GREEN LAKE COUNTY

571 County Road A, Green Lake, WI 54941

The following documents are included in the packet for the Land Use Planning & Zoning Committee meeting on *Thursday, May 2, 2024.*

Packet Pages:

If you have questions or need additional information,
please contact the Land Use Planning & Zoning Department at (920) 294-4156

Land Use Planning & Zoning Committee Meeting Notice

Date: Thursday, May 2, 2024 Time: 9:00 AM
Green Lake County Government Center, County Board Room
571 County Rd A, Green Lake WI

****Amended AGENDA***

Committee Members

Curt Talma, Chair
Chuck Buss, Vice- Chair
Bill Boutwell
Gene Thom
Harley Reabe

Secretary: Karissa Block

Virtual attendance at meetings is optional. If technical difficulties arise, there may be instances when remote access may be compromised. If there is a quorum attending in person, the meeting will proceed as scheduled.

This agenda gives notice of a meeting of the Land Use Planning and Zoning Committee. It is possible that individual members of other governing bodies of Green Lake County government may attend this meeting for informative purposes. Members of the Green Lake County Board of Supervisors or its committees may be present for informative purposes but will not take any formal action. A majority or a negative quorum of the members of the Green Lake County Board of Supervisors and/or any of its committees may be present at this meeting. See State ex rel. Badke v. Vill. Bd. of Vill. of Greendale, 173 Wis.2d 553, 578, 494 N.W. 2d 408 (1993).

1. Call to Order
2. Certification of Open Meeting Law
3. Pledge of Allegiance
4. *Election of Chair and Vice-Chair
5. Minutes of 4/12/2024
6. Department Activity Reports
   a) Land use & septic permits
   b) Violation reports
7. Discuss 2024-25 Comprehensive Plan and Farmland Preservation Plan 10-year update.
8. Zoning Ordinance Amendment
9. *LUP&ZC July Meeting Time - 10:00am, Thursday July 11th
10. Public Comment (3 minute limit)
11. Public Hearing: (Not to begin before 9:30 AM)

Each item below will consist of:
   a) Public Testimony/Comment: 3-minute time limit
   b) Committee Discussion & Deliberation
   c) Committee Decision
   d) Execute Ordinance/Determination Form

Item #1: Owner: S&L Holding, **Location:** Highway 23 & 49, **Parcels:** 004-00314-0200, -0300, -0400, & -0501. **Legal Description:** Lots 2,3,4, and Outlot 1 of CSM 1202, located in Section 15, T16N, R13E, Town of Brooklyn, ±3.88 acres. **Request:** The owners are requesting a Conditional Use Permit for a boat storage building, individual storage units, and a sales office.

Item #2: Owner: Robert and Janel Wustrack, **Location:** N6410 Forest Ridge Road, **Parcel:** 004-00275-0300. **Legal Description:** NE ¼ & NW ¼ of NW ¼ , located in Section 14, T16N, R13E, Town of Brooklyn, ±29.08 acres. **Request:** The owners are requesting a rezone from A1, Farmland Preservation District, to A2, General Agriculture District.

Item #3: Owner: Christopher D. & Ruth M. Retzlaff, **Agent:** Michael McConnell, Kopplin & Kinas Co. Inc., **Location:** County Highway K and Searle Road, **Parcels:** 004-00789-0000 & 004-00792-0000. **Legal Description:** NE ¼ of SE ¼ and SE ¼ of SE ¼ , located in Section 36, T16N, R13E, Town of Brooklyn, ±80.0 acres. **Request:** The owners are requesting a Conditional Use Permit for a limestone quarry.

Item #4: Owner: Christopher D. & Ruth M. Retzlaff, **Agent:** Michael McConnell, Kopplin & Kinas Co. Inc., **Location:** County Highway K and Searle Road, **Parcels:** 004-00789-0000 & 004-00792-0000. **Legal Description:** NE ¼ of SE ¼ and SE ¼ of SE ¼ , located in Section 36, T16N, R13E, Town of Brooklyn, ±80.0 acres. **Request:** The owners are requesting a Non-metallic mining reclamation permit for a limestone quarry.

12. Committee Discussion
    a) Future Meeting Dates: June 6, 2024 @ 9:00am
    b) Future Agenda items for action & discussion
13. Adjourn

Microsoft Teams meeting: This meeting will be conducted through in person attendance or audio/visual communication. Remote access can be obtained through the Microsoft Teams link on the agenda posted on the County website's Events Calendar:

Microsoft Teams meeting
Join on your computer, mobile app or room device
Click here to join the meeting
Meeting ID: 296 349 313 972
Passcode: 9VUWqS
Download Teams | Join on the web
Or call in (audio only)
+1 920-515-0745,,516863131# United States, Green Bay
Phone Conference ID: 516 863 131#
Find a local number | Reset PIN
Please accept at your earliest convenience. Thank you!
Learn More | Help | Meeting options | Legal

GREEN LAKE COUNTY
LAND USE PLANNING AND ZONING
COMMITTEE MEETING MINUTES
Friday, April 12, 2024

CALL TO ORDER
Planning & Zoning Chair Curt Talma called the meeting of the Land Use Planning and Zoning Committee to order at 9:00AM in the Green Lake County Government Center, County Board Room #0902, Green Lake, WI. The requirements of the open meeting law were certified as being met. Public access was available via remote programming as well as in person. The Pledge of Allegiance was recited.

Present: **Bill Boutwell, Harley Reabe, Curt Talma, Chuck Buss, Gene Thom**
Absent:
Also Present: **Matt Kirkman,** Land Use Planning and Zoning Director; **Karissa Block,** Deputy County Clerk; **Noah Brown (Remote),** Land Use Specialist; **Jeff Mann,** Corporation Counsel; **Ryan Schinke,** Land Use Coordinator/Technician; **Cate Wylie**, County Administrator

APPROVAL OF MINUTES
Motion/second (Buss/Boutwell) to approve the minutes of the 03/07/2024 meeting. Motion carried with no negative vote.

DEPARTMENT ACTIVITY REPORTS
- Land Use & Septic Permits
- Violation Reports

- Kirkman & Mann reviewed and discussed reports
- 2 violations were resolved in the month of March

2024-25 COMPEHENSIVE PLAN AND FARMLAND PRESERVATION PLAN 10-YEAR UPDATE
Kirkman shared his idea of having the Planning and Zoning Committee Meetings become a workshop to continue working on the Comprehensive Plan and Farmland Preservation Plan. Kirkman shared they have a grant that will pay for 50% of the hours put into this project.

ZONING ORDINANCE AMENDMENT REGARDING FIRE NUMBERS
Mann spoke with 10 different counties about their procedure with Fire Numbers. Discussion held. Mann will draft an amended ordinance regarding Fire Numbers. The draft of the amended ordinance will be a part of the June agenda.

OPERATOR VS. CARETAKER DISCUSSION
Kirkman would like to add definitions for Operator and Caretake to clarify the meaning of the two. Discussion held.

PUBLIC COMMENT (3 MINUTE LIMIT)
Dick Martens, Green Lake Association Secretary & Former Attorney, would like to work together with the Land Use Planning and Zoning Department of Green Lake County

DISCUSSION REGARDING LETTER ON CONDITIONAL USE PERMIT HEARING PROCESS FOR COUNTY K QUARRY
Discussion held

Motion/second (Boutwell/Buss) to move into recess until the 9:30am hour. Motion carried with no negative vote.

Motion/second (Boutwell/Buss) to resume the meeting at 9:32am. Motion carried with no negative vote.

PUBLIC HEARING
Chair Talma read the Public Hearing rules.

Item #1: Owner: American Baptist Assembly, **Location:** Hillside Road, **Parcel:** 004-00916- 0000**. Legal Description:** Lot 1 of CSM 3944, located in Section 35, T16N, R12E, Town of Brooklyn, ±.499 acres. **Request:** The owners are requesting a rezone from RC, Recreational District, to R1, Single-Family Residence District.

Benjamin Mott, President of the ABA, spoke for the rezone

Motion/second (Thom/Boutwell) to approve the rezone from RC, Recreational District, to R1, Single-Family Residence District. Motion carried with no negative vote.

Item #2: Owner: Michael Mehn, **Location:** N8837 County Road VV, **Parcel:** 002-00255- 0201. **Legal Description:** Lot 1 of CSM 2973, located in Section 15, T17N, R13E, Town of Berlin, ±3.23 acres. **Request:** The owners are requesting a rezone from R4, Rural Residential District, to R1, Single-Family Residence District. To be identified by Certified Survey Map.

Michael Mehn, N8837 County Road VV, spoke for the rezone

Motion/second (Thom/Buss) to approve the rezone from R4, Rural Residential District, to R1, Single-Family Residence District. Motion carried with no negative vote.

Item #3: Owner: Billy Jackowski, **Location:** W1376 Center Road, **Parcel:** 006-00286-0100. **Legal Description:** Lot 1 of CSM 3120, located in Section 16, T15N, R13E, Town of Green Lake, ±5.0 acres. **Request:** The owners are requesting a rezone from A1, Farmland Preservation District, to R4, Rural Residential District.

Charlene Jackowski, W1376 Center Road, spoke for the rezone.

Motion/second (Buss/Reabe) to approve the rezone from A1, Farmland Preservation District, to R4, Rural Residential District. Motion carried with no negative vote.

Item #4: Owner: SX Blasting Real Estate LLC., Location: N7969 County Road A, **Parcel:** 002-00547-0000. **Legal Description:** SE ¼ of NE ¼ of Section 29, T17N, R13E, Town of Berlin, ±38.7 acres. **Request:** The owners are requesting to rezone ±.25 acres from A1, Farmland Preservation District, to R4, Rural Residential District.

Discussion held
Motion/second (Buss/Reabe) to approve the rezone of ±.25 acres from A1, Farmland Preservation District, to R4. Rural Residential District. Motion carried with no negative vote.

COMMITTEE DISCUSSION

a. Next meeting date – May 2, 2024 @ 9:00AM
b. Future agenda items for action & discussion

ADJOURN

Chair Talma adjourned the meeting at 10:00AM.

Respectfully submitted,

Karissa Block
Deputy County Clerk

Land Use Permits: 3/1/2024 - 3/31/2024

Town of Berlin

Permit Number	Parcel Number	Site Address	Issued Date	Owner Name	Estimated Cost	Project_1 Type/SubType	Project_1 Description	Project_2 Type/SubType	Project_2 Description
13603	002006500100	W1055 W FOREST RIDGE RD	03/08/2024	WESLEYF STIBB	350000	Additions / Alterations - Addition/Alteration to Principal Structure	Addition to SFD	Accessory Structure - Porch	Porch

Town of Brooklyn

Permit Number	Parcel Number	Site Address	Issued Date	Owner Name	Estimated Cost	Project_1 Type/SubType	Project_1 Description	Project_2 Type/SubType	Project_2 Description
13606	004003750100	N6264 N LAWSON DR	03/11/2024	DAVIDROY SANTEE	3000	Accessory Structure - Storage Buildings	Shipping Container		
13608	004002800200	W736 STATE ROAD 23 49	03/13/2024	DAVID W LONG	150	Land Use	Accessory Structure - Shed	Replacing an old shed with a new store bought shed. Replaced old shed on same footprint.	
13613	004017880100	N5942 CASS CT	03/18/2024	KENNETHP WARRAS, SUSANM WARRAS	45000	Additions / Alterations - Addition/Alteration to Accessory Structure	Garage Addition to the North.		
13619	004010040100	W2209 HICKORY RD	03/26/2024	HICKORY ROAD REAL ESTATE LLC	75000	Land Disturbing Activity - Driveways	Permeable Paver Driveway	Accessory Structure - Stairs/Walkway	Side walkway/ Patio
13623	004003760200	N6215 N LAWSON DR	03/27/2024	GINNYL SCHULTZ	40000	Land Disturbing Activity - Driveways	Replacement Driveway	Accessory Structure - Shed	Shed
13629	004007340200	N5410 SHORE DR	03/28/2024	FORT LAC VERT LLC	16000	Accessory Structure - Stairs/Walkway	Granite Walkways	Accessory Structure - Attached Deck/Patio	Patio Expansion

