 4c. | Construction complete | 1.2 |
| 4d. | Test operations | 1.2 |
| 4e. | In-service date | 1.2 |
| **Section B** | **Studies** | |
| | Provide a copy of any evaluative studies or assessments of the environmental impact of the proposed facility submitted to any federal, regional, state, or local agency. | Appendices |
| **Section C** | **Need for Facility** | |
| 1. | An analysis of the need for the proposed facility based on present and projected demand for the product to be transmitted by the facility, including the most recent system studies supporting the analysis of the need. | 1.3 |
| 2. | A description of any feasible alternative methods of serving the need. | 1.3.8 |
| 3. | A statement justifying any deviations from the most recent Ten-Year Plan which the proposed facility may present. | 1.3.9 |
| **Section D** | **Location** | |
| 1. | Discuss the utility's policies and commitments to limit the environmental impact of its facilities, including copies of board resolutions and management directives. | 4.0 |

| State Authority | Description | Section |
|---|---|---|
| 2. | Discuss the factors listed in Section 49-22-09, NDCC to aid the NDPSC's evaluation of the proposed route. | 7.0 |
| 3. | Discuss in detail the relative value of each criteria and how the location, construction, and operation of the facility would affect each criteria. | 2.0 |
| 4. | The criteria to be evaluated shall include at a minimum all of the following which are within the designated site: | |
| 4a. | Exclusion areas | 2.1, Table 2-1 |
| 4b. | Avoidance areas | 2.2, Table 2-2 |
| 4c. | Selection criteria | 2.3, Table 2-3 |
| 4d. | Policy criteria | 2.4, Table 2-4 |
| 4e. | Design and construction limitations | 2.5 |
| 4f. | Economic considerations | 2.6 |
| 6. | Discuss the mitigative measures that would be taken to minimize adverse impacts which result from the location, construction, and operation of the proposed facility. | 4.19 |
| 7. | List the qualifications of the people in the various disciplines that contributed to the facility route location study. | 9.0 |
| 8. | Maps | Figures |
| 8a. | Map the criteria within the site. Several different criteria may be shown on each map, depending on the map scale and the density and nature of the criteria. Minimum map scale shall be ½ inch = 1 mile. All maps shall be at the same scale unless otherwise specified. | |
| 8b. | Furnish one (1) set of Mylar maps, separate from the application, of the same scale as the criteria maps and showing the same basic features as the criteria maps, including the designated corridor, but not the proposed route or location of any new associated facilities. | |

| State Authority | Description | Section |
|---|---|---|
| 8c. | Furnish one (1) set of uncontrolled 9x9 inch stereo-pair aerial photographs, separate from the application, with acceptable resolution showing the designated corridor, proposed route and location of any new associated faculties, and Section, Township and Range numbers, at a scale of 1 inch = 2,000 ft, together with a flight map at a scale of ½ inch = 1 mile showing each flight line and the beginning and ending photo number of each flight line. Photo mosaic strip maps would also be acceptable. If the applicant can demonstrate that because of the limited size and scope of the project, aerial photographs would not be practical, this requirement may be waived. | |
| **Chapter 49-22-09** | **Factors to be considered in evaluating applications and designation of sites, corridors, and routes.** | **7.0** |
| 1. | Available research and investigations relating to the effects of the location, construction, and operation of the proposed facility on public health and welfare, natural resources, and the environment. | 4.0, 7.1, & Appendices |
| 2. | The effects of new energy conversion and transmission technologies and systems designed to minimize adverse environmental effects. | 7.2 |
| 3. | The potential for beneficial uses of waste energy from a proposed energy conversion facility | 7.3 |
| 4. | Adverse direct and indirect environmental effects which cannot be avoided should the proposed site. | 7.4 |
| 5. | Alternatives to the proposed site which are developed during the hearing process and which minimize adverse effects. | N/A |
| 6. | Irreversible and irretrievable commitments of natural resources should the proposed site be designated. | 7.5 |
| 7. | The direct and indirect economic impacts of the proposed facility | 7.6 |
| 8. | Existing plans of the state, local government, and private entities for other developments at or in the vicinity of the proposed site. | 7.7 |
| 9. | The effect of the proposed site or route on existing scenic areas, historic sites and structures, and paleontological or archaeological sites. | 7.8 |
| 10. | The effect of the proposed site or route on areas which are unique because of biological wealth or because they are habitats for rare and endangered species | 7.9, 7.10 |
| 11. | Problems raised by federal agencies, other state agencies, and local entities | 7.11 |

## 1.1 Project Description

The following sections provide a description of the proposed Project, including the equipment to be installed and operated and the location of the Project site.

### 1.1.1 Type, Size, and Design

The proposed Project would include 12 nominal 9.22-MW RICE (gas engines) with a total nominal gross electrical output of 111 MW. The engines would be turbo-charged, four-stroke, lean-burn (4SLB) engines. The proposed Project is designed to meet variable electrical demands from as low as 3 MW to as high as 111 MW, if all engines are in service.

Facilities to be constructed on Basin Electric property as part of this Project are:

- 12 9.22-MW RICE units and auxiliary equipment, occupying approximately 8.2 acres
- 115-kV electricity switchyard, approximately 3.4 acres
- Stormwater retention pond, approximately 0.9 acre
- Approximately 408 feet of 3 inch diameter water line
- Approximately 711 feet of 6 inch diameter natural gas line
- Approximately 2,500 feet of additional 115-kV electricity transmission line
- Temporary approximately 1.2-acre material laydown yard
- Temporary approximately 5.9-acre material laydown yard and construction parking area.

The gas engines would combust natural gas and, in case of natural gas curtailment, the engines could combust liquefied propane gas (LPG) as a back-up fuel. The Project incorporates the design to accommodate LPG tanks and supporting interconnections. This infrastructure would not be installed initially. Basin Electric currently operates within the Integrated System (IS) with Western Area Power Administration (Western) and Heartland Power. In fall 2015, Basin Electric will be migrating into the Southwest Power Pool (SPP). If and when the SPP operating criteria require that PGS have a short term secondary fuel supply, the LPG system will be installed. Depending on the criteria, a 20,000-gallon tank would be required for a 4-hour fuel supply, and 120,000 gallon tank would be required for a 24-hr fuel supply. For the purposes of the PSD air permit, the LPG option was incorporated into the application. In the event that LPG is required, the PSD air permit would allow the use of LPG.

For the 12 engines, there would be a total of 2 stacks; 6 gas engines would be vented to each stack. To control emissions of nitrogen oxides ($NO_x$), each engine would be equipped with selective catalytic reduction (SCR) systems and lean-burn combustion systems. To minimize the emissions of sulfur dioxide

($SO_2$), sulfuric acid ($H_2SO_4$) mist, and particulate matter (PM)/particulate matter of 10 microns in diameter or smaller ($PM_{10}$)/particulate matter of 2.5 microns in diameter or smaller ($PM_{2.5}$), the engines would be controlled through the use of low-sulfur/low-ash fuels and good combustion practices. Emissions of carbon monoxide (CO) and volatile organic compounds (VOC) would be controlled through the use of good combustion practices as well as an oxidation catalyst (also referred to as a CO catalyst). Greenhouse gas (GHG) emissions would be minimized with the use of efficient lean-burn engines and the use of natural gas fuel.

Auxiliary equipment for the 12 gas engines would include a dew point heater, an emergency fire pump, an emergency generator, an LPG vaporizer, fuel storage tanks, and circuit breakers.

- *Dew Point Heater* – One 2.5-million British thermal units per hour (MMBtu/hr) dew point heater would be installed to maintain the temperature of the natural gas that would be combusted in the engines, in compliance with the manufacturer's recommendations for fuel quality parameters.
- *Emergency Fire Pump* – An emergency fire pump would be installed for use in case of fire. The emergency fire pump may be tested each week to confirm that it is working properly and for maintenance. The fire pump would have a maximum output of 197 horsepower (hp) and would be operated solely on ultra-low sulfur diesel (ULSD).
- *Emergency Generator* – An 800-kilowatt (kW) emergency generator would be built to support the plant safety and control features in case of a power interruption. The emergency generator would be operated solely on ULSD fuel.
- *LPG Vaporizer* – If required for back-up fuel supply, a 0.75 MMBtu/hr LPG vaporizer would be used to convert liquid propane into gaseous propane. A vaporizer eliminates re-condensation of vapor in the supply lines and provides a constant supply of propane vapor even at very low temperatures. The LPG vaporizer is similar to a boiler that does not build pressure. Liquid propane enters the vaporizer and exits as a gas.
- *Fuel Storage Tanks* – The Project would include two small diesel storage tanks: one 200-gallon tank to provide fuel to the emergency fire pump and one 550-gallon tank to provide fuel to the emergency generator. If required for back-up fuel supply, two LPG tanks (maximum 90,000 gallons total) would be added to the site to store the back-up fuel for the engines.
- *Circuit Breakers* – Eleven 115-kilovolt (kV) circuit breakers would be required for the switchyard located at the site. Each of these circuit breakers would contain sulfur hexafluoride ($SF_6$). $SF_6$ is regulated as a GHG with a global warming potential of 22,800. The circuit breakers would be sealed.

The proposed Project would require six additional full-time employees to operate the PGS. A new power generation building, warehouse, fire water pump house, and urea and lube oil pump enclosure would be constructed on the PGS property for the Project. Additional tanks to be installed onsite include a fire protection water tank, urea storage tank, new engine oil tank, used engine oil tank, maintenance engine oil tank, and an underground oily waste tank.

The existing PGS consists of three GE LM6000 natural gas-fired SCCTs. Each of the SCCTs would have a nominal maximum rating of 45 MW. The facility is designed to be operated locally at the site or remotely from Basin Electric's headquarters located in Bismarck, North Dakota.

Natural gas is supplied to PGS by a WBI Energy Transmission, Inc., existing 1,800-foot long, 8-inch-diameter pipeline that originates at ONEOK's Stateline I Gas Processing Plant gas interconnection to the Northern Border Pipeline. ONEOK's Stateline I Gas Process Plant is located adjacent to PGS, east of County Road 5 (151st Avenue NW). The existing pipeline is large enough to supply the 12 proposed gas engines in addition to the 3 existing turbines. A 6-inch-diameter pipeline would be required to deliver natural gas from the PGS metering station to the Project gas skid. Approximately 711 feet of additional pipeline would be required.

The existing electrical interconnection for the PGS is a 0.5-mile-long, 115-kV transmission line to Mountrail-Williams Electric Cooperative's (MWEC) Stateline I Substation located adjacent to ONEOK's Stateline I Gas Processing Plant. As part of the Project, a new electrical switchyard would be constructed adjacent to the proposed gas engines on the site to deliver power from the new engines to the electrical grid. The existing Sheridan Electric Cooperative's 115-kV line that interconnects to the Stateline Substation would be re-directed across Basin Electric property at the PGS to the new electrical switchyard. The new configuration of the 115-kV line would cut this existing line and extend one end of the line into the new switchyard. A second line would extend from the new switchyard to connect to the other end of the Sheridan Electric Cooperative line.

No additional water supply development would be necessary for the proposed gas engines. The gas engines would not consume water during operation. The only additional water consumption for the proposed Project would be potable water for the six additional employees and a minimal amount of potable water treated with a water softener for cooling water makeup. Potable water is supplied to the PGS from the local rural water distribution system and would be adequate to meet the needs of the proposed facilities. However, an additional approximately 408feet of 3-inch water line would be necessary to extend the existing site infrastructure to the Project.

All stormwater runoff is diverted to an onsite pond. A new stormwater runoff pond, approximately 0.9-acre, would be constructed for runoff from the Project. It would be designed to hold runoff from a 25-year, 24–hour rainfall event and be large enough to handle runoff from the PGS Phase III facilities. Discharge from the new retention pond would be to the west side of the facility, into Muddy Creek.

All waste generated from construction of the Project would be collected and placed in appropriate waste containers, to be hauled offsite and properly disposed of by a licensed contractor.

### 1.1.2 Product

Energy would be generated and distributed to the electrical grid system serving the rapidly increasing electrical load requirements in northwestern North Dakota. The PGS would improve the reliability of service into the area.

### 1.1.3 Location

The proposed site is located approximately 15 miles northwest of the City of Williston in the southeast quarter of Section 20, Township 155 North, Range 103 West; Hebron Township; Williams County; North Dakota.

### 1.1.4 Geographical Service Area

The general area to be served by the Project is Basin Electric's service territory, specifically the area in northwestern North Dakota within the Williston Basin.

## 1.2 Project Schedule

The anticipated schedule for the Project is below:

- Submit Site Application: November 2014
- Obtain Site Compatibility Permit: April 2015
- Start construction: May 15, 2015
- Complete construction April 1, 2016
- Test and commissioning: April 1 through June 1, 2016
- Commence commercial operation: June 1, 2016

Note: Should all approvals be received ahead of schedule, the schedule would be advanced accordingly.

### 1.2.1 Future Plans

The existing PGS electricity, gas and water infrastructure is capable of supporting additional generation. At the time of this application, Basin Electric does not have plans to increase the generation capacity at PGS beyond the proposed Project.

## 1.3 Determination of the Need for Facility

Basin Electric has identified the need for additional electric generation and voltage support in northwestern North Dakota as a result of increased demand and to meet reliability and system stability requirements for the region. This need is determined through the load forecast process developed as a partnership effort between the distribution cooperatives, generation and transmission (G&T) cooperatives, and Basin Electric for the entire service area. Both distribution cooperatives and G&T cooperatives are considered Basin Electric member cooperatives. Subsequent to the completion of the historical database development, regression analysis software is used to identify economic, demographic, and meteorological factors that have affected the member's power requirements. These factors are called explanatory variables as they explain why the electric requirements change. Explanatory variables are first used to develop the econometric models based on historic relationships and are then used to develop the actual forecasts, incorporating historical and forecasted values. The following sections describe the development of the overall load forecasting process and the models and variables used to forecast future system needs.

### 1.3.1 Load Forecast Process

Basin Electric's primary mission is to provide electrical power to its member-owners. In order to accomplish this objective, the cooperatives must understand how consumers presently use their electricity and must forecast consumers' future electrical requirements. The projection of future requirements serves as one of the main planning tools in determining the cooperative's future operating strategy. Adequate resources and transmission facilities must be maintained and, where necessary, developed to deliver the required power to the members.

Two major studies are jointly prepared by the members and Basin Electric to address where the members are presently using their power (end use survey) and how much they would require in the future (load forecast). These studies are prepared in accordance with U.S. Department of Agriculture (USDA), Rural Utilities Service (RUS) general guidelines. Both the end use survey and the load forecast represent a joint effort by the distribution cooperatives, the G&T cooperatives, and Basin Electric. In order to involve all segments of the cooperative's structure, a Load Forecast Technical Committee was established. This committee consists of representatives from the three-tier cooperative structure.

The Load Forecast Technical Committee approved the timetable and procedures used in preparing the 2014 Load Forecast. RUS attendance and participation at the committee meeting provided a forum for the cooperatives and RUS to exchange ideas and discuss problems. This committee establishes the timetable and develops the general procedures to be used. RUS requires the submittal of a board-approved load forecast work plan. The 2014 Load Forecast Work Plan was approved by the Basin Electric Board of Directors and by RUS.

End use surveys and load forecasts are prepared for all Basin Electric members, except Tri-State, which conducts its own studies. The other participating members represent cooperatives located in North Dakota, South Dakota, Minnesota, Montana, Iowa, and Wyoming. Individual studies are prepared for each of the participating distribution cooperatives. The distribution cooperative studies are combined to obtain G&T studies, and the G&T studies are combined to develop a Basin Electric report.

The purpose of the load forecast is to provide the distribution cooperatives, the G&T cooperatives, and Basin Electric with a forecast of their power supply obligations to their consumer-owners. The load forecast, which is prepared on a distribution cooperative basis, is conducted in accordance with RUS criteria. The criteria define a load forecast as a thorough study of a cooperative’s electric loads and the factors that affect those loads, in order to determine as accurately and as practical the cooperative’s future requirements for energy and capacity. The individual member’s load forecast analyzes the cooperative’s service area for historical and projected developments that have and would influence future load growth.

The 2014 Load Forecast is a weather normalized forecast. While the load forecasting process does an adequate job of predicting energy and average demand usage over a long forecast period, short time frame events can affect actual peak demands and cause deviations from the predicted peak demands. These short time frame events include significant heat spells, extended cold snaps, and moisture during critical farming periods.

Heat spells can cause building envelopes to retain heat causing air conditioning to be used for longer periods than expected in the normal weather periods. Less efficient methods of cooling buildings may be used.

Cold snaps generally occur with significant wind that tends to draw heat out of building envelopes causing electric heating installations to use more peak demand than expected.

Rain and high humidity events during the harvest season can cause crops to retain moisture. This can lead to mold and disease issues when crops are placed in a bin causing the valuable commodities to be worthless. Recent increases in on-farm grain storage have necessitated farmers be able to drop the moisture levels in their grain prior to placing the grain in a bin. This has led to increases in on-farm air handling and air drying facilities. This load usually occurs during the “shoulder” months of September, October, and November, when energy demand is typically low. Recently, moist springs and cool damp early summers have pushed crop plantings later into the spring and early summer. This development has pushed the harvest and the subsequent air drying later into October, November, and December, such that it overlaps with the start of the heating season. This shift has caused December peaks to increase in recent years.

The use of average weather is acceptable for planning budgets and sales forecasts. However, the weather factors detailed above, along with localized issues of access to competing fuels, has increased the demand for electricity past normally expected levels. Prior research using primarily residential systems indicated that the weather conditions could increase the projected peak demands approximately 10 percent more than what is prepared within our load forecast report. This issue poses a challenge for distribution and transmission system planning.

#### 1.3.1.1 Econometric Models

Load forecasts are developed through the use of econometric models. The basis for econometric modeling is to identify variables in the economy that have historically affected electrical consumption. This is accomplished by using regression analysis software that establishes a mathematical relationship between the economic variables and power usage. Regression analysis is a statistical technique used to identify a relationship between an observed event and other measured events that can be shown to be related. These are known as the dependent and the independent variables, respectively. The mathematical relationship, in the form of algebraic equations, represents the econometric model.

Independent variables used in the analysis must be applicable to the members’ service territory and be of importance to the local economy. This is the first step to verify the model would accurately explain historical trends and provides confidence that the same factors that influenced previous trends would accurately reflect future expectations.

The next step to determine if the model is acceptable is the combination of the statistical results of the model. The model statistics include the R-squared, adjusted R-squared, and basic statistical information. The R-squared indicates the amount of variation in the dependent variable that can be explained by the independent variables. To show the impact of changes in the number of independent variables used in a model, an adjusted R-squared is used; therefore, the explained variation can be compared with the same dependent variable and different numbers of independent variables.

The statistical significance of the explanatory variables used in the model is measured by a t-statistic. A t-statistic (ignoring negative signs) of at least 2.0 would be required for a 95 percent level of confidence and at least 1.5 for a 90 percent level of confidence, depending upon the number of observations and variables used in the model.

The Durbin-Watson test examines the equation residuals that are the differences between the fitted and actual historical values. In a good model the residuals are randomly distributed and are of approximately constant magnitude. This indicates the model has explained all of the patterns in the data. In general, a Durbin-Watson near 2.00 indicates the absence of autocorrelation.

When residuals are not randomly distributed, a Cochrane-Orcutt transformation (AR term) can be computed to develop an equation that does have randomly distributed residuals. After the variables are transformed by adjusting the equation according to the value of the AR term, a new equation is developed.

The variables selected, model statistics, and forecasted results all are considered together to determine the validity of the forecast.

Econometric models are used for the majority of the member systems to forecast residential energy sales. In most instances, two residential econometric models are developed for each cooperative. The first model relates the number of historical residential consumers to factors that have been shown to influence their numbers in the past. The second model is developed for the average annual usage per residential consumer. Multiplying the forecasts of these two models develops the total residential energy forecast.

The small commercial modeling and other smaller consumer sectors are developed using econometric or trending models. In some cases they may also be judgmental forecasts or a combination of the three.

The distribution member forecasts are forecasts of annual energy requirements by category. To translate the annual energy requirements into monthly energy demand, two econometric models are developed to distribute this correctly. The first model uses historical monthly energy purchases along with actual weather patterns to determine the monthly per unit purchase pattern. This purchase pattern is applied to the annual energy forecast to develop a monthly energy forecast. The second model is used to develop a monthly demand forecast in which an econometric model is fitted through the historical load factors. The resultant load factor pattern is applied to the monthly energy forecast to determine the monthly demand forecast.

#### 1.3.1.2 Explanatory Variables

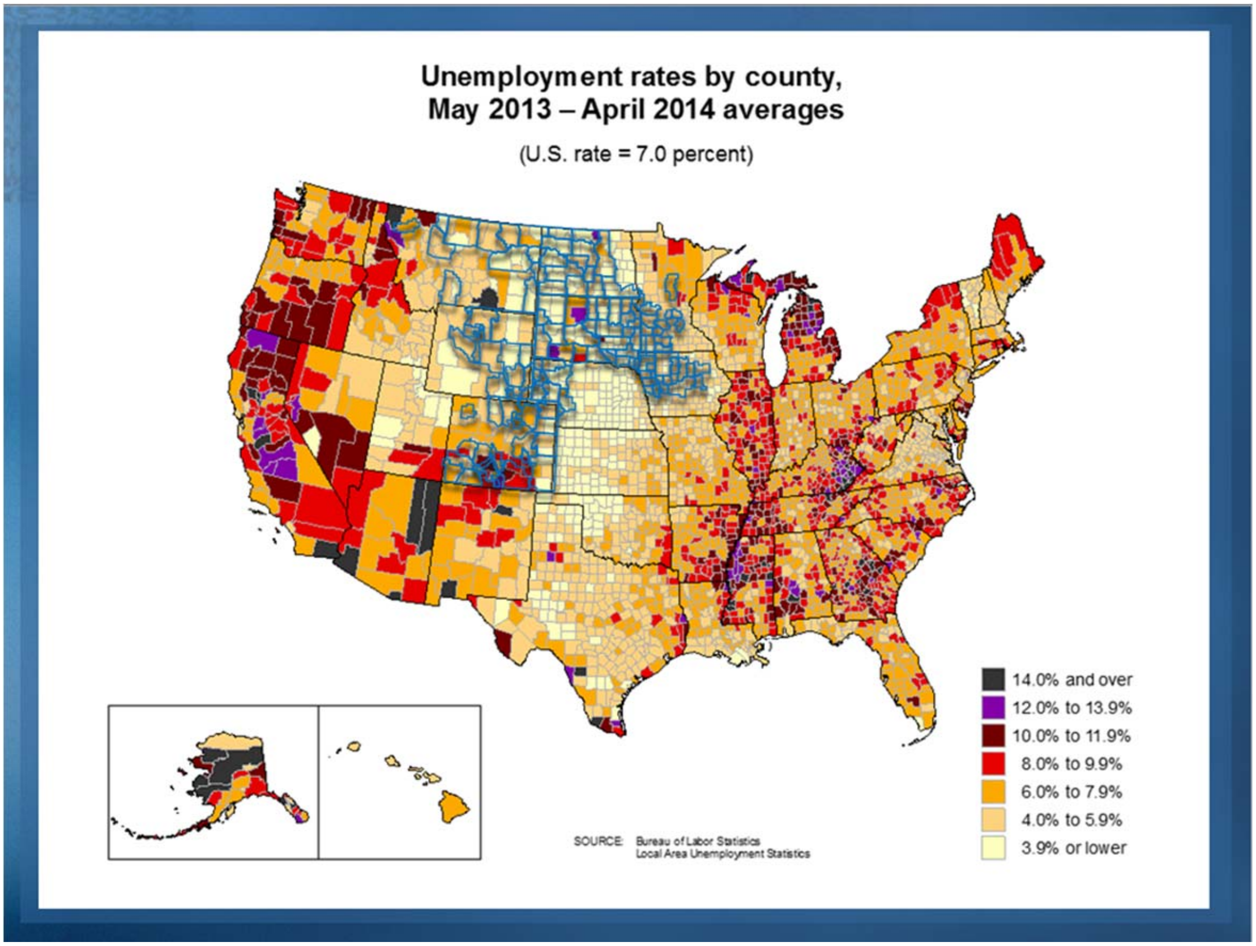
Explanatory variables are factors in the economy that have historically affected electrical consumption. They include economic, demographic, and meteorological factors. The major sources of the explanatory variables within each of these categories and how they can influence power usage are discussed in the following sections.

##### 1.3.1.2.1 Economic and Demographic Data

The economy of the upper Midwest has faired the recent nationwide economic downturn quite well, due to the relative strength of the agricultural economy and energy exploration. Employment in the Basin Electric territory, for the most part, has not seen the major swings that occurred in other areas of the country. Due to a diverse economy that is not centered in a singular industry, these strong historical employment trends are expected to continue into the future. Figure 1-1 indicates the average unemployment rates for 2013 with the Basin Electric cooperative service territory overlaid, and shows the relative strength of the economy in the upper Midwest.

Historical data for county and metropolitan statistical area (MSA) employment, population, earnings, and income is provided by the U.S. Department of Commerce Bureau of Economic Analysis (BEA) and the U.S. Census Bureau. The state and federal governments monitor the data closely as it serves as a measure of condition of the local economies.

**Figure 1-1: Unemployment Rates and Basin Electric Service Territory**




Since the BEA implemented the North American Industrial Classification System (NAICS) to replace its previous Standard Industrial Classification System (SICS), and has only 2001-2010 data available on the new database, the entire set of historical and forecast employment data used was from Woods & Poole Economics, Inc. (W&P). W&P is an econometric forecasting firm that provides projections for employment, earnings, income, and population on a county and MSA basis. W&P used BEA data through year 2010. The exception to this is the population data, in which W&P data was updated to include the 2010 data available from the U.S. Census Bureau. W&P is the source for the economic and demographic historical and forecasted county data. Demographic and economic variables used in the 2014 Load Forecast included:

- Population
- Households
- Total Employment

- Farm Earnings
- Transfer Payments
- Total Personal Income
- Farm Employment

The forecasts for these variables, which are available on a county basis, were obtained from W&P. IHS Energy (IHS) Global is used for county, metro, state, and national economic data.

##### 1.3.1.2.2 Agricultural Data

Historical agricultural production and price data was obtained from the USDA and forecasted data was obtained from the Food and Agricultural Policy Research Institute (FAPRI) 2013 U.S. baseline, as well as the USDA baseline agricultural projections. FAPRI specializes in agricultural research and forecasting.

FAPRI's primary responsibility is to analyze for the U.S. Congress the effects of proposed agricultural legislation. In addition to that primary responsibility, it provides forecasts to many other external organizations that are heavily influenced by agricultural activities. FAPRI is recognized for its expertise in agriculture analysis and forecasting.

The FAPRI baseline projection used in this analysis is a result of a three-step process. It begins with macroeconomic assumptions for the U.S., developed by Global Insight (formally DRI-WEFA). The assumptions are used to develop a FAPRI preliminary baseline, which is then distributed to a group of reviewers. The reviewers critique and comment on the validity of the assumptions and the baseline projection. After receiving comments, the baseline projection is revised and finalized.

The FAPRI baseline includes the assumptions that government laws or policies remain unchanged, that normal weather occurs, and that random events such as droughts, diseases, and floods do not occur. The FAPRI and the USDA historical and projected data are used for forecasting some of the residential service areas where farming and ranching have a big influence.

The majority of the members' consumers are engaged in farming/ranching and agriculture. In most of the states served by the members, farming/ranching and agriculture is first in new wealth creation. Since agriculture is the dominant industry in most of the areas the members serve, agricultural explanatory variables have been heavily incorporated into the econometric models. In the 2014 Load Forecast, agricultural explanatory variables included: national beef production and average prices, national corn production and average prices, national wheat production and average prices, national hog production and average prices, along with county-level production of selected agricultural variables.

#### 1.3.1.2.3 Electricity and Alternate Fuels

Another major consideration in the load forecast econometric modeling is the competition between electricity and alternate fuels. This competition occurs in space heating, water heating, cooking, clothes drying, and grain drying. The future prices of alternate fuels and how they compare with the distribution cooperative's electricity prices affect electric consumption.

Historical alternative fuel prices are obtained on a state level from the Department of Energy's (DOE's) State Energy Data 2011 Price, Consumption and Expenditures Data (SEDS). Basin Electric uses DOE projections of regional price forecasts to develop projections of alternative fuel prices.

IHS Cambridge Energy Research Associates (CERA) is used for natural gas and oil prices for the energy-related loads. Wood Mackenzie, IHS, and DOE data are also used in the energy-related sectors.

Projected electricity prices were obtained from the distribution cooperative's financial forecast. The econometric models address the competition between electricity and alternate fuels by including a ratio computed by dividing electricity costs by the predominant alternate fuel cost in each member's service territory. The ratio is a weighted average of alternate fuels used by the residential consumers for their primary heating system, as indicated by the cooperative's end use survey. In order to uniformly compare the energy alternatives, the alternate fuel and electricity prices are converted to real dollars on a per million British thermal unit (Btu) basis.

#### 1.3.1.2.4 Weather

Weather has a significant effect on the cooperative's energy requirements due to energy uses such as heating, grain drying, and air conditioning. In order to address these effects, the econometric models normally include either heating degree days, cooling degree days, or a combination of both.

Historical heating and cooling degree days weather data was obtained from the National Oceanic and Atmospheric Administration (NOAA). This information is received for first-order stations, as well as all cooperative stations within the geographic region. Forecasts for weather data are assumed to be the simple average of 1998-2012 values.

### 1.3.1.3 Inflation Indexes

For the 2014 Load Forecast, three inflation indexes are used to deflate historical data and project future inflation. These indexes or deflators use the base 2012 equals 100. The three indexes are:

- Producer Price Index (PPI) (all commodities): This index is used to deflate crude oil prices. Real 2012 dollar crude oil prices are used as a variable in the oil-related models and forecasts and also in residential models in oil producing areas. The forecast for the PPI is obtained from the Energy Information Administration's (EIA) 2013 Annual Energy Outlook (AEO).

- Gross Domestic Product - Implicit Price Deflator (GDP-IPD): This index is used to deflate all agricultural monetary data from FAPRI to real 2012 dollars. The forecast is obtained from the Congressional Budget Office.

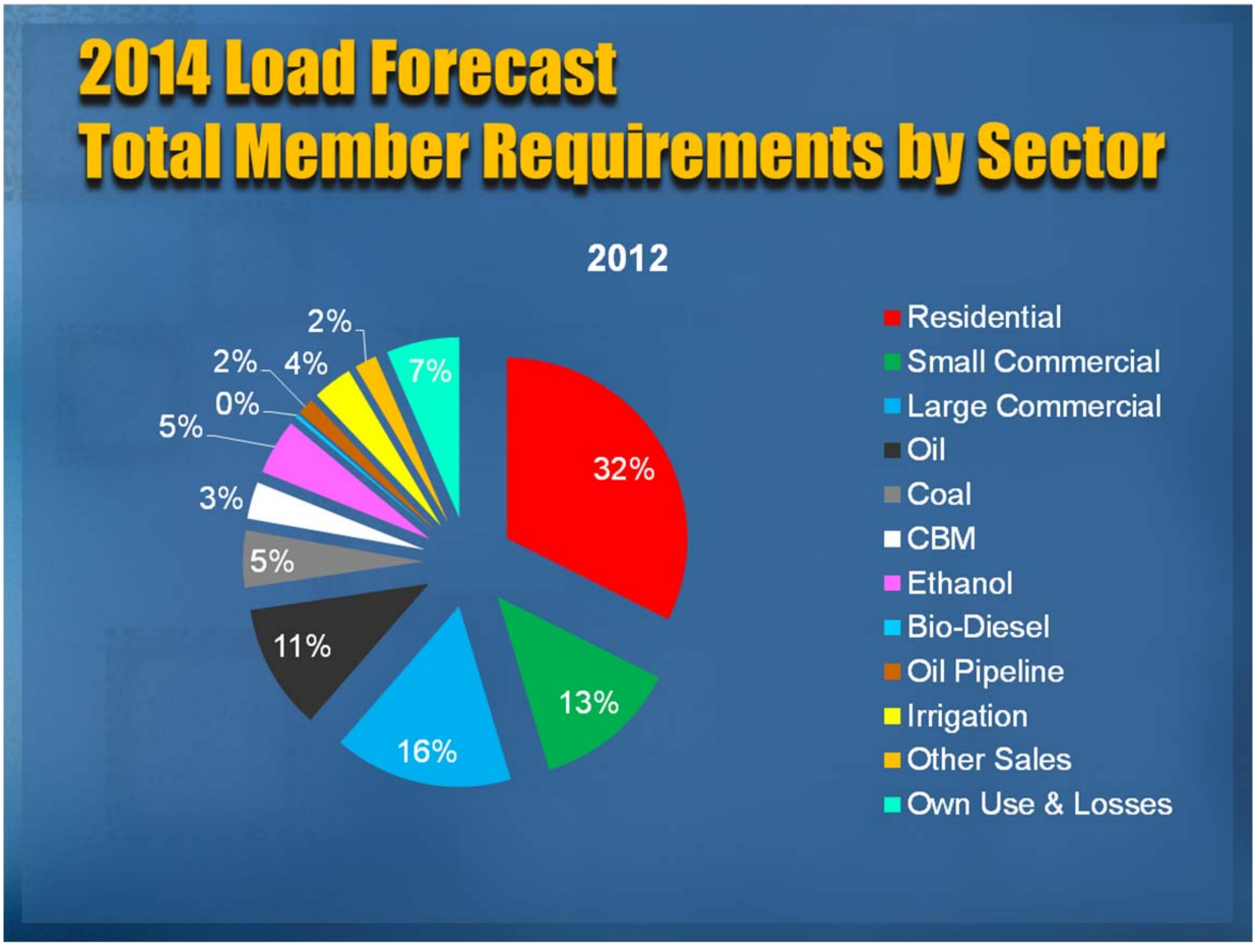
- Personal Consumptions Expenditures - Implicit Price Deflator (PCE-IPD): This index is also obtained from the Congressional Budget Office. This implicit price deflator is used to deflate all non-FAPRI monetary data other than that covered by GDP-IPD and PPI to real 2012 dollars. This index is used to deflate such data as electricity prices, alternative fuels, personal income, and earnings. Also, it is used to convert current prime interest rates to real prime interest rates.

In addition to the previously mentioned forecast variables, tremendous arrays of commercial projects are monitored for their impacts on Basin Electric's wholesale energy sales. These industries are related to oil, coal, coal bed methane (CBM), ethanol, and bio-diesel. Each of these categories is discussed in detail below.

### 1.3.2 Basin Electric Load Forecast Sectors

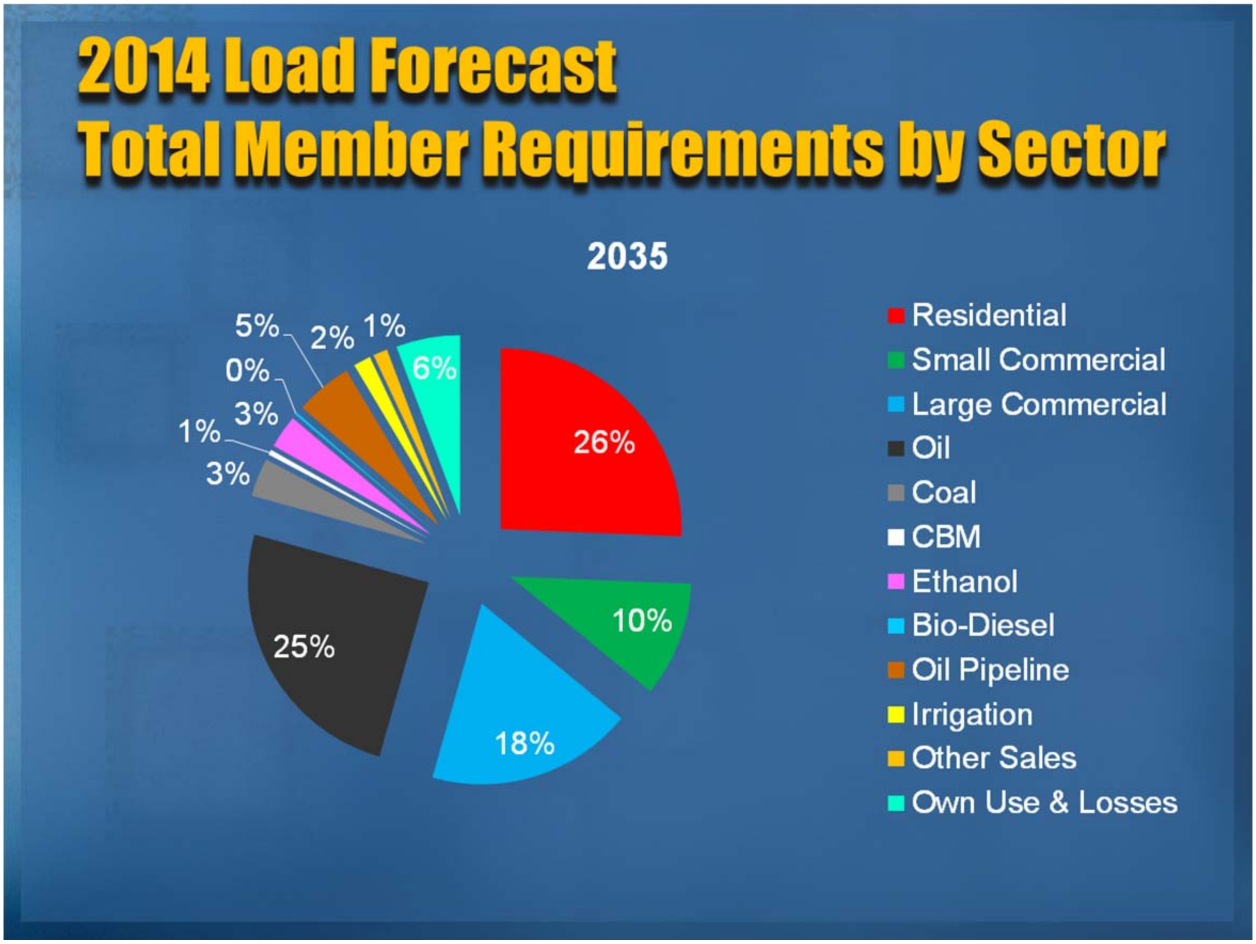
In 2012, Basin Electric's members sold 32 percent of their energy to the residential sector, 16 percent to the large commercial sector, and 13 percent to the small commercial sector (Figure 1-2). The other 39 percent of sales were spread among the remaining sectors.

**Figure 1-2: Basin Electric 2012 Load Requirements**




At the end of the forecast period, the growth in the oil-related sector is evident. Sales to this sector are forecasted to grow from 11 percent of sales in 2012 to 25 percent of sales in 2035 (Figure 1-3). Other growth is overshadowed by the growth in this sector. the following sections discuss each sector in detail.

**Figure 1-3: Basin Electric 2035 Load Forecast**




### 1.3.2.1 Residential Forecasts

The load forecast continues to concentrate on the residential classification since it represents a large portion of the energy sales for Basin Electric. The residential energy forecasts are prepared by (i) forecasting the number of residential consumers; (ii) forecasting the average annual energy consumption per residential consumer; and (iii) multiplying the two forecasts together to obtain a total residential sector energy forecast. All load forecasts are net of demand-side management.

The starting point in the forecasting process is to develop historical databases for each distribution cooperative. These databases contain information on the member's monthly energy sales by consumer classification. They also provide data on the cooperative's own use and losses, and data on monthly demand and energy wholesale power purchases. The databases are developed annually from the information the members report to RUS on Form 7 or its equivalent. The data is updated and modified to reflect reclassifications that occasionally occur between consumer categories at the distribution cooperative. These reclassifications may result from changes in the cooperative’s rate structure or the size criteria of different rate categories.

#### 1.3.2.2 Small Commercial Forecasts

The small commercial classification consists of commercial accounts that are generally 1,000 kilovolt-Ampere (kVA) or less. This section addresses the econometric models that forecast the small commercial consumers and energy use. The models developed took into consideration the historical factors that statistically, demographically, and economically influenced each members number of small commercial consumers and small commercial energy use.

The make-up of the small commercial accounts is generally larger farms, small retail and wholesale establishments, and other types of accounts that do not qualify for residential status. It has been observed that the small commercial sector closely mirrors the cooperative’s local and regional economy. Therefore, the small commercial sector is generally modeled using the same type of variables that are used in the residential modeling.

#### 1.3.2.3 Large Commercial Forecasts

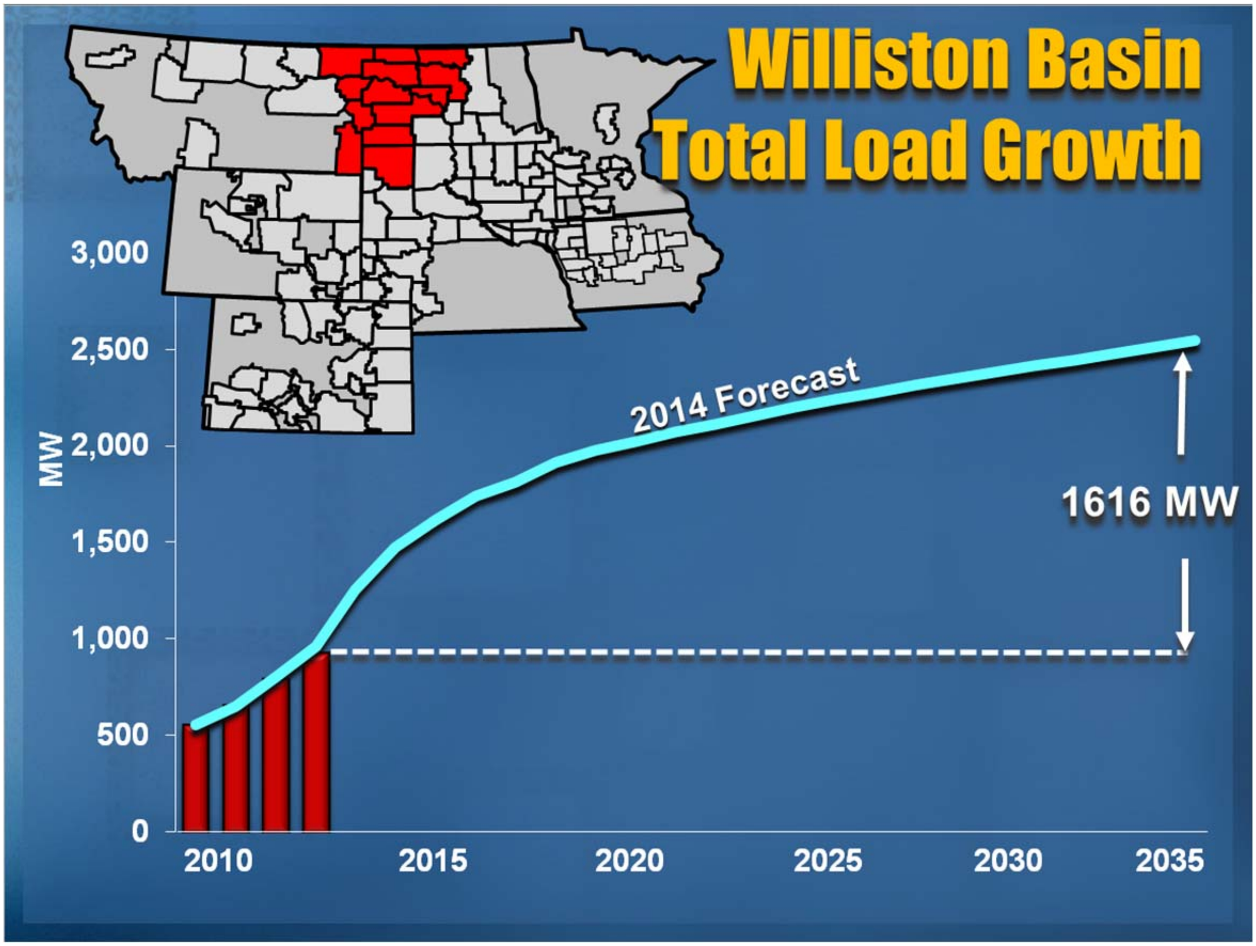
The large commercial classification consists of commercial accounts that are generally 1,000 kVA or larger. The types of businesses that are included in this classification are generally manufacturing, large retail, and processing facilities. These types of businesses do not necessarily mirror the local economy. The factors that drive these accounts usually have national impacts. Therefore, we use national macroeconomic variables to determine annual energy usage.

#### 1.3.2.4 Oil-Related Commercial Forecast

The service territory of Basin Electric’s members in western North Dakota, eastern Montana, and northwest South Dakota lies within a geological formation known as the Williston Basin. In addition to the Williston Basin, Basin Electric also provides wholesale electricity to the Powder River Basin (PRB) in northeastern Wyoming. Like the Williston Basin, PRB also produces a considerable amount of oil. Significant oil-related commercial load growth is not anticipated in the PRB; therefore, the rest of this section addresses the Williston Basin.

Figure 1-4 depicts the growth of the oil-related load within the Williston Basin. A tremendous amount of growth is expected in the next 22 years.

**Figure 1-4: Williston Basin Load Forecast**




The small and large commercial loads of those members that serve in the heavy oil production areas of the basin are heavily influenced by oil and gas exploration, production, and distribution activities. Loads can be direct or indirect. Direct loads, such as oil pumps, pipelines, compressors, and processing plants, contribute directly to the amount of commercial load. Other commercial loads, such as support services, are indirectly related to oil activity as they would not exist without the oil exploration, development, and extraction activities.

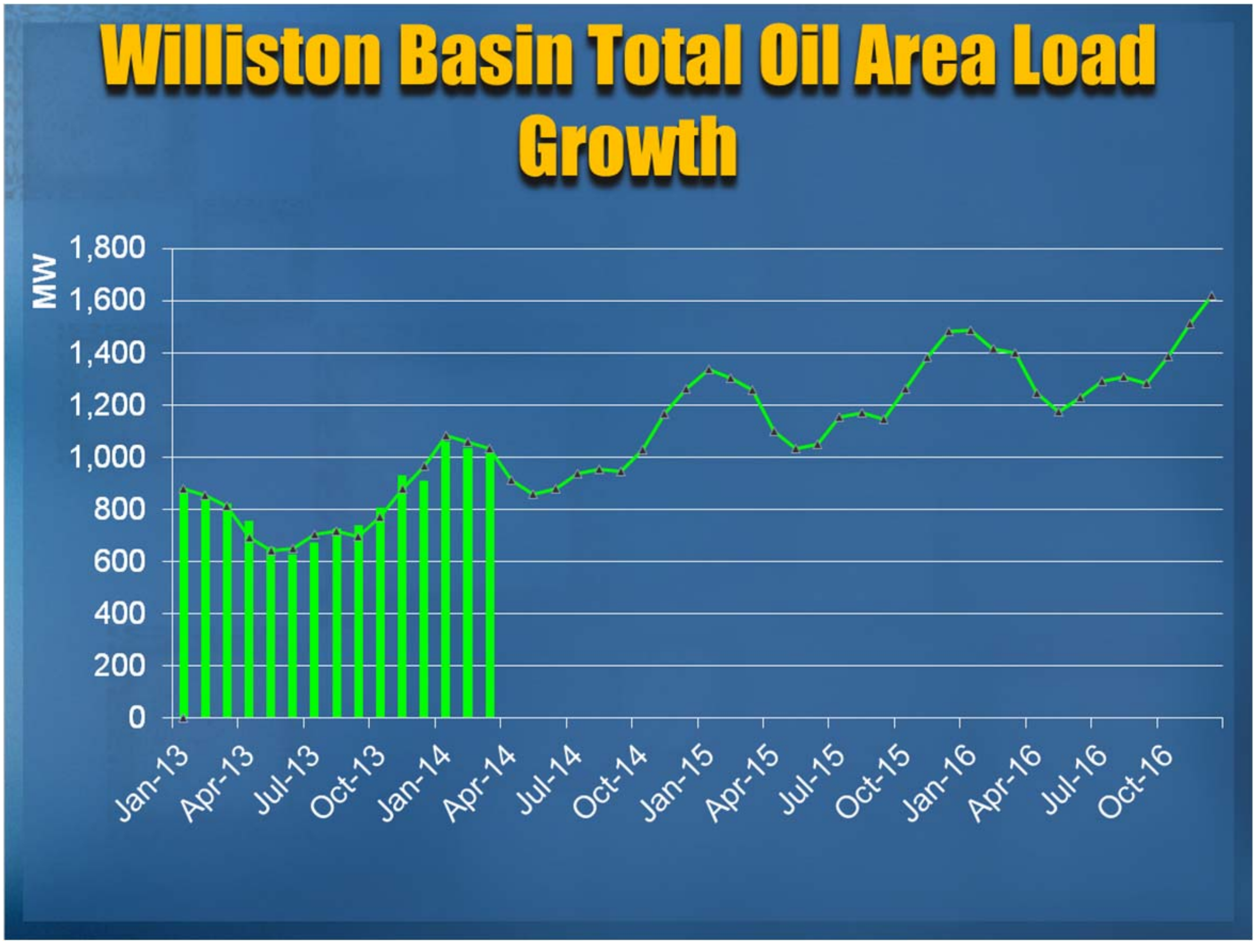
For those members whose commercial loads are heavily influenced by oil activities, three-tier econometric models were developed to project their commercial loads.

The econometric models generally consist of three models for each distribution cooperative. They generally address new oil production, oil prices, number of commercial consumers, total commercial energy, and other factors. New upcoming oil projects and services are also included.

The most important variable in the determination of oil production and related loads is crude oil prices. The crude oil price used in the models is the domestic refiner's acquisition cost of crude oil, which represents an average cost the domestic refiners pay for their crude oil.

Figure 1-5 depicts the monthly performance of the 2014 Load Forecast for the members located within the Williston Basin.

**Figure 1-5: Williston Basin Total Oil Area Load Growth**




Oil loads have been somewhat cyclical in the past. This was mainly due to oil price volatility. Domestic oil prices are largely influenced by international oil markets, which are influenced by geopolitical factors including instability in some geographic regions. Oil prices are also significantly influenced by extreme weather conditions such as hurricanes in the Gulf of Mexico. Oil prices are also influenced by national and international demand, the value of natural gas, and the value of the U.S. dollar. In recent years, developing Indian and Chinese economies have been very significant users of oil, putting upward pressure on oil prices.

### 1.3.2.5 Coal-Related Commercial Forecast

The service territory for the coal production of Basin Electric members is located in Wyoming, Montana, and western North Dakota. Generally, this region is considered by the EIA as United States, Western coal production, which has grown steadily since 1970 and continues to increase. Most of the increase in output originates from mines located in Wyoming, Montana, and North Dakota. The majority of this Western coal production occurs in Wyoming and Montana in the coal fields referred to as the PRB, which includes the Northern PRB (in Montana) and the Southern PRB (in Wyoming).

According to the EIA, Wyoming has been the largest coal-producing state for many years. In 2012, Wyoming produced 401 million short tons of coal.

Econometric forecasts are developed for the coal-related portion of the small and large commercial sector for the PRB in Wyoming. These forecasts are derived by the use of econometric models, as well as upcoming coal projects and services.

The coal production and energy forecasts for western North Dakota’s coal fields are based on the estimated production of the mines located in Mercer County that supply Basin Electric’s Antelope Valley Station (AVS), the Leland Olds Station, and the Dakota Gasification Company.

### 1.3.2.6 Coal Bed Methane Load

A major load development is also occurring in northeastern Wyoming. This load is related to the extraction of methane gas that is contained in the sub-bituminous coal reserves located within Basin Electric’s member service territory.

CBM loads were first considered in the 1998 Power Requirements Study. At that time, only limited activity was taking place and the forecast was not particularly significant. By 2000, the CBM play was more active, and, therefore, a more comprehensive forecast was conducted in-house by Basin Electric staff and was included in the January 1, 2001, Powder River Energy Corporation (PRECorp) Load Forecast.

After the 2001 PRECorp Load Forecast was completed, the Bureau of Land Management (BLM) was required to prepare an environmental impact statement (EIS), which essentially halted further drilling on federal leases until the record of decision (ROD) was finalized. It was also determined by BLM a more thorough, comprehensive, and independent forecast should be conducted. Therefore, PACE Global Energy Services (PACE) was retained to develop the next PRECorp CBM forecast. PACE completed four consecutive CBM load forecasts for Basin Electric. Basin Electric also participated with other companies in a PACE Wyoming Pipeline Study in 2003.

Since the CBM load had been thoroughly researched and developed by external consultants for four consecutive load forecasts, when there was not as much CBM development and little historical data, Basin Electric developed internally the 2009 CBM load forecast. Basin Electric continues to develop the CBM load forecast internally. The IHS Global Database and forecasting software was necessary to create econometric models based on historical data for use in forecasting. These are the same software and databases that were used in the oil load forecasting process.

One of the main drivers of this forecasting process was to develop a CBM well drilling forecast, as well as the company plans for the larger CBM loads, such as water pumping and large gas compressors. Therefore, Basin Electric and PRECorp held joint conference calls with the major CBM producers to get their opinions and outlook for their companies and the industry as a whole.

Twelve regional econometric equations were developed based on PRECorp historical CBM energy data, IHS Global data, projected company drilling plans and other factors, such as water and gas production (from IHS Global). These equations were used to develop forecasts of existing and new CBM loads. All existing loads were included in the historical load data for model development; therefore, any projected loads would include the same ratio of smaller water gathering or treatment, as well as any field gas gathering type of loads. New large loads, such as water pipelines  and large gas compressors (greater than 1,000 hp) were added to these modeled and projected forecasts to produce a total CBM load forecast for PRECorp. Also, the Wyoming Oil and Gas Commission website provided data and information. The website tracks and posts a variety of monthly CBM data.

Due to the increase in shale drilling in the United States, higher cost CBM natural gas has become a relatively less important sector, and growth is not expected.

#### 1.3.2.7 Ethanol- and Bio-Diesel-Related Commercial Load

The ethanol sector loads were projected by the distribution members that have had contact with the companies planning new plants or expansion of existing facilities. No new facilities are expected during the forecast period.

#### 1.3.2.8 Other Commercial Load Forecasts

Those commercial loads that are not oil- or coal-related are generally calculated using trending and sometimes educated forecasts. These forecasts that consider past trends and expected future developments reflect the knowledge and expertise the local cooperatives have of their service territories.

#### 1.3.2.9 Irrigation

Irrigation sales fluctuate during the historical periods due to the weather, the state of the farm economy, and government programs. Trending models were used to forecast consumers and energy demand.

#### 1.3.2.10 Other Sales

Other sales represent categories such as public street and highway, public authorities, and other RUS borrowers. These sales, which are usually quite small, are forecasted using trending models.

#### 1.3.2.11 Losses

The forecasted sales for each of the previous consumer categories are on an at-load basis, meaning the sales represent the amount of power delivered to the retail consumers. One of the objectives of the load forecast process is to obtain a forecast of the distribution cooperative's wholesale power requirements at its substations. These requirements, which correspond to the cooperative's purchases, are obtained by increasing the distribution cooperative sales to reflect its own use, as well as system losses occurring on its transmission and substation facilities. Own use and losses are represented together as a percent of purchases. An estimate is derived by considering historical percentages and planned improvements to the cooperative's distribution system that would affect the amount of future losses.

### 1.3.3 Basin Electric Load Forecast Results

The Basin Electric load forecasts are prepared for three levels of membership. At each level of membership, the energy and demand needed is totaled and is required to be approved by the board of directors of that particular cooperative. Each of the three levels of load forecasts is discussed as follows.

- Distribution Cooperative Load Forecasts: The previous forecasting process is employed, with the exception of Tri-State, for each Basin Electric distribution cooperative. The resultant load forecast provides the member with a detailed document outlining the derivations and assumptions utilized in the preparation of its forecast. Member involvement is an integral part of this process as the members provide retail rate projections, educated forecasts, and review of the econometric models for forecast reasonability and explanatory variable appropriateness. The final product provides each distribution cooperative with a forecast of its annual energy sales by consumer category and monthly forecasts of its wholesale power demand and energy requirements.

- G&T Cooperative Load Forecasts*:* The G&T's load forecasts are prepared by adding together the projected purchases of its distribution members. Transmission losses and member diversity within G&T's are also considered where applicable. The G&T load forecasts provide a forecast of the total sales of the G&T distribution member categorized according to consumer classifications. It also contains a forecast of the total wholesale power requirements of the G&T. These power requirements are separated into Western and Basin Electric, along with any other power suppliers' components in accordance with the member's contracts with the power supply organizations.
- Basin Electric's Load Forecast*:* Basin Electric's load forecast is prepared by adding together the projected power requirements of its Class A and Class D Members (18 Class A Members and only 1 Class D Member). The resultant forecast reflects the combined power requirements of Basin Electric member cooperatives.

These results are then translated into a model that represents the Basin Electric system on a delivery point basis. This allows the planning of infrastructure improvements to be made where needed.

The Load Forecast is then monitored on a monthly basis to check that the forecast is performing as expected. Also, due to the detailed information available from the large commercial sector, individual projects can be monitored to check that they are proceeding as planned. If the load deviates significantly from the forecast, modifications can be made for future load forecasts.

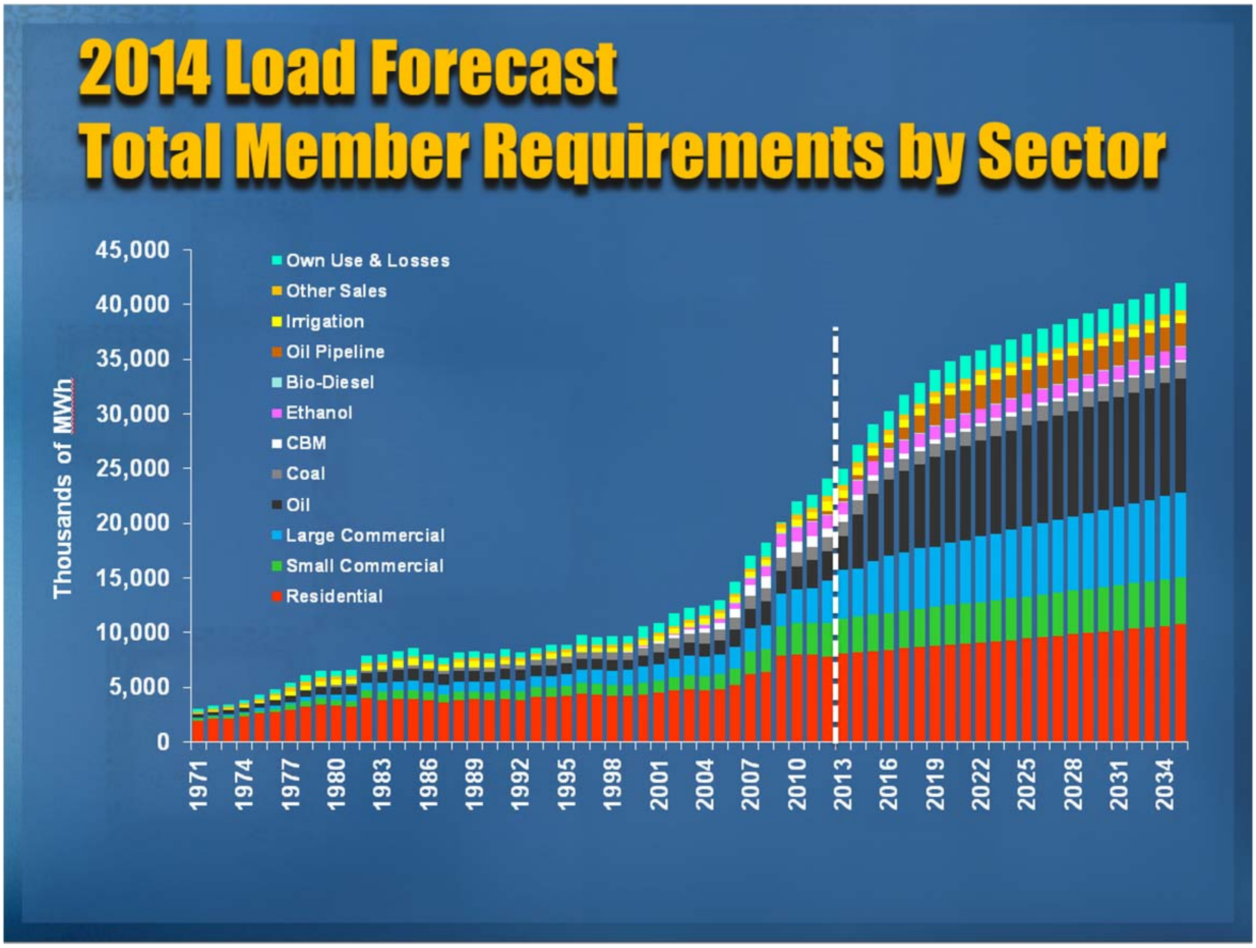
### 1.3.4 Summary of the Latest Load Forecast

Basin Electric finalized the 2014 Load Forecast, which was approved by the Basin Electric Board of Directors in April 2014 and was submitted to the RUS for its consideration and approval in August 2014. The load forecast is net of any member's load management activity, which is discussed in more detail later.

Figure 1-6 shows actual total member sales by class such as residential, commercial, etc., from 1971 to 2012 as well as projected member sales by class from 2013 to 2035. The need for additional generating capacity is driven by the increasing use of electricity and the resulting load growth, including industrial growth, energy sector (coal, oil, gas and ethanol bio-diesel) development, and new rural development. Between actual 2012 and forecasted 2035, Basin Electric's portion of this load growth is expected to grow 17.9 million Megawatt-hour (MWh) in total energy sales, which is approximately 777,055 MWh per year.

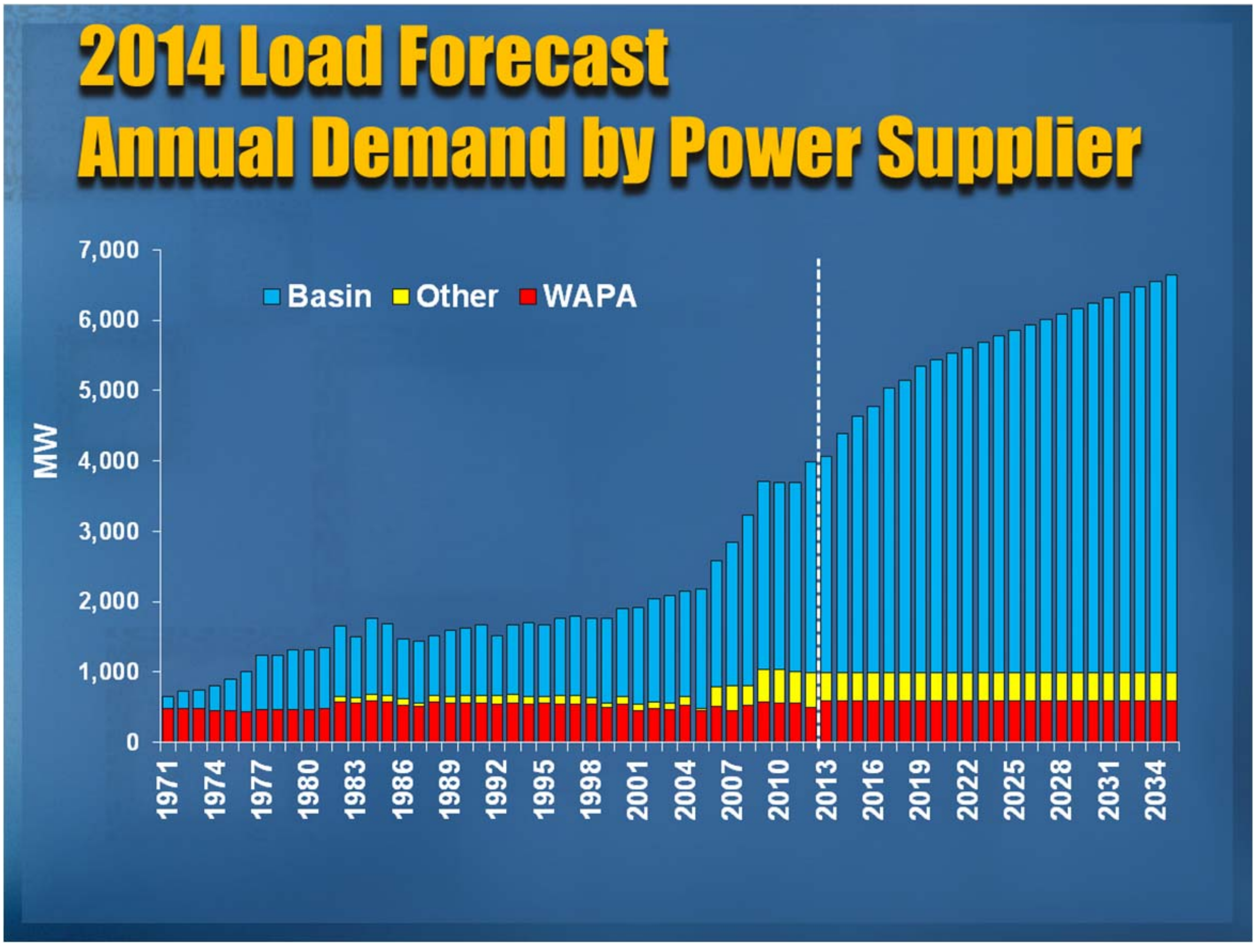
Strong growth in the Williston Basin oil sector is underpinned by historically strong residential and non-energy-related commercial sectors.

**Figure 1-6: Total Member Requirements by Sector**




Basin Electric's supplemental power supply responsibility to its member systems is, in most cases, computed by subtracting the members' direct Western allocation from their total power requirements (Figure 1-7). In instances where other power supply sources are applicable, contractual arrangements are considered.

