

**U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science Directorate
Geologic Resources Division**



Lincoln Boyhood National Memorial

GRI Ancillary Map Information Document

Produced to accompany the Geologic Resources Inventory (GRI) Digital Geologic Data for Lincoln Boyhood National Memorial

libo_bedrock_geology.pdf

Version: 1/11/2023

Geologic Resources Inventory Map Document for Lincoln Boyhood National Memorial

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Geologic Resources Inventory Map Document



Lincoln Boyhood National Memorial, Indiana

Document to Accompany Digital Geologic-GIS Data

[libo_bedrock_geology.pdf](#)

Version: 1/11/2023

This document has been developed to accompany the digital geologic-GIS data developed by the Geologic Resources Inventory (GRI) program for Lincoln Boyhood National Memorial, Indiana (LIBO).

Attempts have been made to reproduce all aspects of the original source products, including the geologic units and their descriptions, geologic cross sections, the geologic report, references and all other pertinent images and information contained in the original publication.

This document contains the following information:

- 1) **About the NPS Geologic Resources Inventory Program** – A brief summary of the Geologic Resources Inventory (GRI) Program and its products. Included are web links to the GRI GIS data model, and to the GRI products page where digital geologic-GIS datasets, scoping reports and geology reports are available for download. In addition, web links to the NPS Data Store and GRI program home page, as well as contact information for the GRI coordinator, are also present.
- 2) **GRI Digital Map and Source Map Citations** – A listing of the GRI digital geologic-GIS map produced for this project along with sources used in their completion. In addition, a brief explanation of how each source map was used is provided.
- 3) **Map Unit List** – A listing of all geologic map units present on maps for this project, generally listed from youngest to oldest.
- 4) **Map Unit Descriptions** – Descriptions for all geologic map units present on the GRI digital geologic-GIS map for Lincoln Boyhood National Memorial.
- 5) **Ancillary Source Map Information** – Addresses the fact that no additional ancillary map information was present on the unpublished source maps used for this project.
- 6) **GRI Digital Data Credits** – GRI digital geologic-GIS data and ancillary map information document production credits.

For information about using GRI digital geologic-GIS data contact:

Stephanie O'Meara
Geologist/GIS Specialist/Data Manager
Colorado State University Research Associate, Cooperator to the National Park Service
Fort Collins, CO 80523
phone: (970) 491-6655
email: stephanie_o'meara@partner.nps.gov

About the NPS Geologic Resources Inventory Program

Background

The Geologic Resources Inventory (GRI) provides geologic map data and pertinent geologic information to support resource management and science-informed decision making in more than 270 natural resource parks throughout the National Park System. Geologic resources for management consideration include both the processes that act upon the Earth and the features formed as a result of these processes. Geologic processes include: erosion and sedimentation; seismic, volcanic, and geothermal activity; glaciation, rockfalls, landslides, and shoreline change. Geologic features include mountains, canyons, natural arches and bridges, minerals, rocks, fossils, cave and karst systems, beaches, dunes, glaciers, volcanoes, and faults.

The GRI is one of 12 inventories funded by the National Park Service (NPS) Inventory and Monitoring Program. The Geologic Resources Division of the NPS Natural Resource Stewardship and Science Directorate administers the GRI. The NPS Geologic Resources Division partners with the Colorado State University Department of Geosciences to produce GRI products. Many additional partners participate in the GRI process by contributing source maps or reviewing products.

The GRI team undertakes three tasks for each park in the Inventory and Monitoring program: (1) conduct a scoping meeting and provide a summary document, (2) provide digital geologic map data in a geographic information system (GIS) format, and (3) provide a GRI report. These products are designed and written for nongeoscientists.

Products

Scoping Meetings: These park-specific meetings bring together local geologic experts and park staff to inventory and review available geologic data and discuss geologic resource management issues. A summary document is prepared for each meeting that identifies a plan to provide digital map data for the park.

Digital Geologic Maps: Digital geologic maps reproduce all aspects of traditional paper maps, including notes, legend, and cross sections. Bedrock, surficial, and special purpose maps such as coastal or geologic hazard maps may be used by the GRI to create digital Geographic Information Systems (GIS) data and meet park needs. These digital GIS data allow geologic information to be easily viewed and analyzed in conjunction with a wide range of other resource management information data.

