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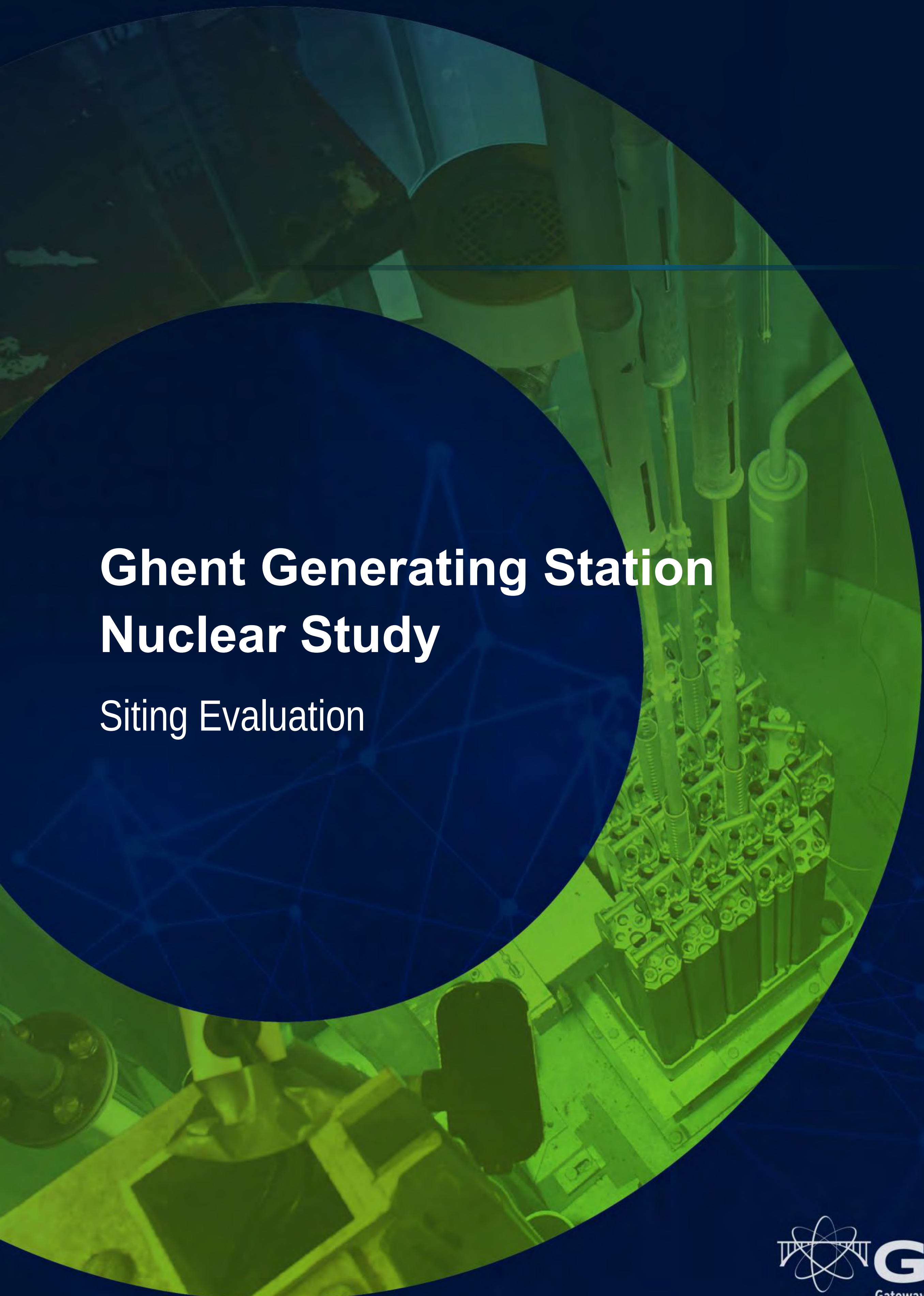

Ghent Generating Station Nuclear Study

Siting Evaluation

GAIN
Gateway for Accelerated Innovation in Nuclear

Ghent Generating Station Nuclear Study

Siting Evaluation

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Acronyms/Abbreviations

ARDP	Advanced Reactor Demonstration Program
ATB	Ash Treatment Basin
BOP	Balance Of Plant
CCR	Coal Combustion Residual
CRN	Clinch River Nuclear
CSXT	CSX Transportation
DOD	Department of Defense
DOE	Department of Energy
EA	Exclusion Area
EAB	Exclusion Area Boundary
EIR	Energy Infrastructure Reinvestment
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
EPZ	Emergency Planning Zone
ESP	Early Site Permit
FEMA	Federal Emergency Management Agency
GAIN	Gateway for Accelerated Innovation in Nuclear
GGS	Ghent Generating Station
GIS	Geographical Information System
GPM	Gallons Per Minute
INL	Idaho National Lab
IRA	Inflation Reduction Act
ITC	Investment Tax Credit

KPDES	Kentucky Pollutant Discharge Elimination System
KU	Kentucky Utilities
LG&E	Louisville Gas & Electric
LPZ	Low Population Zone
MPR	MPR Associates, Inc.
NCEI	National Centers for Environmental Information
NFHL	National Flood Hazard Layer
NOAA	National Oceanic and Atmospheric Administration
NRC	Nuclear Regulatory Commission
PCD	Population Center Distance
PE	Probability of Exceedance
PPE	Plant Parameter Envelope
PPL	PPL Corporation
PSC	Public Service Commission
PTC	Production Tax Credit
R&D	Research and Development
SCEC	State Climate Extremes Committee
SMR	Small Modular Reactors
STAND	Siting Tool for Advanced Nuclear Development
USGS	United States Geological Service

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Ghent Generating Station Nuclear Study
Siting Evaluation

EXECUTIVE SUMMARY

An initial siting evaluation, focused on criteria specific to siting a nuclear generating station, was conducted for the Kentucky Utilities Ghent Generating Station (GGS) site and surrounding PPL Corporation (PPL) owned land. No exclusionary factors (i.e., factors that preclude nuclear) were identified; however, some avoidance factors (i.e., factors that could present challenges and increase costs and/or risk) were identified and warrant additional investigation.

GGS is located in Carroll County, Kentucky and is within 5 miles of several industrial companies (including, but not limited to, North American Stainless, Nucor Steel Gallatin, and Dow Silicones). Siting any energy project can involve factors specific to the technology. In the case of repowering/repurposing, a siting evaluation benefits from what is already known and can compare that information to criteria necessary for the new technology. This initial siting evaluation used publicly available information and information from PPL. Information gathered was reviewed leveraging industry recognized siting criteria and applicable regulatory guidance.

While the formal siting process for a nuclear reactor requires a great level of time (i.e., multiple years), effort, and detail, the purpose of this initial siting evaluation was to assess if the GGS site has characteristics that could preclude nuclear power options or present challenges leading to increased costs and/or risk. These characteristics are referred to as exclusionary and avoidance factors, respectively. This initial siting evaluation also identifies characteristics that require more investigation to support decision planning.

This initial siting evaluation is based on current information. PPL should continue to monitor the site and surrounding area to ensure changes do not impact siting (e.g., population growth around the area could impact evaluation results).

No exclusionary factors were identified at GGS; the identified avoidance factors for the GGS site are as follows:

- The footprint requirements of nuclear compared to the available footprint at GGS. The available footprint is currently limited by highly sloped areas and existing coal plant infrastructure (including coal combustion residuals (CCRs)).
- The potential effects and liabilities associated with CCRs and concurrent coal operations on siting and construction.

These avoidance factors are expected to influence cost and could impact the ability for a nuclear generating station at GGS to meet PPL's business objectives. The capacity of a nuclear generating station at GGS will depend on the nuclear technology selected and the cost and benefits associated with addressing areas of high slope, further remediating CCR storage areas, and/or acquiring nearby land. Opportunities may be available to address these avoidance factors. For example, to address CCR onsite, PPL may choose to explore funding opportunities available for environmental remediation, which would increase the available footprint and reduce environmental liabilities.

Stakeholder engagement is an essential part of nuclear generating station site selection, project planning, and execution. As PPL considers next steps and assesses potential technologies to add to its energy mix, PPL should continue to engage with local and state stakeholders. To promote progress and support decision making, PPL may also focus on developing a site layout and deployment timetable. This includes identifying opportunities to reuse infrastructure (e.g., switchyards, transmission lines, etc.), identifying the effect of construction on GGS coal plant operations, and assessing environmental liabilities. Additional insights regarding nuclear technologies were provided to PPL in a complementary GAIN report focused on identifying candidate nuclear technologies for the GGS site that align with PPL's mission and business objectives. GAIN's approach and insights that are applicable to other coal sites and utilities will be shared in a public report.

PURPOSE AND BACKGROUND

Purpose

The purpose of this initial siting evaluation is to assess the suitability of the PPL Corporation (PPL)[1] owned land at/near the Kentucky Utilities Ghent Generating Station (GGS) for the deployment of advanced nuclear reactors[2] and to determine if there are any exclusionary or avoidance factors associated with siting nuclear power at GGS. The formal siting process for a nuclear reactor requires a great level of time (i.e., multiple years), effort, and detail. The Electric Power Research Institute (EPRI) (Reference 1) estimates the formal siting process could take a dedicated team between one and three years to complete.

This initial siting evaluation considers several characteristics (e.g., environmental conditions, seismic concerns, footprint, water use, etc.) and highlights favorable/preferred characteristics as well as potential risks to feasibility. Potential risks were explored in greater detail to provide PPL with additional insights to support decision planning. The results indicate the strengths and weaknesses associated with the GGS site as a location for a nuclear generating station and are intended to inform PPL's next steps. The results of this initial siting evaluation will also inform the selection of candidate nuclear technologies for the GGS site that align with PPL's mission and business objectives.

This report relies on industry-recognized siting guidance, including EPRI's Siting Guide (Reference 1)[3] and the Nuclear Regulatory Commission's (NRC's) Regulatory Guide 4.7 (Reference 3), as well as nuclear domain expertise within the Gateway for Accelerated Innovation in Nuclear (GAIN), MPR Associates, Inc. (MPR), and Idaho National Laboratory (INL). Additionally, the support of the PPL Corporation R&D team is gratefully acknowledged.

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[1] For this report, any references to "PPL Corporation" include their subsidiaries, such as Louisville Gas & Electric (LG&E) and Kentucky Utilities (KU).
[2] GAIN's Taxonomic Guidance on Advanced Reactors (Reference 7) defines the term 'advanced nuclear reactor' and provides definitions for advanced reactor classes. The term advanced nuclear reactor (also referred to as advanced reactor) refers to a nuclear fission reactor with significant improvements, including additional inherent safety features, compared to reactors operating on December 27, 2020, in the United States.
[3] EPRI's Siting Guide (Reference 1) includes consideration of advanced reactors beyond light water small modular reactors and gigawatt-scale light water reactors, new reactor missions beyond baseload electricity, and the potential for reuse of existing sites and facilities (e.g., coal plants). The 2022 EPRI Siting Guide applies to advanced light water reactors, light water small modular reactors, and non-light-water designs.

Background

GAIN Adding Nuclear to the Energy Mix

Between 2015 and 2020, the United States retired an average of 11 GW of coal capacity each year (Reference 6). Coal retirements are expected to continue as the industry moves to achieve carbon emission reduction goals and shift to a clean energy economy. Communities, government, utilities, and researchers across the United States are seeking options to reduce carbon emissions and preserve jobs by adding nuclear power to the energy mix. Options that utilize past investments in coal facilities, supporting infrastructure, and local staff are being considered and evaluated. As coal plants retire, nuclear technology may be able to be sited on the same property or nearby land. This would enable these new nuclear deployments to utilize the existing brownfield[4] sites' infrastructure (depending on the age and condition) while supporting a just energy transition by providing high paying jobs, contributing to a greener energy portfolio, and reducing local pollution. Deployment of nuclear technology in general will also contribute to resiliency of the electric grid through the distributed siting of firm, dispatchable sources of electricity generation.