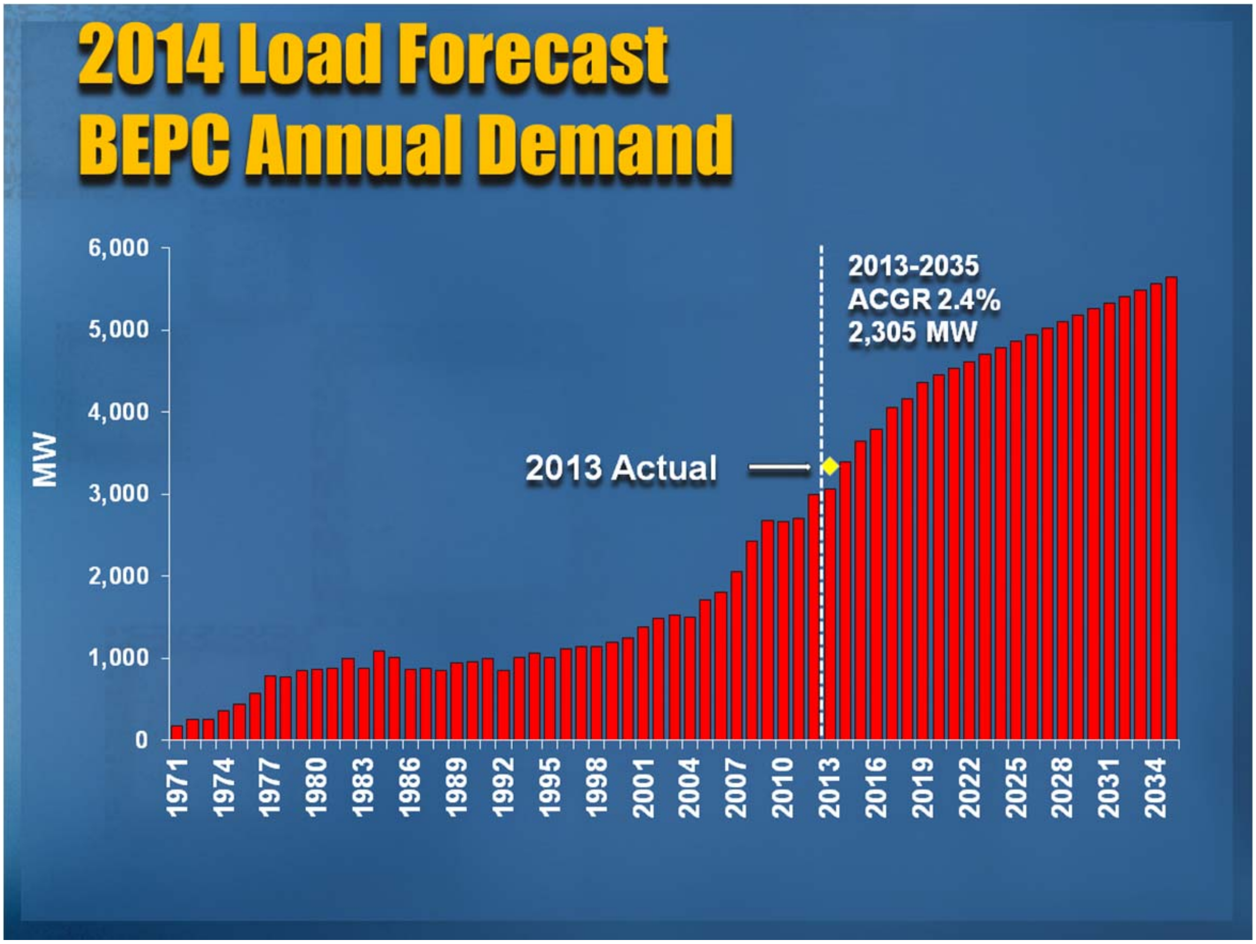
**Figure 1-7: Annual Demand by Power Supplier**




WAPA = Western Area Power Administration

After other power suppliers obligations are considered, the remainders of the loads are Basin Electric's responsibility. Figure 1-8 depicts the expected annual demands for Basin Electric.

**Figure 1-8: Basin Electric Annual Demand**




BEPC = Basin Electric Power Cooperative

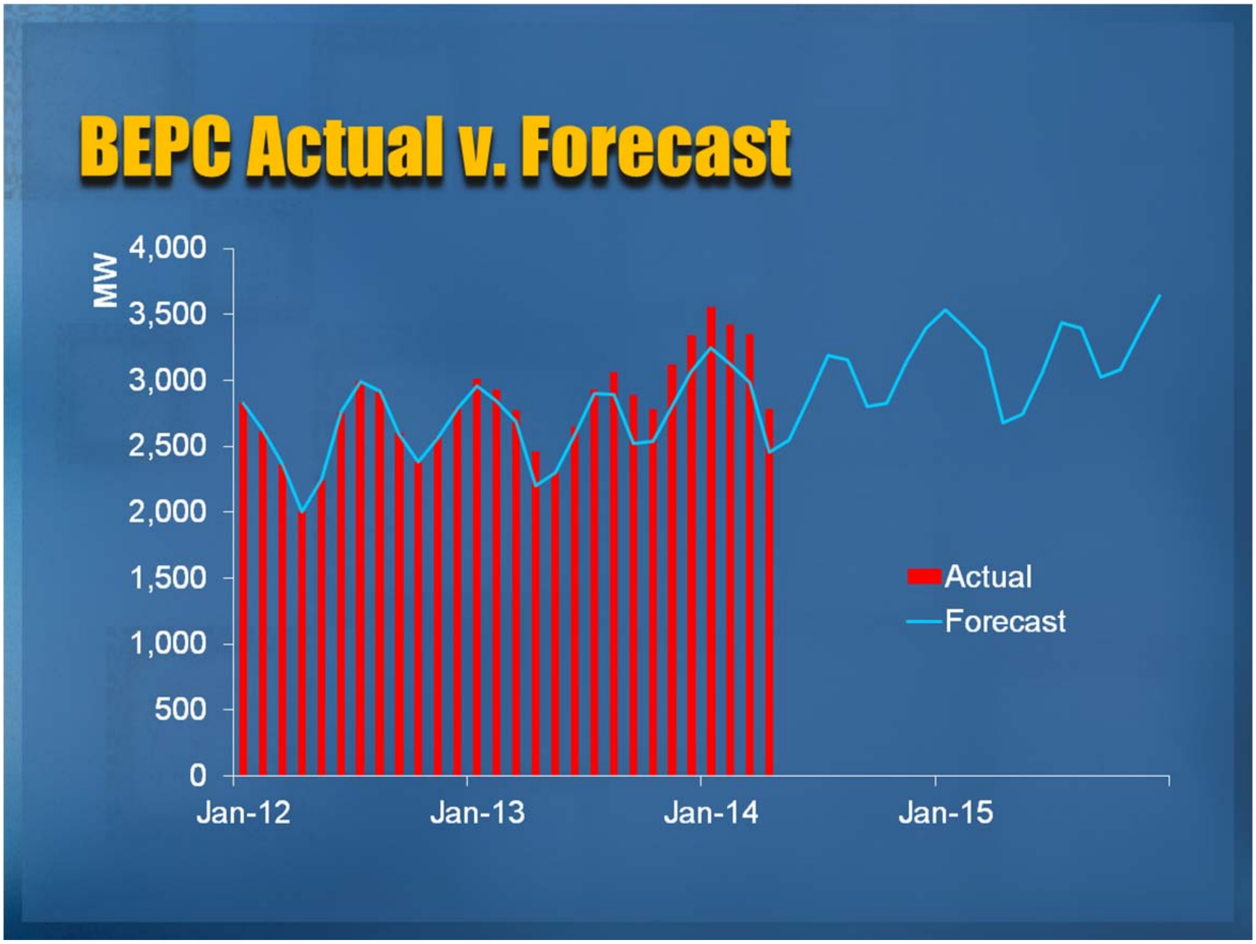
Table 1-3 shows Basin Electric's member energy sales and member peak demand from 2004 through 2013. System peak demand increased on average by 300 MW annually from 2004 to 2013. System energy sales increased on average by 1,804,690 MWh annually from 2004 to 2013. The total system experienced annual average percent load factors in the high 60s during this same time period.

**Table 1-3: Historical Member Sales (Billing Load Levels)**

| Year | Peak Megawatt (MW) | Annual Megawatt-Hour (MWh) |
|---|---|---|
| 2004 | 1,542 | 9,559,319 |
| 2005 | 1,709 | 10,291,152 |
| 2006 | 1,933 | 11,759,408 |
| 2007 | 2,053 | 12,912,847 |
| 2008 | 2,421 | 14,073,369 |
| 2009 | 2,672 | 14,947,627 |
| 2010 | 2,658 | 16,508,356 |
| 2011 | 2,698 | 17,158,823 |
| 2012 | 2,995 | 18,715,148 |
| 2013 | 3,340 | 20,387,458 |
| **Average Annual Increase** | **300** | **1,804,690** |

Figure 1-9 depicts the performance of the 2014 Load Forecast. Significant growth is expected to continue in the future. Winter 2013/2014 actual peak load was 311 MW, or 9.6 percent above the weather normalized forecast.

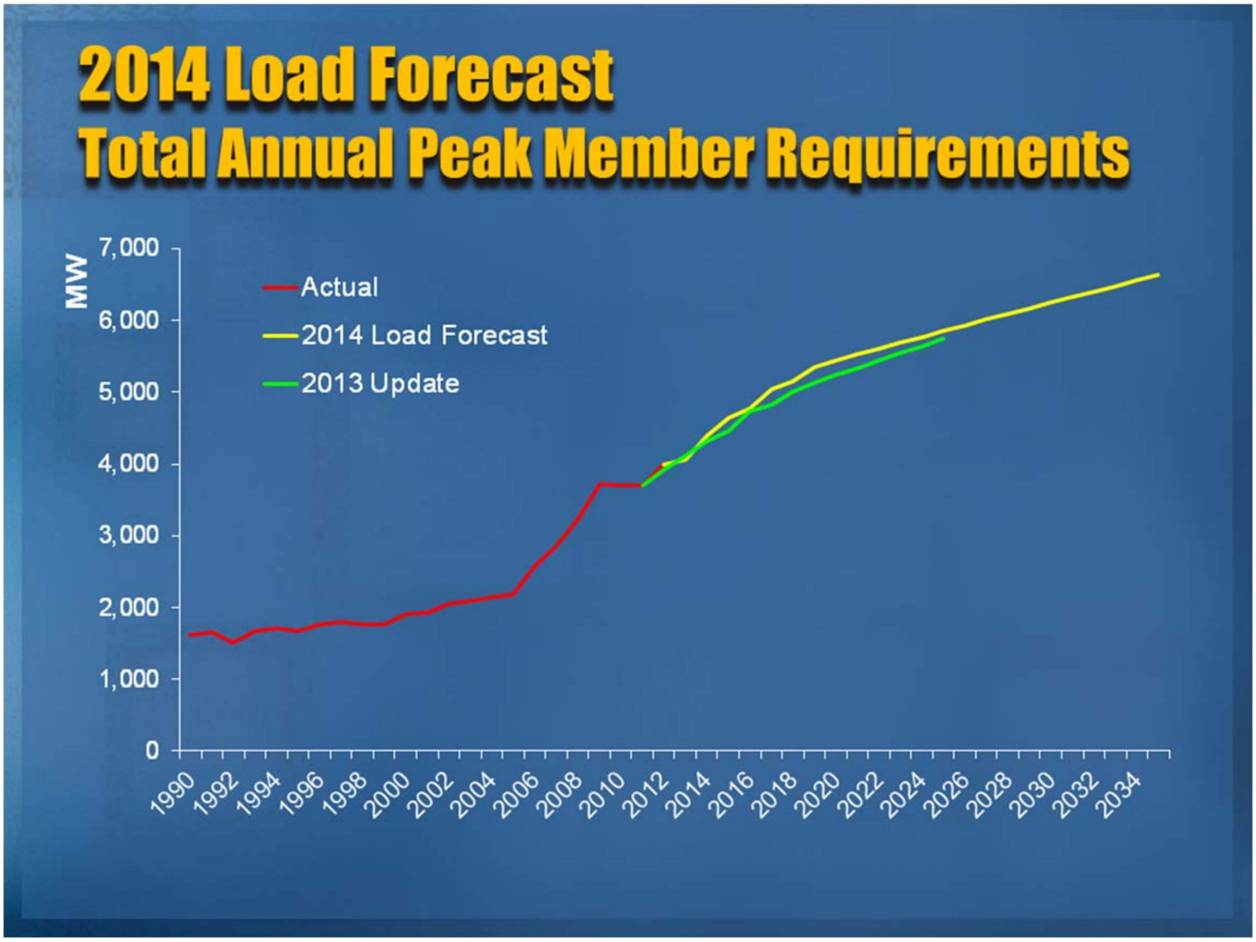
**Figure 1-9: Basin Electric Actual Versus Forecast**




BEPC = Basin Electric Power Cooperative

Basin Electric continues to update the forecast load within the member service territory. The outcome of the 2014 Load Forecast was substantially similar to the 2013 Load Forecast Update. The comparison of the load forecasts can be seen in Figure 1-10 below.

**Figure 1-10: Load Forecast Update Comparison**




### 1.3.5 Existing Resources

#### 1.3.5.1 Supply-side Resources

The following subsections identify existing supply-side resources.

##### 1.3.5.1.1 Leland Olds Station

Leland Olds Unit 1 was placed in-service on January 9, 1966, and is a baseload coal-fueled unit located near Stanton, North Dakota, with a net capacity of 222 MW. Leland Olds Unit 2 is a coal-fueled unit that was placed in-service on December 15, 1975, and its net capacity is rated at 445 MW. Basin Electric installed emission control equipment at the Leland Olds Station, requiring an increase to the station service. This equipment was put in service after the 2012 fall outage on Unit 2, reducing the net capacity from 448 to 445 MW due to additional station service required. The Unit 1 emissions control equipment was placed into service in June 2013 after the spring maintenance outage, reducing the net capacity from 222 to 221 MW. Leland Olds Station Unit 1 is the oldest baseload generating unit in Basin Electric's fleet, and its current depreciable life is listed as 2030. The Unit 2 current depreciable life is listed as 2040. While this seems relatively close, Basin Electric has verified the useable life of the equipment and successfully been granted depreciable life extensions from the RUS in the past.

#### 1.3.5.1.2 Laramie River Station (LRS)

Basin Electric, together with five other consumer-owned power supply entities, began construction of the three coal-fired baseload units at Laramie River Station (LRS) near Wheatland in southeast Wyoming in July 1976. LRS has three steam turbine generators supplied by GE and three steam boilers supplied by Babcock and Wilcox Company. The station's three units (Units 1, 2, and 3) became fully operational on November 1, 1982, each with a net capacity of 570 MW. The current rating of the units is due to turbine upgrades that occurred in 2007, 2008, and 2009. Basin Electric owns 42.27 percent of the entire station, which results in 723 MW available. Basin Electric, as Project Manager and Operating Agent for the Missouri Basin Power Project, was assigned overall responsibility for the design, construction and operation of the power plant and related transmission. Units 2 and 3 of the LRS are electrically connected to the western system; Unit 1 is electrically connected to the eastern system. The amount of power Basin Electric receives from the eastern unit is 48 MW, and the amount of power Basin Electric receives from the western units is 675 MW.

LRS was financed through the RUS for all but 19.8 percent. The 19.8 percent financed elsewhere pertains to pollution control bonds and Tax Benefit Transfers. Tax Benefit Transfers were a financing mechanism allowed by the Internal Revenue Service (IRS) several years ago whereby an entity that was unable to use tax credits was able to sell those to an entity that could use the credits against the income taxes to be paid. Currently, LRS Units 1, 2, and 3 have a depreciable life to 2032, 2033, and 2034, respectively, for financial purposes.

#### 1.3.5.1.3 Antelope Valley Station

Antelope Valley Station is a two-unit lignite-fired steam electric generating station located in Mercer County, North Dakota. AVS Unit 1 went into commercial operation on July 1, 1984, and AVS Unit 2 went into commercial operation June 1, 1986. AVS is equipped with two steam turbine generators supplied by Westinghouse Electric Corporation and two steam boilers supplied by Combustion Engineering. The most recent Uniform Rating of Generating Equipment (URGE) is 450 MW for Unit 1 and 450 MW for Unit 2. AVS provides approximately 135 MW of electric power for the neighboring Dakota Gasification Company’s Great Plains Synfuels Plant.

Designed to be environmentally sound, over $319 million has been invested in capital pollution control asset investments for AVS, to date. Dry scrubbers use lime to capture and remove up to 90 percent of $SO_2$ emissions from stack gases. Fabric filter bag houses capture and remove up to 99 percent of PM. Each bag house contains more than 8,000, 35-ft-tall bags. AVS is a “zero-discharge” facility. Water is used efficiently, only leaving the plant site through evaporation.

Basin Electric is 100 percent owner of AVS. A portion (45.3 percent) of Unit 1 was financed through RUS, while the other portion (54.7 percent) was financed through pollution control financing and a loan from CoBank that subsequently replaced a leveraged lease financing. Unit 2 was not financed by the RUS, but, rather, by pollution control financing and a leveraged lease. For financial purposes, Units 1 and 2 have a depreciable life to the years 2036 and 2038, respectively.

#### 1.3.5.1.4 Spirit Mound Station

Basin Electric placed in service a two-unit, 60-MW nameplate No. 2 fuel oil combustion turbine (CT) facility on June 30, 1978, to provide power as a peaking resource. The combined winter rating of the two units is 120 MW, and the summer rating is 100 MW. The capacity is intended to be used primarily as reserves or replacement during initial outages of baseload units or during peak load periods when existing baseload units cannot meet the demand. The site can store as much as 8 million gallons of fuel in containers. When the station is in use, it consumes 100 gallons of fuel per minute. The Spirit Mound Station is located near Vermillion, South Dakota, and has a depreciable life lasting through 2025 for financial purposes.

#### 1.3.5.1.5 Earl F. Wisdom Unit 1

Earl F. Wisdom Generating Station Unit 1 is a 38-MW coal-based unit located near Spencer, Iowa. Basin Electric and Corn Belt Power Cooperative (Corn Belt), one of Basin Electric’s member cooperatives, negotiated a power supply contract, which provides that Corn Belt sell to Basin Electric 38 MW of uncommitted capacity and associated energy from the Earl F. Wisdom Unit 1. In return, Corn Belt entered into a wholesale power contract with Basin Electric whereby Basin Electric would sell and deliver to Corn Belt all of Corn Belt’s capacity and energy requirements in excess of the power and energy available to Corn Belt from Western. Due to the Utility Mercury and Air Toxics Standards (MATS) rules, Wisdom 1 was converted from coal to natural gas with fuel oil as a backup source in 2014.

#### 1.3.5.1.6 Earl F. Wisdom Unit 2

Basin Electric partnered with Corn Belt to build the 80-MW GE model 7EA natural gas peaking unit near Spencer, Iowa. Although the CT uses natural gas as a primary fuel, it can also burn fuel oil as a contingency. Basin Electric owns one-half of the unit, which was placed in service in April 2004. Basin Electric purchases 87.5 percent of Corn Belt's-owned half in response to Corn Belt entering into a wholesale power contract. Therefore, Basin Electric has 93.75 percent, or 75 MW, from the 80 MW CT. Wisdom Unit 2 has a depreciable life lasting to 2037.

#### 1.3.5.1.7 Wyoming Distributed Generation

The Wyoming Distributed Generation turbines consists of nine peaking resource units located at three sites (Arvada, Hartzog, and Barber Creek) released for commercial operation in 2002. These units are natural gas-fired SCCTs manufactured by Solar and consist of a total net output of 45 MW summer and 54 MW winter. The turbines are used to hold a portion of the necessary reserves for Basin Electric's west side electrical requirements. Financially, the Wyoming Distributed Generation turbines have a depreciable life ending in 2035.

#### 1.3.5.1.8 Groton Generation Station

The Groton Generation Station near Groton, South Dakota, consists of two GE LMS 100 SCCTs that provide about 98 MW for Unit 1 and 97 MW for Unit 2 (winter rating) as peaking resources. Basin Electric commissioned Groton Unit 1 in 2006 which was the first commercial application of GE's LMS 100. Unit 2 began providing power as a peaking resource in 2008. The two gas turbines get their natural gas from the Northern Border Pipeline. Through Dakota Gasification Company's Great Plains Synfuels Plant, the units have firm gas transport, which gives them fuel security without requiring a backup or alternative fuel supply. A unique aspect of the station is the ability for Unit 1 to disconnect the generator from the gas turbine through a clutch, allowing the generator rotor to spin independent from the gas turbine and operate as a synchronous condenser to provide voltage stability to the electrical grid.

#### 1.3.5.1.9 Culbertson Generation Station

The Culbertson Generation Station, near Culbertson, Montana, is a single LMS 100 SCCT providing 95 MW (winter rating) of peaking power. Operating since 2010, Culbertson Unit 1 is Basin Electric's first resource located in Montana. Similar to the Groton Generation Station, Culbertson Unit 1 has no need for an alternative fuel source as it receives its fuel from the Northern Border Pipeline and has firm gas transport via the Great Plains Synfuels Plant.

#### 1.3.5.1.10 Deer Creek Station

The Deer Creek Station combined-cycle natural gas facility is a 300 MW intermediate resource located near White, South Dakota. This unit achieved commercial operation in August of 2012. The combined-cycle plant electrical generators are powered by a GE model 7FA gas turbine and an Alstom steam turbine. The natural gas fuel used by the station comes from the Northern Border Pipeline, where firm gas transport is possible through Dakota Gasification Company's Great Plains Synfuels Plant. The exhaust gases from the gas turbine pass through a heat recovery steam generator, where they boil water into steam and provide steam to the Alstom steam turbine. When the CT has reached full load, duct burners can burn additional fuel within the heat recovery steam generator to produce more steam and reach the full station output ability of 300 MW.

#### 1.3.5.1.11 Dry Fork Station

The Dry Fork Station is a 405-MW coal-fired power plant located 10 miles north of Gillette, Wyoming. It was released for commercial operation in 2011. Basin Electric owns 92.9 percent of the station, or 376 MW of the baseload resource. The station utilizes PRB coal from the next door Dry Fork Mine to allow for an uninterrupted, stable-priced fuel supply. The latest generation of pollution control technology was implemented, resulting in very low emission rates.

#### 1.3.5.1.12 Pioneer Generation Station

Pioneer Generation Station (PGS) is a three-unit GE LM6000 natural gas fired SCCT plant located near Williston, North Dakota. The station's Unit 1 became operational in 2013 at a net capacity of 45 MW, and Units 2 and 3 became operational in 2014 at a net capacity of 45 MW each. This peaking resource uses natural gas fired SCCTs fueled by the Northern Border Pipeline. Unit 1 has a clutch located between the CT and generator, allowing the generator rotor to rotate independent of the turbine and act as a synchronous condenser to provide voltage stability to the electrical grid.

#### 1.3.5.1.13 Lonesome Creek Station

Lonesome Creek Station (LCS) is a three-unit natural gas fired power plant located near Watford City, North Dakota. Unit 1 became commercially operational in September 2013, with a net capacity of 45 MW. Units 2 and 3 are scheduled to be operational in December 2014, with both units having a net capacity of 45 MW each. This peaking resource uses natural gas-fired CTs fueled by natural gas from the Northern Border Pipeline. Unlike Units 2 and 3, Unit 1 has a clutch located between the CT and the generator, allowing the generator rotor to spin independent of the turbine and act as a synchronous condenser providing voltage stability to the electrical grid.

#### 1.3.5.1.14 Chamberlain Wind Project

Basin Electric, in partnership with East River Power Cooperative, has constructed a wind energy project near Chamberlain, South Dakota. The 2.6-MW capacity project was placed into commercial service in January 2002. Chamberlain Wind Project is owned by Basin Electric, and the energy is delivered to members as part of Basin Electric’s overall power supply. The Chamberlain wind turbines have a depreciable life lasting to 2022 for financial purposes.

#### 1.3.5.1.15 Minot Wind Project

Basin Electric, in partnership with Central Power Electric Cooperative, constructed a wind energy project 14 miles south of Minot, North Dakota. The 2.6-MW capacity wind project was placed into commercial service in February 2002. Three additional turbines were added in December 2009 for a total output of 7.1 MW. The facility is owned by Basin Electric’s subsidiary PrairieWinds ND 1 Inc., and energy is purchased by Basin Electric and delivered to members through a long-term power purchase agreement (PPA) with PrairieWinds ND 1 Inc. The Minot Wind turbines have a 20-year depreciable life, putting their financial end of life in 2023 and 2029 per their installation dates.

#### 1.3.5.1.16 PrairieWinds 1

Basin Electric, in partnership with PrairieWinds ND 1 Inc., constructed a wind energy project of 77 turbines near Minot, North Dakota. The project is owned by Basin Electric’s subsidiary PrairieWinds ND 1 Inc. Basin Electric purchases the output of the 115.5-MW capacity wind project via a long-term PPA. PrairieWinds 1 was placed into commercial service in December 2009. With a 20-year depreciable life allowed, the wind turbines are shown with an end of service to 2029 from a financial perspective.

#### 1.3.5.1.17 Crow Lake Wind Project

Basin Electric, in partnership with PrairieWinds SD 1 Inc., South Dakota Wind Partners, and Mitchell Technical Institute, constructed a wind energy project of 108 turbines near White Lake, South Dakota. The 162-MW-capacity wind project was placed into commercial service in 2011. Basin Electric’s subsidiary, PrairieWinds SD 1, owns 100 turbines, or 150 MW. Basin Electric has a purchase power contract for the output from all 108 turbines, or 162 MW. The 20-year depreciable life is 2011 to 2031.

### 1.3.5.2 Power Supply Contracts

The following subsections describe existing power supply contracts.

#### 1.3.5.2.1 George Neal Station Unit 4

Unit 4 is a 644-MW coal-fired electric generation facility located south of Sioux City, Iowa, that has been providing baseload power since 1979. Basin Electric and Northwest Iowa Power Cooperative (NIPCO), one of Basin Electric's member cooperatives, negotiated a power supply contract which provides that NIPCO would sell to Basin Electric NIPCO’s 31 MW of uncommitted capacity and associated energy from Unit 4 of the George Neal Generating Station. In return, NIPCO entered into a wholesale power contract with Basin Electric whereby Basin Electric would sell and deliver to NIPCO all of NIPCO's capacity and energy requirements in excess of the power and energy available to NIPCO from Western.

Basin Electric and Corn Belt, one of Basin Electric’s member cooperatives, negotiated a power supply contract which provides that Corn Belt would sell to Basin Electric its 73 MW of uncommitted capacity and associated energy from Unit 4 of the George Neal Station. In return, Corn Belt entered into a wholesale power contract with Basin Electric whereby Basin Electric would sell and deliver to Corn Belt all of Corn Belt’s capacity and energy requirements in excess of the power and energy available to Corn Belt from Western. Unit 4 is connected to MidAmerican Energy Company (MEC) where NIPCO and Corn Belt have rights to bring this energy to the IS or the Midcontinent Independent System Operator (MISO) via MEC. The IS is owned by Western, Basin Electric, and Heartland Consumers Power District (HCPD). Currently, Basin Electric is bringing this generation to the IS transmission system.

#### 1.3.5.2.2 Walter Scott 3 and 4

The Walter Scott Energy Center, located near Council Bluffs, Iowa, provides baseload power through the 690-MW Unit 3 and the 790-MW Unit 4. Both of the units are coal-based. Unit 3 has been operating since 1979, and Unit 4 began operation in 2007. Basin Electric and Corn Belt, one of Basin Electric’s member cooperatives, negotiated a power supply contract which provides that Corn Belt would sell to Basin Electric its 26 MW of uncommitted capacity and associated energy from Unit 3 and 45 MW of uncommitted capacity and associated energy from Unit 4 of the Walter Scott Energy Center. In return, Corn Belt entered into a wholesale power contract with Basin Electric whereby Basin Electric would sell and deliver to Corn Belt all of Corn Belt’s capacity and energy requirements in excess of the power and energy available to Corn Belt from Western. Walter Scott 3 and 4 are connected to MEC where Corn Belt has rights to bring this energy into the IS or MISO via MEC.

#### 1.3.5.2.3 Duane Arnold Energy Center

The Duane Arnold Energy Center consists of a 615-MW nuclear-powered unit located near Cedar Rapids, Iowa, that has been providing baseload power since 1975. Basin Electric and Corn Belt negotiated a power supply contract which provides that Corn Belt would sell its 10 percent share—about 62 MW of uncommitted capacity and associated energy—from the Duane Arnold Energy Center to Basin Electric. In return, Corn Belt entered into a wholesale power contract with Basin Electric whereby Basin Electric would sell and deliver to Corn Belt all of Corn Belt’s capacity and energy requirements in excess of the power and energy available to Corn Belt from Western. Interconnected to the Alliant West (ALTW) system, Corn Belt has the right s to bring the power to Corn Belt’s transmission system, which is within Western’s Upper Great Plains Region Eastern Division (WAUE) balancing area.

#### 1.3.5.2.4 Western Area Power Administration Peaking Capacity

In 1968, Basin Electric executed a long-term contract with the federal government for U.S. Bureau of Reclamation (now Western) hydroelectric peaking from the dams in the Missouri River Basin. This contract currently provides Basin Electric with 268.2 MW of winter peaking capacity at load, and for Basin Electric to return a like amount of energy to Western during off-peak periods. This contract has been extended through the year 2039.

#### 1.3.5.2.5 Western Native American Purchase

Basin Electric receives a Native American Allocation of 37 MW in the winter and 38 MW in the summer. This allocation is a result of congressional action that made federal power available to Native Americans.

#### 1.3.5.2.6 Madison Diesel

Basin Electric purchases capacity and energy output (when scheduled) from diesel generators owned by the City of Madison, South Dakota. The purchase is for the output from five, 2-MW Caterpillar diesel generators that went commercial in April 2005. The agreement goes through December 2025.

#### 1.3.5.2.7 Northern Border Waste Heat

Basin Electric purchases the energy from eight Recovered Energy Generation (REG) power plants fueled by hot exhaust off the Northern Border Pipeline compression stations. The eight units have a total generating capacity of 44 MW and are comprised of three units in North Dakota, three units in South Dakota, and one in each Montana and Minnesota. In 2006, 22 MW went commercial. An additional 22 MW was commercial by the end of 2009. The generation is environmentally benign, using virtually no additional fuel and producing virtually zero emissions. Basin Electric has signed a 25-year contract with the developer for the output of the REGs.

#### 1.3.5.2.8 NextEra Wind

Basin Electric purchases all of the energy from six wind projects owned and operated by NextEra. The wind projects include:

- Edgeley Wind Project: 40-MW wind facility near Edgeley, North Dakota, that went commercial in 2003. Basin Electric entered into a 25-year PPA for the power from this facility.
- Hyde County Wind Project: 40-MW wind facility near Highmore, South Dakota, that went commercial in 2003. Basin Electric entered into a 25-year PPA for the power from this facility.
- Wilton 1 Wind Project: 49.5-MW wind facility near Wilton, North Dakota, that went commercial in early 2006. Basin Electric entered into a 25-year PPA for the power from this facility.

- Wilton 2 Wind Project: 49.5-MW wind facilities near Wilton, North Dakota, that went commercial November 2009. Basin Electric entered into a 25-year PPA for the power from this facility.
- Day County Wind Project: 99-MW wind facility near Aberdeen, South Dakota, that went commercial in 2010. Basin Electric entered into a 30-year PPA for the power from this facility.
- Baldwin Wind Project: 100-MW wind facility near Baldwin, North Dakota, that went commercial in 2011. Basin Electric entered into a 30-year PPA for the power from this facility.

#### 1.3.5.2.9 Tri-State Sheridan-Johnson

Basin Electric has a PPA with Tri-State to serve a portion of its member obligations in northeast Wyoming's Sheridan and Johnson counties. Under this agreement Basin Electric receives 11 MW to 13 MW varying on a monthly basis. The agreement extends through December 31, 2025 and may be extended for up to two successive terms of five consecutive years.

#### 1.3.5.2.10 Tri-State Nebraska Allocation

The Tri-State Nebraska Allocation is a power allocation from Western–Rocky Mountain Region (RMR). This allocation provides for fixed monthly capacity and energy deliveries that correspond to the monthly resource capability of the federal hydroelectric systems. The Contracted Rates of Delivery (CROD) under the federal power deliveries for Tri-State Nebraska reaches the maximum CROD of 83 MW for the summer season in July. However, as a system, Basin Electric's maximum west side member load obligations may occur in either July or August.

For prudent planning, Basin Electric assumes the maximum member load as occurring in July, as indicated by the Load Forecast, but uses the August CROD of 72.833 MW. The winter CROD at the point of delivery is 48.536 MW. Basin Electric uses these allocations to the extent possible as peaking resources due to the limited amount of energy that can be scheduled to maximize the value of these allocations. Effective October 1, 2014, the seasonal energy and CROD for future winter and summer seasons has been reduced to 72.621 MW and 48.392 MW, respectively. On October 1, 2018, the seasonal energy and CROD for future winter and summer seasons may be reduced by up to 1 percent from the then-current seasonal energy and CROD.

#### 1.3.5.2.11 PRECorp Allocation

The PRECorp Allocation is a power allocation from Western–RMR. The RMR allocation provides for fixed monthly capacity and energy deliveries that correspond to the monthly resource capability of the federal hydroelectric systems. The PRECorp Allocation uses 23.59 MW in the winter season and 20.887

MW in the summer season for planning purposes. Basin Electric uses these allocations to the extent possible as peaking resources due to the limited amount of energy that can be scheduled to maximize the value of these allocations. Effective October 1, 2014, the seasonal energy and CROD for future winter and summer seasons has been reduced to 23.354 MW and 20.678 MW respectively. On October 1, 2024, the seasonal energy and CROD for future winter and summer seasons may be reduced by up to 1 percent from the then-current seasonal energy and CROD.

#### 1.3.5.2.12 Webster City CT

Basin Electric has signed a contract with Corn Belt to purchase the output of the Webster City CT peaking plant (20.8 MW) that is fueled by fuel oil. The purchase began September 1, 2009, and continues through the term of the wholesale power contract between Basin Electric and Corn Belt.

#### 1.3.5.2.13 Estherville Diesel Generators

Basin Electric has signed a contract with Corn Belt to purchase the output from the City of Estherville’s six diesel generators (13.0 MW). The purchase began September 1, 2009, and remains in effect so long as Corn Belt continues to purchase the output of the diesel generators pursuant to the Wholesale Agreement between Iowa Lakes Electric Cooperative and the City of Estherville and provided that this would not extend through the term of the Wholesale Power Contract between Basin Electric and Corn Belt.

#### 1.3.5.2.14 Pocahontas Diesel Generators

Basin Electric has signed a contract with Corn Belt to purchase the output from the City of Pocahontas’s two diesel generators (3.8 MW). The purchase began September 1, 2009, and remains in effect so long as Corn Belt continues to purchase the output of the diesel generators pursuant to the Wholesale Agreement between Iowa Lakes Electric Cooperative and the City of Pocahontas, Iowa, and provided that this would not extend through the term of the Wholesale Power Contract between Basin Electric and Corn Belt.

#### 1.3.5.2.15 Spencer Combustion Turbine (CT) Generator

Basin Electric has signed a contract with Corn Belt to purchase 10 MW from the City of Spencer 20-MW CT. The purchase began September 1, 2009, and remains in effect so long as Corn Belt continues to purchase the output of the CT pursuant to Corn Belt being a party to the Spencer PPA with Spencer Municipal Utilities of the City of Spencer, Iowa, and provided that this would not extend through the term of the Wholesale Power Contract between Basin Electric and Corn Belt.

#### 1.3.5.2.16 Corn Belt Wind

Basin Electric has signed a contract with Corn Belt to purchase the output of Corn Belt's wind projects. The purchase began September 1, 2009, and continues through the term of the Wholesale Power Contract between Basin Electric and Corn Belt. The wind projects include: 7.3 MW from the Hancock County Wind Project, 16.8 MW from the Crosswind Generators, 10.5 MW from the Lakota Wind Project, and 10.5 MW from the Superior Wind Project.

#### 1.3.5.2.17 Minnesota Power Purchase

Basin Electric has signed a contract with Minnesota Power to purchase 100 MW from the Clay Boswell Energy Center. This facility is a four-unit coal-fired power station with a nameplate capacity of 1,025 MW. It is owned and operated by ALLETE and is located near Cohasset, Minnesota. The PPA ends on April 30, 2020.

#### 1.3.5.2.18 PPL Energy Plus, LLC

Basin Electric has signed a contract with PPL Energy Plus, LLC to purchase 50 MW. The purchase began in May 2013 and recently was extended an additional 3 years through the end of April 2020.

#### 1.3.5.2.19 Heartland Consumers Power District

Basin Electric has signed a contract with HCPD to purchase 50 MW, which they provide based on the availability of either HCPD's portion of LRS unit 1 or Whelan Energy Center Unit 2. The PPA has a 5-year term that began in 2013 and ends on December 31, 2017. Basin extended this initial PPA another 3 years, and it is now scheduled to terminate May 31, 2021.

#### 1.3.5.2.20 Minnkota Power Cooperative

Basin Electric has signed a contract with Minnkota Power Cooperative (Minnkota) to purchase 50 to 200 MW, which Minnkota provides based on the availability of the Milton R. Young Generation Station Units 1 and 2. This contract is for this power to be delivered to the IS/SPP system. The PPA began January 1, 2014, and ends December 31, 2018. Currently, Minnkota provides 50 MW year round, but starting in 2016 through the end of the contract, they would provide 200 MW in the months of April through October, zero MW from December through February, and 100 MW in the months of March and November.

Basin Electric has also signed a contract with Minnkota to purchase 100 MW, which Minnkota provides based on the availability of the Milton R. Young Generation Station Unit 2. This contract is for the power to be delivered to the MISO's Zone 1 area. The PPA is scheduled to begin March 1, 2019, and end May 31, 2022.

#### 1.3.5.2.21 Great River Energy

Basin Electric has signed a contract with Great River Energy to purchase 25 MW of capacity from resources located in MISO's Zone 1 area. The PPA started June 1, 2014, and lasts through May 31, 2019.

#### 1.3.5.2.22 Northern States Power Company

Basin Electric has signed a contract with Northern States Power Company to purchase 25 MW of capacity from resources located in MISO's Zone 1 area. The PPA started June 1, 2014, and lasts through May 31, 2019.

#### 1.3.5.2.23 Minnesota Power

Basin Electric has signed a contract with Minnesota Power to purchase 50 MW of capacity from resources located in MISO's Zone 1 area. The PPA will start June 1, 2017, and last through May 31, 2019.

#### 1.3.5.2.24 Infinity Wind

Basin Electric purchases all of the energy from two wind projects owned and operated by Infinity Wind. The wind projects are:

- Sunflower Wind Project: This is a 106-MW wind facility near Hebron, North Dakota, that is scheduled to be commercial in late 2015. Basin Electric entered into a 25-year PPA for the power from this facility.
- Antelope Hills Wind Project: This project is a 172-MW wind facility near the AVS Generation Station which is scheduled to go commercial in late 2015. Basin Electric entered into a 25-year PPA for the power from this facility.

#### 1.3.5.2.25 Dakota Plains

Basin Electric purchases all of the energy from a wind project owned and operated by Dakota Plains.

- Campbell County Wind Project: This is a 98-MW wind facility near Pollock, South Dakota, that is scheduled to be commercial in late 2015. Basin Electric entered into a 30-year PPA for the power from this facility

### 1.3.6 Project Justification and Support

Basin Electric identified the need for PGS Phase III and LCS Phase III during the integrated resource plan process. This process compared the 2014 Load Forecast to the existing generation fleet and purchase agreements in early 2014. The difference in the load forecast plus other obligations (such as non-member sales, losses, and reserves, less Basin Electric's system-wide load management) and existing and committed generating resources along with purchases, define the load and capability of the Basin Electric system. Capacity deficiencies or surplus on Basin Electric's system can then be determined.

#### 1.3.6.1 West and East Surplus/Deficit Capacity

Since Basin Electric's member systems reside on both the eastern and western interconnection and there is limited capability in moving power between the systems, Basin Electric categorizes load and capability separately for the eastern and western systems.

Figure 1-11 shows Basin Electric's western system summer season surplus capacity. The western system is not projected to have a capacity deficit throughout the study period.

**Figure 1-11: West System Surplus/Deficit Capacity**

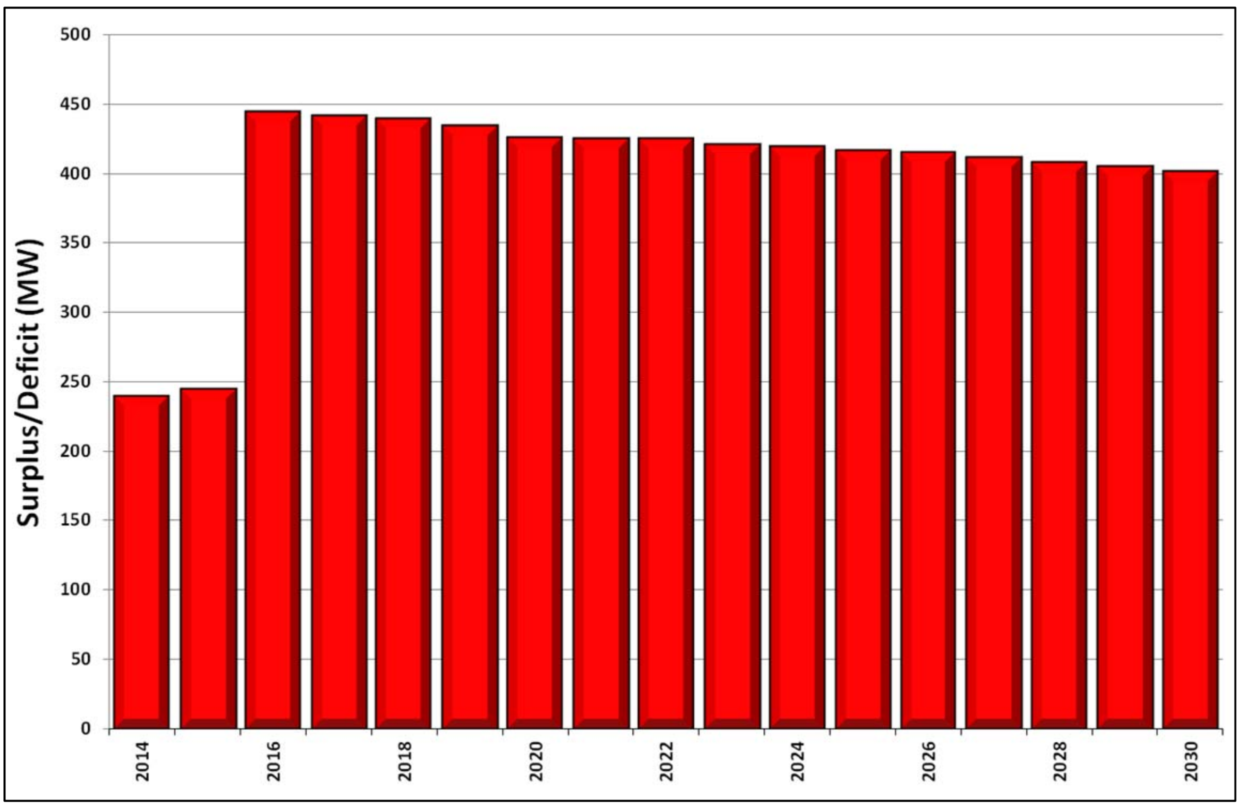
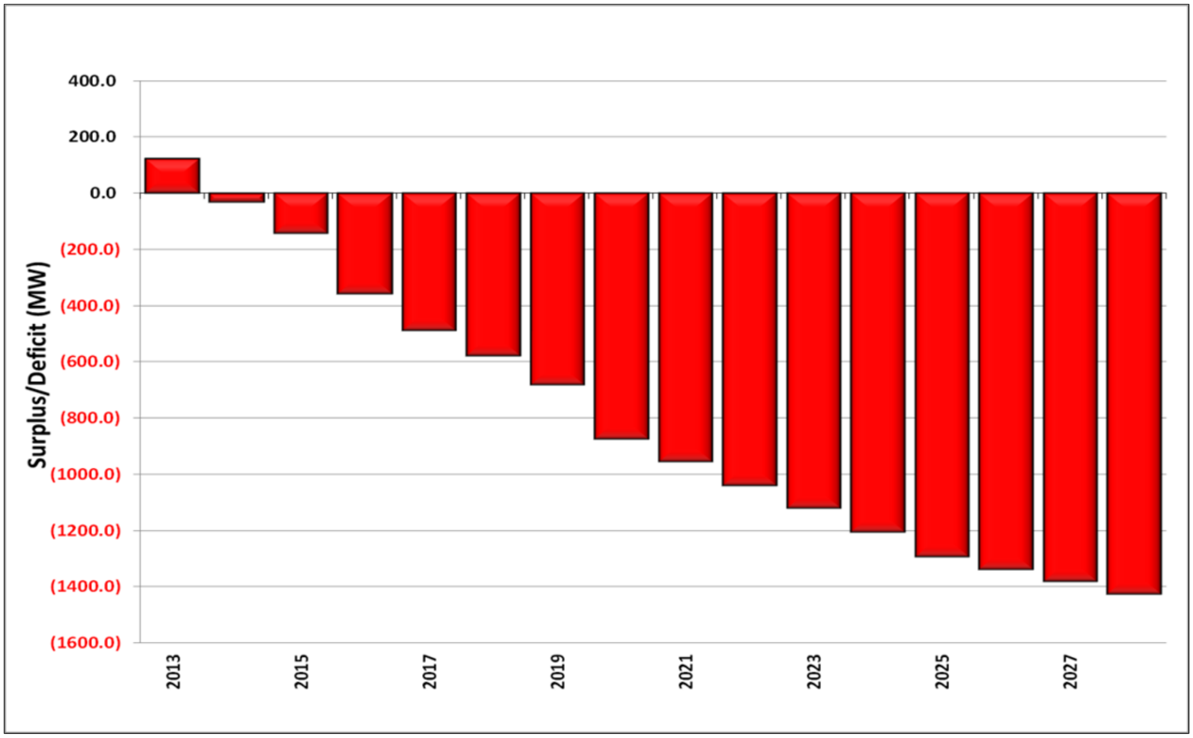


Figure 1-12 shows Basin Electric's eastern system summer season surplus capacity. Basin Electric's eastern system is forecasted to be in a deficit of 145 MW in 2015. This deficit is forecasted to grow greater year over year.

**Figure 1-12: East System Summer Surplus/Deficit Capacity**



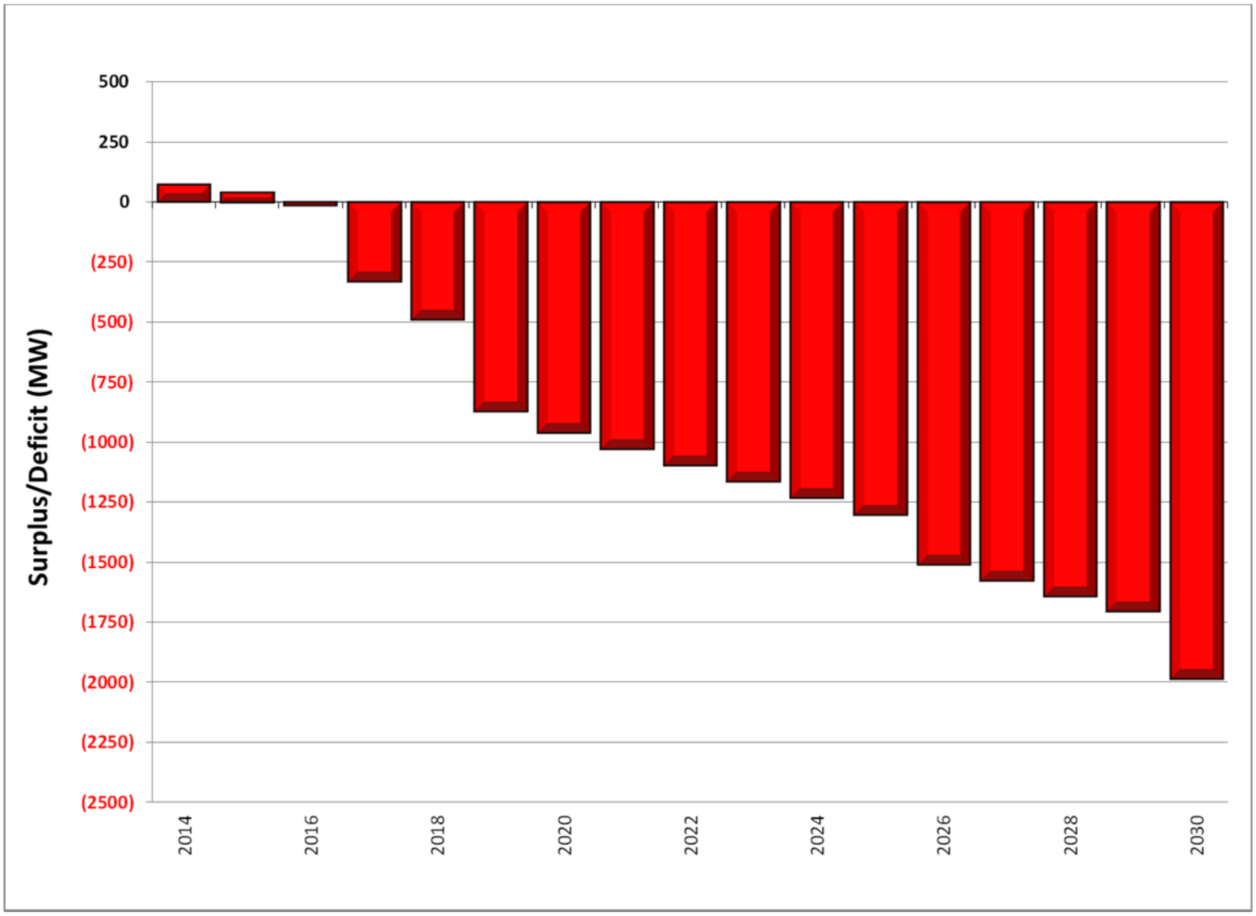

Basin Electric has access to alternating current (AC) to direct current (DC) ties to move power between the eastern and western systems. Transfers utilizing these DC ties are not incorporated into the graphs and would allow Basin Electric to move up to 240 MW of surplus west-side generation to the east, subject to the rights and capacity of the west-to-east ties. Available DC ties are the Rapid City DC Tie or the Stegall DC Tie.

Basin Electric's eastern system can be broken into three areas, the IS, the SPP, and the MISO. The IS is a transmission partnership between Western, Basin Electric, and HCPD. Starting October 1, 2015, the IS parties will each become members in SPP and the historical IS area will be known as the Upper Missouri Zone (UMZ).

Figure 1-13 shows Basin Electric's IS/SPP system. This is the portion of the eastern system showing the greatest growth over the forecasted period. This area encompasses the oil developing region known as the Williston Basin. Basin Electric also has assets that continue to retire throughout the study period, adding to the amount of deficit forecasted. This graph *does* include anticipated transfers across DC ties—the

Rapid City DC Tie and the Stegall DC Tie—to transfer power from the west to the east. The graph shows the IS/SPP to be deficit 13 MW in 2016 and deficit 329 MW by 2017. This deficit is forecasted to increase year over year, to 960 MW by 2020 and 2,000 MW by the end of the forecast period.

**Figure 1-13: IS/SPP System Surplus/Deficit Capacity**




If the DC Tie transfers are unavailable, or there is no surplus on the west to move east, the IS/SPP would show a deficit of 158 MW in 2015, and this deficit would continue to grow year over year.

### 1.3.6.2 Existing Transmission System

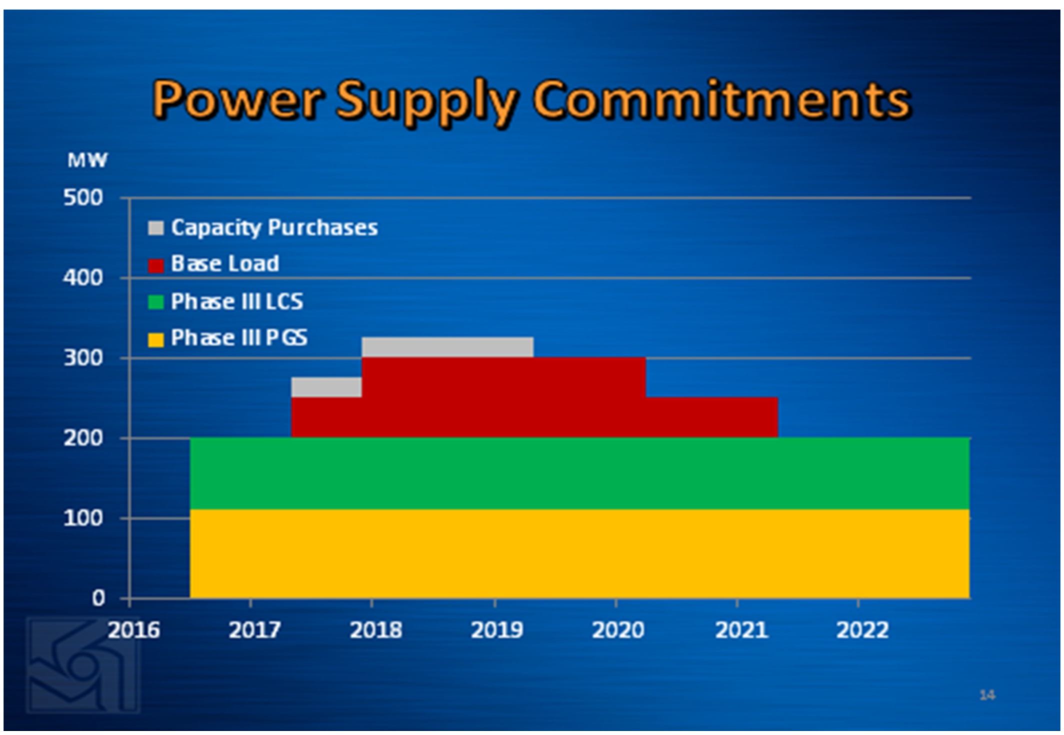
The high voltage transmission system into the Williston Basin area is very close to its maximum load serving capacity, in that the load serving ability of the area may be impacted until additional transmission facilities are built to bring power into the region or Basin Electric has the ability to start generation located within the area. Currently Basin Electric is in the process of building two 345-kV transmission lines. The first segment of the first line from the AVS to Judson Substation (with a tie to the Williston Substation just west of Williston) is scheduled to be completed October 31, 2015. The final segment of this line from Williston to Neset (east of Tioga) is scheduled to be completed October 31, 2017. The second 345-kV transmission line from the proposed Roundup to Patent Gate substations is scheduled to be completed October 31, 2016. Until these lines are completed, the growing load in this area will be constrained by transmission limitations and will limit the amount of load that can be served in the area without the support of local generation.

Basin Electric would need some portion of local generation in 2016 to help with transmission reliability issues in the Williston Basin area until the 345-kV transmission lines are completed. The local generation would also provide for support during transmission outages with the line in place as well as support if the load within the area grows faster than is currently forecasted. These resources contribute to the resource development needed to meet forecasted load growth across the Basin Electric system.

### 1.3.6.3 Power Supply Commitments

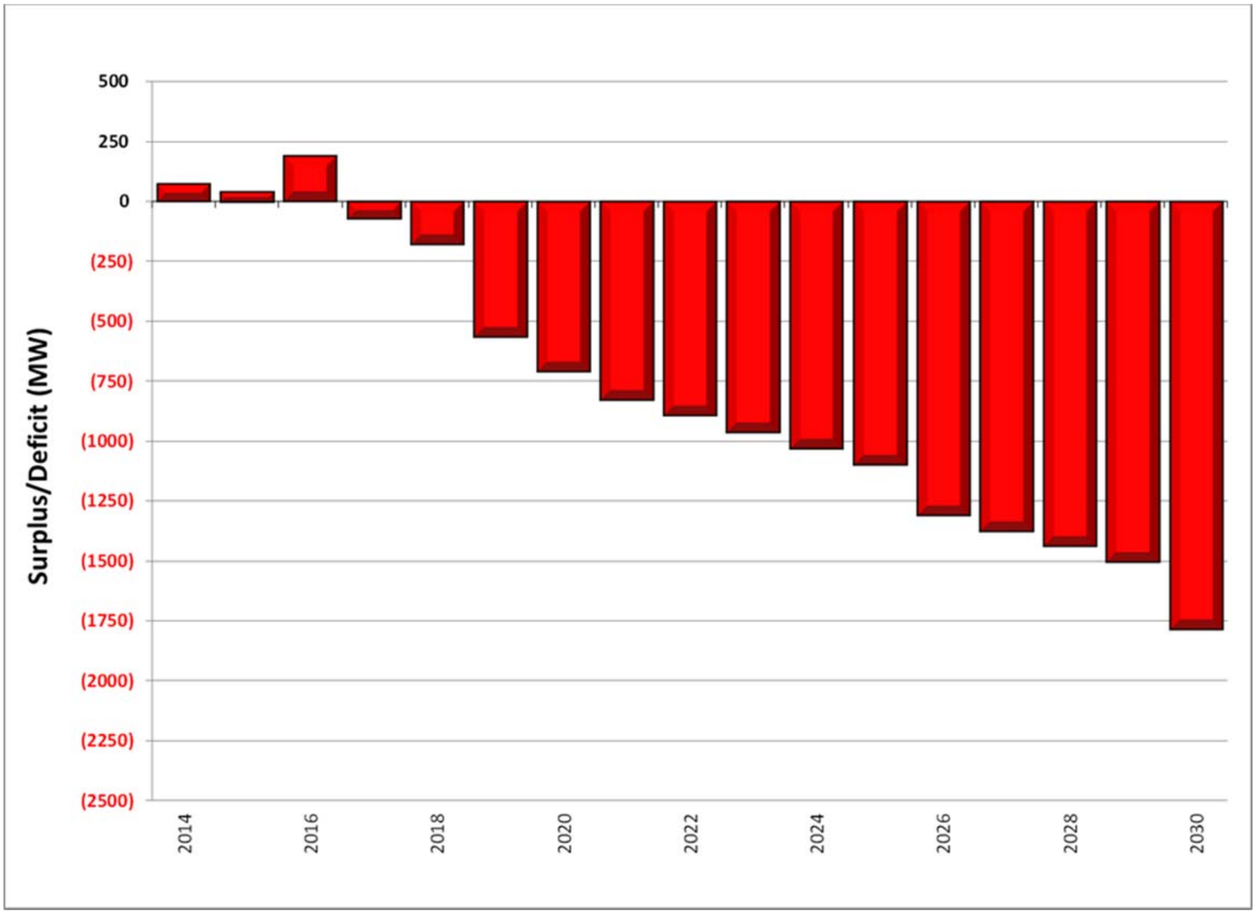
As a result of the integrated resource planning, commitments to power purchases and commitments to build new resources were made, including PGS Phase III and LCS Phase III. Figure 1-14 displays the magnitude of power purchase and new resource commitments that Basin Electric has made in SPP and MISO to meet the growing demand and provide an adequate supply of electrical power for the membership.

**Figure 1-14: Power Supply Commitments**



These commitments to power supply and the 2014 Load Forecast were used to create the updated system capacity graph, Figure 1-15. The purchases and generation fleet expansion pushed the previous first deficit of 13 MW in 2016 (Figure 1-15) to a first deficit of 70 MW in 2017 (Figure 1-15). Basin Electric continues to evaluate the best alternatives in resource planning to meet the substantial demand growth that is projected as well as monitor the load growth with a new load forecast to be completed in early 2015. As the load forecast materializes, additions to the purchases or generation fleet would be made to meet the quickly developing demand for electricity within Basin Electric's membership. Also, because of the size of the Basin Electric system, the significant amount of load growth, and a weather normalized load forecast, Basin Electric believes for prudent power supply planning, Basin Electric's generation portfolio should provide 100 to 150 MW of surplus capacity in the IS/SPP system.

**Figure 1-15: IS/SPP System Surplus/Deficit Capacity**




## 1.3.7 Cost

The cost of construction for the Project is estimated to be approximately $161.2 million.

### 1.3.8 Alternatives

The most economical means of supplying power to a load that varies every hour on an electric power system is to have three basic types of generating assets available for use. These generation assets are commonly referred to as baseload, intermediate, and peaking capacity.

A number of demand-side and supply-side resource alternatives have been considered as a means of meeting the forecasted electrical need for Basin Electric. The alternatives evaluated include:

- Demand-side Management
- Baseload Capacity
- Intermediate Capacity
- Peaking Capacity
- Purchased Power / Request for Proposal (RFP)

These alternatives are discussed below.

#### 1.3.8.1 Demand-side Management

Demand-side Management (DSM) is the process of managing the consumption of energy, generally to optimize available and planned generation resources. DSM refers to actions taken on the customer's side of the meter to change the amount or timing of energy consumption. DSM programs offer a variety of measures that can reduce energy consumption and consumer energy expenses. DSM strategies have the goal of maximizing end-use efficiency to avoid or postpone the construction of new generating plants.

DSM programs aim to achieve three broad objectives: energy conservation, energy efficiency, and load management. Energy conservation can reduce the overall consumption of electricity by reducing the energy required for heating, lighting, cooling, cooking and other energy-dependent functions. Energy efficiency encourages consumers to use energy more efficiently, thus more effectively. Load management allows generation companies to better manage the timing of their consumers' energy use and helps reduce the large discrepancy between on-peak and off-peak demand.

Basin Electric and its members use a variety of conservation and energy efficiency programs. The programs and activities were developed to promote, support, and market such technologies as efficient dual heat, water heaters, heat pumps, air conditioning, storage heating, grain drying, and irrigation. Other examples of programs are solar photovoltaic generation and energy audits. A number of Basin Electric's members have developed DSM programs. These vary depending on the cooperative; some elect to utilize rebates, others use energy resource conservation loans, variable rates, a combination, or elect not to adopt any of the programs.

Prior to 2011, Basin Electric surveyed its membership directly on all DSM activities and reported the information. Starting in 2011, Basin Electric adopted the new RUS and National Rural Utilities Cooperative Finance Corporation (CFC) energy efficiency information reported by Basin Electric's members on RUS Form 7 part P or CFC Form part S documents.

Energy conservation and efficiency programs can lessen the demand for electricity, therefore reducing the capacity needed from additional future generation facilities. However, energy savings through DSM are not enough to alleviate the need for additional peaking capacity resources.

#### 1.3.8.2 Baseload Capacity

Plants that run at baseload capacity run at full capacity continuously throughout the day and night, all year round. The output of baseload-type plants cannot be rapidly decreased or increased to "follow load." Baseload units are designed to optimize the balance between high capital/installation cost and low fuel cost, to give the lowest overall production cost under the assumption that the unit would be heavily loaded for most of its life. Typically, baseload capacity units operate at an 80 percent or more capacity factor. Coal-fired steam-cycle power plants, nuclear plants, and hydroelectric plants are examples of baseload generation capacity plants; however, hydroelectric plants that follow load are not baseload units. Some renewable forms of energy, such as geothermal, biomass power, biogas power, and municipal solid waste, are typically used in a baseload generation mode and are most cost-effective in this mode of operation. While baseload capacity units are being contemplated for inclusion in Basin Electric's resource expansion plan, because of the locality of the load area and the timing required for the new generation to be operational, baseload capacity units would not meet the immediate need for power in the Williston Basin.

#### 1.3.8.3 Intermediate Capacity

Intermediate capacity units are designed to be "cycled" at low load periods, such as evening and weekends. The units are loaded up and down rapidly to handle the load swings of the system while the unit is online. Typically, intermediate capacity units operate between a 20 and 80 percent capacity factor, or between baseload and peaking. Technologies for intermediate load plants include oil- or gas- fired steam-cycle plants, combined-cycle plants, some hydroelectric plants, and internal combustion engine generators.

Renewable generation such as wind, solar, and hydroelectric are intermediate resources. Wind and solar are intermittent resources whose operation cannot be scheduled. Their capacity factor is between 20 and 50 percent. Hydroelectric power generally operates between 40 and 50 percent capacity factor; however, it is very dependent on annual rainfall and therefore can have long periods of low generation.

While intermediate capacity units are being contemplated for inclusion in Basin Electric's resource expansion plan, because of the locality of the load area and the timing required for the new generation to be operational, intermediate capacity units would not meet the immediate need for power in McKenzie County and the Bakken oil field.

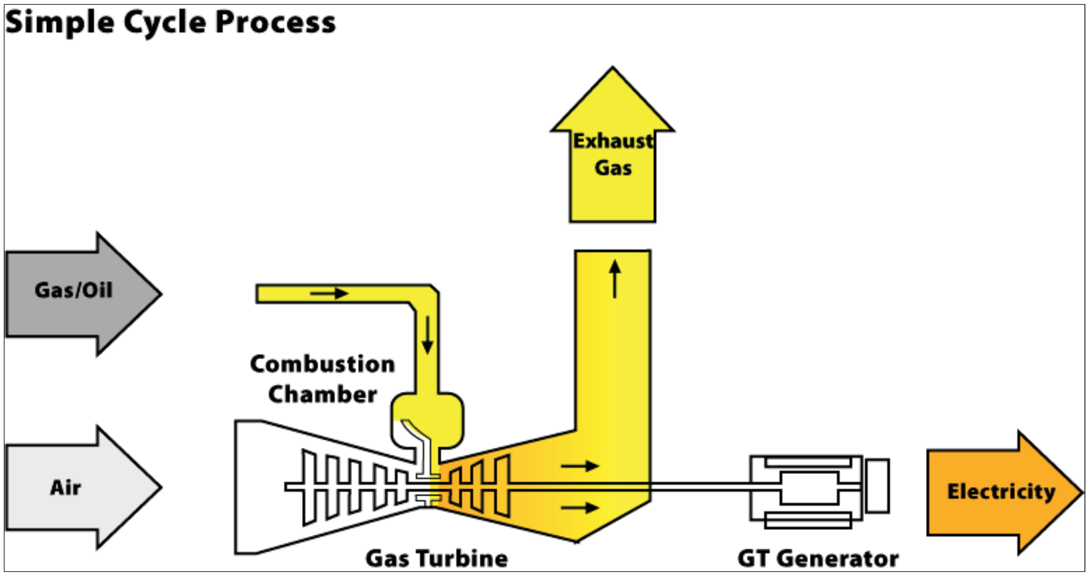
#### 1.3.8.4 Peaking Capacity

Peaking capacity units are only operated during peak load periods and during emergencies. Very low capital/installation costs are important due to the fact these units are typically not operated for long periods. The production costs are relatively high due to the high cost and volatility in the price of fuel; resulting in limited operation of these resources. Types of peaking capacity power plants include CTs, internal combustion engine plants, and pumped storage hydroelectric facilities. Typically, a peaking capacity unit is operated at a capacity factor of 20 percent or less. The LCS Phase III (the subject of a separate application) and PGS Phase III peaking generation units are proposed to meet a portion of Basin Electric's projected local generation requirement.