Town of Green Lake

Permit Number	Parcel Number	Site Address	Issued Date	Owner Name	Estimated Cost	Project_1 Type/SubType	Project_1 Description	Project_2 Type/SubType	Project_2 Description
13584	006020710000	W2284 OAKWOOD AVE	03/04/2024	GREGORYH NOETHLICH, RONNICAV NOETHLICH	1000000	Accessory Structure - Stairs/Walkway	South Flagstone Walkway	Accessory Structure - Stairs/Walkway	South Walkway
13599	006000030000	W241 COUNTY ROAD K	03/05/2024	DEBRAJ GOHLKE, SCOTTW GOHLKE	36000	Accessory Structure - Accessory Structure	Breezeway	Accessory Structure - Detached Garage	Detached garage
13604	006010410102	W1484 SPRING GROVE RD	03/08/2024	BRIDGETA VREDEVELD, DANIELC VREDEVELD	105000	Accessory Structure - Detached Deck/Patio	Patio	Accessory Structure - Stairs/Walkway	Walkway
13609	006017270101	W3052 MCAFEE RD	03/18/2024	JAMESA VOGEL, NICOLEA PASSMANN	175000	Accessory Structure - Detached Garage	detached garage		
13614	006017420000	W3029 MCAFEE RD	03/18/2024	CRAIGA JONES	40000	Accessory Structure - Storage Buildings	Detached Residential Storage		
13615	006013840000	N2811 PARK RD	03/19/2024	LITTLE GREEN LODGE LLC	15000	Accessory Structure - Sign	Road Sign	Accessory Structure - Shed	Storage Shed
13616	006006170000	N2804 PARK RD	03/19/2024	LITTLE GREEN LODGE LLC	6500	Land Disturbing Activity - Driveways	928sqft driveway		
13617	006008920100	N3633 ROY CREEK RD	03/19/2024	JASONE POLLESCH, JENNIFERA POLLESCH	60000	Accessory Structure - Accessory Structure	Pool		

13621	006002580000	W801 CENTER RD	03/21/2024	BENJAMINJ BRUSS, CHADM BRUSS	35000	Accessory Structure - Shed	Shed for animals with a concrete slab, steel siding, and insulated.		
13624	006018640100	W1985 TWIN LAKES RD	03/22/2024	STEPHAN W & CANDYCE S EILER REVOCABLE TRUST	20000	Additions / Alterations - Addition/Alteration to Accessory Structure	Garage Addition		
13627	006014720000	W2644 OAKWOOD BEACH RD	03/27/2024	JULIED PORTER, RICHARDE PORTER	658000	Accessory Structure - Attached Garage	Attached garage	Principal Structure - Single Family	Tear down and rebuild of existing house

Town of Kingston

Permit Number	Parcel Number	Site Address	Issued Date	Owner Name	Estimated Cost	Project_1 Type/SubType	Project_1 Description	Project_2 Type/SubType	Project_2 Description
NONE									

Town of Mackford

Permit Number	Parcel Number	Site Address	Issued Date	Owner Name	Estimated Cost	Project_1 Type/SubType	Project_1 Description	Project_2 Type/SubType	Project_2 Description
NONE									

Town of Manchester

Permit Number	Parcel Number	Site Address	Issued Date	Owner Name	Estimated Cost	Project_1 Type/SubType	Project_1 Description	Project_2 Type/SubType	Project_2 Description
13610	012004130000	N1260 PROSCARIAN RD	03/18/2024	ANDREWJ WELHOUSE, SHARONR LUBKEMAN	50000	Accessory Structure - Storage Buildings	Storage Building - New Construction		

Town of Marquette

Permit Number	Parcel Number	Site Address	Issued Date	Owner Name	Estimated Cost	Project_1 Type/SubType	Project_1 Description	Project_2 Type/SubType	Project_2 Description
13598	014006460100	N3305 ISLAND RD	03/05/2024	DEANH PUGH	20000	Additions / Alterations - Addition/Alteration to Principal Structure	3 Season Room		
13611	014005060000	N3091 COUNTY ROAD B AND H	03/18/2024	LEETTAO MAST, PAULW MAST	75000	Accessory Structure - Accessory Structure	New Pole Shed		
13622	014007420000	W4304 COUNTY ROAD B	03/25/2024	ZACHERYERIC KIRCHNER	15000	Accessory Structure - Storage Buildings	3 Steel Shipping Containers no concrete slab		

Town of Princeton

Permit Number	Parcel Number	Site Address	Issued Date	Owner Name	Estimated Cost	Project_1 Type/SubType	Project_1 Description	Project_2 Type/SubType	Project_2 Description
13600	016010820000	N4603 OAK RD	03/05/2024	RICHARD J & PAMELA A TINAGLIA	80000	Accessory Structure - Attached Deck/Patio	Deck	Additions / Alterations - Addition/Alteration to Principal Structure	House Addition
13602	016013280000	W3619 S PARKWAY	03/08/2024	MORTLE REVOCABLE TRUST	195000	Principal Structure - Single Family	Rebuild SFD	Accessory Structure - Stairs/Walkway	Walkway replacement
13605	016013440000	N4251 LAKEVIEW DR	03/11/2024	JULIEA MATHIAS, LYLEG MATHIAS	950	Accessory Structure - Porch	Covered Porch		
13612	016003970601	N4578 N LILL AVE	03/18/2024	JOYCEH HOFFMAN SURVIVORS TRUST	8700	Land Use	Accessory Structure - Stairs/Walkway	Flagstone stepper walkway	

Town of Saint Marie

Permit Number	Parcel Number	Site Address	Issued Date	Owner Name	Estimated Cost	Project_1 Type/SubType	Project_1 Description	Project_2 Type/SubType	Project_2 Description
NONE									

Town of Seneca

Permit Number	Parcel Number	Site Address	Issued Date	Owner Name	Estimated Cost	Project_1 Type/SubType	Project_1 Description	Project_2 Type/SubType	Project_2 Description
NONE									

March 2023 Estimated Cost: $4,801,368.00 | March 2024 Estimated Cost: $3,124,300.00

2023 YTD Estimated Cost: $10,288,683.00 | **2024 YTD Estimated Cost: $7,225,130.00**

Sanitary Permits: 3/1/2024 - 3/31/2024

Sanitary Permit	County Permit	Parcel Number	Site Address	Owners	Date Issued	Permit Type	System Type	Plumber Name	Additional Permit Type	Final Insp Date	Ind Site Dsgn	Additional Explanation	County Fee	DSPS FEE	Total cost to applicant
202424012		002000110000	W457 E WAUSHARA ST	ERIC VANDENHOUT, RACHEL VANDENHOUT	03/04/2024	Replacement System	Conventional (Non-Pressurized In-Ground)	William Thoma		03/11/2024	No	3 Bed House	$ 280.00	$ 100.00	$ 380.00
202424013		002006500100	W1055 W FOREST RIDGE RD	WESLEYF STIBB	03/05/2024	Replacement System	Conventional (Non-Pressurized In-Ground)	Jeffrey Novak		03/13/2024	No	3 Bed House	$ 280.00	$ 100.00	$ 380.00
202424014		008001820102	N1799 LOVERS LN	JAMESP BONTRAGER, RUTHE BONTRAGER	03/07/2024	New System	Conventional (Non-Pressurized In-Ground)	Dustin Hoffmann		01/02/1900	No	4 Bed House	$ 280.00	$ 100.00	$ 380.00
202424015		002002100000	N8822 WHITE RIDGE RD	CYNTHIAJ GRISWOLD, KIRKW GRISWOLD	03/18/2024	New System	Conventional (Non-Pressurized In-Ground)	Ben Kinas		01/02/1900	No	3 Bed House	$ 280.00	$ 100.00	$ 380.00
202424016		008005940000	W6521 W NORTH ST	RHONDAK BARKER	03/18/2024	New System	Holding Tank	Ben Kinas		01/02/1900	No	2 Bed House	$ 355.00	$ 100.00	$ 455.00
202424017		006018160000	W2212 SPRING LAKE RD	PHILIPL SCHUPMANN, SARAJ SCHUPMANN	03/19/2024	New System	Conventional (Non-Pressurized In-Ground)	Roller, J		01/02/1900	No	3 Bed House	$ 280.00	$ 100.00	$ 380.00
												Total	$ 1,755.00	$ 600.00	$ 2,355.00

* There are additional properties associated with the permit

Total Sanitary Permits Issued 3/1/2024 - 3/31/2024

System Type	Total Count	New System Total Count	Replacement System Total Count	Revision Total Count
Conventional (Non-Pressurized In-Ground)	5	3	2	0
Holding Tank	1	1	0	0
Grand Total	**6**	**4**	**2**	**0**

Total Sanitary Permits Inspected 3/1/2024 - 3/31/2024

System Type	Total Count	New System Total Count	Replacement System Total Count	Revision Total Count
Conventional (Non-Pressurized In-Ground)	2	0	2	0
Grand Total	**2**	**0**	**2**	**0**

April, 2024

Land Use Violations Report

First Notice

Parcel Number	Site Address	Owner Name	Permit #	Violation Type	Violation Description
014005110201	N2875 Nicolet Rd	Carolyn & Corneal Troyer	13383	Zoning, Junk	Movement of mobile home and construction of basement without a permit. Inoperable camper/mobile home and trailer/trailer frame. Junk includes: plastic drums, metal drums, ac unit, chest freezers, appliances, propane tanks, bins, buckets, lumber, etc. scattered throughout property. 3 boats on property when two rec vehicles allowed on R-4 zoned parcel. Waiting on certified mail receipt. Otherwise will have Sheriff's deputy serve the notice.
008004680000	W6502 STATE ROAD 44	Carolee Miller	13533	Shoreland	No LUP and building within the shoreland setback. Certified Mailing -unclaimed resent through S.O.
014005090000	N3098 COUNTY ROAD H	DENNIS ZINK	13592	Junk	Inoperable truck with a pile of scrap metal and tires
014001810000	N4356 PINE RD E	PAUL PETERSEN	13618	Zoning	3 Recreational Campers in A-1, Farmland Preservation District

Second Notice

Parcel Number	Site Address	Owner Name	Permit #	Violation Type	Violation Description
006010940000	W1240 SPRING GROVE RD	JAMES LOGAN	13587	Shoreland	Structure within shoreland setback.
002002260200	W282 County Road V	Stanley Hallman	13532	Zoning, POWTS	No LUP for conversion of Ag building to house, No reconnection permit for sanitary system, House not being lived in by owner / operator of the farm.
006008380100	N3969 COUNTY ROAD O	COLLEEN POMPLUN;JAKE POMPLUN	13625	Zoning	Accessory structures and uses without principal structure.

Sent to Corp. Counsel

Parcel Number	Site Address	Owner Name	Permit #	Violation Type	Violation Description
004003750100	N6264 N lawson Dr	David Santee	13356	Zoning	Establishing a residence without a conditional use permit on C-2 parcel.
004003750100	N6264 N Lawson Dr	David Santee	13460	Zoning	Operating a long term rental in a zoning district that does not allow long term rentals as an allowed use.
020004510000, 0200045!	Hopp Road Right of way	Hopp	13395	Floodplain	Installed three sets of three culverts in 2008 without WDNR or County Zoning approval. Resolution is to remove all three sets of culverts to restore natural flooding conditions. Update: Joe said he would work with the Town's attorney to draft a legal letter to Mike Arrowhead of Walleyes for Tomorrow. The letter would be worded in such a way that Walleyes for Tomorrow will be responsible for removing the culvert sets on both parcels.

Monthly Violations Resolved	YTD Violations Resolved
3	6
Schultz	
Ruck	
Swanke	

POWTS Violation Report 4/18/24

First Notice

Parcel Number	Site Address	Owner Name	Permit #	Violation Type	Violation Description	Violation Date	Mailing Addr	Add2	City	State	Zip	Zip4
002002391300	W768 OAK DR	MORK LYNN D & PAMELA K	000264879	POWTS Failure	Tank not watertight	4/16/2024	W768 OAK DR		BERLIN	WI	54923	

Final Notice

Parcel Number	Site Address	Owner Name	Permit #	Violation Type	Violation Description	Violation Date	Mailing Addr	Add2	City	State	Zip	Zip4
004003750100	N6264 N LAWSON DR	SANTEE DAVID ROY	326	POWTS Failure	Drain field is failing and pump/float wiring is not legal.	1/31/2024	N6264 N LAWSON DR		GREEN LAKE	WI	54941	