Evaluating, planning for, and successfully completing the deployment of an advanced nuclear generating station is a complex task for a power company. Such projects require the right partnerships to ensure the nuclear technology options and licensing pathways are available to meet business and community goals. Critical to evaluation and planning is engagement with the community to understand and incorporate their vision for a successful transition of the coal station.

GAIN is working with a diverse group of participants to evaluate several specific sites in different regions to establish a broad foundation and framework for successful nuclear implementation across the United States.

GAIN serves as an independent resource for nuclear innovation and deployment, without bias towards site location or technology selections. GAIN engages with the U.S. Department of Energy (DOE), industry, communities, and decision-makers on a regular basis to strengthen and optimize the program and resulting products.

PPL Corporation

PPL is the parent company of utilities serving the states of Kentucky, Pennsylvania, Rhode Island, and Virginia. In Kentucky, PPL's holdings include two regulated utilities based in

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[4] A brownfield is a property where expansion, redevelopment or reuse may be complicated by the presence or potential presence of a hazardous substance, pollutant or contaminant (Reference 10).

Louisville, Kentucky: Louisville Gas and Electric (LG&E) and Kentucky Utilities (KU). Combined, these utilities serve more than 1.3 million customers across more than 90 counties in Kentucky and five in Virginia with a total of 7500 MW of generation (Reference 8).

In Kentucky, only one electricity provider per service area is permitted to service and deliver electricity (Reference 16), and balancing authorities ensure the balance of supply and demand on the electric grid (Reference 17). In the area surrounding GGS, PPL companies serve as both the electricity provider (KU) and balancing authority (LG&E and KU). LG&E and KU are regulated in the state of Kentucky by the Kentucky Public Service Commission (PSC). The PSC regulates the rates and services of LG&E and KU and has regulatory responsibility for construction and operation of utility facilities as well as the review and approval of LG&E and KU's integrated resource plan, among other responsibilities.

PPL is committed to reducing its carbon emissions. PPL has published goals to achieve net-zero carbon emissions by 2050 and is targeting a 70% reduction from 2010 levels of carbon emissions by 2035 and an 80% reduction by 2040 (Reference 11). To meet their goals, PPL is taking an all-of-the-above approach in investigating alternative low carbon or carbon-free generating sources to add to the energy mix in Kentucky and is considering nuclear power as a viable alternative. Table 1 provides a list of PPL owned and operated coal-fired power stations in Kentucky.

Table 1. PPL Coal Generating Assets in Kentucky (Reference 9)

Station Name	Location	Total Capacity [MWe]
E.W. Brown Generating Station (one coal-fired unit, Unit 3)	Harrodsburg, KY	457
Ghent Generating Station (4 units)	Ghent, KY	1919
Mill Creek Generating Station (4 units)	Louisville, KY	1465
Trimble County Generating Station (2 coal-fired units)	Bedford, KY	1274

Ghent Generating Station

GGS is a four-unit, coal-fired power station located near Ghent, Kentucky in Carroll County (see Figure 1). The four units have a net generating capacity of 1,919 MWe (Reference 9) and are planned for phased retirement based on discussions with PPL, with Units 1 and 2 retiring first and Units 3 and 4 retiring afterwards.

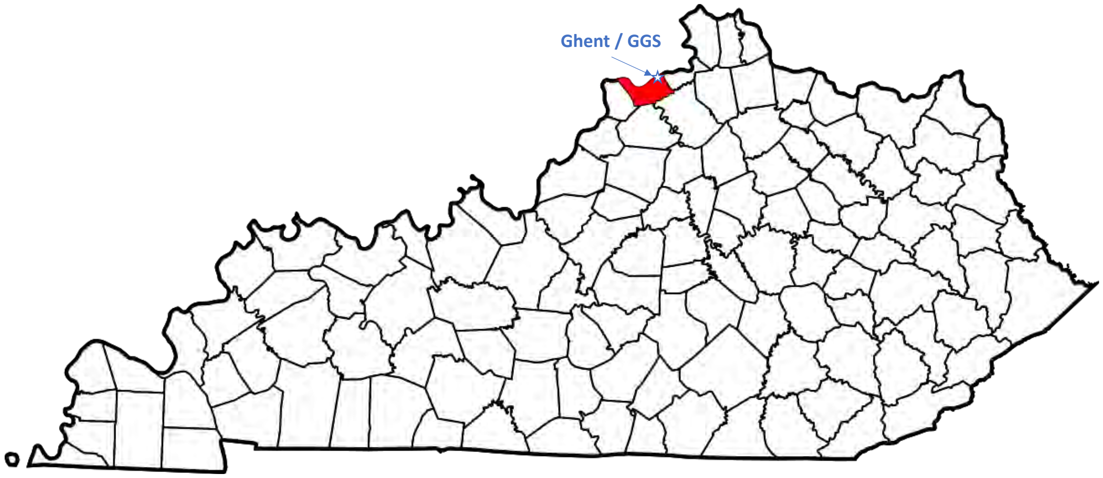

Figure 1. Map of Kentucky Counties and Ghent / GGS

PPL owns approximately 2,300 acres of land around and including the GGS site (Reference 12). Figure 2 shows the parcels owned by PPL around the GGS site. This ownership map was generated with a parcel ownership mapping tool (Reference 13) and with a PPL-provided perimeter evaluation (Reference 14).

Figure 2. PPL Land Ownership at GGS (in white) (Reference 13)

The GGS site includes the areas of interest shown in Figure 3 and Figure 4. The following areas of interest are included in the figures (determined from Reference 14 and discussions with PPL):

- Power station and associated structures (cooling towers, pumps, etc.)
- Transmission substation
- Coal combustion residual (CCR) storage facilities
- Ash treatment basins
- Gypsum reclaim pond and gypsum stack
- CCR loading and dry storage
- Coal yard
- Ponds used for leachate and sediment
- Parking/office space (e.g., Admin Building)

Figure 3. GGS Plant Areas of Interest

Figure 4. GGS Auxiliary Areas of Interest, Southeast of GGS

The status of the CCR storage facilities as of this writing is as follows (Reference 15):

- Ash Treatment Basin #1 (ATB-1): Remediated by closure in place (completed in 2023)
- Ash Treatment Basin #2 (ATB-2): In process of closure in place (estimated completion in 2024)
- Gypsum Stack and Gypsum Reclaim Pond: Remediated by removal of CCR (completed in 2021 and 2019, respectively)
- Secondary Ash Pond: Remediated by removal of CCR and is now a lined storm water pond (completed in 2021)
- CCR Dry Storage/CCR Landfill: Planned to be closed in place (estimated completion in 2043)

GGS is also situated in an industrial area next to steel and chemical manufacturers, as shown in Figure 5. These manufacturers (as well as the town of Ghent) could be potential end-users of carbon free electrical power, process heat provided by a nuclear generating station, and/or hydrogen produced by electrolyzers powered by a nuclear generating station.

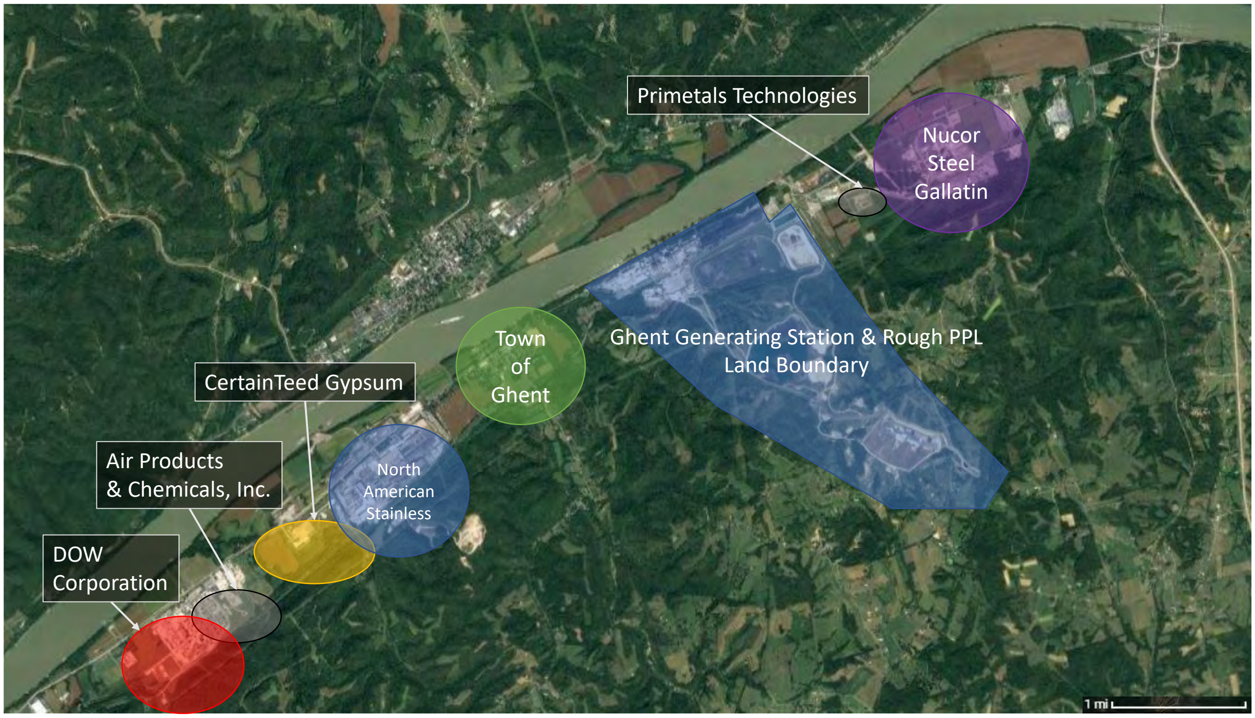

Figure 5. GGS Nearby Industries

Available Siting Guidance

Numerous siting guidance documents are available to assist utilities and communities in evaluating suitability for siting a nuclear generating station. These guidance documents are best used early in the siting process and provide high-level overviews of exclusionary and avoidance criteria, as well as guidance on more detailed nuclear siting considerations. A primary objective of this guidance is to confirm high-level site suitability. Guidance documents also detail nuclear siting aspects (e.g., future adjacent land usage, housing availability to support construction/operations, etc.) that will be required if a utility decides to continue the nuclear siting process and to pursue an early site or construction permit. Ultimately, a combination of proprietary knowledge and data, publicly available records, market research, and use of industry siting guidance will best inform a utility's site selection.

The GAIN/MPR team leveraged the following siting guidance to assess suitability of the GGS site and nearby PPL owned land.

1. "**Advanced Nuclear Technology: Site Selection and Evaluation Criteria for New Nuclear Power Generation Facilities (Siting Guide**)" (Reference 1): This guide was published by EPRI and provides siting guidance to prospective utilities throughout the lifecycle of the siting process. This guide provides regulatory guidance as well as business related considerations for siting purposes and is a good starting point and comprehensive reference for any siting activities.
2. **Coal Repowering – A White Paper Series** (Reference 2): This white paper series, published by EPRI, discusses some of the high-level benefits, drawbacks, and considerations for repowering coal-fired power stations with nuclear generating stations. Information in the whitepaper series complements siting considerations in the EPRI Siting Guide.
3. **Nuclear Regulatory Commission (NRC) Regulatory Guide 4.7** (Reference 3): This NRC guidance document provides explanations of the NRC's specific siting criteria and defines specific requirements for siting a nuclear reactor. This guide is limited in scope to NRC-related requirements.
4. **The Department of Energy's (DOEs) "Investigating Benefits and Challenges of Converting Retiring Coal Plants into Nuclear Plants"** (Reference 4): This report specifically considers the transition of coal-fired power stations to nuclear generating stations and addresses some of the key pros and cons to converting. This report also highlights some of the economic aspects of converting a coal-fired power station into a nuclear generating station.
5. **Previous Early Site Permit Applications:** To date, six early site permits (ESPs) have been approved by the NRC for utility companies considering building nuclear generating stations. The ESPs themselves are the end-product of siting-related work and can be leveraged to (1) identify the level of effort required to site a nuclear generating station, and (2) provide inputs to use for scoping purposes for early siting activities when leveraging the above guidance documents. ESPs can be viewed on the NRC website directly (Reference 5).