##### 1.3.8.4.1 Simple-cycle Combustion Turbine

Simple-cycle is a type of natural gas-fired CT generation unit. In SCCT operation, gas turbines are operated alone, without any recovery of the energy from the hot exhaust gases. SCCTs require relatively smaller capital investment than coal, nuclear, or combined-cycle natural gas plants, and SCCTs can be designed to generate small or large amounts of power. Also, the actual construction process can take as little as several weeks to a few months, compared to years for baseload power plants. Another main advantage of SCCTs is that they can be turned on and off within minutes, supplying power during peak demand or during transmission outages. They are usually operated only as peaking power plants, which primarily are used during the peak months and less than a total of 2,000 hours per year. A typical large SCCT may produce 45 to 150 MW of power and have 35 to 40 percent thermal efficiency. SCCTs are rarely used in baseload capacity units because of the lower heat rate efficiencies. Figure 1-16 shows a typical SCCT process flow diagram.

**Figure 1-16: Simple-Cycle Unit Process Flow Diagram**




There are two types of combustion gas turbines: heavy industrial “frame” machines and aero-derivative machines. Gas turbine power plants are pre-assembled at the factory, skid or baseplate mounted, and then shipped to the site along with other major components including the generator, cooling, lube oil, and electrical modules. Because they are pre-assembled and modular, field erection hours are significantly reduced, particularly as compared to a coal-fired plant.

The capital cost component of the levelized cost of SCCT power is approximately $51/MWh for a plant that runs at about 20 percent annual capacity factor. The total levelized cost of SCCT power is projected to be relatively high at approximately $104/MWh for about 1,750 hours of operation in a year or about 20 percent annual capacity factor. If a SCCT were operated at 80 percent annual capacity factor, the levelized cost of power would be about $66/MWh. Most of the power-generation cost for SCCT is from the variable fuel cost of approximately $48/MWh, assuming the cost of fuel is about $4.50/MMBtu. Natural gas cost is highly variable and strongly affected by the economy, production and supply, demand, weather, and storage levels. Weather and demand are large factors that affect gas prices and are unpredictable. Traditionally, demand for natural gas peaks in the coldest months, but with the nation’s power increasingly being generated by natural gas, demand also spikes in summer, when companies operate peaking plants to provide more power for cooling needs.

Permitting of SCCTs has an average time frame of 2 to 3 years. This permitting time frame is dependent on the type of machine selected and the area where it is constructed. The construction time for a simple-cycle unit is relatively short, ranging from 1 to 1.5 years. This is of course dependent on availability of units, transmission, and construction resources.

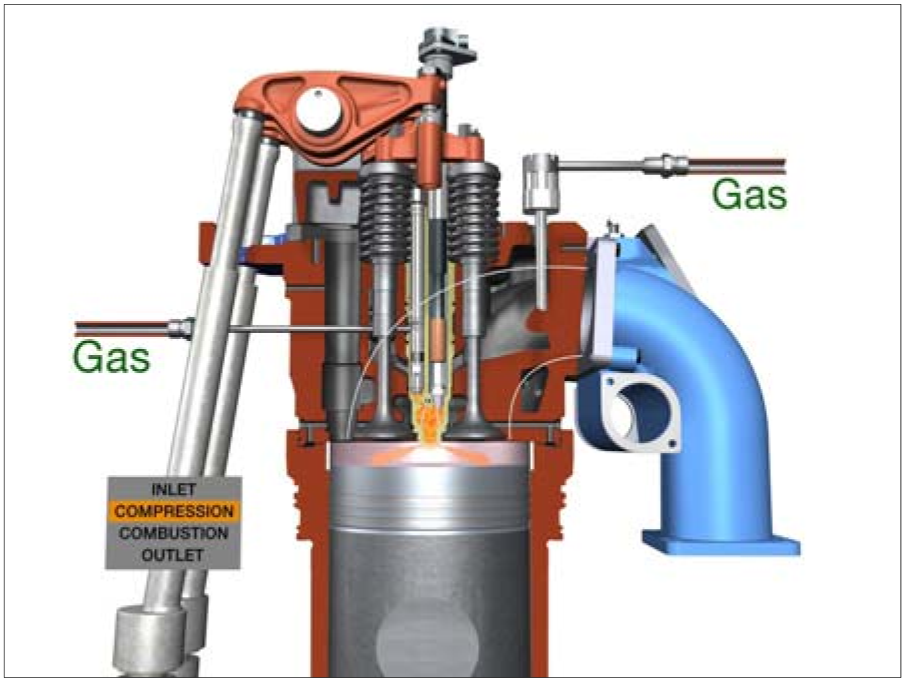
SCCT could fulfill Basin Electric's peaking power need or local generation need for the Williston Basin area. Natural gas prices are currently low and are projected to remain low for the foreseeable future. With the increased oil (and, as a result, natural gas) production in North Dakota and Montana, natural gas-fired generation is considered in Basin Electric's future resource portfolios.

#### 1.3.8.4.2 Reciprocating Internal Combustion Engine

RICE is a well-known technology used in automobiles, trucks, construction equipment, marine propulsion, and backup power applications. Reciprocating engines use the expansion of hot gases to push a piston within a cylinder, converting the linear movement of the piston into the rotating movement of a crankshaft to generate power. While the steam engines that powered the industrial revolution were driven by externally-produced steam, modern reciprocating engines used for electric power generation are internal combustion engines in which an air-fuel mixture is compressed by a piston and ignited within a cylinder. RICE engines are characterized by the type of combustion: spark-ignited or compression-ignited/diesel.

The spark-ignited engine is based on the Otto cycle and uses a spark plug to ignite an air-fuel mixture injected at the top of a cylinder. In the Otto cycle, the fuel mixture does not get hot enough to burn without a spark, which differentiates it from the diesel cycle. In diesel engines, air is compressed until the temperature rises to the auto-ignition temperature of the fuel. As the fuel is injected into the cylinder, it immediately combusts with the hot compressed air, expanding combustion gases that then push the piston to the bottom of the cylinder. Figure 1-17 shows a typical spark-ignited reciprocating engine process flow diagram.

**Figure 1-17: Spark-Ignited Reciprocating Engine During Compression Stroke**




RICE sizes for power generation range from 4 to 20 MW. In a power plant, many spark-ignited or diesel engines are grouped into blocks of engines, called generating sets, to provide modular electric generating capacity in standardized sizes (Figure 1-18). RICE power plants are highly efficient with simple-cycle efficiencies of 46 to 49 percent, surpassing the performance of steam electric or simple-cycle gas turbine power plants.

**Figure 1-18: Engine Hall at Goodman Energy Center in Kansas**

Also, the actual construction process can take as little as several weeks to a few months, compared to years for baseload power plants. The other main advantage of RICE is the ability to be turned on and off within minutes, supplying power during peak demand or during transmission outages.

Permitting of RICE units has an average time frame of 2 to 3 years. This permitting time frame is dependent on the type of machine selected and the area for construction. If it is on or near an environmentally protected area, this time frame could increase. The construction period for a RICE unit is relatively small, 1 to 1.5 years. This is of course dependent on availability of units, transmission, and construction resources.

RICE units could fulfill Basin Electric's peaking power need or need for local area generation to the Williston Basin area. Natural gas prices are currently low and are projected to remain low for the foreseeable future. With the increased oil (and, as a result, natural gas) production in North Dakota and Montana, natural gas-fired generation is considered in Basin Electric's future resource portfolios.

### 1.3.8.5 Purchase Power/Request for Proposals

Basin Electric developed and issued a RFP in mid-2013 for short- and long-term power supply on its eastern system. The long-term proposals were used to evaluate against Basin Electric's self-build options. The short-term proposals could be used to meet some of Basin Electric's need in the next couple of years.

Basin Electric received 10,605 MW of power supply proposals. Basin Electric evaluated the short- and long-term proposals and shortlisted the total number of qualifying bids to 21 bids totaling 2,669 MW.

The details of these shortlisted proposals were evaluated in power supply modeling software, along with Basin Electric's self-build options, and were included in the future resource portfolio modeling runs. If the model indicates an option is justified to move forward, Basin Electric would further evaluate that option.

#### 1.3.8.6 Summary of Alternatives

Basin Electric would need additional quick start, local generation in 2016 to help with transmission load-serving issues in the Williston Basin area until the 345-kV transmission line from Antelope Valley Station to Williston (via a connection to the new Judson Substation) to Tioga (via a connection to the new Neset Substation) is completed. The generation types that are capable of meeting Basin Electric's local generation need should be constructed in the area and in the time frame required to service the increased load. Based on these parameters, either SCCT or RICE engines are the best alternative.

Of the resource expansion portfolios produced using Basin Electric's software modeling and load serving analysis, the preferred portfolio included 200 MW of peaking resources located in the heart of the Williston Basin where the needed generation would be provided by both the PGS Phase III and LCS Phase III. This generation would provide additional reliability benefits during transmission outages and system-wide generation shortfalls and would provide a contingency if the load in the Williston Basin region grows faster than is currently forecasted. Both the PGS and LCS sites were selected for development of additional generation. As currently configured, development of all necessary generation at only one site would create additional infrastructure needs such as water supply, gas supply, and electricity connections, resulting in increased potential environmental impacts and construction schedules. By developing both sites for lower levels of generation capacity, Basin Electric is able to more efficiently use the existing infrastructure at each site, reducing potential environmental impacts, and maintaining a commercial operation date of 2016.

RICE generation, providing up to approximately 111 MW of the identified 200 MW requirement, would be placed at the existing PGS site near Williston, North Dakota. The PGS is an existing 135 MW peaking station with areas designated for growth.[1]

[1] The expansion of the LCS to provide additional generation is the subject of another Application.

Three GE-LM6000PC (water injected NOx control) units are currently operating at PGS. The natural gas fuel supply at PGS is rich in ethane and propane, which is incompatible with the dry GE-LM6000PF units that are located at LCS. The water injected GE-LM6000PC units are capable of combusting this fuel. However, operating experience on the GE-LM6000PC has shown that protecting water lines from freezing is problematic, making the units less reliable. Further, the water must be treated to a high level of purity, adding significantly to the variable operating cost, thus making them less economical. The water treatment system at PGS is currently operating at capacity and would require extensive upgrade to serve additional GE-LM6000PC units.

Twelve 9.34-MW natural gas RICEs are proposed to be constructed at the PGS, for a total addition of 111 MW. RICEs are capable of combusting the fuel rich in ethane and propane without using water. Further, because of the small capacity of each engine, there is a high degree of inherent redundancy and flexibility. The units are all the same, resulting in operating and maintenance efficiencies such as reduced spare parts inventory, little additional employee training, and simplified maintenance scheduling. Additionally, depending on demand, anywhere from zero to all 12 units can operate, enabling load requirements to be met in 9.34 MW intervals, rather than powering up a much larger unit and running at only partial capacity. These factors help increase the operational efficiencies and reliability of the facility.

RICE are more efficient than the GE-LM6000PC, but at a higher capital cost. The GE-LM6000PC has the added cost for the water treatment activities. Considering these factors, the total lifetime cost of the two technologies is very similar for the capacity factor these units are expected to run.

The operation of a 9.34 MW RICE provides the added benefit of operating in a more efficient operating zone, than a larger CT. A larger 40 to 45 MW CT has an increased likelihood of being operated at half-load and, thus, a less efficient operating level.

### 1.3.9 Ten-Year Plan

Basin Electric filed a Ten-Year Plan with the Commission in June 2014. The PGS Phase III Project is consistent with the Ten-Year Plan on file with the NDPSC.

# 2.0 SITE COMPATIBILITY CRITERIA

Basin Electric determined that additional quick-start generation was required in the heart of the Williston Basin to help with transmission load serving issues. This generation is required on an expedited schedule to meet the growth needs in the area; it needs to be commercially operational in 2016. As a result, Basin Electric conducted a site selection investigation focused on identifying a site, in compliance with North Dakota Administrative Code (NDAC) Section 69-06-08-01, that would meet the project need requirements. This investigation included potential sites throughout the Williston Basin. The site selection included an inventory and suitability analysis of criteria listed in NDAC Section 69-06-08-01, including exclusion and avoidance area criteria; selection criteria that relate to minimizing potential land use and environmental impacts; policy criteria that relate to maximizing public benefits; and design and construction limitations. Basin Electric also included economic considerations as part of the analysis.

## 2.1 Site Selection

Recognizing that additional generation was required in the Williston Basin in the very near future, Basin Electric conducted an investigation of the northwestern area of North Dakota to identify a suitable site for project construction. The guiding considerations in this investigation included:

- Adhering to NDAC Section 69-06-08-01
- Minimizing additional infrastructure development (electricity transmission line connections, gas pipeline development, water pipeline development)
- Using existing facilities to minimize environmental and land use impacts and avoid the need for additional property acquisition
- Minimizing site development cost and time

Basin Electric investigated numerous potential sites for the proposed Project. These sites included expansion of existing energy conversion facilities to accommodate the RICE engines at:

- Lonesome Creek Station
- Pioneer Generation Station
- Culbertson Generation Station

Basin Electric also considered development of new, greenfield sites in the Tioga, Williston, Watford City, and Killdeer areas.

Siting investigations identified PGS and LCS as the preferred sites for additional generation development. Infrastructure and space at both sites were determined suitable for development of additional generation. Both sites would allow use of existing generation facilities with minimal, if any, additional infrastructure development; would minimize land use, environmental, and socioeconomic impacts; and would not require additional land acquisition or changes in zoning. Environmental permitting investigations previously had been completed for both sites, and no environmental issues or concerns were identified.

The ability to use existing infrastructure made the expansion of the LCS and PGS the most economic sites for development of additional generation. The limited overall impacts and construction required to develop these sites provide opportunities to shorten permitting and construction schedules in order to attain commercial operation within the required time frame. Basin Electric, therefore, selected both the PGS and LCS sites for development of additional generation. The expansion of the PGS site to included RICE engines is addressed by this application. Construction of additional generation at the LCS site is the subject of a separate application.

During site selection investigation, Basin Electric considered the exclusion and avoidance areas and selection criteria identified in the NDAC. These factors as they apply to the PGS site are summarized in the following sections.

## 2.2 Exclusion Areas

Per NDAC Section 69-06-08-01(1), the geographic areas listed in

Table 2-1 shall be excluded in the consideration of an energy conversion facility and shall include a buffer zone of reasonable width to protect the integrity of the area.

**Table 2-1: Exclusion Areas**

| Geographic Area | Present within Project Site | Section Addressed |
|---|---|---|
| Designated or registered national: parks; memorial parks; historic sites and landmarks; natural landmarks; historic districts; monuments; wilderness areas; wildlife areas; wild, scenic, or recreational rivers; wildlife refuges; and grasslands | Not present | 4.9, 4.10 |
| Designated or registered state: parks; forests; forest management lands; historic sites; monuments; historical markers; archaeological sites; grasslands; wild, scenic, or recreational rivers; game refuges; game management areas; management areas; and nature preserves | Not present | 4.9, 4.10 |
| County parks and recreational areas; municipal parks; and parks owned or administered by other governmental subdivisions; hardwood draws; and enrolled woodlands | Not present | 4.4.1.1, 4.10 |
| Prime farmland and unique farmland, as defined by the land inventory and monitoring division of the soil conservation service, U.S. Department of Agriculture, in 7 CFR 657; provided, however, that if the NDPSC finds that the prime farmland and unique farmland that will be removed from use for the life of the facility is of such small acreage as to be of negligible impact on agricultural productions, this exclusion does not apply | Negligible | 4.11, 4.12 |
| Irrigated lands | Not present | 4.3, 4.11 |
| Areas critical to the life stages of threatened or endangered animal or plant species | Not present | 4.18 |
| Areas where animal or plant species that are unique or rare to this state would be irreversibly damaged | Not present | 4.18 |
| Areas within 1,200 feet of the geographic center of an intercontinental ballistic missile launch or launch control facility | Not present | 4.3 |

## 2.3 Avoidance Areas

Per NDAC Section 69-06-08-01(3), the geographic areas listed in Table 2-2 shall not be considered in the siting of an energy conversion facility unless the applicant shows that under the circumstances there is no reasonable alternative. In determining whether an avoidance area should be designated for a facility, the NDPSC may consider, among other things, the proposed management of adverse impacts, the orderly siting of facilities, system reliability and integrity, the efficient use of resources, and alternative routes. Economic considerations alone shall not justify approval of these areas. A buffer zone of a reasonable width to protect the integrity of the area shall be included unless a distance is specified in the criteria. Natural screening may be considered in determining the width of the buffer zone.

**Table 2-2: Avoidance Areas**

| Avoidance Area | Present within Project Site | Section Addressed |
|---|---|---|
| Historical resources which are not specifically designated as exclusion areas | Not present | 4.9 |
| Areas within the city limits of a city or the boundaries of a military installation | Not present | 4.3 |
| Areas within known floodplains as defined by the geographical boundaries of the 100-year flood | Not present | 4.14 |
| Areas that are geologically unstable | Not present | 4.13 |
| Woodlands and wetlands | Not present | 4.11, 4.15 |
| Areas of recreational significance which are not designated as exclusion areas | Not present | 4.10 |

## 2.4 Selection Criteria

Per NDAC Section 69-06-08-01(5), a site shall be designated only when it is demonstrated to the NDPSC by the applicant that, for select criteria, any significant adverse effects resulting from the location, construction, and maintenance of the facility would be at an acceptable minimum, or that those effects would be managed and maintained at an acceptable minimum (

Table 2-3).

**Table 2-3: Selection Criteria**

| Selection Criteria | Potential Adverse Effects | Section Addressed |
|---|---|---|
| Agricultural production | None | 4.3, 4.11 |
| Family farms and ranches | None | 4.11 |
| Land which the owner can demonstrate has soil, topography, drainage, and an available water supply that cause the land to be economically suitable for irrigation | None | 4.11, 4.12 |
| Surface drainage patterns and ground water flow patterns | None | 4.12, 4.13, 4.14 |
| The agricultural quality of the cropland | None | 4.3, 4.11 |
| Law enforcement | None | 4.4 |
| School systems and education programs | None | 4.4 |
| Governmental services and facilities | None | 4.4 |
| General and mental health care facilities | None | 4.4 |
| Recreational programs and facilities | None | 4.4, 4.10 |
| Transportation facilities and networks | None | 4.4 |
| Retail service facilities | None | 4.4 |
| Utility services | None | 4.4 |
| Local institutions | None | 4.4 |
| Noise-sensitive land uses | None | 4.7 |
| Rural residences and businesses | None | 4.3 |
| Aquifers | None | 4.13 |
| Human health and safety | None | 4.5 |
| Animal health and safety | None | 4.11, 4.17, 4.18 |
| Plant life | None | 4.11, 4.16 |
| Temporary and permanent housing | None | 4.2 |
| Temporary and permanent skilled and unskilled labor | None | 4.2 |

## 2.5 Policy Criteria

Per NDAC Section 69-06-08-01(6), the NDPSC may give preference to an applicant that would maximize benefits that result from the adoption of certain policies and practices, and in a proper case may require the adoption of such policies and practices (

Table 2-4). The NDPSC may also give preference to an applicant that would maximize interstate benefits.

**Table 2-4: Policy Criteria**

| Policy Criteria | Suitable Policy or Practice of Applicant | Section Addressed |
|---|---|---|
| Recycling of the conversion of byproducts and effluents | No byproducts or effluents would be created by this facility. | 1.0, 3.0 |
| Energy conservation through location, process, and design | Basin Electric's policy is to locate and design to minimize environmental impacts and utilize existing developed sites. | 1.0, 3.0 |
| Training and utilization of available labor in this state for the general and specialized skills required | Basin Electric would use local labor to the extent practicable. | 4.2.2 |
| Use of a primary energy source or raw material located within the state | Basin Electric would use natural gas from within the state to the extent practicable. | 1.0, 3.0 |
| Not relocating residents | No residents would be relocated for the Project. | 4.2.2 |
| The dedication of an area adjacent to the facility to land uses such as recreation, agriculture, or wildlife management | Areas outside of the generation facility that are not required to support the PGS would continue to be used for agricultural purposes. | 4.11.2.1 |
| Economies of construction and operation | The Project creates economies of construction and operation by constructing the facility in a location with existing infrastructure such as the highways, transmission line, gas line, and other industrial facilities (adjacent ONEOK Stateline I processing plant). | 4.2.2 |
| Secondary uses of appropriate associated facilities for recreation and the enhancement of wildlife | The Project does not include associated facilities that would be appropriate for recreation or wildlife enhancement. | 1.1, 3.0 |
| Use of citizen coordinating committees | The use of citizen coordinating committees is not expected for this Project. | N/A |
| A commitment of a portion of the energy produced for use in this state | The Project would meet the need for additional electric generation capacity in northwestern North Dakota as a result of increased demand and would meet reliability and system stability requirements for the region. | 1.3 |
| Labor relations | No labor relations would be negatively affected by the Project. | 4.2.2 |
| The coordination of facilities | New right of way corridors would not be needed for construction or operation of the PGS Phase III Project | 1.2.1 |

| | | |
|---|---|---|
| Monitoring of impacts | Basin Electric would use Best Management Practices (BMPs) during construction to minimize environmental impacts and would monitor construction compliance with the commitments made in this application and applicable permit conditions, including the NDPSC's Order. | 4.5.3.2, 4.6.3, 4.12.3, 4.13.3, 4.14.3, 4.16.3, 4.17.3 |

## 2.6 Design and Construction Limitations

Project construction and design would meet the requirements of the National Electrical Safety Code (NESC), Basin Electric design criteria, and other applicable local or national building codes.

## 2.7 Economic Considerations

There are many economic considerations in the design and siting of a power generation facility. Basin Electric has designed the Project to take advantage of the proximity to existing energy supplies (natural gas from the adjacent ONEOK Stateline I Gas Processing Plant), Sheridan Electric Cooperative's adjacent 115-kV line, and MWEC's Stateline I Substation for energy delivery in an area with existing roadways. In general, siting the PGS Phase III Project on a previously zoned industrial site (existing PGS site) minimizes impacts to the surrounding community. Additionally, the close proximity to complementary facilities (energy acquisition and energy distribution) creates efficiency and condenses the development into a compact area.

# 3.0 LOCATION, PROPOSED FACILITY PROCESS DESCRIPTION, AND RESTORATION PROCEDURES

## 3.1 Location

The proposed facility would be located approximately 15 miles northwest of the City of Williston in the southeast quarter of Section 20, Township 155 North, Range 103 West; Hebron Township; Williams County; North Dakota (Figure 3-1). The permanent PGS Phase III facilities would occupy approximately 12.5 acres, along with the existing 7.1 acres occupied by PGS Phases I and II, on the existing 120-acre PGS energy conversion facility property. The new facilities would be installed adjacent and to the south of the three existing turbines onsite. The 12.5-acre site would include approximately 8.2 acres for the new gas engines, approximately 3.4 acres for the new switchyard, and approximately 0.9 acre for the new stormwater retention pond. Basin Electric owns the entire 120-acre parcel on which the PGS energy conversion facility is located; areas not developed are leased for agriculture and used for crop production. Figures 3-2 and 3-3 show the proposed Project facilities on topographic and aerial mapping.

## 3.2 Facility Process Description

The proposed Project would include up to 12 nominal 9.34-MW gas engines with a nominal gross electrical output of 111 MW. The engines would be turbo-charged 4SLB engines. The proposed Project is designed to meet variable electrical demands from as low as 3 MW to as high as 111 MW if all engines are in service. The engines would combust natural gas and, in case of natural gas curtailment, the engines would combust LPG as a back-up fuel. A site layout diagram has been included in Appendix A.

For the 12 engines, there would be a total of 2 stacks; 6 engines would be vented to each stack. To control emissions of $NO_x$, each engine would be equipped with SCR systems and lean-burn combustion systems. To minimize the emissions of $SO_2$, $H_2SO_4$ mist, and $PM/PM_{10}/PM_{2.5}$, the engines would be controlled through the use of low-sulfur/low-ash fuels and good combustion practices. Emissions of CO and VOC would be controlled through the use of good combustion practices as well as an oxidation catalyst (also referred to as a CO catalyst). GHG gas emissions would be minimized with the use of efficient lean-burn engines and the use of natural gas fuel.

**Figure 3-1: Project Location**

**Figure 3-2: Site Layout – topographic**

Figure 3-33: Site Layout – aerial

Auxiliary equipment for the 12 gas engines would include a dew point heater, an emergency fire pump, an emergency generator, an LPG vaporizer, fuel storage tanks, and circuit breakers, described as follows:

- *Dew Point Heater* – One 2.5 MMBtu/hr dew point heater would be installed to maintain the temperature of the natural gas that would be combusted in the engines, in compliance with the manufacturer's recommendations for fuel quality parameters.
- *Emergency Fire Pump* – An emergency fire pump would be installed for use in case of fire. The emergency fire pump may be tested each week to confirm that it is working properly and for maintenance. The fire pump would have a maximum output of 197 hp and would be operated solely on ULSD.
- *Emergency Generator* – An 800-kW emergency generator would be built to support the plant safety and control features in case of a power interruption. The emergency generator would be operated solely on ULSD fuel.
- *LPG Vaporizer* – An LPG vaporizer would be used to convert liquid propane into gaseous propane if LPG is utilized at PGS Phase III. A vaporizer eliminates re-condensation of vapor in the supply lines and provides a constant supply of propane vapor even at very low temperatures. The LPG vaporizer is similar to a boiler that does not build pressure. Liquid propane enters the vaporizer and exits as a gas.
- *Fuel Storage Tanks* – The Project would include two small diesel storage tanks: one 20-gallon tank to provide fuel to the emergency fire pump and one 200-gallon tank to provide fuel to the emergency generator. In addition, two LPG tanks would be added to the site to store the back-up fuel for the engines.
- *Circuit Breakers* – Eleven 115-kV circuit breakers would be required for the switchyard located at the site. Each of these circuit breakers would contain $SF_6$. $SF_6$ is regulated as a GHG with a global warming potential of 22,800. The circuit breakers would be sealed.

The proposed Project would require six additional full-time employees to operate the PGS. A new power generation building, warehouse, fire water pump house, and urea and lube oil pump enclosure would be constructed on the PGS property for the Project. Additional tanks to be installed onsite would include a fire protection water tank, urea storage tank, new engine oil tank, used engine oil tank, maintenance engine oil tank, underground oily waste tank and, if required, LPG storage tanks.

The existing PGS consists of three GE LM6000 natural gas-fired SCCTs. Each of the SCCTs has a nominal maximum rating of 46 MW. The facility is designed to be operated locally at the site or remotely from either Basin Electric's Culbertson Station located near Culbertson, Montana, or Basin Electric's Headquarters located in Bismarck, North Dakota.

Natural gas is supplied to PGS by a WBI Energy Transmission, Inc., 1,800-foot long, 8-inch-diameter pipeline that originates at ONEOK's Stateline I Gas Processing Plant gas interconnection to the Northern Border Pipeline. ONEOK's Stateline I Gas Process Plant is located adjacent to PGS, east of County Road 5 (151st Avenue NW). The existing pipeline is large enough to provide for the 12 proposed gas engines in addition to the 3 existing turbines. An additional approximately 711 feet of 6-inch-diameter pipeline would be required to deliver natural gas from the PGS metering station to PGS Phase III.

The electrical interconnection for the PGS is a 0.5-mile-long, 115-kV transmission line to MWEC's Stateline I Substation, which is located adjacent to ONEOK's Stateline I Gas Processing Plant. A new electrical switchyard would be constructed on the PGS site (adjacent to the proposed gas engines) to deliver power from the new engines to the electrical grid. The existing Sheridan Electric Cooperatives 115-kV line that interconnects to the Stateline Substation would be re-directed to the new PGS III electrical switchyard.

## 3.3 Restoration Procedures

During construction, crews would limit ground disturbance wherever feasible. Temporary disturbance areas, including two areas for material laydown yards and construction parking (1.2 and 5.9 acres in size) would be restored to their original condition to the extent practicable. Reclamation activities include removing and disposing of debris, dismantling all temporary facilities (including staging and temporary material storage areas), and leveling or filling tire ruts. Erosion control measures would be implemented during construction to minimize runoff into the PGS stormwater pond. Erosion control measures such as silt fence, rock checks, flow diverters, mulching, seeding, or mesh fabric overlay would be installed when and where appropriate.

# 4.0 ENVIRONMENTAL ANALYSIS

## 4.1 Overview

This section describes the existing environmental setting in the planned area of disturbance (including the 8.2-acre gas engine site and 3.7-acre switchyard site), and discusses potential impacts associated with construction and operation of the proposed Project. When applicable to a specific resource, the larger 120-acre PGS property and surrounding vicinity are also discussed. For each resource, a general environmental setting description is provided, followed by a discussion of potential impacts and potential mitigation measures proposed to address the impacts.

The existing plant site was previously disturbed for construction of PGS Phases I and II. PGS Phase I (Unit 1) was non-jurisdictional with regard to the NDPSC Siting Act because the generation capacity (45 MW) and the associated 115-kV transmission line were both below jurisdictional levels. The NDPSC issued a Site Compatibility Certificate (PU-12-509) for Phase II (Units 2 and 3) in March 2013. The 120-acre PGS property was rezoned from Agricultural to Industrial for development of the previous phases.. In addition, Basin Electric obtained conditional use permits from Williams County to construct PGS I and PGS II. PGS Unit 1 started commercial operation in September 2013, Unit 2 started commercial operation in February 2014, and Unit 3 started commercial operation in March 2014.

The description of resources subsections describe the resources and environmental settings found on the Project site and in the vicinity. The impact discussion subsections describe the potential effects on each resource from the construction and operation of the Project. The mitigation discussion subsections provide potential measures to reduce or eliminate anticipated impacts identified for each resource. Mitigation measures are not discussed for identified potential effects that are either not anticipated to occur under construction or operation of the Project or are anticipated to result in a beneficial effect.

Standard mitigation measures have been incorporated into the development and construction of the proposed Project. These mitigation measures are designed to reduce or eliminate anticipated impacts resulting from construction or operation. They include Best Management Practices (BMPs) such as the use of silt fencing and other erosion-control measures.

## 4.2 Demographics and Socioeconomics

### 4.2.1 Description of Resources

The Project is located within an area in northwestern North Dakota with relatively low population density. Population data for this section was taken from the U.S. Census Bureau 2008-2012 American Community Survey (ACS) 5-Year Estimates.

The 2012 population of Williams County is 23,287. The county seat of Williams County is the City of Williston, which is the closest city to the proposed facility and has a 2012 population of 15,553. The Project site is located in Hebron Township, which has a 2012 population of 66. U.S. Census Bureau population estimates for 2013 suggest that Williams County is experiencing rapid population growth, with a 2013 population estimate of 29,595, an increase of 27 percent from 2012 to 2013. The population of the City of Williston also grew rapidly over this same time period, increasing 34 percent to an estimated 20,850 in 2013.

**Table 4-1: 2012 Population and Economic Characteristics**

| Location | Population | Per Capita Income | Below Poverty Level |
|---|---|---|---|
| Williams County | 23,287 | $35,824 | 8.1% |
| Hebron Township | 66 | $40,682 | 0.0% |
| City of Williston | 15,553 | $35,658 | 8.8% |

Source: U.S. Census Bureau 2008-2012 American Community Survey 5-Year Estimates Data

According to the 2008-2012 ACS 5-Year Estimates, the largest industry category employing residents of Williams County was agriculture and mining (including oil and gas extraction), followed by education and healthcare, and then retail trade.

### 4.2.2 Impacts

Construction of the proposed Project could temporarily stimulate additional jobs in the construction trades such as electricians, laborers, and carpenters. Basin Electric would use local labor to the extent practicable, and no labor relations would be negatively affected by the Project. Peak construction labor force for the PGS Phase III Project would be approximately 225 employees. With an estimated construction schedule of 10.5 months, length of employment would range from a few weeks to several months, dependent on skill and/or specialty. The majority of construction contractors and workers would temporarily relocate to the Project area as construction of the Project would require a specialized workforce. A small number of local construction workers could be hired for more general activities such as grading and earthwork. However, due to the tight labor market in the region and low unemployment rates, it is anticipated that the majority of the construction workforce would come from outside the region. Gas stations, convenience stores, and restaurants in communities such as the City of Williston may experience minimal increases in business during the construction period in response to activity from construction workers.

Many of the construction workers would seek temporary housing for varying time periods based on their individual roles in the proposed Project. Generally, housing options for construction crews would consist of area hotels, existing crew camps, or RV camps. Arrangement for longer-term housing may be established by the construction contractor, with crews rotating in and out as their assignments begin and are completed.

Significant growth has occurred throughout the Williston Basin as a result of development of the Bakken shale oil and gas. This growth has contributed to a dramatic increase in workers to the area that has in the past, strained the available resources, including lodging, in the area. However, over the past months, considerable housing has been developed in the form of additional hotels, man-camps and apartments. While the lodging market is still tight and has few vacancies, it continues to development and increase capacity. It is anticipated that there would be an adequate supply of temporary housing units available in Williams County for use by construction workers relocating to the area on a temporary basis due to the relatively few workers necessary compared to the overall workforce in the area and the continued development of housing capacity in the area.

The proposed Project would require six additional full-time employees to operate the PGS. Because of the low number of personnel required, operation of the proposed Project would not result in a large increase in the number of permanent residents in the communities near the site.

The PGS Phase III Project would provide estimated annual property taxes of $154,100. Expenditures made for equipment, fuel, operating supplies, and other products and services would benefit businesses in the county and State of North Dakota. Businesses and oil/gas development near the site would not be disrupted by construction or operation of the Project as Basin Electric currently owns all the property that is part of the Project. Only the ONEOK Stateline I gas processing plant across Highway 5, the only business in the Project vicinity, would potentially be affected during Project construction from increased traffic. Any effects would be minimal and temporary during construction. Overall, regional businesses would benefit from the continued reliability of the electrical system.

### 4.2.3 Mitigation

Socioeconomic impacts associated with the PGS Phase III are expected to be positive, with an influx of wages and expenditures made at local businesses during the construction period. Operation of the proposed Project would create six additional jobs and would result in reliable power supply for the region. Therefore, no mitigation is proposed.

## 4.3 Land Use

### 4.3.1 Description of Resources

Current land uses on the 120-acre PGS property are industrial and agricultural. The existing turbines occupy approximately 7.1 acres on the property. Areas of the property not currently developed as part of power generation activities  are leased for agriculture and used for crop production. Land to the east of the PGS property (east of County Road 5) is industrial and includes ONEOK's Stateline I Gas Processing Plant and MWEC's Stateline I Substation. The surrounding area consists of rural agricultural land used for crops and grazing cattle (see Figure 3-1). Oil and gas wells and associated energy development infrastructure are also located throughout the area. The PGS is not within a city limit or an area of military installation and would not displace any residences or existing or planned industrial facilities.

Basin Electric obtained conditional use permits for PGS I and II. The entire 120-acre PGS property was rezoned from Agricultural to Industrial. PGS Unit 1 started commercial operation in September 2013, Unit 2 started commercial operation in February 2014, and Unit 3 started commercial operation in March 2014.

### 4.3.2 Impacts

The new gas engines and switchyard would occupy approximately 12 acres on the existing 120-acre PGS property and would be installed adjacent to the three existing turbines onsite (Figure 3-2). Construction of the Project would result in the conversion of 12 acres of agricultural land to industrial use. However, this portion of the property is zoned Industrial; thus, the change in land use would be consistent with current zoning. Areas outside of the generation facility that are not needed to support the PGS would continue to be used for agricultural purposes.

Approximately 7.2 acres of the Basin Electric property would be used for laydown area. This would include a 1.1-acre laydown yard south of the existing facility and north of the proposed Project; a 4.8-acre laydown yard south of the proposed Project; and a 1.3-acre construction parking area. These areas would be temporarily unavailable for agricultural purposes during construction. Following construction, these areas would be restored to their original condition to the extent practicable and would be available again for agricultural purposes.

As required by Williams County, Basin Electric would apply for and obtain a conditional use permit from to construct the additional PGS Phase III facilities.

#### 4.3.3 Mitigation

Since the site has already been designated for development as part of PGS, no mitigation efforts are necessary.

## 4.4 Public Services

### 4.4.1 Description of Resources

#### 4.4.1.1 Local Services – General Discussion

The PGS is located in a low population density, rural area in northwestern North Dakota. The area has an established transportation and utility network that provides access and necessary services to light industry, homesteads, and farms located near the PGS. Williams County provides emergency and social services and manages several county parks. The closest city to the PGS is Williston, located approximately 15 miles southeast. Williston provides recreation and parks, a community center, a golf course, a community pool, and a community library. Additionally, the Williston's local services include emergency services, such as a fire department, ambulance service, and a police department. There are also hospitals, medical services, and local retail service facilities.

#### 4.4.1.2 Electrical and Gas Service

The PGS site is located within the MWEC service area. MWEC, one of Basin Electric's member cooperatives, is a not-for-profit, member-owned electric distribution cooperative that provides electrical services to northwestern North Dakota. Basin Electric, through the operation of the IS transmission system, also delivers electrical supply to the area. Sheridan Electric is also a Basin Electric member cooperative. Sheridan Electric presently is interconnected to the Stateline Substation. This interconnection would be redirected to the PGS Phase III Switchyard.

Natural gas is supplied to PGS by a WBI Energy Transmission, Inc., 1,800-ft-long, 8-inch-diameter pipeline that originates at ONEOK's Stateline I Gas Processing Plant gas interconnection to the Northern Border Pipeline.

#### 4.4.1.3 Roads

County and township (section line) roads characterize the existing roadway infrastructure around the PGS. The PGS is located northwest of the intersection of 56th Street NW and County Road 5 (151st Avenue NW). The nearest highway, U.S. Highway 2, is located approximately 6 miles south of the PGS.

#### 4.4.1.4 Traffic

The existing traffic volume on nearby U.S. Highway 2 is documented in Table 4-2. Determining the specific capacity of any highway is a complex process; however, general estimates are used for planning purposes. For purposes of comparison, the functional capacity of a two-lane paved rural highway is approximately 5,000 vehicles per day, or Average Annual Daily Traffic (AADT). In general, highways near the PGS carry higher levels of traffic than what is average for rural North Dakota.

**Table 4-2: Existing Daily Traffic Levels**

| Roadway Segment | 2013 AADT | 2013 Commercial Truck Traffic |
|---|---|---|
| U.S. Highway 2 west of Williston | 5,985 | 2,005 |

Source: 2013 Traffic Volumes from NDDOT, Bismarck

The county and township roads near the PGS have no vehicle count data available. In general, the North Dakota Department of Transportation (NDDOT) provides traffic counts for designated U.S. and state highways (NDDOT 2013). As per NDDOT, the routes with no counts likely have lower traffic levels than those with count data.

#### 4.4.1.5 Water Supply

Hebron Township and the surrounding area have limited public infrastructure services, which is typical of most rural townships in western North Dakota. Homes typically use septic systems and water wells for their household needs. Water is supplied to PGS by the Williams Rural Water District, which has lines located in this area.

#### 4.4.1.6 Telephone, Fiber Optic, Television and Radio Communications

The PGS would make use of existing underground fiber cable. PGS is interconnected with Basin Electric facilities through Basin Electric's microwave communication system.

### 4.4.2 Impacts

#### 4.4.2.1 Local Services

Construction workers would potentially use local services, such as emergency services, medical facilities, community facilities, and recreational facilities. Considerable increases in local services have occurred in recent months throughout the area. The Project workforce would be small compared to the overall workforce in the area and the amount of service development. No negative impacts to these local services are anticipated because the existing services/facilities in the City of Williston and Williams County would likely be able to accommodate use by construction workers that would be in the area on a temporary basis.

#### 4.4.2.2 Electrical and Gas Service

Basin Electric has identified the need for additional electric generation in northwestern North Dakota as a result of increased demand and to meet reliability and system stability requirements for the region. Investigations and analyses conducted for the overall power delivery systems found that without improvements, the flow of power along existing lines may result in local line overloads.

Energy would be generated and distributed to the electrical grid system serving the rapidly increasing electrical load requirements in northwestern North Dakota. The PGS Phase III Project would improve the reliability of service into the area. The current electrical system in the area is capable of receiving the additional generation without additional equipment or facility upgrades.

#### 4.4.2.3 Roads

The main access road to the PGS site is from County Road 5. The proposed Project could result in minor wear-and-tear on this road as a result of construction traffic. The Switchyard access road would be off of 56th Street.

#### 4.4.2.4 Traffic

The peak construction labor force for the Project would be approximately 225 employees. The equipment and material deliveries would be approximately 750 truckloads over the life of the Project, although they would be concentrated in the first few weeks before and after the initiation of construction. Deliveries and workers could use any combination of federal, state, and county highways and other township roads throughout the Project area. The traffic volume in and around Williston has increased significantly with the oil and gas development occurring in the area, with an AADT of nearly 6,000 vehicles. Highway 5, which provides access to the Project site, is a paved rural highway designed, as noted previously, for an

AADT of approximately 5,000 vehicles.. Additional vehicles in the area as a result of the PGS would be considerably below these levels and temporary in nature. Vehicle trips resulting from Project construction would be insignificant compared to existing levels. The capacity of any route and level of service on existing roads would not be impacted.

The proposed Project would require six additional full-time employees to operate the PGS. This workforce and support services would generate an approximate maximum of 10 additional vehicle trips per day. No impacts to area roads would occur from Project operation.

Truck access to the PGS is served by County Road 5 and U.S. Highway 2. The proposed Project could result in temporary traffic delays on these roads as a result of wide-load or other construction traffic accessing the site. Additional operating permits would be issued by the state, county, and/or township for over-sized truck movements.

#### 4.4.2.5 Water Supply

No additional water supply development would be necessary for the proposed gas engines. Water use during construction would be limited to water used for dust control. The gas engines do not consume water during operation. The only additional water consumption for the proposed Project would be potable water for the six additional employees and a minimal amount of potable water treated with a water softener for cooling water makeup. Potable water is supplied to the PGS from the local rural water distribution system and would be adequate to meet the needs of the proposed facilities.

#### 4.4.2.6 Telephone, Fiber Optic, Television and Radio Communications

No impacts to these communication resources are anticipated.

### 4.4.3 Mitigation

Construction and operation of the Project would be in accordance with applicable federal, state, and local permits and laws, as well as industry construction and operation standards. Due to the minor impacts expected on the existing infrastructure during Project construction and operation, no mitigation is proposed.

#### 4.4.3.1 Local Services

Construction, operation, and maintenance of the Project would not impact local services, and no mitigation is proposed.

#### 4.4.3.2 Electrical and Gas Service

The construction of the Project would not negatively impact existing electrical or gas service; therefore, no mitigation is proposed.

#### 4.4.3.3 Roads

Construction, operation, and maintenance of the Project would not negatively impact existing roadways; therefore, no mitigation is proposed.

#### 4.4.3.4 Traffic

Construction, operation, and maintenance of the Project would not negatively impact traffic; therefore, no mitigation is proposed.

#### 4.4.3.5 Water Supply

Construction, operation, and maintenance of the Project would not negatively impact local water supply; therefore, no mitigation is proposed.

#### 4.4.3.6 Telephone, Fiber Optic, Television, and Radio Communications

Construction, operation, and maintenance of the Project would not negatively impact telephone, fiber optic, television, or radio communications; therefore, no mitigation is proposed.

## 4.5 Human Health and Safety

### 4.5.1 Description of Resources

#### 4.5.1.1 Human Health

Human health risks in and around the PGS site include potential exposure to electromagnetic fields (EMF) associated with transmission lines and substations/switchyards. The term EMF references two separate fields: electric fields and magnetic fields. Electric fields are produced by the line voltage, and magnetic fields are produced by the electric current in the lines. An electric field results from the voltage on an electrical wire as caused by electric charges, and electric fields can exert forces on other nearby charges. The intensity of the electric field is related to the voltage of the line and proximity to the conductor. Electric fields are measured in volts per meter (V/m) or kilovolts per meter (kV/m).

The National Institutes of Health (NIH) indicates that for a 115-kV transmission line, the typical electric field at 50 feet from the centerline is 0.5 kV/m and 6.5 milligaus (mG) (NIH 2002). Both values are far less than the International Commission on Non-Ionizing Radiation Protection (ICNIRP) levels for members of the general public of 4.2 kV/m for electric fields and 833 mG for magnetic fields (ICNIRP 1998). The NIH, National Institute of Environmental Health Science (NIEHS) has prepared a document summarizing EMF issues. This document is included in Appendix B.

#### 4.5.1.2 Human Safety

Occupational hazards include risks associated with construction and construction equipment, installation of equipment, heavy equipment transportation, and contact with electric lines. Potential public hazards include increased traffic volume due to construction vehicles in the area, and large construction vehicles and equipment using local roadways designed for lighter traffic.

Proper safeguards would be implemented during construction and operation of the facility. The transmission line and associated facilities would be designed to meet local, state, NESC, and Basin Electric safety standards. Construction crews would comply with local, state, NESC, and Basin Electric standards regarding the installation of facilities.

### 4.5.2 Impacts

#### 4.5.2.1 Human Health

The proposed Project would result in potential exposure of PGS employees and the public to EMF associated with the switchyard and associated transmission lines. EMF would be strongest directly adjacent to the switchyard or under transmission lines and would decrease with increasing distance from the switchyard or transmission lines.

Based on NIH (2002), the EMF levels at the edge of the right of way for the 115-kV transmission segment under maximum operating conditions and normal operating conditions are below the published ICNIRP Guidelines. The nearest sensitive receptors from the PGS are residences located greater than 1 mile from the PGS. EMF from the transmission line is predicted to be within the standards for protection of the general public. No adverse impacts are anticipated.

#### 4.5.2.2 Human Safety

During construction, potential safety hazards may occur as a result of heavy equipment operation, the presence of overhead materials and cranes, and the use of construction tools. Construction personnel are at a higher risk than the general public during this phase of the proposed Project, but the risk is temporary.

Construction and operation of the proposed Project would involve the use and storage of regulated and hazardous materials. During construction, diesel fuel, gasoline, and lubricating oils from heavy equipment and vehicles could be accidentally leaked or spilled. Hydraulic fluid, paints, and solvents would likely be used during the construction phase as well. All used oil generated at the proposed Project site and other potentially hazardous materials (automotive fluids, spray paint cans, etc.) at the site would be collected by a licensed/permitted recycler. To reduce the potential for a release of regulated or hazardous materials during the construction phase of the proposed Project, work would be planned and performed in accordance with Occupational Safety and Health Administration (OSHA) standards and protocols addressing the use of potentially hazardous materials and applicable federal and State environmental regulations. If a hazardous release were to occur, cleanup, management, and disposal of contaminated soils would be conducted according to U.S. Environmental Protection Agency (EPA) and State standards. Conformance to these standards and procedures would reduce the potential for significant impacts resulting from the release of hazardous materials during the construction phase. During plant operation, petroleum products would be stored in areas designed for liquid storage.

The general public would not be allowed to enter any construction areas associated with the proposed Project. The switchyard would be contained within a secured fence to prevent direct contact with energized equipment within the switchyard fence. Standardized agency procedures would be used should the switchyard need maintenance or repair to help maintain the safety of both workers and those in the surrounding area. The major risk to the general public would be from increased traffic volume on the roadways near or adjacent to the proposed Project as a result of commuting construction workers and transportation of equipment and materials. Construction-related traffic would be temporary. Project operation would require only six permanent employees as well as period materials deliveries, which would not be expected to result in significant safety risks, as discussed in Section 4.4.

### 4.5.3 Mitigation

#### 4.5.3.1 Human Health

No EMF-related impacts to humans or animals are anticipated; therefore, no additional mitigation is required.

#### 4.5.3.2 Human Safety

Construction-related hazards would be effectively mitigated by complying with applicable federal and state occupational safety and health standards, applicable NESC regulations, and utility design and safety standards.

In addition, Basin Electric would develop a Health and Safety Plan to address public and worker safety during the construction and operation of the proposed Project. The Health and Safety Plan would identify requirements for minimum construction or operation distances from residences or businesses, as well as requirements for temporary fencing around staging, excavation, and laydown areas during construction. It would also include provisions for worker protection, as required under OSHA with emphasis on CFR 1926 – *Safety and Health Regulations for Construction.* During construction, all employees, contractors, and sub-contractors would be required to conform to OSHA safety procedures. Adequate training would be mandatory for all construction workers onsite. Heavy equipment would be in compliance with OSHA requirements for safety devices such as back-up warnings, seat belts, and rollover protection. Personal safety equipment such as hard hats, ear and eye protection, and safety boots would be required for all workers onsite. Accidents and injuries would be reported to the designated safety officer at each site.

Risk of accidental fire during construction could occur from human activities such as refueling, cigarette smoking, and use of vehicles and construction equipment in dry, grassy areas. The Health and Safety Plan would reduce fire-related risks to acceptable levels by imposing restrictions or procedures regarding these activities. A risk of fire would be present during operation of the proposed Project due to the use and storage of fuel and chemicals within the facility. The proposed Project would have a built-in fire suppression system. In addition, implementation of industry-approved design measures for all proposed Project components would help keep fire-related risks acceptably low.

## 4.6 Air Quality

### 4.6.1 Description of Resources

Air quality is generally determined by comparing existing pollutant concentrations with regulated standards. The maximum acceptable level of a pollutant is specified by the EPA. The Clean Air Act (CAA) established two types of National Ambient Air Quality Standards (NAAQS), primary and secondary. The EPA has established NAAQS for six criteria air pollutants: $SO_2$, CO, nitrogen dioxide ($NO_2$), ozone ($O_3$), respirable particulate matter ($PM_{10}$ and $PM_{2.5}$), and lead (Pb). Primary standards set limits to protect human health, and secondary standards set limits to protect public welfare. For the criteria pollutants, the North Dakota Ambient Air Quality Standards (NDAAQS) are the same as the federal NAAQS. Williams County is currently classified as attainment or unclassifiable (to be treated as attainment) for all NAAQS criteria pollutants.

Emissions from all phases of construction and operation of the proposed Project would be subject to applicable state and federal air regulations. Most air quality regulatory programs address emissions from stationary sources of air pollution; these programs would primarily affect ongoing operations of the

Project. Air quality regulations affecting construction are primarily concerned with reducing emissions associated with construction equipment and fugitive dust.

PGS currently consists of three GE LM6000PC SCCTs, each with a nominal generation capacity of 45 MW. The proposed addition would consist of 12 RICE engines and associated auxiliary equipment. The total nominal generation capacity of the proposed Project would be 111 MW.

The Project’s air emission sources would be regulated at the federal level by the CAA, as amended, and at the state level by North Dakota Administrative Rules. Regulations that are applicable to the Project include:

- North Dakota Construction and Operating Permit Rules
- NAAQS
- New Source Performance Standards (NSPS)
- National Emission Standards for Hazardous Air Pollutants (NESHAP)

North Dakota air permitting requirements are codified in Article 33-15, Air Pollution Control. Chapter 33-15-14 establishes permit review procedures for all facilities that can emit pollutants to the ambient air. New facilities are required to obtain a Permit to Construct prior to initiating construction activities. Basin Electric applied for and received a Permit to Construct from the North Dakota Department of Health (NDDH) for the three existing PGS units.

NSPS regulations (40 CFR 60) establish pollutant emission limits and monitoring, reporting, and recordkeeping requirements for various emission sources based on source type and size. The NSPS applies to new, modified, or reconstructed sources. The RICE engines are subject to NSPS Subpart JJJJ, *Standards of Performance for Stationary Spark Ignition Internal Combustion Engines.* In addition, Subpart IIII, *Standards of Performance for Stationary Compression Ignition Internal Combustion Engines*, apply to the emergency fire pump and emergency generator.

The proposed Project would comply with applicable state and federal air quality regulations and obtain applicable air quality permits prior to commencing construction. Basin Electric submitted an application to NDDH for a Permit to Construct for the proposed Project in August 2014.

### 4.6.2 Impacts

Construction of the proposed Project would potentially have minor and temporary impacts on air quality. This would be due to fugitive dust emissions during ground-disturbing activities associated with construction and installation of the equipment and associated infrastructure of the Project. Construction emissions would also result from combustion of fuel in construction equipment/vehicles, fugitive dust associated with site preparation/grading, and movement of construction equipment/vehicles onsite.

Because of their temporary nature, construction emissions would not have a long-term impact on ambient air quality, and Basin Electric's implementation of proposed emission control measures as well as other measures specified by NDDH is anticipated to reduce construction emissions impacts to less than significant levels.

Operation of the proposed Project would result in air emissions from stationary fuel burning equipment. There would be 12 RICE engines fueled by natural gas. The Project would operate as allowed under applicable air permits obtained prior to construction and operation. Operation of the Project in compliance with the applicable permit limits would not result in an adverse impact to public health and welfare.

The existing PGS is a minor stationary source that does not require a Prevention of Significant Deterioration (PSD) permit. Therefore, the Project may emit up to 250 tons per year (tpy) of any criteria pollutant before the Project would be subject to a PSD review. The maximum potential emissions from the Project and PSD applicability are shown in Table 4-3. As this table demonstrates, the Project would not exceed 250 tpy for any pollutant; therefore, the Project would not be subject to PSD review for any pollutant.

**Table 4-3: Project Potential Emissions and PSD Major Source Thresholds**

| Pollutant | Preliminary Estimated Potential Emissions (tons per year)[a] | PSD Major Source Thresholds (tons per year) | PSD Review Applicable (Yes, No) |
|---|---|---|---|
| $NO_X$ | 105 | 250 | No |
| CO | 141 | 250 | No |
| $SO_2$ | 3.1 | 250 | No |
| VOC | 206 | 250 | No |
| $PM/PM_{10}$[b]/$PM_{2.5}$[b] | 92.8 | 250 | No |
| $CO_2e$ | 495,574 | --[c] | No |
| $H_2SO_4$ Mist | 0.48 | -- | No |
| Pb | $5.3 \times 10^{-6}$ | -- | No |

(a) Numbers in **bold** indicate the PSD significance level is exceeded
(b) Filterable plus condensable
(c) The Project does not trigger PSD review for any other pollutant; therefore, the CO2e PSD threshold does not apply per Utility Air Regulatory Group vs EPA (Case#12-1146, June 23, 2014 before the Supreme Court of the United States Court).

Although the Project is not subject to PSD review, NDDH requested that air dispersion modeling be performed for all pollutants above the PSD major source threshold rates to demonstrate compliance with NAAQS and PSD Class I and II Increment. Therefore, an air quality analysis was performed for $NO_2$, CO, and $PM_{10}$/$PM_{2.5}$. Air dispersion modeling was conducted to determine the impacts of operation of the proposed Project on the Class I national park and wilderness areas near the PGS site. These modeling impacts indicated that there would be insignificant air quality, plume visibility, sulfur and nitrogen deposition, soil and vegetation, air toxic, and carcinogen impacts in the Theodore Roosevelt National Park, Medicine Lake National Wildlife Refuge, and Lostwood National Wildlife Refuge Class I areas. Modeling indicated that the air quality impacts from PGS would not exceed the modeling significance level for the pollutants and averaging periods modeled.

GHG emissions of 495,574 tpy from the Project (PGS Phase III) would represent a small fraction of one percent of United States emissions of 6,708 Terragrams in 2011. Thus, construction and operation of the Project would not contribute measurably to global GHG emissions. While global climate change in the 21st century is expected to affect northwestern North Dakota through higher temperatures and higher precipitation (Karl, Melillo, and Peterson 2009), this change is not expected to affect by the Project or the demand for electricity in the near term, which is primarily driven by Bakken oil field development.

### 4.6.3 Mitigation

During construction, it is proposed that standard dust control measures be used to reduce generation of fugitive dust due to surface disturbance. Dust control measures would include, but are not limited to, the following:

- Applications of water during grading
- Paving, chemical stabilization, or watering of internal roadways after completion of grading
- Reduction of speed on unpaved roadways to 15 miles per hour or less
- Use of sweepers or water trucks to remove “track-out” at any point of public street access
- Stabilization of dirt storage piles by chemical binders, tarps, fencing, or other erosion control

Construction of the proposed Project would also result in exhaust pipe emissions from a variety of sources, including cranes, loaders, excavators, graders, generators, vibratory rollers, concrete emplacement trucks, and crew trucks. It is proposed that the following measures be used to reduce emissions from vehicles and construction equipment during Project construction:

- Properly maintain construction equipment in accordance with manufacturers' specifications or standard practices
- Limit truck idling to the extent practicable

The 12 engines would be equipped with SCR and lean-burn combustion systems to control $NO_x$ emissions. Use of these control systems, use of natural gas as the primary fuel, and compliance with operating limits imposed by required air emissions operating permits are anticipated to mitigate impacts to ambient air quality and maintain compliance with applicable NDAAQS and NAAQS.

## 4.7 Noise

### 4.7.1 Acoustic Background and Terminology

The term "sound level" is often used to describe two different sound characteristics called sound power and sound pressure. Every source that produces sound has a sound power level ($L_w$). The sound power level is the acoustical energy emitted by a sound source and is an absolute number that is not affected by the environment. The acoustical energy produced by a source propagates through a medium as pressure fluctuations. These pressure fluctuations, also called sound pressure ($L_p$), are what human ears hear and microphones measure.

Sound energy is physically characterized by amplitude and frequency. Sound amplitude is measured in decibels (dB) as the logarithmic ratio of a sound pressure to a reference sound pressure (20 microPascals). The reference sound pressure corresponds to the typical threshold of human hearing. A 3-dB change in a continuous broadband sound is generally considered "just barely perceptible" to the average listener. A 5-dB change is generally considered "clearly noticeable," and a 10-dB change is generally considered a doubling (or halving, if the sound is decreasing) of the apparent loudness.

Frequency is measured in hertz (Hz), which is the number of cycles per second. The typical human ear can hear frequencies ranging from approximately 20 to 20,000 Hz. Normally, the human ear is most sensitive to sounds in the middle frequencies (1,000 to 8,000 Hz) and is less sensitive to sounds in the low and high frequencies. As such, the A-weighting scale was developed to simulate the frequency response of the human ear to sounds at typical environmental levels. The A-weighting scale emphasizes sounds in the middle frequencies and de-emphasizes sounds in the low and high frequencies. Any sound level to which the A-weighting scale has been applied is expressed in A-weighted decibels (dBA). For reference, the A-weighted sound pressure level and subjective loudness associated with some common sound sources are listed in Table 4-4.

**Table 4-4: Sound Pressure Level, Subjective Evaluation, and Environment**

| Sound Pressure Level (dBA) | Subjective Evaluation | Environment | |
|---|---|---|---|
| | | Outdoor | Indoor |
| 140 | Deafening | Jet aircraft at 75 feet (ft) | |
| 130 | Threshold of pain | Jet aircraft during takeoff at a distance of 300 ft | |
| 120 | Threshold of feeling | Elevated train | Hard rock band |
| 110 | | Jet flyover at 1,000 ft | Inside propeller plane |
| 100 | Very loud | Power mower, motorcycle at 25 ft, auto horn at 10 ft, crowd sound at football game | |
| 90 | | Propeller plane flyover at 1,000 ft, noisy urban street | Full symphony or band, food blender, noisy factory |
| 80 | Moderately loud | Diesel truck (40 miles per hour [mph]) at 50 ft | Inside auto at high speed, garbage disposal |
| 70 | Loud | B-757 cabin during flight | Close conversation, vacuum cleaner |
| 60 | Moderate | Air-conditioner condenser at 15 ft, near highway traffic | General office |
| 50 | Quiet | | Private office |
| 40 | | Farm field with light breeze, birdcalls | Soft stereo music in residence |
| 30 | Very quiet | Quiet residential neighborhood | Inside average residence (without TV and stereo) |
| 20 | | Rustling leaves | Quiet theater, whisper |
| 10 | Just audible | | Human breathing |
| 0 | Threshold of hearing | | |

Source: Adapted from *Architectural Acoustics*, M. David Egan, 1988 and *Architectural Graphic Standards*, Ramsey and Sleeper, 1994

Sound in the environment is constantly fluctuating, such as when a car drives by, a dog barks, or an aircraft passes overhead. Therefore, sound metrics have been developed to quantify fluctuating environmental sound levels. These metrics include the exceedance sound levels. The exceedance sound level ($L_x$) is the sound level exceeded "x" percent of the sampling period and is referred to as a statistical sound level. The most common $L_x$ value is the average sound level for a given time period ($L_{eq}$). Another common sound metric is the day-night sound level ($L_{dn}$). $L_{dn}$ is a 24-hour average sound level that is often used to represent community sound levels. A 10-dB nighttime penalty is added to the nighttime hours (10 P.M. to 7 A.M.) to account for added sensitivity to noise during the night. $L_{eq}$ and $L_{dn}$ are presented in this analysis.

Burns & McDonnell Engineering, Inc., analyzed the sound levels of the proposed Project and existing PGS facility using a predictive, three-dimensional noise model, Computer Aided Noise Abatement (CadnaA), based on the methodologies presented in the International Organization for Standardization(ISO)-9613 standards. The model analyzed the sound levels expected at the nearest residences to PGS during normal operation of the existing facility and with the proposed Project. Additionally, the model analyzed sound levels over a gridded area to produce sound contours demonstrating how sound would propagate in and around PGS.

### 4.7.2 Description of Resources

The closest sensitive noise receptors (SR) to PGS include a church (SR1) located approximately 1 mile north of the facility, a farm-storage facility (SR2) located approximately 1 mile northeast of the facility, and a residence (SR3) located approximately 1.75 miles south of the facility. SR2 is likely not occupied but was included in the noise analysis as a SR due to its proximity to PGS. At this existing PGS, there is occasional, operational noise from the existing CTs and continuous noise from the adjacent ONEOK Stateline I Gas Processing Plant. Other noise sources present are insects and vehicular traffic. Due to dominant insect noise, $L_{dn}$ sound levels due to the operation of the existing facility at SR1 through SR3 were predicted based on an interpolation calculation performed on the measurements taken at the facility fence line. These $L_{dn}$ sound levels were determined to be approximately 48 dBA at SR1, 44 dBA at SR2, and 41 dBA at SR3.

### 4.7.3 Impacts

#### 4.7.3.1 Facility Noise

The noise model was run for the Project assuming use of standard equipment and no mitigation incorporated. The results of this noise model revealed that the EPA-recommended $L_{dn}$ noise limit of 55 dBA would be exceeded for nearby noise receptors. As such, mitigation (silencers) on the two most significant noise producers, the charge air intakes and exhausts, was deemed required. Two mitigation options were presented for both pieces of equipment: 35 dBA of reduction or 45 dBA of reduction. It was determined that 35 dBA of reduction on all charge air intakes and exhausts would be sufficient in quieting noise levels at surrounding noise sensitive receivers to acceptable levels, and the 45 dBA reduction option was not necessary. The modeled $L_{dn}$ sound levels due to full operation of the existing facility plus the

Project (with mitigation included) at each of the SRs are shown in Table 4-5. Figure 4-1 provides a graphic illustration of the $L_{dn}$ sound levels expected with the existing and proposed facility operating under normal conditions. Additional details are included in the noise analysis report in Appendix C.

**Table 4-5: Expected Worst-Case $L_{dn}$ Sound Levels**

| Residence | Predicted $L_{dn}$ Sound Level (dBA) |
|---|---|
| SR1 | 49.4 |
| SR2 | 46.2 |
| SR3 | 41.6 |

During simultaneous operation of the existing PGS and proposed Project, the maximum $L_{dn}$ sound level would approach 49.4 dBA at SR1. This predicted sound level is noticeably less than the EPA noise guideline $L_{dn}$ sound level of 55 dBA. Noise levels due to operation of the existing equipment at PGS and the proposed Project are expected to have little or no impact on the closest residences or commercial areas, after incorporating mitigation.

#### 4.7.3.2 Construction Noise

Project construction has the potential to elevate local noise levels due to traffic, construction of transmission lines, and reciprocating engines with associated equipment. However, these noise levels would be relatively short and temporary in nature over the life of the Project. Therefore, impacts related to construction noise would be less than significant.

**Figure 4-1: PGS $L_{dn}$ Noise Contours**

### 4.7.4 Mitigation

As stated in Section 4.7.3.1, the predicted operational noise levels shown in Table 4-5 were modeled with the inclusion of charge air intake silencers and exhaust silencers. By completing multiple iterations of the noise model, it was determined that 35 dBA of noise reduction on all charge air intakes and exhausts would be sufficient in quieting noise levels at surrounding noise SRs to acceptable levels. With these two types of noise sources mitigated, noise levels due to the operation of the existing PGS and proposed Project are expected to have little impact on the closest noise SRs.

## 4.8 Visual Impacts

### 4.8.1 Description of Resources

The topography in the vicinity of the PGS is predominantly flat with some rolling hills. Elevation of the PGS is approximately 2,400 feet above sea level. The landscape is characterized by crop fields interspersed with man-made features. These man-made structures are focal points in the dominant open space character of the Project vicinity. Existing electric infrastructure, such as transmission lines, distribution lines and substations, and oil and gas facilities, are scattered throughout the surrounding landscape. The ONEOK Stateline I Gas Processing Plant and the MWEC Stateline Substation I are located adjacent to the PGS, east of County Road 5. Residences and farm buildings (inhabited and uninhabited) are located along the county and township roads. The nearest occupied residences to the PGS are located approximately 1.5 miles north, 1.5 miles northeast, and 1.75 miles south.

### 4.8.2 Impacts

The PGS is an existing facility and is currently visible in the landscape. The addition of the new gas engines on the generation station site would be visible to landowners and community residents who live and travel near the station. There would be two 170-ft-tall stacks built as part of the PGS Phase III Project. The three stacks for the existing turbines are each 80 feet in height. The proposed Project would add additional visual elements to a power plant site that already exists.

### 4.8.3 Mitigation

Although the PGS Phase III Project would contrast with the historical surrounding land use, these areas have already recently been impacted visually by the existing power plant, the 115-kV transmission infrastructure that connects to the Stateline I Substation, the existing ONEOK Stateline I Gas Process facility, and oil and gas facilities in the area. No mitigation is required.

## 4.9 Cultural Resources

### 4.9.1 Description of Resources

Seven properties in Williams County are listed on the National Register of Historic Places (NRHP), including James Memorial Library, Old Armory, Old U.S. Post Office, and Williston High School in Williston; Ray Opera House in Ray; Fort Buford southwest of Williston; and Fort Union Trading Post west of Buford. None of these properties are close to the proposed Project. A Class III cultural resource inventory was conducted in 2012 by Metcalf Archaeological Consultants, Inc. (MAC) for the PGS property prior to construction of Phase I (Appendix D). No historic properties were found.