For detailed information regarding GIS parameters such as data attribute field definitions, attribute field codes, value definitions, and rules that govern relationships found in the data, refer to the NPS Geology-GIS Data Model document available at: <https://www.nps.gov/articles/gri-geodatabase-model.htm>

Geologic Reports: GRI reports synthesize discussions from the original scoping meeting, follow up conference call(s), and subsequent research. Chapters of each report discuss the geologic setting of the park, distinctive geologic features and processes within the park, highlight geologic issues facing resource managers, and describe the geologic history leading to the present-day landscape. Each report also includes a poster illustrating these GRI digital geologic-GIS data.

For a complete listing of GRI products visit the GRI publications webpage: <https://go.nps.gov/gripubs>. GRI digital geologic-GIS data is also available online at the NPS Data Store: <https://irma.nps.gov/DataStore/Search/Quick>. To find GRI data for a specific park or parks select the appropriate park(s), enter "GRI" as a Search Text term, and then select the Search button.

For more information about the Geologic Resources Inventory Program visit the GRI webpage: <https://www.nps.gov/subjects/geology/gri.htm>. At the bottom of that webpage is a "Contact Us" link if you

need additional information. You may also directly contact the program coordinator:

Jason Kenworthy
Inventory Coordinator
National Park Service Geologic Resources Division
P.O. Box 25287
Denver, CO 80225-0287
phone: (303) 987-6923
fax: (303) 987-6792
email: Jason_Kenworthy@nps.gov

The Geologic Resources Inventory (GRI) program is funded by the National Park Service (NPS) Inventory and Monitoring (I&M) Division. Learn more about I&M and the 12 baseline inventories at the I&M webpage: <https://www.nps.gov/im/inventories.htm>.

GRI Digital Map and Source Map Citations

The GRI digital geologic-GIS map for Lincoln Boyhood National Memorial, Indiana (LIBO):

Digital Bedrock Geologic-GIS Map of Lincoln Boyhood National Memorial and Vicinity, Indiana (*GRI MapCode LIBO_bedrock*)

The above digital geologic-GIS map was produced from the following unpublished source maps. The full extent of each source map was used, and all geologic features, as well as mine point features, were captured from these sources.

Hutchinson, H.C., 1959, Distribution, Structure, and Mined Areas of Coal in Spencer County, Chrisney Quadrangle, Indiana: Indiana Geological Survey, unpublished working maps, scale 1:24,000. (*GRI Source Map ID 75487*).

Hutchinson, H.C., 1959, Distribution, Structure, and Mined Areas of Coal in Spencer County, Dale Quadrangle, Indiana: Indiana Geological Survey, unpublished working maps, scale 1:24,000. (*GRI Source Map ID 75484*).

Hutchinson, H.C., 1959, Distribution, Structure, and Mined Areas of Coal in Spencer County, Holland Quadrangle, Indiana: Indiana Geological Survey, unpublished working maps, scale 1:24,000. (*GRI Source Map ID 75485*).

Hutchinson, H.C., 1959, Distribution, Structure, and Mined Areas of Coal in Spencer County, Santa Claus Quadrangle, Indiana: Indiana Geological Survey, unpublished working maps, scale 1:24,000. (*GRI Source Map ID 75486*).

Unit descriptions relevant to units present in the GRI digital geologic-GIS data that are present in this document were taken from the following source map. In addition, coal mining area feature were also derived from this source.

Weber, Licia, Meyer, Becky, Eaton, Nathan and Irwin, Paul, 2010, Surface Coal Mines in Indiana (Indiana Coal Mine Information System or CMIS): Indiana Geological Survey and Indiana Department of Natural Resources, vector digital data, scale 1:24,000. (*GRI Source Map ID 75587*).

Additional information pertaining to each source map is also presented in the GRI Source Map Information (LIBOMAP) table included with the GRI digital geologic-GIS data.

Index Map

The following index map displays the extent of the GRI digital geologic-GIS map produced for Lincoln Boyhood National Memorial (LIBO). The boundary for Lincoln Boyhood National Memorial (as of January 2023) is outlined in green. The extent of the four 7.5 quadrangles that comprise the map, as well as their names, are also displayed.



Index map by Stephanie O'Meara (Colorado State University)

Map Unit List

The bedrock geologic units present in the digital geologic-GIS data produced for Lincoln Boyhood National Memorial, Indiana (LIBO) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., PNs - Staunton Formation). Units are listed from youngest to oldest. Information about each geologic unit is also presented in the GRI Geologic Unit Information (LIBOUNIT_bedrock) table included with the GRI digital geologic-GIS data.