GGS SITING EVALUATION RESULTS

An initial siting evaluation, focused on criteria specific to siting a nuclear generating station, was conducted for the GGS site and surrounding PPL-owned land. This evaluation used both publicly available information and information from PPL. Information gathered was reviewed while leveraging industry-recognized siting criteria and applicable regulatory guidance.

The formal siting process for a nuclear reactor is a multi-year process requiring a great level of time, effort, and detail. The purpose of this initial siting evaluation was to assess if the GGS site has characteristics that could preclude or present challenges leading to increased costs and/or risk. These characteristics are referred to as exclusionary and avoidance factors, respectively. This initial siting evaluation also identifies characteristics that require more investigation to support decision planning.

No exclusionary factors (i.e., factors precluding nuclear) were identified at GGS. However, some avoidance factors (i.e., factors that could present challenges and increase costs/risk) were identified and warrant additional consideration and investigation. It is important to note that this initial siting evaluation is based on current information and PPL should continue to monitor the site and surrounding area to ensure changes do not impact siting (e.g., population growth could impact siting results).

Details associated with desirable GGS site characteristics, possible GGS site challenges and risks, and options regarding next steps are provided below and further expanded in subsequent sections.

Key desirable factors at GGS include the following:

- **Ohio River Access** – GGS is situated on the Ohio River and has ample cooling water for a nuclear generating station.
- **Potential Nearby Industrial Customers** – GGS is near several chemical and steel manufacturers that may be industrial customers for nuclear-powered and carbon-free process heat or hydrogen, depending on their carbon-emission goals.
- **Later Coal Plant Retirement Date** – Based on discussions with PPL, the coal units at GGS are planned to retire on a timeline that allows certain advanced nuclear technologies to mature, which reduces risks in estimating cost, schedule, and supply chain.

Factors that may present challenges during either licensing or construction/operation that could lead to undesirable costs and /or risks include:

- **Nuclear Footprint Requirements vs. GGS Available Footprint** – The estimated site footprint for a single-unit site hosting a small advanced reactor (50 to 300 MWe) is 50 to 500 acres, with an additional 50 to 100 acres estimated for construction laydown. The largest continuous area that avoids CCR storage, high sloped areas, and existing roads from the coal plant to the CCR landfill at GGS is approximately 300 acres. A nuclear generating station's capacity (dependent on the technology selected) may be limited on the available footprint without additional CCR storage remediation, effects to coal plant operations, increased construction costs from addressing high slope, and/or additional land acquisition.

- **Coal Operations and CCR Effects on Siting and Construction** – Coal operations are planned to continue through new-build nuclear construction. Coal operations and the existing/legacy CCR storage could introduce complexity to the siting and construction process of new nuclear due to potential environmental-related liabilities on the nuclear generating station. Without a clear boundary for new-build nuclear, the nuclear generating station may be accountable for radionuclides and contamination that originally resulted from coal plant operations. Additionally, construction activities for new-build nuclear may have effects on existing CCR storage post-closure requirements.

The capacity of a nuclear generating station at GGS will depend on the footprint requirements associated with the nuclear technology selected and the cost and benefits associated with addressing areas of high slope, further remediating CCR storage areas, and/or acquiring nearby land. To address CCR onsite, PPL may choose to explore funding opportunities available for environmental remediation, which would increase the available footprint and reduce CCR-related liabilities for a nuclear generating station.

Based on the findings from this initial siting evaluation, if nuclear power is to be explored at GGS with concurrent coal operations, PPL has several options:

1. Deploy nuclear at GGS without any additional remediation (which may limit nuclear capacity at GGS). Define a clear boundary for the nuclear generating station to limit liabilities introduced from coal operations.
2. Remove CCR from CCR storage areas at GGS to increase the footprint available for siting nuclear and reduce any liabilities to siting a nuclear generating station from CCR. Pursue funding opportunities for the remediation effort as available.
3. Acquire favorable land near GGS to expand the available footprint for nuclear or explore other areas beyond GGS for nuclear development.
4. Explore areas of high slope for nuclear construction and determine if construction costs would be prohibitive. This option may be pursued with any of the previous options.

Stakeholder engagement is an essential part of nuclear generating station site selection, project planning, and execution. As PPL considers next steps and assesses whether to add nuclear to its energy mix, PPL should continue to engage with local and state stakeholders. To promote progress and support decision making, PPL may also focus on developing a site layout, cost estimates for different deployment options, and a deployment timetable. This includes determining reusable infrastructure (e.g., switchyards, transmission lines, etc.), the effect of construction on GGS operations, and assessing environmental liabilities. The results are intended to inform PPL on the strengths and weaknesses associated with the GGS site and support technology selection.

GGS SITING EVALUATION APPROACH

As recommended in the EPRI Siting Guide, the evaluation leveraged a graded approach when assessing the suitability of the GGS site and nearby PPL-owned land for a nuclear generating station[5].

The siting criteria identified in available industry guidance (References 1 and 2) can be grouped into three stages of assessment, described below. The main focus of this initial siting evaluation is the first stage, the Exclusionary/Avoidance Factor Assessment, and selected Decision Planning criteria.

1. **Exclusionary/Avoidance Factor Assessment**: During this stage, utilities determine if the site(s) of interest have any exclusionary factors or nuclear siting-related criteria that would preclude the construction of a nuclear reactor. The Exclusionary/Avoidance Factor Assessment will also identify any avoidance factors that should be considered and further assessed as part of Decision Planning (see Stage 2). The EPRI Siting Guide (Reference 1) defines exclusionary and avoidance factors as:

    - **Exclusionary** – Factors that preclude nuclear construction (e.g., located within 10 miles of a major airport, situated on federally protected land, etc.),
    - **Avoidance** – Factors that are not exclusionary, but may present challenges during licensing, construction, or operation that could lead to undesirable costs or risks (e.g., presence of high slope that may incur large costs to backfill/excavate).

    Sites that do not have any exclusionary nuclear siting factors should be studied further in the subsequent stages. Typically, Exclusionary/Avoidance Factor Assessments can rely on publicly available data, or limited utility information (e.g., water usage rights, insights on community support, etc.).

[5] This initial siting evaluation is focused on a site of interest (i.e., the GGS site) versus a region of interest due to the unique opportunities associated with adding nuclear to the energy mix at the GGS site. As a result, to satisfy NRC requirements, PPL will need to evaluate alternative sites to justify selection of GGS during future stages of the siting evaluation process (see Reference 3).

2. **Decision Planning**: During this stage, more investigation is required to assess siting considerations and develop a deployment schedule to coordinate information gathering and siting activities. At this point in the process, utilities have confirmed that the site(s) of interest do not have any exclusionary factors and have plans to assess risks associated with any avoidance factors identified during the Exclusionary/Avoidance Factor Assessment. While criteria addressed in this stage are not exclusionary factors, the assessed criteria in this stage will help a utility down-select to the "best" site and preferred site layout, from regulatory and business perspectives. Where information is available, this initial siting evaluation qualitatively assesses Decision Planning criteria. Note that Decision Planning criteria will require further investigation in subsequent siting evaluations if PPL decides to pursue future stages.
3. **Licensing**: During this stage, a utility has selected the site for hosting a nuclear generating station, has developed a deployment schedule, and is applying for either an ESP[6] or construction permit from the NRC. Activities during this stage often involve site specific work, such as geotechnical assessments, meteorological and environmental monitoring, and stakeholder engagement.

Criteria were assessed on a pass/fail/more investigation required basis. Note that the Decision Planning criteria spans a wide range of the siting process and will likely involve a more formal siting evaluation process as outlined in NRC Regulatory Guide 4.7 (Reference 3). For this initial siting evaluation, Decision Planning criteria where data either publicly exists or was provided by PPL is included in this report. Insights regarding future stages (e.g., later stages of Decision Planning and Licensing) are also provided for PPL's consideration. Potential risks were explored in greater detail to provide PPL with additional insights to support Decision Planning.

Table 2 lists the scope of siting considerations to be evaluated at each stage, by order of appearance in the Siting Guide (Reference 1). Criteria from these references are suitable for conducting an Exclusionary/Avoidance Factor Assessment and early Decision Planning investigations. However, the licensing criteria in Table 2 are highly condensed. If PPL advances to a licensing stage of planning, siting-related industry experts should be consulted for further clarity on specific requirements for licensing.

[6] An Early Site Permit (ESP) is a siting permit granted by the NRC and can be technology agnostic. Once approved, an ESP is valid for 10-20 years, and can be renewed for an additional 10-20 years.

Table 2. Nuclear Siting Considerations by Planning Stage

Category	Siting Guide Section	Exclusionary/Avoidance Factor Assessment (Focus of the GGS Initial Siting Evaluation)	Decision Planning	Licensing
Geology Seismology	3.1.1.1	• Exclude areas where peak ground acceleration exceeds 0.3gs at a probability of exceedance of 2% in 50 years.		• Quantify: o Vibratory Ground Motion. o Capable Tectonic Structures/Sources. o Surface Faulting/Deformation. o Geologic Hazards. o Soil Stability.
Cooling Water Supply	3.1.1.2.1	• Ensure water availability for potential technology.	• Quantify water source low flow conditions.	• Develop water supply plan.
Ambient Air Requirements	3.1.1.2.2	• Evaluate ambient air temperatures as it relates to cooling options (i.e., water cooled, air-cooled, or hybrid methods) to support more detailed analyses later in siting process.		• Quantify: o Minimum and maximum ambient air temperatures on site. o Annual average monthly dry-bulb temperatures. o Consideration of general climate conditions and effects of climate change.
Flooding	3.1.1.3	• Avoid high probability floodplains.	• Determine flooding potential with 100- and 500-year flood zone. • Subjectively characterize other flooding hazards (e.g., tsunamis, dam breaks, etc.).	• Evaluate other flooding hazards (e.g., tsunamis, dam breaks, etc.). • Evaluate cost of engineered flood-mitigation structures.

Table 2. Nuclear Siting Considerations by Planning Stage

Category	Siting Guide Section	Exclusionary/Avoidance Factor Assessment (Focus of the GGS Initial Siting Evaluation)	Decision Planning	Licensing
Nearby Hazardous Land Uses	3.1.1.4	• Exclude Department of Defense (DOD)-reserved Land. • Ensure no major airport is within 10 miles of site. • Avoid areas that may incur additional liabilities to a nuclear reactor (e.g., coal ash ponds).	• Maximize distance (greater than 5 miles) from nearby hazardous land usage (e.g., mining, chemical processing, fossil fuel operations, heavy manufacturing, etc.) (2).	• Evaluate all adjacent hazardous land use (i.e., hazards associated with nearby transportation routes, and industrial and military facilities).
Extreme Weather Conditions	3.1.1.5	• Quantitatively assess extreme weather conditions on site, and effects of climate change increasing frequency of extreme weather events.		• Quantify: o Fastest Wind Mile Speed. o Number of Tornadoes (per 10,000 sq. mi). o Number of Hurricanes. o Maximum 24-hour precipitation values.
Population	3.1.2.1	• Exclude areas which have a population density greater than 300 persons per sq. mi. (2) • Minimize nearby population centers (>25,000 residents). (2)	• Ensure that distance to population density centers meets Exclusion Area (EA)/Low Population Zone (LPZ) requirements.	• Quantify: o Transient populations. o Proximity to densely populated areas. o Population growth rates.