### 4.9.2 Impacts

Based on the results of the Class III cultural resource inventory conducted for the PGS, MAC recommended a finding of "no historic properties affected." In a letter dated February 29, 2012, the State Historic Preservation Officer (SHPO) concurred with this determination (Appendix D). Based on a review of Project information for the proposed PGS Phase III Project, SHPO concurred with a "no significant sites" determination for the proposed Project (see letter dated August 27, 2014, in Appendix D). There would be no impacts to cultural resources as a result of the proposed Project.

### 4.9.3 Mitigation

No mitigation is needed because no cultural resources would be affected. In the event of unanticipated discoveries, Basin would implement an Unanticipated Discoveries Plan (Appendix E).

## 4.10 Recreational Resources

### 4.10.1 Description of Resources

Recreational opportunities in Williams County include camping, hiking, biking, swimming, golfing, hunting, fishing, and nature observation. Review of state and federal databases indicates that no national wildlife refuges, state wildlife management areas, state game refuges, game management areas, nature preserves, or county parks are present within the PGS area. The closest public land is school trust property (North Dakota State Land Department lands) with tracts located approximately 2 miles southwest (T155N, R104W, Section 36), 3 miles southeast (T155N, R103W, Section 36), and 4 miles northwest (T156N, R104W, Section 36). These lands are open to walk-in hunting unless otherwise posted. Lake Sakakawea, a federal reservoir used for water supply and recreation, is located approximately 12 miles southeast.

No National Wild and Scenic Rivers or streams on the Nationwide Rivers Inventory (NRI) are located near the site. However, the Missouri River at its confluence with the Yellowstone River near Fort Union Trading Post National Historic Site is on the NRI list. The Yellowstone-Missouri confluence is 17 miles southwest of the Project site.

### 4.10.2 Impacts

Impacts to recreation would primarily be visual in nature and limited to few individuals using private property surrounding PGS for hiking, hunting, fishing, or nature observation. No adverse effects to recreational resources are anticipated.

### 4.10.3 Mitigation

Recreational resources would not be impacted by the proposed Project; therefore, no mitigation is proposed.

## 4.11 Effects on Land-based Economics

### 4.11.1 Description of Resources

#### 4.11.1.1 Agriculture/Farming

In 2012, Williams County had 1,063,109 acres (80 percent of the total county area) classified as farmland from 758 farms (USDA, 2012). Crop sales accounted for the majority of products sold; $167,572,000 (94 percent) of sales was crops and $11,131,000 (6 percent) of sales was livestock. Wheat is the primary crop in the County, and in 2012, the County ranked first in the state for wheat production. Areas on the 120-acre PGS property but outside of the existing generation facilities are leased for crop production.

#### 4.11.1.2 Woodlands

No forestry resources, woodland, shelterbelts, or areas of woody vegetation are located on the PGS property.

### 4.11.2 Impacts

#### 4.11.2.1 Agriculture/Farming

Construction of the Project would result in the removal of 12 acres of agricultural land to accommodate the new gas engines and switchyard. However, this is a very small percentage of the total farmland in Williams County, and, therefore, the proposed Project would not impact the overall value of agricultural production in the county. No impacts are anticipated to animal health and safety due to the construction or operation of the proposed Project because the site is currently used for cropland and not pasture. Areas outside of the generation facility that are not required to support the PGS would continue to be used for agricultural purposes.

Temporary impacts, such as soil disturbance, would occur on the additional 7.1 acres for laydown and parking areas required to support Project construction activity. These areas would be temporarily unavailable for agricultural uses during construction. Following construction, this area would be restored to its original condition to the extent practicable and would be available again for agricultural uses.

#### 4.11.2.2 Woodlands

Because no forestry resources are located on the site, there would be no impacts to woodlands.

### 4.11.3 Mitigation

#### 4.11.3.1 Agriculture/Farming

Impacts to agriculture would be negligible. The proposed Project site, although currently used for agriculture, is zoned Industrial and is permitted by the county for development of the PGS. Therefore, no mitigation is proposed.

#### 4.11.3.2 Woodlands

No woodlands are located within the PGS site, and no mitigation is proposed.

## 4.12 Soils

### 4.12.1 Description of Resources

The proposed Project site contains two soil units: Williams-Bowbells loams with 3 to 6 percent slopes and Williams-Zahl loams with 6 to 9 percent slopes. The majority of the site contains Williams-Bowbells loams with 3 to 6 percent slopes. Both of the soil units on the Project site consist of very deep, moderately well- to well-drained, moderately high to highly permeable soils formed in fine, loamy till (NRCS, 2014). Neither of these soils is considered hydric. The Williams-Bowbells loams unit is classified as prime farmland. The soils on the Project site are shown in Figure 4-2.

**Figure 4-2: Soils Map**

### 4.12.2 Impacts

Construction of the Project would result in the removal of 12 acres of soils to accommodate the new gas engines and switchyard. Impacted soil types would include approximately 8.5 acres of Williams-Bowbells loams and 3.5 acres of Williams-Zahl loams. The approximately 7.1 acres for laydown and parking areas would be temporarily disturbed during construction. Crews would limit ground disturbance wherever possible, and the laydown area would be restored to its original condition to the extent practicable.

### 4.12.3 Mitigation

To minimize erosion during and after construction, North Dakota BMPs for erosion and sediment control (SN 19389 9/99) would be utilized. These practices include temporary seeding, permanent seeding, mulching, filter strips, erosion blankets, grassed waterways, and sod stabilization. Erosion control measures would be implemented as necessary for the construction of Project. Basin Electric would prepare and submit a Stormwater Pollution Prevention Plan (SWPPP) to the NDDH for approval and implementation during construction.

## 4.13 Geologic and Groundwater Resources

### 4.13.1 Description of Resources

The geologic formation underlying the PGS property consists of Paleocene Epoch (65.5 to 56 million years ago) Sentinel Butte Formation. The Sentinel Butte Formation consists of alternating beds of grayish brown to gray sandstone, siltstone, mudstone, claystone, and lignite (USGS, 2005). It contains river, lake, and swamp sediment and can range up to 600 feet in thickness.

The surficial geology in the PGS area is Pleistocene Epoch (2.6 million to 11,700 years ago) Coleharbor Formation. The Coleharbor Formation is a moderately well sorted cross-bedded sand and plane-bedded gravel deposit of glacial till. The formation also includes sediment of melt-water and other river deposits and can reach a thickness of 100 to 600 feet. Paleontological resources associated with the Coleharbor Formation may include fossils of animals that lived during the Ice Age, including remains of mammoths, mastodons, giant bison, ground sloths, and horses (Hoganson, 2006).

The Basin Electric service area in northwestern North Dakota is experiencing a rapid increase in development as a result of the activities associated with oil and gas extraction from the Bakken shale formation, currently concentrated in McKenzie, Mountrail and Williams Counties

According to the North Dakota Geological Survey (NDGS), North Dakota is located in an area of very low earthquake probability. There are no known active tectonic features in south-central North Dakota and the deep geologic formations underlying North Dakota are expected to be geologically stable (Bluemle, 1991). This information is supported by U.S. Geological Survey (USGS) seismic hazard maps, which show that the Project would be located in an area with very low seismic risk (USGS, 2008). Related hazards, such as soil liquefaction, are therefore also unlikely.

According to the USGS, the PGS area is included in the Northern Great Plains regional aquifer system. Groundwater resources in the PGS area are included in the Fort Union and Fox Hills Formations, Tertiary period aquifers. Tertiary aquifers consist mostly of semi-consolidated to consolidated sandstone beds of Oligocene to Paleocene age (USGS, 1996). These water-yielding sandstones are an important water source in the region.

### 4.13.2 Impacts

There are no anticipated impacts to geologic resources. However if an unanticipated spill occurs at the PGS site, Basin Electric has a Spill Prevention, Control, and Countermeasure (SPCC) plan and mitigation in place to avoid introduction of spilled materials into the groundwater.

### 4.13.3 Mitigation

The construction contractor would minimize the likelihood of spilling fuel, hydraulic fluid, or other regulated materials by limiting refueling to secure areas. Spill kits would be maintained at these sites to contain and clean up any spills that may occur. Construction crew members would be trained in spill prevention and clean up.

## 4.14 Surface Water and Floodplain Resources

### 4.14.1 Description of Resources

Only small, isolated wetlands occur on the PGS site. No waterways or streams cross the property. The PGS is located on the border between two watersheds, the Upper Painted Woods Creek and Upper Little Muddy Creek Watersheds. Painted Woods Creek is an intermittent stream, which drains to Lake Sakakawea, approximately 13 miles southeast of the PGS. Little Muddy Creek, which is also intermittent, drains to the Missouri River approximately 16 miles southwest of the PGS. No surface waters are located on the PGS property. Flood Insurance Rate Maps (FIRMs) have not been prepared for this portion of Williams County. However, because there are no major streams near the site, the site does not appear to be located within a floodplain.

### 4.14.2 Impacts

A rural water line currently supplies water to the site and has adequate capacity for the proposed Project. Stormwater from the existing PGS facility is captured in a retention pond on the north side of the existing facility, and after achieving discharge quality standards, it is released at a controlled rate and flows offsite. All stormwater runoff from the Project would be diverted to a new second stormwater pond that would serve the Project. This pond would be located at the northwest corner of the proposed Project, north of the proposed switchyard. After achieving discharge quality standards, water would be released at a controlled rate to the west and offsite, eventually into Muddy Creek. Sanitary wastewater from the Project would be generated as a result of staffing the facility and would be directed to a second state-approved mound septic system. Therefore, construction and operation of the proposed Project would not result in any long-term or short-term impacts to water quality. Because stormwater would be captured in an onsite pond and because of the distance from PGS to Painted Woods Creek and Muddy Creek, there would be no impacts to surface water or floodplains.

### 4.14.3 Mitigation

Basin Electric would prepare, apply for, and obtain the necessary National Pollutant Discharge Elimination System (NPDES) stormwater permit and approved SWPPP for the Project. Basin Electric would maintain an NPDES permit for the continued operation of the stormwater pond. No impacts to surface water or floodplains are anticipated; therefore, no mitigation is being proposed.

## 4.15 Wetlands

### 4.15.1 Description of Resources

There are two freshwater emergent wetlands, both less than approximately 0.1 acre, located on the PGS property (Figure 4-3). On February 9, 2012, the U.S. Army Corps of Engineers (USACE) provided a jurisdictional determination for the PGS property prior to construction of Phase I (Appendix F). USACE determined that these wetlands are isolated, intrastate, and non-navigable and therefore non-jurisdictional. Therefore, no permits are required for their disturbance. The determination remains valid for 5 years, as confirmed in USACE correspondence dated August 26, 2014 (Appendix G).

### 4.15.2 Impacts

There are no jurisdictional wetlands within the PGS property. No impacts to jurisdictional wetlands would occur.

### 4.15.3 Mitigation

Because no jurisdictional wetlands are present on the site, no mitigation is necessary.

**Figure 4-3: Water Resources**

## 4.16 Vegetation

### 4.16.1 Description of Resources

The PGS is located in the Northern Dark Brown Glaciated Plans Major Land Resource Area (MLRA) (NRCS, 2014). Vegetative cover in this region primarily consists of cropland, pastured mixed-grass prairie, and non-native grassland. Native vegetation consists of mixed and tall grass prairie. Spring wheat is a predominant crop with other acreage in flax, oats, and barley. Native prairie vegetation consists of western wheatgrass (*Pascopyrum smithii*), needle-and-thread (*Hesperostipa comata*), green needlegrass (*Stipa viridula*), and blue grama (*Bouteloua gracilis*). Little bluestem (*Schizachyrium scoparium*) may be present on shallow soils, and prairie cordgrass (*Spartina pectinata*), northern reedgrass (*Calamagrostis stricta* spp.), and slim sedge (*Carex praegracilis*) may be present on wet soils. Western snowberry (*Symphoricarpos occidentalis*), stiff goldenrod (*Oligoneuron rigidum*), coneflower (*Echinacea* spp.), and prairie rose (*Rosa arkansana*) are also interspersed throughout the region. Areas of the PGS property outside of the existing facilities, including the proposed Project site, are crop fields.

### 4.16.2 Impacts

Construction of the Project would result in the removal of 12 acres of vegetation to accommodate the new gas engines and switchyard. Vegetation in this area consists of crops. Movement of vehicles and materials to and from the site could transport invasive plants and noxious weeds. The approximately 7.2 acres for laydown and parking areas would be temporarily disturbed during construction and would not be available for agricultural use.

### 4.16.3 Mitigation

Basin Electric would inspect and control noxious weeds on the property during and after the reclamation processes that follow construction activities and periodically for the life of the Project. Crews would limit ground disturbance wherever possible, and the laydown area would be restored to its original condition to the extent practicable.

## 4.17 Wildlife

### 4.17.1 Description of Resources

Wildlife found in the vicinity of the PGS would be species typical of the northern Great Plains. Typical big game species may include white-tailed deer (*Odocoileus virginianus*) and mule deer (*Odocoileus hemionus*). Game birds expected in the area are ring-necked pheasant (*Phasianus colchicus*), gray partridge (*Perdix perdix*), sharp-tailed grouse (*Tympanuchus phasianellus*), and wild turkey (*Meleagris* *gallopavo*). Migratory birds would be those of the western prairies, including western meadowlark (*Sturnella neglecta*), yellow warbler (*Setophaga petechial*), black-headed grosbeak (*Pheucticus melanocephalus*), chipping sparrow (*Spizella passerina*), grasshopper sparrow (*Ammodramus savannarum*), northern oriole (*Icterus galbula*), and loggerhead shrike (*Lanius ludovicianus*). Resident birds may include horned lark (*Eremophila alpestris*), black-capped chickadee (*Poecile atricapillus*), white-breasted nuthatch (*Sitta carolinensis*), blue jay (*Cyanocitta cristata*), and American crow (*Corvus brachyrhynchos*). Raptors such as red-tailed hawk (*Buteo jamaicensis*), American kestrel (*Falco sparverius*), prairie falcon (*Falco mexicanus*), and turkey vulture (*Cathartes aura*) are likely found in the area, but there are no raptor nests observed near the site.

The proposed Project site consists of crop fields, which could provide some limited wildlife habitat for foraging, migratory stopover, breeding, and/or shelter.

### 4.17.2 Impacts

The proposed Project is not anticipated to result in any long-term or permanent impacts to wildlife species. Construction of the Project would result in the removal of 12 acres of potential wildlife habitat to accommodate the new gas engines and switchyard. Noise and human activity that are associated with construction would result in short-term, temporary displacement impacts to wildlife species foraging in the area. The noise and human activity would temporarily deter wildlife species from using the areas in the immediate vicinity of construction; however, following completion of construction, the wildlife species would be expected to return.

### 4.17.3 Mitigation

To minimize wildlife impacts during construction and operation, Basin Electric would maintain good water and soil conservation practices during construction and operation of the PGS to protect topsoil and adjacent resources and to minimize soil erosion. To minimize erosion during and after construction, North Dakota BMPs for erosion and sediment control (SN 19389 9/99) would be utilized. These practices include temporary seeding, permanent seeding, mulching, filter strips, erosion blankets, grassed waterways, and sod stabilization.

## 4.18 Rare and Unique Natural Resources

### 4.18.1 Description of Resources

The Endangered Species Act (ESA) of 1973, as amended, provides for the conservation of ecosystems upon which threatened and endangered species of fish, wildlife, and plants depend. Federally listed threatened species are those species likely to become endangered within the foreseeable future throughout all or a significant portion of their range. Federally listed endangered species are those species already in danger of extinction throughout all, or a significant portion of, their range. According to the U.S. Fish and Wildlife Service (USFWS) Information, Planning, and Conservation System (IPaC), Williams County may contain suitable habitat for, or have known occurrences of, four federally listed endangered species and one federally listed threatened species (Appendix G). Listed species, along with their federal and state designations, of possible occurrence are shown in **Error! Reference source not found.**.

**Table 4-6: Listed Species Known or Likely to Occur Near Project Site**

| Common Name | Scientific Name | Federal Status | Critical Habitat in Williams County |
|---|---|---|---|
| Interior least tern | *Sterna antillarum* | Endangered | N/A |
| Piping plover | *Charadrius melodus* | Threatened | Yes[a] |
| Red knot | *Calidris canutus rufa* | Proposed Threatened | N/A |
| Spragues pipit | *Anthus spragueii* | Candidate | N/A |
| Whooping crane | *Grus americana* | Endangered | No |
| Pallid sturgeon | *Scaphirhynchus albus* | Endangered | N/A |
| Gray wolf | *Canis lupus* | Endangered | N/A |

Source: USFWS IPaC Project Review
(a) Critical habitat in Williams County is sparsely vegetated sandbars along the Missouri River.

Three of these listed species, the interior least tern, piping plover, and pallid sturgeon, are associated with large rivers such as the Missouri and would not be found at the proposed Project site. Critical habitat for the piping plover in Williams County is along the Missouri River and does not include the Project site. The Project site is located in the migration corridor of the Aransas Wood Buffalo Population of the whooping crane. However, the proposed Project is not located near any wetlands or riparian areas that would be used for feeding or roosting. The presence of gray wolves in most of North Dakota is sporadic and consists of occasional dispersing animals from Minnesota and Manitoba. The Project site does not contain suitable habitat for the gray wolf, due to the proximity to the existing PGS facilities and adjacent industrial development.

One candidate species and one species proposed for listing as threatened may occur in the Project vicinity. The Sprague's pipit is associated with native short- to mixed-grass prairie, preferring large prairie patches of at least approximately 72 acres. Sprague's pipit are unlikely to use the Project site, which contains cultivated crops in an area fragmented by industrial and oil/gas development. Red knots, which migrate through the contiguous United States, are primarily found along the coasts but may also occur inland. However, the proposed Project is not located near any wetlands or riparian areas that would be used for feeding or roosting.

The Bald and Golden Eagle Protection Act (BGEPA) provides for the protection of the bald eagle and golden eagle, both of which may occur within Williams County. Migratory bird habitats generally consist of breeding and foraging habitat. Many migratory waterfowl use wetland areas within Williams County during the breeding season, while additional species may use agricultural fields and wetland areas for foraging. Bald and golden eagles can occur throughout Williams County, but are found more often near food sources and nesting areas. Bald eagles are primarily found in forested areas near large bodies of water such as the Missouri River and Lake Sakakawea. Golden eagles may be found in more rugged badland areas associated with the Missouri River and Lake Sakakawea.

### 4.18.2 Impacts

Suitable habitat for protected species is not present within the Project site. Therefore, no impacts on rare and unique resources would occur as a result of the construction of the Project.

### 4.18.3 Mitigation

Because the proposed Project would not impact rare and unique resources, no mitigation is necessary.

## 4.19 Summary of Site Impacts

Table 4-7 summarizes the resources that would be impacted as a result of the construction of the Project and the appropriate mitigation.

**Table 4-7: Summary of Impacts and Mitigation**

| Resource | Impact | Mitigation |
|---|---|---|
| Demographics and Socioeconomics | Socioeconomic impacts are primarily positive due to increased expenditures during construction and the long-term benefits of an increased tax base for the county due to property taxes. | No mitigation measures are necessary. |
| Land Use | Approximately 12.5 acres on the existing PGS property would be converted from agricultural to industrial use.<br>Approximately 7.1 acres for laydown and parking areas would be temporarily unavailable for agricultural purposes during construction. | No mitigation measures are necessary. |
| Public Services | No impacts. | No mitigation measures are necessary. |
| Human Health and Safety | No impacts. | Basin Electric would develop a Health and Safety Plan and would coordinate with local emergency responders. |
| Air | Minor impacts would occur from natural gas combustion and fugitive dust during construction. | Fugitive dust would be controlled by standard dust control measures. The 12 engines would be equipped with SCR and lean-burn combustion systems to achieve NOx control. Basin Electric has applied for a Permit to Construct from the NDDH for PGS Phase III. |
| Noise | Noise sensitive land uses near the PGS include a church and residences. Noise impacts are nominal, after incorporation of mitigation. No impacts to noise sensitive land uses are anticipated. | Charge air intake silencers and exhaust silencers, providing 35 dBA of mitigation, would be installed to lower operational noise levels to below 55 dBA at sensitive noise receptors. |
| Visual | The proposed Project would add additional visual elements to the landscape where a power generation site already exists. | Because the area has already been impacted by the existing PGS facilities, transmission infrastructure, industrial development, and oil and gas facilities, no additional mitigation is necessary. |
| Cultural and Archaeological | No impacts. | No mitigation measures are necessary. |
| Recreational Resources | No impacts. | No mitigation measures are necessary. |
| Land Based Economies | No impacts. | No mitigation measures are necessary. |

| Resource | Impact | Mitigation |
|---|---|---|
| Soils | Approximately 12.5 acres of soils would be removed to accommodate the new gas engines and switchyard.<br>Approximately 7.1 acres for laydown and parking areas would be temporarily disturbed during construction. | Basin Electric would maintain good water and soil conservation practices during construction and operation of the Project to protect topsoil and adjacent resources and to minimize soil erosion. Basin Electric would implement a SWPPP during construction and would limit surface disturbance to only those areas necessary for construction. |
| Geologic and Groundwater Resources | No impacts. | The construction contractor would minimize the likelihood of spilling fuel, hydraulic fluid, or other regulated materials by requiring that refueling takes place at secure areas. Spill kits would be maintained at these sites to contain and clean up any spills that may occur. Construction crew members would be trained in spill prevention and clean up. |
| Surface Water and Floodplain Resources | No impacts. | An NPDES permit and approved SWPPP would be prepared and obtained for the project. |
| Wetlands | No impacts. | No mitigation measures are necessary |
| Vegetation | Approximately 12.5 acres of vegetation would be removed to accommodate the new gas engines and switchyard.<br>Approximately 7.1 acres for laydown and parking areas would be temporarily disturbed during construction. | Basin Electric would inspect and control noxious weeds immediately after construction and periodically for the life of the Project. |
| Wildlife | No impacts. | No mitigation measures are necessary. |
| Rare and Unique Natural Resources | No impacts. | No mitigation measures are necessary. |

# 5.0 PUBLIC AND AGENCY COORDINATION

Correspondence regarding the PGS Phase III Project was sent to federal and state agencies for comment. Agency response letters for the Project are included in Appendix G. Responses were received from the USACE, USDA-Natural Resources Conservation Service, NDDH, USFWS, North Dakota Game and Fish Department, North Dakota State Water Commission, and State Historical Society of North Dakota.

## 6.0 IDENTIFICATION OF REQUIRED PERMITS/APPROVALS

The federal and state permits or approvals that have been identified as potentially being required for the construction and operation of the Project are shown in Table 6-1.

**Table 6-1: Possible Permits and Approvals**

| Agency | Type of Approval | Status | Need |
|---|---|---|---|
| **State of North Dakota** | | | |
| Public Service Commission | Certificate of Site Compatibility | Subject of this Application | Included herein |
| | Site Permit | Subject of this Application | Included herein |
| North Dakota Department of Health | Minor Source Air Construction Permit | Application submitted September 2014 | A permit to construct is required for any new stationary source or modification to an existing source |
| | NPDES Permit: General Construction Stormwater | Would be acquired by Basin Electric's Contractor | Permits required if:<br>• Land disturbance (clearing, grading or excavating) is greater than or equal to 1 acre, or<br>• Land disturbance is less than 1 acre and the site is part of a larger common plan of development or sale with the total land area disturbed in the development being equal to or greater than 1 acre or,<br>• There is potential for contribution to a violation of a water quality standard or potential for significant contribution of pollutants to waters of the state<br><br>Permit application requires the preparation of a SWPPP |
| North Dakota Highway Patrol | Overheight/ Overweight Permit | Contractors would obtain as necessary, prior to transporting equipment | Permit required for hauling construction equipment and materials on state highways |
| **County/Local** | | | |
| Williams County | Conditional Use Permit | Would be obtained prior to construction | Permit required for construction of power generation facility |

# 7.0 FACTORS CONSIDERED

North Dakota Century Code (NDCC) Section 49-22-09 of the North Dakota Energy Conversion and Transmission Facility Siting Act lists 11 factors to guide the NDPSC in evaluation of the site. The following sections address these factors where applicable to the Project.

## 7.1 Public Health and Welfare, Natural Resources, and the Environment

The preceding sections discuss the potential effects of the proposed facility on public health and welfare, natural resources, and the environment. Chapter 4 details the research and investigations that were used to identify expected environmental impacts and mitigation in relation to the Project. Chapter 3 discussed construction and operation techniques. All impacts evaluated for the Project would be minor.

## 7.2 Technologies to Minimize Adverse Environmental Effects

Basin Electric would use the most recent generation station technologies and systems that minimize impacts to the environment. Chapter 3 discusses the engineering and operational design of the Project, including the proposed gas engine type. These technologies and techniques are the most appropriate technologies to minimize adverse environmental effects. This is evident in the minimal environmental effects identified by the research and investigations discussed in this application.

## 7.3 Potential for Beneficial Uses of Waste Energy

This factor is not applicable to this Project.

## 7.4 Unavoidable Adverse Environmental Effects

Chapter 4 details the research and investigations that were used to identify expected environmental impacts and mitigation in relation to the Project. The environmental effects of the Project would be minor. Unavoidable adverse environmental effects include the visual impacts associated with the PGS facility and noise from operation of the facility. This is an area with other pre-existing visual and noise impacts including industrial development, transmission lines, and oil and gas development; the proposed facility would not significantly increase these impacts.

## 7.5 Irreversible and Irretrievable Commitment of Natural Resources for the Site

Irreversible and irretrievable resource commitments are related to the use of nonrenewable resources and the effects that the use of these resources would have on future generations. Irreversible effects primarily result from use or destruction of a specific resource that cannot be replaced within a reasonable time frame. Irretrievable resource commitments involve the loss in value of an affected resource that cannot be restored as a result of the action. The proposed Project would result in the conversion of approximately 12 acres of cropland for the construction of the gas engines and switchyard. This land would be unavailable for agricultural production for the life of the Project. There are few commitments of resources associated with construction of the proposed Project that are irreversible and irretrievable. Resources that would be used to construct the Project include aggregate resources, concrete, steel, and hydrocarbon fuel.

## 7.6 Direct and Indirect Economic Impacts of the Proposed Facility

The direct and indirect economic impacts are positive. To the extent that local contractors are used for portions of the construction, total wages and salaries paid to contractors and workers would contribute to the total personal income of the region. Additional personal income would be generated for residents in the county and the state by circulation and recirculation of dollars paid out by Basin Electric as business expenditures and state and local taxes. Expenditures made for equipment, energy, fuel, operating supplies, and other products and services also benefit businesses in the county and the state.

## 7.7 Existing Development Plans of the State, Local Government, and Private Entities at or in the Vicinity of the Site

No conflicts with existing development plans were identified as part of this application. In recent years, oil and gas development has continued to expand in the Williams County area. It is reasonably foreseeable that areas near the PGS would be considered for gas and oil development. This is evidenced by the existing oil wells. The location of the PGS is not expected to inhibit the potential for future gas and oil development.

## 7.8 Effect on Scenic Areas, Cultural Resources, and Paleontological Sites

The PGS site is not located in a locally or nationally recognized scenic area or near any known paleontological sites. As indicated in Chapter 4, cultural resource surveys of the PGS property recommended a finding of no historic properties affected. The SHPO concurred with this determination. There would be no impacts to cultural resources.

## 7.9 Effect on Biological Resources

Chapter 4 discusses potential impacts to biological resources such as wetlands, vegetation, wildlife, and rare and unique species. There would be no impacts to wetlands and rare or unique species and only minor impacts to vegetation and wildlife.

## 7.10 Effects of Site on Sensitive Species and Habitats

Federally listed species are not known to occur within the PGS area and are not likely to be adversely impacted. Habitat for listed species is either completely lacking or is extremely limited in the PGS area.

## 7.11 Concerns Raised by Agencies

The area in the vicinity of the PGS was reviewed by state and federal agencies as part of this NDPSC permitting process. Agency comments varied according to agency function and jurisdiction, but agency comments generally emphasized a desire to minimize impacts to environmental resources such as wetlands, wildlife, and cultural resources. These environmental resources are addressed in Chapter 4 of this application. Agency response letters for the Project are included in Appendix G.

# 8.0 QUALIFICATIONS OF CONTRIBUTORS

| Name, Role, and Company | Education and Professional Experience |
|---|---|
| Cris Miller<br>Environmental Permitting<br>Basin Electric Power Cooperative | B.S. Civil Engineering<br>32 Years' Experience<br>Registered Professional Engineer |
| Josh Rossow<br>Project Manager<br>Basin Electric Power Cooperative | B.S. Mechanical Engineering<br>10 Years' Experience<br>Registered Professional Engineer |
| Becky Kern<br>Manager of Strategic Planning<br>Basin Electric Power Cooperative | B.S. Electrical Engineering<br>11 Years' Experience |
| Lucas Teigen<br>Manager of Construction<br>Basin Electric Power Cooperative | B.S. Industrial Technology<br>7 Years' Experience |
| Steve Thornhill<br>Project Manager<br>Burns & McDonnell Engineering Company, Inc. | B.S. Biology<br>M.S. Biology<br>25 Years' Experience |
| Cailee Crist<br>Air and Noise Permitting<br>Burns & McDonnell Engineering Company, Inc. | B.S. Atmospheric Science<br>2 Years' Experience |
| Jennifer Bell<br>Environmental Studies<br>Burns & McDonnell Engineering Company, Inc. | B.S. Environmental Studies<br>Master of Urban & Regional Planning (M.U.R.P.)<br>7 Years' Experience |

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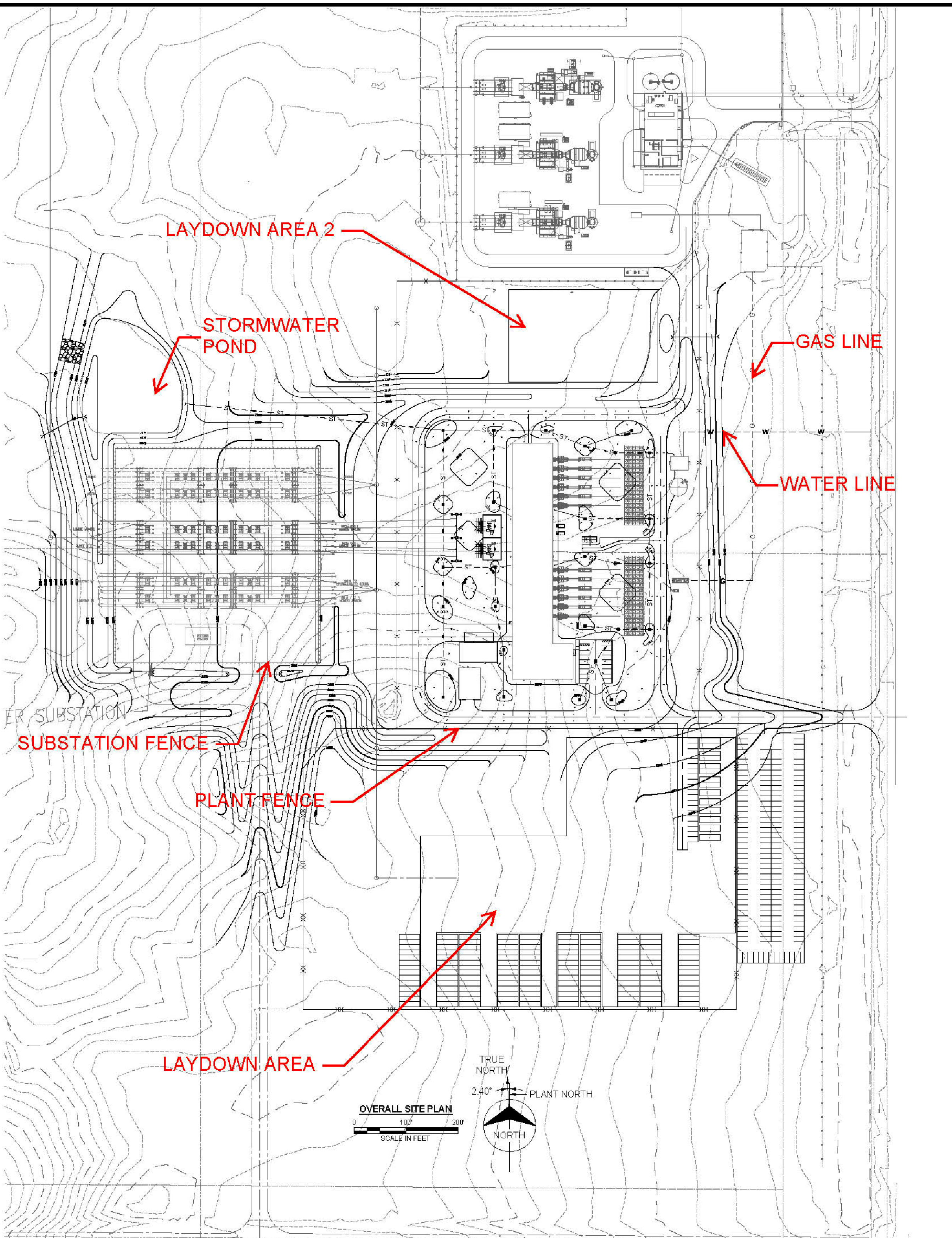
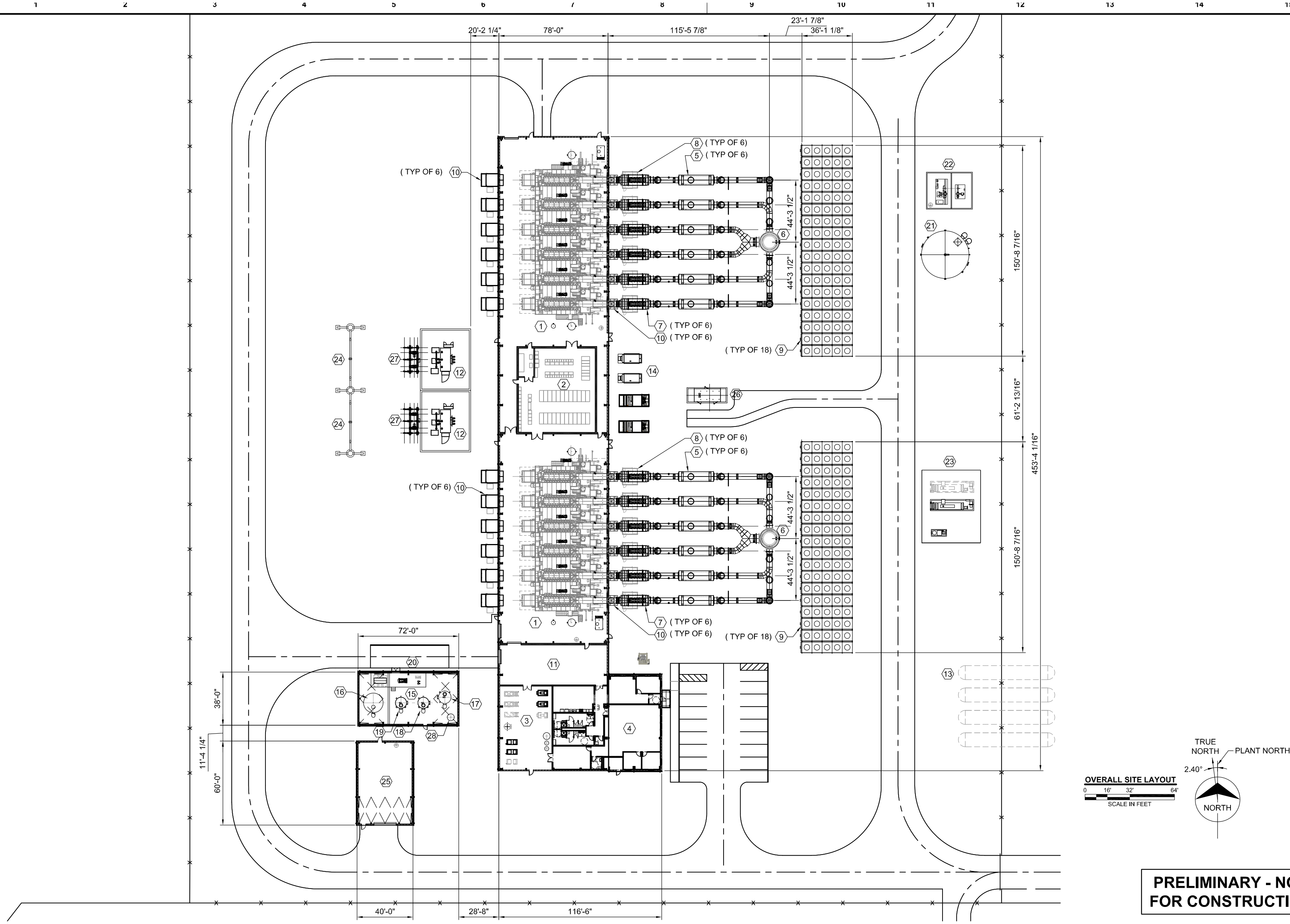
# APPENDIX A - SITE PLAN




Project Facilities Overview
Pioneer Generation Station
Phase III Project
Basin Electric Power Cooperative
Williams County, ND

Source: USDA NAIP 2014 Aerial Photography, ESRI, and Burns & McDonnell

Issued: 12/1/2014




**PRELIMINARY - NOT FOR CONSTRUCTION**

## SITE KEY

| | |
|---|---|
| 1 | ENGINE HALL |
| 2 | SWITCHGEAR ROOM |
| 3 | MECHANICAL ROOM |
| 4 | CONTROL ROOM |
| 5 | SILENCERS |
| 6 | STACK |
| 7 | SELECTIVE CATALYTIC REDUCER |
| 8 | CHARGE AIR FILTERS |
| 9 | RADIATORS |
| 10 | VENTILATION FAN |
| 11 | MAINTENANCE AREA |
| 12 | STEP-UP TRANSFORMER AND CONTAINMENT |
| 13 | LPG STORAGE TANKS ( FUTURE ) |
| 14 | STATION TRANSFORMER |
| 15 | OIL-UREA CONTAINMENT |
| 16 | UREA TANK |
| 17 | NEW LUBE OIL TANK |
| 18 | SERVICE LUBE OIL TANK |
| 19 | USED LUBE OIL TANK |
| 20 | OIL-UREA UNLOADING STATION |
| 21 | FIRE WATER TANK |
| 22 | FIRE PUMP HOUSE |
| 23 | GAS CONDITIONING |
| 24 | DEADEND STRUCTURE |
| 25 | WAREHOUSE |
| 26 | AUXILLARY GENERATOR |
| 27 | DISCONNECT SWITCH |
| 28 | OILY WASTE TANK |

| no. | date | by | ckd | description |
|---|---|---|---|---|
| E | 10/01/14 | MO | CJM | UPDATED BUILDING INTERIOR DESIGN |
| D | 09/26/14 | MO | CJM | ISSUED FOR REVIEW |
| C | 09/10/14 | WRL | CJM | FINAL GENERAL ARRANGEMENT |
| B | 06/30/14 | WRL | CJM | REVISED GSU LOCATION |
| A | 06/06/14 | WRL | CJM | PRELIMINARY |

| no. | date | by | ckd | description |
|---|---|---|---|---|
| H | 11/07/14 | MO | CJM | UPDATED PER REVIEW COMMENTS |
| G | 10/17/14 | MO | CJM | ISSUED FOR CLIENT REVIEW |
| F | 10/03/14 | WRL | CJM | REVISED WAREHOUSE LOCATION AND SIZE |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816-333-9400
designed M. OKAZ
detailed M. OKAZ


BASIN ELECTRIC POWER COOPERATIVE
A Touchstone Energy® Cooperative
WILLISTON, NORTH DAKOTA

PIONEER GENERATION STATION PHASE III
GENERAL ARRANGEMENT
OVERALL SITE PLAN

project 80767 | contract MULTIPLE

drawing GA-1000-0002 - rev. H

sheet of sheets

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# APPENDIX B - ELECTRIC AND MAGNETIC FIELD QUESTIONS AND ANSWERS

June 2002

# EMF

## Electric and Magnetic Fields Associated with the Use of Electric Power

# Questions & Answers

prepared by the
National Institute of Environmental Health Sciences
National Institutes of Health

sponsored by the
NIEHS/DOE EMF RAPID Program

# Contents

# Introduction

Since the mid-twentieth century, electricity has been an essential part of our lives. Electricity powers our appliances, office equipment, and countless other devices that we use to make life safer, easier, and more interesting. Use of electric power is something we take for granted. However, some have wondered whether the electric and magnetic fields (EMF) produced through the generation, transmission, and use of electric power [power-frequency EMF, 50 or 60 hertz (Hz)] might adversely affect our health. Numerous research studies and scientific reviews have been conducted to address this question.

Unfortunately, initial studies of the health effects of EMF did not provide straightforward answers. The study of the possible health effects of EMF has been particularly complex and results have been reviewed by expert scientific panels in the United States and other countries. This booklet summarizes the results of these reviews. Although questions remain about the possibility of health effects related to EMF, recent reviews have substantially reduced the level of concern.

The largest evaluation to date was led by two U.S. government institutions, the National Institute of Environmental Health Sciences (NIEHS) of the National Institutes of Health and the Department of Energy (DOE), with input from a wide range of public and private agencies. This evaluation, known as the Electric and Magnetic Fields Research and Public Information Dissemination (EMF RAPID) Program, was a six-year project with the goal of providing scientific evidence to determine whether exposure to power-frequency EMF involves a potential risk to human health.

In 1999, at the conclusion of the EMF RAPID Program, the NIEHS reported to the U.S. Congress that the overall scientific evidence for human health risk from EMF exposure is weak. No consistent pattern of biological effects from exposure to EMF had emerged from laboratory studies with animals or with cells. However, epidemiological studies (studies of disease incidence in human populations) had shown a fairly consistent pattern that associated potential EMF exposure with a small increased risk for leukemia in children and chronic lymphocytic leukemia in adults. Since 1999, several other assessments have been completed that support an association between childhood leukemia and exposure to power-frequency EMF. These more recent reviews, however, do not support a link between EMF exposures and adult leukemias. For both childhood and adult leukemias, interpretation of the epidemiological findings has been difficult due to the absence of supporting laboratory evidence or a scientific explanation linking EMF exposures with leukemia.

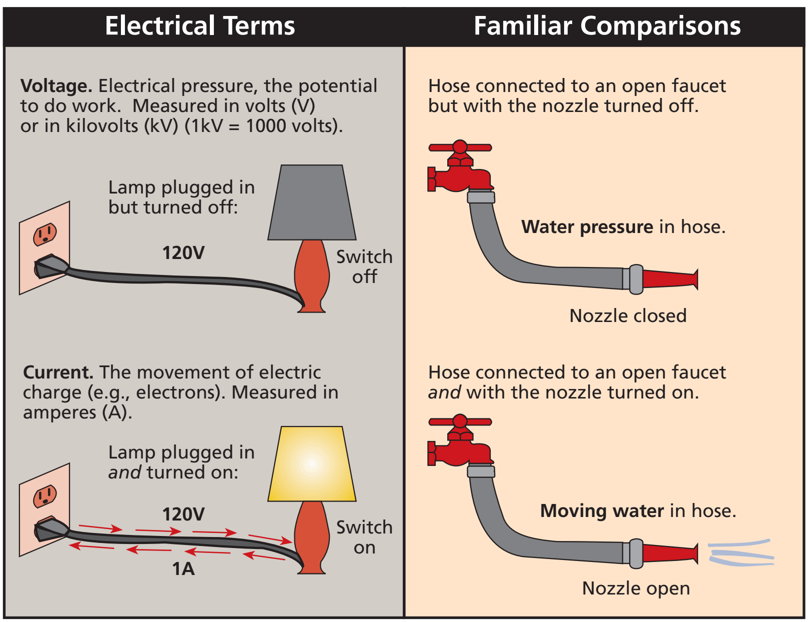
EMF exposures are complex and exist in the home and workplace as a result of all types of electrical equipment and building wiring as well as a result of nearby power lines. This booklet explains the basic principles of electric and magnetic fields, provides an overview of the results of major research studies, and summarizes conclusions of the expert review panels to help you reach your own conclusions about EMF-related health concerns.

# 1 EMF Basics

*This chapter reviews terms you need to know to have a basic understanding of electric and magnetic fields (EMF), compares EMF with other forms of electromagnetic energy, and briefly discusses how such fields may affect us.*

## Q What are electric and magnetic fields?

**A** Electric and magnetic fields (EMF) are invisible lines of force that surround any electrical device. Power lines, electrical wiring, and electrical equipment all produce EMF. There are many other sources of EMF as well (see pages 33–35). The focus of this booklet is on power-frequency EMF—that is, EMF associated with the generation, transmission, and use of electric power.




Voltage produces an electric field and current produces a magnetic field.

Electric fields are produced by voltage and increase in strength as the voltage increases. The electric field strength is measured in units of volts per meter (V/m). Magnetic fields result from the flow of current through wires or electrical devices and increase in strength as the current increases. Magnetic fields are measured in units of gauss (G) or tesla (T).

Most electrical equipment has to be turned on, i.e., current must be flowing, for a magnetic field to be produced. Electric fields are often present even when the equipment is switched off, as long as it remains connected to the source of electric power. Brief bursts of EMF (sometimes called "transients") can also occur when electrical devices are turned on or off.

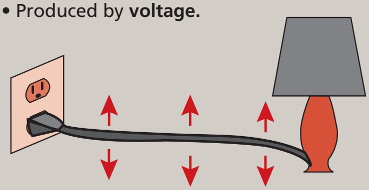
Electric fields are shielded or weakened by materials that conduct electricity—even materials that conduct poorly, including trees, buildings, and human skin. Magnetic fields, however, pass through most materials and are therefore more difficult to shield. Both electric fields and magnetic fields decrease rapidly as the distance from the source increases.

Even though electrical equipment, appliances, and power lines produce both electric and magnetic fields, most recent research has focused on potential health effects of magnetic field exposure. This is because some epidemiological studies have reported an increased cancer risk associated with estimates of magnetic field exposure (see pages 19 and 20 for a summary of these studies). No similar associations have been reported for electric fields; many of the studies examining biological effects of electric fields were essentially negative.

## A Comparison of Electric and Magnetic Fields

### Electric Fields

- Produced by **voltage.**

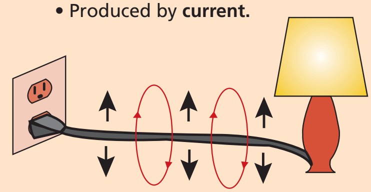


Lamp plugged in but turned off. Voltage produces an electric field.

- Measured in **volts per meter (V/m)** or in **kilovolts per meter (kV/m).**
- **Easily shielded** (weakened) by conducting objects such as trees and buildings.
- Strength decreases rapidly with increasing distance from the source.

### Magnetic Fields

- Produced by **current.**

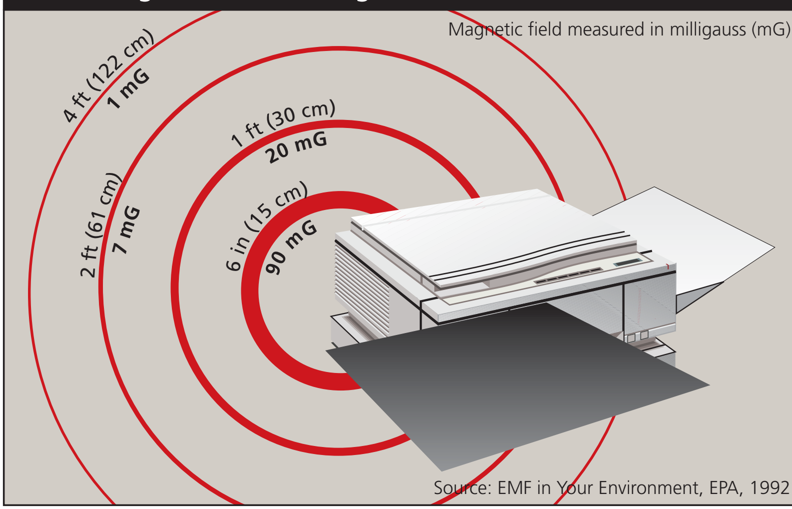


Lamp plugged in and turned on. Current now produces a magnetic field also.

- Measured in **gauss (G)** or **tesla (T).**
- **Not easily shielded** (weakened) by most material.
- Strength decreases rapidly with increasing distance from the source.

An appliance that is plugged in and therefore connected to a source of electricity has an electric field even when the appliance is turned off. To produce a magnetic field, the appliance must be plugged in and turned on so that the current is flowing.

## Magnetic Field Strength Decreases with Distance




Source: EMF in Your Environment, EPA, 1992.

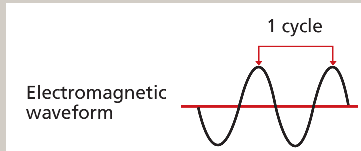
You cannot see a magnetic field, but this illustration represents how the strength of the magnetic field can diminish just 1–2 feet (30–61 centimeters) from the source. This magnetic field is a 60-Hz power-frequency field.

### Characteristics of electric and magnetic fields

Electric fields and magnetic fields can be characterized by their wavelength, frequency, and amplitude (strength). The graphic below shows the waveform of an alternating electric or magnetic field. The direction of the field alternates from one polarity to the opposite and back to the first polarity in a period of time called one cycle. Wavelength describes the distance between a peak on the wave and the next peak of the same polarity. The frequency of the field, measured in hertz (Hz), describes the number of cycles that occur in one second. Electricity in North America alternates through 60 cycles per second, or 60 Hz. In many other parts of the world, the frequency of electric power is 50 Hz.

**Frequency and Wavelength**

Frequency is measured in hertz (Hz).
1 Hz = 1 cycle per second.




**Examples:**

| Source | Frequency | Wavelength |
|---|---|---|
| Power line (North America) | 60 Hz | 3100 miles (5000 km) |
| Power line (Europe and most other locations) | 50 Hz | 3750 miles (6000 km) |

## Q How is the term EMF used in this booklet?

**A** The term "EMF" usually refers to electric and magnetic fields at extremely low frequencies such as those associated with the use of electric power. The term EMF can be used in a much broader sense as well, encompassing electromagnetic fields with low or high frequencies (see page 8).

**Measuring EMF: Common Terms**

**Electric fields**

Electric field strength is measured in volts per meter (V/m) or in kilovolts per meter (kV/m). 1 kV = 1000 V

**Magnetic fields**

Magnetic fields are measured in units of gauss (G) or tesla (T). Gauss is the unit most commonly used in the United States. Tesla is the internationally accepted scientific term. 1 T = 10,000 G

Since most environmental EMF exposures involve magnetic fields that are only a fraction of a tesla or a gauss, these are commonly measured in units of microtesla (μT) or milligauss (mG). A milligauss is 1/1,000 of a gauss. A microtesla is 1/1,000,000 of a tesla. 1 G = 1,000 mG; 1 T = 1,000,000 μT

To convert a measurement from microtesla (μT) to milligauss (mG), multiply by 10.
1 μT = 10 mG; 0.1 μT = 1 mG

When we use EMF in this booklet, we mean extremely low frequency (ELF) electric and magnetic fields, ranging from 3 to 3,000 Hz (see page 8). This range includes power-frequency (50 or 60 Hz) fields. In the ELF range, electric and magnetic fields are not coupled or interrelated in the same way that they are at higher frequencies. So, it is more useful to refer to them as “electric and magnetic fields” rather than “electromagnetic fields.” In the popular press, however, you will see both terms used, abbreviated as EMF.

This booklet focuses on extremely low frequency EMF, primarily power-frequency fields of 50 or 60 Hz, produced by the generation, transmission, and use of electricity.

## Q How are power-frequency EMF different from other types of electromagnetic energy?

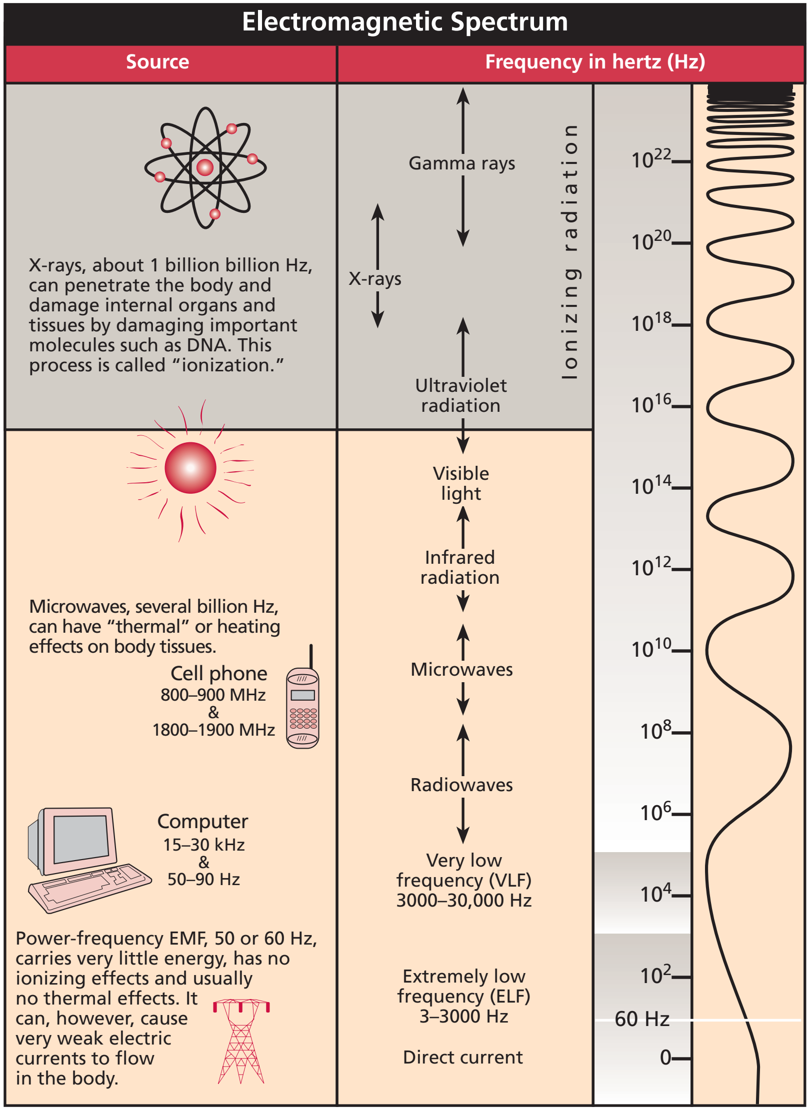
**A** X-rays, visible light, microwaves, radio waves, and EMF are all forms of electromagnetic energy. One property that distinguishes different forms of electromagnetic energy is the frequency, expressed in hertz (Hz). Power-frequency EMF, 50 or 60 Hz, carries very little energy, has no ionizing effects, and usually has no thermal effects (see page 8). Just as various chemicals affect our bodies in different ways, various forms of electromagnetic energy can have very different biological effects (see “Results of EMF Research” on page 16).

Some types of equipment or operations simultaneously produce electromagnetic energy of different frequencies. Welding operations, for example, can produce electromagnetic energy in the ultraviolet, visible, infrared, and radio-frequency ranges, in addition to power-frequency EMF. Microwave ovens produce 60-Hz fields of several hundred milligauss, but they also create microwave energy inside the oven that is at a much higher frequency (about 2.45 billion Hz). We are shielded from the higher frequency fields inside the oven by its casing, but we are not shielded from the 60-Hz fields.

Cellular telephones communicate by emitting high-frequency electric and magnetic fields similar to those used for radio and television broadcasts. These radio-frequency and microwave fields are quite different from the extremely low frequency EMF produced by power lines and most appliances.

## Q How are alternating current sources of EMF different from direct current sources?

**A** Some equipment can run on either alternating current (AC) or direct current (DC). In most parts of the United States, if the equipment is plugged into a household wall socket, it is using AC electric current that reverses direction in the electrical wiring—or alternates—60 times per second, or at 60 hertz (Hz). If the equipment uses batteries, then electric current flows in one direction only. This




The wavy line at the right illustrates the concept that the higher the frequency, the more rapidly the field varies. The fields do not vary at 0 Hz (direct current) and vary trillions of times per second near the top of the spectrum. Note that $10^4$ means 10 x 10 x 10 x 10 or 10,000 Hz. 1 kilohertz (kHz) = 1,000 Hz. 1 megahertz (MHz) = 1,000,000 Hz.

produces a "static" or stationary magnetic field, also called a direct current field. Some battery-operated equipment can produce time-varying magnetic fields as part of its normal operation.

## Q What happens when I am exposed to EMF?

**A** In most practical situations, DC electric power does not induce electric currents in humans. Strong DC magnetic fields are present in some industrial environments, can induce significant currents when a person moves, and may be of concern for other reasons, such as potential effects on implanted medical devices (see page 47 for more information on pacemakers and other medical devices).

AC electric power produces electric and magnetic fields that create weak electric currents in humans. These are called "induced currents." Much of the research on how EMF may affect human health has focused on AC-induced currents.

### Electric fields

A person standing directly under a high-voltage transmission line may feel a mild shock when touching something that conducts electricity. These sensations are caused by the strong electric fields from the high-voltage electricity in the lines. They occur only at close range because the electric fields rapidly become weaker as the distance from the line increases. Electric fields may be shielded and further weakened by buildings, trees, and other objects that conduct electricity.

### Magnetic fields

Alternating magnetic fields produced by AC electricity can induce the flow of weak electric currents in the body. However, such currents are estimated to be smaller than the measured electric currents produced naturally by the brain, nerves, and heart.

## Q Doesn't the earth produce EMF?

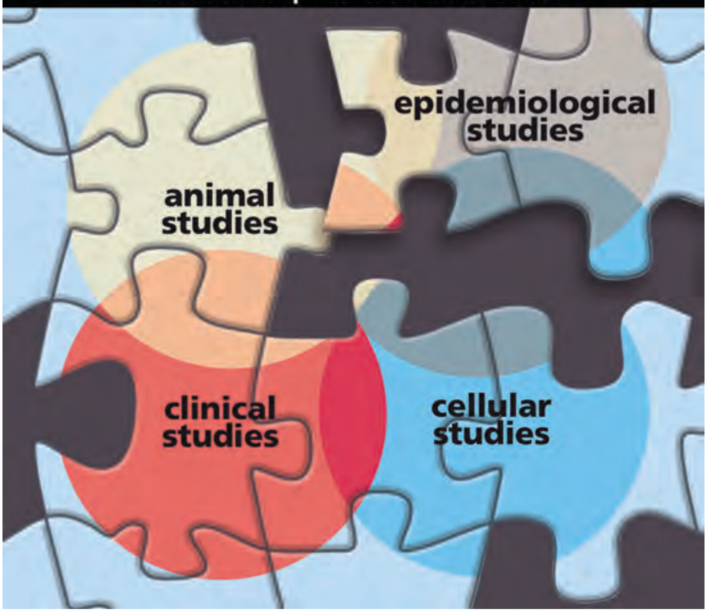
**A** Yes. The earth produces EMF, mainly in the form of static fields, similar to the fields generated by DC electricity. Electric fields are produced by air turbulence and other atmospheric activity. The earth's magnetic field of about 500 mG is thought to be produced by electric currents flowing deep within the earth's core. Because these fields are static rather than alternating, they do not induce currents in stationary objects as do fields associated with alternating current. Such static fields can induce currents in moving and rotating objects.

# 2 Evaluating Potential Health Effects

*This chapter explains how scientific studies are conducted and evaluated to assess potential health effects.*

## Q How do we evaluate whether EMF exposures cause health effects?

**A** Animal experiments, laboratory studies of cells, clinical studies, computer simulations, and human population (epidemiological) studies all provide valuable information. When evaluating evidence that certain exposures cause disease, scientists consider results from studies in various disciplines. No single study or type of study is definitive.




Laboratory studies and human studies provide pieces of the puzzle, but no single study can give us the whole picture.

### Laboratory studies

Laboratory studies with cells and animals can provide evidence to help determine if an agent such as EMF causes disease. Cellular studies can increase our understanding of the biological mechanisms by which disease occurs. Experiments with animals provide a means to observe effects of specific agents under carefully controlled conditions. Neither cellular nor animal studies, however, can recreate the complex nature of the whole human organism and its environment. Therefore, we must use caution in applying the results of cellular or animal studies directly to humans or concluding that a lack of an effect in laboratory studies proves that an agent is safe. Even with these limitations, cellular and animal studies have proven very useful over the years for identifying and understanding the toxicity of numerous chemicals and physical agents.

Very specific laboratory conditions are needed for researchers to be able to detect EMF effects, and experimental exposures are not easily comparable to human exposures. In most cases, it is not clear how EMF actually produces the effects observed in some experiments. Without understanding how the effects occur, it is difficult to evaluate how laboratory results relate to human health effects.

Some laboratory studies have reported that EMF exposure can produce biological effects, including changes in functions of cells and tissues and subtle changes in hormone levels in animals. It is important to distinguish between a biological effect and a health effect. Many biological effects are within the normal range of variation and are not necessarily harmful. For example, bright light has a biological effect on our eyes, causing the pupils to constrict, which is a normal response.

## Clinical studies

In clinical studies, researchers use sensitive instruments to monitor human physiology during controlled exposure to environmental agents. In EMF studies, volunteers are exposed to electric or magnetic fields at higher levels than those commonly encountered in everyday life. Researchers measure heart rate, brain activity, hormonal levels, and other factors in exposed and unexposed groups to look for differences resulting from EMF exposure.

## Epidemiology

A valuable tool to identify human health risks is to study a human population that has experienced the exposure. This type of research is called epidemiology.

The epidemiologist observes and compares groups of people who have had or have not had certain diseases and exposures to see if the risk of disease is different between the exposed and unexposed groups. The epidemiologist does not control the exposure and cannot experimentally control all the factors that might affect the risk of disease.

Most researchers agree that epidemiology—the study of patterns and possible causes of diseases—is one of the most valuable tools to identify human health risks.

## Q How do we evaluate the results of epidemiological studies of EMF?

**A** Many factors need to be considered when determining whether an agent causes disease. An exposure that an epidemiological study associates with increased risk of a certain disease is not always the actual cause of the disease. To judge whether an agent actually causes a health effect, several issues are considered.

### Strength of association

The stronger the association between an exposure and disease, the more confident we can be that the disease is due to the exposure being studied. With cigarette smoking and lung cancer, the association is very strong—20 times the normal risk. In the studies that suggest a relationship between EMF and certain rare cancers, the association is much weaker (see page 19).

### Dose-response

Epidemiological data are more convincing if disease rates increase as exposure levels increase. Such dose-response relationships have appeared in only a few EMF studies.

### Consistency

Consistency requires that an association found in one study appears in other studies involving different study populations and methods. Associations found consistently are more likely to be causal. With regard to EMF, results from different studies sometimes disagree in important ways, such as what type of cancer is associated with EMF exposure. Because of this inconsistency, scientists cannot be sure whether the increased risks are due to EMF or other factors.

### Biological plausibility

When associations are weak in an epidemiological study, results of laboratory studies are even more important to support the association. Many scientists remain skeptical about an association between EMF exposure and cancer because laboratory studies thus far have not shown any consistent evidence of adverse health effects, nor have results of experimental studies revealed a plausible biological explanation for such an association.

### Reliability of exposure information

Another important consideration with EMF epidemiological studies is how the exposure information was obtained. Did the researchers simply estimate people's EMF exposures based on their job titles or how their houses were wired, or did they actually conduct EMF measurements? What did they measure (electric fields, magnetic fields, or both)? How often were the EMF measurements made and at what time? In how many different places were the fields measured? More recent studies have included measurements of magnetic field exposure. Magnetic fields measured at the time a study is conducted can only estimate exposures that occurred in previous years (at the time a disease process may have begun). Lack of comprehensive exposure information makes it more difficult to interpret the results of a study, particularly considering that everyone in the industrialized world has been exposed to EMF.

### Confounding

Epidemiological studies show relationships or correlations between disease and other factors such as diet, environmental conditions, and heredity. When a disease is correlated with some factor, it does not necessarily mean that the correlated factor causes the disease. It could mean that the factor occurs together with some other factor, not measured in the study, that actually causes the disease. This is called confounding.

For example, a study might show that alcohol consumption is correlated with lung cancer. This could occur if the study group consists of people who drink and also smoke tobacco, as often happens. In this example, alcohol use is correlated with lung cancer, but cigarette smoking is a confounding factor and the true cause of the disease.

### Statistical significance

Researchers use statistical methods to determine the likelihood that the association between exposure and disease is due simply to chance. For a result to be considered "statistically significant," the association must be stronger than would be expected to occur by chance alone.

### Meta-analysis

One way researchers try to get more information from epidemiological studies is to conduct a meta-analysis. A meta-analysis combines the summary statistics of many studies to explore their differences and, if appropriate, calculates an overall summary risk estimate. The main challenge faced by researchers performing meta-analyses is that populations, measurements, evaluation techniques, participation rates, and potential confounding factors vary in the original studies. These differences in the studies make it difficult to combine the results in a meaningful way.

### Pooled analysis

Pooled analysis combines the original data from several studies and conducts a new analysis on the primary data. It requires access to the original data from individual studies and can only include diseases or factors included in all the studies, but it has the advantage that the same parameters can be applied to all studies. As with meta-analysis, pooled analysis is still subject to the limitations of the experimental design of the original studies (for example, evaluation techniques, participation rates, etc.). Pooled analysis differs from meta-analysis, which combines the summary statistics from different studies, not their original data.

## Q How do we characterize EMF exposure?

**A** No one knows which aspect of EMF exposure, if any, affects human health. Because of this uncertainty, in addition to the field strength, we must ask how long an exposure lasts, how it varies, and at what time of day or night it occurs. House wiring, for example, is often a significant source of EMF exposure for an individual, but the magnetic fields produced by the wiring depend on the amount of current flowing. As heating, lighting, and appliance use varies during the day, magnetic field exposure will also vary.

For many studies, researchers describe EMF exposures by estimating the average field strength. Some scientists believe that average exposure may not be the best measurement of EMF exposure and that other parameters, such as peak exposure or time of exposure, may be important.

## Q What is the average field strength?

**A** In EMF studies, the information reported most often has been a person's EMF exposure averaged over time (average field strength). With cancer-causing chemicals, a person's average exposure over many years can be a good way to predict his or her chances of getting the disease.

There are different ways to calculate average magnetic field exposures. One method involves having a person wear a small monitor that takes many measurements over a work shift, a day, or longer. Then the average of those measurements is calculated. Another method involves placing a monitor that takes many measurements in a residence over a 24-hour or 48-hour period. Sometimes averages are calculated for people with the same occupation, people working in similar environments, or people using several brands of the same type or similar types of equipment.