Paleozoic Era

Pennsylvanian Period

[PNs](#) - Staunton Formation

[PNscb](#) - Staunton Formation, coal bed

[PNbbc](#) - Brazil Formation, Buffaloville Coal Member

[PNbm](#) - Brazil Formation and Mansfield Formation, undivided

[PNbmcb](#) - Brazil Formation and Mansfield Formation (undivided), coal bed

Map Unit Descriptions

Descriptions of all geologic map units, generally listed from youngest to oldest, are presented below.

PNs - Staunton Formation (Pennsylvanian)

Raccoon Creek Group, Staunton Formation (Pennsylvanian System)

Type locality, history of name, and related nomenclature: The Staunton Formation was named by Cumings (1922, p. 525) for rocks exposed near Staunton, Clay County. As defined by Cumings, this formation consisted of the interval from the disconformity above Coal II to the disconformity above Coal IV (Survant Coal Member) and therefore also included the Seelyville Coal Member and the Colchester Coal Member. As restricted by Wier (1960), however, the Staunton Formation consisted of those rocks in the interval between the disconformity above Coal II and the disconformity above the Seelyville. Still later, the upper boundary of the Staunton was changed to the top of the Seelyville (Wier and Gray, 1961), and the lower boundary was changed to the top of the Minshall Coal Member (Hutchison, 1976, p. 18). The Perth Limestone Member, which formerly belonged to the underlying Brazil Formation, was therefore reassigned to the Staunton Formation. In the same report by Hutchison, the poorly defined and miscorrelated Coal II was abandoned as a stratigraphic name.

Description: The Staunton Formation consists of 75 to 150 feet (23 to 46 m) of sandstone and shale and as many as eight coalbeds. These coalbeds are generally of little areal extent and variable in quality and thickness. Three lithologies characterize the roof of the coals: (1) black fissile shale overlain by limestone, (2) gray soft silty or sandy shale and interbedded fossiliferous shale or limestone, and (3) gray massive to shaly hard to friable sandstone. The floor of the coals is underclay, clay shale, or sandy shale. The four named members of the Staunton are the Perth, Holland, and Silverwood Limestone Members and the Seelyville Coal Member. The Perth limestone lies at or near the base of the Staunton, the Silverwood and Holland limestones are in the middle part of the formation, and the Seelyville, a commercially mined coalbed, is at the top of the formation.

Correlation: The Staunton Formation is considered to consist of basal rocks of the Desmoinesian Series in Indiana and is recognizable throughout the Indiana coalfield. Probable equivalents of the Staunton Formation are the uppermost part of the Tradewater Formation and the lowermost part of the Carbondale Formation of western Kentucky and part of the Spoon Formation of Illinois. According to Shaver and Smith (1974, p. 18) and Shaver (1984), the Atokan-Desmoinesian series boundary should be placed at the base of the Staunton Formation, that is, below the Perth Limestone Member in western Indiana and the limestone next above the Buffaloville Coal Member (Brazil Formation) in southern Indiana. This limestone contains microfaunas characterized by an unidentified species of *Fusulinella*, *F. iowensis*, and the ostracod *Amphissites centronotus*. Indiana Geological Survey Geologic Names Information System (2010): <http://igs.indiana.edu/GNIS/search.cfm>

Description from source map: [Surface Coal Mines in Indiana \(2010\)](#).

This unit includes coal beds of [PNs**cb**](#) mapped as linear/line features in the GRI digital geologic-GIS data. Some of these coal beds within this unit may be the Buffaloville Coal Member of the Brazil Formation, especially if mapped within a mine area and near the Staunton-Brazil contact.

PNs**cb** - Staunton Formation, coal bed (Pennsylvanian)

This unit is comprised of coal beds mapped as linear/line features in the GRI digital geologic-GIS data. Some of these coal beds within this unit may be the Buffaloville Coal Member of the Brazil Formation, especially if mapped within a mine area and near the Staunton-Brazil contact. See unit [PNs](#) for additional information concerning this unit.