Table 2. Nuclear Siting Considerations by Planning Stage

Category	Siting Guide Section	Exclusionary/Avoidance Factor Assessment (Focus of the GGS Initial Siting Evaluation)	Decision Planning	Licensing
Emergency Planning	3.1.2.2			• Evaluate area egress limitations (e.g., water crossings, physical barriers, etc.). • Evaluate distance to the nearest major US interstate. • Evaluate institutions which require special evacuation considerations (e.g., schools, prisons, nursing homes, etc.). • Characterize any natural hazard impediments (e.g., flash flooding, hurricanes, etc.).
Atmospheric Dispersion	3.1.2.3	• Subjectively characterize nearby topographical features which may lead to atmospheric dispersion (e.g., hills, valleys, etc.).		• Calculate atmospheric dispersion function using either: 1. On-site meteorological monitoring. 2. Atmospheric data. • Ensure requirements of the Clean Air Act are met accounting for cooling tower plume interactions of a nuclear generating station with nearby industrial facilities and the current air quality on site.

Table 2. Nuclear Siting Considerations by Planning Stage

Category	Siting Guide Section	Exclusionary/Avoidance Factor Assessment (Focus of the GGS Initial Siting Evaluation)	Decision Planning	Licensing
Radionuclide Pathways	3.1.3[(1)]	• Exclude siting on and avoid siting near Environmental Protection Agency (EPA) Class I (special groundwater) sources.		• Quantify o Dilution Capacity. o Baseline Loadings. o Proximity to Consumptive Users. o Agricultural statistics (e.g., irrigation activity nearby).
Transportation Safety	3.1.3.6			• Evaluate transportation hazards (e.g., fog, blizzards, etc.) that can affect hazardous material transport to site.

Table 2. Nuclear Siting Considerations by Planning Stage

Category	Siting Guide Section	Exclusionary/Avoidance Factor Assessment (Focus of the GGS Initial Siting Evaluation)	Decision Planning	Licensing
Effects on Surrounding Ecology	3.2[(1)]	• Exclude areas designated as critical habitats for endangered/ threatened species. • Exclude major, high-quality wetland areas. • Exclude areas where cooling water/other operational affects may affect endangered/threatened species. • Avoid ecologically sensitive and special designation wildlife/wetland/aquatic areas.	• Evaluate the number of rare, threatened, or endangered species which may migrate to future sites, and what effect station operations will have on them. • Define the total area and boundary of each potential site.	• Quantify: o The extent of possible contamination to water sediments and grain size of the sediments in the area. o The effect on state or local protected species. o Areas within the site boundary which can be reserved for protected species. o All information regarding wetlands within the site boundary and surrounding aquatic habitats where station construction/ operations might affect.

Table 2. Nuclear Siting Considerations by Planning Stage

Category	Siting Guide Section	Exclusionary/Avoidance Factor Assessment (Focus of the GGS Initial Siting Evaluation)	Decision Planning	Licensing
Socio-economic Considerations	3.3(1)	• Exclude public amenity areas established by federal, state, and local agencies. • Exclude national parkland. • Exclude national wildlife refuges. • Exclude wilderness areas. • Exclude national marine sanctuaries. • Exclude cultural resources, such as American Indian lands, national/historic landmarks, etc. • Maximize distance, to the extent practical, to the above criteria.	• For sites nearby exclusionary or avoidance criteria, engage stakeholders early on plans regarding nuclear siting/planning. • Evaluate labor requirements and the region's ability to support nuclear labor pool. • Assess local community support for project. • Quantify local/state/federal future adjacent land uses, including zoning.	• Engage with local communities regarding construction/operations plans, and the positive and negative effects to the community. • Collect and compare population data for minorities and low-income populations.
Engineering and Cost-Related Considerations	3.4(1)	• Exclude areas beyond maximum practical pumping distance. • Avoid areas of high slope. • Avoid areas that may incur high costs for remediation for site suitability (e.g., coal ash ponds).	• Qualitatively evaluate associated engineering and regulatory costs associated with water supply, pumping distance, seismic, civil works, environmental remediation, heavy transport access, transmission costs, land rights, and labor rates for each potential site.	

Notes:

1. Multiple subsections in the EPRI Siting Guide for noted sections are applicable. Consult the EPRI Siting Guide (Reference 1) for specifics.
2. Population density and proximity to "hazardous land usage" requirements are applicable to gigawatt-scale light water reactors. These requirements are not expected to be applicable to smaller advanced reactors currently in development. Nuclear developers are currently working to allow their designs to site closer to population and to integrate potential use cases for co-generation (i.e., process heat, hydrogen production, etc.) leveraging nuclear power.

GGS SITING EVALUATION

The following sections outline the results of the GGS initial siting evaluation, including detailed information regarding health and safety criteria, ecological considerations, and socioeconomic considerations. This section provides an evaluation of the exclusionary and avoidance factors listed in Table 2, as well as insights regarding future stages (e.g., later stages of Decision Planning and Licensing) for PPL's consideration.

Health and Safety Criteria

Criteria in this section assess a site's feasibility to host a nuclear reactor within its design limits. Any site should seek to minimize both natural and manmade hazards to a potential nuclear generating station.

Geology/Seismology

There are no exclusionary or avoidance factors related to geology/seismology for GGS.

Geology and seismology considerations during nuclear regulatory siting often require extensive investigation and technical considerations from a design perspective. At a high level, areas which have a greater than 2% probability of exceedance (PE) chance of exceeding 0.3g of ground acceleration in 50 years should be excluded from consideration. While new reactors are designed to take on higher seismic loading, accommodating for higher, site-specific seismic loading may become cost prohibitive. Therefore, nuclear generating station sites should seek to minimize seismic loading potential to the extent practical.

The United States Geological Service (USGS) publishes hazard maps assessing seismic activities. According to the USGS Unified Hazard Tool, the GGS site has a 2% PE less than 0.08g, as shown in Figure 6, and is well below the 0.3g limit.

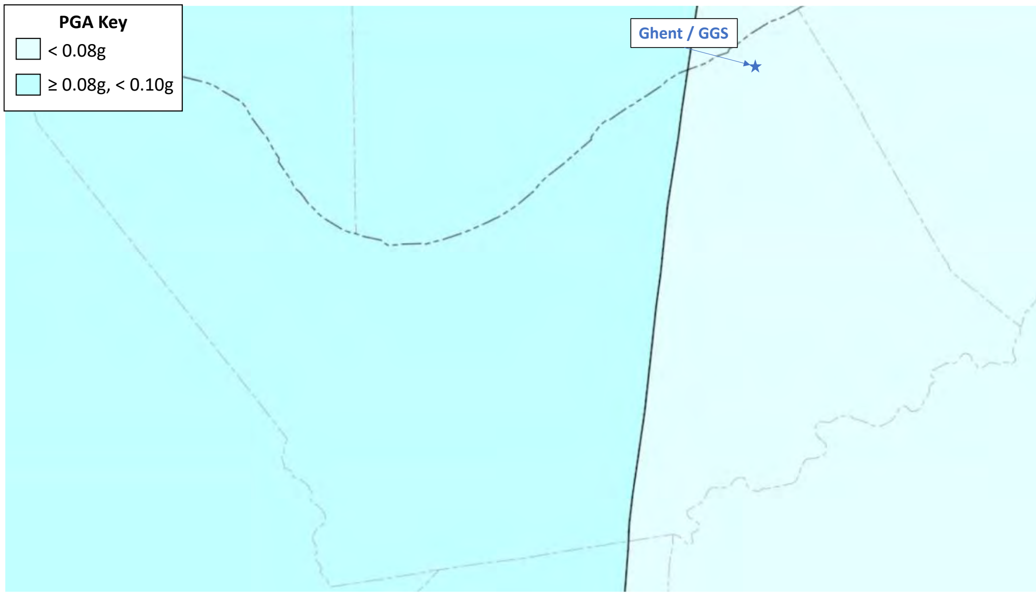

Figure 6 USGS 2% PE Map over 50 Year Timespan for GGS site (Reference 18)

Other geologic/seismologic siting considerations must be made during later stages of evaluation (i.e., licensing) which require extensive use of geologic/seismologic specialty subcontractors who can quantify credible threats in the area.

Cooling Water Requirements

There are no exclusionary or avoidance factors related to water supply for nuclear siting at GGS.

Water supply is a key consideration when it comes to siting a nuclear generating station. There are several methods for utilizing cooling water at a nuclear generating station, and as such, water supply availability is a key influencer of balance of plant (BOP) design. The most limiting configuration (e.g., the configuration which consumes the most water) is a once-through cooling system using water cooled condensers. More water efficient systems use the atmosphere as a final cooling source/heat sink. Special attention must be given to BOP systems, their implicit tradeoffs between water usage and overall efficiency from an economics and electrical output perspective, and potential low flow conditions of the Ohio River. Additionally, attention should be given to the policies and laws regarding the use and consumption of cooling water from the Ohio River (e.g., water withdrawal and discharge permits).

Exclusionary / Avoidance Factor Assessment

GGS has four pumps, each with 21,000 gallons per minute (GPM) of pumping capacity, for a maximum of 84,000 GPM. Based on input from PPL, a minimum of two pumps are used during operation, corresponding to 42,000 GPM when each pump is operating at maximum capacity.

Historical data lists station water usage as 56.9 million gallons per day, which corresponds to approximately 39,500 GPM (Reference 19).

Streamflow and water level of the Ohio River is measured by the United States Geological Survey (USGS) agency at many locations along the river. Upstream of GGS, water conditions are measured by the USGS at the Markland Dam near Warsaw, KY. Historical streamflow conditions in ft^3/s (1 ft^3/s ≈ 448.83 GPM) from October 2015 through December 2022 are shown in Figure 7.

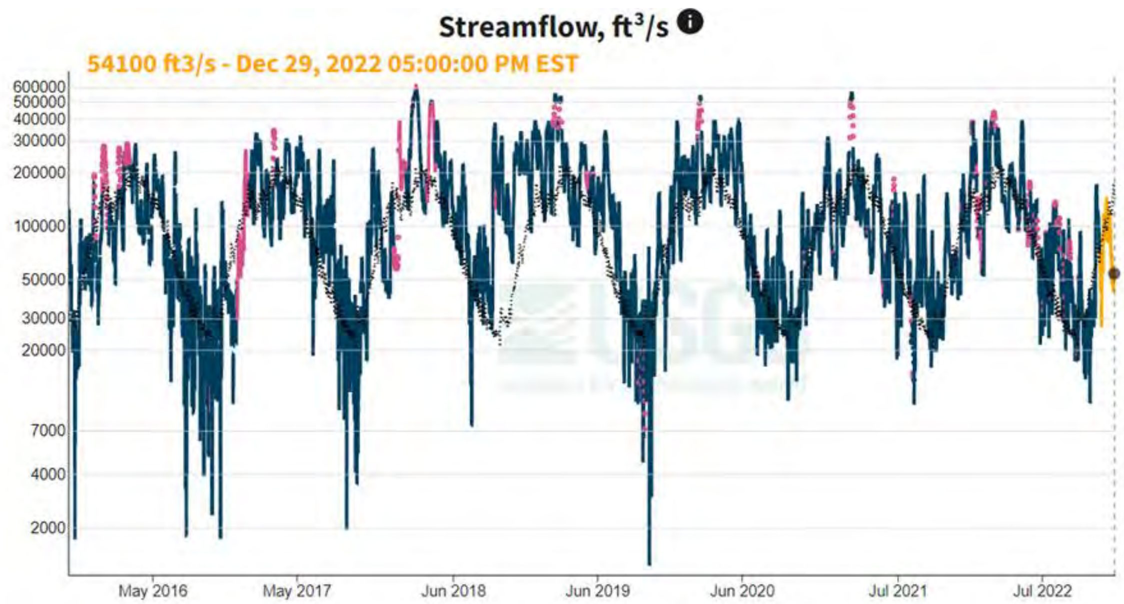

Figure 7 Historical Markland Dam Flow Conditions (Reference 20)

As shown in the figure, stream flow conditions vary based on the season, with the lowest flow rate occurring in fall. The lowest value in the recorded data range is 1240 ft^3/s (~556,500 GPM) measured in October 2019. Assuming a nuclear generating station's water usage is bounded by the current maximum water intake at GGS, the Ohio River provides suitable cooling water. If water availability changes or regulations on using water from the Ohio River change, many nuclear technology vendors are developing air-cooled options that can be leveraged.