Corporation Counsel

Parcel Number	Site Address	Owner Name	Permit #	Violation Type	Violation Description	Violation Date	Mailing Addr	Add2	City	State	Zip	Zip4
006001980000	W591 THOMAS RD	WILKE CARL H	00624010	POWTS Failure	Tank not Watertight	5/18/2022	W591 THOMAS RD		RIPON	WI	54971	8660
006010220701	W1740 SANDSTONE AVE	WOOD MAUREEN ; WOOD SIMON	000159178	POWTS Failure	Tank not watertight	10/22/2019	120 LAKEWOOD CIRCLE		WILLOWBROOK	IL	60527	
006010221104	N5107 SANDSTONE AVE	VANDERVELDE NANCY	00624041	POWTS Failure	Tank not watertight	6/29/2023	387 SCOTT ST		GREEN LAKE	WI	54941	
006010221105	N5113 SANDSTONE AVE	VANDERVELDE NANCY	00624042	POWTS Failure	Tank not watertight	6/16/2023	387 SCOTT ST		GREEN LAKE	WI	54941	
008005940000	W6521 W NORTH ST	BARKER RHONDA K	000000011	POWTS Failure	Tank Failure	10/27/2021	PO BOX 114		KINGSTON	WI	53939	
014001720000	W5156 PINE RD N	HEINECKE RANDAL R ET AL	26724	POWTS Failure	Tank Failure	11/8/2019	5531 ST ANTHONY RD		WEST BEND	WI	53090	
016000090000	N6123 SWAMP RD	HEBBE JAMES A	01624006	POWTS Failure	Tank not Watertight	4/26/2022	W1531 BLUFFTON RD		GREEN LAKE	WI	54941	
016004630000	N4487 MAPLE LN	KLEIN JUSTIN T	58848	POWTS Failure	Tank not Watertight	8/5/2022	1623 E SUNSET DR	APARTMENT 103	WAUKESHA	WI	53189	
016007700000	W5897 STATE ROAD 23	HAZELWOOD WANETTA ET AL	26752	POWTS Failure	Tank Failure	8/13/2019	7849 N EDGEWORTH DR		MILWAUKEE	WI	53223	
016008010300	N5587 LOCK RD	WEIHBRECHT JEREMY WAYNE; WEIHBRECHT TAMI LYNN	000037516	POWTS Failure	Tank not Watertight	8/26/2022	2385 KEY WAY		GREEN BAY	WI	54313	
016008320000	N5528 COUNTY ROAD T	WEIR LAVERNE J	01624079	POWTS Failure	Tank not Watertight	12/12/2023	C/O BARBARA MORRISON	535 FENTON ST	RIPON	WI	54971	
016009230000	W5894 WALTER WILLIAMS RD	PROG ROD-GUN CLUB	010024095	POWTS Failure	Tank unsound	6/24/2020	TREASURER	PO BOX 288940	CHICAGO	IL	60628	
016009230000	W5886 WALTER WILLIAMS RD	PROG ROD-GUN CLUB	010024249	POWTS Failure	Tank unsound	6/24/2020	TREASURER	PO BOX 288940	CHICAGO	IL	60628	
016009230000	N4922 RAY SHORTER RD	PROG ROD-GUN CLUB	010024256	POWTS Failure	Tank Failure	5/29/2021	TREASURER	PO BOX 288940	CHICAGO	IL	60628	
016009230000	N4904 RAY SHORTER RD	PROG ROD-GUN CLUB	010024259	POWTS Failure	Tank compromised	6/24/2020	TREASURER	PO BOX 288940	CHICAGO	IL	60628	
016015530000	N4164 NANCY DR	RUBACH RYAN W	000018212	POWTS Failure	Effluent discharging to ground surface	9/13/2023	N4164 NANCY DR		MARKESAN	WI	53946	

ORDINANCE NO. –2024

Amending § 350-65 B., Land Use Permit Applications to require fire number

The County Board of Supervisors of Green Lake County, Green Lake Wisconsin, duly assembled at its regular meeting begun on the day of ________, 2024, does ordain as follows:

WHEREAS, the Planning and Zoning Committee has deemed it advantageous and in the interest of safety for fire numbers to be issued as early as practical in the improvement of properties located within the County.

WHEREAS, designating fire numbers contemporaneously with the issuance of land use permits will assist in a more efficient delivery of emergency services.

NOW, THEREFORE, THE COUNTY BOARD OF SUPERVISORS OF THE COUNTY OF GREEN LAKE DOES ORDAIN AS FOLLOWS:

Green Lake County Ordinance § 350-65 B. shall be amended as follows:

All applications for land use permits shall be accompanied by a location sketch drawn to scale, showing the location, actual shape and dimensions of the lot to be built upon, the exact size and location of the building on the lot, the existing and intended use of the building, the number of families to be accommodated, its situation with reference to the highway, the distance between the nearest point on the building and the center line of the highway, and such other information with regard to the proposed building and neighboring lots or buildings as may be called for on the application or may be necessary to provide for the enforcement of this chapter. Additionally, all applications shall require a rural address and/or fire number assigned by the Real Property Lister as referenced in Chapter 217. The Land Use Planning and Zoning Department may require satisfactory evidence of actual lot line location, including a surveyor's certificate and map where necessary.

Roll Call on Resolution No. -2024

Ayes , Nays , Absent , Abstain 0

Passed and Enacted/Rejected this DATE day of ________,2024.

Submitted by Planning & Zoning Committee:

____
Curt Talma, Chair

____
Charles Buss, Vice-Chair

County Board Chairman	Bill Boutwell
ATTEST: County Clerk Approve as to Form:	Harley Reabe
Corporation Counsel	Gene Thom

BE IT FURTHER ORDAINED, that this ordinance shall become effective upon passage and publication.

BE IT FURTHER ORDAINED, that the amendment of this chapter herein shall not have any effect on existing litigation and shall not operate as an abatement of any action or proceeding then pending or by virtue of the repealed or amended sections.

NOTICE OF PUBLIC HEARING

The Green Lake County Land Use Planning and Zoning Committee will hold a public hearing in County Board Room #0902 of the Green Lake County Government Center, 571 County Road A, Green Lake, WI, on ***Thursday, May 2, 2024, at 9:30 a.m.*** to consider the following requests:

Item #1: Owner: S&L Holding, **Location:** Highway 23 & 49, **Parcels:** 004-00314-0200, -0300, -0400, & -0501. **Legal Description:** Lots 2,3,4 and Outlot 1 of CSM 1202, located in Section 15, T16N, R13E, Town of Brooklyn, ±3.88 acres. **Request:** The owners are requesting a Conditional Use Permit for a boat storage building, individual storage units, and a sales office.

Item #2: Owner: Robert and Janel Wustrack, **Location:** N6410 Forest Ridge Road, **Parcel:** 004-00275-0300. **Legal Description:** NE ¼ & NW ¼ of NW ¼ , located in Section 14, T16N, R13E, Town of Brooklyn, ±29.08 acres. **Request:** The owners are requesting a rezone from A1, Farmland Preservation District, to A2, General Agriculture District.

Item #3: Owner: Christopher D. & Ruth M. Retzlaff, **Agent:** Michael McConnell, Kopplin & Kinas Co. Inc., **Location:** County Highway K and Searle Road, **Parcels:** 004-00789-0000 & 004-00792-0000. **Legal Description:** NE ¼ of SE ¼ and SE ¼ of SE ¼ of Section 36, T16N, R13E, Town of Brooklyn, ±80.0 acres. **Request:** The owners are requesting a Conditional Use Permit for a limestone quarry.

All interested persons wishing to be heard at the public hearing are invited to attend. For further detailed information concerning this notice and for information related to the outcome of public hearing items, contact the Green Lake County **Land Use Planning and Zoning Department** at (920) 294-4156.

Publish: April 18, 2024

NOTICE OF PUBLIC HEARING

The Green Lake County Land Use Planning and Zoning Committee will hold a public hearing in County Board Room #0902 of the Green Lake County Government Center, 571 County Road A, Green Lake, WI, on ***Thursday, May 2, 2024, at 9:30 a.m.*** to consider the following requests:

Item #4: Owner: Christopher D. & Ruth M. Retzlaff, **Agent:** Michael McConnell, Kopplin & Kinas Co. Inc., **Location:** County Highway K and Searle Road, **Parcels:** 004-00789-0000 & 004-00792-0000. **Legal Description:** NE ¼ of SE ¼ and SE ¼ of SE ¼ of Section 36, T16N, R13E, Town of Brooklyn, ±80 acres. **Request:** The owners are requesting a Non-metallic mining reclamation permit for a limestone quarry.

All interested persons wishing to be heard at the public hearing are invited to attend. For further detailed information concerning this notice and for information related to the outcome of public hearing items, contact the Green Lake County **Land Use Planning and Zoning Department** at (920) 294-4156.

Publish: March 28, 2024

Land Use Planning and Zoning Committee Staff Report

Public Hearing May 2, 2024

Item I: Conditional Use Permit (CUP)

Owner:	**Applicant:**
S&L Holdings WI LLC	Lee Garro

Request: The owner/applicant is requesting a conditional use permit for a boat storage building, individual storage units, and a sales office.

Parcel Number/ Location: The request affects parcels 004-003144-0200, -0300, -0400, and -0510 (±3.88 acres). The parcels are in the SE ¼ of the SW ¼ of Section 15, T16N, R13E, Town of Brooklyn. The site is located south of State Highway 23 and 49.

Existing Zoning and Uses of Adjacent Area: The parcels referenced above are zoned C-2, Extensive Commercial District and combined make up ±3.88 acres. The property currently is undeveloped and used as farm fields. Parcels to the east are zoned as A-1, Farmland Preservation District and used as farmland. The properties to the south are zoned by the City of Green Lake. The parcels to the south are used as farmland and commercially as a gas station and grocery store. The property to the west is zoned as R-1, Single-Family Residence District with a house on it. To the north across the highway, the properties are zoned as C-2 and used commercially.

Additional Information/Analysis: The applicant wants to build a stackable boat storage building. The CUP application proposes a 250ft x 120ft building footprint with a height of 37 feet. However, the provided site plan proposes this building to be 300ft long by 80ft deep. A follow-up email from the applicant reduced this building to be 180ft long by 80ft deep. The applicant stated that the building will start as 180ft long and 80ft wide but through future additions the building would be 250ft long by 125ft wide. The applicant plans to increase the size through a lean to roof structure to provide an under-roof showroom. The applicant has been made aware that the maximum height allowable by the zoning ordinance is 35ft. It would be important for the LUP&Z Committee to nail down the exact dimensions of this building prior to deciding on this CUP.

The applicant also proposed 16 storages units (24ftx50ft) in one storage building that is 384ftx50ft. Each unit would have a garage door and a service door. The applicant is also requesting a sales office for Sterling Marina and Rentals and a sales office for the applicant's wife to utilize as a real estate office. The site plan is unclear as to where the sales office and real estate office would be located. The final ask for this CUP application is a proposed sign (see site plan) which would need to meet the ordinance standards listed in 350-43.

General Standards for Review of Conditional Use Requests: It is important that the Committee maintain the purpose and intent of the County Zoning Ordinance when reviewing and approving a request of this nature. The Committee shall take into consideration, among other things, the recommendation of the affected town and the particular facts and circumstances of each proposed use in terms of the standards found in Section 350-56 "Review of permit application; standards and conditions" of the County Zoning Ordinance. The Committee need not consider requirements that would apply to the local Town, other County, State or Federal entities of jurisdiction.

County Staff Comments: This request should be reviewed by the Committee to determine if it meets the general criteria for review as listed above. If the Committee wishes to approve this request, the following conditions may be appropriate:

1. No additional expansion or addition of structures and/or uses relating to this conditional use permit shall occur without review and approval through future conditional use permit(s).
2. No outside storage of materials and other items is allowed.
3. An "As-Built" certificate of survey shall be provided to the Land Use Planning & Zoning Department within one year of project completion. The certificate of survey shall show all existing buildings, building setback dimensions to lot lines, all access locations, electrical distribution equipment, easements, and any stormwater management appurtenances.
4. Any outdoor lighting shall comply with Section 350-23 of the County Zoning Ordinance.
5. Prior to construction all parcels must be combined into a single parcel through a CSM.
6. A fire number application must be applied for and issued before Land Use Permit approval.
7. The applicant must obtain a Land Use Permit before any building construction starts.
8. No buildings shall be taller than 35 feet at peak height.

Town of Brooklyn: The Town Board Action request for the Conditional Use Permit was sent to the Town Clerk on March 13, 2024. The Town Board took no action on this request.

n Lake
County

Land Use Planning & Zoning Department

County Government Center
571 County Road A
Green Lake, WI 54941-8630

Phone 920-294-4156 Website: http://www.co.green-lake.wi.us/

Land Development Code Enforcement County Surveyor GIS Land Information

APPLICATION FOR CONDITIONAL USE PERMIT

The purpose of the conditional use permit process is to utilize the minimum review standards of the zoning ordinance (Green Lake County Code Chapter 350, Section 56) to determine the effect of the proposed use on the neighborhood and suitability of proposed development at the proposed location. Conditions are added to the request to minimize any impacts to the surrounding properties, if the request is consistent with the adopted Green Lake County Comprehensive Plan.