PNbbc - Brazil Formation, Buffaloville Coal Member (Pennsylvanian)

Racoon Group, Brazil Formation, Buffaloville Coal Member (Pennsylvanian System)

Type section: The Buffaloville Coal Member was first named, simply as the Buffaloville Coal, by Franklin and Wanless (1944, p. 89, 90) for the coal that was surface mined near Buffaloville, Spencer County, Ind. Although not specifically designated as type, the originally described section was in a surface mine in the center of the NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 9, T. 5 S., R. 5 W. The Buffaloville Coal was assigned member rank by Gray, Wayne, and Wier (1970).

Description: According to Franklin and Wanless, the Buffaloville coal is blocky and has a floor of underclay some 3 feet (0.9 m) thick. The roof of the coal is black sheety unfossiliferous shale, half a foot (0.2 m) thick, which is overlain by dark-gray shale that is soft, calcareous, fossiliferous, and slightly silty and which is overlain in turn by dark-blue to black argillaceous and fossiliferous limestone as much as 2 feet (0.6 m) thick. In some areas the shale is absent, and the limestone rests directly on the coal.

Correlation: The Buffaloville coal was tentatively correlated by Franklin and Wanless (1944) with Coal II of Ashley (1909), but the Buffaloville was later assigned to the Brazil Formation by Hutchison (1959), who considered that it was continuous with the Minshall Coal Member of Clay and Parke Counties. If this correlation is correct, a single coalbed, called both the Buffaloville and the Minshall, is present from the Ohio River to Warren County at the north end of the Indiana coalfield. According to Thompson and Shaver (1964, p. 20, 21), the limestone in the roof of the Buffaloville marks the lowest known Indiana position containing microfaunas that are characterized by the fusulinid *Fusilinella* and ostracods *Amphissites centronotus* and *A. girtyi*. (See the Perth Limestone Member for a discussion of the coal and the associated limestone). Indiana Geological Survey Geologic Names Information System (2010): <http://igs.indiana.edu/GNIS/search.cfm>

Description from source map: [Surface Coal Mines in Indiana \(2010\)](#).

This unit is mapped as linear/line features in the GRI digital geologic-GIS data. Some of these coal beds are interpreted to be the Buffaloville Coal Member of the Brazil Formation if mapped within the Staunton Formation, in a mine area, and near the Staunton-Brazil contact.

PNbm - Brazil Formation and Mansfield Formation, undivided (Pennsylvanian)

Racoon Group, Brazil Formation (Pennsylvanian System)

Type locality and history of name: The Brazil Formation as originally named by Fuller and Ashley (1902, p. 2) for Brazil, Clay County, Ind., included the rocks in the interval between the top of the Mansfield Sandstone and the bottom of the Petersburg Coal (Springfield Coal Member of present usage). Cumings (1922, p. 525) amended the Brazil Formation to include only the rocks in the interval between the base of the Lower Block Coal Member and the unconformity above what was then called Coal II. Hutchison (1976, p. 22-23) further amended the Brazil to include only those rocks between the top of the Minshall Coal Member and the base of the Lower Block Coal Member.

Description: In the Brazil area the formation consists of shale, sandstone, underclay, and coal and ranges from 40 to 90 feet (12 to 27 m) in thickness (Hutchison, 1960, p. 13). The Brazil Formation consists in ascending order of the Lower Block, Upper Block, and Minshall Coal Members and other rocks unnamed to member. In places a thin coalbed referred to as the rider of the Upper Block Coal Member is present in the interval between the Upper Block and the Minshall Coal Members.

Irregularity, both in thickness and in persistence of recognizable beds, is characteristic of the Brazil Formation in much of its area of outcrop from Warren County on the north (Hutchison, 1961) to

Spencer County (Hutchison, 1959) on the Ohio River. North of southern Parke County, for example, the Lower Block coal is absent or untraceable, so that it is nearly impossible to separate the Brazil and Mansfield Formations in southern Indiana, in Daviess (Hutchison, 1971a), Dubois (Hutchison, 1964), and Spencer (Hutchison, 1959) Counties, coalbeds believed to be equivalent to the block coals are present over most of the area but are difficult to distinguish from upper Mansfield coals. Numerous drill holes penetrate the Brazil in the subsurface in Indiana, but detailed information on the character of the coals and other marker beds is wanting in extreme western and southwestern Indiana because of lack of coring or detailed mapping.

Correlation: The rocks assigned to the Brazil Formation in Indiana are equivalent to the upper and lower parts respectively of the Abbott and Spoon Formations of Illinois and part of the Tradewater Formation in western Kentucky (Kosanke and others, 1960, pl. 1).