Water Permits

GGS currently has a wastewater discharge permit through the Kentucky Pollutant Discharge Elimination System (KPDES) (Reference 21). The KPDES permit defines the water discharge requirements of GGS, including effluent limitations and monitoring requirements. It is likely that a nuclear generating station at GGS will require a similar KPDES permit for water discharges.

Currently, GGS does not require a water withdrawal permit due to its status as a steam generating plant whose retail rates are regulated by the Kentucky PSC (Reference 22). However, for use cases beyond providing electricity to the grid, such as for providing process heat to industrial customers, a water withdrawal permit may be needed. PPL may coordinate with the Kentucky Energy and Environment Cabinet Division of Water to determine water permitting requirements.

Ambient Air

Ambient air temperatures are not used as exclusionary or avoidance criteria. Rather, publicly available temperature information should be used to inform station cooling considerations at later stages of planning.

The objective of this criterion is to rate sites with respect to specific cooling system requirements related to ambient air characteristics. Ambient air characteristics of a potential site affect the design of heat removal systems. Ambient temperature levels found at sites evaluated in recent siting studies have not been a major concern, and it has not been necessary to apply this as either an exclusionary or avoidance factor in the early phases of site selection (Reference 1).

High-level temperature data for the GGS site are provided in this section for reference during the Decision Planning stage. Figure 8 summarizes average high and low temperature data from the National Oceanic and Atmospheric Administration (NOAA) (Reference 23).

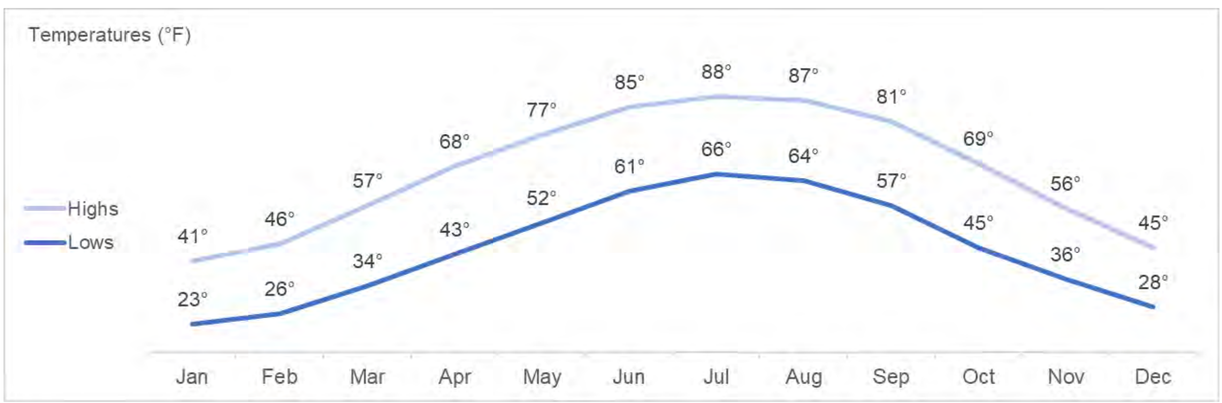

Figure 8 Average Ambient High and Low Temperature by Month for Ghent, KY.

Flooding

Some PPL-owned land near GGS is classified as “Zone A” probability floodplain and should be excluded when developing a nuclear site layout/plot plan. All other land owned by PPL within their site boundary do not present any exclusionary or avoidance factors related to potential flooding considerations. Additionally, while not an exclusionary factor, PPL will need to evaluate flooding considerations associated with the Ohio River, and what engineering measures will need to be taken (if any) to mitigate the risk of site flooding.

The Federal Emergency Management Agency (FEMA) provides flood maps for insurance related purposes. Figure 9 shows areas of potential flood risks around the GGS site. Areas known as “100-year flood zones” or “Zone A” areas are areas that have a 1% chance of experiencing or exceeding “base flood” conditions per year. These areas are shown in light blue and are marked as “1% Annual Chance Flood Hazard” areas in Figure 9.

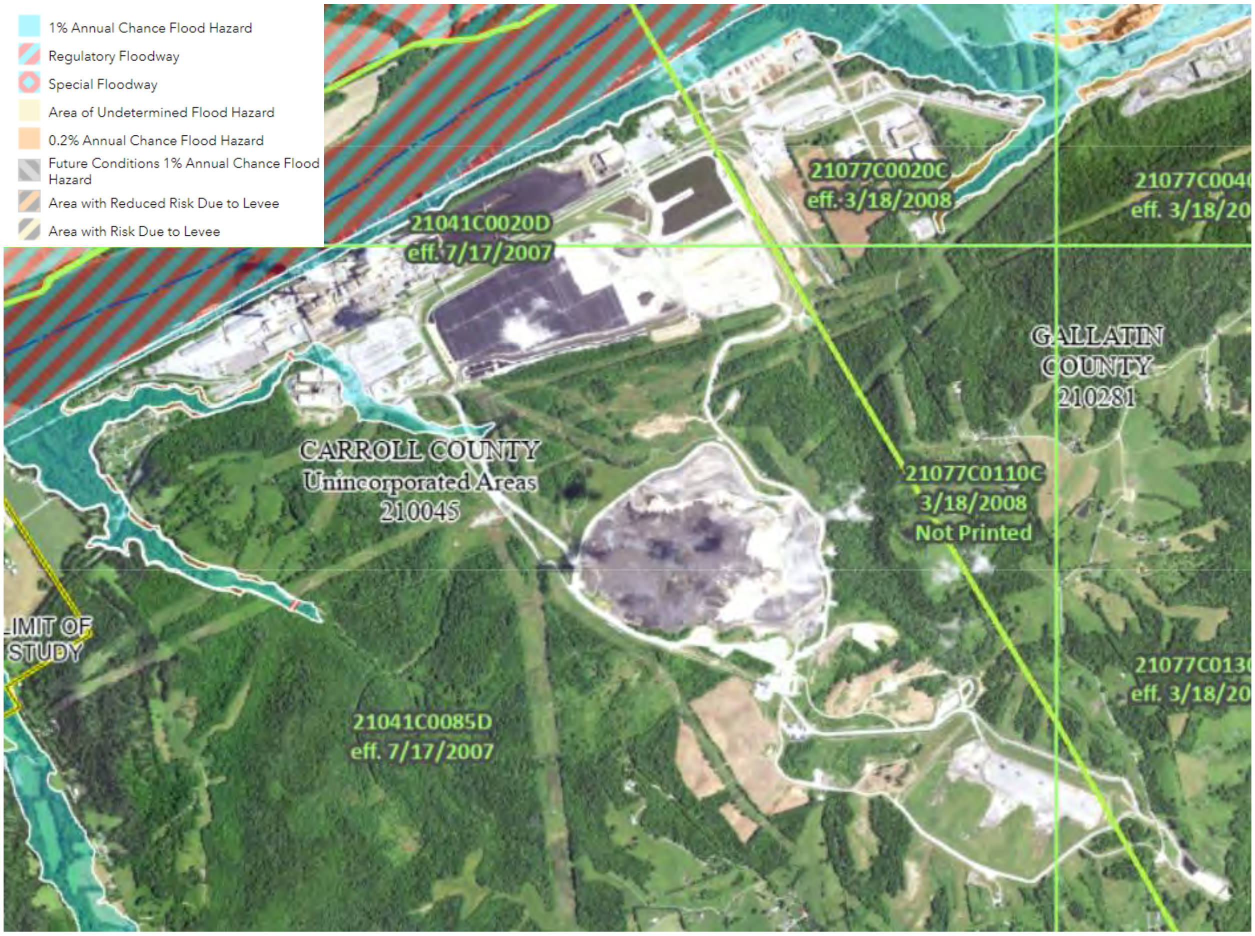

Figure 9. FEMA Flood map of GGS (Reference 24).

Later evaluations should determine the flooding potential of GGS and characterize other possible flooding hazards, potentially including the Markland Dam, which is within 5 miles of GGS and upstream of GGS on the Ohio River.

Nearby Hazardous Land Uses

There are no exclusionary factors at GGS related to nearby hazardous land uses, but there are some avoidance factors that require additional investigation.

Historically, the NRC required applicants to characterize nearby hazardous land uses when assessing site feasibility. Hazardous land uses are associated with external stakeholders that may pose a threat to nuclear station construction and operation, such as nearby transportation routes, and industrial and military facilities. Ideal candidate sites have suitable distance between the site and potential hazardous land uses. For potential hazardous land use, NRC Regulatory Guide 4.7 (Reference 3) suggests candidate sites should avoid hazardous land uses within 5 miles of a proposed site and avoid major airports within 10 miles of a proposed site. This requirement is applicable to large light water reactors and is not expected to be applicable to smaller advanced reactors currently in development. Currently, nuclear developers are considering potential use cases for co-generation (i.e., process heat, hydrogen production, etc.) in addition to electricity leveraging nuclear power. These use cases would require a nuclear reactor to be sited close to potentially hazardous land uses.

Exclusionary Factor Evaluation

Nuclear generating stations cannot be sited on DOD reserved land or be located within 10 miles of a major airport. Figure 10 shows federally reserved land in Kentucky, Indiana, and Ohio and that GGS is not located on DOD reserved land (Reference 25). Additionally, the largest airports near Ghent, KY, are located more than 10 miles away from GGS (Reference 26). Table 3 summarizes hazardous land screening criteria for the GGS site.

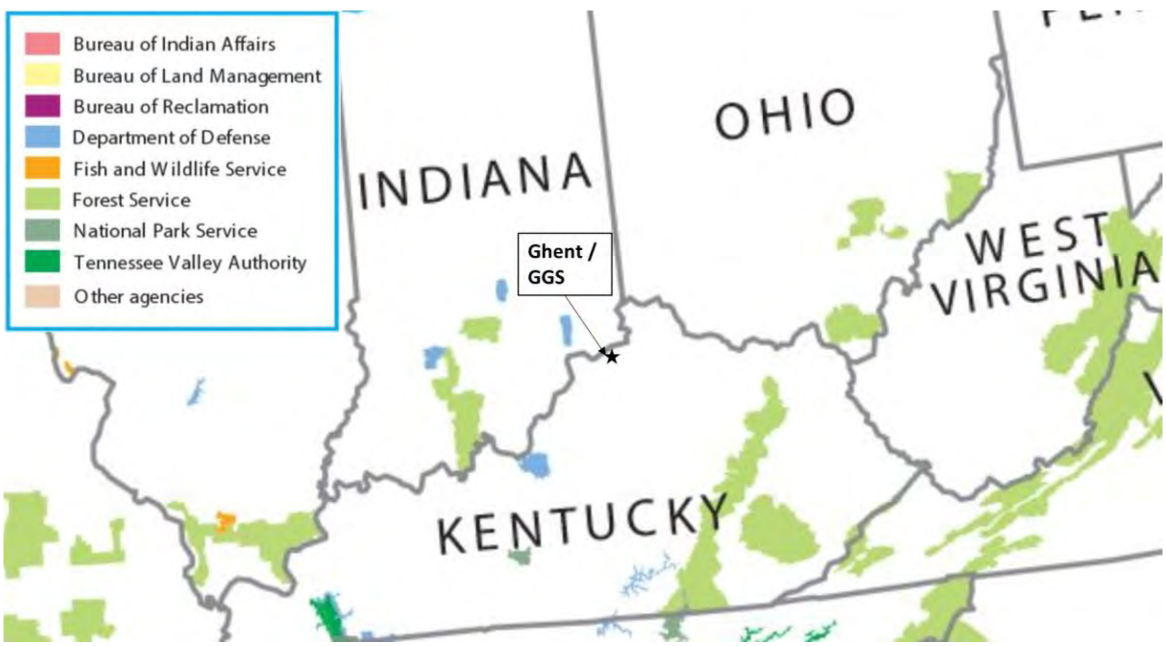

Figure 10. Overview of federally reserved land in Kentucky, Indiana, and Ohio (DOD-owned land is in blue) (Reference 25).