Prior to the Department accepting the application, the following items need to be completed and/or provided by the owner or applicant:

- ☐ Consultation with the staff in the Land Use Planning & Zoning Department
- ☐ Application completely filled out, including property information, legal description, and detailed description of proposed use
- ☐ Detailed site plan on paper not larger than 11" x 17", drawn to scale and including location of: lot lines, all building and structures with dimensions, all components of private onsite wastewater treatment systems like septic tanks and drain fields, public and private roads including access easements, navigable waterbodies, well location, and the setback distances between all the above
- ☐ Fee as set by the Committee for a public hearing item

OPERATIONAL PLAN NARRATIVE

The operational plan is intended to address all components of the business, from establishment through to present operation. This narrative should be two or more paragraphs that address the following questions, from the perspective of the proposed use:

- What is the history of the business and/or applicant?
- What is the history of the property and its current use?
- Describe in detail the proposed use of the property.
- If applicable, include an operation and/or maintenance plan.
- When will the property be used? (Seasonally? Set daily hours?)
- What will be done with the current structures, if any?
- Will any new structures be built? If yes, how will they be used and where will they be located?
- What hazards, concerns, or disruptions may your proposed use pose to neighboring properties and the community as a whole? How can those concerns be addressed?
- What will be done to protect the human and environmental health of the surrounding area from negative impacts of this use?
- Why was this property chosen for this business activity? How will this use benefit the community by being located on this specific property?
- ~~How would this business activity meet goals and objectives of the County's Comprehensive Plan? (This will be clear after meeting with Department staff prior to submitting the Conditional Use Permit application, as required above.)~~ answer in person

Fee Received (Non-Refundable) ____________ Date 2/15/24

By signing and submitting this completed application with public hearing fee, the applicant or agent requests the Land Use Planning & Zoning Committee consider the conditional use permit request at the next available public hearing.

PROPERTY OWNER / APPLICANT

Name S & L Holding

Mailing Address P O Box 436 Green Lake

Phone Number 920-294-3000 Email Lee.garro@gmail.com

Signature Lee Garro Date 2/15/24

AGENT IF OTHER THAN OWNER

Name ____________

Mailing Address ____________

Phone Number ____________ Email ____________

Signature ____________ Date ____________

PROPERTY INFORMATION

Town of Brooklyn Location of Property ____________

Section 15 Town 16 N Range 13 E

Affected Parcel Number(s) 004003140200-0300-0400-0501 Affected Acres 3.88

Subdivision ____________ Lot ________ Block ________

CSM 1202 Lot 2, 3, 4, Outlot 1. or COS ____________

Legal Description Lot 2, Lot 3, Lot 4, Outlot #1. of CSM 1202

Current Zoning Classification Business / Industrial

Present Use of Property: (List all current uses and improvements, i.e. home, store, farm field, wooded, etc.)

Farm Land until i bought it, currently selling boats and other various items

PROPOSAL - Use separate or additional sheet(s) IF necessary

Describe **specifically** the nature of this request (List all proposed uses of the parcel.) What do you plan to do? ① boat storage building 120' wide X 250' long. ② individual storage units 24' X 50' total of 16 units condenced in one building 384' X 50'. ③ reselling various items Boats, Equipment, tractors, cars, semis, trailers, Atv. Utv. Bikes, p.w.c. Etc...

If this application is for a use that will be contained to a part of the parcel, specify the exact dimensions of the affected area. ______

☐ If this box is checked, provide the following information:

Proposed use has additional minimum development standards in Section ______.
Explain how your proposal meets or exceeds these requirements.

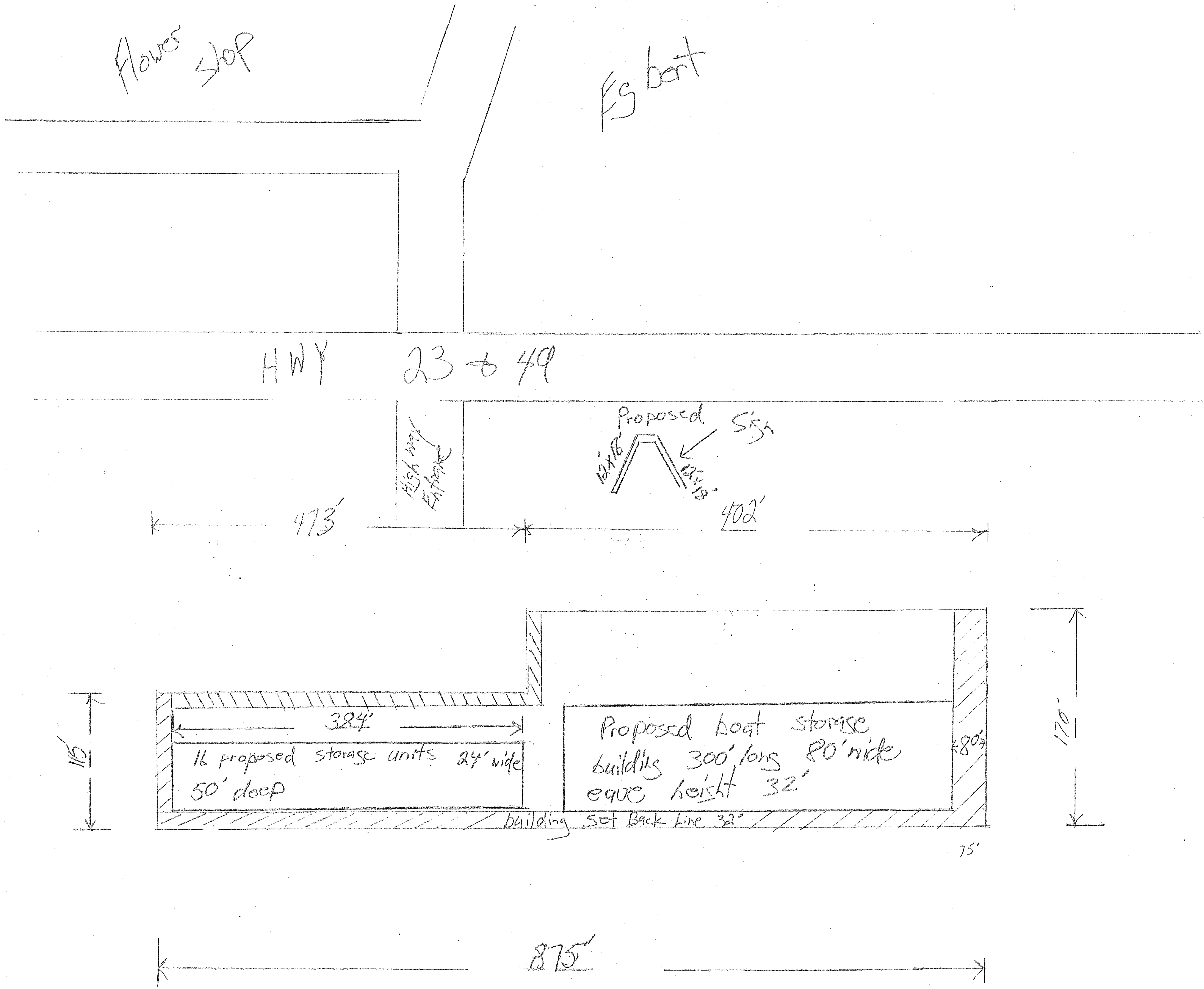
OPERATIONAL PLAN NARRATIVE

☆ 4 light pole towers & 10 building wall pack lights for security lights.

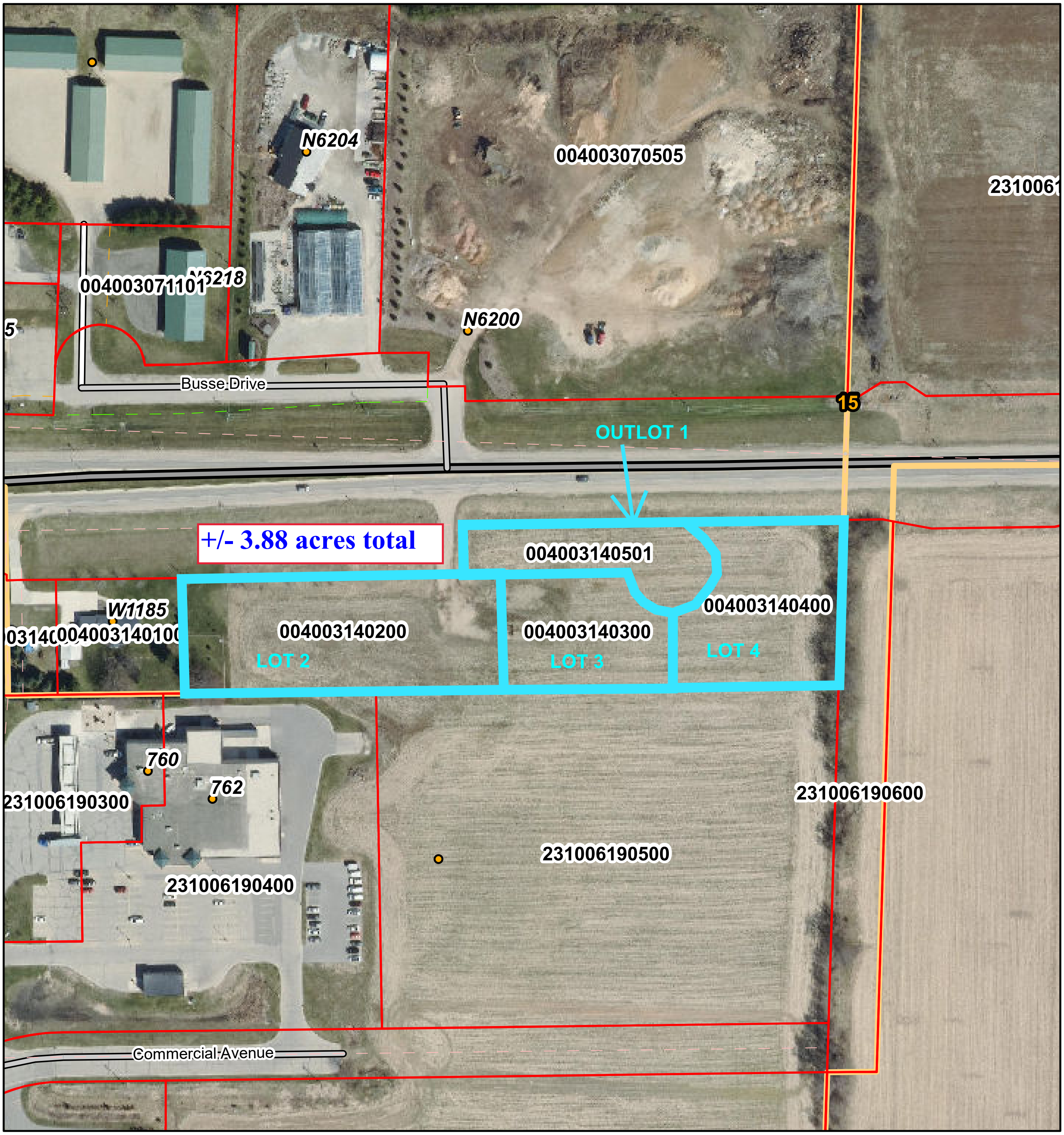
☆ condo storage units as per set back rules starting from West heading east deminsions 384' ft long X 50' ft deep with 16 garage doors & 16 walk doors 3' wide facing the North (Absolutely No garbage or debris will ever be allowed to be left on site.)

☆ Boat storage building location #3 for Sterling Marina & Rentals which is also a company owned by Lee Garro dimensions are 250' ft long X 120' wide with a height of 37' ft tall at the peak

☆ Sales office for Sterling Marina & Rentals / Big power Sports
small Sales office for my wife to sell real estate


Flower shop
Esbert
HWY 23 & 49
High way Entrance
Proposed Sign
12x18'
12x18'
473'
402'
384'
16 proposed storage units 24' wide 50' deep
Proposed boat storage buildings 300' long 80' wide eave height 32'
80'
115'
170'
building Set Back Line 32'
75'
875'