## Q How is EMF exposure measured in epidemiological studies?

**A** Epidemiologists study patterns and possible causes of diseases in human populations. These studies are usually observational rather than experimental. This means that the researcher observes and compares groups of people who have had certain diseases and exposures and looks for possible "associations." The epidemiologist must find a way to estimate the exposure that people had at an earlier time.

### Association

In epidemiology, a positive association between an exposure (such as EMF) and a disease is not necessarily proof that the exposure *caused* the disease. However, the more often the exposure and disease occur together, the stronger the association, and the stronger is the possibility that the exposure may increase the risk of the disease.

Some exposure estimates for residential studies have been based on designation of households in terms of "wire codes." In other studies, measurements have been made in homes, assuming that EMF levels at the time of the measurement are similar to levels at some time in the past. Some studies involved "spot measurements." Exposure levels change as a person moves around in his or her environment, so spot measurements taken at specific locations only approximate the complex variations in exposure a person experiences. Other studies measured magnetic fields over a 24-hour or 48-hour period. Exposure levels for some occupational studies are measured by having certain employees wear personal monitors. The data taken from these monitors are sometimes used to estimate typical exposure levels for employees with certain job titles. Researchers can then estimate exposures using only an employee's job title and avoid measuring exposures of all employees.

## Methods to Estimate EMF Exposure

**Wire Codes**

A classification of homes based on characteristics of power lines outside the home (thickness of the wires, wire configuration, etc.) and their distance from the home. This information is used to code the homes into groups with higher and lower predicted magnetic field levels.

**Spot Measurement**

An instantaneous or very short-term (e.g., 30-second) measurement taken at a designated location.

**Time-Weighted Average**

A weighted average of exposure measurements taken over a period of time that takes into account the time interval between measurements. When the measurements are taken with a monitor at a fixed sampling rate, the time-weighted average equals the arithmetic mean of the measurements.

**Personal Monitor**

An instrument that can be worn on the body for measuring exposure over time.

**Calculated Historical Fields**

An estimate based on a theoretical calculation of the magnetic field emitted by power lines using historical electrical loads on those lines.

# 3 Results of EMF Research

*This chapter summarizes the results of EMF research worldwide, including epidemiological studies of children and adults, clinical studies of how humans react to typical EMF exposures, and laboratory research with animals and cells.*

## Q Is there a link between EMF exposure and childhood leukemia?

**A** Despite more than two decades of research to determine whether elevated EMF exposure, principally to magnetic fields, is related to an increased risk of childhood leukemia, there is still no definitive answer. Much progress has been made, however, with some lines of research leading to reasonably clear answers and others remaining unresolved. The best available evidence at this time leads to the following answers to specific questions about the link between EMF exposure and childhood leukemia:

*Is there an association between power line configurations (wire codes) and childhood leukemia?* No.

*Is there an association between measured fields and childhood leukemia?* Yes, but the association is weak, and it is not clear whether it represents a cause-and-effect relationship.

## Q What is the epidemiological evidence for evaluating a link between EMF exposure and childhood leukemia?

**A** The initial studies, starting with the pioneering research of Dr. Nancy Wertheimer and Ed Leeper in 1979 in Denver, Colorado, focused on power line configurations near homes. Power lines were systematically evaluated and coded for their presumed ability to produce elevated magnetic fields in homes and classified into groups with higher and lower predicted magnetic field levels (see discussion of wire codes on page 15). Although the first study and two that followed in Denver and Los Angeles showed an association between wire codes indicative of elevated magnetic fields and childhood leukemia, larger, more recent studies in the central part of the United States and in several provinces of Canada did not find such an association. In fact, combining the evidence from all the studies, we can conclude with some confidence that wire codes are not associated with a measurable increase in the risk of childhood leukemia.

The other approach to assessing EMF exposure in homes focused on the measurements of magnetic fields. Unlike wire codes, which are only applicable in North America due to the nature of the electric power distribution system, measured fields have been studied in relation to childhood leukemia in research conducted around the world, including Sweden, England, Germany, New Zealand, and Taiwan. Large, detailed studies have recently been completed in the United States, Canada, and the United Kingdom that provide the most evidence for making an evaluation. These studies have produced variable findings, some reporting small associations, others finding no associations.

### National Cancer Institute Study

In 1997, after eight years of work, Dr. Martha Linet and colleagues at the National Cancer Institute (NCI) reported the results of their study of childhood acute lymphoblastic leukemia (ALL). The case-control study involved more than 1,000 children living in 9 eastern and midwestern U.S. states and is the largest epidemiological study of childhood leukemia to date in the United States. To help resolve the question of wire code versus measured magnetic fields, the NCI researchers carried out both types of exposure assessment. Overall, Linet reported little evidence that living in homes with higher measured magnetic-field levels was a disease risk and found no evidence that living in a home with a high wire code configuration increased the risk of ALL in children.

### United Kingdom Childhood Cancer Study

In December 1999, Sir Richard Doll and colleagues in the United Kingdom announced that the largest study of childhood cancer ever undertaken—involving nearly 4,000 children with cancer in England, Wales, and Scotland—found no evidence of excess risk of childhood leukemia or other cancers from exposure to power-frequency magnetic fields. It should be noted, however, that because most power lines in the United Kingdom are underground, the EMF exposures of these children were mostly lower than 0.2 microtesla or 2 milligauss.

After reviewing all the data, the U.S. National Institute of Environmental Health Sciences (NIEHS) concluded in 1999 that the evidence was weak, but that it was still sufficient to warrant limited concern. The NIEHS rationale was that no individual epidemiological study provided convincing evidence linking magnetic field exposure with childhood leukemia, but the overall pattern of results for some methods of measuring exposure suggested a weak association between increasing exposure to EMF and increasing risk of childhood leukemia. The small number of cases in these studies made it impossible to firmly demonstrate this association. However, the fact that similar results had been observed in studies of different populations using a variety of study designs supported this observation.

A major challenge has been to determine whether the most highly elevated, but rarely encountered, levels of magnetic fields are associated with an increased risk of leukemia. Early reports focused on the risk associated with exposures above 2 or 3 milligauss, but the more recent studies have been large enough to also provide some information on levels above 3 or 4 milligauss. It is estimated that 4.5% of homes in the United States have magnetic fields above 3 milligauss, and 2.5% of homes have levels above 4 milligauss.

## What is Cancer?

**Cancer**

"Cancer" is a term used to describe at least 200 different diseases, all involving uncontrolled cell growth. The frequency of cancer is measured by the incidence—the number of new cases diagnosed each year. Incidence is usually described as the number of new cases diagnosed per 100,000 people per year.

The incidence of cancer in adults in the United States is 382 per 100,000 per year, and childhood cancers account for about 1% of all cancers. The factors that influence risk differ among the forms of cancer. Known risk factors such as smoking, diet, and alcohol contribute to specific types of cancer. (For example, smoking is a known risk factor for lung cancer, bladder cancer, and oral cancer.) For many other cancers, the causes are unknown.

**Leukemia**

Leukemia describes a variety of cancers that arise in the bone marrow where blood cells are formed. The leukemias represent less than 4% of all cancer cases in adults but are the most common form of cancer in children. For children age 4 and under, the incidence of childhood leukemia is approximately 6 per 100,000 per year, and it decreases with age to about 2 per 100,000 per year for children 10 and older. In the United States, the incidence of adult leukemia is about 10 cases per 100,000 people per year. Little is known about what causes leukemia, although genetic factors play a role. The only known causes are ionizing radiation, benzene, and other chemicals and drugs that suppress bone marrow function, and a human T-cell leukemia virus.

**Brain Cancer**

Cancer of the central nervous system (the brain and spinal cord) is uncommon, with incidence in the United States now at about 6 cases in 100,000 people per year. The causes of the disease are largely unknown, although a number of studies have reported an association with certain occupational chemical exposures. Ionizing radiation to the scalp is a known risk factor for brain cancer. Factors associated with an increased risk for other types of cancer—such as smoking, diet, and excessive alcohol use—have not been found to be associated with brain cancer.

To determine what the integrated information from all the studies says about magnetic fields and childhood leukemia, two groups have conducted pooled analyses in which the original data from relevant studies were integrated and analyzed. One report (Greenland et al., 2000) combined 12 relevant studies with magnetic field measurements, and the other considered 9 such studies (Ahlbom et al., 2000). The details of the two pooled analyses are different, but their findings are similar. There is weak evidence for an association (relative risk of approximately 2) at exposures above 3 mG. However, few individuals had high exposures in these studies; therefore, even combining all studies, there is uncertainty about the strength of the association.

The following table summarizes the results for the epidemiological studies of EMF exposure and childhood leukemia analyzed in the pooled analysis by Greenland et al. (2000). The focus of the summary review was the magnetic fields that occurred three months prior to diagnosis. The results were derived from either calculated historical fields or multiple measurements of magnetic fields. The North American

**Residential Exposure to Magnetic Fields and Childhood Leukemia**

| | Magnetic field category (mG) | | | | | |
|---|---|---|---|---|---|---|
| | >1 – ≤2 mG | | >2 – ≤3 mG | | >3 mG | |
| First author | Estimate | 95% CL | Estimate | 95% CL | Estimate | 95% CL |
| Coghill | 0.54 | 0.17, 1.74 | No controls | | No controls | |
| Dockerty | 0.65 | 0.26, 1.63 | 2.83 | 0.29, 27.9 | No controls | |
| Feychting | 0.63 | 0.08, 4.77 | 0.90 | 0.12, 7.00 | 4.44 | 1.67, 11.7 |
| Linet | 1.07 | 0.82, 1.39 | 1.01 | 0.64, 1.59 | 1.51 | 0.92, 2.49 |
| London | 0.96 | 0.54, 1.73 | 0.75 | 0.22, 2.53 | 1.53 | 0.67, 3.50 |
| McBride | 0.89 | 0.62, 1.29 | 1.27 | 0.74, 2.20 | 1.42 | 0.63, 3.21 |
| Michaelis | 1.45 | 0.78, 2.72 | 1.06 | 0.27, 4.16 | 2.48 | 0.79, 7.81 |
| Olsen | 0.67 | 0.07, 6.42 | No cases | | 2.00 | 0.40, 9.93 |
| Savitz | 1.61 | 0.64, 4.11 | 1.29 | 0.27, 6.26 | 3.87 | 0.87, 17.3 |
| Tomenius | 0.57 | 0.33, 0.99 | 0.88 | 0.33, 2.36 | 1.41 | 0.38, 5.29 |
| Tynes | 1.06 | 0.25, 4.53 | No cases | | No cases | |
| Verkasalo | 1.11 | 0.14, 9.07 | No cases | | 2.00 | 0.23, 17.7 |
| Study summary | 0.95 | 0.80, 1.12 | 1.06 | 0.79, 1.42 | 1.69* | 1.25, 2.29 |
| | 1 – <2 mG | | 2 – <4 mG | | ≥4 mG | |
| **United Kingdom | 0.84 | 0.57, 1.24 | 0.98 | 0.50, 1.93 | 1.00 | 0.30, 3.37 |

95% CL = 95% confidence limits.
Source: Greenland et al., 2000.
* Mantel-Haenszel analysis ($p$ = 0.01). Maximum-likelihood summaries differed by less than 1% from these summaries; based on 2,656 cases and 7,084 controls. Adjusting for age, sex, and other variables had little effect on summary results.
** These data are from a recent United Kingdom study not included in the Greenland analysis but included in another pooled analysis (Ahlbom et al. 2000). The United Kingdom study included 1,073 cases and 2,224 controls.
For this table, the column headed "estimate" describes the relative risk. Relative risk is the ratio of the risk of childhood leukemia for those in a magnetic field exposure group compared to persons with exposure levels of 1.0 mG or less. For example, Coghill estimated that children with exposures between 1 and 2 mG have 0.54 times the risk of children whose exposures were less than 1 mG. London's study estimates that children whose exposures were greater than 3 mG have 1.53 times the risk of children whose exposures were less than 1 mG. The column headed "95% CL" (confidence limits) describes how much random variation is in the estimate of relative risk. The estimate may be off by some amount due to random variation, and the width of the confidence limits gives some notion of that variation. For example, in Coghill's estimate of 0.54 for the relative risk, values as low as 0.17 or as high as 1.74 would not be statistically significantly different from the value of 0.54. Note there is a wide range of estimates of relative risk across the studies and wide confidence limits for many studies. In light of these findings, the pooling of results can be extremely helpful to calculate an overall estimate, much better than can be obtained from any study taken alone.

studies (Linet, London, McBride, Savitz) were 60 Hz; all other studies were 50 Hz. Results from the recent study from the United Kingdom (see page 17) are also included in the table. This study was included in the analysis by Ahlbom et al. (2000). The relative risk estimates from the individual studies show little or no association of magnetic fields with childhood leukemia. The study summary for the pooled analysis by Greenland et al. (2000) shows a weak association between childhood leukemia and magnetic field exposures greater 3 mG.

## Q Is there a link between EMF exposure and childhood brain cancer or other forms of cancer in children?

**A** Although the earliest studies suggested an association between EMF exposure and all forms of childhood cancer, those initial findings have not been confirmed by other studies. At present, the available series of studies indicates no association between EMF exposure and childhood cancers other than leukemia. Far fewer of these studies have been conducted than studies of childhood leukemia.

## Q Is there a link between residential EMF exposure and cancer in adults?

**A** The few studies that have been conducted to address EMF and adult cancer do not provide strong evidence for an association. Thus, a link has not been established between residential EMF exposure and adult cancers, including leukemia, brain cancer, and breast cancer (see table below).

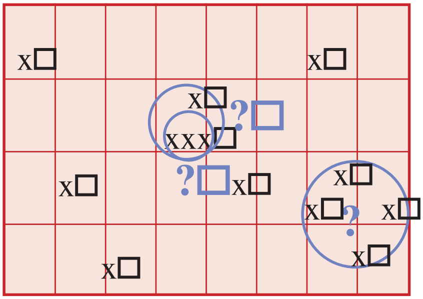
**Residential Exposure to Magnetic Fields and Adult Cancer**

| First author | Location | Type of exposure data | Results (odds ratios) Leukemia | CNS tumors | All cancers |
|---|---|---|---|---|---|
| Coleman | United Kingdom | Calculated historical fields | 0.92 | NA | NA |
| Feychting and Ahlbom | Sweden | Calculated & spot measurements | 1.5* | 0.7 | NA |
| Li | Taiwan | Calculated historical fields | 1.4* | 1.1 | NA |
| Li | Taiwan | Calculated historical fields | 1.1 (breast cancer) | | |
| McDowall | United Kingdom | Calculated historical fields | 1.43 | NA | 1.03 |
| Severson | Seattle | Wire codes & spot measurements | 0.75 | NA | NA |
| Wrensch | San Francisco | Wire codes & spot measurements | NA | 0.9 | NA |
| Youngson | United Kingdom | Calculated historical fields | 1.88 | NA | NA |

CNS = central nervous system.
*The number is statistically significant (greater than expected by chance).
Study results are listed as "odds ratios" (OR). An odds ratio of 1.00 means there was no increase or decrease in risk. In other words, the odds that the people in the study who had the disease (in this case, cancer) and were exposed to a particular agent (in this case, EMF) are the same as for the people in the study who did not have the disease. An odds ratio greater than 1 may occur simply by chance, unless it is statistically significant.

## Q Have clusters of cancer or other adverse health effects been linked to EMF exposure?

**A** An unusually large number of cancers, miscarriages, or other adverse health effects that occur in one area or over one period of time is called a "cluster." Sometimes clusters provide an early warning of a health hazard. But most of the time the reason for the cluster is not known. There have been no proven instances of cancer clusters linked with EMF exposure.




The definition of a "cluster" depends on how large an area is included. Cancer cases (x's in illustration) in a city, neighborhood, or workplace may occur in ways that suggest a cluster due to a common environmental cause. Often these patterns turn out to be due to chance. Delineation of a cluster is subjective—where do you draw the circles?

## Q If EMF does cause or promote cancer, shouldn't cancer rates have increased along with the increased use of electricity?

**A** Not necessarily. Although the use of electricity has increased greatly over the years, EMF exposures may not have increased. Changes in building wiring codes and in the design of electrical appliances have in some cases resulted in lower magnetic field levels. Rates for various types of cancer have shown both increases and decreases through the years, due in part to improved prevention, diagnosis, reporting, and treatment.

## Q Is there a link between EMF exposure in electrical occupations and cancer?

**A** For almost as long as we have been concerned with residential exposure to EMF and childhood cancers, researchers have been studying workplace exposure to EMF and adult cancers, focusing on leukemia and brain cancer. This research began with surveys of job titles and cancer risks, but has progressed to include very large, detailed studies of the health of workers, especially electric utility workers, in the United States, Canada, France, England, and several Northern European countries. Some studies have found evidence that suggests a link between EMF exposure and both leukemia and brain cancer, whereas other studies of similar size and quality have not found such associations.

**California**
A 1993 study of 36,000 California electric utility workers reported no strong, consistent evidence of an association between magnetic fields and any type of cancer.

**Canada/France**
A 1994 study of more than 200,000 utility workers in 3 utility companies in Canada and France reported no significant association between all leukemias combined and cumulative exposure to magnetic fields. There was a slight, but not statistically significant, increase in brain cancer. The researchers concluded that the study did not provide clear-cut evidence that magnetic field exposures caused leukemia or brain cancer.

**North Carolina**
Results of a 1995 study involving more than 138,000 utility workers at 5 electric utilities in the United States did not support an association between occupational magnetic field exposure and leukemia, but suggested a link to brain cancer.

**Denmark**
In 1997 a study of workers employed in all Danish utility companies reported a small, but statistically significant, excess risk for all cancers combined and for lung cancer. No excess risk was observed for leukemia, brain cancers, or breast cancer.

**United Kingdom**
A 1997 study among electrical workers in the United Kingdom did not find an excess risk for brain cancer. An extension of this work reported in 2001 also found no increased risk for brain cancer.

Efforts have also been made to pool the findings across several of the above studies to produce more accurate estimates of the association between EMF and cancer (Kheifets et al., 1999). The combined summary statistics across studies provide insufficient evidence for an association between EMF exposure in the workplace and either leukemia or brain cancer.

## Q Have studies of workers in other industries suggested a link between EMF exposure and cancer?

**A** One of the largest studies to report an association between cancer and magnetic field exposure in a broad range of industries was conducted in Sweden (1993). The study included an assessment of EMF exposure in 1,015 different workplaces and involved more than 1,600 people in 169 different occupations. An association was reported between estimated EMF exposure and increased risk for chronic lymphocytic leukemia. An association was also reported between exposure to magnetic fields and brain cancer, but there was no dose-response relationship.

Another Swedish study (1994) found an excess risk of lymphocytic leukemia among railway engine drivers and conductors. However, the total cancer incidence (all tumors included) for this group of workers was lower than in the general Swedish population. A study of Norwegian railway workers found no evidence for an association between EMF exposure and leukemia or brain cancer. Although both positive and negative effects of EMF exposure have been reported, the majority of studies show no effects.

## Q Is there a link between EMF exposure and breast cancer?

**A** Researchers have been interested in the possibility that EMF exposure might cause breast cancer, in part because breast cancer is such a common disease in adult women. Early studies identified a few electrical workers with male breast cancer, a very rare disease. A link between EMF exposure and alterations in the hormone melatonin was considered a possible hypothesis (see page 24). This idea provided motivation to conduct research addressing a possible link between EMF exposure and breast cancer. Overall, the published epidemiological studies have not shown such an association.

## Q What have we learned from clinical studies?

**A** Laboratory studies with human volunteers have attempted to answer questions such as,

*Does EMF exposure alter normal brain and heart function?*
*Does EMF exposure at night affect sleep patterns?*
*Does EMF exposure affect the immune system?*
*Does EMF exposure affect hormones?*

The following kinds of biological effects have been reported. Keep in mind that a biological effect is simply a measurable change in some biological response. It may or may not have any bearing on health.

### Heart rate

An inconsistent effect on heart rate by EMF exposure has been reported. When observed, the biological response is small (on average, a slowing of about three to five beats per minute), and the response does not persist once exposure has ended.

Two laboratories, one in the United States and one in Australia, have reported effects of EMF on heart rate variability. Exposures used in these experiments were relatively high (about 300 mG), and lower exposures failed to produce the effect. Effects have not been observed consistently in repeated experiments.

### Sleep electrophysiology

A laboratory report suggested that overnight exposure to 60-Hz magnetic fields may disrupt brain electrical activity (EEG) during night sleep. In this study subjects were exposed to either continuous or intermittent magnetic fields of 283 mG. Individuals exposed to the intermittent magnetic fields showed alterations in traditional EEG sleep parameters indicative of a pattern of poor and disrupted sleep. Several studies have reported no effect with continuous exposure.

### Hormones, immune system, and blood chemistry

Several clinical studies with human volunteers have evaluated the effects of power-frequency EMF exposure on hormones, the immune system, and blood chemistry. These studies provide little evidence for any consistent effect.

### Melatonin

The hormone melatonin is secreted mainly at night and primarily by the pineal gland, a small gland attached to the brain. Some laboratory experiments with cells and animals have shown that melatonin can slow the growth of cancer cells, including breast cancer cells. Suppressed nocturnal melatonin levels have been observed in some studies of laboratory animals exposed to both electric and magnetic fields. These observations led to the hypothesis that EMF exposure might reduce melatonin and thereby weaken one of the body’s defenses against cancer.

Many clinical studies with human volunteers have now examined whether various levels and types of magnetic field exposure affect blood levels of melatonin. Exposure of human volunteers at night to power-frequency EMF under controlled laboratory conditions has no apparent effect on melatonin. Some studies of people exposed to EMF at work or at home do report evidence for a small suppression of melatonin. It is not clear whether the decreases in melatonin reported under environmental conditions are related to the presence of EMF exposure or to other factors.

## Q What effects of EMF have been reported in laboratory studies of cells?

**A** Over the years, scientists have conducted more than 1,000 laboratory studies to investigate potential biological effects of EMF exposure. Most have been *in vitro* studies; that is, studies carried out on cells isolated from animals and plants, or on cell components such as cell membranes. Other studies involved animals, mainly rats and mice. In general, these studies do not demonstrate a consistent effect of EMF exposure.

Most *in vitro* studies have used magnetic fields of 1,000 mG (100 µT) or higher, exposures that far exceed daily human exposures. In most incidences, when one laboratory has reported effects of EMF exposure on cells, other laboratories have not been able to reproduce the findings. For such research results to be widely accepted by scientists as valid, they must be replicated—that is, scientists in other laboratories should be able to repeat the experiment and get similar results. Cellular studies have investigated potential EMF effects on cell proliferation and differentiation, gene expression, enzyme activity, melatonin, and DNA. Scientists reviewing the EMF research literature find overall that the cellular studies provide little convincing evidence of EMF effects at environmental levels.

## Q Have effects of EMF been reported in laboratory studies in animals?

**A** Researchers have published more than 30 detailed reports on both long-term and short-term studies of EMF exposures in laboratory animals (bioassays). Long-term animal bioassays constitute an important group of studies in EMF research. Such studies have a proven record for predicting the carcinogenicity of chemicals, physical agents, and other suspected cancer-causing agents. In the EMF studies, large groups of mice or rats were continuously exposed to EMF for two years or longer and were then evaluated for cancer. The U.S. National Toxicology Program (http://ntp-server.niehs.nih.gov/) has an extensive historical database for hundreds of different chemical and physical agents evaluated using this model. EMF long-term bioassays examined leukemia, brain cancer, and breast cancer—the diseases some epidemiological studies have associated with EMF exposure (see pages 16–23).

Several different approaches have been used to evaluate effects of EMF exposure in animal bioassays. To investigate whether EMF could promote cancer after genetic damage had occurred, some long-term studies used cancer initiators such as ultraviolet light, radiation, or certain chemicals that are known to cause genetic damage. Researchers compared groups of animals treated with cancer initiators to groups treated with cancer initiators and then exposed to EMF, to see if EMF exposure promoted the cancer growth (initiation-promotion model). Other studies tested the cancer promotion potential of EMF using mice that were predisposed to cancer because they had defects in the genes that control cancer.

| Animal Leukemia Studies: Long-Term, Continuous Exposure Studies, Two or More Years in Length | | | |
|---|---|---|---|
| First author | Sex/species | Exposure/animal numbers | Results |
| Babbitt (U.S.) | Female mice | 14,000 mG, 190 or 380 mice per group. Some groups treated with ionizing radiation. | No effect |
| Boorman (U.S.) | Male and female rats | 20 to 10,000 mG, 100 per group | No effect |
| McCormick (U.S.) | Male and female mice | 20 to 10,000 mG, 100 per group | No effect |
| Mandeville (Canada) | Female rats | 20 to 20,000 mG, 50 per group *In utero* exposure | No effect |
| Yasui (Japan) | Male and female rats | 5,000 to 50,000 mG, 50 per group | No effect |

10 milligauss (mG) = 1 microtesla (μT) = 0.001 millitesla (mT)

## Leukemia

Fifteen animal leukemia studies have been completed and reported. Most tested for effects of exposure to power-frequency (60-Hz) magnetic fields using rodents. Results of these studies were largely negative. The Babbitt study evaluated the subtypes of leukemia. The data provide no support for the reported epidemiology findings of leukemia from EMF exposure. Many scientists feel that the lack of effects seen in these laboratory leukemia studies significantly weakens the case for EMF as a cause of leukemia.

## Breast cancer

Researchers in the Ukraine, Germany, Sweden, and the United States have used initiation-promotion models to investigate whether EMF exposure promotes breast cancer in rats.

The results of these studies are mixed; while the German studies showed some effects, the Swedish and U.S. studies showed none. Studies in Germany reported effects on the numbers of tumors and tumor volume. A National Toxicology Program long-term bioassay performed without the use of other cancer-initiating substances showed no effects of EMF exposure on the development of mammary tumors in rats and mice.

The explanation for the observed difference among these studies is not readily apparent. Within the limits of the experimental rodent model of mammary carcinogenesis, no conclusions are possible regarding a promoting effect of EMF on chemically induced mammary cancer.

## Other cancers

Tests of EMF effects on skin cancer, liver cancer, and brain cancer have been conducted using both initiation-promotion models and non-initiated long-term bioassays. All are negative.

Three positive studies were reported for a co-promotion model of skin cancer in mice. The mice were exposed to EMF plus cancer-causing chemicals after cancers had already been initiated. The same research team as well as an independent laboratory were unable to reproduce these results in subsequent experiments.

### Non-cancer effects

Many animal studies have investigated whether EMF can cause health problems other than cancer. Researchers have examined many endpoints, including birth defects, immune system function, reproduction, behavior, and learning. Overall, animal studies do not support EMF effects on non-cancer endpoints.

## Q Can EMF exposure damage DNA?

**A** Studies have attempted to determine whether EMF has genotoxic potential; that is, whether EMF exposure can alter the genetic material of living organisms. This question is important because genotoxic agents often also cause cancer or birth defects. Studies of genotoxicity have included tests on bacteria, fruit flies, and some tests on rats and mice. Nearly 100 studies on EMF genotoxicity have been reported. Most evidence suggests that EMF exposure is not genotoxic. Based on experiments with cells, some researchers have suggested that EMF exposure may inhibit the cell's ability to repair normal DNA damage, but this idea remains speculative because of the lack of genotoxicity observed in EMF animal studies.

# 4 Your EMF Environment

*This chapter discusses typical magnetic field exposures in home and work environments and identifies common EMF sources and field intensities associated with these sources.*

## Q How do we define EMF exposure?

**A** Scientists are still uncertain about the best way to define "exposure" because experiments have yet to show which aspect of the field, if any, may be relevant to reported biological effects. Important aspects of exposure could be the highest intensity, the average intensity, or the amount of time spent above a certain baseline level. The most widely used measure of EMF exposure has been the time-weighted average magnetic field level (see discussion on page 15).

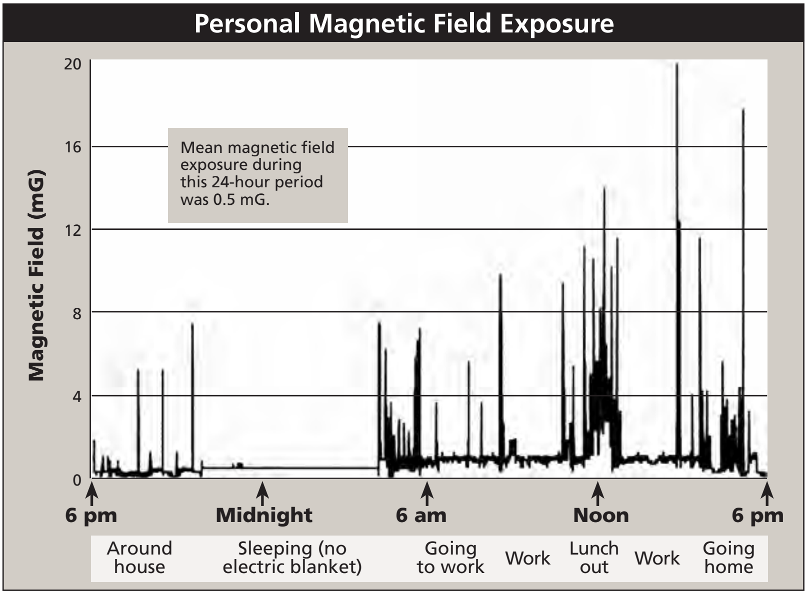
## Q How is EMF exposure measured?

**A** Several kinds of personal exposure meters are now available. These automatically record the magnetic field as it varies over time. To determine a person's EMF exposure, the personal exposure meter is usually worn at the waist or is placed as close as possible to the person during the course of a work shift or day.

EMF can also be measured using survey meters, sometimes called "gaussmeters." These measure the EMF levels in a given location at a given time. Such measurements do not necessarily reflect personal EMF exposure because they are not always taken at the distance from the EMF source that the person would typically be from the source. Measurements are not always made in a location for the same amount of time that a person spends there. Such "spot measurements" also fail to capture variations of the field over time, which can be significant.

## Q What are some typical EMF exposures?

**A** The figure below is an example of data collected with a personal exposure meter.




In the above example, the magnetic field was measured every 1.5 seconds over a period of 24 hours. For this person, exposure at home was very low. The occasional spikes (short exposure to high fields) occurred when the person drove or walked under power lines or over underground power lines or was close to appliances in the home or office.

Several studies have used personal exposure meters to measure field exposure in different environments. These studies tend to show that appliances and building wiring contribute to the magnetic field exposure that most people receive while at home. People living close to high voltage power lines that carry a lot of current tend to have higher overall field exposures. As shown on page 32, there is considerable variation among houses.

## Q What are typical EMF exposures for people living in the United States?

**A** Most people in the United States are exposed to magnetic fields that average less than 2 milligauss (mG), although individual exposures vary.

The following table shows the estimated average magnetic field exposure of the U.S. population, according to a study commissioned by the U.S. government as part of the EMF Research and Public Information Dissemination (EMF RAPID) Program (see page 50). This study measured magnetic field exposure of about 1,000 people of all ages randomly selected among the U.S. population. Participants wore or carried with them a small personal exposure meter and kept a diary of their activities both at home and away from home. Magnetic field values were automatically recorded twice a second for 24 hours. The study reported that exposure to magnetic fields is similar in different regions of the country and similar for both men and women.

**Estimated Average Magnetic Field Exposure of the U.S. Population**

| Average 24-hour field (mG) | Population exposed (%) | 95% confidence interval (%) | People exposed* (millions) |
|---|---|---|---|
| > 0.5 | 76.3 | 73.8–78.9 | 197–211 |
| > 1 | 43.6 | 40.9–46.5 | 109–124 |
| > 2 | 14.3 | 11.8–17.3 | 31.5–46.2 |
| > 3 | 6.3 | 4.7–8.5 | 12.5–22.7 |
| > 4 | 3.6 | 2.5–5.2 | 6.7–13.9 |
| > 5 | 2.42 | 1.65–3.55 | 4.4–9.5 |
| > 7.5 | 0.58 | 0.29–1.16 | 0.77–3.1 |
| > 10 | 0.46 | 0.20–1.05 | 0.53–2.8 |
| > 15 | 0.17 | 0.035–0.83 | 0.09–2.2 |

*Based on a population of 267 million. This table summarizes some of the results of a study that sampled about 1,000 people in the United States. In the first row, for example, we find that 76.3% of the sample population had a 24-hour average exposure of greater than 0.5 mG. Assuming that the sample was random, we can use statistics to say that we are 95% confident that the percentage of the overall U.S. population exposed to greater than 0.5 mG is between 73.8% and 78.9%. Source: Zaffanella, 1993.

The following table shows average magnetic fields experienced during different types of activities. In general, magnetic fields are greater at work than at home.

**Estimated Average Magnetic Field Exposure of the U.S. Population for Various Activities**

| Average field (mG) | Population exposed (%) | | | | |
|---|---|---|---|---|---|
| | Home | Bed | Work | School | Travel |
| > 0.5 | 69 | 48 | 81 | 63 | 87 |
| > 1 | 38 | 30 | 49 | 25 | 48 |
| > 2 | 14 | 14 | 20 | 3.5 | 13 |
| > 3 | 7.8 | 7.2 | 13 | 1.6 | 4.1 |
| > 4 | 4.7 | 4.7 | 8.0 | < 1 | 1.5 |
| > 5 | 3.5 | 3.7 | 4.6 | | 1.0 |
| > 7.5 | 1.2 | 1.6 | 2.5 | | 0.5 |
| > 10 | 0.9 | 0.8 | 1.3 | | < 0.2 |
| > 15 | 0.1 | 0.1 | 0.9 | | |

Source: Zaffanella, 1993.

## Q What levels of EMF are found in common environments?

**A** Magnetic field exposures can vary greatly from site to site for any type of environment. The data shown in the following table are median measurements taken at four different sites for each environment category.

**EMF Exposures in Common Environments**
Magnetic fields measured in milligauss (mG)

| Environment | Median* exposure | Top 5th percentile |
|---|---|---|
| OFFICE BUILDING | | |
| Support staff | 0.6 | 3.7 |
| Professional | 0.5 | 2.6 |
| Maintenance | 0.6 | 3.8 |
| Visitor | 0.6 | 2.1 |
| SCHOOL | | |
| Teacher | 0.6 | 3.3 |
| Student | 0.5 | 2.9 |
| Custodian | 1.0 | 4.9 |
| Administrative staff | 1.3 | 6.9 |
| HOSPITAL | | |
| Patient | 0.6 | 3.6 |
| Medical staff | 0.8 | 5.6 |
| Visitor | 0.6 | 2.4 |
| Maintenance | 0.6 | 5.9 |
| MACHINE SHOP | | |
| Machinist | 0.4 | 6.0 |
| Welder | 1.1 | 24.6 |
| Engineer | 1.0 | 5.1 |
| Assembler | 0.5 | 6.4 |
| Office staff | 0.7 | 4.7 |
| GROCERY STORE | | |
| Cashier | 2.7 | 11.9 |
| Butcher | 2.4 | 12.8 |
| Office staff | 2.1 | 7.1 |
| Customer | 1.1 | 7.7 |

*The median of four measurements. For this table, the median is the average of the two middle measurements.
Source: National Institute for Occupational Safety and Health.

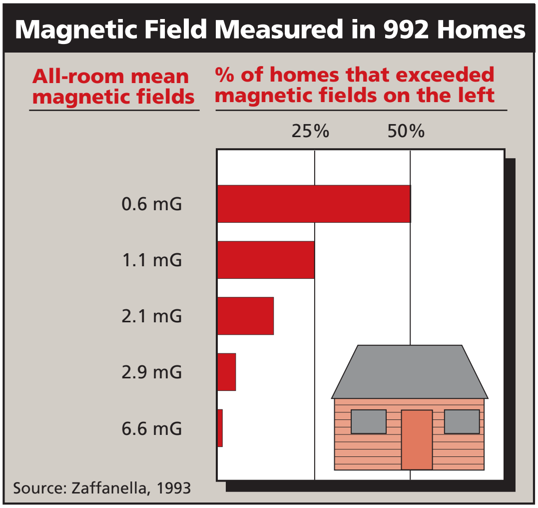
## Q What EMF field levels are encountered in the home?

### A Electric fields

Electric fields in the home, on average, range from 0 to 10 volts per meter. They can be hundreds, thousands, or even millions of times weaker than those encountered outdoors near power lines. Electric fields directly beneath power lines may vary from a few volts per meter for some overhead distribution lines to several thousands of volts per meter for extra high voltage power lines. Electric fields from power lines rapidly become weaker with distance and can be greatly reduced by walls and roofs of buildings.

### Magnetic fields

Magnetic fields are not blocked by most materials. Magnetic fields encountered in homes vary greatly. Magnetic fields rapidly become weaker with distance from the source.



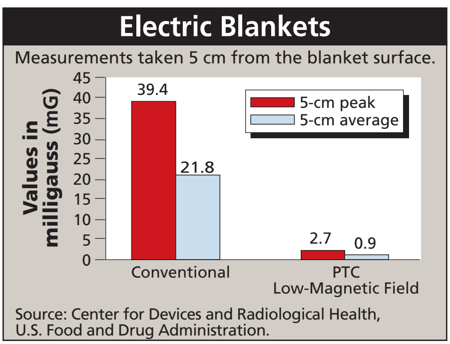

The chart on the left summarizes data from a study by the Electric Power Research Institute (EPRI) in which spot measurements of magnetic fields were made in the center of rooms in 992 homes throughout the United States. Half of the houses studied had magnetic field measurements of 0.6 mG or less, when the average of measurements from all the rooms in the house was calculated (the all-room mean magnetic field). The all-room mean magnetic field for all houses studied was 0.9 mG. The measurements were made away from electrical appliances and reflect primarily the fields from household wiring and outside power lines.

If you are comparing the information in this chart with measurements in your own home, keep in mind that this chart shows averages of measurements taken throughout the homes, not the single highest measurement found in the home.

## Q What are EMF levels close to electrical appliances?

**A** Magnetic fields close to electrical appliances are often much stronger than those from other sources, including magnetic fields directly under power lines. Appliance fields decrease in strength with distance more quickly than do power line fields.

The following table, based on data gathered in 1992, lists the EMF levels generated by common electrical appliances. Magnetic field strength (magnitude) does not depend on how large, complex, powerful, or noisy the appliance is. Magnetic fields near large appliances are often weaker than those near small devices. Appliances in your home may have been redesigned since the data in the table were collected, and the EMF they produce may differ considerably from the levels shown here.




The graph shows magnetic fields produced by electric blankets, including conventional 110-V electric blankets as well as the PTC (positive temperature coefficient) low-magnetic-field blankets. The fields were measured at a distance of about 2 inches from the blanket's surface, roughly the distance from the blanket to the user's internal organs. Because of the wiring, magnetic field strengths vary from point to point on the blanket. The graph reflects this and gives both the peak and the average measurement.

**Sources of Magnetic Fields (mG)***

## Office Sources

| | Distance from source 6″ | 1′ | 2′ | 4′ |
|---|---|---|---|---|
| **AIR CLEANERS** | | | | |
| Lowest | 110 | 20 | 3 | – |
| Median | 180 | 35 | 5 | 1 |
| Highest | 250 | 50 | 8 | 2 |
| **COPY MACHINES** | | | | |
| Lowest | 4 | 2 | 1 | – |
| Median | 90 | 20 | 7 | 1 |
| Highest | 200 | 40 | 13 | 4 |
| **FAX MACHINES** | | | | |
| Lowest | 4 | – | – | – |
| Median | 6 | – | – | – |
| Highest | 9 | 2 | – | – |
| **FLUORESCENT LIGHTS** | | | | |
| Lowest | 20 | – | – | – |
| Median | 40 | 6 | 2 | – |
| Highest | 100 | 30 | 8 | 4 |
| **ELECTRIC PENCIL SHARPENERS** | | | | |
| Lowest | 20 | 8 | 5 | – |
| Median | 200 | 70 | 20 | 2 |
| Highest | 300 | 90 | 30 | 30 |
| **VIDEO DISPLAY TERMINALS (see page 48) (PCs with color monitors)**** | | | | |
| Lowest | 7 | 2 | 1 | – |
| Median | 14 | 5 | 2 | – |
| Highest | 20 | 6 | 3 | – |

## Bathroom Sources

| | 6″ | 1′ | 2′ | 4′ |
|---|---|---|---|---|
| **HAIR DRYERS** | | | | |
| Lowest | 1 | – | – | – |
| Median | 300 | 1 | – | – |
| Highest | 700 | 70 | 10 | 1 |
| **ELECTRIC SHAVERS** | | | | |
| Lowest | 4 | – | – | – |
| Median | 100 | 20 | – | – |
| Highest | 600 | 100 | 10 | 1 |

## Workshop Sources

| | Distance from source 6″ | 1′ | 2′ | 4′ |
|---|---|---|---|---|
| **BATTERY CHARGERS** | | | | |
| Lowest | 3 | 2 | – | – |
| Median | 30 | 3 | – | – |
| Highest | 50 | 4 | – | – |
| **DRILLS** | | | | |
| Lowest | 100 | 20 | 3 | – |
| Median | 150 | 30 | 4 | – |
| Highest | 200 | 40 | 6 | – |
| **POWER SAWS** | | | | |
| Lowest | 50 | 9 | 1 | – |
| Median | 200 | 40 | 5 | – |
| Highest | 1000 | 300 | 40 | 4 |
| **ELECTRIC SCREWDRIVERS (while charging)** | | | | |
| Lowest | – | – | – | – |
| Median | – | – | – | – |
| Highest | – | – | – | – |

## Living/Family Room Sources

| | Distance from source 1′ | 2′ | 4′ |
|---|---|---|---|
| **CEILING FANS** | | | |
| Lowest | – | – | – |
| Median | 3 | – | – |
| Highest | 50 | 6 | 1 |
| **WINDOW AIR CONDITIONERS** | | | |
| Lowest | – | – | – |
| Median | 3 | 1 | – |
| Highest | 20 | 6 | 4 |
| **COLOR TELEVISIONS**** | | | |
| Lowest | – | – | – |
| Median | 7 | 2 | – |
| Highest | 20 | 8 | 4 |

*Continued*

## Sources of Magnetic Fields (mG)*

Distance from source: 6″, 1′, 2′, 4′

### Kitchen Sources

| BLENDERS | 6″ | 1′ | 2′ | 4′ |
|---|---|---|---|---|
| Lowest | 30 | 5 | – | – |
| Median | 70 | 10 | 2 | – |
| Highest | 100 | 20 | 3 | – |

| CAN OPENERS | 6″ | 1′ | 2′ | 4′ |
|---|---|---|---|---|
| Lowest | 500 | 40 | 3 | – |
| Median | 600 | 150 | 20 | 2 |
| Highest | 1500 | 300 | 30 | 4 |

| COFFEE MAKERS | 6″ | 1′ | 2′ | 4′ |
|---|---|---|---|---|
| Lowest | 4 | – | – | – |
| Median | 7 | – | – | – |
| Highest | 10 | 1 | – | – |

| DISHWASHERS | 6″ | 1′ | 2′ | 4′ |
|---|---|---|---|---|
| Lowest | 10 | 6 | 2 | – |
| Median | 20 | 10 | 4 | – |
| Highest | 100 | 30 | 7 | 1 |

| FOOD PROCESSORS | 6″ | 1′ | 2′ | 4′ |
|---|---|---|---|---|
| Lowest | 20 | 5 | – | – |
| Median | 30 | 6 | 2 | – |
| Highest | 130 | 20 | 3 | – |

| GARBAGE DISPOSALS | 6″ | 1′ | 2′ | 4′ |
|---|---|---|---|---|
| Lowest | 60 | 8 | 1 | – |
| Median | 80 | 10 | 2 | – |
| Highest | 100 | 20 | 3 | – |

| MICROWAVE OVENS*** | 6″ | 1′ | 2′ | 4′ |
|---|---|---|---|---|
| Lowest | 100 | 1 | 1 | – |
| Median | 200 | 4 | 10 | 2 |
| Highest | 300 | 200 | 30 | 20 |

| MIXERS | 6″ | 1′ | 2′ | 4′ |
|---|---|---|---|---|
| Lowest | 30 | 5 | – | – |
| Median | 100 | 10 | 1 | – |
| Highest | 600 | 100 | 10 | – |

### Kitchen Sources

| ELECTRIC OVENS | 6″ | 1′ | 2′ | 4′ |
|---|---|---|---|---|
| Lowest | 4 | 1 | – | – |
| Median | 9 | 4 | – | – |
| Highest | 20 | 5 | 1 | – |

| ELECTRIC RANGES | 6″ | 1′ | 2′ | 4′ |
|---|---|---|---|---|
| Lowest | 20 | – | – | – |
| Median | 30 | 8 | 2 | – |
| Highest | 200 | 30 | 9 | 6 |

| REFRIGERATORS | 6″ | 1′ | 2′ | 4′ |
|---|---|---|---|---|
| Lowest | – | – | – | – |
| Median | 2 | 2 | 1 | – |
| Highest | 40 | 20 | 10 | 10 |

| TOASTERS | 6″ | 1′ | 2′ | 4′ |
|---|---|---|---|---|
| Lowest | 5 | – | – | – |
| Median | 10 | 3 | – | – |
| Highest | 20 | 7 | – | – |

### Bedroom Sources

| DIGITAL CLOCK**** | 6″ | 1′ | 2′ | 4′ |
|---|---|---|---|---|
| Lowest | | – | – | – |
| Median | | 1 | – | – |
| High | | 8 | 2 | 1 |

| ANALOG CLOCKS (conventional clockface)**** | 6″ | 1′ | 2′ | 4′ |
|---|---|---|---|---|
| Lowest | | 1 | – | – |
| Median | | 15 | 2 | – |
| Highest | | 30 | 5 | 3 |

| BABY MONITOR (unit nearest child) | 6″ | 1′ | 2′ | 4′ |
|---|---|---|---|---|
| Lowest | 4 | – | – | – |
| Median | 6 | 1 | – | – |
| Highest | 15 | 2 | – | – |

*Continued*

**Sources of Magnetic Fields (mG)***

| Laundry/Utility Sources | 6″ | 1′ | 2′ | 4′ |
|---|---|---|---|---|
| **ELECTRIC CLOTHES DRYERS** | | | | |
| Lowest | 2 | – | – | – |
| Median | 3 | 2 | – | – |
| Highest | 10 | 3 | – | – |
| **WASHING MACHINES** | | | | |
| Lowest | 4 | 1 | – | – |
| Median | 20 | 7 | 1 | – |
| Highest | 100 | 30 | 6 | – |
| **IRONS** | | | | |
| Lowest | 6 | 1 | – | – |
| Median | 8 | 1 | – | – |
| Highest | 20 | 3 | – | – |

| Laundry/Utility Sources | 6″ | 1′ | 2′ | 4′ |
|---|---|---|---|---|
| **PORTABLE HEATERS** | | | | |
| Lowest | 5 | 1 | – | – |
| Median | 100 | 20 | 4 | – |
| Highest | 150 | 40 | 8 | 1 |
| **VACUUM CLEANERS** | | | | |
| Lowest | 100 | 20 | 4 | – |
| Median | 300 | 60 | 10 | 1 |
| Highest | 700 | 200 | 50 | 10 |

**SEWING MACHINES**

Home sewing machines can produce magnetic fields of 12 mG at chest level and 5 mG at head level. Magnetic fields as high as 35 mG at chest level and 215 mG at knee level have been measured from industrial sewing machine models (Sobel, 1994).

Source: EMF In Your Environment, U.S. Environmental Protection Agency, 1992.

* Dash (–) means that the magnetic field at this distance from the operating appliance could not be distinguished from background measurements taken before the appliance had been turned on.

** Some appliances produce both 60-Hz and higher frequency fields. For example, televisions and computer screens produce fields at 10,000-30,000 Hz (10-30 kHz) as well as 60-Hz fields.

*** Microwave ovens produce 60-Hz fields of several hundred milligauss, but they also create microwave energy inside the appliance that is at a much higher frequency (about 2.45 billion hertz). We are shielded from the higher frequency fields but not from the 60-Hz fields.

**** Most digital clocks have low magnetic fields. In some analog clocks, however, higher magnetic fields are produced by the motor that drives the hands. In the above table, the clocks are electrically powered using alternating current, as are all the appliances described in these tables.

## Q What EMF levels are found near power lines?

**A** Power transmission lines bring power from a generating station to an electrical substation. Power distribution lines bring power from the substation to your home. Transmission and distribution lines can be either overhead or underground. Overhead lines produce both electric fields and magnetic fields. Underground lines do not produce electric fields above ground but may produce magnetic fields above ground.

### Power transmission lines

Typical EMF levels for transmission lines are shown in the chart on page 37. At a distance of 300 feet and at times of average electricity demand, the magnetic fields from many lines can be similar to typical background levels found in most homes. The distance at which the magnetic field from the line becomes indistinguishable from typical background levels differs for different types of lines.

### Power distribution lines

Typical voltage for power distribution lines in North America ranges from 4 to 24 kilovolts (kV). Electric field levels directly beneath overhead distribution lines may vary from a few volts per meter to 100 or 200 volts per meter. Magnetic fields directly beneath overhead distribution lines typically range from 10 to 20 mG for main feeders and less than 10 mG for laterals. Such levels are also typical directly above underground lines. Peak EMF levels, however, can vary considerably depending on the amount of current carried by the line. Peak magnetic field levels as high as 70 mG have been measured directly below overhead distribution lines and as high as 40 mG above underground lines.

## Q How strong is the EMF from electric power substations?

**A** In general, the strongest EMF around the outside of a substation comes from the power lines entering and leaving the substation. The strength of the EMF from equipment within the substations, such as transformers, reactors, and capacitor banks, decreases rapidly with increasing distance. Beyond the substation fence or wall, the EMF produced by the substation equipment is typically indistinguishable from background levels.

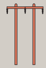
## Q Do electrical workers have higher EMF exposure than other workers?

**A** Most of the information we have about occupational EMF exposure comes from studies of electric utility workers. It is therefore difficult to compare electrical workers' EMF exposures with those of other workers because there is less information about EMF exposures in work environments other than electric utilities. Early studies did not include actual measurements of EMF exposure on the job but used job titles as an estimate of EMF exposure among electrical workers. Recent studies, however, have included extensive EMF exposure assessments.

A report published in 1994 provides some information about estimated EMF exposures of workers in Los Angeles in a number of electrical jobs in electric utilities and other industries. Electrical workers had higher average EMF exposures (9.6 mG) than did workers in other jobs (1.7 mG). For this study, the category "electrical workers" included electrical engineering technicians, electrical engineers, electricians, power line workers, power station operators, telephone line workers, TV repairers, and welders.

## Typical EMF Levels for Power Transmission Lines*

### 115 kV



| | | Approx. Edge of Right-of-Way 15 m (50 ft) | 30 m (100 ft) | 61 m (200 ft) | 91 m (300 ft) |
|---|---|---|---|---|---|
| Electric Field (kV/m) | 1.0 | 0.5 | 0.07 | 0.01 | 0.003 |
| Mean Magnetic Field (mG) | 29.7 | 6.5 | 1.7 | 0.4 | 0.2 |

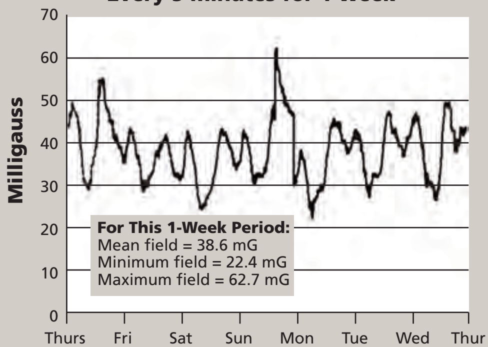
### 230 kV

| | | Approx. Edge of Right-of-Way 15 m (50 ft) | 30 m (100 ft) | 61 m (200 ft) | 91 m (300 ft) |
|---|---|---|---|---|---|
| Electric Field (kV/m) | 2.0 | 1.5 | 0.3 | 0.05 | 0.01 |
| Mean Magnetic Field (mG) | 57.5 | 19.5 | 7.1 | 1.8 | 0.8 |

### 500 kV

| | | Approx. Edge of Right-of-Way 20 m (65 ft) | 30 m (100 ft) | 61 m (200 ft) | 91 m (300 ft) |
|---|---|---|---|---|---|
| Electric Field (kV/m) | 7.0 | 3.0 | 1.0 | 0.3 | 0.1 |
| Mean Magnetic Field (mG) | 86.7 | 29.4 | 12.6 | 3.2 | 1.4 |

**Magnetic Field from a 500-kV Transmission Line Measured on the Right-of-Way Every 5 Minutes for 1 Week**




Electric fields from power lines are relatively stable because line voltage doesn't change very much. Magnetic fields on most lines fluctuate greatly as current changes in response to changing loads. Magnetic fields must be described statistically in terms of averages, maximums, etc. The magnetic fields above are means calculated for 321 power lines for 1990 annual mean loads. During peak loads (about 1% of the time), magnetic fields are about twice as strong as the mean levels above. The graph on the left is an example of how the magnetic field varied during one week for one 500-kV transmission line.

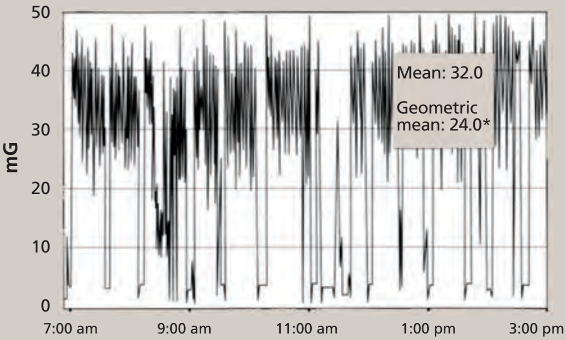
*These are typical EMFs at 1 m (3.3 ft) above ground for various distances from power lines in the Pacific Northwest. They are for general information. For information about a specific line, contact the utility that operates the line.
Source: Bonneville Power Administration, 1994.

# Q What are possible EMF exposures in the workplace?

**A** The figures below are examples of magnetic field exposures determined with exposure meters worn by four workers in different occupations. These measurements demonstrate how EMF exposures vary among individual workers. They do not necessarily represent typical EMF exposures for workers in these occupations.

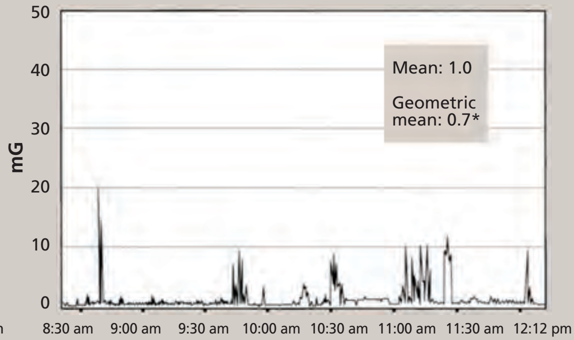
## Magnetic Field Exposures of Workers (mG)

**Sewing machine operator in garment factory**



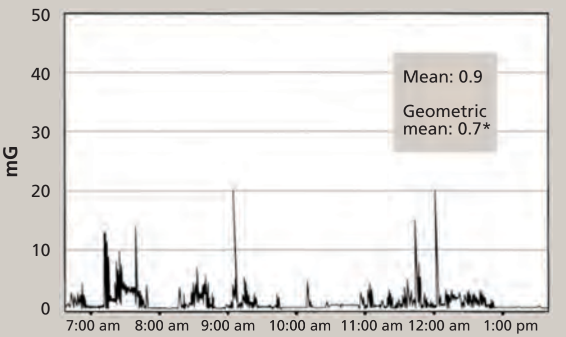

*The sewing machine operator worked all day, took a 1-hour lunch break at 11:15 am, and took 10-minute breaks at 8:55 am and 2:55 pm.*

**Maintenance mechanic**



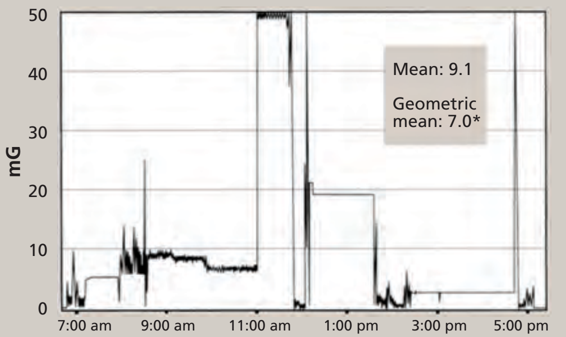

*The mechanic repaired a compressor at 9:45 am and 11:10 am.*

**Electrician**




*The electrician repaired a large air-conditioning motor at 9:10 am and at 11:45 am.*

**Government office worker**




*The government worker was at the copy machine at 8:00 am, at the computer from 11:00 am to 1:00 pm and also from 2:30 pm to 4:30 pm.*

*The geometric mean is calculated by squaring the values, adding the squares, and then taking the square root of the sum.
Source: National Institute for Occupational Safety and Health and U.S. Department of Energy.

The tables below and on page 41 can give you a general idea about magnetic field levels for different jobs and around various kinds of electrical equipment. It is important to remember that EMF levels depend on the actual equipment used in

**EMF Measurements During a Workday**

| Industry and occupation | ELF magnetic fields measured in mG: Median for occupation* | ELF magnetic fields measured in mG: Range for 90% of workers** |
|---|---|---|
| **ELECTRICAL WORKERS IN VARIOUS INDUSTRIES** | | |
| Electrical engineers | 1.7 | 0.5–12.0 |
| Construction electricians | 3.1 | 1.6–12.1 |
| TV repairers | 4.3 | 0.6–8.6 |
| Welders | 9.5 | 1.4–66.1 |
| **ELECTRIC UTILITIES** | | |
| Clerical workers without computers | 0.5 | 0.2–2.0 |
| Clerical workers with computers | 1.2 | 0.5–4.5 |
| Line workers | 2.5 | 0.5–34.8 |
| Electricians | 5.4 | 0.8–34.0 |
| Distribution substation operators | 7.2 | 1.1–36.2 |
| Workers off the job (home, travel, etc.) | 0.9 | 0.3–3.7 |
| **TELECOMMUNICATIONS** | | |
| Install, maintenance, & repair technicians | 1.5 | 0.7–3.2 |
| Central office technicians | 2.1 | 0.5–8.2 |
| Cable splicers | 3.2 | 0.7–15.0 |
| **AUTO TRANSMISSION MANUFACTURE** | | |
| Assemblers | 0.7 | 0.2–4.9 |
| Machinists | 1.9 | 0.6–27.6 |
| **HOSPITALS** | | |
| Nurses | 1.1 | 0.5–2.1 |
| X-ray technicians | 1.5 | 1.0–2.2 |
| **SELECTED OCCUPATIONS FROM ALL ECONOMIC SECTORS** | | |
| Construction machine operators | 0.5 | 0.1–1.2 |
| Motor vehicle drivers | 1.1 | 0.4–2.7 |
| School teachers | 1.3 | 0.6–3.2 |
| Auto mechanics | 2.3 | 0.6–8.7 |
| Retail sales | 2.3 | 1.0–5.5 |
| Sheet metal workers | 3.9 | 0.3–48.4 |
| Sewing machine operators | 6.8 | 0.9–32.0 |
| Forestry and logging jobs | 7.6 | 0.6–95.5*** |

Source: National Institute for Occupational Safety and Health.
ELF (extremely low frequency)—frequencies 3–3,000 Hz.
* The median is the middle measurement in a sample arranged by size. These personal exposure measurements reflect the median magnitude of the magnetic field produced by the various EMF sources and the amount of time the worker spent in the fields.
** This range is between the 5th and 95th percentiles of the workday averages for an occupation.
*** Chain saw engines produce strong magnetic fields that are not pure 60-Hz fields.

the workplace. Different brands or models of the same type of equipment can have different magnetic field strengths. It is also important to keep in mind that the strength of a magnetic field decreases quickly with distance.

If you have questions or want more information about your EMF exposure at work, your plant safety officer, industrial hygienist, or other local safety official can be a good source of information. The National Institute for Occupational Safety and Health (NIOSH) is asked occasionally to conduct health hazard evaluations in workplaces where EMF is a suspected cause for concern. For further technical assistance contact NIOSH at 800-356-4674.

## Q What are some typical sources of EMF in the workplace?

**A** Exposure assessment studies so far have shown that most people's EMF exposure at work comes from electrical appliances and tools and from the building's power supply. People who work near transformers, electrical closets, circuit boxes, or other high-current electrical equipment may have 60-Hz magnetic field exposures of hundreds of milligauss or more. In offices, magnetic field levels are often similar to those found at home, typically 0.5 to 4.0 mG. However, these levels can increase dramatically near certain types of equipment.

**EMF Spot Measurements**

| Industry and sources | ELF magnetic fields (mG) | Other frequencies | Comments |
|---|---|---|---|
| **ELECTRICAL EQUIPMENT USED IN MACHINE MANUFACTURING** | | | |
| Electric resistance heater | 6,000–14,000 | VLF | |
| Induction heater | 10–460 | High VLF | |
| Hand-held grinder | 3,000 | – | Tool exposures measured at operator's chest. |
| Grinder | 110 | – | Tool exposures measured at operator's chest. |
| Lathe, drill press, etc. | 1–4 | – | Tool exposures measured at operator's chest. |
| **ALUMINUM REFINING** | | | |
| Aluminum pot rooms | 3.4–30 | Very high static field | Highly-rectified DC current (with an ELF ripple) refines aluminum. |
| Rectification room | 300–3,300 | High static field | |
| **STEEL FOUNDRY** | | | |
| Ladle refinery | | | |
| Furnace active | 170–1,300 | High ULF from the ladle's big magnetic stirrer | Highest ELF field was at the chair of control room operator. |
| Furnace inactive | 0.6–3.7 | High ULF from the ladle's big magnetic stirrer | Highest ELF field was at the chair of control room operator. |
| Electrogalvanizing unit | 2–1,100 | High VLF | |
| **TELEVISION BROADCASTING** | | | |
| Video cameras (studio and minicams) | 7.2–24.0 | VLF | |
| Video tape degaussers | 160–3,300 | – | Measured 1 ft away. |
| Light control centers | 10–300 | – | Walk-through survey. |
| Studio and newsrooms | 2–5 | – | Walk-through survey. |
| **HOSPITALS** | | | |
| Intensive care unit | 0.1–220 | VLF | Measured at nurse's chest. |
| Post-anesthesia care unit | 0.1–24 | VLF | |
| Magnetic resonance imaging (MRI) | 0.5–280 | Very high static field, VLF and RF | Measured at technician's work locations. |
| **TRANSPORTATION** | | | |
| Cars, minivans, and trucks | 0.1–125 | Most frequencies less than 60 Hz | Steel-belted tires are the principal ELF source for gas/diesel vehicles. |
| Bus (diesel powered) | 0.5–146 | Most frequencies less than 60 Hz | |
| Electric cars | 0.1–81 | Some elevated static fields | |
| Chargers for electric cars | 4–63 | – | Measured 2 ft from charger. |
| Electric buses | 0.1–88 | – | Measured at waist. Fields at ankles 2-5 times higher. |
| Electric train passenger cars | 0.1–330 | 25 & 60 Hz power on U.S. trains | Measured at waist. Fields at ankles 2-5 times higher. |
| Airliner | 0.8–24.2 | 400 Hz power on airliners | Measured at waist. |
| **GOVERNMENT OFFICES** | | | |
| Desk work locations | 0.1–7 | – | Peaks due to laser printers. |
| Desks near power center | 18–50 | – | |
| Power cables in floor | 15–170 | – | |
| Building power supplies | 25–1,800 | – | |
| Can opener | 3,000 | – | Appliance fields measured 6 in. away. |
| Desktop cooling fan | 1,000 | – | Appliance fields measured 6 in. away. |
| Other office appliances | 10–200 | – | |

Source: National Institute for Occupational Safety and Health, 2001.
ULF (ultra low frequency)—frequencies above 0, below 3 Hz.
ELF (extremely low frequency)—frequencies 3–3,000 Hz.
VLF (very low frequency)—frequencies 3,000–30,000 Hz (3–30 kilohertz).

## Q What EMF exposure occurs during travel?

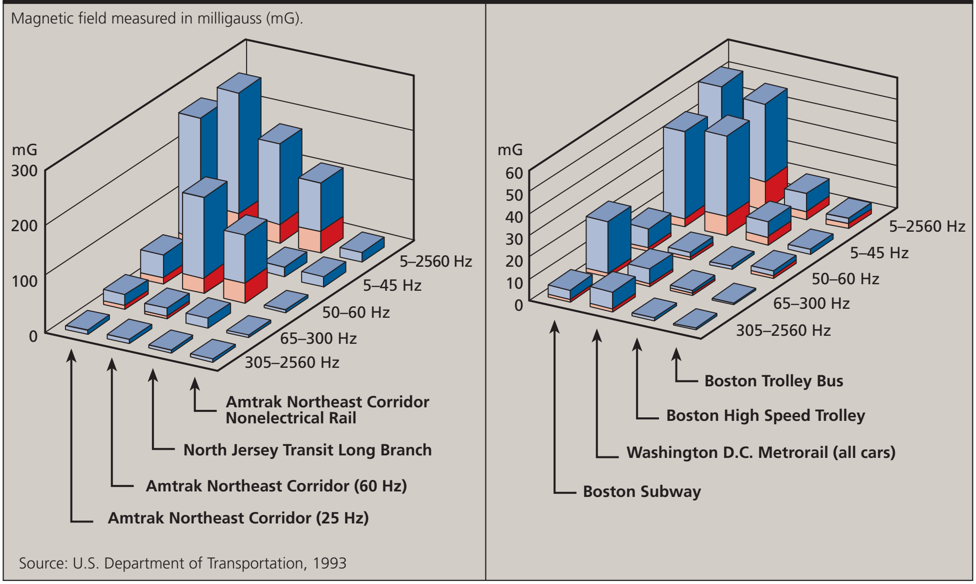
**A** Inside a car or bus, the main sources of magnetic field exposure are those you pass by (or under) as you drive, such as power lines. Car batteries involve direct current (DC) rather than alternating current (AC). Alternators can create EMF, but at frequencies other than 60 Hz. The rotation of steel-belted tires is also a source of EMF.