Table 3. GGS Hazardous Land Use Exclusionary Factor Evaluation

Criteria	Acceptance Criteria	Assessment	Notes
DOD Military Installations	Reactor should not be sited on DoD reserved land	Satisfactory	GGS Site Property Boundary Not Situated on DOD Reserved Land (Reference 25)
Major Airports	At least 10 Miles from the nearest major airport	Satisfactory	No Major Airport Situated within 10 miles of GGS site (Reference 26)

Based on publicly available information, GGS has no nearby hazardous land use that would preclude the siting of a nuclear generating station. There are a few nearby potential land hazards that require additional investigation as avoidance factors (e.g., CCR storage, nearby industrial facilities). Additionally, PPL should monitor local plans for potential future hazardous land uses and monitor evolutions in NRC's requirements for smaller advanced reactors.

CCR Storage and Concurrent Coal Unit Operations

When siting a nuclear generating station on land near an operational coal plant, it is important to consider the status and location of CCR storage facilities on the site property. CCR, due to the combustion process, typically contains higher concentrations of metallic compounds, heavy metals, and radionuclides than coal does. These components of CCR require proper controls to prevent the contamination of air, waterways, and drinking water (Reference 27). Additionally, the NRC requires the assessment of baseline or background environmental conditions at a site, which includes radiological and non-radiological contamination in soils and groundwater. An entity submitting a license application must identify in its environmental report to the NRC "all relevant, reasonably foreseeable mitigation measures that could reduce or avoid adverse effects, even if they are outside the jurisdiction of the NRC" (Reference 28). It is likely that an environmental report for GGS would include discussion of the remediation strategy for the CCR storage facilities at GGS and any EPA requirements as they relate to CCR.

CCR can also add complexity to the siting process due to potentially radioactive material. Coal can naturally contain trace quantities of radioactive material (e.g., natural uranium and thorium, along with their natural decay products) and after combustion, the radioactive material may be more concentrated. According to the EPA and depending on the amount of radioactive material in the coal before combustion, radioactive material concentrations may be 3 to 5 times higher than background levels in the average soil of the United States. The most common radionuclides and their decay products in CCR are uranium, thorium, potassium, and radium (Reference 29). These may increase base radionuclide loading in or near the CCR storage facilities. The added siting process complexity comes from the effort of quantifying base radionuclides in site soil samples; any additional radionuclides in the soil following nuclear generating station operation will be the nuclear generating station owner's responsibility.

Without setting a clear boundary for nuclear generating station operations, concurrent coal plant operations (including the transport of CCR to a storage location) may result in the nuclear generating station being held responsible for radionuclides that were originally from coal plant operations. Due to footprint constraints and other considerations related to engineering and costs at GGS, if a new nuclear generating station is to be sited at GGS, additional CCR remediation and adjustments to current CCR transport practices may be required. Currently, PPL is selling some of its CCR to other users and should continue to do so to reduce overall ash inventory on site.

Nearby Industries

Although nuclear power has historically been used for electricity generation, nuclear power can also be used for co-generation (i.e., using steam for both electricity and process heat production). The high temperatures that some advanced reactors are being designed for may improve the business case for integrating industrial customers for process heat or producing hydrogen via electrolyzers. GGS is situated near several chemical and manufacturing facilities that may benefit as end-users of nuclear-generated process heat or hydrogen. In general, smaller advanced reactors, due to the inherently safe nature of their designs, are expected to be able to be sited close to or adjacent to nearby industries and other hazardous land uses. One project worth monitoring for their progress in nuclear cogeneration is the Dow and X-energy Advanced Reactor Demonstration Program (ARDP) project. In this project, Dow is collaborating with X-energy to install Xe-100 reactors at one of Dow's U.S. Gulf Coast sites. The reactors are intended to provide both power and steam to the site (Reference 30). This project may establish an NRC precedent for siting a nuclear reactor near industrial facilities and should be monitored if PPL decides to move forward with the Decision Planning stage, especially if GGS is to provide process heat or hydrogen to local industries. The potential for a nuclear generating station sited near GGS to provide heat to nearby industrial customers was explored further in the complementary technology assessment provided to PPL. Insights for industrial heating are also provided in a public report.

Hazardous Land Use Initial Decision Planning Assessment

Industrial facilities and hazardous land uses were explored based on the EPRI Siting Guide and are summarized below. Because ample data is publicly available, Table 4 provides observations regarding Decision Planning criteria, provided for convenience. All criteria depend on local development plans, which should be monitored for any changes. Additional investigation of all criteria highlighted in Table 4 is required to support completion of the Design Planning stage.

Table 4. GGS Decision Planning Observations

Criteria	Observations
Other Airports	Gallatin County Regional Airport opened in 2023 and is located approximately 5 miles from GGS (Reference 31).
Mining	The USGS lists several past mining features and mineral resources near GGS, but their status is either shutdown or unknown (Reference 32).
Nearby Power Stations	One hydroelectric plant (Markland Locks and Dam) is located within 5 miles of the current GGS site (Reference 33) and is discussed in the next row. Additionally, the coal plant retirement date should be considered early in the planning process. Depending on coal plant operations and decommissioning plans, additional evaluations may be required (e.g., a control room habitability analysis due to anhydrous ammonia from coal plant storage (Reference 34)).
Dams	One hydroelectric dam (Markland Locks and Dam) is located within 5 miles from GGS and upstream on the Ohio River (Reference 33).
Projected Facilities	PPL should monitor local activities to assess if hazardous facilities will be constructed soon within 5 miles of GGS.
Distance from Oil and Gas Fields	Several oil and gas fields are located near GGS (Reference 35).
Buried Pipelines	Crude oil and natural gas pipelines are located more than 5 miles from GGS (Reference 33).
Major Manufacturing and Chemical Facilities	Several manufacturing and chemical facilities are located within 5 miles of GGS (Reference 36). These facilities may present a risk to siting or could benefit from a nearby carbon-free generation facility (e.g., if the facilities could be customers of nuclear-produced steam).
Rail Lines	There is a rail line situated near the GGS site (CSXT) (Reference 37).
Major Ports/ Docks	There are no major ports/docks located within 5 miles of GGS site (Reference 36), though there is a port in Ghent that moves commodities such as liquid chemicals (Reference 38).
Refineries	No refineries are located within 5 miles of GGS (Reference 36).

Extreme Weather Conditions

There are no exclusionary or avoidance factors related to extreme weather conditions for GGS.

A site's meteorological attributes are seldom considered an exclusionary factor for siting. A power station is typically engineered to withstand extreme weather conditions. As a result, designing to withstand extreme weather is a matter of cost. Meteorological considerations are primarily important when comparing candidate sites to one another.

During the Licensing stage, PPL will need to collect multiple years of high quality, on-site meteorological data to quantify the potential for extreme weather conditions. To provide an assessment of GGS weather conditions, Table 5 shows publicly available meteorology data for GGS. To compare GGS weather data to an approved nuclear generating station siting permit, Clinch River Nuclear (CRN) Plant Parameter Enveloper (PPE) and ESP values and NRC regulatory requirements are provided for context (Reference 5).

Table 5. GGS Extreme Weather Observations and Comparison

Assessment Criteria	GGS Information [CRN PPE/ESP Values]
Fastest mile speed (often recorded as peak gusts)	The fastest 5-second wind speed recorded between 2000-2023 according to NOAA Climate Data Online tools was 76.1 MPH in 2006 (Reference 39). Note: The closest weather station to Ghent, KY, with peak gust data is located at Cincinnati/Northern Kentucky International Airport. Weather conditions at Ghent, KY may vary slightly. Additionally, the definition of a wind gust is a “sudden, brief increase in speed of the wind,” with durations “usually less than 20 seconds.” As such, the fastest 5-second wind speed data is applicable as a peak gust measurement (Reference 40). [CRN: 73 MPH]
Number of tornadoes per 10,000 square miles (state average)	Kentucky averages between 4 and 5 tornadoes per 10,000 sq. miles a year (Reference 41). Per Reg Guide 1.76 (Reference 42), GGS falls into intensity Region I, where maximum tornado windspeeds are not expected to exceed 230 MPH. [CRN Location: between 1 and 3 tornadoes per 10,000 sq. mi.]
Number of hurricanes making landfall, direct hits on state	Kentucky, being a landlocked state, does not experience the winds that would be associated with a hurricane on a coastal location. However, it can experience the effects of the weather system as it passes through the state. From 1990 to 2019, Kentucky has experienced 8 tropical depressions, with maximum wind gusts reported at over 40 mph (Reference 43). [CRN: 1 tropical cyclone]
24-hour precipitation values	Kentucky’s 24-hour precipitation record is 10.48 inches. This is less than outlined in the CRN PPE and is therefore not expected to be an issue (Reference 44). [CRN: 18.8 in/hr]

Population

Based on a preliminary analysis, population should not be an exclusionary or avoidance factor at GGS. Depending on the area of analysis around GGS and the concentration of the large transient worker population at Ghent, the population density criterion may need to be explored in more detail during later planning phases.

The purpose for evaluating the surrounding population is to minimize the effect to surrounding communities in the event of inadvertent radioactive release. Population is a driving consideration for general nuclear generating station siting, since relocating surrounding population to host a site is something that cannot be resolved with engineering solutions.

The NRC Reg Guide 4.7 states the following related to population (Reference 3): "A reactor should be located so that, at the time of initial plant approval within about 5 years thereafter, the population density, including weighted transient population, averaged over any radial distance out to 20 mi (cumulative population at a distance divided by the circular area at that distance), does not exceed 500 persons per square mile. A reactor should not be located at a site where the population density is well in excess of this value."

The EPRI Siting Guide provides a more conservative criterion than the NRC Reg Guide 4.7 and limits the population density criterion to 300 persons per square mile. This conservatism potentially accounts for additional population growth that could occur between the time of siting and plant construction. It should be noted that the NRC population density criterion is not a strict requirement and exceedances of the limit are acceptable provided the population density is not significantly above the limit. However, choosing a site with an exceedance in population density will require a clear basis, rationale, and justification for using the proposed site compared to alternative sites with lower population densities.

As of 2020, the United States Census Bureau data for Ghent, Kentucky, shows that an estimated 2,409 workers commute to Ghent on a normal basis (Reference 45). Additionally, based on the census data, the town of Ghent has a permanent population of 363. Ghent is ~1.3 miles away from GGS. For population density, larger populations fitting in smaller areas would be most conservative. Using a conservative assumption that the 2,409 commuters work 12-hour days / 7 days a week (i.e., 2,409 people are only near GGS half the time) and that all population is within the 1.3-mile radius of GGS, the commuter-weighted population density around GGS is calculated as shown below.

$$Circular\ Area\ around\ GGS = \pi * (1.3\ mi)^2 = 5.31\ mi^2$$

$$Pop. Density\ near\ GGS = \frac{2{,}409\ commuters * 0.5 + 363\ permanent}{5.31\ mi^2} = 296\ \frac{people}{mi^2}$$

Based on this calculation, population density is not an exclusionary factor to siting at Ghent, though it is close to exceeding EPRI's Siting Guidance criterion (Reference 1). Furthermore, the distribution of the transient worker population, the proposed location of a nuclear generating station, and the population's proximity to the nuclear generating station may impact the population density criterion. It is expected that because of the amount of unpopulated land near GGS, the population density will be within limits. However, continued population monitoring should be performed if GGS is to be pursued for a nuclear generating station. The regulator's stance on population density should also be monitored, as the population density criterion may be revised to account for the inherently safe nature of advanced reactor designs.