S&L Holding CUP Aerial Map 2020



3/6/2024, 12:22:11 PM

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0 0.03 0.06 0.12 km

Address

Section

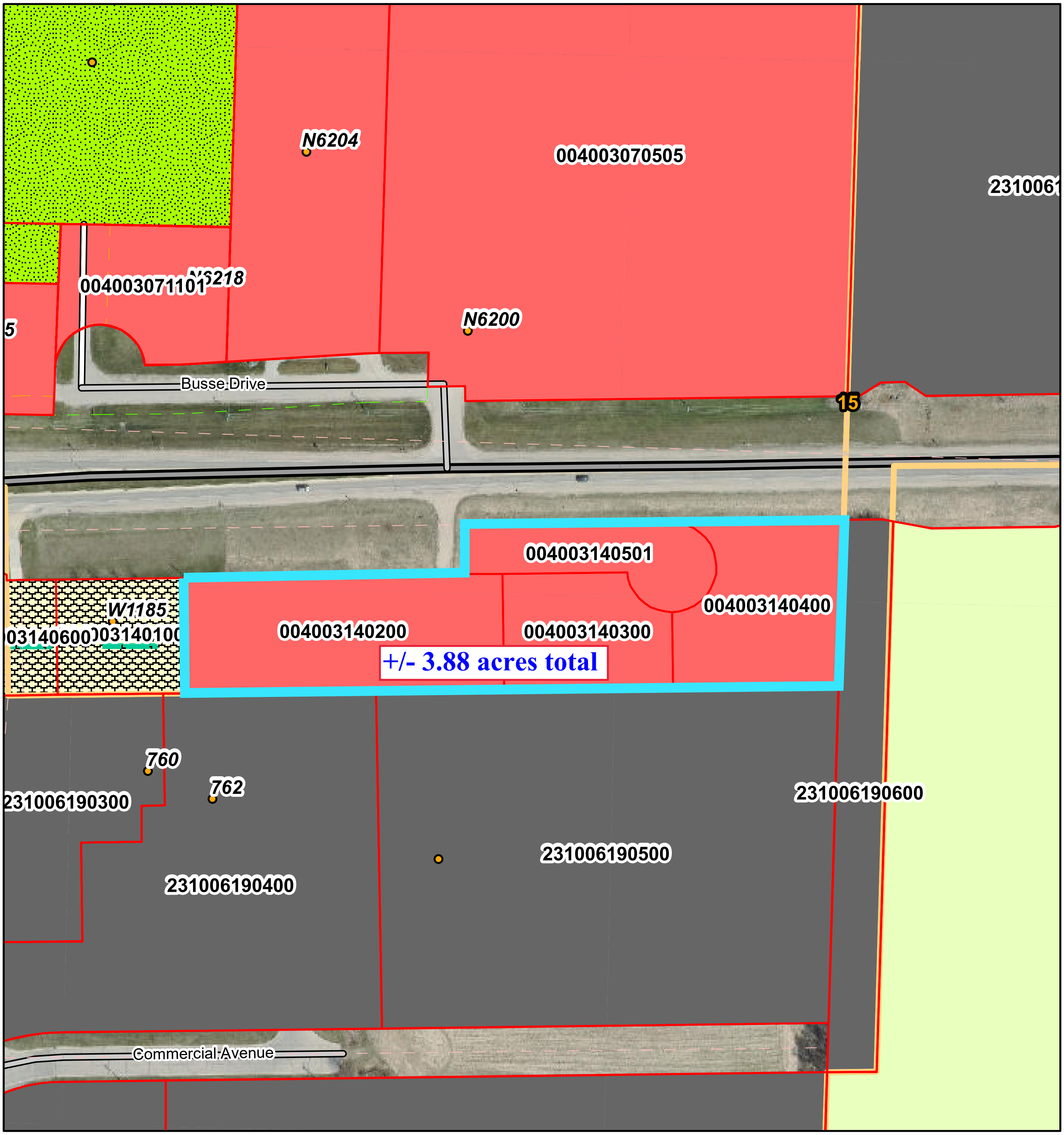
Corner

SUB

TaxParcel

Green Lake County, WI
www.greenlakecountywi.gov

S & L Holding CUP Zoning Map



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Address

Section

Corner

SUB

TaxParcel

1:2,257

0 0.02 0.04 0.07 mi

0 0.03 0.06 0.12 km

Green Lake County, WI
www.greenlakecountywi.gov

TOWN BOARD ACTION

Dear Land Use Planning and Zoning Committee:

Please be advised that the Town Board of Brooklyn, County of Green Lake, took the following action on – (Date) ______—______.

Owner/Applicant: S&L Holding/Lee Garro

Site Location: Highway 23 & 49

General legal description: Parcels 004-00314-0200, -0300, -0400, -0501, Lots 2,3,4 & Outlot 1 of CSM 1202, Town of Brooklyn, ±3.88 acres.

Request: Conditional Use Permit for a boat storage building, individual storage units, and a sales office.

Planned public hearing date for the above requests: May 2, 2024

_____ **Town Does Not object to and Approves of request**

__X__ **No action taken**

_____ **Objects to and requests denial of request**

NOTE: If denial – please enclose Town Resolution of denial

- Reason(s) for objection:

____

____

____

TOWN OF BROOKLYN
N5988 COUNTY ROAD A
GREEN LAKE WI 54941

______________________________ ______________________

Town Representative **Date Signed**

NOTES: ____

____

____

Please return this form to the Land Use Planning & Zoning Office by: April 19, 2024

DETERMINATION OF THE LAND USE PLANNING AND ZONING COMMITTEE

Public Hearing Date: May 2, 2024

Owner: S&L Holding

Agent: Lee Garro

Parcels: #004-00314-0200, -0300, 0400, & -0501, Highway 23 & 49, Town of Brooklyn.

Request: Conditional Use Permit for a boat storage building, individual storage units, and a sales office.

Land Use Planning and Zoning Committee:

____
Curt Talma, Chair

____
Harley Reabe

____
William Boutwell

____
Chuck Buss, Vice Chair

____
Gene Thom

Date signed: May 2, 2024

Committee vote: Ayes ____ Nays____ Abstain____ Absent____

☐ **Approve**

☐ **With the conditions (listed on page 2)**

☐ **Deny.**

☐ **Modify as follows:**

Conditions of Approval:

General Conditions:

1. No additional expansion or addition of structures and/or uses relating to this conditional use permit shall occur without review and approval through future conditional use permit(s).
2. No outside storage of materials and other items is allowed.
3. An “As-Built” certificate of survey shall be provided to the Land Use Planning & Zoning Department within one year of the project completion. The certificate of survey shall show all existing buildings, building setback dimensions to lot lines, all access locations, electrical distribution equipment, easements, and any stormwater management appurtenances.
4. Any outdoor lighting shall comply with Section 350-23 of the County Zoning Ordinance.
5. Prior to construction, all parcels must be combined into a single parcel through a CSM.
6. A fire number application must be applied for and issued before Land Use Permit approval.
7. The applicant must obtain a Land Use Permit before any building construction starts.
8. No buildings shall be taller than 35 feet at peak height.

LAND USE PLANNING AND ZONING COMMITTEE STAFF REPORT

PUBLIC HEARING May 2, 2024

ITEM II: ZONING CHANGE

OWNER:
Robert and Janel Wustrack

APPLICANT:
Robert and Janel Wustrack

REQUEST: The owner is requesting a zoning change for ±29.06 acres from A-1, Farmland Preservation District, to A-2, General Agriculture District.

PARCEL NUMBER / LOCATION: The request affects parcel number 004-00275-0300 (±29.06 acres). The parcel is located in the NE ¼ of the NW ¼ Section 14, T16N, R13E, and NW ¼ of the NW ¼ Section 14, T16N, R13E Town of Berlin. The site address for the zoning change is N6410 Forest Ridge Rd.

EXISTING ZONING AND USES OF ADJACENT AREA: The current zoning of parcel 004-00275-0300 is A-1 Farmland Preservation and is used agriculturally and recreationally. To the North, East, and West, the surrounding parcels are zoned A-1 Farmland Preservation and are used for agriculture and rural residential use. To the South, some parcels are zoned A-2 General Agriculture and I Industrial. The A2 General Agriculture parcels are used as farmland and residentially. The I Industrial parcels are used as farmland, residentially, and for industrial uses. All but about 5 acres of the parcel are WI DNR mapped wetlands. A large portion of the property falls under shoreland zoning if WBIC 5026410 and/or WBIC 146900 are classified as navigable waterways. The proposed rezone area does not fall within floodplain jurisdiction.

ADDITIONAL INFORMATION / ANALYSIS: The current use of the proposed rezone area is for agriculture and recreation. The intention is to establish a residence on the western side of the parcel while maintaining the recreation and agricultural uses on the rest of the property.

STATUTORY CRITERIA PER 91.48(1): Land may be rezoned out of a farmland preservation zoning district if all of the following are found after public hearing: **(Staff comments in bold)**

a) The land is better suited for a use not allowed in the farmland preservation zoning district. **24 acres (or so) of this parcel are mapped as wetlands and have never been farmed. Farming these lands would require drainage of WI DNR mapped wetlands. It is clear that that lands are not suited to agriculture. The remaining ±5 acres of uplands have been farmed and have crop history. It is less clear that these productive farmlands would be better suited as a site for a new home. When examined as a whole (±29 acres), the wetlands being 82% of the parcel could allow for this criterion to be met.**

b) The rezoning is consistent with any applicable comprehensive plan. **The proposed rezone is consistent with the county's comprehensive plan as it upholds the goals and objectives of the comprehensive plan, most prominently the goal to preserve the rural characteristic of the county. Section 350-41 of the County Zoning Ordinance states that the A-2 district is intended to preserve and enhance land for agricultural uses.**

c) The rezoning is substantially consistent with the county certified farmland preservation plan. **The overall goal of the county certified Farmland Preservation Plan is to maintain the integrity and viability of county agriculture…without damaging the economic and social environment or the natural resources..." Due to A-2's uses being agricultural in nature and not in conflict with agricultural lands and uses, it is staff's belief that the request does not negatively impact the integrity or viability of county agriculture and is, therefore, <u>substantially consistent with the county's certified Farmland Preservation Plan</u>.**

d) The rezoning will not substantially impair or limit current or future agricultural use of the surrounding parcels of land that are zoned for or are legally restricted to agricultural use. **The A-2, General Agriculture District is intended to preserve and enhance land for agricultural uses. The A-2 district is intended <u>not to impair or limit future agricultural use of surrounding parcels.</u>**

<u>TOWN OF BROOKLYN</u>: An Action Form requesting the Town's input related to this zoning change request was sent to the Town Clerk on 3/13/2024. At their meeting the Town Board did not take action on the rezone.

Please type or use black ink

Return to: Green Lake County
Planning & Zoning Department
571 County Road A
Green Lake, WI 54941

GENERAL APPLICATION

Fee 375 (not refundable) Date 03/01/2024

Zone Change from A1 to A2

Conditional Use Permit for ______

Other ______

PROPERTY OWNER / APPLICANT

Name ROBERT WUSTRACK and JANEL A WUSTRACK

Mailing Address W3584 OLD GREEN LAKE RD PRINCETON, WI 54968

Phone Number 920-369-6411

Signature *Robert Wustrack* Robert Wustrack Date 3-1-24

Signature *Janel A Wustrack* Janel Wustrack Date 3-1-24

PROPERTY INFORMATION

Town of Brooklyn Parcel Number 004-00275-0300 Acres 29.0800 Lot ___ Block ___

Subdivision ______

Section 14 Town 16 North Range 13 East

Location of Property NE-NW,Sect. 14, T16N,R13E, NW-NW,Sect. 14, T16N,R13E

Legal Description COMMENCING AT THE NW CORNER OF SAID SEC 14, THENCE NORTH 54-37'09" EAST, 195.54 FEET;, THENCE SOUTH 86 - 35'-32" EAST, 647.62 FEET; THENCE NORTH 52 - 40'-05" EAST, 347.87 FEET; THENCE NORTH 81 - 21'-01" EAST, 255.86 FEET TO A POINT ON THE EAST LINE OF THE NW 1/4 OF SAID SEC 14 AND TO THE WEST LINE OF LOT 2 OF CSM 3390, THENCE SOUTH 00 - 13'-59" WEST ALONG SAID EAST LINE AND THE WEST LINE OF SAID LOT 2, 632.62 FEET TO THE SW CORNER OF THEN W 1/4 OF THE NE 1/4 OF SAID SEC 14; THENCE EAST 430.49 FEET, 112.69 FEET TO THE NORTHERLY RIGHT OF WAY...