The Brazil Formation was assigned by Wanless (1962) to the upper part of what was then called the Pottsville Series in the Appalachian area, but later it was assigned to the Atokan Series in the North American Pennsylvanian standard by Shaver and Smith (1974, p. 17-20), Shaver (1984), and Shaver and others (1985). Much of the basis for the Atokan assignment is the occurrence of a species of the fusulinid genus *Fusulinella* (identified by M. L. Thompson) in an unnamed limestone between the Lower and Upper Block coals in Clay County, Ind. Its stratigraphic position is below the lowest occurrence in Indiana of the lower type Desmoinesian indicator *Fusulinella iowaensis* and above the known occurrences of the Morrowan indicators that are discussed in the articles on the Lead Creek Limestone Member and its Ferdinand and Fulda Beds. Indiana Geological Survey Geologic Names Information System (2010): <http://igs.indiana.edu/GNIS/search.cfm>

Description from source map: [Surface Coal Mines in Indiana \(2010\)](#).

Raccoon Group, Mansfield Formation (Pennsylvanian System)

Type area and use of name: The Mansfield Formation was originally named the Mansfield Sandstone by Hopkins (1896, p. 199-200) for rocks exposed at Mansfield, Parke County, Ind. Cumings (1922, p. 527-528) amended the Mansfield to include all the rocks between the base of the Pennsylvanian System and the base of the Lower Block Coal Member, and this is the current definition. Kottlowski (1959), recognizing that the unit contains much shale and thin beds of coal, clay, and limestone, designated the unit as the Mansfield Formation.

Description and related nomenclature: The Mansfield rests unconformably, with as much as 150 feet (46 m) of local relief, on Mississippian rocks that are generally progressively older northward. Progressive northward overlap is also suggested by the 50- to 300-foot (15- to 91-m) range in thickness of the exposed Mansfield. The lowermost part of the Mansfield commonly consists of sandstone, generally crossbedded and containing a quartz-pebble and chert conglomerates in places, but it also includes dark carbonaceous shale in many places. The quartz-pebble conglomerate is also found in higher parts of the formation.

In the Shoals area of southwestern Indiana, the Mansfield has two broad, more or less distinct, vertically separate divisions the lower consists mostly of sandstone, and the upper consists dominantly of shale and mudstone (Gray, Jenkins, and Weidman 1960, p. 23). The divisional boundary is at the position, or inferred position, of the Pinnick Coal Member, which near Shoals lies 50 to 185 feet (15 to 56 m) above the base and 200 feet (61 m) below the top of the formation. Three lithologies, passing laterally into one another, also have been recognized in southwestern Indiana (Gray, 1962, p. 28-33). The Cannelton Lithofacies, nearest the Ohio River, consists dominantly of siltstone and mudstone the Shoals Lithofacies, well exposed near Shoals, Martin County, has many cross-stratified sandstones and the Bloomfield Lithofacies, named for that town in Greene County, is characterized by an abundance of gray shales.

The seven named members of the Mansfield in ascending order are the French Lick, St. Meinrad, Pinnick, Blue Creek, and Mariah Hill Coal Members the Lead Creek Limestone Member and the Shady Lane Coal Member.

Other member and bed names having limited, colloquial, or outdated use are the Cannelton Sandstone, which was the name applied by Hopkins (1896, p. 314) to the massive sandstone that crops out in the bluff of the Ohio River behind Cannelton, Perry County; the Cannelton Coal of Logan (1922, p. 623), which was probably applied to both the Upper and Lower Cannelton Coals, especially the upper nearer Tell City and the lower near Cannelton, Perry County; the Lower Huntingburg Coal, which is Franklin and Wanless's (1944, p. 87) designation for what is also the Mariah Hill Coal Member; the Shoals Coal (Logan, 1922, p. 623), which is near the base of Pennsylvanian rocks in the railroad cut west of Shoals, Martin County; the Kirksville Coal (Logan, 1922, p. 623-624), which is found in the southwestern part of Monroe County near Kirksville; and the Grandview Limestone of Franklin and Wanless (1944, p. 89-90), which is probably coextensive with the Ferdinand Limestone Bed.