The other exclusionary / avoidance factor of population is related to the nuclear generating station's distance to population centers. For this analysis, there are three main parameters that must be defined:

1. Exclusion Area (EA) Boundary (EAB) – Reg Guide 4.7 (Reference 3) states the EAB as where the station owner(s) "have authority to determine all activities within that area, including removal of personnel and property".
2. Low Population Zone (LPZ) – The LPZ is an area immediately beyond the EAB where population should be limited. Reg Guide 4.7 states a requirement on the LPZ boundary: "… the distance to the nearest boundary of a densely populated center containing more than about 25,000 residents ("population center distance") must be at least one-and-one-third times the distance from the reactor to the outer boundary of the LPZ."
3. Population Center Distance (PCD) – Population centers, as defined by 10 CFR 100.3, are densely populated clusters containing more than 25,000 people. The boundary of the population center should be determined based on population distribution, not political boundaries (Reference 3).

Because there are no densely populated areas containing more than 25,000 people near GGS, the distance to population center criteria is considered satisfied.

Table 6 summarizes the population screening criteria for the GGS site.

Table 6. GGS Population Exclusionary/Avoidance Factor Assessment

Criteria	Acceptance Criteria [1]	Assessment	Notes
Densely Populated Regions	Areas must not have more than 300 people per square mile	Satisfactory, but more investigation may be needed	Population density may be affected by transient populations and their distribution in relation to the site.
Population-center Distance	At least 1.33x the distance from exclusion area boundary to the outer boundary of LPZ (i.e., area with greater than 25,000 residents)	Satisfactory	No population centers located within hypothetical EA or LPZ surrounding GGS (Reference 36).

Notes:

1. Current reactor designers and industry groups are working to reduce the size of EAs and LPZs and associated population density requirements given the inherently safe nature of advanced reactor designs (i.e., passive safely systems). If EA and LPZ sizes are reduced, nuclear generating stations could be sited closer to population centers.

Emergency Planning

Emergency planning exclusionary or avoidance factors are not evaluated during the Exclusionary/Avoidance Factor Assessment stage. Emergency planning details often emerge during the Licensing Stage of nuclear generating station siting, and frequently require specialized subcontractor support to develop emergency planning procedures, and coordination with local communities.

New advanced reactor developers are proposing emergency planning zones (EPZs) extending only to the site boundary. This greatly simplifies emergency planning efforts during licensing and allows some plant designs to be sited closer to population centers and industrial facilities.

The GGS site is located on the Ohio River and is less than one mile away from the Indiana border and approximately 30 miles away from the Ohio border. However, the scope of stakeholders involved in emergency planning efforts will depend on the reactor design that is selected and associated EPZ size.

Regardless of the EPZ size, emergency planning may still require coordination with local industries and traffic to and from those industries, especially if hazardous materials are to be shipped. Should PPL pursue next steps, coordination with local industries and emergency response teams is encouraged. PPL should also engage with vendors for information on their EPZ plans and monitor the NRC's posture on reducing EPZ size to determine the scope of an EPZ around a nuclear generating station at GGS.

Atmospheric Dispersion

There are no exclusionary or avoidance factors related to atmospheric dispersion for GGS.

In evaluating sites for nuclear generating station feasibility, areas of greater atmospheric dispersion are preferred. Based on GGS's location within the Ohio River valley, the nearby topology could potentially lead to events where short-term atmospheric dispersion is limited (see Figure 11 for a topological map of GGS). The atmospheric dispersion characteristics at GGS should be further evaluated during Decision Planning.

Figure 11. Topology Map of Ghent Generating Station Location (Reference 46)

In later stages of siting, atmospheric dispersion is quantified by an atmospheric dispersion function (X/Q) calculated using on-site meteorological data. X/Q is determined through wind speed, wind direction, and atmospheric stability (Reference 47). GGS currently monitors wind speed and wind direction with a meteorological tower began recording data in August 2022 (Reference 48). If next steps are pursued, PPL should determine where the NRC requirements overlap with current monitoring programs.

Because of PPL's goal of operating a new nuclear generating station concurrently with the existing coal station, as well as GGS's proximity to nearby industrial facilities that may have plume interactions with the new nuclear generating station, additional analysis should be performed to ensure State and Federal requirements of the Clean Air Act are met (42 U.S.C.

7401 et seq.). Reg Guide 4.7 (Reference 3) states that the Clean Air Act may be an important consideration for nuclear generating station siting if the following factors apply:

- The site is in an area where existing air quality is near or exceeds standards
- There is a potential for interaction of the cooling system plume with a plume containing noxious or toxic substances from a nearby facility
- Auxiliary generators are expected to operate routinely

In summary, the local topology's effects on atmospheric dispersion, the area's current air quality, and potential interactions of the cooling system plume with nearby facility plumes should be quantified in later siting evaluations. Like emergency planning, atmospheric dispersion is quantified by specialized subcontracting firms leveraging on-site monitoring information and historical atmospheric data.

Radioactive Release Pathways

There are no exclusionary or avoidance factors related to radioactive release pathways for GGS.

The sole exclusionary factor for radioactive release pathways is the exclusion of areas on or near any Class I (special groundwater) sources or sole source aquifers. Per current EPA mapping systems, GGS is not situated on or near any of these areas (Reference 49). Radioactive release pathways, such as surface water and food ingestion pathways, are characterized and quantified in later stages of site planning. The effort of characterization often requires the support of specialty contractors to quantify potential radioactivity release pathways during the Licensing Stage. Since the coal plant will be operational during construction, radioactive release pathways associated with coal operations and any potential radionuclides in CCR may need to be characterized and quantified as well. Additionally, if pursuing process heat integration with industrial customers at GGS, connections to other industrial systems (e.g., providing process heat to end-users) may contribute to the potential radionuclide pathways and should be explored as well.

Transportation Safety

There are no exclusionary or avoidance factors related to transportation factors for GGS and transportation safety.

During a detailed siting evaluation, maps detailing heavy fog (<0.25 miles of visibility) around the site should be quantified. Icy conditions should also be considered.

Effects on Surrounding Ecology

For initial siting evaluations focused on assessing exclusionary and avoidance factors, nuclear generating stations must exclude or avoid areas reserved for critically endangered or threatened species and high-quality wetlands. Additionally, nuclear generating stations must exclude or avoid areas where cooling water, nuclear generating station construction, and nuclear generating station operational activities threaten local protected wildlife and wetlands.

During the Exclusionary/Avoidance Factor Assessment stage, ecological effects are difficult to characterize, as federal and state wildlife agencies continuously update threatened or endangered species and wetlands lists, and publicly available information often lags behind these decisions. Additionally, migratory behavior of potentially endangered or threatened species is difficult to assess without consulting federal and state wildlife agencies and is therefore determined during the Decision Planning stage.

Using available data, GGS is not situated near any endangered or threatened species habitats, or any protected wetlands (Reference 36), and therefore as of this writing, the GGS site is considered satisfactory from an exclusionary/avoidance factor standpoint. PPL should monitor the migratory behavior of potentially endangered/threatened species and develop environmental protection plans should endangered or threatened species migrate to land on or near GGS.

Socio-Economic Criteria

Socio-economic criteria include a wide array of considerations, including the effects on marginalized communities and minority populations, environmental justice, and effects on nearby land reserved for recreational purposes. Most of the criteria in this section rely on external stakeholder engagement and their support of a potential nuclear generating station.

The siting of a nuclear generating station can have beneficial impacts on local populations and economies. However, its siting may place strain on the available workforce and existing infrastructure (e.g., the influx of workers during a large construction project in a rural community may overwhelm hotels and local businesses). For regulatory siting purposes, the consequences and effects on the surrounding population from a socio-economic perspective must be evaluated and documented.

Land Use

There are no exclusionary or avoidance factors at GGS related to land use.

Nuclear generating stations cannot be sited on publicly reserved lands (e.g., national parkland, historic and culturally significant locations, etc.), and developers should avoid siting nuclear generating stations near these reserved lands, noting that "near" is defined by potential radionuclide release pathways.

Per publicly available maps (Reference 36), GGS is situated near (within 50 miles) reserved land (i.e., Big Oaks National Wildlife Refuge, and several Kentucky, Ohio, and Indiana state parks), representatives of which should be consulted during the Decision Planning stage. PPL would need to either develop a list of appropriate stakeholders or review a list of existing potential stakeholders who should be made aware of the potential for nuclear generating station construction and operation.

Construction and Operations-Related Effects

Construction and operations-related effects are not exclusionary/avoidance criteria but serve to inform of the capability of local communities to support the influx of workers needed to construct and operate a nuclear generating station.

Ghent, KY, is a small town, hosting 363 people as of the 2020 census (Reference 50) with an estimated transient worker population of 2,409 people (Reference 45). The EPRI Siting Guide (Reference 1) provides estimates for the number of personnel needed for nuclear generating stations. It indicates that between 900 and 2200 construction workers are needed for plants between 1000 MW and 2420 MW thermal and between 50 and 500 permanent staff are required to operate plants of the same output. Maintenance and refueling outages can typically increase the number of onsite personnel by two to six times. These values can be scaled to estimate the number of personnel needed for smaller nuclear deployments.

Because of Ghent's ability to support its current commuter population, there is unlikely to be any adverse effects from increases in population to support construction or operation of a nuclear generating station should PPL decide to continue nuclear siting efforts. Additionally, based on the town of Ghent's proximity to major metropolitan areas, such as Louisville, KY, and Cincinnati, OH, there will likely be enough housing to support the influx of staff needed to support the nuclear generating station. However, a further detailed socioeconomic assessment of the capacity of the communities around Ghent, KY to support the necessary number of workers and associated family members should be performed during later evaluations to give clarity on the expected labor resources and effects on local communities.

Environmental Justice

The environmental justice criterion is not an exclusionary/avoidance factor but informs whether disproportionate effects to minority and low-income communities could arise from siting a nuclear generating station in a location. Coal operations, including both mining and electric generation, remain a significant proportion of Kentucky's economy. Because of this, communities may be sensitive to the effects of coal facility retirements.

Proactive engagement between PPL and all relevant stakeholders (e.g., local communities, state stakeholders) for nuclear development will be an essential step during all stages of the project lifecycle. When engaging with local communities, it is important to understand the needs and perspectives of community members as well as the community's experience with the nuclear industry (e.g., power generation, waste management, uranium mining, etc.). Engagement model and conversations should be catered to individual group(s) and their interests and needs.

ENGINEERING AND COST-RELATED CONSIDERATIONS

This section discusses engineering and cost-related considerations of siting a nuclear generating station at or near GGS. This section describes exclusionary and avoidance factors related to cost, potential revenue streams from industrial customers, opportunities to reuse infrastructure, funding opportunities that PPL may choose to pursue, and PPL's potential options for a nuclear deployment at GGS.

Exclusion and Avoidance Factor Evaluation

For this initial siting evaluation, the land constraints (related to slope and CCR storage), and the maximum practical pumping distance criterion were explored due to the GGS area's site-specific topography and economic considerations for deploying nuclear on the GGS site. PPL's goal of operating the coal plant and constructing a nuclear generating station simultaneously means that a new nuclear generating station cannot be constructed on the exact coal plant footprint and nearby areas must be used instead.

Land Constraints

Areas of high slope and the allocated land for coal operations and CCR storage are avoidance factors at GGS. Addressing these factors for siting may incur significant investment.

The available land to build a nuclear generating station on PPL-owned land is limited by existing coal plant infrastructure, areas of high slope, and CCR storage areas. The amount of capacity that can be supplied by nuclear at GGS will depend on the nuclear technology chosen and its footprint requirements, as well as the costs and benefits associated with addressing slope, additional CCR storage remediation, and/or land acquisition.

PPL owns approximately 2,300 acres of land around and including the GGS site, with a significant proportion of the land allocated to CCR storage and the operating coal plant. Based on existing CCR files for GGS, all CCR storage facilities have either been remediated or will be remediated through closure-in-place or excavation (Reference 15). Remaining unallocated land within the PPL-owned land boundary is situated near CCR storage areas and/or the operating plant, which, as discussed in the Nearby Hazardous Land Uses section, may present risks to a new nuclear generating station. Additional remediation of the CCR storage areas and moving CCR offsite may open additional land for nuclear generating station development and reduce the environmental risks associated with CCR at GGS.