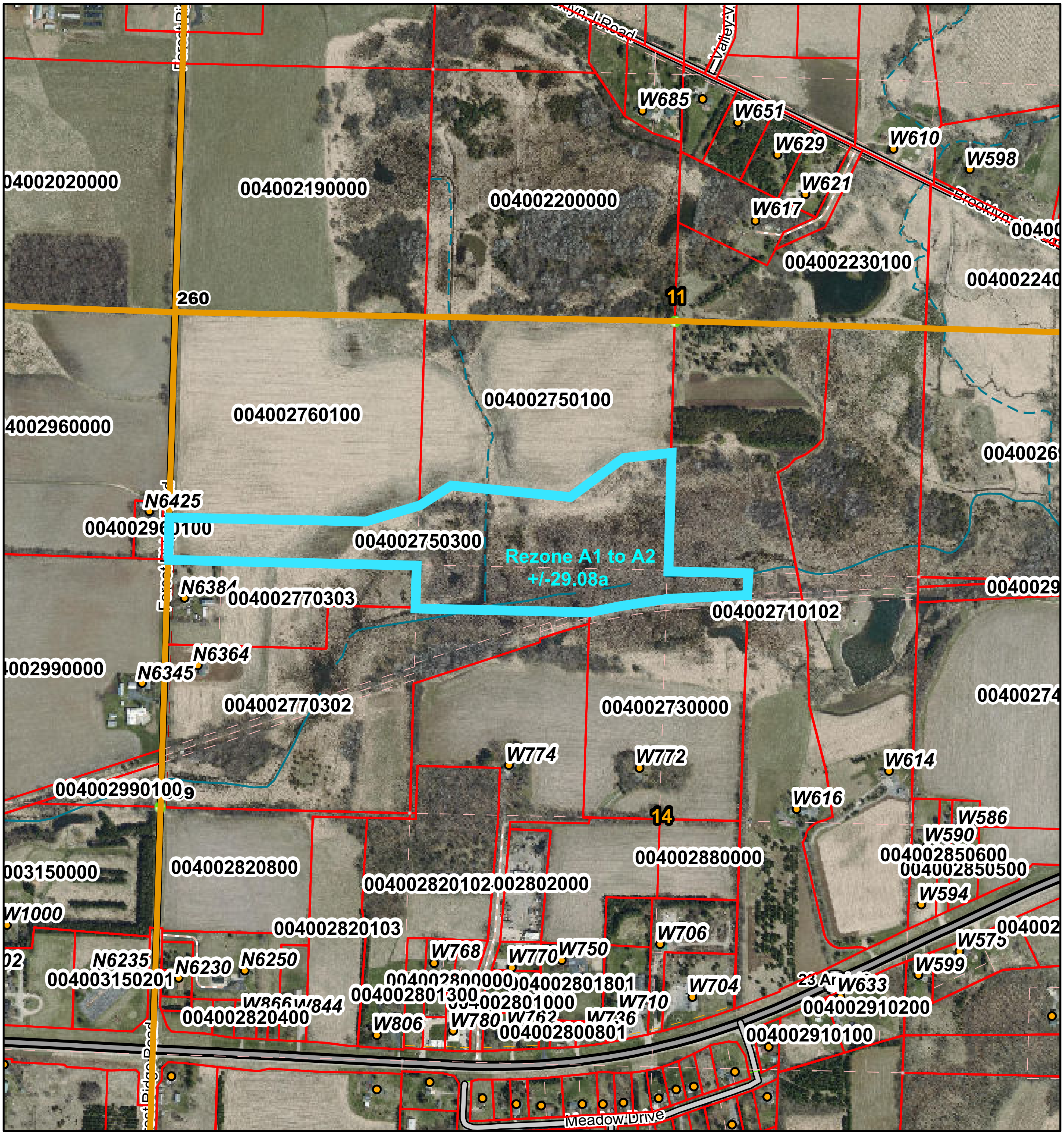
Current Zoning Classification A1 Current Use of Property Small agricultural use in the Western side and then wetlands for recreation in the Eastern side of the parcel.

Detailed Description of Proposed Use Construct a single family residential dwelling and utilize the wetlands for recreation.

PLEASE PROVIDE A DETAILED SITE PLAN WITH THE APPLICATION

Fees: Zone Change $375
Conditional Use Permit $375.00
Variance $375.00
Special Exception $375.00

Wustrack Rezone Aerial Map 2020



3/6/2024, 2:43:08 PM

Address	Corner	CENTER
Section	SECTION	SUB
	QUARTER	TaxParcel

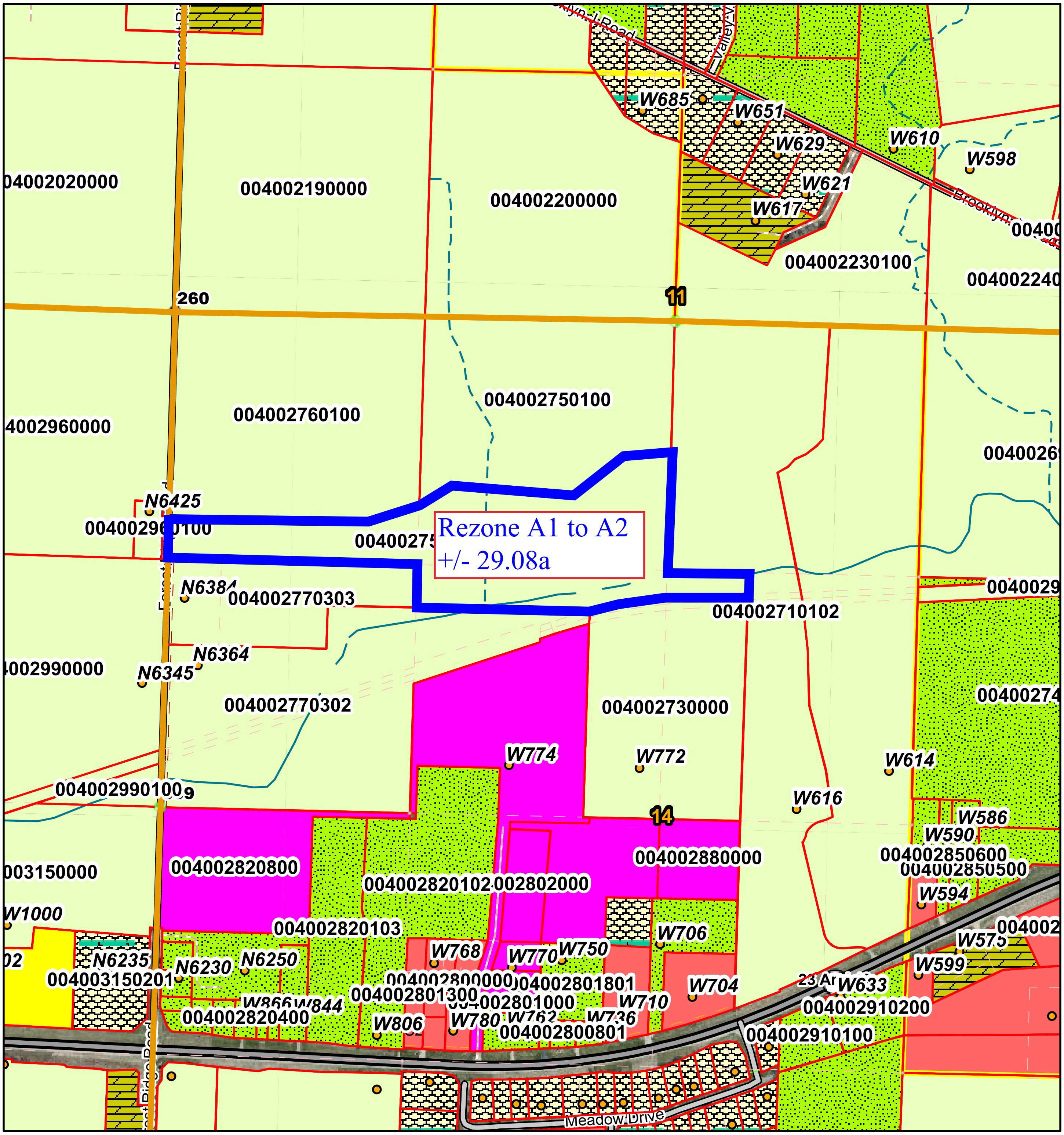
1:9,028

0 | 0.07 | 0.15 | 0.3 mi

0 | 0.1 | 0.2 | 0.4 km

Green Lake County, WI
www.greenlakecountywi.gov

Wustrack Rezone Zoning Map



3/6/2024, 2:52:57 PM

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0 | 0.07 | 0.15 | 0.3 mi

0 | 0.1 | 0.2 | 0.4 km

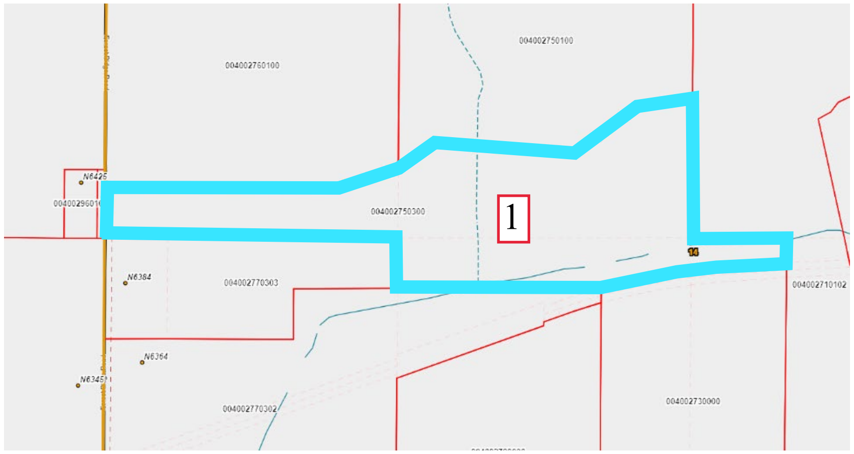
Address
Section
Corner
SECTION
QUARTER
CENTER
SUB
TaxParcel

Green Lake County, WI
www.greenlakecountywi.gov

Robert and Janel Wustrack
Town of Brooklyn
Forest Ridge Road, Parcel #004-00275-0300
Located in NE ¼ & NW ¼ of NW ¼ of Section 14, T16N, R13E

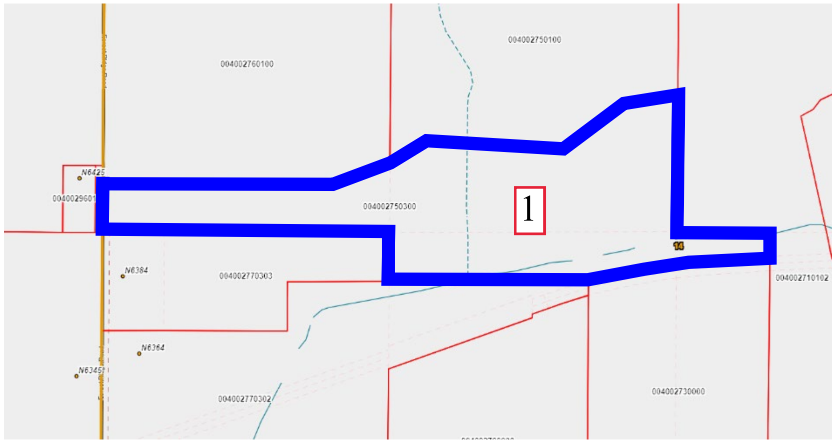
Existing Configuration

1 = 29.08-acre parcel zoned A1, Farmland Preservation District.



Proposed Configuration

1 = 29.08-acre parcel zoned A2, General Agriculture District.



Land Use Planning & Zoning Public Hearing 5/2/2024

From:	Kirkman, Matt
To:	Schinke, Ryan
Subject:	FW: Rezone N6410 forest ridge
Date:	Tuesday, April 16, 2024 11:17:15 AM

Ryan,
Please print this off and place it in the Wustrack rezone file.
Thanks,
Matt

From: Becki Sonnenberg <sendmail2beck@gmail.com>
Sent: Tuesday, April 16, 2024 9:19 AM
To: Reabe, Harley <hreabe@greenlakecountywi.gov>; Thom, Gene <gthom@greenlakecountywi.gov>; Boutwell, Bill <bboutwell@greenlakecountywi.gov>; Talma, Curtis <ctalma@greenlakecountywi.gov>; Buss, Chuck <cbuss@greenlakecountywi.gov>
Cc: clerk@tn.brooklyn.wi.gov; Kirkman, Matt <mkirkman@greenlakecountywi.gov>
Subject: Rezone N6410 forest ridge

[CAUTION: EXTERNAL SENDER This email originated from outside Green Lake County. Do not click links or open attachments unless you recognize the sender and know the content is safe.]

Good morning,
I have recently received notice from the Green Lake County Planning and Zoning committee that there is a hearing on May 2, 2024, regarding a planned rezone of ~29 acres at N6410 Forest Ridge Road. The planned rezone is to take the land out of A1 farmland preservation and put it into A2 general AG.

Twenty-four of these acres are considered wetlands and are not viable AG land at all but are still classified as such. The remaining ~5 acres are grade 1 and 2 soil tillable farmland.

I was under the impression that farmland preservation was a goal for Green Lake County as well as the Town of Brooklyn? Not to mention all of the grant monies that could be lost by not being an active participant in the Farmland Preservation program.

To remain consistent with prior opinions and rulings, this rezoning should be denied due to soil type and current participation in the Farmland Preservation program.

Please contact me if further discussion is required.

Respectfully
Becki Sonnenberg
W616 State Road 23
920.229.2465

TOWN BOARD ACTION

Dear Land Use Planning and Zoning Committee:

Please be advised that the Town Board of Brooklyn, County of Green Lake, took the following action on –
(Date) ______________________.

Owner/Applicant: Robert and Janel Wustrack

Site Location: Forest Ridge Road

General legal description: Parcel 004-00275-0300, Located in NE ¼ & NW ¼ of NW ¼ of Section 14, T16N, R13E, Town of Brooklyn, ±.29.08 acres

Request: Rezone ±29.08 acres zoned A1, Farmland Preservation District, to A2, General Agriculture District.