Most trains in the United States are diesel powered. Some electrically powered trains operate on AC, such as the passenger trains between Washington, D.C. and New Haven, Connecticut. Measurements taken on these trains using personal exposure monitors have suggested that average 60-Hz magnetic field exposures for passengers and conductors may exceed 50 mG. A U.S. government-sponsored exposure assessment study of electric rail systems found average 60-Hz magnetic field levels in train operator compartments that ranged from 0.4 mG (Boston high speed trolley) to 31.1 mG (North Jersey transit). The graph on the next page shows average and maximum magnetic field measurements in operator compartments of several electric rail systems. It illustrates that 60 Hz is one of several electromagnetic frequencies to which train operators are exposed.

Workers who maintain the tracks on electric rail lines, primarily in the northeastern United States, also have elevated magnetic field exposures at both 25 Hz and 60 Hz. Measurements taken by the National Institute for Occupational Safety and Health show that typical average daily exposures range from 3 to 18 mG, depending on how often trains pass the work site.

Rapid transit and light rail systems in the United States, such as the Washington D.C. Metro and the San Francisco Bay Area Rapid Transit, run on DC electricity. These DC-powered trains contain equipment that produces AC fields. For example, areas of strong AC magnetic fields have been measured on the Washington Metro close to the floor, during braking and acceleration, presumably near equipment located underneath the subway cars.

**Magnetic Field Measurements in Train Operators' Compartments**




These graphs illustrate that 60 Hz is one of several electromagnetic frequencies to which train operators are exposed. The maximum exposure is the top of the blue (upper) portion of the bar; the average exposure is the top of the red (lower) portion.

## Q How can I find out how strong the EMF is where I live and work?

**A** The tables throughout this chapter can give you a general idea about magnetic field levels at home, for different jobs, and around various kinds of electrical equipment. For specific information about EMF from a particular power line, contact the utility that operates the line. Some will perform home EMF measurements.

You can take your own EMF measurements with a magnetic field meter. For a spot measurement to provide a useful estimate of your EMF exposure, it should be taken at a time of day and location when and where you are typically near the equipment. Keep in mind that the strength of a magnetic field drops off quickly with distance.

Independent technicians will conduct EMF measurements for a fee. Search the Internet under "EMF meters" or "EMF measurement." You should investigate the experience and qualifications of commercial firms, since governments do not standardize EMF measurements or certify measurement contractors.

At work, your plant safety officer, industrial hygienist, or other local safety official can be a good source of information. The National Institute for Occupational Safety and Health (NIOSH) sometimes conducts health hazard evaluations in workplaces where EMF is a suspected cause for concern. For further technical assistance, contact NIOSH at 800-356-4674.

## Q How much do computers contribute to my EMF exposure?

**A** Personal computers themselves produce very little EMF. However, the video display terminal (VDT) or monitor provides some magnetic field exposure unless it is of the new flat-panel design. Conventional VDTs containing cathode ray tubes use magnetic fields to produce the image on the screen, and some emission of those magnetic fields is unavoidable. Unlike most other appliances which produce predominantly 60-Hz magnetic fields, VDTs emit magnetic fields in both the extremely low frequency (ELF) and very low frequency (VLF) frequency ranges (see page 8). Many newer VDTs have been designed to minimize magnetic field emissions, and those identified as “TCO’99 compliant” meet a standard for low emissions (see page 48).


## Q What can be done to limit EMF exposure?

**A** Personal exposure to EMF depends on three things: the strength of the magnetic field sources in your environment, your distance from those sources, and the time you spend in the field.

If you are concerned about EMF exposure, your first step should be to find out where the major EMF sources are and move away from them or limit the time you spend near them. Magnetic fields from appliances decrease dramatically about an arm’s length away from the source. In many cases, rearranging a bed, a chair, or a work area to increase your distance from an electrical panel or some other EMF source can reduce your EMF exposure.

Another way to reduce EMF exposure is to use equipment designed to have relatively low EMF emissions. Sometimes electrical wiring in a house or a building can be the source of strong magnetic field exposure. Incorrect wiring is a common source of higher-than-usual magnetic fields. Wiring problems are also worth correcting for safety reasons.

In its 1999 report to Congress, the National Institute of Environmental Health Sciences suggested that the power industry continue its current practice of siting power lines to reduce EMF exposures.

There are more costly actions, such as burying power lines, moving out of a home, or restricting the use of office space that may reduce exposures. Because scientists are still debating whether EMF is a hazard to health, it is not clear that the costs of such measures are warranted. Some EMF reduction measures may create other problems. For instance, compacting power lines reduces EMF but increases the danger of accidental electrocution for line workers.

We are not sure which aspects of the magnetic field exposure, if any, to reduce. Future research may reveal that EMF reduction measures based on today's limited understanding are inadequate or irrelevant. No action should be taken to reduce EMF exposure if it increases the risk of a known safety hazard.

# 5 EMF Exposure Standards

*This chapter describes standards and guidelines established by state, national, and international safety organizations for some EMF sources and exposures.*

## Q Are there exposure standards for 60-Hz EMF?

A In the United States, there are no federal standards limiting occupational or residential exposure to 60-Hz EMF.

At least six states have set standards for transmission line electric fields; two of these also have standards for magnetic fields (see table below). In most cases, the maximum fields permitted by each state are the maximum fields that existing lines produce at maximum load-carrying conditions. Some states further limit electric field strength at road crossings to ensure that electric current induced into large metal objects such as trucks and buses does not represent an electric shock hazard.

**State Transmission Line Standards and Guidelines**

| | Electric Field | | Magnetic Field | |
|---|---|---|---|---|
| State | On R.O.W.* | Edge R.O.W. | On R.O.W. | Edge R.O.W. |
| Florida | 8 kV/m[a]<br>10 kV/m[b] | 2 kV/m | — | 150 mG[a] (max. load)<br>200 mG[b] (max. load)<br>250 mG[c] (max. load) |
| Minnesota | 8 kV/m | — | — | — |
| Montana | 7 kV/m[d] | 1 kV/m[e] | | |
| New Jersey | — | 3 kV/m | | |
| New York | 11.8 kV/m<br>11.0 kV/m[f]<br>7.0 kV/m[d] | 1.6 kV/m | — | 200 mG (max. load) |
| Oregon | 9 kV/m | — | — | — |

*R.O.W. = right-of-way (or in the Florida standard, certain additional areas adjoining the right-of-way). kV/m = kilovolt per meter. One kilovolt = 1,000 volts. [a]For lines of 69-230 kV. [b]For 500 kV lines. [c]For 500 kV lines on certain existing R.O.W. [d]Maximum for highway crossings. [e]May be waived by the landowner. [f]Maximum for private road crossings.

Two organizations have developed voluntary occupational exposure guidelines for EMF exposure. These guidelines are intended to prevent effects, such as induced currents in cells or nerve stimulation, which are known to occur at high magnitudes, much higher (more than 1,000 times higher) than EMF levels found typically in occupational and residential environments. These guidelines are summarized in the tables on the right.

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) concluded that available data regarding potential long-term effects, such as increased risk of cancer, are insufficient to provide a basis for setting exposure restrictions.

The American Conference of Governmental Industrial Hygienists (ACGIH) publishes "Threshold Limit Values" (TLVs) for various physical agents. The TLVs for 60-Hz EMF shown in the table are identified as guides to control exposure; they are not intended to demarcate safe and dangerous levels.

**ICNIRP Guidelines for EMF Exposure**

| Exposure (60 Hz) | Electric field | Magnetic field |
|---|---|---|
| Occupational | 8.3 kV/m | 4.2 G (4,200 mG) |
| General Public | 4.2 kV/m | 0.833 G (833 mG) |

International Commission on Non-Ionizing Radiation Protection (ICNIRP) is an organization of 15,000 scientists from 40 nations who specialize in radiation protection.
Source: ICNIRP, 1998.

**ACGIH Occupational Threshold Limit Values for 60-Hz EMF**

| | Electric field | Magnetic field |
|---|---|---|
| Occupational exposure should not exceed | 25 kV/m | 10 G (10,000 mG) |
| Prudence dictates the use of protective clothing above | 15 kV/m | – |
| Exposure of workers with cardiac pacemakers should not exceed | 1 kV/m | 1 G (1,000 mG) |

American Conference of Governmental Industrial Hygienists (ACGIH) is a professional organization that facilitates the exchange of technical information about worker health protection. It is not a government regulatory agency.
Source: ACGIH, 2001.

## Q Does EMF affect people with pacemakers or other medical devices?

**A** According to the U.S. Food and Drug Administration (FDA), interference from EMF can affect various medical devices including cardiac pacemakers and implantable defibrillators. Most current research in this area focuses on higher frequency sources such as cellular phones, citizens band radios, wireless computer links, microwave signals, radio and television transmitters, and paging transmitters.

Sources such as welding equipment, power lines at electric generating plants, and rail transportation equipment can produce lower frequency EMF strong enough to interfere with some models of pacemakers and defibrillators. The occupational exposure guidelines developed by ACGIH state that workers with cardiac pacemakers should not be exposed to a 60-Hz magnetic field greater than 1 gauss (1,000 mG) or a 60-Hz electric field greater than 1 kilovolt per meter (1,000 V/m) (see ACGIH guidelines above). Workers who are concerned about EMF exposure effects on pacemakers, implantable defibrillators, or other implanted electronic medical devices should consult their doctors or industrial hygienists.

Nonelectronic metallic medical implants (such as artificial joints, pins, nails, screws, and plates) can be affected by high magnetic fields such as those from magnetic resonance imaging (MRI) devices and aluminum refining equipment, but are generally unaffected by the lower fields from most other sources.

The FDA MedWatch program is collecting information about medical device problems thought to be associated with exposure to or interference from EMF. Anyone experiencing a problem that might be due to such interference is encouraged to call and report it (800-332-1088).

## Q What about products advertised as producing low or reduced magnetic fields?

**A** Virtually all electrical appliances and devices emit electric and magnetic fields. The strengths of the fields vary appreciably both between types of devices and among manufacturers and models of the same type of device. Some appliance manufacturers are designing new models that, in general, have lower EMF than older models. As a result, the words “low field” or “reduced field” may be relative to older models and not necessarily relative to other manufacturers or devices. At this time, there are no domestic or international standards or guidelines limiting the EMF emissions of appliances.

The U.S. government has set no standards for magnetic fields from computer monitors or video display terminals (VDTs). The Swedish Confederation of Professional Employees (TCO) established in 1992 a standard recommending strict limits on the EMF emissions of computer monitors. The VDTs should produce magnetic fields of no more than 2 mG at a distance of 30 cm (about 1 ft) from the front surface of the monitor and 50 cm (about 1 ft 8 in) from the sides and back of the monitor. The TCO’92 standard has become a *de facto* standard in the VDT industry worldwide. A 1999 standard, promulgated by the Swedish TCO (known as the TCO’99 standard), provides for international and environmental labeling of personal computers. Many computer monitors marketed in the U.S. are certified as compliant with TCO’99 and are thereby assured to produce low magnetic fields.

Beware of advertisements claiming that the federal government has certified that the advertised equipment produces little or no EMF. The federal government has no such general certification program for the emissions of low-frequency EMF. The U.S. Food and Drug Administration’s Center for Devices and Radiological Health (CDRH) does certify medical equipment and equipment producing high levels of ionizing radiation or microwave radiation. Information about certain devices as well as general information about EMF is available from the CDRH at 888-463-6332.

## Q Are cellular telephones and towers sources of EMF exposure?

**A** Cellular telephones and towers involve radio-frequency and microwave-frequency electromagnetic fields (see page 8). These are in a much higher frequency range than are the power-frequency electric and magnetic fields associated with the transmission and use of electricity.

The U.S. Federal Communications Commission (FCC) licenses communications systems that use radio-frequency and microwave electromagnetic fields and ensures that licensed facilities comply with exposure standards. Public information on this topic is published on two FCC Internet sites: http://www.fcc.gov/oet/info/documents/bulletins/#56 and http://www.fcc.gov/oet/rfsafety/

The U.S. Food and Drug Administration also provides information about cellular telephones on its web site (http://www.fda.gov/cdrh/ocd/mobilphone.html).

# 6 National and International EMF Reviews

*This chapter presents the findings and recommendations of major EMF research reviews, including the U.S. government's EMF RAPID Program.*

## Q What have national and international agencies concluded about the impact of EMF exposure on human health?

**A** Since 1995, two major U.S. reports have concluded that limited evidence exists for an association between EMF exposure and increased leukemia risk, but that when all the scientific evidence is considered, the link between EMF exposure and cancer is weak. The World Health Organization in 1997 reached a similar conclusion.

The two reports were the U.S. National Academy of Sciences report in 1996 and, in 1999, the National Institute of Environmental Health Sciences report to the U.S. Congress at the end of the U.S. EMF Research and Public Information Dissemination (RAPID) Program.

### The U.S. EMF RAPID Program

Initiated by the U.S. Congress and established by law in 1992, the U.S. EMF Research and Public Information Dissemination (EMF RAPID) Program set out to study whether exposure to electric and magnetic fields produced by the generation, transmission, or use of electric power posed a risk to human health. For more information about the EMF RAPID Program, visit the web site (http://www.niehs.nih.gov/emfrapid).

The U.S. Department of Energy (DOE) administered the overall EMF RAPID Program, but health effects research and risk assessment were supervised by the National Institute of Environmental Health Sciences (NIEHS), a branch of the U.S. National Institutes of Health (NIH). Together, DOE and NIEHS oversaw more than 100 cellular and animal studies, as well as engineering and exposure assessment studies. Although the EMF RAPID Program did not fund any additional epidemiological studies, an analysis of the many studies already conducted was an important part of its final report.

The electric power industry contributed about half, or $22.5 million, of the $45 million eventually spent on EMF research over the course of the EMF RAPID Program. The NIEHS received $30.1 million from this program for research, public outreach, administration, and the health assessment evaluation of extremely low frequency (ELF) EMF. The DOE received approximately $15 million from this program for engineering and EMF mitigation research. The NIEHS contributed an additional $14.5 million for support of extramural and intramural research including long-term toxicity and carcinogenicity studies conducted by the National Toxicology Program.

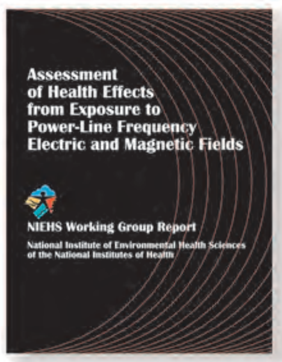
**EMF RAPID Program Interagency Committee**

- National Institute of Environmental Health Sciences
- Department of Energy
- Department of Defense
- Department of Transportation
- Environmental Protection Agency
- Federal Energy Regulatory Commission
- National Institute of Standards and Technology
- Occupational Safety and Health Administration
- Rural Electrification Administration

An interagency committee was established by the President of the United States to provide oversight and program management support for the EMF RAPID Program. The interagency committee included representatives from NIEHS, DOE, and seven other federal agencies with EMF-related responsibilities.

The EMF RAPID Program also received advice from a National EMF Advisory Committee (NEMFAC), which included representatives from citizen groups, labor, utilities, the National Academy of Sciences, and other groups. They met regularly with DOE and NIEHS staff to express their views. NEMFAC meetings were open to the public. The EMF RAPID Program sponsored citizen participation in some scientific meetings as well. A broad group of citizens reviewed all major public information materials produced for the program.

## NIEHS Working Group Report 1998




In preparation for the EMF RAPID Program's goal of reporting to the U.S. Congress on possible health effects from exposure to EMF from power lines, the NIEHS convened an expert working group in June 1998. Over 9 days, about 30 scientists conducted a complete review of EMF studies, including those sponsored by the EMF RAPID Program and others. Their conclusions offered guidance to the NIEHS as it prepared its report to Congress.

Using criteria developed by the International Agency for Research on Cancer, a majority of the members of the working group concluded that exposure to power-frequency EMF is a possible human carcinogen.

The majority called their opinion "a conservative public health decision based on limited evidence for an increased occurrence of childhood leukemias and an increased occurrence of chronic lymphocytic leukemia (CLL) in occupational settings." For these diseases, the working group reported that animal and cellular studies neither confirm nor deny the epidemiological studies' suggestion of a disease risk. This report is available on the NIEHS EMF RAPID web site (http://www.niehs.nih.gov/emfrapid).

## NIEHS Report to Congress at Conclusion of EMF RAPID Program


In June 1999, the NIEHS reported to the U.S. Congress that scientific evidence for an EMF-cancer link is weak.

The following are excerpts from the 1999 NIEHS report:

> The NIEHS believes that the probability that ELF-EMF exposure is truly a health hazard is currently small. The weak epidemiological associations and lack of any laboratory support for these associations provide only marginal, scientific support that exposure to this agent is causing any degree of harm.
>
> The scientific evidence suggesting that extremely low frequency EMF exposures pose any health risk is weak. The strongest evidence for health effects comes from associations observed in human populations with two forms of cancer: childhood leukemia and chronic lymphocytic leukemia in occupationally exposed adults. While the support from individual studies is weak, the epidemiological studies demonstrate, for some methods of measuring exposure, a fairly consistent pattern of a small, increased risk with increasing exposure that is somewhat weaker for chronic lymphocytic leukemia than for childhood leukemia. In contrast, the mechanistic studies and the animal toxicology literature fail to demonstrate any consistent pattern across studies, although sporadic findings of biological effects (including increased cancers in animals) have been reported. No indication of increased leukemias in experimental animals has been observed.

The full report is available on the NIEHS EMF RAPID web site (http://www.niehs.nih.gov/emfrapid).

No regulatory action was recommended or taken based on the NIEHS report. The NIEHS director, Dr. Kenneth Olden, told the Congress that, in his opinion, the conclusion of the NIEHS report was not sufficient to warrant aggressive regulatory action.

The NIEHS did not recommend adopting EMF standards for electric appliances or burying electric power lines. Instead, it recommended providing public information about practical ways to reduce EMF exposure. The NIEHS also suggested that power companies and utilities "continue siting power lines to reduce exposures and . . . explore ways to reduce the creation of magnetic fields around transmission and distribution lines without creating new hazards." The NIEHS encouraged manufacturers to reduce magnetic fields at a minimal cost, but noted that the risks do not warrant expensive redesign of electrical appliances.

The NIEHS also encouraged individuals who are concerned about EMF in their homes to check to see if their homes are properly wired and grounded, since incorrect wiring or other code violations are a common source of higher-than-usual magnetic fields.

## National Academy of Sciences Report

In October 1996, a National Research Council committee of the National Academy of Sciences (NAS) released its evaluation of research on potential associations between EMF exposure and cancer, reproduction, development, learning, and behavior. The report concluded:

> Based on a comprehensive evaluation of published studies relating to the effects of power-frequency electric and magnetic fields on cells, tissues, and organisms (including humans), the conclusion of the committee is that the current body of evidence does not show that exposure to these fields presents a human-health hazard. Specifically, no conclusive and consistent evidence shows that exposures to residential electric and magnetic fields produce cancer, adverse neurobehavioral effects, or reproductive and developmental effects.

The NAS report focused primarily on the association of childhood leukemia with the proximity of the child's home to power lines. The NAS panel found that although a link between EMF exposure and increased risk for childhood leukemia was observed in studies that had estimated EMF exposure using the wire code method (distance of home from power line), such a link was not found in studies that had included actual measurements of magnetic fields at the time of the study. The panel called for more research to pinpoint the unexplained factors causing small increases in childhood leukemia in houses close to power lines.

## World Health Organization International EMF Project

The World Health Organization (WHO) International EMF Project, with headquarters in Geneva, Switzerland, was launched at a 1996 meeting with representatives of 23 countries attending. It was intended to respond to growing concerns in many member states over possible EMF health effects and to address the conflict between such concerns and technological and economic progress. In its advisory role, the WHO International EMF Project is now reviewing laboratory and epidemiological evidence, identifying gaps in scientific knowledge, developing an agenda for future research, and developing risk communication booklets and other public information. The WHO International EMF Project is funded with contributions from governments and institutions and is expected to provide an overall EMF health risk assessment. Additional information about this program can be found on the WHO EMF web site (http://www.who.int/peh-emf).

As part of this project, in 1997 a working group of 45 scientists from around the world surveyed the evidence for adverse

EMF health effects. They reported that, "taken together, the findings of all published studies are suggestive of an association between childhood leukemia and estimates of ELF (extremely low frequency or power-frequency) magnetic fields."

Much like the 1996 U.S. NAS report, the WHO report noted that living in homes near power lines was associated with an approximate 1.5-fold excess risk of childhood leukemia. But unlike the NAS panel, WHO scientists had seen the results of the 1997 U.S. National Cancer Institute study of EMF and childhood leukemia (see page 17). This work showed even more strongly the inconsistency between results of studies that used a wire code to estimate EMF exposure and studies that actually measured magnetic fields.

Regarding health effects other than cancer, the WHO scientists reported that the epidemiological studies "do not provide sufficient evidence to support an association between extremely-low-frequency magnetic-field exposure and adult cancers, pregnancy outcome, or neurobehavioural disorders."

## World Health Organization International Agency for Research on Cancer

The WHO International Agency for Research on Cancer (IARC) produces a monograph series that reviews the scientific evidence regarding potential carcinogenicity associated with exposure to environmental agents. An international scientific panel of 21 experts from 10 countries met in June 2001 to review the scientific evidence regarding the potential carcinogenicity of static and ELF (extremely low frequency or power-frequency) EMF. The panel categorized its conclusions for carcinogenicity based on the IARC classification system—a system that evaluates the strength of evidence from epidemiological, laboratory (human and cellular), and mechanistic studies. The panel classified power-frequency EMF as "possibly carcinogenic to humans" based on a fairly consistent statistical association between a doubling of risk of childhood leukemia and magnetic field exposure above 0.4 microtesla (0.4 µT, 4 milligauss or 4 mG).

In contrast, they found no consistent evidence that childhood EMF exposures are associated with other types of cancer or that adult EMF exposures are associated with increased risk for any kind of cancer. The IARC panel reported that no consistent carcinogenic effects of EMF exposure have been observed in experimental animals and that there is currently no scientific explanation for the observed association between childhood leukemia and EMF exposure. Further information can be obtained at the IARC web sites (http://www.iarc.fr and http://monographs.iarc.fr).

## International Commission on Non-Ionizing Radiation Protection

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) issued exposure guidelines to guard against known adverse effects such as stimulation of nerves and muscles at very high EMF levels, as well as shocks and burns caused by touching objects that conduct electricity (see page 47). In April 1998, ICNIRP revised its exposure guidelines and characterized as "unconvincing" the evidence for an association between everyday power-frequency EMF and cancer.

## European Union

In 1996, a European Union (EU) advisory panel provided an overview of the state of science and standards among EU countries. With respect to power-frequency EMF, the panel members said that there is no clear evidence that exposure to EMF results in an increased risk of cancer.

## Australia—Radiation Advisory Committee Report to Parliament

In 1997, Australia's Radiation Advisory Committee briefly reviewed the EMF scientific literature and advised the Australian Parliament that, overall, there is insufficient evidence to come to a firm conclusion regarding possible health effects from exposure to power-frequency magnetic fields.

The committee also reported that "the weight of opinion as expressed in the U.S. National Academy of Sciences report, and the negative results from the National Cancer Institute study (Linet et al., 1997) would seem to shift the balance of probability more towards there being no identifiable health effects" (see pages 17 and 53).

## Canada—Health Canada Report

In December 1998, a working group of public health officers at Health Canada, the federal agency that manages Canada's health care system, issued a review of the scientific literature regarding power-frequency EMF health effects. They found the evidence to be insufficient to conclude that EMF causes a risk of cancer.

The report concluded that while EMF effects may be observed in biological systems in a laboratory, no adverse health effects have been demonstrated at the levels to which humans and animals are typically exposed.

As for epidemiology, 25 years of study results are inconsistent and inconclusive, the panel said, and a plausible EMF-cancer mechanism is missing. Health Canada pledged to continue monitoring EMF research and to reassess this position as new information becomes available.

## Germany—Ordinance 26

On January 1, 1997, Germany became the first nation to adopt a national rule on EMF exposure for the general public. Ordinance 26 applies only to facilities such as overhead and underground transmission and distribution lines, transformers, switchgear and overhead lines for electric-powered trains. Both electric (5 kV/m) and magnetic field exposure limits (1 Gauss) are high enough that they are unlikely to be encountered in ordinary daily life. The ordinance also requires that precautionary measures be taken on a case-by-case basis when electric facilities are sited or upgraded near homes, hospital, schools, day care centers, and playgrounds.

### Great Britain—National Radiological Protection Board Report

The National Radiological Protection Board (NRPB) in Great Britain advises the government of the United Kingdom regarding standards of protection for exposure to non-ionizing radiation. The NRPB's advisory group on non-ionizing radiation periodically reviews new developments in EMF research and reports its findings. Results of the advisory group's latest review were published in 2001. The report reviewed residential and occupational epidemiological studies, as well as cellular, animal, and human volunteer studies that had been published.

The advisory group noted that there is "some epidemiological evidence that prolonged exposure to higher levels of power frequency magnetic fields is associated with a small risk of leukaemia in children." Specifically, the NRPB advisory group's analysis suggests "that relatively heavy average exposures of 0.4 µT [4 mG] or more are associated with a doubling of the risk of leukaemia in children under 15 years of age." The group pointed out, however, that laboratory experiments have provided "no good evidence that extremely low frequency electromagnetic fields are capable of producing cancer."

### Scandinavia—EMF Developments

In October 1995, a group of Swedish researchers and government officials published a report about EMF exposure in the workplace. This "Criteria Group" reviewed EMF scientific literature and, using the IARC classification system, ranked occupational EMF exposure as "possibly carcinogenic to humans." They also endorsed the Swedish government's 1994 policy statement that public exposure limits to EMFs were not needed, but that people might simply want to use caution with EMFs.

In 1996, five Swedish government agencies further explained their precautionary advice about EMF. EMF exposure should be reduced, they said, but only when practical, without great inconvenience or cost.

Health experts in Norway, Denmark, and Finland generally agreed in reviews published in the 1990s that if an EMF health risk exists, it is small. They acknowledged that a link between residential magnetic fields and childhood leukemia cannot be confirmed or denied. In 1994, several Norwegian government ministries also recommended increasing the distance between residences and electrical facilities, if it could be done at low cost and with little inconvenience.

## Q What other U.S. organizations have reported on EMF?

A

### American Medical Association

In 1995, the American Medical Association advised physicians that no scientifically documented health risk had been associated with "usually occurring" EMF, based on a review of EMF epidemiological, laboratory studies, and major literature reviews.

### American Cancer Society

In 1996, the American Cancer Society released a review of 20 years of EMF epidemiological research including occupational studies and residential studies of adult and childhood cancer. The society noted that some data support a possible relationship of magnetic field exposure with leukemia and brain cancer, but further research may not be justified if studies continue to find uncertain results. Of particular interest is the summary of results from eight studies of risk from use of household appliances with relatively high magnetic fields, such as electric blankets and electric razors. The summary suggested that there is no persuasive evidence for increased risk with more frequent or longer use of these appliances.

### American Physical Society

The American Physical Society (APS) represents thousands of U.S. physicists. Responding to the NIEHS Working Group's conclusion that EMF is a possible human carcinogen, the APS executive board voted in 1998 to reaffirm its 1995 opinion that there is "no consistent, significant link between cancer and power line fields."

### California's Department of Health Services

In 1996, California's Department of Health Services (DHS) began an ambitious five-year effort to assess possible EMF public health risk and offer guidance to school administrators and other decision-makers. The California Electric and Magnetic Fields (EMF) Program is a research, education, and technical assistance program concerned with the possible health effects of EMF from power lines, appliances, and other uses of electricity. The program's goal is to find a rational and fair approach to dealing with the potential risks, if any, of exposure to EMF. This is done through research, policy analysis, and education. The web site has educational materials on EMF and related health issues for individuals, schools, government agencies, and professional organizations (http://www.dhs.ca.gov/ps/deodc/ehib/emf).

## Q What can we conclude about EMF at this time?

**A** Electricity is a beneficial part of our daily lives, but whenever electricity is generated, transmitted, or used, electric and magnetic fields are created. Over the past 25 years, research has addressed the question of whether exposure to power-frequency EMF might adversely affect human health. For most health outcomes, there is no evidence that EMF exposures have adverse effects. There is some evidence from epidemiology studies that exposure to power-frequency EMF is associated with an increased risk for childhood leukemia. This association is difficult to interpret in the absence of reproducible laboratory evidence or a scientific explanation that links magnetic fields with childhood leukemia.

EMF exposures are complex and come from multiple sources in the home and workplace in addition to power lines. Although scientists are still debating whether EMF is a hazard to health, the NIEHS recommends continued education on ways of reducing exposures. This booklet has identified some EMF sources and some simple steps you can take to limit your exposure. For your own safety, it is important that any steps you take to reduce your exposures do not increase other obvious hazards such as those from electrocution or fire. At the current time in the United States, there are no federal standards for occupational or residential exposure to 60-Hz EMF.

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# APPENDIX C - SOUND ASSESSMENT STUDY

# Sound Assessment Study

**Basin Electric Power Cooperative**

**Pioneer Generation Station Gas Engine Project**
**Project No. 79557**

**September 2014**

# Sound Assessment Study

**prepared for**

**Basin Electric Power Cooperative**
**Pioneer Generation Station Gas Engine Project**
**Williams County, ND**

**Project No. 79557**

**September 2014**

**prepared by**

**Burns & McDonnell Engineering Company, Inc.**
**Kansas City, Missouri**

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# 1.0 EXECUTIVE SUMMARY

Burns & McDonnell Engineering Company, Inc. (Burns & McDonnell) has been contracted by Basin Electric Power Cooperative (Basin Electric) to conduct a facility noise assessment study for a proposed addition to the existing Pioneer Generation Station (PGS) located in Williams County, North Dakota. Basin Electric is proposing to build a 111-megawatt (MW) electric generating facility that would consist of 12 reciprocating internal combustion engines (RICE) and associated auxiliary equipment, cumulatively referred to as "Project." The proposed addition would be constructed to accommodate forecasted, increased energy demands in the area.

There were several objectives of this study, which included:

- Identification of any applicable city, county, state, or federal noise ordinances and other applicable noise guidelines
- Estimation of the operational noise levels from the proposed Project, using an industry-accepted three-dimensional noise modeling program
- Determination if operation of the Project and existing facility can expect to be in compliance with the applicable regulatory standards for noise
- A noise mitigation analysis, if necessary, to determine how Basin Electric would comply with regulatory standards for noise

No applicable city, county, or state numerical noise regulations were found for this project. With the absence of any enforceable noise regulations, the noise levels due to operation of the facility have been compared to the Environmental Protection Agency (EPA) noise guideline. The EPA guideline recommends not exceeding a day-night sound level ($L_{dn}$) of 55 A-weighted decibels (dBA) at surrounding noise-sensitive receivers.

Based on a previous study completed in September 2014, it has been determined that the noise model for all existing equipment provides a conservative representation of operational sound levels. The proposed equipment associated with the Project was added to the existing noise model, and the operational sound levels from the existing equipment and proposed addition, combined, were predicted. Appropriate sound power levels were applied to all noise-radiating equipment and a number of conservative assumptions were used to provide worst-case predicted sound pressure level results.

The results of this analysis indicate that in order to expect to be below the EPA-recommended $L_{dn}$ noise level, the proposed Project would need to include silencers for all charge air intakes and exhaust stacks. If all new equipment meets the manufacturer-provided sound power levels, full operation of the combined existing and proposed PGS facility can expect to be below an $L_{dn}$ of 55 dBA at all noise-sensitive receivers.

# 2.0 INTRODUCTION

Burns & McDonnell Engineering Company, Inc. (Burns & McDonnell) has been contracted by Basin Electric Power Cooperative (Basin Electric) to conduct a facility noise assessment study for a proposed addition to the existing Pioneer Generation Station (PGS) located in Williams County, North Dakota. Basin Electric is proposing to build a 111-megawatt (MW) electric generating facility that would consist of 12 reciprocating internal combustion engines (RICE) and associated auxiliary equipment (cumulatively referred to as "Project"). The proposed addition is being built to accommodate forecasted, increased energy demands in the area.

There were several objectives of this study, which included:

- Identification of any applicable city, county, state, or federal noise ordinances and other applicable noise guidelines
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- Determination if operation of the Project and existing facility can expect to be in compliance with the applicable regulatory standards for noise
- A noise mitigation analysis, if necessary, to determine how Basin Electric would comply with regulatory standards for noise

The following sections describe the project approach, ambient measurements, methodology for modeling noise, and results.

# 3.0 ACOUSTICAL TERMINOLOGY

The term “sound level” is often used to describe two different sound characteristics called sound power and sound pressure. Every source that produces sound has a sound power level ($L_w$). The sound power level is the acoustical energy emitted by a sound source and is an absolute number that is not affected by the environment. The acoustical energy produced by a source propagates through the air as air pressure fluctuations. These pressure fluctuations, also called sound pressure ($L_p$), are what human ears hear and microphones measure.

Sound energy is physically characterized by amplitude and frequency. Sound amplitude is measured in decibels (dB) as the logarithmic ratio of a sound pressure to a reference sound pressure (20 microPascals). The reference sound pressure corresponds to the typical threshold of human hearing. A 3 dB change in a continuous broadband noise is generally considered “just barely perceptible” to the average listener. A 6 dB change is generally considered “clearly noticeable,” and a 10 dB change is generally considered a doubling (or halving, if the sound is decreasing) of the apparent loudness.

Frequency is measured in hertz (Hz), which is the number of cycles per second. The typical human ear can hear frequencies ranging from approximately 20 to 20,000 Hz. Normally, the human ear is most sensitive to sounds in the middle frequencies (1,000 to 8,000 Hz) and is less sensitive to sounds in the low and high frequencies. As such, the A-weighting scale was developed to simulate the frequency response of the human ear to sounds at typical environmental levels. The A-weighting scale emphasizes sounds in the middle frequencies and de-emphasizes sounds in the low and high frequencies. Any sound level to which the A-weighting scale has been applied is expressed in dBA. For reference, the A-weighted sound pressure level and subjective loudness associated with some common noise sources are listed in Table 3-1.

**Table 3-1: Typical Sound Pressure Levels Associated with Common Noise Sources**

| Sound Pressure Level (dBA) | Subjective Evaluation | Environment | |
|---|---|---|---|
| | | Outdoor | Indoor |
| 140 | Deafening | Jet aircraft at 75 ft | -- |
| 130 | Threshold of pain | Jet aircraft during takeoff at a distance of 300 ft | -- |
| 120 | Threshold of feeling | Elevated train | Hard rock band |
| 110 | | Jet flyover at 1000 ft | Inside propeller plane |
| 100 | Very loud | Power mower, motorcycle at 25 ft, auto horn at 10 ft, crowd noise at football game | -- |
| 90 | -- | Propeller plane flyover at 1000 ft, noisy urban street | Full symphony or band, food blender, noisy factory |
| 80 | Moderately loud | Diesel truck (40 mph) at 50 ft | Inside auto at high speed, garbage disposal |
| 70 | Loud | B-757 cabin during flight | Close conversation, vacuum cleaner |
| 60 | Moderate | Air-conditioner condenser at 15 ft, near highway traffic | General office |
| 50 | Quiet | | Private office |
| 40 | -- | Farm field with light breeze, birdcalls | Soft stereo music in residence |
| 30 | Very quiet | Quiet residential neighborhood | Bedroom, average residence (without TV and stereo) |
| 20 | -- | Rustling leaves | Quiet theater, whisper |
| 10 | Just audible | -- | Human breathing |
| 0 | Threshold of hearing | -- | -- |

Source: Adapted from *Architectural Acoustics*, M. David Egan, 1988 and *Architectural Graphic Standards*, Ramsey and Sleeper, 1994.

Noise in the environment is constantly fluctuating. Some examples could be when a car drives past, a dog barks, or a plane passes overhead. Therefore, sound metrics have been developed to quantify fluctuating environmental sound levels. These metrics include the average sound level ($L_{eq}$) and the day-night sound level ($L_{dn}$). $L_{eq}$ is the average sound level for a specific time period. $L_{dn}$ is the average A-weighted equivalent sound level over a 24-hour period with the inclusion of a 10-dB penalty added to the equivalent sound levels during the nighttime hours of 10 P.M. to 7 A.M. The 10-dB nighttime penalty is added to the nighttime sound levels to account for added sensitivity to noise during the night. $L_{eq}$ and $L_{dn}$ are the metrics that are presented in this report.

# 4.0 APPLICABLE REGULATIONS

## 4.1 Local Noise Regulations

Burns & McDonnell reviewed applicable city, county, state, and federal noise regulations for the Project site. PGS is located in Williams County and northwest of the City of Williston. The State of North Dakota and the County of Williams do not have noise regulations. Although PGS is well outside the city limits, the City of Williston's ordinances were reviewed for noise regulations to provide context for acceptable noise levels in the region. The City of Williston has a nuisance noise ordinance, which is a non-quantitative noise regulation. Therefore, there are no specific government agency-regulated numeric noise limits for the Project, only the city nuisance noise ordinance, which does not have specific noise level limitations and would not apply to PGS.

## 4.2 Noise Control Act of 1972 and EPA Guidelines

The Noise Control Act of 1972 (the Act)[1] mandated a national policy "to promote an environment for all Americans free from noise that jeopardizes their health or welfare, to establish a means for effective coordination of federal research activities in noise control, to authorize the establishment of federal noise emission standards for products distributed in commerce, and to provide information to the public respecting the noise emission and noise reduction characteristics of such products." As required by the Act, the Environmental Protection Agency (EPA) published *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*[2] in 1974. These levels are shown in Table 4-1.

**Table 4-1: EPA Noise Levels Identified to Protect Public Health and Welfare**

| Effect | Noise Level | Area |
|---|---|---|
| Hearing Loss | $L_{eq(24)} \leq 70$ dBA | All areas. |
| Outdoor activity interference | $L_{dn} \leq 55$ dBA | Outdoor residential and farm areas, and other outdoor areas where people spend widely varying amounts of time and other places in which quiet is a basis for use |
| | $L_{eq(24)} \leq 55$ dBA | Outdoor areas where people spend limited amounts of time, such as school yards, playgrounds, etc. |
| Indoor activity interference and annoyance | $L_{dn} \leq 45$ | Indoor residential areas. |
| | $L_{eq(24)} \leq 45$ dBA | Other indoor areas with human activities, such as schools, etc. |

[1] United States Code (U.S.C.): 42 U.S.C. 4901 to 4918
[2] The United States Environmental Protection Agency, Office of Noise Abatement and Control

The levels contained in Table 4-1 were established as required by the Act, but do not constitute enforceable federal regulations or standards. However, these noise levels represent valid criteria for evaluating the effect of project-generated noise on public health and welfare. Many noise studies performed for new projects compare residential noise levels to these EPA-established guidelines.

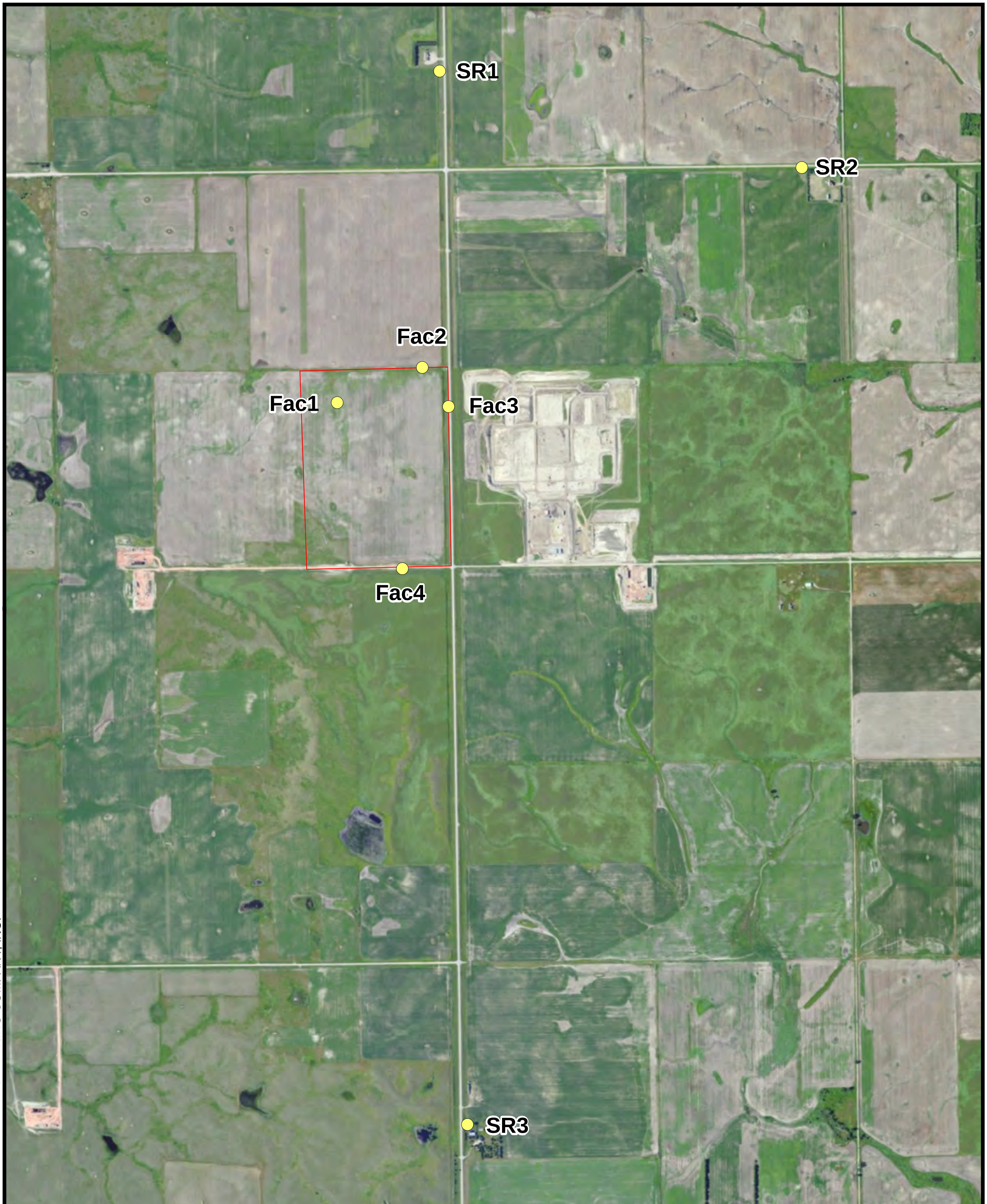
The recommended EPA guideline for outdoor activity in residential areas is an $L_{dn}$ of 55 dBA or less. An $L_{dn}$ of 55 dBA can be equated to a steady-state sound level of 48.6 dBA for a 24-hour period, incorporating the 10-dB penalty that is applied to the nighttime hours.

Due to the absence of local noise regulations, the overriding design goal for noise generated by the existing PGS and proposed Project at surrounding noise-sensitive receivers will be an $L_{dn}$ of 55 dBA, per the EPA guidance.

# 5.0 EXISTING NOISE ENVIRONMENT AND MODEL VALIDATION

As part of a separate noise compliance study performed on the existing PGS facility, operational and nonoperational sound measurements were taken by two Burns & McDonnell noise specialists in August 2014. Sound level measurements were taken along the fence line (Fac1, Fac2, Fac3, and Fac4) so that an existing noise model could be validated, and near three noise-sensitive receivers to determine ambient conditions (SR1, SR2, and SR3). These measurement points are shown in Figure 5-1.

The September 2014 study determined that there was not a noticeable increase between nonoperational and operational sound levels at the noise-sensitive receivers around the facility. Further, sound levels due to the facility's operation were less than an $L_{dn}$ of 55 dBA at these receivers. The study also confirmed that the existing noise model provided a conservative estimate of operational sound levels generated by the existing PGS. All of the measured sound levels were quieter than the model-predicted sound levels at the noise-sensitive receivers by approximately 2 to 4 dBA. For more information on the existing noise environment and model validation, please see the Noise Compliance Study contained in Appendix A.




NORTH

**Legend**

PGS Fenceline

Measurement Point

1,700 850 0 1,700

Scale in Feet

Burns & McDonnell SINCE 1898

**Figure 5-1**
**Basin Electric**
**Power Cooperative**
**Pioneer Generation Station**
**Measurement Point**
**Locations**

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, and the GIS User Community, and Burns & McDonnell Engineering

Issued: 9/3/2014

Path: R:\Basin\79557_Pioneer_Recip\Noise\ArcDocs\Figure 5-1 Measurement Points.mxd cmcrist 9/3/2014

# 6.0 PREDICTED OPERATIONAL NOISE LEVELS

In order to evaluate the expected noise levels from the proposed Project, noise data for sources to be located onsite were obtained and the equipment modeled. Using industry-accepted noise modeling software, the expected operational noise levels were predicted for areas in and around the site. The program used for noise modeling was the Computer Aided Design for Noise Abatement (CadnaA), Version 4.4.145, published by DataKustik, Ltd., Munich, Germany. The CadnaA program is a scaled, three-dimensional program which takes into account each piece of noise-emitting equipment onsite and predicts potential noise levels. The model calculates noise propagation based on ISO 9613-2:1996, General Method of Calculation. ISO 9613-2 assesses the sound levels based on the octave band center frequency range from 31.5 Hz to 8,000 Hz. The atmospheric conditions were assumed to be calm, and the temperature and relative humidity were set to 50 degrees Fahrenheit and 70 percent, respectively, based on program defaults.

The validated, existing noise model was used as a conservative baseline for this analysis. The proposed Project was added to this model, and potential, future sound levels for PGS with the Project were predicted. The modeling layout is presented in Figure 6-1. Appropriate sound generation was applied for all sound-radiating surfaces and points, and reflections were considered when sound encountered a physical structure. Sound power and sound pressure levels were provided for the engines and radiators that would be operated. Sound level data sheets that were provided are included in Appendix B.

**Legend**



Burns & McDonnell SINCE 1898

**Figure 6-1**
**Basin Electric Power Cooperative**
**Pioneer Generation Station**
**Noise Model Layout**

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, and the GIS User Community, and Burns & McDonnell Engineering

Issued: 9/3/2014

In order to expect to meet the EPA guideline noise limit at nearby noise-sensitive receivers, all charge air intakes and exhausts required additional mitigation. Table 6-1 shows the pieces of equipment that would need further mitigation and the amount of mitigation necessary.

**Table 6-1: Mitigation Requirements**

| Equipment Description | Mitigation Required |
|---|---|
| Charge Air Intakes | 35 dBA |
| Exhausts | 35 dBA |

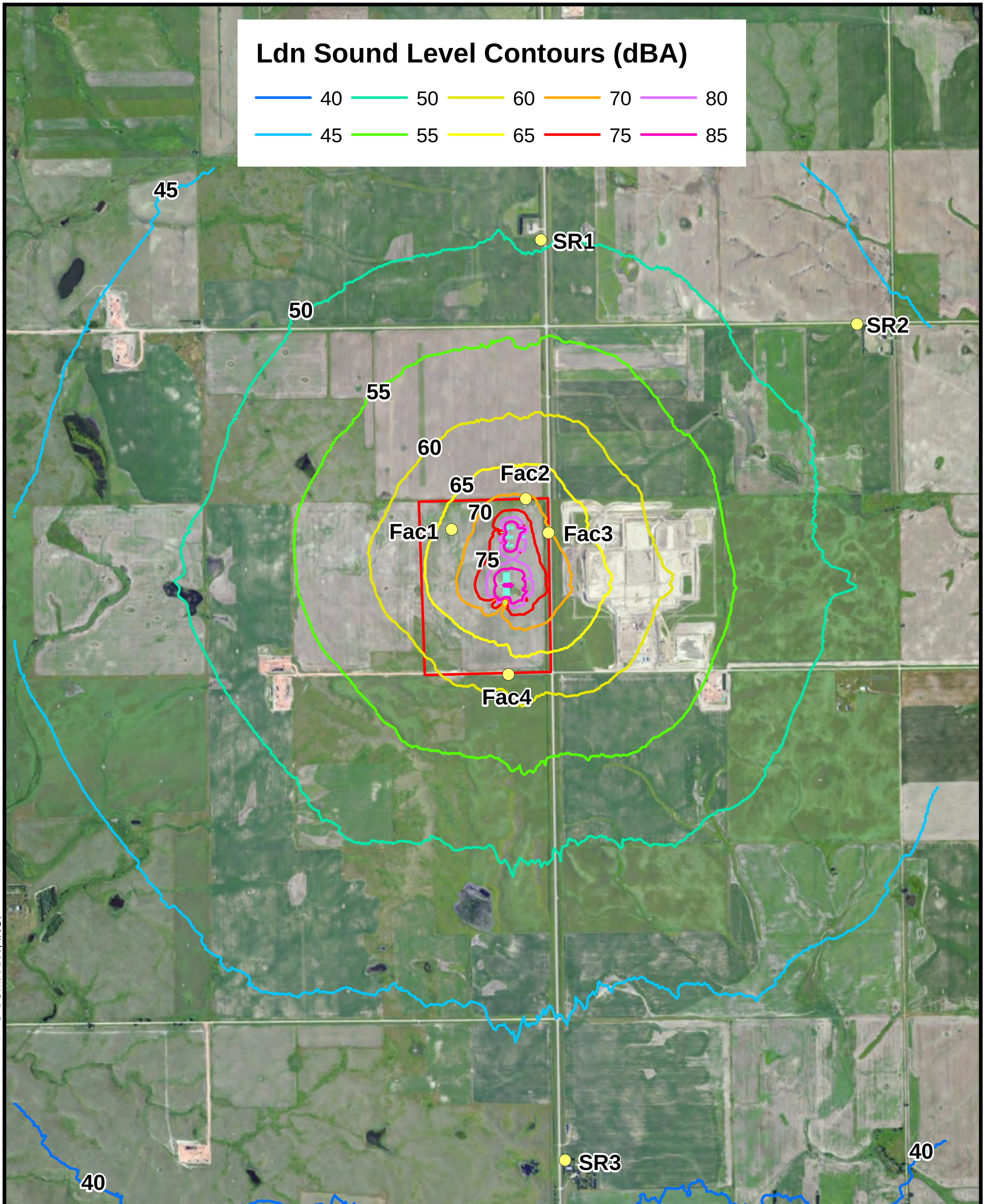
Two mitigation options were available for the charge air intakes and exhausts; 35 dBA of reduction and 45 dBA of reduction. After it was determined mitigation would be necessary, 35 dBA of reduction was applied to all charge air intakes and new exhausts in the noise model. Sound pressure levels at the surrounding noise sensitive receivers were then predicted with this adjustment. The results demonstrated that 35 dBA of reduction would provide sufficient noise mitigation and 45 dBA of reduction was not necessary. Standard building construction was assumed to provide enough attenuation on all sound-emitting equipment inside the engine halls such that the sound levels measured 3 feet from the outside of the building would not exceed 85 dBA. Standard radiators were also assumed in the noise model and were specified to measure 64 dBA at 40 meters per bank, each containing 3 fans. All sound levels used in the noise model have been included in Appendix C for reference.

Using these specifications and after the incorporation of mitigation (shown in Table 6-1), the predicted $L_{dn}$ sound levels due to the operation of the proposed Project and the existing facility at each noise-sensitive receiver are shown in Table 6-2.

**Table 6-2: Predicted Sound Levels due to Operation of the Project and Existing Facility**

| Residence | Predicted $L_{dn}$ Sound Level (dBA) |
|---|---|
| SR1 | 49.4 |
| SR2 | 46.2 |
| SR3 | 41.6 |

Figure 6-2 illustrates the $L_{dn}$ noise contours generated due to operation of the proposed Project and existing facility on the surrounding area in a 5-dB color contour format. Different sound level ranges are represented by various colors on the aerial map. These contours represent noise emitted by the Project and existing PGS, and do not include extraneous, non-PGS sound levels.




Legend

PGS Fenceline

PGS Structure

Measurement Point

NORTH

1,900 950 0 1,900

Scale in Feet

**Figure 6-2**
**Basin Electric Power Cooperative**
**Pioneer Generation Station**
**Ldn Sound Level Contours**

Burns & McDonnell SINCE 1898

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, and the GIS User Community, and Burns & McDonnell Engineering

Issued: 9/3/2014

Path: R:\Basin\79557_Pioneer_Recip\Noise\ArcDocs\Figure 6-2 Sound Level Contours.mxd cmcrist 9/3/2014

As Figure 6-2 and Table 6-2 indicate, the EPA guideline $L_{dn}$ noise level of 55 dBA is not expected to be exceeded due to the operation of PGS and the proposed Project, combined. If all new pieces of equipment were to operate at or below the sound levels assumed in the noise modeling, the EPA noise level identified to protect public health and welfare would not be exceeded.

It is important to note that other extraneous noises such as vehicles, planes, and insects may cause sound levels to temporarily exceed an $L_{dn}$ of 55 dBA, but the operation of the Project and existing PGS facility is not expected to cause that to happen.

# 7.0 CONCLUSION

A noise assessment was performed for Basin Electric's proposed addition to PGS in Williams County, North Dakota. The addition would include a 111-MW electric generating facility that would consist of 12 RICE engines and associated auxiliary equipment. The noise assessment included noise modeling to predict sound levels in the area that would result from the operation of the existing and proposed facility. The noise assessment also included a mitigation analysis and an overall noise analysis.

There are no specific government agency-regulated numeric noise limits for the Project. The EPA-established noise guideline was assumed for this analysis and recommends outdoor activity in residential areas be at an $L_{dn}$ of 55 dBA or less. This level provided the criterion for evaluating the effect of project-generated noise on public health and welfare, but does not constitute an enforceable federal regulation.

Based on previous analyses, it has been shown that the noise model for the existing facility provides a conservative estimation of operational sound levels. The proposed Project's additions to PGS were added to the existing noise model such that a conservative baseline was used.

The CadnaA model was utilized to predict noise levels from the operation of the existing facility and proposed Project, combined. After sound profiles were applied to each piece of sound-emitting equipment, a mitigation analysis was performed to determine how to achieve sound levels at surrounding receivers that would fall below the EPA-established noise guideline. In order to operate below an $L_{dn}$ of 55 dBA at surrounding noise-sensitive receivers, Basin Electric would need to include mitigation to reduce exhaust noise and charge air intake noise by 35 dBA. This noise reduction can be achieved through the installation of exhaust silencers and charge air intake silencers. The buildings to house the engines would need to be capable of absorbing enough sound such that noise levels emanating from the building would be reduced to 85 dBA when measured 3 feet from the building. In addition, each bank of radiators would need to measure 64 dBA at 40 meters from the bank. With all of these specifications in place, the greatest predicted $L_{dn}$ noise level at a receiver surrounding the site would be 49 dBA, well-below the EPA guideline.

# APPENDIX A -PGS NOISE COMPLIANCE STUDY, SEPTEMBER 2014

# Noise Compliance Study

**Basin Electric Power Cooperative**

**Pioneer Generation Station**

**Project No. 80338**

**September 2014**

# Noise Compliance Study

**prepared for**

**Basin Electric Power Cooperative**
**Pioneer Generation Station**
**Williams County, ND**

**Project No. 80338**

**September 2014**

**prepared by**

**Burns & McDonnell Engineering Company, Inc.**
**Kansas City, Missouri**

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# 1.0 EXECUTIVE SUMMARY

In September 2012, Burns & McDonnell Engineering Company, Inc. (Burns & McDonnell) was contracted by Basin Electric Power Cooperative (Basin Electric) to conduct an operational noise assessment study in which sound levels due to the operation of Pioneer Generation Station (PGS) were predicted. This study was performed for the Application for a Certificate of Site Compatibility. The facility, located in Williams County, North Dakota, and now consisting of three natural gas-fired combustion turbines (GE LM6000 turbines, 45 megawatt (MW) each) and associated equipment had not been constructed at that time. The predicted sound levels were compared to the recommended Environmental Protection Agency (EPA) noise guidelines to determine if noise impacts due to the operation of the facility could be expected. Since that time, PGS has become operational and Basin Electric has contracted Burns & McDonnell again to perform a noise compliance study at PGS to verify that the previously predicted sound levels are appropriate and that no adverse noise impacts are present due to the operation of the facility.

There were several objectives of this study, which included:

- Identification of any applicable city, county, state, or federal noise ordinances and other applicable noise guidelines
- Measurements of noise levels around the PGS fence line and nearby sensitive receivers when the facility was not operating to determine the ambient noise environment
- Measurements of noise levels around the PGS fence line and nearby sensitive receivers when the facility was operating at full capacity to determine the operational sound levels
- Comparison of the measured, operational noise levels to the predicted noise levels from the original noise study
- Determination if operation of the facility is within the applicable noise regulations

No applicable state, county, or city noise regulations were found for this project. With the absence of any enforceable noise regulations, the noise levels due to operation of the facility have been compared to the EPA noise guidelines. The EPA guidelines recommend not exceeding a day-night sound level ($L_{dn}$) of 55 dBA at surrounding sensitive receivers.

Due to insect noise contaminating the nighttime measurements, only daytime measurements were used, when insect noise was less significant. A distance calculation was performed using the operational measurements taken at the fence line to predict expected sound levels at surrounding sensitive receivers due solely to the operation of PGS. These calculations provided a conservative estimate and were performed because the measured sound levels were contaminated by other extraneous noises such that the impact due to the operation of the facility alone could not be measured.

The original noise model was proven to predict overly-conservative noise levels due to the operation of PGS (i.e., predicted sound levels were higher than the measured sound levels). Also, during full operation of the facility, the model calculated sound levels less than 55 $L_{dn}$ dBA at all sensitive receivers. Thus, it can be concluded that the EPA guideline $L_{dn}$ sound level was not exceeded due to the operation of the facility.

# 2.0 INTRODUCTION

In September 2012, Burns & McDonnell Engineering Company, Inc. (Burns & McDonnell) was contracted by Basin Electric Power Cooperative (Basin Electric) to conduct an operational noise assessment study in which sound levels due to the operation of Pioneer Generation Station (PGS) were predicted. This report has been included for reference in Appendix A. The facility, located in Williams County, North Dakota, and consisting of three natural gas-fired combustion turbines (GE LM6000 turbines, 45 megawatt (MW) each) and associated equipment had not been constructed at that time. These predicted sound levels were compared to the recommended Environmental Protection Agency (EPA) noise guidelines to determine if noise impacts due to the operation of the facility could be expected. Since then, PGS has become operational and Basin Electric has contracted Burns & McDonnell again to perform a noise compliance study at PGS to make sure the previously predicted sound levels are appropriate and that no adverse noise impacts are present due to the operation of the facility.

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**Table 3-1: Typical Sound Pressure Levels Associated with Common Noise Sources**

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|---|---|---|---|
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| 100 | Very loud | Power mower, motorcycle at 25 ft, auto horn at 10 ft, crowd noise at football game | -- |
| 90 | -- | Propeller plane flyover at 1000 ft, noisy urban street | Full symphony or band, food blender, noisy factory |
| 80 | Moderately loud | Diesel truck (40 mph) at 50 ft | Inside auto at high speed, garbage disposal, dishwasher |
| 70 | Loud | B-757 cabin during flight | Close conversation, vacuum cleaner, electric typewriter |
| 60 | Moderate | Air-conditioner condenser at 15 ft, near highway traffic | General office |
| 50 | Quiet | | Private office |
| 40 | -- | Farm field with light breeze, birdcalls | Soft stereo music in residence |
| 30 | Very quiet | Quiet residential neighborhood | Bedroom, average residence (without TV and stereo) |
| 20 | -- | Rustling leaves | Quiet theater, whisper |
| 10 | Just audible | -- | Human breathing |
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Source: Adapted from *Architectural Acoustics*, M. David Egan, 1988 and *Architectural Graphic Standards*, Ramsey and Sleeper, 1994.

Noise in the environment is constantly fluctuating; examples could be when a car drives by, a dog barks, or a plane passes overhead. Therefore, sound metrics have been developed to quantify fluctuating environmental sound levels. These metrics include the exceedance sound levels. The exceedance sound level, $L_x$, is the sound level exceeded “x” percent of the sampling period and is referred to as a statistical sound level. Two common $L_x$ values are $L_{eq}$ and $L_{90}$. $L_{eq}$ is the average sound level for a specific time period. The $L_{90}$ is the sound level exceeded 90 percent of the sampling period and represents the sound level without the influence of loud, transient noise sources. This metric is often used to represent the ambient sound level in an area. An additional sound metric is the day-night sound level ($L_{dn}$). $L_{dn}$ is the average A-weighted equivalent sound level over a 24-hour period with the inclusion of a 10-dB penalty added to the equivalent sound levels during the nighttime hours of 10 P.M. to 7 A.M. The 10-dB nighttime penalty is added to the nighttime sound levels to account for added sensitivity to noise during the night. For this report, $L_{90}$ will be used to represent the measured sound levels around the PGS facility, as it captures steady-state noise levels and removes the sporadic, extraneous sounds. These measured $L_{90}$ levels will be compared to the original model-predicted sound levels for model validation. In addition, $L_{90}$ values will be used to calculate $L_{dn}$ noise levels for comparison to the EPA guideline noise levels.

# 4.0 APPLICABLE REGULATIONS

## 4.1 Local Noise Regulations

Burns & McDonnell reviewed applicable city, county, state, and federal noise regulations for the Project site. PGS is located in Williams County and northwest of the City of Williston. The State of North Dakota and the County of Williams do not have noise regulations. Although PGS is well outside the city limits, the City of Williston's ordinances were reviewed for noise regulations to provide context for acceptable noise levels in the region. The City of Williston has a nuisance noise ordinance, which is a non-quantitative noise regulation. Therefore, there are no specific government agency-regulated numeric noise limits for the Project, only the city nuisance noise ordinance, which does not have specific noise level limitations and would not apply to PGS.

## 4.2 Noise Control Act of 1972 and EPA Guidelines

The Noise Control Act of 1972 (the Act)[1] mandated a national policy "to promote an environment for all Americans free from noise that jeopardizes their health or welfare, to establish a means for effective coordination of Federal research activities in noise control, to authorize the establishment of Federal noise emission standards for products distributed in commerce, and to provide information to the public respecting the noise emission and noise reduction characteristics of such products." As required by the Act, the EPA published *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*[2] in 1974. These levels are shown in Table 4-1.

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| | $L_{eq(24)} \leq 55$ dBA | Outdoor areas where people spend limited amounts of time, such as school yards, playgrounds, etc. |
| Indoor activity interference and annoyance | $L_{dn} \leq 45$ | Indoor residential areas. |
| | $L_{eq(24)} \leq 45$ dBA | Other indoor areas with human activities, such as schools, etc. |

[1] United States Code (U.S.C.): 42 U.S.C. 4901 to 4918
[2] The United States Environmental Protection Agency, Office of Noise Abatement and Control

The levels contained in Table 4-1 were established as required by the Act, but do not constitute enforceable federal regulations or standards. However, these noise levels represent valid criteria for evaluating the effect of project-generated noise on public health and welfare. Many noise studies performed for new projects compare residential noise levels to these EPA-established guidelines.

The recommended EPA guideline for outdoor activity in residential areas is an $L_{dn}$ of 55 dBA or less. An $L_{dn}$ of 55 dBA can be equated to a steady-state sound level of 48.6 dBA for a 24-hour period, incorporating the 10-dB penalty that is applied to the nighttime hours.

Due to the absence of local noise regulations, the overriding design goal for noise generated by PGS at surrounding sensitive receivers will be an $L_{dn}$ of 55 dBA, per the EPA guidance. This is the same design goal assumed in the original noise assessment that was prepared for the Application for a Certificate of Site Compatibility.

# 5.0 EXISTING NOISE ENVIRONMENT

On August 13 and 14, 2014, between the hours of 10:00 P.M. and 12:00 A.M., and on August 14, 2014, between the hours of 10:00 A.M. and 12:00 P.M., Burns & McDonnell personnel obtained ambient sound level measurements to establish sound levels near and around the PGS facility. During this time, PGS was not operational.

Operational measurements were taken on August 14, 2014 between the hours of 3:00 P.M. and 5:00 P.M. and again between 9:00 P.M. and 11:00 P.M. Due to equipment malfunction, only Units 1 and 2 were operational between 3:00 P.M. and 5:00 P.M. However, all three units were operating at full load between 9:00 P.M. and 11:00 P.M. Appendix B contains a noise model layout with each unit identified.

Weather conditions were favorable for conducting ambient sound measurements during all survey periods, with mostly clear skies and minimal winds. Meteorological conditions measured at the Sloulin Field International Airport, approximately 15 miles from the site, during the noise measurement periods have been included in Appendix C.

Sound level measurements were made at seven locations around PGS, along the fence line and near sensitive receivers such as a residence and church, as shown in Figure 5-1. The four fence line measurement locations (Fac1, Fac2, Fac3, and Fac4) were selected so that the existing noise model could be validated. The remaining three measurement locations (SR1, SR2, and SR3) were selected because they were deemed to be representative of existing environmental conditions at sensitive receivers and, thus, could be compared to the EPA noise guideline.

Measurements were taken using a Larson-Davis Model 831 ANSI S1.4 Type I sound level meter. The sound level meter was calibrated before and after each set of measurements. None of the calibration level changes exceeded ± 0.2 dB. A windscreen was used at all times on the meter, and the meter was mounted on a tripod, approximately 5 feet above ground, with the microphone directed toward PGS.

Sound levels at each frequency were measured for 5 minutes and logged by the noise meter at each location. The sound levels were relatively constant and measurements longer than 5 minutes were not deemed necessary. The sound levels varied at each measurement point depending on the proximity to industrial facilities and roadways and the intensity of insect noise. The measurement points were located at approximately the same elevation as the facility.


NORTH

**Legend**

PGS Fenceline

Measurement Point

1,750 875 0 1,750

Scale in Feet

Burns & McDonnell
SINCE 1898

**Figure 5-1**
**Basin Electric Power Cooperative**
**Pioneer Generation Station**
**Measurement Points**

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, and the GIS User Community, and Burns & McDonnell Engineering

Issued: 8/25/2014

Path: R:\Basin\79557_Pioneer_Recip\Noise\ArcDocs\Figure 5-1 Measurement Points.mxd cmcrist 8/25/2014

Extraneous noises during the measurement periods included noise associated with vehicular traffic, insects, birds, facility noise from other existing industrial facilities, and facility noise from PGS during the two operational measurement periods. The measured ambient sound levels, depicted by the $L_{90}$ values captured when PGS was not operating, are presented in Table 5-1.