Additionally, the GGS site slope may present an economic limitation, as sites with steeper slopes cost more to prepare for construction through grading and backfilling of the land. Oak Ridge National Laboratory (ORNL) siting analyses exclude land with slopes greater than 12% when evaluating sites for nuclear reactors (Reference 51); advanced reactor technologies with smaller footprints may have greater flexibility in slope, but 12% slope remains a conservative value for this initial siting evaluation. The Oak Ridge Siting Analysis for Power Generation Expansion (OR-SAGE) tool was used to characterize the slope around the GGS site (Reference 52).

Areas in purple shown in Figure 12 are areas with slope greater than 12% in the GGS site and nearby PPL-owned land; areas in red in the figure are areas that are currently being used for other purposes, such as the coal plant, CCR storage facilities, or the transmission substation that are recommended to be avoided (see Figure 3 and Figure 4); the area in light blue is the largest contiguous area that avoids high slope and allocated land.

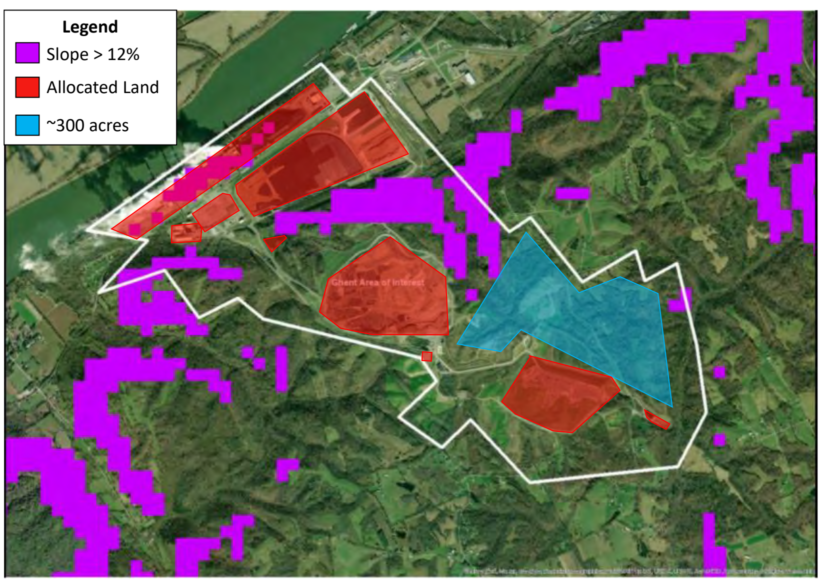

Figure 12. Slope and Allocated Land Around GGS.

There are approximately 1,300-1,500 acres of land at GGS that avoid high slope and allocated areas, which could be used for a nuclear generating station. This total area of land, however, is dispersed throughout the site; contiguous areas that avoid high slope and allocated areas are limited. In the ideal case, the nuclear generating station and its construction lay-down area would have the following characteristics:

- The nuclear generating station and its construction lay-down area would not impact current coal operations (e.g., disturb roads from the plant to the CCR landfill or existing transmission lines).
- The site would be situated far enough away from the existing coal plant and CCR storage facilities to limit interaction with a nuclear generating station (as discussed in the Nearby Hazardous Lands section),
- The site would only use contiguous areas for siting the nuclear units (e.g., units would be sited next to each other).

The largest continuous area that avoids existing roads leading from the coal plant to the CCR landfill is approximately 300 acres (see area in light blue of Figure 12).

The EPRI Siting Guide (Reference 1) estimates that, for small advanced reactors (50 to 300 MWe), the plant footprint is between 25 to 200 acres and the site footprint is between 50 and 500 acres. An additional 50 to 100 acres is estimated for construction laydown. Without additional investment to address noted avoidance factors, a new nuclear generating station's capacity may be limited on the land currently owned by PPL.

The site footprint is dependent on site-specific characteristics and encompasses the plant footprint. The plant footprint, site footprint, additional construction, and the components in each are described below (Reference 1):

- Plant footprint – includes all areas needed to support the operating plant, such as parking, administrative buildings/offices, warehouses, waste storage, switchyard, cooling towers, laydown and storage areas, nuclear reactor, and power generation system. This also includes the protected area over and above any components.
- Site footprint – includes the plant footprint and any additional areas declared as part of the site, which can depend on characteristics such as existing property boundaries, locations of water sources, environmental considerations, the exclusion area boundary (EAB), and future site plans (e.g., plans to build additional nuclear units).

  EPRI siting guidance states that when exact values for site footprints are not known, a plant's footprint can serve as the absolute minimum size for a site. Additionally, the size of the EAB may also serve as a lower estimate for site footprint.
- Additional construction area– includes temporary area needed for construction that may or may not end up as part of the site footprint. This land must be accounted for in an environmental review.

To expand the amount of land available for a nuclear generating station, and to reduce risks associated with CCR storage facilities on the station, CCR may need to be moved offsite. PPL should also explore whether areas of high slope would be needed for construction and if they could be used to host a nuclear generating station.

Maximum Practical Pumping Distance

Maximum practical pumping distance is a cost-related exclusionary factor to consider for siting a new nuclear generating station. Oak Ridge National Laboratory analyses exclude land areas greater than 20 miles from a cooling water makeup source with at least 50,000 gpm for small modular reactor (SMR) plants (Reference 51); this 20-mile upper limit was applied to this initial siting evaluation. PPL may choose to increase or decrease their maximum pumping distance limit based on their engineering judgement. Based on the assumption that the Ohio River will be the source of cooling water, all areas owned by PPL around GGS are considered satisfactory.

Integration with Potential Industrial Customers

PPL should consider the cost implications and revenue benefits associated with integrating nuclear technology at GGS with industrial neighbors. Some advanced reactors are being designed for cogeneration, with process heat and hydrogen through electrolysis as potential products delivered to industrial customers. Integrating process heat or hydrogen production at a nuclear generating station at GGS may improve the nuclear business case due to enabling additional revenue sources from industrial customers. However, the associated infrastructure for transporting and storing the products would need to be developed (e.g., steam or hydrogen pipelines, and/or hydrogen storage) and would increase infrastructure cost.

The conditions that an industrial customer requires (e.g., steam temperature and pressure) and the distance from the generating source to the end user will need to be evaluated to ensure customer needs can be met and to evaluate efficiency losses through piping. If process heat or hydrogen is to be sold to industrial customers from GGS, PPL should coordinate with nearby industrial facilities or seek government funding for building the infrastructure. Additional insights were provided to PPL in a complementary GAIN report focused on nuclear technology assessment at GGS. PPL may also be able to leverage insights from ongoing EPRI work regarding potential for nuclear-powered process heat or hydrogen production.

Reusable Infrastructure Considerations

Because GGS currently has infrastructure in place for the coal station, certain site attributes (e.g., transmission substation, railways for material access) should be evaluated for potential re-use as infrastructure for a nuclear generating station (References 2 and 4). Reuse of some equipment/infrastructure may be limited if the coal plant is to operate during a nuclear deployment. During the Decision Planning stage, PPL should evaluate any potential cost savings associated with existing coal infrastructure on site and where appropriate leverage existing infrastructure as a means of reducing overall costs. GAIN provided additional insights to PPL related to preferred nuclear technologies in the complementary GAIN nuclear technology assessment report.

Remediation Considerations

As discussed previously, CCR presents challenges to a nuclear generating station, including environmental risks and limiting available land for siting a nuclear reactor. However, nuclear generating station construction on the GGS site may also affect the existing CCR storage facilities (i.e., due to construction laydown). If construction activities for a new nuclear generating station are situated near a closed-in-place CCR storage facility, then the facility's post-closure care plan may require amendment (Reference 53).

Because of the previously discussed complications and depending on the capacity planned for the nuclear generating station, additional remediation may be required beyond what is currently included in GGS's plans. The additional remediation could serve multiple purposes: 1) to increase the land available for siting a nuclear generating station[7] and 2) to reduce the potential risks of CCR effects on the nuclear generating station siting process. The amount of investment may differ depending on the scope and purpose of the remediation (e.g., remediation to increase available land may cost significantly more than smaller scope efforts to reduce environmental risks). Additional remediation options include:

- Removing CCR from GGS through recycling or reuse (i.e., beneficial use) of the CCR
- Transporting CCR from GGS offsite to a permitted landfill by truck, rail, or barge

Costs for removing CCR from the site may be significant, as shown by an assessment prepared for Dominion Energy by AECOM in 2017 (Reference 54). The report estimated CCR remediation costs may range from tens of millions of dollars to several billion dollars, depending on the size of CCR storage, closure and CCR transport option, time frame for closure, and the site's proximity to permitted landfills or CCR end-users. There are also additional considerations for removal, such as transportation increasing the risk of spills or CCR dust exposure.

PPL may consider exploring opportunities to remove CCR from the GGS site or acquire additional land prior to the nuclear generating station siting process. If CCR removal is pursued, PPL may choose to leverage existing funding opportunities from state or federal resources.

[7] An owner or operator that closes a CCR unit by removing CCR is not subject to post-closure care criteria of the CCR unit based on 40 CFR 257.104(a)(2), a regulation describing post-closure care requirements of CCR units. As a result, removing CCR should enable the land to be used for other purposes.

Funding Opportunities for Nuclear

The Inflation Reduction Act (IRA) includes funding opportunities and incentives for the private sector to invest in and pursue clean energy technologies. Provisions include both Production Tax Credits (PTCs) and Investment Tax Credits (ITCs) that are available to developers and owners of future advanced reactor projects. It is important to note that these tax credits are applied after the facility is constructed and operating. Both the PTCs and ITCs include eligibility criteria that will affect not just the yes/no eligibility, but also the available credit amount when it is available. These considerations include (Reference 55):

- Facilities deployed in energy communities (e.g., coal communities) receive larger credits.
- Facilities deployed with significant US content can capture larger credits.
- Credits can be dependent on overall US progress achieving target greenhouse gas reductions.
- There are options for tax credits as well as direct payment from the Treasury (albeit with a reduction in credit amount).

Energy communities, including areas economically reliant on coal-fired power plants, are one of the areas targeted for support by the IRA. For clean energy projects and facilities (e.g., nuclear projects) located in energy communities, developers can receive a bonus of up to 10 percentage points on top of the ITC or an increase of 10 percent for the PTC (Reference 56). In addition to the previous credits and depending on federal guidance, new reactor developers may be able to leverage production tax credits for up to ten years to generate clean hydrogen; these credits may be useful for GGS depending on nearby industrial customer needs (Reference 56).

Another program included in the IRA for supporting energy communities is the Energy Infrastructure Reinvestment (EIR) Financing Program at the Department of Energy (Reference 57). The EIR includes funding for projects that:

1. Retool, repower, repurpose, or replace energy infrastructure that has ceased operations, or
2. Enable operating energy infrastructure to avoid, reduce, utilize, or sequester air pollutants or anthropogenic emissions of greenhouse gases.

The EIR also includes the remediation of environmental damage associated with energy infrastructure under its scope (Reference 58). The program appropriates $5 billion in credit subsidies through September 30, 2026, to support loan guarantees of up to $250 billion for eligible projects (Reference 55).

Potential Options for GGS

The limited footprint at GGS for a nuclear generating station could challenge potential nuclear deployment, with additional remediation or land acquisition potentially providing a solution for larger capacity deployments. PPL has the following options if nuclear power is to be explored at GGS:

1. Deploy nuclear at GGS without any additional remediation (which may limit the nuclear-provided capacity available at GGS). Define a clear boundary for the nuclear generating station to limit liabilities introduced from coal operations.
2. Remove CCR from CCR storage areas at GGS to increase the footprint available for siting nuclear and reduce any liabilities to siting a nuclear generating station from CCR. Pursue funding opportunities for the remediation effort as available.
3. Acquire favorable land near GGS to expand the available footprint for nuclear or explore other areas beyond GGS for nuclear development.
4. Explore areas of high slope for nuclear construction and determine if construction costs would be prohibitive. This option may be pursued with any of the previous options.

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