Planned public hearing date for the above requests: May 2, 2024

_____ **Town Does Not object to and Approves of request**

__X__ **No action taken**

_____ **Objects to and requests denial of request**

NOTE: If denial – please enclose Town Resolution of denial

- Reason(s) for objection:

____

____

____

TOWN OF BROOKLYN
N5988 COUNTY ROAD A
GREEN LAKE WI 54941

Town Representative **Date Signed**

NOTES: ______________________________

Please return this form to the Land Use Planning & Zoning Office by: April 19, 2024

ORDINANCE NO. –2024

Relating to: Rezone in the Town of Brooklyn
Owner: Robert and Janel Wustrack

The County Board of Supervisors of Green Lake County, Green Lake, Wisconsin, duly assembled at its regular meeting begun on the 21st of May 2024, does ordain as follows:

NOW, THEREFORE, BE IT ORDAINED that the Green Lake County Zoning Ordinance, Chapter 350 as amended, Article IV Zoning Districts, Section 350-26 Official Map, as relates to the Town of Brooklyn, shall be amended as follows:

Owner: Robert and Janel Wustrack**, Location:** N6410 Forest Ridge Road, **Parcel:** 004-00275-0300. **Legal Description:** NE ¼ & NW ¼ of NW ¼ , located in Section 14, T16N, R13E, Town of Brooklyn, ±29.08 acres. **Request:** The owners are requesting to rezone ±29.08 acres from A1, Farmland Preservation District, to A2, General Agriculture District.

BE IT FURTHER ORDAINED, that this ordinance shall become effective upon passage and publication.

Roll Call on Resolution No. -2024

Ayes , Nays , Absent , Abstain

Passed and Enacted/Rejected this 21st Day of May 2024.

____
County Board Chairman

____
ATTEST: County Clerk
Approve as to Form:

____
Jeffrey Mann , Corporation Counsel

Submitted by Land Use Planning & Zoning Committee:

____
Curt Talma, Chair

____
Chuck Buss, Vice Chair

____
Harley Reabe

____
Gene Thom

____
William Boutwell

Land Use Planning and Zoning Committee Staff Report

Public Hearing May 2, 2024

Item III: Conditional Use Permit (CUP)

Owner:	**Applicant:**
Christopher D and Ruth M Retzlaff	Kopplin & Kinas Co.,Inc Michael McConnell

Request: The owner/applicant is requesting a conditional use permit to operate a non-metallic mine.

Parcel Number/ Location: The request affects parcels 004-00789-0000 (±40.56 acres) and 004-00792-0000 (± 38.86 acres). The parcels are located in the NE and SE ¼ of the SE ¼ of Section 36, T16N, R13E, Town of Brooklyn. The site is located on County Rd K at the Fond Du Lac County Border.

Existing Zoning and Uses of Adjacent Area: The parcel referenced above is zoned A-1, Farmland Preservation District. The property is currently being used as a farm field. With 58.87 acres currently used for crop production. A total of 20.55 acres are not currently used for crop production. Most of the surrounding lands are also zoned as A-1. Directly to the West is a parcel zoned Industrial. The surrounding lands appear to be predominantly used for farm crops. There are three rural residences within 600ft of the subject parcel. The adjacent lands in Fond Du Lac County are zoned farmland preservation and rural residential.

Additional Information/Analysis: Kopplin & Kinas Co., Inc has been operating mines in Green Lake County and surrounding areas for almost 100 years. Currently Kopplin & Kinas operates six other non-metallic mines in Green Lake County.

The A-1 district allows for non-metallic mining operations as a conditional use. The mine is required to have a minimal impact on the surrounding Ag lands, and the agricultural land is to be restored back to an agricultural use in the final reclamation.

The proposed mined area will maintain a 100-foot buffer from all property lines. The mine would impact about 80 acres. The topsoil and overburden already on the site will be stripped and stored as screening berms around the property. The mine will focus on extracting limestone starting on the Northeast corner of the property. To extract the limestone, it will be “intermittently drilled and blasted” according to the Mine Safety and Health Administration Code. Limestone will be extracted down to ten feet above the depth of the high ground water elevation. Occasionally there may be portable processing equipment on site. There will also be a portable scale stored onsite and a gate will be built across the entrance. There will also be a portable sanitary station for customers/employees. The operator would like to have the mine open from 5:30am to 6:30pm Monday through Friday and 6:00am to 3:00pm on Saturday. They would also like the opportunity to occasionally work extended hours and at night.

Some major hazards for this facility are open mines/pits, aesthetics, noise, air quality, groundwater & surface water quality, and blasting. The safety aspects of a mine are regulated by the Wisconsin Department of Natural Resources, the Occupational Safety and Health Administration, the Wisconsin Department of Safety and Professional Standards, the Mine Safety and Health Administration, and the Bureau of Alcohol, Tobacco, Firearms, and Explosives. The mine will also have a gate across the entrance and signs posted around the mine's perimeter stating, "No Trespassing" and "Danger Active Quarry". To address the aesthetics of the mine it will be conducted below grade and the screening berms, with two staggered rows of Norway Spruce trees, will be built in a way to help block the view of the mine. To limit the impact of noise the operator will be using mufflers (as applicable), maintaining their equipment, and strategically placing material stockpiles in-between exterior parcels and processing equipment. To address air quality, they plan on following a fugitive dust control plan found in Appendix G of the Operation, Environmental Control, and Reclamation Plan. To address Groundwater & Surface water quality concerns they plan on following the Pollution Prevention Best Management Practices Plan found in Appendix F of the Operation, Environmental Control, and Reclamation Plan. To address blasting Kopplin and Kinas will record each blast with a seismograph, log it, and make it available upon request. The seismograph will be used to make sure that vibration levels meet State and Federal limits.

It is important that the Committee maintain the purpose and intent of the County Zoning Ordinance when reviewing and approving a request of this nature. The following criteria are to be used by the Committee when making conditional use permit decisions:

General Standards for Review of Conditional Use Requests: When reviewing a conditional use permit, the Committee shall take into consideration, among other things, the recommendation of the affected town and the particular facts and circumstances of each proposed use in terms of the following standards:

a) If an applicant meets or agrees to meet all of the requirements specified in this chapter and any conditions imposed by the Committee, based on substantial evidence, the Committee shall grant the conditional use permit.
b) Any condition imposed must be related to the purpose of the ordinance and be based on substantial evidence.
c) The requirements and conditions must be reasonable and, to the extent practicable, measurable, and may include conditions such as the permit's duration, transfer, or renewal.
d) The applicant must demonstrate that the application and all requirements and conditions related to the conditional use, are or shall be satisfied, and supported by substantial evidence. The Committee's decision to approve or deny the conditional use permit must be supported by substantial evidence.

Substantial evidence is defined as: facts and information, other than merely personal preferences or speculation, directly pertaining to the requirements and conditions an applicant must meet to *obtain a conditional use permit and that reasonable persons would accept in support of a conclusion.*

No conditional use permit for a non-metallic mine in the A-1 Farmland Preservation District shall be issued or approved with conditions by the Committee unless it shall find the conditional use:

a) Will not have a negative effect upon the health, safety, and general welfare of occupants of surrounding lands; and
b) Will be designed, constructed, operated, and maintained so as to be harmonious, be appropriate in appearance with the existing or intended character of the general vicinity, and that such use will not change the essential character of the same area; and
c) Will not be hazardous or disturbing to existing or future neighboring uses; and
d) Will not be detrimental to property in the immediate vicinity or to the community as a whole; and
e) Will be served by essential public facilities and services such as highways, streets, police and fire protection, drainage structures, and schools; the persons or agencies responsible for the establishment of the proposed use shall be able to provide, adequately, any such service; and
f) Will have vehicular approaches to the property that shall be so designed as not to create an interference with traffic on surrounding public or private streets or roads.
g) Will comply with Subchapter I of Chapter 295, Wisconsin Statutes, and rules promulgated under that subchapter, with applicable provisions of local ordinances under § 295.14, Wis. Stats. and with any applicable requirements of the Wisconsin Department of Natural Resources concerning the restoration of non-metallic mining sites.
h) Operation and Its location in the farmland preservation zoning district is consistent with the purposes of the farmland preservation zoning district.
i) Operation and its location in the farmland preservation zoning district is reasonable and appropriate, considering alternative locations outside the farmland preservation zoning district, or is specifically approved under state or federal law.
j) Operation is reasonably designed to minimize the conversion of land around the extraction site from agricultural use or open space use.
k) Operation does not substantially impair or limit the current or future agricultural use of surrounding parcels of land that are zoned for or legally restricted to agricultural use.
l) Owner agrees to restore the land to agricultural use, consistent with any required reclamation plan, when extraction is completed.
m) Will comply with Green Lake County Code Chapter 323 (Non-Metallic Mining Reclamation).

County Staff Comments: The Committee should review this request to determine if it meets the general criteria for review as listed above. If the Committee wishes to approve this request, the following conditions may be appropriate:

1. No additional expansion or addition of structures, mined area, and/or uses relating to this conditional use permit shall occur without review and approval through future conditional use permit(s).
2. The site shall obtain a fire number prior to the start of mining operations.
3. Any outdoor lighting shall comply with Section 350-23 of the County Zoning Ordinance.
4. Any restroom facilities/POWTS located on site must be compliant with Wisconsin Administrative code SPS 381-387 or SPS 391 as applicable.
5. Hours of Operation are from Monday- Friday from 5:30am to 6:00pm and Saturday from 6:00am to 3:00pm. Blasting may only occur Monday through Friday 9:00am to 3:00pm.
6. All mining equipment must have mufflers (when applicable).
7. That the owners/applicants are responsible for obtaining permits and licenses from any other regulatory agency.
8. Owner must obtain and follow an Erosion control and Storm Water Management Plan from the Wisconsin Department of Natural Resources.
9. Owner must receive and follow a Non-Metallic Mining Reclamation Permit from Green Lake County.
10. Owner must remain current with annual Non-Metallic Mining Fees and Financial Assurance requirements.
11. No excavation or blasting of materials shall occur within a 100ft buffer of all property lines excluding the property line separating parcels 004-00792-0000 and 004-00789-0000. Construction, maintenance, or removal of the following features shall not be considered excavating or blasting for the purpose of this condition: quarry entrance, exterior berms, stormwater basin, and diversion of unnamed stream (WBIC 5027058).
12. The Green Lake County Land Use Planning and Zoning Department shall be contacted prior to the use of a wash plant on site. All byproducts of the wash process shall be disposed of in a manner following the current applicable regulations and so as not to contaminate ground or surface water quality.
13. Any well, constructed or abandoned on site must be in compliance with NR 141 and done in a manner that prevents substantial contamination of ground water quality.
14. The elevation of groundwater within the proposed mining site shall be determined. This shall be accomplished by installing four groundwater monitoring wells, two in the Northern edge, one on the western edge, and the other in the SE corner of the proposed site. Each well shall be constructed into the groundwater table.
15. No material shall be removed below the aquifer or within 10 feet of the high ground water elevation as determined in condition 14 of this permit.

16. No material extraction shall occur within five feet of any feature that could substantially harm human health, ground water quality, surface water quality, or neighboring properties.
17. The Green Lake County Land Use Planning and Zoning Department must be contacted immediately if mining operations disturb a feature that could pose a serious risk to: human health, ground water, surface waters, or neighboring properties.
18. The Green Lake County Land Use Planning and Zoning Department shall be notified at least 24 hours prior to any blasting operations.
19. Information about blasting seismograph data as required by WI State Administrative code SPS 307.31(4)(18) shall be made public upon request by a member of the public, an employee of: Green Lake County, the State of Wisconsin, or the United States Federal Government.

Town of Brooklyn: An Action Form requesting the Town's input related to this CUP request was emailed to the Town Clerk on March 13, 2024. The town of Brooklyn took no action.

Please type or use black ink

Return to: Green Lake County
Planning & Zoning Department
571 County Road A
Green Lake, WI 54941

GENERAL APPLICATION

Fee $375.00 (not refundable) Date 02/29/2024

Zone Change from ________ to ________

Conditional Use Permit for Non-Metallic Mineral Extraction

Other ____________________

PROPERTY OWNER / APPLICANT

Name Christopher D. & Ruth M. Retzlaff

Mailing Address W14445 Retzlaff Dr, Ripon, WI 54971

Phone Number (920) 229-2853

Signature [signature] Date 02/29/2024

AGENT IF OTHER THAN OWNER

Name Michael C McConnell, Kopplin & Kinas Co., Inc.

Mailing Address W1266 N Lawson Dr., Green Lake, WI 54941

Phone Number (920) 294-6451

Signature [signature] Date 02/29/2024

PROPERTY INFORMATION

Town of Brooklyn Parcel Number 004-00789-0000 004-00792-0000 Acres 80

Lot ___ Block ___ Subdivision ____________

Section 36 Town 16 North Range 13 East

Location of Property CTH K & Searle Rd

Legal Description The Northeast Quarter of the Southeast Quarter (NE 1/4 SE 1/4) and the Southeast Quarter of the Southeast Quarter (SE 1/4 SE 1/4) of Section Thirty Six (36), Township Sixteen (16) North, Range Thirteen (13) East, Town of Brooklyn, GreenLake County, Wisconsin.