**Table 5-1: Existing Ambient Noise Level Measurements**

| Time Period | Measurement Point | Measured $L_{90}$ (dBA) | Extraneous Noises |
|---|---|---|---|
| 10 P.M. to 12 A.M. | Fac1 | 56 | Pump/fan operating at PGS dominant, insect noise also significant, slight whooshing sound and rumble |
| | Fac2 | 61 | Insect noise, neighboring natural gas facility dominant - engine noise, fans and pumps |
| | Fac3 | 56 | Heavy machinery operating at natural gas facility dominant, insect noise |
| | Fac4 | 58 | Facility noise at natural gas facility dominant, insect noise, grinding noise at PGS at times |
| | SR1 | 50 | Facility noise at natural gas facility dominant in low frequencies, insects dominant in high frequencies, faint distant traffic, high pitched noise at facility to north, semi-truck on nearby road got louder at end of measurement |
| | SR2 | 50 | Insect noise dominant, faint distant traffic noise, natural gas facility not audible, animal squeaking noise, faint facility noise to the north |
| | SR3 | 50 | Insect noise dominant in high frequencies, facility noise in the distance to the south dominant in low frequencies, natural gas facility not audible |
| 10 A.M. to 12 P.M. | Fac1 | 49 | Fan or pump operating at PGS, noise from natural gas facility , insects, equipment (trucks) operating at natural gas facility |
| | Fac2 | 50 | Noise from natural gas facility dominant, insects, 1 motorcycle on road |
| | Fac3 | 48 | Plant across road dominant, traffic from highway, insects, 2 large trucks on road |
| | Fac4 | 46 | Equipment noise from natural gas facility dominant, trucks operating at natural gas facility, insects, traffic on road (3 large trucks) |
| | SR1 | 36 | Noise from natural gas facility dominant, insects, birds chirping, 1 large truck on road |
| | SR2 | 44 | Insects dominant, distant equipment operating (possibly tractors), birds chirping, cars driving in distance on gravel roads |
| | SR3 | 43 | Traffic on highway dominant, insects, 1 large truck |

The measured $L_{90}$ sound levels, representative of the sound level exceeded 90 percent of the sampling period, that were captured when PGS was operating are presented in Table 5-2.

**Table 5-2: Operational Noise Level Measurements**

| Time Period | Measurement Point | Measured $L_{90}$ (dBA) | Extraneous Noises |
|---|---|---|---|
| 3 P.M. to 5 P.M.[1] | Fac1 | 57 | PGS dominant- rumble and whooshing noise, insect noise, evaporative coolers appear to be loudest source, engine seemed to ramp up more at end of measurement when motor kicked on |
| | Fac2 | 55 | PGS noise dominant in all frequencies, insect noise significant, birds chirping, soft wind rustle, natural gas facility audible and has occasional back up beeping, semi-truck on 151st |
| | Fac3 | 50 | Rumbling at PGS appears to be dominant in lower frequencies, fan noise at natural gas facility dominant in higher frequencies, insect noise, occasional high pitched rattle noise at PGS, back up beeps at natural gas facility , cars along 151st (x5) |
| | Fac4 | 44 | Natural gas facility dominant in low frequencies, insects in high, PGS not audible, noise from construction at end of road, engine rumbling at end of street, distant traffic, 2 cars on 151st, whistle, soft wind rustle |
| | SR1 | 35 | Birds chirping, insect noise, faint corona noise, 1 car and 1 truck on 151st, clicking/dripping noise from car, PGS/natural gas facility barely audible when no distant traffic and calm wind, high pitched noise at plant to north, rumble at natural gas facility appears to be louder than PGS, faint jet noise at end of measurement |
| | SR2 | 42 | Tractor/combine in field nearby, insect noise, faint back up beep, distant traffic noise, no facility noise audible (PGS or natural gas facility), high pitched hum at site to north occasionally at end of measurement |
| | SR3 | 41 | Distant traffic, car dripping noise, insects dominant, soft wind rustle, birds, both plants not audible, 2 cars |
| 10 A.M. to 12 P.M.[2] | Fac1 | 61 | PGS units and other plant equipment dominant, insects, motor kicked on a couple minutes into measurement |
| | Fac2 | 61 | PGS units and auxiliary equipment dominant, natural gas facility audible, insects |
| | Fac3 | 56 | Natural gas facility running full load- dominant in high frequencies, 3 PGS turbines dominant in lower frequencies, insects, 2 trucks on 151st |
| | Fac4 | 59 | PGS units audible directly north, natural gas facility to NE audible, insects, 3 trucks on 151st |
| | SR1 | 50 | PGS and natural gas facility audible, insects, traffic in distance |
| | SR2 | 53 | Insects dominant at high frequencies, equipment operating in distance, industrial facility to north |
| | SR3 | 52 | Insects dominant at higher frequencies, PGS and natural gas facility audible in distance, 1 truck on highway |

[1]Units 1 and 2 were operating
[2]Units 1, 2, and 3 were operating

As shown in Table 5-1, ambient A-weighted $L_{90}$ sound levels ranged from 36 dBA at SR1 in the late morning to 61 dBA at Fac2 during the nighttime. As the table demonstrates, sound levels were considerably louder during the nighttime than they were in the afternoon. This is atypical and was due to substantial insect noise. Because the insect noise contaminated the measurements most during the nighttime, the afternoon sound level measurements were more representative of actual sound levels in the area. The nighttime measurements were therefore not used for validation purposes.

As shown in Table 5-2, A-weighted $L_{90}$ sound levels ranged from 35 dBA at SR1 in the afternoon to 61 dBA at Fac1 and Fac2 during the nighttime. Again, sound levels were louder during the nighttime than they were in the afternoon. Though all three units were operating during the nighttime measurements, compared to the two units operating during the afternoon, the elevated sound levels at the sensitive receivers can again be attributed to significant insect noise, not the addition of the third unit. Because the insect noise contaminated the measurements most during the nighttime, the afternoon sound level measurements were more representative of actual sound levels due to operation of PGS. The nighttime measurements were therefore not used for validation purposes.

Comparing the non-operational sound levels to the operational sound levels reveals that the operation of PGS does not have a significant impact at surrounding sensitive receivers. Table 5-3 compares the non-operational and operational sound levels at corresponding times.

**Table 5-3: Non-operational vs. Operational Noise Level Measurements**

| | Daytime | | Nighttime | |
|---|---|---|---|---|
| **Measurement Point** | **Measured Sound Level (dBA) – Non-operational** | **Measured Sound Level (dBA) - Operational** | **Measured Sound Level (dBA) – Non-operational** | **Measured Sound Level (dBA) - Operational** |
| SR1 | 36 | 35 | 50 | 50 |
| SR2 | 44 | 42 | 50 | 53 |
| SR3 | 43 | 41 | 50 | 52 |

During the daytime, operational sound levels were similar, yet quieter than sound levels measured when PGS was not operating. This fact demonstrates that noise sources other than the operation of PGS have a larger impact on sound levels at these sensitive receivers. Plant noise from both PGS (operating Units 1 and 2) and the natural gas facility adjacent to PGS were noted to be barely audible at SR1 when winds were calm and no distant traffic was present. Plant noise from both facilities was not audible at SR2 or SR3 during this time.

During the nighttime measurements, operational sound levels were the same or slightly higher than the non-operational sound levels. PGS and the adjacent facility were audible, but faint, at SR1 and SR3 during all conditions. Neither facility was audible at SR2 during the nighttime. As stated in Section 3.0, a 3-dBA change is a barely perceptible change in sound. As such, a noticeable increase in sound levels due to the full operation of PGS is not expected at any sensitive receiver around the site, and was not noted by the noise specialists.

# 6.0 VALIDATION OF OPERATIONAL NOISE LEVELS

An analysis was performed on the model-predicted operational sound levels from the original noise study completed in September 2012. These predicted sound levels have been compared to the measured, operational sound levels captured during the field study in August 2014. Though Fac1 through Fac4 and SR2 and SR3 were not included in the original study, these receptors have been added to the original noise model for validation purposes. These sensitive receivers have been analyzed in lieu of others in the original study because they are closer to the facility and would have higher noise impacts due to the operation of PGS. Because the sound level measurements taken at the sensitive receivers around the site were contaminated by insects, a distance propagation calculation was performed to determine the facility's impact at these locations, further described below. The measured sound levels used in this analysis were the sound levels taken during operation of Units 1 and 2; during the afternoon when insect noise was less significant. Sound sources associated with Unit 3 were able to be temporarily turned off in the noise model to match the measured sound level scenario. Table 6-1 shows the predicted noise levels from the updated, original noise model versus the measured sound levels.

**Table 6-1: Predicted Versus Measured Sound Levels**

| Measurement Point | Predicted Sound Level (dBA)[1] | Measured Sound Level (dBA)[2] |
|---|---|---|
| Fac1 | 64 | 57 |
| Fac2 | 63 | 55 |
| Fac3 | 59 | 50 |
| Fac4 | 48 | 44 |

[1]Model-predicted sound levels due to operation of Units 1 and 2
[2]Measured during operation of Units 1 and 2

The equation used to find the assumed facility noise contribution at each of the sensitive receivers is as follows:

$$SPL2 = SPL1 - 20 * log(D2/D1)$$

Where: SPL2 = sound pressure level being calculated at D2

SPL1 = known sound pressure level at D1, used as reference

D2 = distance from facility to the receptor where noise is being calculated

D1 = distance from facility to the receptor of known SPL1, used as reference

Fac1 was used as a reference for SR1 and SR3, and Fac2 was used as a reference for SR2. These representative points were chosen due to location relative to the sensitive receiver and similar shielding from buildings and structures in the noise propagation path. This distance propagation calculation is a conservative approach to calculating sound at a distance and has been used in this instance because of the significant insect noise skewing the measurements taken at SR1 through SR3. The equation does not take into account the vegetation, terrain, and other structures that may be in the noise propagation path. These sound levels are also an over-prediction of noise due solely to the operation of PGS because other extraneous noises are included in the measurements along the fence line used to calculate these sound levels.

**Table 6-2: Predicted Versus Projected Sound Levels**

| Measurement Point | Predicted Sound Level (dBA)[1] | Projected Sound Level (dBA)[2] |
|---|---|---|
| SR1 | 40.8 | 36.4 |
| SR2 | 36.6 | 32.5 |
| SR3 | 31.5 | 29.7 |

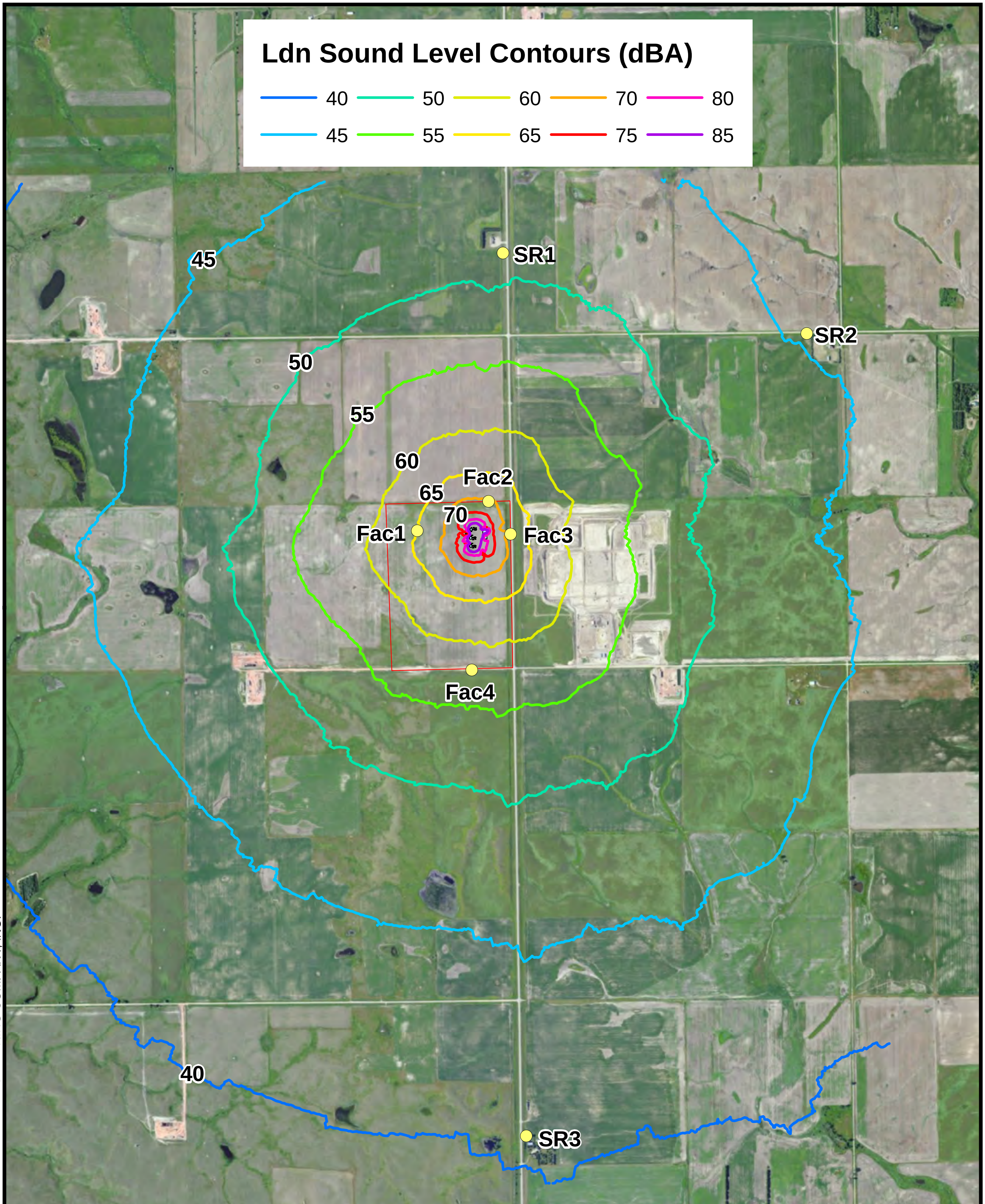
[1]Model-predicted sound levels due to operation of Units 1 and 2
[2]Projected based on operation of Units 1 and 2

As Table 6-1 and Table 6-2 show, all of the measured and projected sound levels are quieter than the original model-predicted sound levels. The noise model was built and run using a degree of conservatism to provide a worst-case analysis.

The original analysis stated that, based on model-predicted sound levels, all sensitive receivers located around the PGS facility could expect to be within the EPA noise guideline of an $L_{dn}$ of 55 dBA. A steady-state sound level of 48.6 dBA over a 24-hour period would equate to an $L_{dn}$ of 55 dBA, due to the 10-dB penalty applied to the noise during the nighttime hours (10 P.M. to 7 A.M.). Table 6-3 contains the predicted sound levels due to full operation of Units 1, 2 and 3. Since the nighttime measurements taken during operation of all units were unable to be used in this analysis, and it has been concluded that the noise model projects conservative noise levels, it is assumed for the purposes of this study that the model-predicted sound levels due to full operation of the facility would also be greater than the measured sound levels in the area. As the results in Table 6-3 show, all predicted sound levels at surrounding sensitive receivers are below an $L_{dn}$ of 55 dBA, and the conclusion from the original analysis has been supported. Figure 6-1 illustrates the $L_{dn}$ noise contours due to operation of PGS on the surrounding area in a 5 dB color-contour format, generated from the updated, original noise model. As the figure shows, the 55 dBA $L_{dn}$ noise contour is a significant distance from any sensitive receiver in the area.

**Table 6-3: Predicted $L_{dn}$ Sound Levels During Full Operation of PGS**

| Measurement Point | Predicted $L_{dn}$ Sound Level (dBA) |
|---|---|
| SR1 | 48.4 |
| SR2 | 44.4 |
| SR3 | 40.6 |




NORTH

2,000 1,000 0 2,000

Scale in Feet

**Legend**

PGS Fenceline

Measurement Point

PGS Structures

Burns & McDonnell
SINCE 1898

**Figure 6-1**
**Basin Electric**
**Power Cooperative**
**Pioneer Generation Station**
**Ldn Sound Level**
**Contours**

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, and the GIS User Community, and Burns & McDonnell Engineering

Issued: 8/28/2014

Path: R:\Basin\79557_Pioneer_Recip\Noise\80338- Noise Compliance Study and Report\ArcDocs\Figure 6-1 Sound Level Contours.mxd cmcrist 8/28/2014

# 7.0 CONCLUSION

A noise compliance study was performed for Basin Electric's PGS in Williams County, North Dakota. The study included an ambient noise survey to quantify the acoustical environment during periods of non-operation and operation of PGS. A second part of this study included a comparison of the 2014 measured values to the model-predicted values from the original noise assessment study completed in September 2012 to verify no adverse noise impacts are present due to the operation of PGS.

There are no specific government agency-regulated numeric noise limits for the area of the facility. Therefore, the EPA-established noise guideline was used in this analysis and in the original noise study. The recommended EPA guideline for outdoor activity in residential areas is an $L_{dn}$ of 55 dBA or less. This level is criterion for evaluating the effect of project-generated noise on public health and welfare, but does not constitute an enforceable federal regulation.

Measured, ambient noise levels varied at each measurement point depending on the proximity to local traffic on roads and intensity of insect noise. The ambient sound levels ranged from a low of 36 dBA to a high of 58 dBA. Sound level measurements taken while PGS was operating did not vary from the ambient sound levels significantly. During periods of operation, sound levels ranged from a low of 36 dBA to a high of 61 dBA.

Because insect noise contaminated the nighttime measurements, the daytime measurements taken along the PGS fence line, both non-operational and operational, were used for noise model validation. Comparing the model-predicted sound levels to the measured sound levels along the fence line, it was determined that the noise model provided an overly conservative estimate of sound levels due to the operation of PGS. Since the noise model was over-predicting sound levels, but still calculated sound levels less than an $L_{dn}$ of 55 dBA at surrounding sensitive receivers during full operation of PGS, it was determined that operation of PGS did not cause any exceedances of the EPA guideline $L_{dn}$ noise level of 55 dBA. Thus, the conclusions from the original noise study performed for the Application for a Certificate of Site Compatibility have been supported.

# APPENDIX A - ORIGINAL NOISE ASSESSMENT STUDY, SEPTEMBER 2012

Report on the

# Operational Noise Assessment Study

## Pioneer Generation Station

Williston, North Dakota

# OPERATIONAL NOISE ASSESSMENT STUDY

# PIONEER GENERATION STATION
## WILLISTON, NORTH DAKOTA

**prepared for**

## Basin Electric Power Cooperative

**September 2012**

**prepared by**


## Burns & McDonnell Engineering Company, Inc.
## Kansas City, Missouri

## EXECUTIVE SUMMARY

Burns & McDonnell analyzed the expected noise impacts from the proposed Pioneer Generation Station (PGS), to be located near Williston, North Dakota for Basin Electric Power Cooperative (Basin Electric). Basin Electric's PGS Phase I, consisted of the installation of one 45-MW, simple cycle combustion turbine (GE LM6000) with associated equipment (collectively referred to as "Unit"). PGS Phase II Project is the addition of similar Units, for a maximum total of 135 MW (3 combustion turbine Units) at the site. Basin Electric requested that the noise analysis be performed on a single Unit as well as a three-Unit facility as a conservative evaluation approach.

Burns & McDonnell analyzed the sound levels of the proposed Project using a predictive, 3-dimensional noise model (CadnaA) based on the methodologies presented in the ISO-9613 standards. The model analyzed the sound levels expected at the nearest residences to the Project for two scenarios: 1) one combustion turbine Unit, and 2) three combustion turbine Units. Additionally, the model analyzed sound levels over a gridded area to produce sound contours that covered the area that could possibly be impacted from the sound levels of the Project.

There are no applicable noise regulations for the Project. However, EPA has created guidelines noise levels to which facilities such as this can be compared. While they are not federally enforceable noise limits, they can provide valid criteria for which to evaluate the effects of project-generated noise on public health. This analysis compared the project-generated sound levels to the EPA guidelines and it was determined that there are not expected to be any exceedances of the EPA guidelines with the Project as proposed. Additionally, there is a large, existing natural gas processing plant located directly adjacent to the PGS. This gas facility has no operational noise limits and contains equipment typical of these types of facilities: engines, compressors, etc. Based on past experience with these types of gas facilities, it is anticipated that the PGS will operate at or below the sound levels produced by the gas processing facility.

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# 1.0 INTRODUCTION

Burns & McDonnell Engineering Company, Inc. (Burns & McDonnell) was contracted as a third-party independent contractor by Basin Electric Power Cooperative to perform an operational noise assessment study for the PGS Phase II Project, located northwest of Williston, North Dakota. The proposed facility will include three natural gas-fired combustion turbines (45-MW GE LM6000) and other associated equipment (collectively referred to as a facility). Each combustion turbine will have a Selective Catalytic Reduction (SCR) system installed to reduce NOx emissions.

The closest residences are located to the east and north, but there are residences to the south and southwest of the facility as well. Additionally, there is an existing natural gas processing plant located directly adjacent to the PGS. The gas facility consists of equipment typical to those types of facilities: engines, compressors, etc. Figure 1-1 shows the facility location and the location of the closest identified noise sensitive receptors. The figure indicates the nature of each sensitive noise receptor, where “R#” is a residence, “FS#” is a farm storage area, and “C#” is a church.

This report details the methodology used to obtain the expected Pioneer Generation Station noise levels and then compares those modeled noise levels to the United States Environmental Protection Agency’s (EPA) sound criteria to determine compliance.

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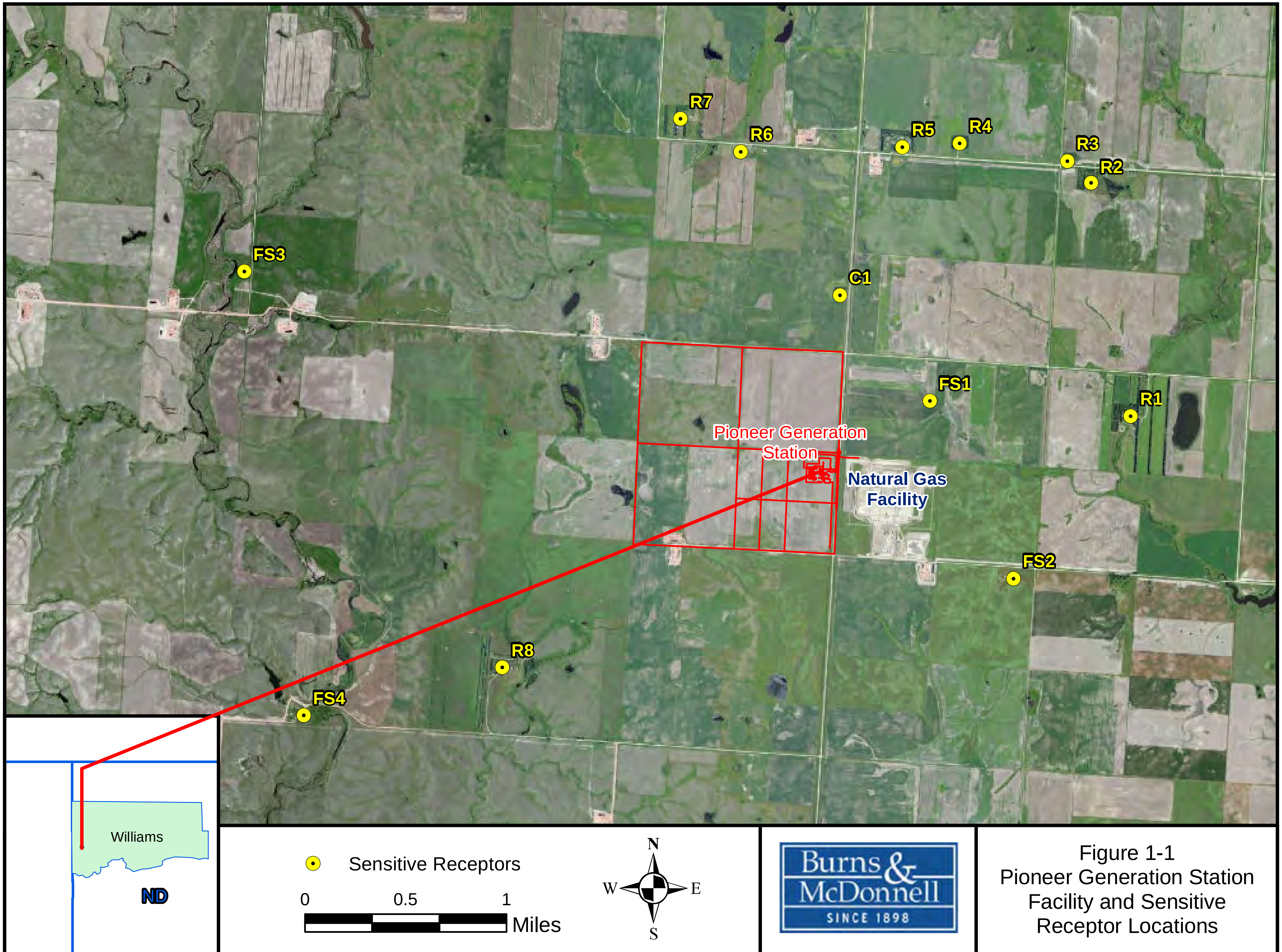



Burns & McDonnell SINCE 1898

Figure 1-1
Pioneer Generation Station Facility and Sensitive Receptor Locations

# 2.0 ACOUSTICAL TERMINOLOGY

The term "sound level" is often used to describe two different sound characteristics called sound power and sound pressure. Every source that produces sound has a sound power level ($L_w$). The sound power level is the acoustical energy emitted by a sound source and is an absolute number that is not affected by the environment. The acoustical energy produced by a source propagates through a media as pressure fluctuations. These pressure fluctuations, also called sound pressure ($L_p$), are what human ears hear and microphones measure.

Sound energy is physically characterized by amplitude and frequency. Sound amplitude is measured in decibels (dB) as the logarithmic ratio of a sound pressure to a reference sound pressure (20 microPascals). The reference sound pressure corresponds to the typical threshold of human hearing. A three dB change in a continuous broadband sound is generally considered "just barely perceptible" to the average listener. A five dB change is generally considered "clearly noticeable" and a 10 dB change is generally considered a doubling (or halving) of the apparent loudness.

Frequency is measured in hertz (Hz), which is the number of cycles per second. The typical human ear can hear frequencies ranging from approximately 20 to 20,000 Hz. Normally, the human ear is most sensitive to sounds in the middle frequencies (1,000 to 8,000 Hz) and is less sensitive to sounds in the low and high frequencies. As such, the A-weighting scale was developed to simulate the frequency response of the human ear to sounds at typical environmental levels. The A-weighting scale emphasizes sounds in the middle frequencies and de-emphasizes sounds in the low and high frequencies. Any sound level to which the A-weighting scale has been applied is expressed in A-weighted decibels or dBA. For reference, the A-weighted sound pressure level and subjective loudness associated with some common sound sources are listed in Table 2-1.

**Table 2-1: Typical Sound Pressure Levels Associated with Common Sound Sources**

| Sound Pressure Level (dBA) | Subjective Evaluation | Environment | |
|---|---|---|---|
| | | Outdoor | Indoor |
| 140 | Deafening | Jet aircraft at 75 ft. | |
| 130 | Threshold of pain | Jet aircraft during takeoff at a distance of 300 ft. | |
| 120 | Threshold of feeling | Elevated train | Hard rock band |
| 110 | | Jet flyover at 1,000 ft. | Inside propeller plane |
| 100 | Very loud | Power mower, motorcycle at 25 ft., auto horn at 10 ft., crowd sound at football game | |
| 90 | | Propeller plane flyover at 1,000 ft., noisy urban street | Full symphony or band, food blender, noisy factory |
| 80 | Moderately loud | Diesel truck (40 mph) at 50 ft. | Inside auto at high speed, garbage disposal, dishwasher |
| 70 | Loud | B-757 cabin during flight | Close conversation, vacuum cleaner |
| 60 | Moderate | Air-conditioner condenser at 15 ft., near highway traffic | General office |
| 50 | Quiet | | Private office |
| 40 | | Farm field with light breeze, birdcalls | Soft stereo music in residence |
| 30 | Very quiet | Quiet residential neighborhood | Inside average residence (without TV and stereo) |
| 20 | | Rustling leaves | Quiet theater, whisper |
| 10 | Just audible | | Human breathing |
| 0 | Threshold of hearing | | |

Source: Adapted from Architectural Acoustics, M. David Egan, 1988 and Architectural Graphic Standards, Ramsey and Sleeper, 1994.

Sound in the environment is constantly fluctuating; examples could be when a car drives by, a dog barks, or an aircraft passes overhead. Therefore, sound metrics have been developed to quantify fluctuating environmental sound levels. These metrics include the exceedance sound levels. The exceedance sound level, $L_x$, is the sound level exceeded “x” percent of the sampling period and is referred to as a statistical sound level. The most common $L_x$ value is $L_{eq}$. $L_{eq}$ is the average sound level for a given time period. Another common sound metric is $L_{dn}$. $L_{dn}$ is a 24-hour average sound level that is often used to represent community sound levels. A 10-dB nighttime penalty is added to the nighttime hours to account for added sensitivity to noise during the night. $L_{eq}$ and $L_{dn}$ are presented in this analysis.

* * * * *

## 3.0 APPLICABLE REGULATIONS

The site, located near Williston in Williams County, North Dakota does not have state, city or county noise regulations applicable to the Project. Therefore, the EPA-recommended noise levels have been used to evaluate if future sound levels of the proposed Project could be problematic.

The Noise Control Act of 1972 (the Act) (U.S.C. 4901) mandated a national policy "to promote an environment for all Americans free from noise that jeopardizes their health or welfare, to establish a means for effective coordination of Federal research activities in noise control, to authorize the establishment of Federal noise emission standards for products distributed in commerce, and to provide information to the public respecting the noise emission and noise reduction characteristics of such products."

As required by the Act, the EPA published *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety* in 1974 (USEPA, 1974 and 1978) (Table 3-1). These levels were established as required by the Act but do not constitute enforceable federal regulations or standards. However, these noise levels represent valid criteria for evaluating the effect of project-generated noise on public health and welfare and many noise studies performed for new projects will therefore compare residential noise levels to these EPA-established guidelines even though they are not considered federally enforceable limits.

**Table 3-1: EPA Noise Levels Identified to Protect Public Health and Welfare**

| Effect | Noise Level | Area |
|---|---|---|
| Hearing Loss | $L_{eq(24)} \leq 70$ dBA | All areas. |
| Outdoor activity interference | $L_{dn} \leq 55$ dBA | Outdoor residential and farm areas, and other outdoor areas where people spend widely varying amounts of time and other places in which quiet is a basis for use |
| | $L_{eq(24)} \leq 55$ dBA | Outdoor areas where people spend limited amounts of time, such as school yards, playgrounds, etc. |
| Indoor activity interference and annoyance | $L_{dn} \leq 45$ | Indoor residential areas. |
| | $L_{eq(24)} \leq 45$ dBA | Other indoor areas with human activities, such as schools, etc. |

The recommended EPA guideline for outdoor activity in residential areas is an $L_{dn}$ of 55 dBA. An $L_{dn}$ of 55 dBA can be equated to a 1-hour $L_{eq}$ value of 48.6 dBA assuming the Project operates continuously at the same level for 24-hours and a 10-dB penalty is applied to nighttime hours.

* * * * *

# 4.0 MODELING METHODOLOGY

The main generation equipment that is expected to be installed for this Project is the GE model LM6000 combustion turbine Unit with an SCR system. PGS Phase I project consists of one combustion turbine Unit. PGS Phase II Project will install two additional Units of the same model with SCR systems. There are several auxiliary pieces of equipment associated with each combustion turbine Unit, including fin-fan coolers, air compressors, water pump skids, and auxiliary equipment skids. There will be natural gas conditioning equipment on-site that would service all three Units.

The sound profile used for modeling purposes was provided by GE for most of the equipment. The sound power profiles that were used in the modeling for the Project are shown below in Table 4-1.

## Table 4-1: Equipment Sound Power Levels

| Equipment | Transformer Sound Power Level (Lw) at Octave Band Frequency (Hz) (dBA) | | | | | | | | | Overall Sound Level (dBA) |
|---|---|---|---|---|---|---|---|---|---|---|
| | 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 | |
| Air Filter House | 113.2 | 107.8 | 98.5 | 106.4 | 102.2 | 99.8 | 95.4 | 98.5 | 83.0 | 105.7 |
| Ammonia Injection Skid | 82.0 | 90.0 | 92.0 | 84.0 | 86.0 | 86.0 | 84.0 | 78.0 | 72.0 | 90.4 |
| Auxiliary Skid Cooler | 80.0 | 81.0 | 87.0 | 98.0 | 87.0 | 84.0 | 86.0 | 79.0 | 70.0 | 93.0 |
| Fin Fan | 107.7 | 109.0 | 102.0 | 99.0 | 97.0 | 93.0 | 90.0 | 86.0 | 79.0 | 99.0 |
| Fuel Gas Treatment System | - | - | 56.0 | 64.0 | 67.0 | 65.0 | 60.0 | 54.0 | 48.0 | 68.8 |
| Generator Base | 95.1 | 94.8 | 101.6 | 91.4 | 83.0 | 84.3 | 78.8 | 70.3 | 64.5 | 90.1 |
| Generator Enclosure | 96.3 | 100.6 | 101.5 | 93.9 | 87.6 | 87.8 | 81.6 | 75.8 | 65.0 | 92.6 |
| Generator Exhaust Silencer | 105.2 | 99.6 | 108.4 | 108.7 | 99.6 | 100.3 | 95.4 | 88.3 | 76.4 | 105.1 |
| Generator Inlet Fan | 99.1 | 100.5 | 100.4 | 114.5 | 102.0 | 101.3 | 97.0 | 91.4 | 77.1 | 108.4 |
| Liquid Fuel Forwarding Skid | - | 78.0 | 83.0 | 88.0 | 88.0 | 84.0 | 83.0 | 79.0 | 73.0 | 90.1 |
| Miscellaneous Pumps[NP] | 96.0 | 95.0 | 97.0 | 97.0 | 97.0 | 97.0 | 97.0 | 94.0 | 87.0 | 102.6 |
| SCR_COR | 113.8 | 106.4 | 100.9 | 94.1 | 97.7 | 99.2 | 97.4 | 91.1 | 85.2 | 103.2 |
| Silenced Stack[NP] | 123.0 | 120.0 | 107.0 | 96.0 | 85.0 | 80.0 | 77.0 | 77.0 | 79.0 | 96.9 |
| Sprint Skid | 80.0 | 78.0 | 79.0 | 79.0 | 81.0 | 80.0 | 76.0 | 70.0 | 62.0 | 83.8 |
| Tempering Fan[NP] | 99.1 | 100.5 | 100.4 | 114.5 | 102.0 | 101.3 | 97.0 | 91.4 | 77.1 | 108.4 |
| Transformer[NP] | 119.9 | 112.7 | 104.6 | 92.1 | 86.7 | 77.5 | 71.3 | 66.5 | 61.6 | 92.5 |
| Turbine Base | 96.5 | 92.6 | 92.5 | 95.1 | 96.2 | 88.8 | 84.4 | 81.7 | 74.9 | 95.8 |
| Turbine Enclosure | 98.4 | 97.6 | 95.1 | 95.2 | 95.4 | 89.9 | 86.0 | 85.3 | 81.8 | 96.3 |
| Turbine Exhaust Fan | 104.2 | 104.5 | 104.7 | 105.1 | 99.1 | 95.2 | 92.5 | 88.7 | 80.8 | 102.0 |
| Turbine Inlet Silencer | 111.8 | 115.6 | 112.1 | 96.6 | 87.4 | 98.9 | 104.2 | 98.3 | 77.9 | 107.5 |
| Water Injection Skid | 84.0 | 95.0 | 96.0 | 94.0 | 98.0 | 94.0 | 92.0 | 87.0 | 83.0 | 99.5 |

NP – Not Provided by GE. Data from similar or larger projects was used to be conservative.

Noise receivers were placed at the identified noise sensitive locations closest to the proposed facility and at Basin Electric's facility boundary. See Figure 1-1 for the sensitive noise receptors and the Project location.

A moderate ground absorption value was chosen that appropriately reflects the agricultural nature of the area surrounding the Project. The effects of shielding due to terrain were conservatively ignored. Second-order reflections were considered to account for the effects of reflected sound within the power block.

* * * * *

# 5.0 PREDICTED NOISE LEVELS

The predicted sound levels at each sensitive noise receptor are the sound levels that could reasonably be expected to occur as a result of this Project being built in the absence of any other noise sources (i.e., highway noise, adjacent gas facility, etc. are all excluded from this value). The predicted $L_{eq}$ and $L_{dn}$ sound levels for the single-Unit and three-Unit scenarios are shown in Table 5-1. The $L_{dn}$ values were calculated based on the Project operating continuously for 24 hours at full load, and applying a 10-dB penalty to the nighttime hours. The $L_{dn}$ values were used to determine if the Project would be acceptable per the EPA guidelines.

**Table 5-1: Expected Worst-Case $L_{eq}$ and $L_{dn}$ Sound Levels**

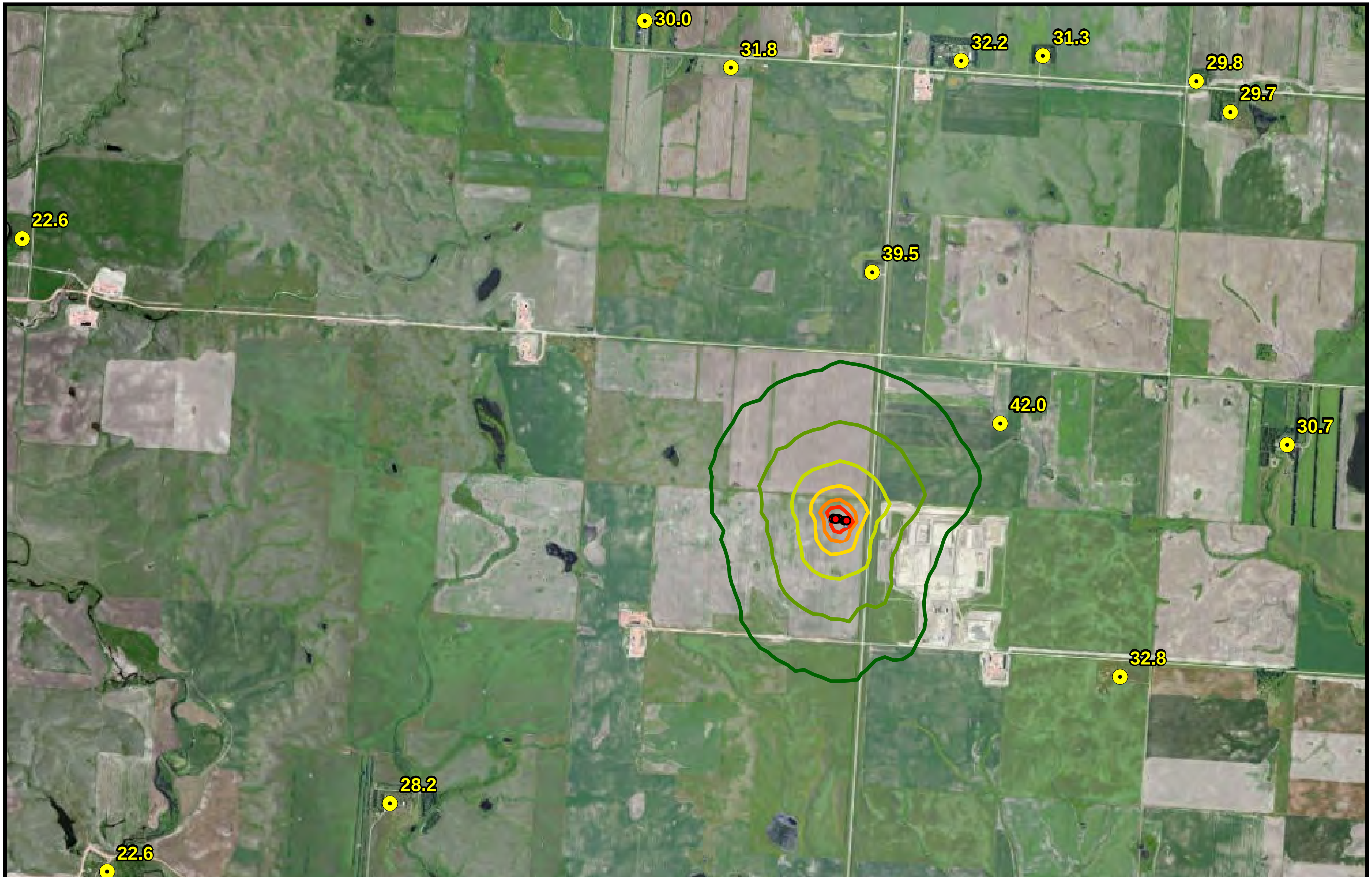
| Receptor | Sound Pressure Level | | | |
|---|---|---|---|---|
| | One Unit $L_{eq}$ (dBA) | One Unit $L_{dn}$ (dBA) | Three Units $L_{eq}$ (dBA) | Three Units $L_{dn}$ (dBA) |
| Farm Storage 1 (FS1) | 42.0 | 48.4 | 44.1 | 50.5 |
| Chruch1 (C1) | 39.5 | 45.9 | 41.8 | 48.2 |
| Farm Storage 2 (FS2) | 32.8 | 39.2 | 39.3 | 45.7 |
| Residence 1 (R1) | 32.2 | 38.6 | 35.2 | 41.6 |
| Residence 2 (R2) | 31.8 | 38.2 | 34.6 | 41.0 |
| Residence 3 (R3) | 31.3 | 37.7 | 34.2 | 40.6 |
| Residence 4 (R4) | 30.7 | 37.1 | 34.9 | 41.3 |
| Residence 5 (R5) | 30.0 | 36.4 | 32.9 | 39.3 |
| Residence 6 (R6) | 29.8 | 36.2 | 32.7 | 39.1 |
| Residence 7 (R7) | 29.7 | 36.2 | 32.7 | 39.1 |
| Residence 8 (R8) | 28.2 | 34.6 | 33.1 | 39.5 |
| Farm Storage 3 (FS3) | 22.6 | 29.0 | 27.7 | 34.1 |
| Farm Storage (FS4) | 22.6 | 29.0 | 26.4 | 32.8 |

Initially, the maximum $L_{eq}$ sound level at any sensitive noise receptor is expected to be 42.0 dBA with only one Unit operating. This equates to an $L_{dn}$ sound level of 48.4 dBA, noticeably lower than the EPA guideline of 55 dBA. In addition to this being considered a quiet sound level at the exterior of a residence, standard housing construction will reduce outside noise levels by 10 to 20 dB inside of a house. Further, this location is used for farm storage and is unlikely to be disturbed by noise at night. In fact, the top three affected receptors are all non-residential. Therefore, noise levels due to operation of one Unit are expected to have little or no impact on the closest residences.

If three Units are placed into operation, the maximum $L_{eq}$ sound level at a sensitive noise receptor could reasonably be expected to approach 44.1 dBA. This equates to an $L_{dn}$ sound level of 50.5 dBA, which is lower than the EPA guideline of 55 dBA by a noticeable amount. This would still be considered a quiet sound level at the exterior of a residence, and standard housing construction will reduce outside noise levels by 10 to 20 dB inside of a house. Similarly to one Unit, the top three affected receptors are non-residential and are unlikely to be disturbed by noise at night. Therefore, noise levels due to the operation of three Units are expected to have little or no impact on the closest residences.

To demonstrate the results graphically, Figures 5-1 through Figure 5-4 have been included. These figures show the expected $L_{eq}$ and $L_{dn}$ sound contours generated by each scenario for the Project. The individual colored lines in the figures represent different sound levels in 5-decibel increments.

* * * * *




0 0.4 0.8 Miles

N S W E

**Legend**

| | | | | | |
|---|---|---|---|---|---|
| | Point Sources | | 45 | | 60 |
| | Area Sources | | 50 | | 65 |
| | Structures | | 55 | | 70 |

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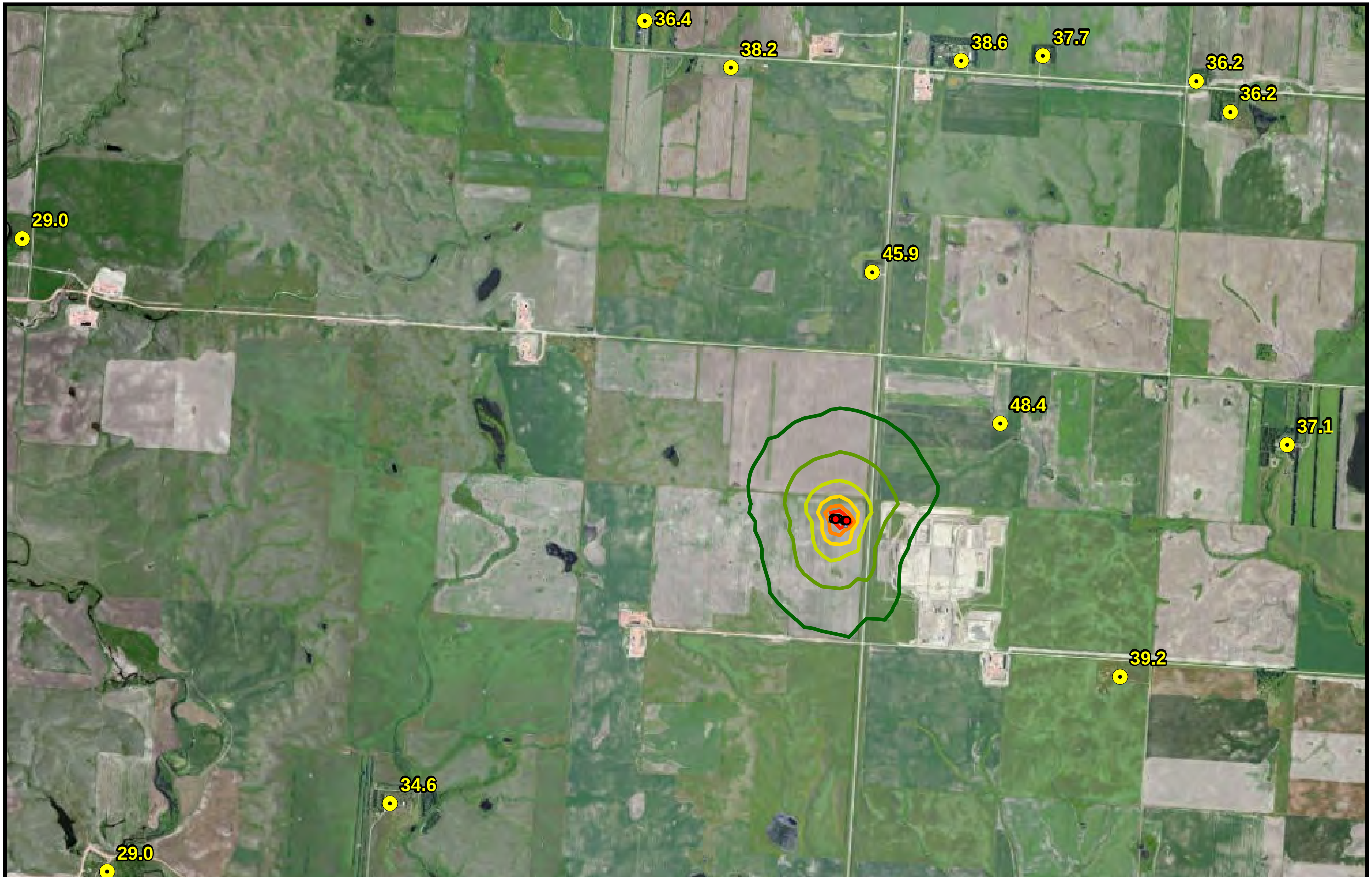
Figure 5-1
Pioneer Generation Station
1 Unit
Sound Contours (Leq)




0 0.4 0.8 Miles

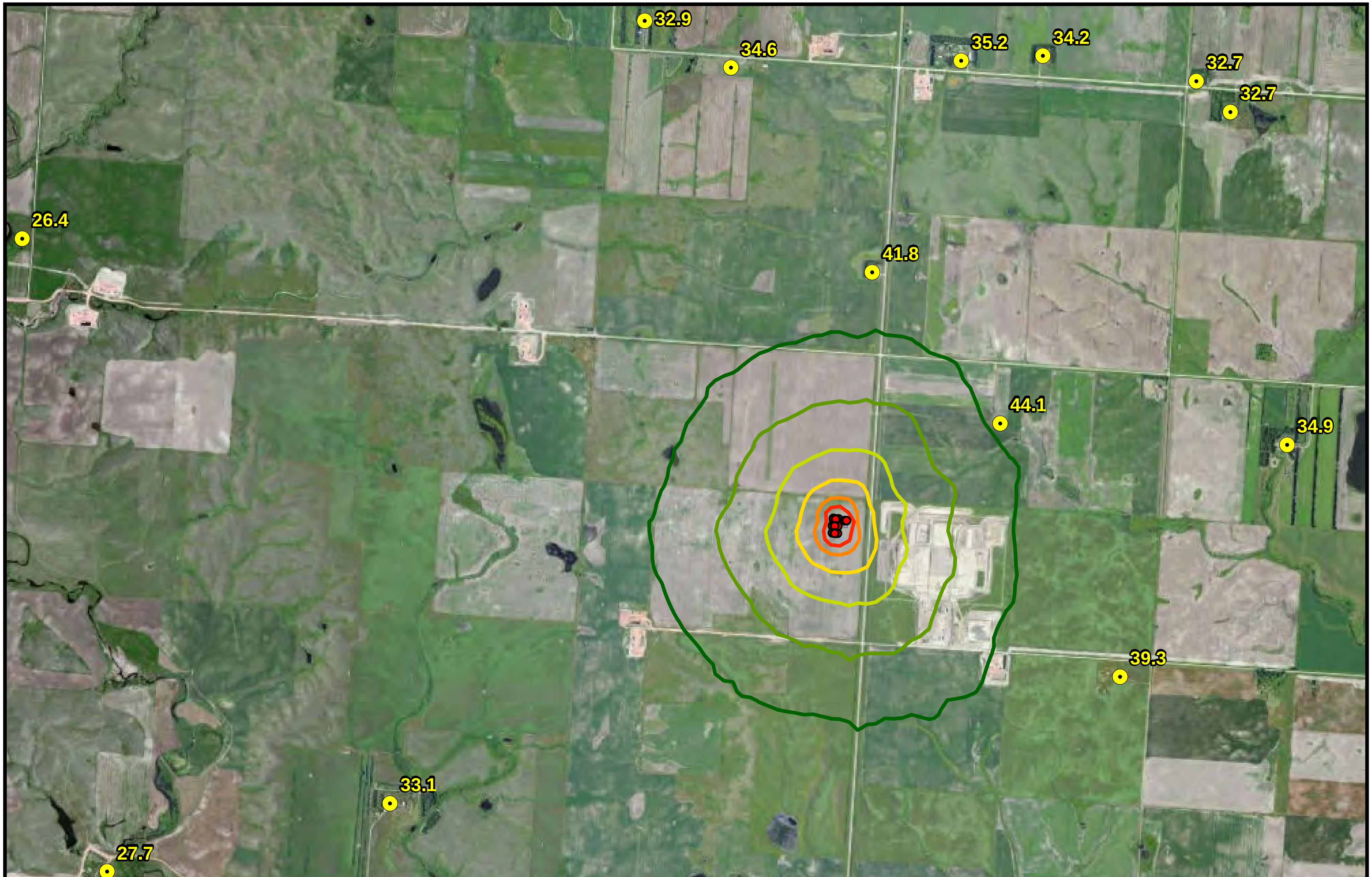
N S W E

**Legend**

Point Sources
Area Sources
Structures
55
60
65
70
75
80

Burns & McDonnell SINCE 1898

Figure 5-2
Pioneer Generation Station
1 Unit
Sound Contours (Ldn)




0 0.4 0.8 Miles

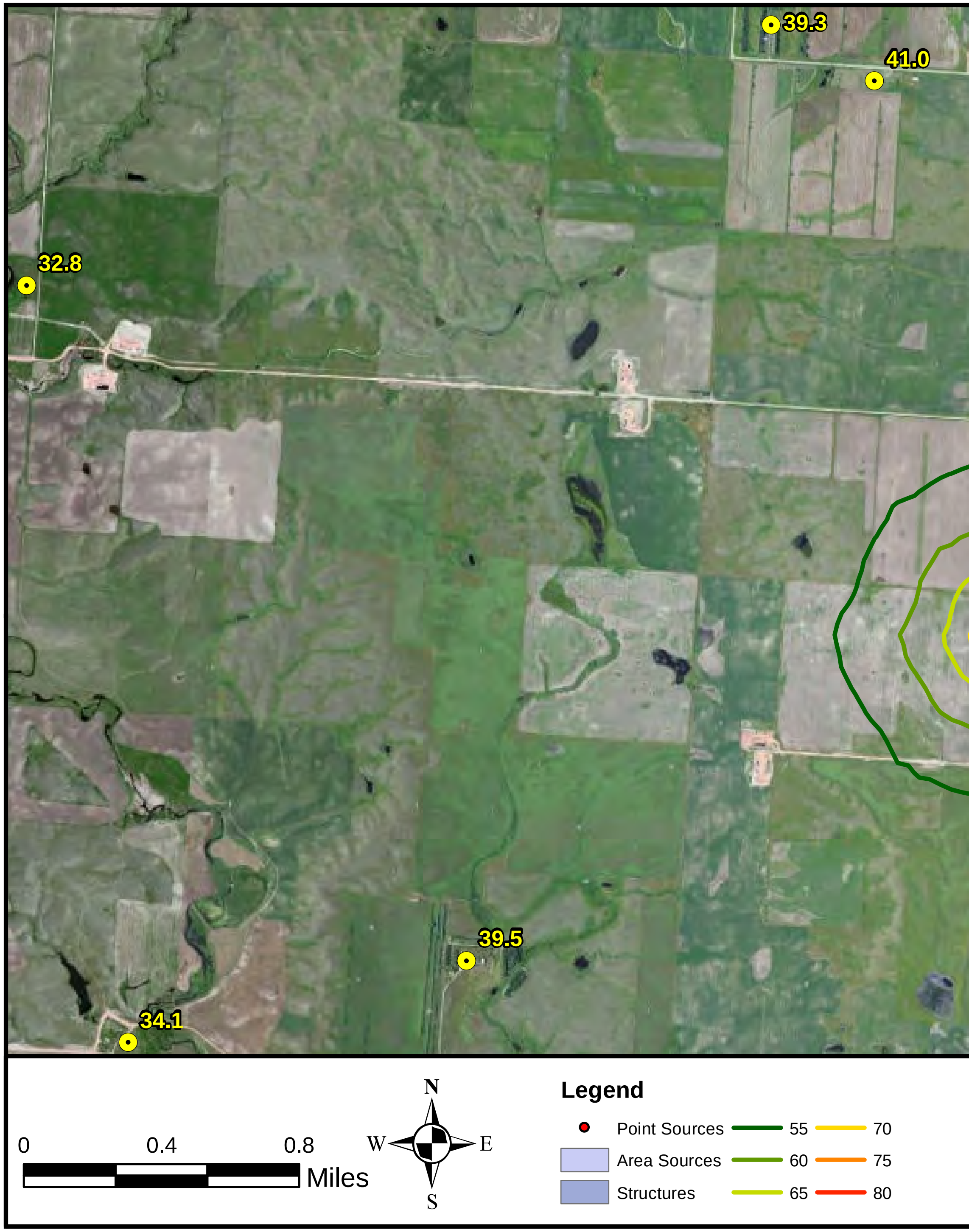
N W E S

**Legend**

| | | | |
|---|---|---|---|
| Point Sources | 45 | 60 | |
| Area Sources | 50 | 65 | |
| Structures | 55 | 70 | |

Burns & McDonnell SINCE 1898

Figure 5-3
Pioneer Generation Station
3 Unit
Sound Contours (Leq)

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SINCE 1898

Figure 5-4
Pioneer Generation Station
3 Unit
Sound Contours (Ldn)

# 6.0 CONCLUSION

An operational noise assessment study was performed for the Basic Electric Power Cooperative Pioneer Generation Station. The noise analysis consisted of modeling the proposed equipment to quantify the expected operational sound levels and compare them to EPA noise guidelines.

EPA has recommended noise guidelines as measured at the exterior of a residence. The guideline noise level for a residence is an $L_{dn}$ sound level of 55 dBA. While this is not a federally enforceable limit, it is a reasonable value to determine if noise may be a problem in the future.

The modeled operational noise levels at the sensitive noise receptors varied slightly, but all of the sound levels were below the EPA's recommended noise guidelines. The maximum $L_{eq}$ sound level at a sensitive noise receptor is expected to be 42.0 dBA with one Unit operating. This is equivalent to an $L_{dn}$ sound level of 48.4 dBA, noticeably lower than the EPA guideline of 55 dBA. The maximum $L_{eq}$ sound level a sensitive noise receptor with three Units operating is expected to be 44.1 dBA, which equates to an $L_{dn}$ sound level of 50.5 dBA. Even with three Units operating, the predicted noise levels are below the EPA guideline of 55 dBA. Therefore, noise levels due to the operation of one or three Units are expected to have little impact on the closest sensitive noise receptors. Additionally, the adjacent natural gas processing facility contains noise-producing equipment, but the facility has no operational noise limits. Based on past experience with these types of facilities, it is anticipated that the PGS will operate at or below the sound levels produced by the gas processing facility.

* * * * *

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# APPENDIX B - NOISE MODEL LAYOUT


## Legend

PGS Fenceline
Area Source
Building/Tank
Point Source

NORTH

100 50 0 100
Scale in Feet

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SINCE 1898

**Figure B-1**
**Basin Electric**
**Power Cooperative**
**Pioneer Generation Station**
**Noise Model Layout**

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, and the GIS User Community, and Burns & McDonnell Engineering

Issued: 9/10/2014

Path: R:\Basin\79557_Pioneer_Recip\Noise\80338- Noise Compliance Study and Report\ArcDocs\Figure B-1 Noise Model Layout.mxd cmcrist 9/10/2014

# APPENDIX C - WEATHER CONDITIONS DURING NOISE MEASUREMENTS

## Meteorological Conditions During Noise Measurements

Sloulin Field International Airport - Approximately 15 miles from Pioneer Generation Station

| Wednesday, August 13, 2014 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Time** (CDT) | **Temp.** | **Heat Index** | **Dew Point** | **Humidity** | **Pressure** | **Visibility** | **Wind Dir** | **Wind Speed** | **Gust Speed** | **Precip** | **Events** | **Conditions** |
| 8:52 PM | **80.1** °F | **81.2** °F | **62.1** °F | 54% | **29.89** in | **10.0** mi | ENE | **9.2** mph | - | **0.00** in | | Partly Cloudy |
| 9:52 PM | **78.1** °F | - | **63.0** °F | 60% | **29.88** in | **10.0** mi | ENE | **4.6** mph | - | N/A | | Clear |
| 11:52 PM | **79.0** °F | - | **59.0** °F | 50% | **29.88** in | **10.0** mi | ESE | **11.5** mph | - | N/A | | Clear |
| **Thursday, August 14, 2014** | | | | | | | | | | | | |
| **Time** (CDT) | **Temp.** | **Heat Index** | **Dew Point** | **Humidity** | **Pressure** | **Visibility** | **Wind Dir** | **Wind Speed** | **Gust Speed** | **Precip** | **Events** | **Conditions** |
| 7:52 AM | **69.1** °F | - | **55.0** °F | 61% | **29.93** in | **10.0** mi | ESE | **4.6** mph | - | N/A | | Clear |
| 9:52 AM | **75.2** °F | - | **55.4** °F | 50% | **29.96** in | **10.0** mi | SE | **9.2** mph | - | N/A | | Clear |
| 10:52 AM | **78.1** °F | - | **55.9** °F | 46% | **29.91** in | **10.0** mi | ESE | **10.4** mph | - | N/A | | Clear |
| 11:52 AM | **82.0** °F | **81.7** °F | **57.0** °F | 42% | **29.90** in | **10.0** mi | SSE | **12.7** mph | - | N/A | | Clear |
| 12:52 PM | **84.0** °F | **83.5** °F | **57.9** °F | 41% | **29.89** in | **10.0** mi | SSE | **9.2** mph | - | N/A | | Clear |
| 1:52 PM | **86.0** °F | **85.0** °F | **57.9** °F | 38% | **29.88** in | **10.0** mi | SSE | **5.8** mph | - | N/A | | Clear |
| 2:52 PM | **89.6** °F | **89.5** °F | **60.8** °F | 38% | **29.91** in | **10.0** mi | South | **10.4** mph | - | N/A | | Clear |
| 3:52 PM | **90.0** °F | **90.0** °F | **61.0** °F | 38% | **29.87** in | **10.0** mi | South | **12.7** mph | - | N/A | | Clear |
| 4:52 PM | **91.0** °F | **90.5** °F | **60.1** °F | 35% | **29.87** in | **10.0** mi | South | **8.1** mph | - | N/A | | Clear |
| 5:52 PM | **91.0** °F | **90.9** °F | **61.0** °F | 36% | **29.87** in | **10.0** mi | SE | **6.9** mph | - | N/A | | Clear |
| 6:52 PM | **90.0** °F | **89.7** °F | **60.1** °F | 37% | **29.88** in | **10.0** mi | NW | **5.8** mph | - | N/A | | Scattered Clouds |
| 7:52 PM | **84.9** °F | **83.6** °F | **55.0** °F | 36% | **29.87** in | **10.0** mi | North | **18.4** mph | - | **0.00** in | Rain | Light Rain |
| 8:52 PM | **80.1** °F | **81.2** °F | **62.1** °F | 54% | **29.89** in | **10.0** mi | ENE | **9.2** mph | - | **0.00** in | | Partly Cloudy |
| 9:52 PM | **78.1** °F | - | **63.0** °F | 60% | **29.88** in | **10.0** mi | ENE | **4.6** mph | - | N/A | | Clear |
| 11:52 PM | **79.0** °F | - | **59.0** °F | 50% | **29.88** in | **10.0** mi | ESE | **11.5** mph | - | N/A | | Clear |

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# APPENDIX B - MANUFACTURER-PROVIDED NOISE DATA SHEETS

| | | | |
|---|---|---|---|
| | | **Doc. Classification:** | Confidential |
| **Title:** | W20V32/34SG/34DF noise data sheet | **Doc.ID:** | DBAA994751 |
| | | **Revision:** | c |
| **Author:** | Ville Veijanen/ 06-Sep-2011 | **Status:** | Approved |
| **Approved by:** | Tommi Rintamäki / 07-Jun-2011 | **Pages:** | 1 (1) |
| **Project:** | IN070 - WFI-P ENG | | |
| **Description:** | Power Plants General Word Template | | |
| **Type:** | Data sheet | | |

**Wärtsilä Finland Oy**

**Power Plants**

# W20V32/34SG/34DF noise data sheet

## 1. Engine

### a. Sound power level

A-weighted sound power level of the engine, ref. 1pW:

| Frequency [Hz] | 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| A-weighted sound power level $L_{w,A}$ [dB] | - | 101 | 109 | 120 | 125 | 129 | 124 | 126 | 119 | **133** |

Sound power level is based on measurement made according to standard ISO 9614-2:1996 Acoustics -- Determination of sound power levels of noise sources using sound intensity -- Part 2: Measurement by scanning. This is to be treated as primary noise data for engine.

### b. Spatial averaged sound pressure level

Typical spatial averaged A-weighted sound pressure level inside engine hall is 110 dB(A). The spatial average sound pressure value represents noise incident on engine hall walls and could then be used for power plant structure acoustic design.

### c. Surface averaged sound pressure level

Typical surface averaged A-weighted sound pressure level of Wärtsilä genset is 115 dB(A) at 1 m distance. In case of separate concrete engine cell installation, absorption material may be needed in the engine cell to reduce unnecessary reflections and reach the stated value.

## 2. Exhaust gas outlet

Exhaust gas outlet A-weighted sound power level without silencer, ref. 1pW:

| Frequency [Hz] | 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| A-weighted sound power level $L_{w,A}$ [dB] | 97 | 120 | 117 | 121 | 124 | 128 | 129 | 121 | - | **133** |

One outlet per engine.