The term Coal I was intended to apply to the lowest Mansfield coalbed, but as used by Ashley (1899) it actually refers to the lowest commercial coal at any given place. The name, therefore, applied to more than one bed, and it has not been widely used. The French Lick Coal Member is the lowest named member and is overlain by about 50 feet (15 m) of mudstone, siltstone, and fine-grained sandstone of remarkably even bedding. These silty rocks, best exhibited and formerly quarried near French Lick in Orange County, were called the Hindostan Whetstone Beds as early as 1838 by Owen (1859, p. 16) and were described in detail by Cox (1876, p. 6-8). The Pinnick Coal Member lies some 50 feet (15 m) above the French Lick in the French Lick area. The Upper and Lower Cannelton Coals were extensively mined near Cannelton, Perry County, and were first described by Lesley (1862, p. 343-344). Apparently, these coals are the same coals described as the Troy Coal and the Upper Troy Coal at Troy, Perry County, by Franklin and Wanless (1944, p. 86-87).

The Upper Troy Coal of Franklin and Wanless (1944, p. 88) appears to be the same as the St. Meinrad Coal Member, which is sufficiently thick to be extensively mined near St. Meinrad, Spencer County, and throughout northwestern Perry County.

North of southern Parke County the Lower Block Coal Member (Brazil Formation) is absent or unidentifiable, so that it is nearly impossible to separate the Brazil and Mansfield Formations in southern Indiana, in Daviess (Hutchison, 1971a), Dubois (Hutchison, 1964), and Spencer (Hutchison, 1959) Counties, coalbeds believed to be the equivalent of the block coals are present over most of the area but are difficult to distinguish from coals in the upper Mansfield.

Correlation: The rocks assigned to the Mansfield Formation are equivalent to the Caseyville Formation and the lower part of the Abbott Formation of Illinois, the Caseyville Formation and the lower part of the Tradewater Formation of western Kentucky, part of what has commonly been called the Pottsvillian Series of the Appalachian area, and to the Morrowan Series of the midcontinent area. The Hindostan flora was described by Read (1947) as early Pottsvillian in age. Unnamed Mansfield limestones in Parke County are in the ostracod Zone of *Amphissites rothi*, and unnamed Mansfield limestones near Troy and Cannelton, Spencer and Perry Counties, contain the fusulinid *Profusulinella*, the *Amphissites rothi* fauna, and the ostracod *Cavellinella casei*, all of which are thought to indicate a Morrowan age. (see Thompson and Shaver, 1964, Shaver and Smith, 1974, and Shaver, 1984, and for additional faunal evidence see the article on the Lead Creek Limestone Member). Indiana Geological Survey Geologic Names Information System (2010): <http://igs.indiana.edu/GNIS/search.cfm>

Description from source map: [Surface Coal Mines in Indiana \(2010\)](#).

This unit includes coal beds, unit [PNbmcb](#), that are mapped as linear/line features in the GRI digital geologic-GIS data. Differentiating coal beds wasn't possible given that the Brazil and Mansfield formations were not divided on the source maps.

PNbmcb - Brazil Formation and Mansfield Formation (undivided), coal bed (Pennsylvanian)

This unit is comprised of coal beds within unit [PNbm](#) that are mapped as linear/line features in the GRI digital geologic-GIS data. Differentiating coal beds wasn't possible given that the Brazil and Mansfield formations were not divided on the source maps. See unit [PNbm](#) for additional information concerning this unit.

Ancillary Source Map Information

The unpublished source maps used to produce the GRI digital geologic-GIS data possessed no additional information. Additional information pertaining the Surface Coal Mines source data (Weber, Meyer, Eaton and Irwin, 2010) maybe present online, but is not included in this document.

GRI Digital Data Credits

This document was developed and completed by Stephanie O'Meara (Colorado State University) for the NPS Geologic Resources Division (GRD) Geologic Resources Inventory (GRI) Program. Quality control of this document by Ron Karpilo (Colorado State University).

The information in this document was compiled from GRI source maps, and is intended to accompany the digital geologic-GIS map and other digital data for Lincoln Boyhood National Memorial, Indiana (LIBO) developed by Stephanie O'Meara and Georgia Hybels (Colorado State University) (see the [GRI Digital Map and Source Map Citations](#) section of this document for all sources used by the GRI in the completion of this document and related GRI digital geologic-GIS maps).

GRI finalization by Stephanie O'Meara (Colorado State University).

GRI program coordination and scoping provided by Bruce Heise, Jason Kenworthy and Tim Connors (NPS GRD, Lakewood, Colorado).