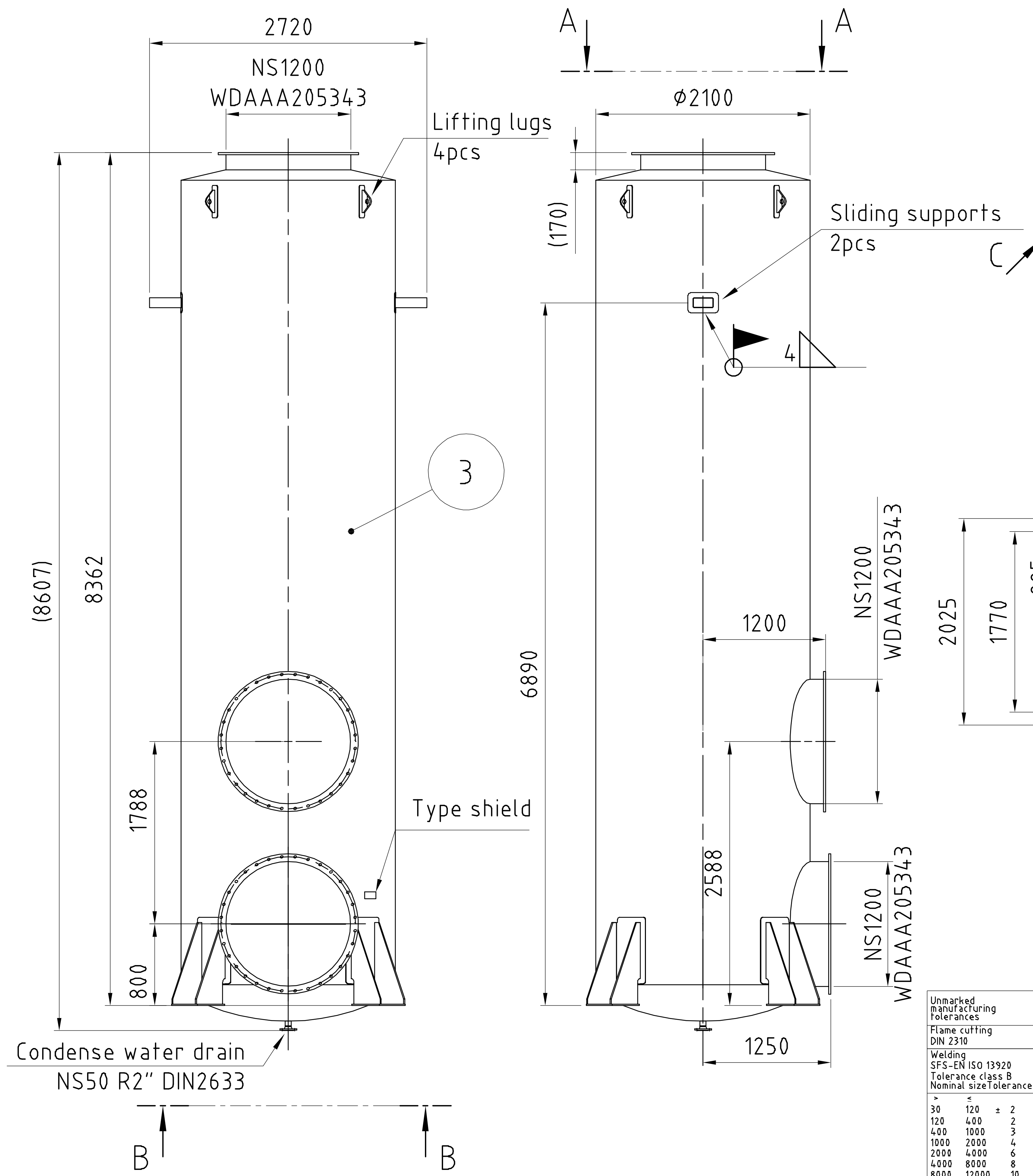
## 3. Charge air intake

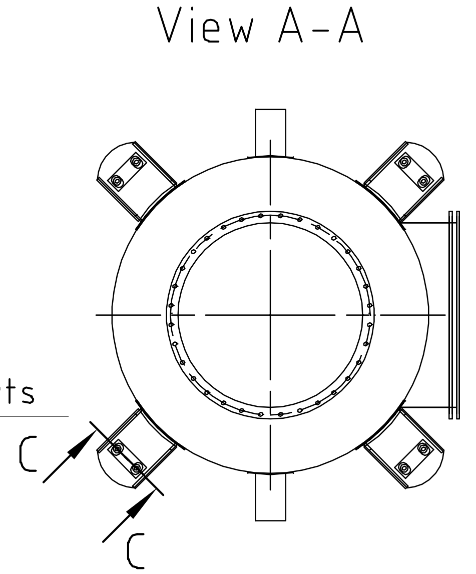
Charge air intake A-weighted sound power level without silencer, ref. 1pW:

| Frequency [Hz] | 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| A-weighted sound power level $L_{w,A}$ [dB] | 81 | 89 | 98 | 105 | 112 | 128 | 133 | 137 | 128 | **139** |

Two intakes per engine.

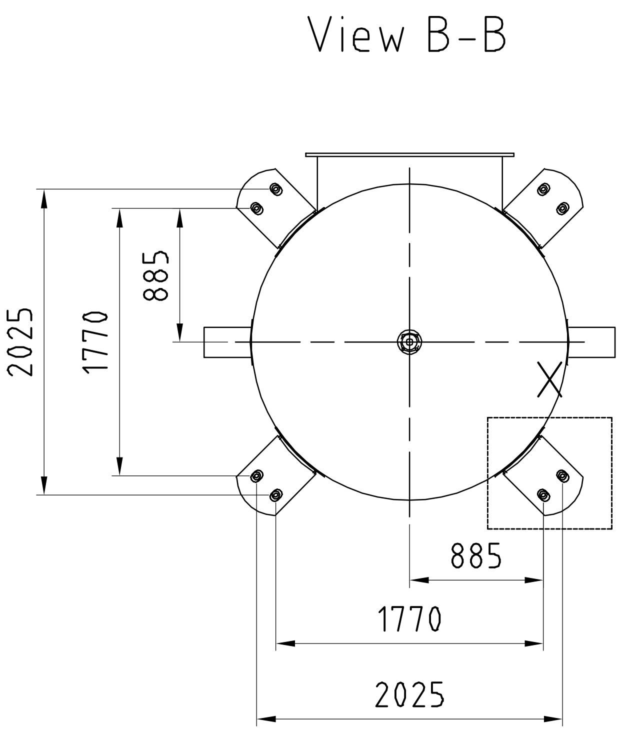
*Data for environmental impact assessment use only - not to be taken as guaranteed values.*

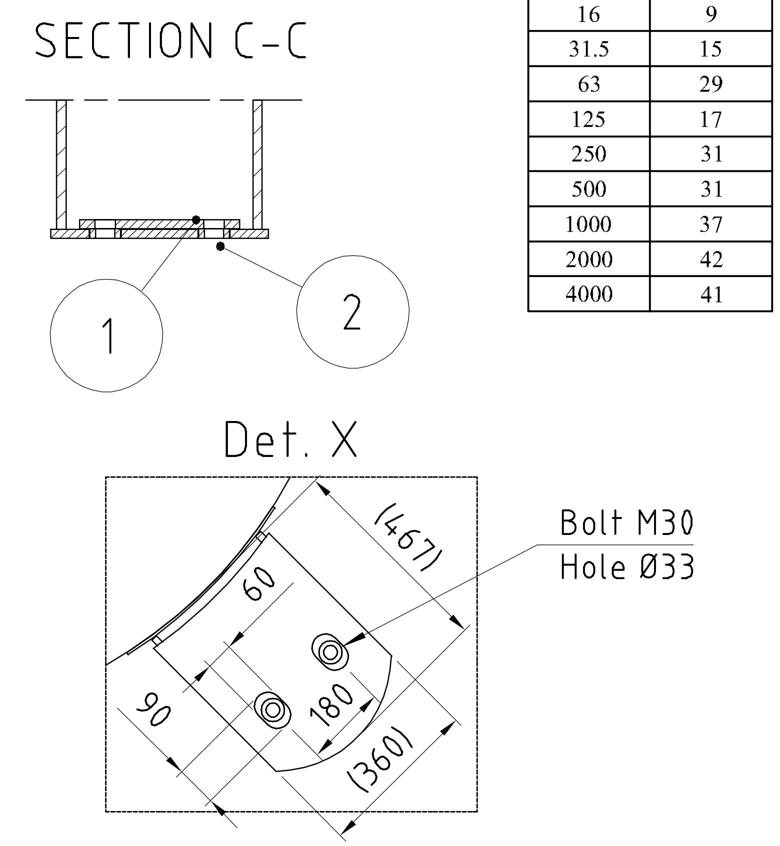



| EXHAUST SILENCER FOR GAS ENGINES | |
|---|---|
| **TECHNICAL DATA** | |
| Engine type: | Wärtsilä 20V34SG |
| Exhaust gas flow: | 15,5 kg/s |
| Temperature: | 369 ° |
| Pressure drop Δp: | 41 mmWc (400 Pa) |
| Silencer type: | Reactive and absorption model with explosion relief |
| Flanges | WD drawing no: WDAAA205343 |
| Condense water drains: | DIN 2633 |
| Welding class: | D (SFS-EN ISO 5817) |
| Mounting | Vertical |
| Surface treatment: | No painting (Cor-Ten B) |
| Total weight: | 4950 kg |
| (xxx) = auxiliary dimension | |

| Hz | TL (dB) |
|---|---|
| 16 | 9 |
| 31.5 | 15 |
| 63 | 29 |
| 125 | 17 |
| 250 | 31 |
| 500 | 31 |
| 1000 | 37 |
| 2000 | 42 |
| 4000 | 41 |




| Part no: | Name | Material / Quality | Dimensions | Std / ref. | Quantity | Weight | Tot. Weight |
|---|---|---|---|---|---|---|---|
| 3 | EXHAUST GAS SILENCER | COR-TEN B | | | 1 | 4950.0 | |
| 2 | PIPE | S355 | Ø51.3/ Ø32.1 L=16 | | 8 | 0.0 | |
| 1 | TOP PLATE | COR-TEN B | PL15x100x265 | | 4 | 0.0 | |

Unmarked manufacturing tolerances

Flame cutting DIN 2310

Welding SFS-EN ISO 13920 Tolerance class B

| Nominal size > | ≤ | Tolerance ± |
|---|---|---|
| 30 | 120 | 2 |
| 120 | 400 | 2 |
| 400 | 1000 | 3 |
| 1000 | 2000 | 4 |
| 2000 | 4000 | 6 |
| 4000 | 8000 | 8 |
| 8000 | 12000 | 10 |
| 12000 | 16000 | 12 |
| 16000 | 20000 | 14 |
| 20000 | | 16 |

Welding SFS-EN ISO 13920 Tolerance class D For total length only

WÄRTSILÄ

© Wärtsilä Finland Oy Power Plants

Drawing

W20V34SG DN1200 Side-In-End-out 35 dB(A)

WFI-P PP TECH

Proj. no. IN023

Product:

ACA

ASLY DRG:

| | | | |
|---|---|---|---|
| MADE | 16-Nov-2010 | Jukka Karjanlahti | Units: |
| CHKD | 26-Sep-2011 | Ville Veijanen | Page No. 1 |
| APPD | 26-Sep-2011 | Tommi Rintamäki | |

Based on Document:

Customer Document:

Scale: 1:50 1:1

Size: A3

Doc. ID: DBAB607655 – Rev.

Internal

**CONFIDENTIAL Data sheet**

| | | | |
|---|---|---|---|
| **Title:** | Radiator Noise Data Sheet W18V46-50DF-50SG | **Doc.ID:** | DBAC316202 |
| | | **Revision:** | - |
| **Author:** | Godwin Agbenyoh / 24.08.2012 | **Status:** | Approved |
| **Approved by:** | Ville Veijanen / 24.08.2012 | **Pages:** | 1 (1) |
| **Organisation:** | - General<br>Power Plants | | |
| **Project :** | IN070 – WFI-P ENG | | |

We have assumed that these sound power levels for the standard noise radiator will be similar to those to be installed at PGS.

# Radiator Noise Data Sheet W18V46/50DF/50SG

## 50 Hz Standard Noise Radiator

**6-fan cooling radiator**, A-weighted sound power level $L_{w,A}$ for one radiator unit, ref. 1pW.

| Frequency [Hz] | 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| A-weighted sound power level $L_{w,A}$ [dB] | 79 | 79 | 87 | 96 | 100 | 102 | 100 | 97 | 94 | **107** |

**For 60 Hz Standard Noise Radiator, add 3 dB to A-weighted sound power level**

Four radiator units per engine.

## Low Noise Radiator W18V46/50SG

**7-fan cooling radiator**, A-weighted sound power level $L_{w,A}$ for one radiator unit, ref. 1pW.

| Frequency [Hz] | 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| A-weighted sound power level $L_{w,A}$ [dB] | 75 | 75 | 82 | 92 | 96 | 98 | 96 | 93 | 90 | **103** |

Four radiator units per engine.

## Low Noise Radiator W18V50DF

**6-fan cooling radiator**, A-weighted sound power level $L_{w,A}$ for one radiator unit, ref. 1pW.

| Frequency [Hz] | 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| A-weighted sound power level $L_{w,A}$ [dB] | 75 | 75 | 82 | 91 | 96 | 97 | 95 | 92 | 87 | **102** |

Four radiator units per engine.

## Ultra Low Noise Radiator

**Cooling radiator**, A-weighted sound power level $L_{w,A}$ for one radiator unit, ref. 1pW.

| Frequency [Hz] | 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| A-weighted sound power level $L_{w,A}$ [dB] | - | 67 | 75 | 78 | 86 | 87 | 87 | 84 | 75 | **93** |

Five radiator units per engine.

*Data for environmental impact assessment use only - not to be taken as guaranteed values.*

# APPENDIX C -SOUND LEVELS USED IN NOISE MODEL

## Appendix C

**Pioneer Generation Station Gas Engine Project**

**Sound Power Levels used in Noise Model**

| | Name | Oktave Spectrum (dB) 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 | Overall dBA A | Overall dB lin | Source |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Existing Facility Equipment | Auxilary Skid Cooler | 80 | 81 | 87 | 98 | 87 | 84 | 86 | 79 | 70 | 93 | 99.2 | General Electric (GE) |
| | Fin Fan | 107.7 | 109 | 102 | 99 | 97 | 93 | 90 | 86 | 79 | 99 | 112.3 | General Electric (GE) |
| | Gas Filter Skid | - | - | 56 | 64 | 67 | 65 | 60 | 54 | 48 | 68.8 | 70.9 | General Electric (GE) |
| | Liquid Fuel Forwarding Skid | - | 78 | 83 | 88 | 88 | 84 | 83 | 79 | 73 | 90.1 | 93.2 | General Electric (GE) |
| | NXGN Auxilary Skid | 82 | 90 | 92 | 84 | 86 | 86 | 84 | 78 | 72 | 90.4 | 96.1 | General Electric (GE) |
| | Transformer | 119.9 | 112.7 | 104.6 | 92.1 | 86.7 | 77.5 | 71.3 | 66.5 | 61.6 | 92.5 | 120.8 | Various - used IEEE C57.12.90 for 75 dBA |
| | Silenced Stack | 123 | 120 | 107 | 96 | 85 | 80 | 77 | 77 | 79 | 96.9 | 124.8 | BMcD Database |
| | Water Injection Skid | 84 | 95 | 96 | 94 | 98 | 94 | 92 | 87 | 83 | 99.5 | 103.2 | General Electric (GE) |
| | SCR | 113.8 | 106.4 | 100.9 | 94.1 | 97.7 | 99.2 | 97.4 | 91.1 | 85.2 | 103.2 | 115 | General Electric (GE) |
| | Sprint Skid | 80 | 78 | 79 | 79 | 81 | 80 | 76 | 70 | 62 | 83.8 | 87.8 | General Electric (GE) |
| | Air Filter House | 113.2 | 107.8 | 98.5 | 106.4 | 102.2 | 99.8 | 95.4 | 98.5 | 83 | 105.7 | 115.5 | General Electric (GE) |
| | Generator Base | 95.1 | 94.8 | 101.6 | 91.4 | 83 | 84.3 | 78.8 | 70.3 | 64.5 | 90.1 | 103.6 | General Electric (GE) |
| | Generator Exhaust Silencer | 105.2 | 99.6 | 108.4 | 108.7 | 99.6 | 100.3 | 95.4 | 88.3 | 76.4 | 105.1 | 113.2 | General Electric (GE) |
| | Generator Inlet Fan | 99.1 | 100.5 | 100.4 | 114.5 | 102 | 101.3 | 97 | 91.4 | 77.1 | 108.4 | 115.4 | General Electric (GE) |
| | Generator Enclosure | 96.3 | 100.6 | 101.5 | 93.9 | 87.6 | 87.8 | 81.6 | 75.8 | 65 | 92.6 | 105.3 | General Electric (GE) |
| | Turbine Base | 96.5 | 92.6 | 92.5 | 95.1 | 96.2 | 88.8 | 84.4 | 81.7 | 74.9 | 95.8 | 102.2 | General Electric (GE) |
| | Turbine Exhaust Fan | 104.2 | 104.5 | 104.7 | 105.1 | 99.1 | 95.2 | 92.5 | 88.7 | 80.8 | 102 | 111.2 | General Electric (GE) |
| | Turbine Enclosure | 98.4 | 97.6 | 95.1 | 95.2 | 95.4 | 89.9 | 86 | 85.3 | 81.8 | 96.3 | 103.9 | General Electric (GE) |
| | Turine Inlet Silencer | 111.8 | 115.6 | 112.1 | 96.6 | 87.4 | 98.9 | 104.2 | 98.3 | 77.9 | 107.5 | 118.6 | General Electric (GE) |
| | Misc Pump | 96 | 95 | 97 | 97 | 97 | 97 | 97 | 94 | 87 | 102.6 | 105.5 | BMcD Database |
| New Equipment | Wartsila Engine | - | 101 | 109 | 120 | 125 | 129 | 124 | 126 | 119 | 132.7 | 132.9 | Wartsila W20V32/34SG/34DF Noise Data Sheet |
| | One Silenced Wartsila Exhaust | 82 | 91 | 100 | 90 | 93 | 91 | 87 | 80 | - | 95.3 | 102.1 | Wartsila W20V32/34SG/34DF Noise Data Sheet |
| | Wartsila Air Intake (unsilenced)* | 81 | 89 | 98 | 105 | 112 | 128 | 133 | 137 | 128 | 140 | 139.2 | Wartsila W20V32/34SG/34DF Noise Data Sheet |
| | Standard Radiator | 77 | 77 | 85 | 94 | 98 | 100 | 98 | 95 | 92 | 104.3 | 104.8 | Wartsila |
| | 6 Silenced Wartsila Exhausts | 89.8 | 98.8 | 107.8 | 97.8 | 100.8 | 98.8 | 94.8 | 87.8 | - | 103.1 | 109.9 | Wartsila |
| | Main Transformer | 128.9 | 121.7 | 113.6 | 101.1 | 95.7 | 86.5 | 80.3 | 75.5 | 69.6 | 101.5 | 129.8 | IEEE Guidance |

*35 dB of attenuation was applied to each inlet in the noise model to account for silencer

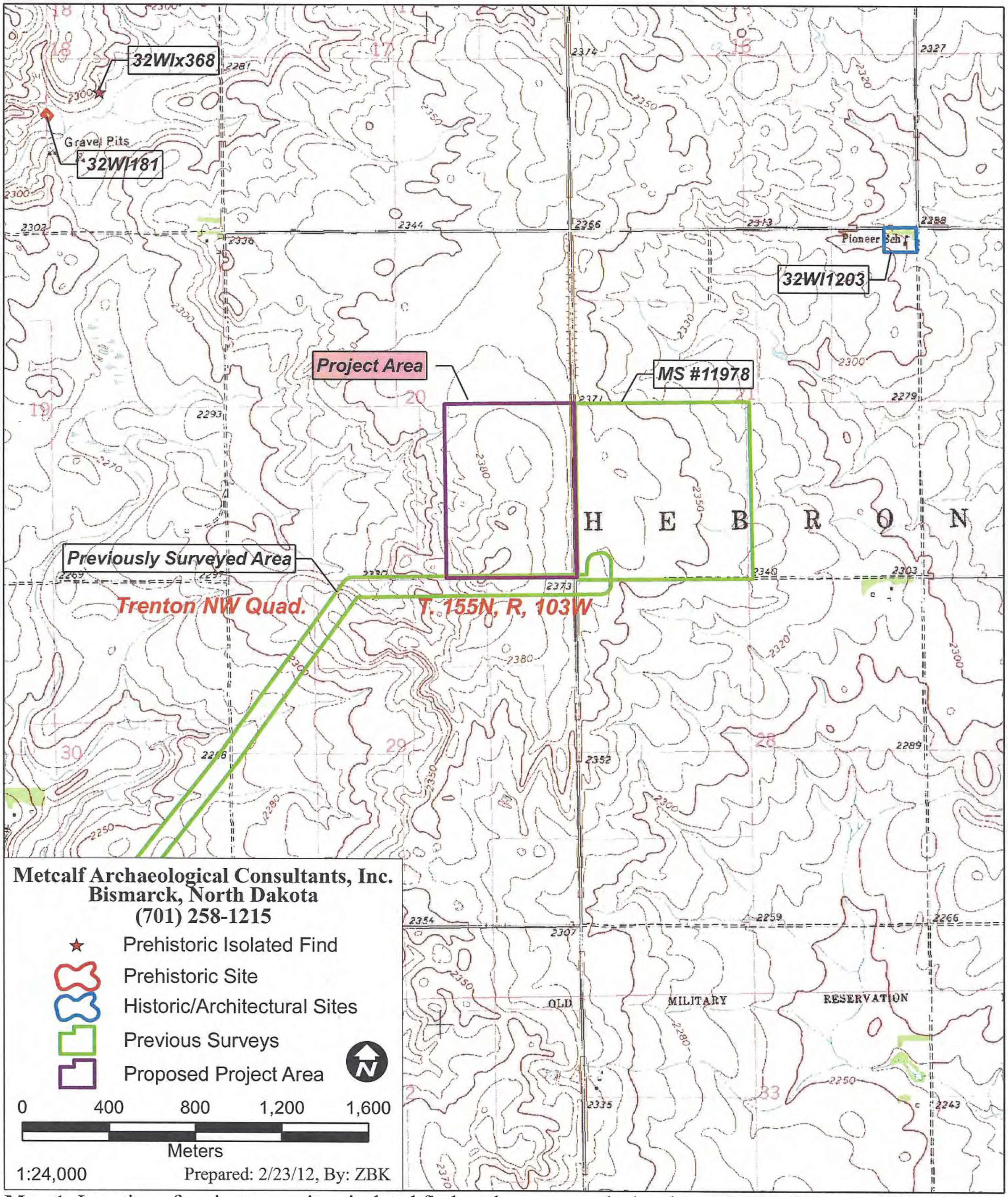
**Building Reduction used in Noise Model (New Buildings)**

| | Oktave Spectrum (dB) 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 | Total Sound Reduction Index |
|---|---|---|---|---|---|---|---|---|---|---|
| Standard Building Reduction | 8 | 13 | 18 | 23 | 28 | 33 | 28 | 18 | 8 | 30 |

Burns & McDonnell World Headquarters
9400 Ward Parkway
Kansas City, MO 64114
Phone: 816-333-9400
Fax: 816-333-3690
www.burnsmcd.com

**Burns & McDonnell: Making our clients successful for more than 100 years**

# APPENDIX D - SURVEY AREA MAP AND SHPO CONCURRENCE




**Map 1:** Location of project area, sites, isolated find, and surveys as depicted on USGS 7.5' Trenton NW (1974) quadrangle map.

STATE HISTORICAL SOCIETY
OF NORTH DAKOTA

RECEIVED
MAR - 2 2012
PLANT OPERATIONS
RECORDS YES NO



February 29, 2012

Mr. Kevin Solie
Basin Electric Power Cooperative
1717 East Interstate Avenue
Bismarck ND 58503

**ND SHPO Ref.:12-0698 "Basin Electric Power Cooperative's Pioneer Station: A Class III CRI in Williams County, North Dakota" in portions of [T155N R103W Section 20]**

Dear Mr. Solie,

We reviewed ND SHPO Ref.:12-0698 "Basin Electric Power Cooperative's Pioneer Station: A Class III CRI in Williams County, North Dakota," and find the report acceptable. If consulted by a federal agency we would concur with a "No Historic Properties Affected" determination provided the project remains as described and mapped in the associated MAC report.

Thank you for the opportunity to review this project. Please include the ND SHPO Reference number listed above in further correspondence for this specific project. If you have any questions please contact Susan Quinnell, Review and Compliance Coordinator at (701) 328-3576, or squinnell@nd.gov
If you have any questions please contact Susan Quinnell at (701) 328-3576 or squinnell@nd.gov

Sincerely,

Merlan E. Paaverud, Jr.
State Historic Preservation Officer
(North Dakota)

# APPENDIX E - UNANTICIPATED DISCOVERIES PLAN

# Unanticipated Discoveries Plan

For

# Basin Electric Power Cooperative

# Pioneer Generation Station – Phase III Project

November 2014

# Table of Contents

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# 1.0 Emergency Contact List

| Entity | Name | Role | Telephone Number |
|---|---|---|---|
| Basin Electric Power Cooperative | Josh Rossow | Manager of Construction | 701.223-0441 |
| Basin Electric Power Cooperative | Cris Miller | Senior Environmental Project Administrator | 701.223-0441 |
| Basin Electric Power | Myron Steckler | Project Manager | 701.223-0441 |
| Metcalf and Associates | | Project Archaeologist | 701.258-1518 |
| State Historical Society of North Dakota | Paul Picha | State Archaeologist | 701.328-3574 |

# 2.0 Unanticipated Discovery of Cultural Resources

## 2.1 Procedures at Time of Discovery of Unanticipated Cultural Resources

If unanticipated cultural resources are discovered during construction of Basin Electric Power Cooperative's (Basin Electric) Pioneer Generation Station Project (Project), all construction activity will immediately cease within 100 feet in all directions from the discovery. Basin Electric's project inspector and/or the contractor will immediately report the discovery to all parties identified in the Emergency Contact List in Section 1.0 of this plan. Ground-disturbing construction activities will not occur within 100 feet in any direction from the cultural resource until the State Historical Society of North Dakota (SHSND) permits construction to resume. In the event that an archaeologist, tribal monitor, or other necessary persons are not immediately available, the contractor will secure and protect the discovery until such time that the archaeologist and tribal monitor, if appropriate, can inspect and evaluate the discovery.

Metcalf's archaeologist will investigate any unanticipated discovery in consultation with the SHSND. Basin Electric may invite a tribal monitor to participate in the investigation, as appropriate. Metcalf's archaeologist, in conjunction with the tribal monitor if appropriate, will ascertain the nature and the extent of the resource, and the potential for intact deposits Evaluation will involve an examination of the ground surface, backfill piles, and exposed construction surfaces. Metcalf's archaeologist will discuss the potential for additional impacts to the resource with the construction manager. Based on this examination, Metcalf's archaeologist will recommend the locus is:
(1) not a site (e.g., isolated find or less than 50 years in age);
(2) not a historic property, ie. not eligible for inclusion in the National Register of Historic Places (NRHP);
(3) a historic property, ie. eligible for inclusion in NRHP-eligible or culturally sensitive site for which no further impacts are likely to occur;
(4) an NRHP-eligible or culturally sensitive site (e.g. exposed hearths, house pits) that is likely to be impacted with further construction; or,
(5) a site for which additional information is required to ascertain extent and NRHP eligibility.

Metcalf's archaeologist will provide information about the resource to SHSND to determine the most appropriate action.

## 2.2 Emergency Salvage of Cultural Resources

Unstable earth conditions in trenches or other unforeseen natural or cultural events could endanger cultural resources discovered during construction of the transmission line. If cultural resources are in imminent danger of destruction, Basin Electric will apply prudent methods to stabilize landforms around the unanticipated discovery. Once stabilized the resource shall be assessed as described above, subject to safety concerns.

## 2.3 Curation or Disposition of Cultural Materials

All cultural materials recovered from privately owned lands are the property of the landowner. After necessary laboratory analysis is completed, Basin Electric will provide the landowner with photographs and descriptions of cultural materials from his/her property. The landowner will be encouraged to contribute the materials for curation at the SHSND. If the landowner desires, Basin Electric will return cultural materials from his/her land to him/her.

# 3.0 Unanticipated Discovery of Human Remains

Any human remains encountered in a discovery situation will be handled according to the provisions of North Dakota Law. Treatment of human remains found on state or private lands in North Dakota is governed primarily under two laws: Protection of Human Burial Sites, Human Remains and Burial Goods in North Dakota Century Code (NDCC 23-06-27) and Protection of Prehistoric Sites and Deposits in the North Dakota Administrative Code (NDAC 40-02-03).

If human remains are discovered, all ground-disturbing construction activity will be immediately suspended within 100 feet in all directions from the human remains, and Basin Electric and Metcalf's archaeologist will be notified immediately. As required by law, Basin Electric will notify the Williams County Sheriff within 24 hours of discovery. Basin Electric will also notify the SHSND's of the finding.

If allowed by law enforcement, Basin Electric and/or the contractor will secure the location by means of flagging or roping the perimeter of the avoidance area and covering or otherwise protecting the human remains and any associated materials. The remains will not be further disturbed prior to completion of consultations with respective agencies unless such disturbance is necessary to preserve or protect the human remains. Any disturbance necessary to preserve or protect the remains must be done in consultation with law enforcement, SHSND, and Metcalf's archaeologist. The 100-foot-radius avoidance area may be expanded if the context of the human remains suggests additional human remains may exist within the construction area or if construction activities outside the 100-foot-radius area might destabilize or otherwise degrade the context of the human remains.

Law enforcement will determine whether the finding is associated with a crime scene within 15 days. If deemed not a crime scene, law enforcement will notify the SHSND of their findings. **No cultural resource investigations of human remains can occur without a permit from SHND.** Metcalf's archaeologist will work with SHSND to obtain a permit to conduct investigations of the location. If the remains are determined Native American, or if the ethnic identity of the remains is unknown, SHSND will notify the Intertribal Re-interment Committee. A meeting of interested parties will be set up as soon as possible, preferably within 36 hours of the decision that there is no evidence of a crime, to ensure that the disturbed remains receive the maximum protection and that costly delays are avoided. Together the SHSND, in consultation with the tribes (as appropriate) and Basin Electric will agree upon a suitable action.

Work cannot proceed until the stipulations of Protection of Human Burial Sites, Human Remains and Burial Goods in North Dakota Century Code (NDCC 23-06-27) and Protection of Prehistoric Sites and Deposits in the North Dakota Administrative Code (NDAC 40-02-03) have been met.

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# APPENDIX F - USACE DETERMINATION

**DEPARTMENT OF THE ARMY**
CORPS OF ENGINEERS, OMAHA DISTRICT
NORTH DAKOTA REGULATORY OFFICE
1513 SOUTH 12TH STREET
BISMARCK ND 58504-6640

REPLY TO
ATTENTION OF

February 9, 2012

North Dakota Regulatory Office

[NWO-2012-0167-BIS]



Basin Electric Power Cooperative
ATTN: Kevin L. Solie, Sr Water Quality/Waste Mgmt Coordinator
1717 East Interstate Avenue
Bismarck, North Dakota 58503-0564

Dear Mr. Solie:

This is in reference to your request on behalf of **Basin Electric Power Cooperative** for a jurisdictional determination (JD) for wetlands proposed to be impacted by the proposed Pioneer Generating Station. The Station will be located approximately 20 miles northwest of Williston, ND on a 40-acre tract in the NE¼SE¼ of Section 20, Township 155 North, Range 103 West, Williams County, North Dakota.

Based on the information provided, we have determined that the two (2) wetlands identified are isolated, intrastate and non-navigable; therefore, not jurisdictional. No permits are required under Section 404 of the Clean Water Act.

An approved JD has been completed for your project (copy enclosed). Copies of supporting materials used in making this determination are available upon request. Within 30 days, the JD will also be posted on our website at https://www.nwo.usace.army.mil/html/od-rnd/jur/jur.htm. **This JD is valid for a period of five (5) years.**

If you do not agree with the JD, you may request an administrative appeal under US Army Corps of Engineers regulations found at 33 CFR 331. A *Notification of Administrative Appeal Options and Process and Request for Appeal (NAO-RFA)* is enclosed. The NAO-RFA must be received in the Office specified on the second page within 60 days from the date of this letter. **It is not necessary to submit the NAO-RFA if you do not object to the determination made in the JD.** If you would like more information on the appeal process, please contact this Office.

The Omaha District, North Dakota Regulatory Office is committed to providing quality and timely service to our customers. In an effort to improve customer service, please take a moment to complete our Customer Service Survey found on our website at http://per2.nwp.usace.army.mil/survey.html. If you do not have Internet access, you may call and request a paper copy of the survey that you can complete and return to us by mail or fax.

Should you have any questions regarding this determination, please do not hesitate to contact Toni R. Erhardt of my staff by letter or telephone (701)-255-0015 and reference Project Number **NWO-2012-0167-BIS**.

Sincerely

Daniel E. Cimarosti
Regulatory Program Manager
North Dakota

Enclosures

**APPROVED JURISDICTIONAL DETERMINATION FORM**
**U.S. Army Corps of Engineers**

This form should be completed by following the instructions provided in Section IV of the JD Form Instructional Guidebook.

## SECTION I: BACKGROUND INFORMATION

**A. REPORT COMPLETION DATE FOR APPROVED JURISDICTIONAL DETERMINATION (JD): 9 February 2012**

**B. DISTRICT OFFICE, FILE NAME, AND NUMBER: Omaha District (ND) | Basin Electric's Pioneer Generator Station | NWO-2012-0167-BIS**

**C. PROJECT LOCATION AND BACKGROUND INFORMATION: Isolated Wetlands in SE¼ of Section 20, Township 155 North, Range 103 West**

State:North Dakota County/parish/borough: Williams City: rural
Center coordinates of site (lat/long in degree decimal format):
Wetland #1: Lat. 48.23168 N; Long. -103.95315 W
Wetland #2: Lat. 48.23039 N; Long. -103.95247 W

Universal Transverse Mercator: 14
Name of nearest waterbody: Painted Woods Creek (2 miles)

Name of nearest Traditional Navigable Water (TNW) into which the aquatic resource flows: Missouri River (17+ miles)
Name of watershed or Hydrologic Unit Code (HUC): Lake Sakakawea| 10110101

☒ Check if map/diagram of review area and/or potential jurisdictional areas is/are available upon request.
☐ Check if other sites (e.g., offsite mitigation sites, disposal sites, etc…) are associated with this action and are recorded on a different JD form.

**D. REVIEW PERFORMED FOR SITE EVALUATION (CHECK ALL THAT APPLY):**

☒ Office (Desk) Determination. Date: 24 January 2012
☐ Field Determination. Date(s):

## SECTION II: SUMMARY OF FINDINGS

**A. RHA SECTION 10 DETERMINATION OF JURISDICTION.**

There **Are no** "*navigable waters of the U.S.*" within Rivers and Harbors Act (RHA) jurisdiction (as defined by 33 CFR part 329) in the review area. [*Required*]

☐ Waters subject to the ebb and flow of the tide.
☐ Waters are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce. Explain: .

**B. CWA SECTION 404 DETERMINATION OF JURISDICTION.**

There **Are no** "*waters of the U.S.*" within Clean Water Act (CWA) jurisdiction (as defined by 33 CFR part 328) in the review area. [*Required*]

1. **Waters of the U.S.**
   a. **Indicate presence of waters of U.S. in review area (check all that apply):** [1]
   ☐ TNWs, including territorial seas
   ☐ Wetlands adjacent to TNWs
   ☐ Relatively permanent waters[2] (RPWs) that flow directly or indirectly into TNWs
   ☐ Non-RPWs that flow directly or indirectly into TNWs
   ☐ Wetlands directly abutting RPWs that flow directly or indirectly into TNWs
   ☐ Wetlands adjacent to but not directly abutting RPWs that flow directly or indirectly into TNWs
   ☐ Wetlands adjacent to non-RPWs that flow directly or indirectly into TNWs
   ☐ Impoundments of jurisdictional waters
   ☒ Isolated (interstate or intrastate) waters, including isolated wetlands

   b. **Identify (estimate) size of waters of the U.S. in the review area:**
   Non-wetland waters: linear feet: width (ft) and/or acres.
   Wetlands: acres.

   c. **Limits (boundaries) of jurisdiction** based on:
   Elevation of established OHWM (if known): .

2. **Non-regulated waters/wetlands (check if applicable):**[3]

---

[1] Boxes checked below shall be supported by completing the appropriate sections in Section III below.
[2] For purposes of this form, an RPW is defined as a tributary that is not a TNW and that typically flows year-round or has continuous flow at least "seasonally" (e.g., typically 3 months).
[3] Supporting documentation is presented in Section III.F.

☒ Potentially jurisdictional waters and/or wetlands were assessed within the review area and determined to be not jurisdictional. Explain: Two (2) wetland basins were identified in the 120-acre parcel proposed for development. They are isolated, intrastate and non-navigable. Neither basin is utilized for recreational or industrial purposes. As indicated above, the basins are located approximately 2-miles from Painted Woods Creek and over 17 miles from the Missouri River (TNW). There is currently no hydrological connection between the basins and either of the nearest waterways.

**F. NON-JURISDICTIONAL WATERS, INCLUDING WETLANDS (CHECK ALL THAT APPLY):**

☐ If potential wetlands were assessed within the review area, these areas did not meet the criteria in the 1987 Corps of Engineers Wetland Delineation Manual and/or appropriate Regional Supplements.
☒ Review area included isolated waters with no substantial nexus to interstate (or foreign) commerce.
  ☒ Prior to the Jan 2001 Supreme Court decision in "*SWANCC*," the review area would have been regulated based solely on the "Migratory Bird Rule" (MBR).
☐ Waters do not meet the "Significant Nexus" standard, where such a finding is required for jurisdiction. Explain: .
☐ Other: (explain, if not covered above): .

Provide acreage estimates for non-jurisdictional waters in the review area, where the sole potential basis of jurisdiction is the MBR factors (i.e., presence of migratory birds, presence of endangered species, use of water for irrigated agriculture), using best professional judgment (check all that apply):
☐ Non-wetland waters (i.e., rivers, streams): linear feet width (ft).
☐ Lakes/ponds: acres.
☐ Other non-wetland waters: acres. List type of aquatic resource: .
☒ Wetlands: 0.2 acres.

Provide acreage estimates for non-jurisdictional waters in the review area that do not meet the "Significant Nexus" standard, where such a finding is required for jurisdiction (check all that apply):
☐ Non-wetland waters (i.e., rivers, streams): linear feet, width (ft).
☐ Lakes/ponds: acres.
☐ Other non-wetland waters: acres. List type of aquatic resource: .
☐ Wetlands: acres.

## SECTION IV: DATA SOURCES.

**A. SUPPORTING DATA. Data reviewed for JD (check all that apply -** checked items shall be included in case file and, where checked and requested, appropriately reference sources below):
☒ Maps, plans, plots or plat submitted by or on behalf of the applicant/consultant:
☐ Data sheets prepared/submitted by or on behalf of the applicant/consultant.
  ☐ Office concurs with data sheets/delineation report.
  ☐ Office does not concur with data sheets/delineation report.
☐ Data sheets prepared by the Corps: .
☐ Corps navigable waters' study: .
☒ U.S. Geological Survey Hydrologic Atlas: .
  ☐ USGS NHD data.
  ☒ USGS 8 and 12 digit HUC maps. Lake Sakakawea Watershed | 10110101
☒ U.S. Geological Survey map(s). Cite scale & quad name: 1:24,000 | Trenton NW, ND.
☐ USDA Natural Resources Conservation Service Soil Survey. Citation: .
☒ National wetlands inventory map(s). Cite name: Trenton NW, ND.
☐ State/Local wetland inventory map(s): .
☐ FEMA/FIRM maps: .
☐ 100-year Floodplain Elevation is: (National Geodectic Vertical Datum of 1929)
☒ Photographs: ☒ Aerial (Name & Date): ArcGIS/ORM2/GoogleEarth
  or ☐ Other (Name & Date):.
☐ Previous determination(s). File no. and date of response letter: .
☐ Applicable/supporting case law: .
☐ Applicable/supporting scientific literature: .
☐ Other information (please specify): .

**B. ADDITIONAL COMMENTS TO SUPPORT JD:** .

# Pioneer Gas Plant Area

## NOTIFICATION OF ADMINISTRATIVE APPEAL OPTIONS AND PROCESS AND REQUEST FOR APPEAL

| Applicant: **Basin Electric Power Cooperative** | File Number: **NWO-2012-0167-BIS** | Date: **09Feb12** |
|---|---|---|

| Attached is: | | See Section below |
|---|---|---|
| | INITIAL PROFFERED PERMIT (Standard Permit or Letter of permission) | A |
| | PROFFERED PERMIT (Standard Permit or Letter of permission) | B |
| | PERMIT DENIAL | C |
| X | APPROVED JURISDICTIONAL DETERMINATION | D |
| | PRELIMINARY JURISDICTIONAL DETERMINATION | E |

SECTION I - The following identifies your rights and options regarding an administrative appeal of the above decision. Additional information may be found at http://usace.army.mil/inet/functions/cw/cecwo/reg or Corps regulations at 33 CFR Part 331.

A: INITIAL PROFFERED PERMIT: You may accept or object to the permit.

- ACCEPT: If you received a Standard Permit, you may sign the permit document and return it to the district engineer for final authorization. If you received a Letter of Permission (LOP), you may accept the LOP and your work is authorized. Your signature on the Standard Permit or acceptance of the LOP means that you accept the permit in its entirety, and waive all rights to appeal the permit, including its terms and conditions, and approved jurisdictional determinations associated with the permit.

- OBJECT: If you object to the permit (Standard or LOP) because of certain terms and conditions therein, you may request that the permit be modified accordingly. You must complete Section II of this form and return the form to the district engineer. Your objections must be received by the district engineer within 60 days of the date of this notice, or you will forfeit your right to appeal the permit in the future. Upon receipt of your letter, the district engineer will evaluate your objections and may: (a) modify the permit to address all of your concerns, (b) modify the permit to address some of your objections, or (c) not modify the permit having determined that the permit should be issued as previously written. After evaluating your objections, the district engineer will send you a proffered permit for your reconsideration, as indicated in Section B below.

B: PROFFERED PERMIT: You may accept or appeal the permit

- ACCEPT: If you received a Standard Permit, you may sign the permit document and return it to the district engineer for final authorization. If you received a Letter of Permission (LOP), you may accept the LOP and your work is authorized. Your signature on the Standard Permit or acceptance of the LOP means that you accept the permit in its entirety, and waive all rights to appeal the permit, including its terms and conditions, and approved jurisdictional determinations associated with the permit.

- APPEAL: If you choose to decline the proffered permit (Standard or LOP) because of certain terms and conditions therein, you may appeal the declined permit under the Corps of Engineers Administrative Appeal Process by completing Section II of this form and sending the form to the division engineer. This form must be received by the division engineer within 60 days of the date of this notice.

C: PERMIT DENIAL: You may appeal the denial of a permit under the Corps of Engineers Administrative Appeal Process by completing Section II of this form and sending the form to the division engineer. This form must be received by the division engineer within 60 days of the date of this notice.

D: APPROVED JURISDICTIONAL DETERMINATION: You may accept or appeal the approved JD or provide new information.

- ACCEPT: You do not need to notify the Corps to accept an approved JD. Failure to notify the Corps within 60 days of the date of this notice, means that you accept the approved JD in its entirety, and waive all rights to appeal the approved JD.

- APPEAL: If you disagree with the approved JD, you may appeal the approved JD under the Corps of Engineers Administrative Appeal Process by completing Section II of this form and sending the form to the division engineer. This form must be received by the division engineer within 60 days of the date of this notice.

E: PRELIMINARY JURISDICTIONAL DETERMINATION: You do not need to respond to the Corps regarding the preliminary JD. The Preliminary JD is not appealable. If you wish, you may request an approved JD (which may be appealed), by contacting the Corps district for further instruction. Also you may provide new information for further consideration by the Corps to reevaluate the JD.

## SECTION II - REQUEST FOR APPEAL or OBJECTIONS TO AN INITIAL PROFFERED PERMIT

REASONS FOR APPEAL OR OBJECTIONS: (Describe your reasons for appealing the decision or your objections to an initial proffered permit in clear concise statements. You may attach additional information to this form to clarify where your reasons or objections are addressed in the administrative record.)

ADDITIONAL INFORMATION: The appeal is limited to a review of the administrative record, the Corps memorandum for the record of the appeal conference or meeting, and any supplemental information that the review officer has determined is needed to clarify the administrative record. Neither the appellant nor the Corps may add new information or analyses to the record. However, you may provide additional information to clarify the location of information that is already in the administrative record.

## POINT OF CONTACT FOR QUESTIONS OR INFORMATION:

| If you have questions regarding this decision and/or the appeal process you may contact: | If you only have questions regarding the appeal process you may also contact: |
|---|---|
| US Army Corps of Engineers, North Dakota Regulatory Office<br>Attn: Daniel E. Cimarosti, Regulatory Program Manager<br>1513 South 12th Street<br>Bismarck, ND 58504 Telephone (701) 255-0015<br>Daniel.E.Cimarosti@usace.army.mil | US Army Corps of Engineers, Northwestern Division<br>Attn: David Gesl, Appeal Review Officer<br>1125 NW Couch Street<br>Portland, OR 97208-2870 Telephone (503) 808-3825<br>David.W.Gesl@usace.army.mil |

RIGHT OF ENTRY: Your signature below grants the right of entry to Corps of Engineers personnel, and any government consultants, to conduct investigations of the project site during the course of the appeal process. You will be provided a 15 day notice of any site investigation, and will have the opportunity to participate in all site investigations.

| _______________________<br>Signature of appellant or agent. | Date: | Telephone number: |
|---|---|---|

# APPENDIX G - AGENCY LETTERS

NORTH DAKOTA
DEPARTMENT *of* HEALTH

ENVIRONMENTAL HEALTH SECTION
Gold Seal Center, 918 E. Divide Ave.
Bismarck, ND 58501-1947
701.328.5200 (fax)
www.ndhealth.gov

September 2, 2014

Ms. Jennifer Bell
Burns & McDonnell
9785 Maroon Circle, Suite 400
Centennial, CO 80112

Re: Basin Electric Power Cooperative
Pioneer Generation Station Gas Engine Project
Williams County

Dear Ms. Bell:

This department has reviewed the information concerning the above-referenced project submitted under date of August 22, 2014, with respect to possible environmental impacts.

This department believes that environmental impacts from the proposed construction will be minor and can be controlled by proper construction methods. With respect to construction, we have the following comments:

1. All necessary measures must be taken to minimize fugitive dust emissions created during construction activities. Any complaints that may arise are to be dealt with in an efficient and effective manner.

2. Care is to be taken during construction activity near any water of the state to minimize adverse effects on a water body. This includes minimal disturbance of stream beds and banks to prevent excess siltation, and the replacement and revegetation of any disturbed area as soon as possible after work has been completed. Caution must also be taken to prevent spills of oil and grease that may reach the receiving water from equipment maintenance, and/or the handling of fuels on the site. Guidelines for minimizing degradation to waterways during construction are attached.

3. Projects disturbing one or more acres are required to have a permit to discharge storm water runoff until the site is stabilized by the reestablishment of vegetation or other permanent cover. Further information on the storm water permit may be obtained from the Department's website or by calling the Division of Water Quality (701-328-5210). Also, cities may impose additional requirements and/or specific best management practices for construction affecting their storm drainage system. Check with the local officials to be sure any local storm water management considerations are addressed.

   As a reminder, an NDPDES waste water discharge permit is required prior to discharging wastes to waters of the state.

4. Noise from construction activities may have adverse effects on persons who live near the construction area. Noise levels can be minimized by ensuring that construction equipment is equipped with a recommended muffler in good working order. Noise effects can also be minimized by ensuring that construction activities are not conducted during early morning or late evening hours.

5. The Department's Air Pollution Control Program is reviewing Basin Electric Power Cooperative's application for an Air Pollution Control Permit to Construct/Operate for this project.

The department owns no land in or adjacent to the proposed improvements, nor does it have any projects scheduled in the area. In addition, we believe the proposed activities are consistent with the State Implementation Plan for the Control of Air Pollution for the State of North Dakota.

If you have any questions regarding our comments, please feel free to contact this office.

Sincerely,

L. David Glatt, P.E., Chief
Environmental Health Section

LDG:cc
Attach.

NORTH DAKOTA
DEPARTMENT *of* HEALTH

ENVIRONMENTAL HEALTH SECTION
Gold Seal Center, 918 E. Divide Ave.
Bismarck, ND 58501-1947
701.328.5200 (fax)
www.ndhealth.gov

# Construction and Environmental Disturbance Requirements

These represent the minimum requirements of the North Dakota Department of Health. They ensure that minimal environmental degradation occurs as a result of construction or related work which has the potential to affect the waters of the State of North Dakota. All projects will be designed and implemented to restrict the losses or disturbances of soil, vegetative cover, and pollutants (chemical or biological) from a site.

## Soils

Prevent the erosion of exposed soil surfaces and trapping sediments being transported. Examples include, but are not restricted to, sediment dams or berms, diversion dikes, hay bales as erosion checks, riprap, mesh or burlap blankets to hold soil during construction, and immediately establishing vegetative cover on disturbed areas after construction is completed. Fragile and sensitive areas such as wetlands, riparian zones, delicate flora, or land resources will be protected against compaction, vegetation loss, and unnecessary damage.

## Surface Waters

All construction which directly or indirectly impacts aquatic systems will be managed to minimize impacts. All attempts will be made to prevent the contamination of water at construction sites from fuel spillage, lubricants, and chemicals, by following safe storage and handling procedures. Stream bank and stream bed disturbances will be controlled to minimize and/or prevent silt movement, nutrient upsurges, plant dislocation, and any physical, chemical, or biological disruption. The use of pesticides or herbicides in or near these systems is forbidden without approval from this Department.

## Fill Material

Any fill material placed below the high water mark must be free of top soils, decomposable materials, and persistent synthetic organic compounds (in toxic concentrations). This includes, but is not limited to, asphalt, tires, treated lumber, and construction debris. The Department may require testing of fill materials. All temporary fills must be removed. Debris and solid wastes will be removed from the site and the impacted areas restored as nearly as possible to the original condition.

## Bell, Jennifer

**From:** Schumacher, John D. <jdschumacher@nd.gov>
**Sent:** Tuesday, September 16, 2014 1:58 PM
**To:** Bell, Jennifer
**Subject:** Pioneer Generation Station Gas Engine Project (#79557)

Ms. Bell,

The North Dakota Game and Fish Department has reviewed this project for wildlife concerns. We do not believe it will have a significant adverse effect on wildlife or wildlife habitat based on the information provided.


**JOHN SCHUMACHER**
**RESOURCE BIOLOGIST**
**ND GAME AND FISH DEPT**
**701.328.6321**

**North Dakota State Water Commission**

900 EAST BOULEVARD AVENUE, DEPT 770 • BISMARCK, NORTH DAKOTA 58505-0850
701-328-2750 • TDD 701-328-2750 • FAX 701-328-3696 • INTERNET: http://swc.nd.gov

September 8, 2014

Jennifer Bell
Burns & McDonnell
9785 Maroon Circle, STE 400
Centennial CO 80112-2692

Dear Ms. Bell:

This is in response to your request for review of environmental impacts associated with the Basin Electric Power Cooperative and Barnes & McDonnell Project #79557, preparing Application to the ND Public Service Commission for a Certificate of Site Compatibility for the Pioneer Generation Station Gas Engine Project. The project includes the construction of up to 12 reciprocating internal combustion engines (gas engines) at the existing Pioneer Generation Station located in Williams County, ND. The Pioneer Generation Station is located approximately 15 miles northwest of the City of Williston in the southeast quarter of Section 20, Township 155 North, Range 103 West.

The proposed project has been reviewed by State Water Commission staff and the following comments are provided:

- There are no floodplains identified and/or mapped where this proposed project is to take place. It is also believed that the project will not affect an identified floodplain as identified by the National Flood Insurance Program (NFIP).

- It is the responsibility of the project sponsor to ensure that local, state and federal agencies are contacted for any required approvals, permits, and easements.

- All waste material associated with the project must be disposed of properly and not placed in identified floodway areas.

- No sole-source aquifers have been designated in ND.

Thank you for the opportunity to provide review comments. If you have any questions, please call me at 701-328-4967.

Sincerely,

Linda Weispfenning
Water Resource Planner

LW:dp/1570

## Bell, Jennifer

**From:** Stika, Jon - NRCS, Dickinson, ND <Jon.Stika@nd.usda.gov>
**Sent:** Tuesday, September 02, 2014 2:32 PM
**To:** Bell, Jennifer
**Subject:** RE: Burns & McDonnell Project #79557

Jennifer,

I reviewed your description of project #79557 and if Basin Electric owns the site and no federal funds will be spent in support of the project, then the Natural Resources Conservation Service has no additional comment on the project.

Jon Stika
NRCS Area Resource Soil Scientist
Dickinson, ND

**STATE HISTORICAL SOCIETY OF NORTH DAKOTA**



August 27, 2014

Ms. Jennifer Bell
Burns & McDonnell
9785 Maroon Circle, Suite 400
Centennial, CO 80112

**ND SHPO REF.: 14-1614 PSC Basin Electric Power Cooperative Pioneer Generation Station Gas Engine Project to construct up to 12 gas engines at the existing Pioneer Generation Station in portions of [T155N R103W Section 20, SE ¼] Williams County, North Dakota**

Dear Ms. Bell,

We reviewed ND SHPO REF.: 14-1614 PSC Basin Electric Power Cooperative Pioneer Generation Station Gas Engine Project to construct up to 12 gas engines at the existing Pioneer Generation Station in portions of [T155N R103W Section 20, SE ¼] Williams County, North Dakota. We concur with a "No Significant Sites" determination for the project, provided the project remains as described and mapped in your letter addressed to this office and dated August 22, 2014.

Thank you for the opportunity to review this project. If you have questions please contact Susan Quinnell at squinnell@nd.gov or (701) 328-3576.

Sincerely,

Merlan E. Paaverud, Jr.
Director, State Historical Society of North Dakota

North Dakota Heritage Center • 612 East Boulevard Avenue, Bismarck, ND 58505-0830 • Phone: 701-328-2666 • Fax: 701-328-3710
Email: histsoc@nd.gov • Web site: http://history.nd.gov • TTY: 1-800-366-6888

## Bell, Jennifer

**From:** Erhardt, Toni R NWO <Toni.R.Erhardt@usace.army.mil>
**Sent:** Tuesday, August 26, 2014 11:24 AM
**To:** Bell, Jennifer
**Cc:** cmiller@bepc.com
**Subject:** BEPC - Pioneer Generation Station Gas Engine Project #79557 (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Thank you for your solicitation dated August 22, 2014. On February 9, 2012 we provided Basin Electric a jurisdictional determination for the Pioneer Generation Station Site. We determined the site does not contain jurisdictional waters of the United States based on current rules and regulations; therefore, no permits are required. The determination remains valid for 5 years. We have no further comments on construction of up to 12 additional gas engines at the site.

Feel free to contact me if you have any further questions.

Toni R. Erhardt, Project Manager
USACE, North Dakota Regulatory Office
1513 South 12th Street
Bismarck, North Dakota 58504
701-255-0015, extension 2203

Classification: UNCLASSIFIED
Caveats: NONE

# Telephone Memorandum

Burns & McDonnell SINCE 1898

Caller: Kevin Shelley, Acting Supervisor
Organization: North Dakota Ecological Services, U.S. Fish and Wildlife Service
Subject of Call: Information request letter for Basin Electric's Pioneer Generation Station Gas Engine Project
Call Date: September 19, 2014

Project Name: Basin Electric Power Cooperative
Pioneer Generation Station Gas Engine Project
Project No.: 79557

Memo Prepared By: Jennifer Bell, Environmental Scientist, Burns & McDonnell
Date Memo Issued: September 19, 2014

Summary:

Mr. Shelley called in regards to the information request letter that was sent to the U.S. Fish and Wildlife Service (USFWS) for Basin Electric's proposed Pioneer Generation Station Gas Engine Project. Mr. Shelly indicated that the USFWS reviewed the project for wetlands, bald/golden eagle nests, critical habitat, etc. and did not identify any concerns. Given that the project does not involve federal funding and that the USFWS did not identify any concerns with the project, Mr. Shelley indicated that USFWS would not send a formal response letter unless requested.

U.S. Fish and Wildlife Service

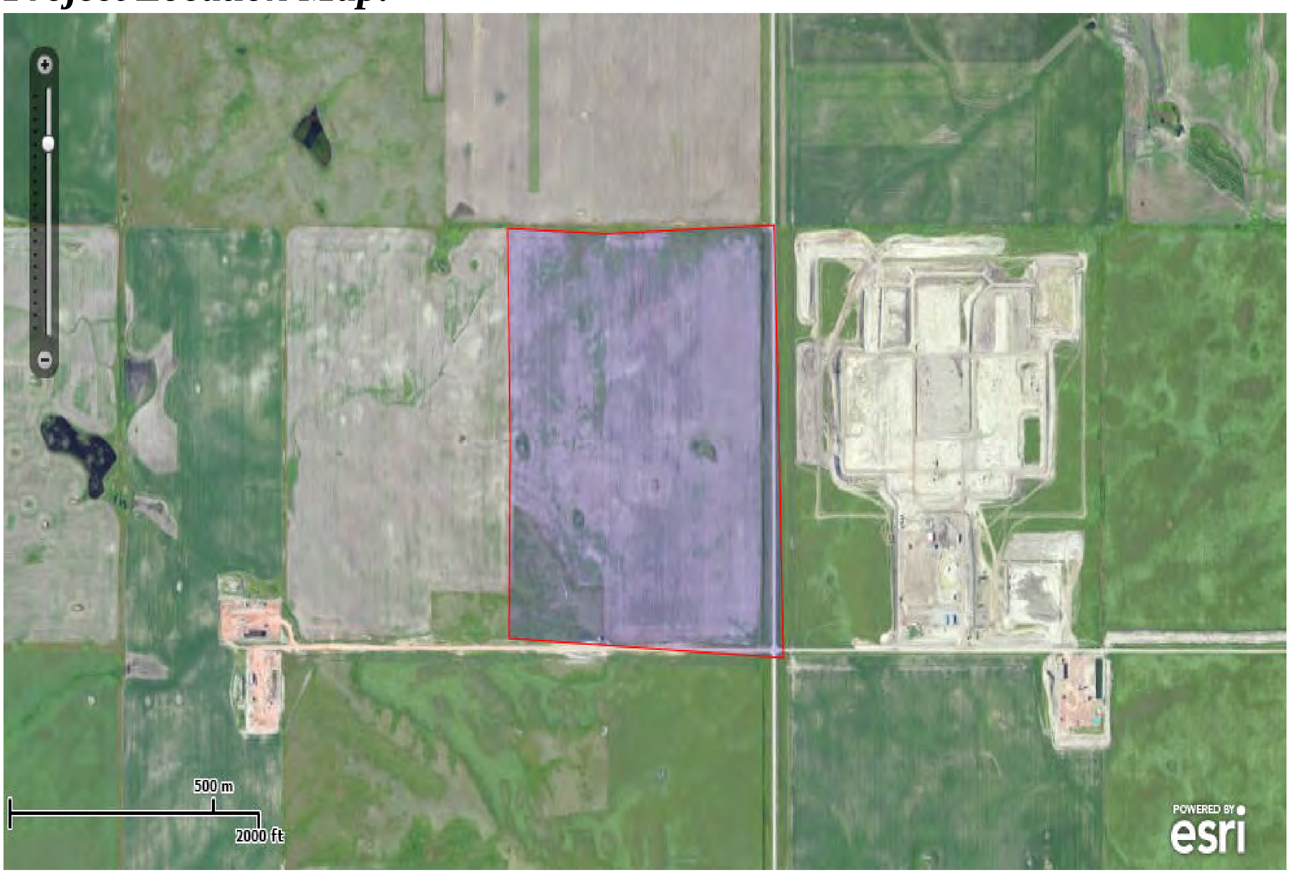
# Trust Resources List

**This resource list is to be used for planning purposes only — it is not an official species list.**

**Endangered Species Act species list information for your project is available online and listed below for the following FWS Field Offices:**

**North Dakota Ecological Services Field Office**
3425 MIRIAM AVENUE
BISMARCK, ND 58501
(701) 250-4481
http://www.fws.gov/northdakotafieldoffice/endspecies/endangered_species.htm

## *Project Location Map:*



U.S. Fish and Wildlife Service

# Trust Resources List

## *Project Counties:*

Williams, ND

## *Geographic coordinates (Open Geospatial Consortium Well-Known Text, NAD83):*

MULTIPOLYGON (((-103.958781 48.2341124, -103.9555011 48.2340152, -103.9499478 48.2341667, -103.9496373 48.2267394, -103.9587424 48.2270771, -103.9586995 48.2303976, -103.958781 48.2341124)))

## *Project Type:*

Power Generation

## *Endangered Species Act Species List (USFWS Endangered Species Program).*

There are a total of **7** threatened, endangered, or candidate species on your 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 fishes may appear on the species list because a project could cause downstream effects on the species. Critical habitats listed under the **Has Critical Habitat** column may or may not lie within your project area. See the **Critical habitats within your project area** section below for critical habitat that lies within your project area. Please contact the designated FWS office if you have questions.

**Species that should be considered in an effects analysis for your project:**

| Birds | Status | | Has Critical Habitat | Contact |
|---|---|---|---|---|
| Least tern (*Sterna antillarum*) Population: interior pop. | Endangered | species info | | North Dakota Ecological Services Field Office |
| Piping Plover (*Charadrius melodus*) Population: except Great Lakes watershed | Threatened | species info | Final designated critical habitat Final designated critical habitat | North Dakota Ecological Services Field Office |
| Red Knot (*Calidris canutus rufa*) | Proposed Threatened | species info | | North Dakota Ecological Services Field Office |

# Trust Resources List

| | | | | |
|---|---|---|---|---|
| Sprague's Pipit<br>(*Anthus spragueii*) | Candidate | species info | | North Dakota Ecological Services Field Office |
| Whooping crane<br>(*Grus americana*)<br>Population: except where EXPN | Endangered | species info | Final designated critical habitat | North Dakota Ecological Services Field Office |
| Fishes | | | | |
| Pallid sturgeon<br>(*Scaphirhynchus albus*)<br>Population: Entire | Endangered | species info | | North Dakota Ecological Services Field Office |
| Mammals | | | | |
| Gray wolf<br>(*Canis lupus*)<br>Population: U.S.A.: All of AL, AR, CA, CO, CT, DE, FL, GA, KS, KY, LA, MA, MD, ME, MO, MS, NC, NE, NH, NJ, NV, NY, OK, PA, RI, SC, TN, VA, VT and WV; those portions of AZ, NM, and TX not included in an experimental population; and portions of IA, IN, IL, ND, OH, OR, SD, UT, and WA. Mexico. | Endangered | species info | | North Dakota Ecological Services Field Office |

**Critical habitats within your project area:**

*There are no critical habitats within your project area.*

## *FWS National Wildlife Refuges (USFWS National Wildlife Refuges Program).*

There is **1** refuge in your refuge list

| | |
|---|---|
| Crosby Wetland Management District<br>(701) 965-6488<br>10100 HIGHWAY 42 NW<br>CROSBY, ND58730 | refuge profile |

# Trust Resources List

## *FWS Migratory Birds (USFWS Migratory Bird Program).*

The protection of birds is regulated by the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA). Any activity, intentional or unintentional, resulting in take of migratory birds, including eagles, is prohibited unless otherwise permitted by the U.S. Fish and Wildlife Service (50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)). The MBTA has no provision for allowing take of migratory birds that may be unintentionally killed or injured by otherwise lawful activities. For more information regarding these Acts see http://www.fws.gov/migratorybirds/RegulationsandPolicies.html.

All project proponents are responsible for complying with the appropriate regulations protecting birds when planning and developing a project. To meet these conservation obligations, proponents should identify potential or existing project-related impacts to migratory birds and their habitat and develop and implement conservation measures that avoid, minimize, or compensate for these impacts. The Service's Birds of Conservation Concern (2008) report identifies species, subspecies, and populations of all migratory nongame birds that, without additional conservation actions, are likely to become listed under the Endangered Species Act as amended (16 U.S.C 1531 et seq.).

For information about Birds of Conservation Concern, go to http://www.fws.gov/migratorybirds/CurrentBirdIssues/Management/BCC.html.

**Migratory birds of concern that may be affected by your project:**

There are **11** birds on your Migratory birds of concern list. The Division of Migratory Bird Management is in the process of populating migratory bird data with an estimated completion time of Fall 2014; therefore, the list below may not include all the migratory birds of concern in your project area at this time. While this information is being populated, please contact the Field Office for information about migratory birds in your project area.

| Species Name | Bird of Conservation Concern (BCC) | Species Profile | Seasonal Occurrence in Project Area |
|---|---|---|---|
| American bittern (*Botaurus lentiginosus*) | Yes | species info | Breeding |
| Bald eagle (*Haliaeetus leucocephalus*) | Yes | species info | Wintering |
| Black tern (*Chlidonias niger*) | Yes | species info | Breeding |
| Black-billed Cuckoo (*Coccyzus erythropthalmus*) | Yes | species info | Breeding |
| Brewer's Sparrow (*Spizella breweri*) | Yes | species info | Breeding |

| | | | |
|---|---|---|---|
| Burrowing Owl (*Athene cunicularia*) | Yes | species info | Breeding |
| Common tern (*Sterna hirundo*) | Yes | species info | Breeding |
| Ferruginous hawk (*Buteo regalis*) | Yes | species info | Breeding |
| Golden eagle (*Aquila chrysaetos*) | Yes | species info | Year-round |
| Grasshopper Sparrow (*Ammodramus savannarum*) | Yes | species info | Breeding |
| Marbled Godwit (*Limosa fedoa*) | Yes | species info | Breeding |

## *NWI Wetlands (USFWS National Wetlands Inventory).*

The U.S. Fish and Wildlife Service is the principal Federal agency that provides information on the extent and status of wetlands in the U.S., via the National Wetlands Inventory Program (NWI). In addition to impacts to wetlands within your immediate project area, wetlands outside of your project area may need to be considered in any evaluation of project impacts, due to the hydrologic nature of wetlands (for example, project activities may affect local hydrology within, and outside of, your immediate project area). It may be helpful to refer to the USFWS National Wetland Inventory website. The designated FWS office can also assist you. Impacts to wetlands and other aquatic habitats from your project may be subject to regulation under Section 404 of the Clean Water Act, or other State/Federal Statutes. Project Proponents should discuss the relationship of these requirements to their project with the Regulatory Program of the appropriate U.S. Army Corps of Engineers District.

**Data Limitations, Exclusions and Precautions**

The Service's objective of mapping wetlands and deepwater habitats is to produce reconnaissance level information on the location, type and size of these resources. The maps are prepared from the analysis of high altitude imagery. Wetlands are identified based on vegetation, visible hydrology and geography. A margin of error is inherent in the use of imagery; thus, detailed on-the-ground inspection of any particular site may result in revision of the wetland boundaries or classification established through image analysis.

The accuracy of image interpretation depends on the quality of the imagery, the experience of the image analysts, the amount and quality of the collateral data and the amount of ground truth verification work conducted. Metadata should be consulted to determine the date of the source imagery used and any mapping problems.

# Trust Resources List

Wetlands or other mapped features may have changed since the date of the imagery and/or field work. There may be occasional differences in polygon boundaries or classifications between the information depicted on the map and the actual conditions on site.

**Exclusions** - Certain wetland habitats are excluded from the National mapping program because of the limitations of aerial imagery as the primary data source used to detect wetlands. These habitats include seagrasses or submerged aquatic vegetation that are found in the intertidal and subtidal zones of estuaries and nearshore coastal waters. Some deepwater reef communities (coral or tuberficid worm reefs) have also been excluded from the inventory. These habitats, because of their depth, go undetected by aerial imagery.

**Precautions** - Federal, state, and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than that used in this inventory. There is no attempt, in either the design or products of this inventory, to define the limits of proprietary jurisdiction of any Federal, state, or local government or to establish the geographical scope of the regulatory programs of government agencies. Persons intending to engage in activities involving modifications within or adjacent to wetland areas should seek the advice of appropriate federal, state, or local agencies concerning specified agency regulatory programs and proprietary jurisdictions that may affect such activities.

***IPaC is unable to display wetland information at this time.***

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