Current Zoning Classification A-1 Current Use of Property Ag/Non-Ag

Detailed Description of Proposed Use Limestone quarry. See attached documentation.

PLEASE PROVIDE A DETAILED SITE PLAN WITH THE APPLICATION

Fees: Zone Change $375
Conditional Use Permit $375.00
Variance $375.00
Special Exception $375.00
NMM Reclamation Permit $450

PZP-010 (04/09)

KOPPLIN & KINAS CO., INC.

GREEN LAKE, WISCONSIN

NONMETALLIC MINING OPERATION & RECLAMATION PLAN

FOR THE

K QUARRY

SECTION 36
TOWN OF BROOKLYN, GREEN LAKE COUNTY

December 2023

SITE & CONTACT INFORMATION

SITE LOCATION:

SE ¼ OF THE SE ¼, SECTION 36, T16N-R13E
TOWN OF BROOKLYN
GREEN LAKE COUNTY, WISCONSIN

TAX PARCEL NUMBERS: 004-00789-0000,

004-00792-0000

CURRENT SITE ADDRESS:

THE NORTH SIDE OF CTH K
AT THE EAST COUNTY LINE

OPERATOR:

KOPPLIN & KINAS CO., INC.
W1266 NORTH LAWSON DRIVE
GREEN LAKE, WI 54941
PHONE: (920)294-6451
FAX: (920)294-6489
https://kkci.us

DONALD E. KINAS, JR. – PRESIDENT
CHRISTOPHER KINAS – AGGREGATE OPERATIONS
MIKE MCCONNELL - PROJECT MANAGER

PROPERTY OWNER:

CHRISTOPHER D. & RUTH M. RETZLAFF
W14445 RETZLAFF DR.
RIPON, WI 54971

1 TABLE OF CONTENTS

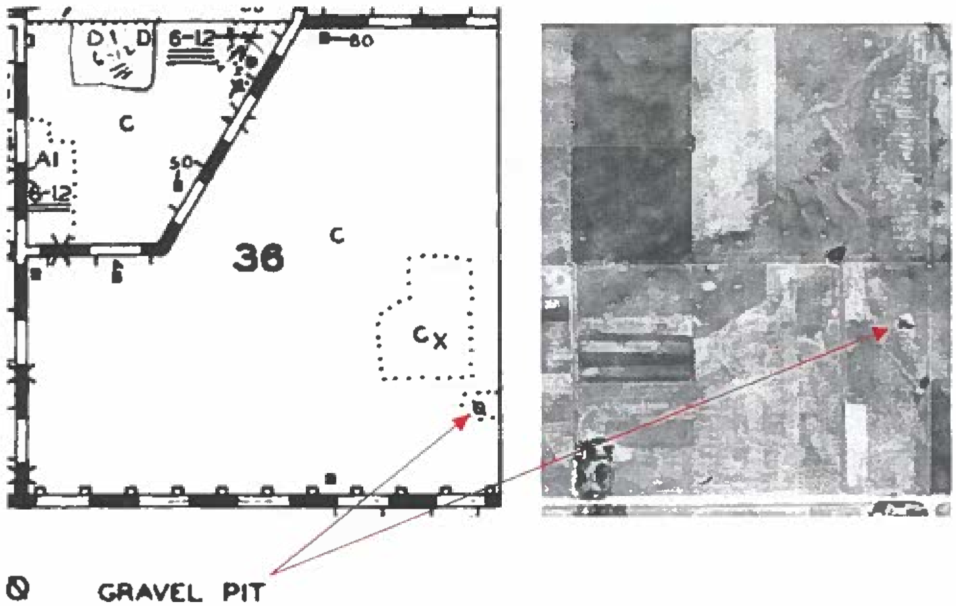
2 INTRODUCTION

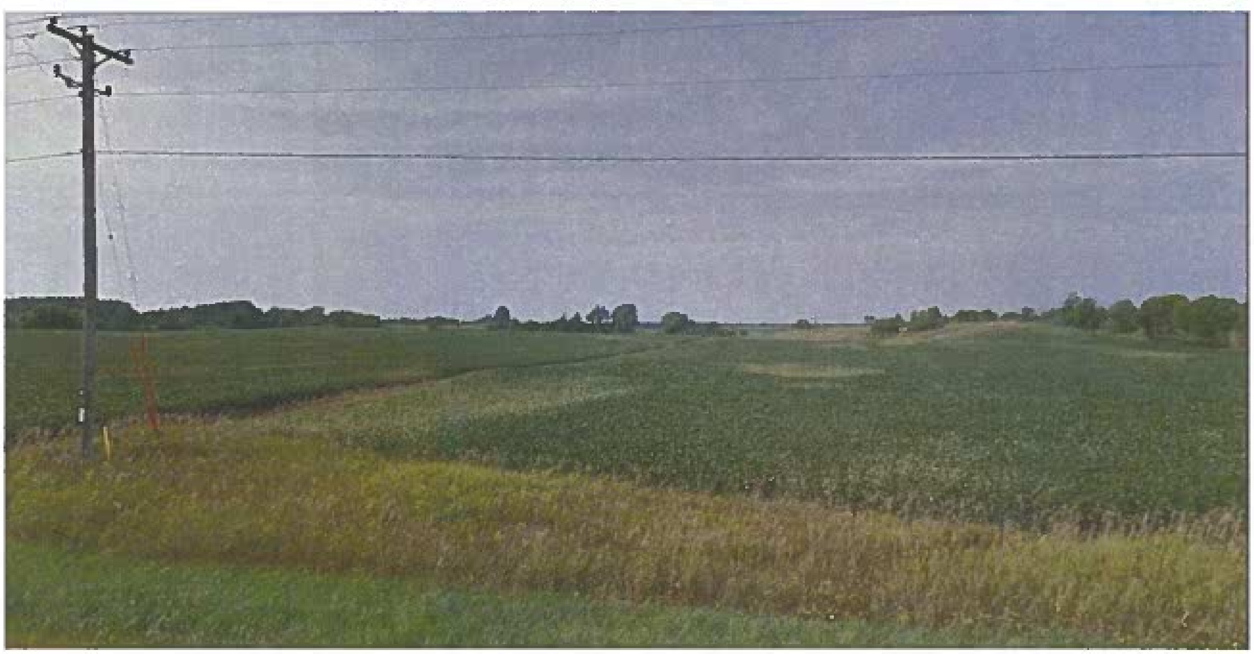
Kopplin & Kinas Company Incorporated (KKCI) is an aggregate producer and heavy/civil construction company serving communities in Green Lake and the surrounding counties since 1926. As the cost of transporting aggregates to construction sites steadily increases, KKCI must work to secure new sources of crushed stone, sand, and gravel to meet the needs of their customers by producing aggregates at locations closer to the geographic markets which they serve. The Retzlaff property located on CTH K at the east county line, contains a commercial grade limestone deposit. The site's location is ideal to service customers in Green Lake, Markesan, Fairwater, and Ripon.

This report has been prepared to: (1) fulfill the requirements of NR135, Wisconsin Stats. administered by Green Lake County Nonmetallic Mining Reclamation Code Ch. 323, (2) supplement KKCI's conditional use permit application for Green Lake County and the Town of Brooklyn, and (3) comply with other applicable local, state, and federal laws governing human health and environmental protection.

3 BACKGROUND

The Retzlaff property has historically been an agricultural field. The limestone formation beneath the field averages twelve feet from the surface. The southern forty-acres of the property has had some small-scale mining of glacial deposits in the past, evidenced from historic aerial photography and the Wisconsin Land Economic Inventory Survey (Bordner Survey) conducted in the nineteen-thirties and forties.





4 EXISTING SITE CONDITIONS

This section contains a review of the site's physical location and geographic setting, and information on soils, geology, surface and groundwater, wetlands, and existing biological resources.

4.1 LOCATION AND LAND USE

The 80-acre property is located on the north side of CTH K at the east Green Lake County line, in the Town of Brooklyn, Green Lake County, Wisconsin (See A-1: USGS Quadrangle/Property Overlay, Appendix A). The legal description and parcel number for the property is as follows:

Parcel IDs: 004-00789-0000, 004-00792-0000

Legal Descriptions: NE ¼ of the SE ¼, Sec. 36, SE ¼ of the SE ¼, Sec. 36

Additional parcel information for the property and surrounding area can be found in A-1: USGS Quadrangle/Property Overlay, Appendix A.

The property is zoned A-1 Farmland Preservation and is predominantly neighbored by agricultural zoning and land use, an Industrial use, and small amounts of rural residential housing.

4.2 GEOGRAPHIC SETTING

The topographic features of the property consist of a gradually sloped topography with several moraines, shaped by the recession of the Green Bay Lobe of the Laurentide ice sheet. Natural changes in elevation on the property range from approximately 977' to 1032' above mean sea level (AMSL) (See A-2: Existing Ground, Appendix A).

4.3 DISTRIBUTION, THICKNESS, AND TYPE OF SOILS

The soil types found on the property consist of the Markesan, Mendota, Plano, and LeRoy series. A description of these soil types is provided in A-3: Soil Map, Appendix A.

The predominant soil types found on the property within the proposed area of mineral extraction are the Markesan Silt Loam and the Plano Silt Loam. Commonly found in the glacial till plains of the area, these soils have an average A-horizon depth of six to eleven inches, and the underlying soil is comprised mostly of silt loam, and clay loam. According to the USDA Soil Survey these soils are well drained and contain a high content of calcium carbonate (limestone); limestone bedrock is present at an average depth of twelve feet.

4.4 GEOLOGY & DESCRIPTION OF THE MINERAL RESOURCES

The glacial till that overlays the property is classified as part of the Horicon member of the Holy Hill Formation. The property is underlain by Ordovician aged dolomitic limestone of the Sinnipee Group containing the Galena, Decorah, and Platteville formations. The top of the limestone formation ranges between 965' and 1020' AMSL. The well reports for the immediate area show the Sinnipee group limestone ranging from 53' to 117' in thickness.

4.5 Surface Water, Wetlands & Groundwater

Existing drainage patterns on the property are shown on A-2: Existing Ground, Appendix A. Surface water at the site currently drains to the north through an agricultural drainageway that collects surface water from the property and agricultural lands to the south of the property. The drainageway meanders northwest from the property for approximately 1.31 miles where it flows into Dakin Creek.

There are no known or mapped wetlands on the property.

Groundwater flow across the property runs at approximately a 1% grade based on local well data. The predominate groundwater flow direction is to the north-west, towards Green Lake. Water supply wells in the area are generally installed into the water bearing sandstone aquifer. The groundwater elevation at the property is estimated to range from 937' AMSL at the south end of the property to 916' AMSL at the north end of the property based on local well logs. The residential wells in the area surrounding the property range from approximately 140' to 220' in depth and are cased anywhere from 42' to 178' in depth.

4.6 LOCAL WELL CONSTRUCTION SUMMARY

Well Owner Name** & Address	Casing Length	Depth of Well	Static Water Level	Water Elevation AMSL
Roy Voss (1977) N7251 Searle Rd	75'	215'-Limestone/Dolomite	100'	930'
Edward Manske (1965) W103 CTH K	48.5'	158'-Sandstone	*83'	939'
Art Herschberger (1997) W208 CTH K	103'	177'-Sandstone	85'	937'
Richard Hahn (1975) W244 CTH K	75'	190'-Sandstone	79'	940'
Gloria Kemnitz (2009) W241 CTH K	178'	218'-Sandstone	85'	935'
John Limboch (1959) W14310 Prairie Rd	42'	200'-Sandstone	60'	924'
Eric Godfrey (1990) W14411 Prairie Rd	62'	220'-Limestone/Dolomite	64'	901'
August Quick (1950) W239 Prairie Rd	75'	140'-Sandstone	52'	902'
Steve Machkovich (2004) Well Log & (2013) WGNHS Log W235 Prairie Rd Irrigation Well	61'	415'-Sandstone	92'	896'

**** Owner at the time of construction, year of construction is in parentheses.**
***Static water level on well report incorrectly recorded as 38'.**

4.7 Agricultural Vegetation & Wildlife

Approximately 59.45 acres of the property is used as an agricultural field. Row crops such as corn or soybeans are planted on an annual basis. The remaining 20.55 acres of the property is not suitable for agricultural use and is covered by grass and brush.

The Retzlaff property provides support for transient species such as Canada Geese and Sandhill Cranes. Year-round wildlife species in the area include hawks, foxes, skunks, White-Tail Deer, rabbits, coyotes, raccoons, and field mice.

4.8 Cultural resources

There are no known sites of cultural significance or catalogued/uncatalogued human burial grounds on the property. The results of several archaeological investigations in Section 36 support this finding. The site will be further reviewed by a Wisconsin Department of Natural Resources archaeologist during the Stormwater/WPDES permitting process.

4.9 Wisconsin Chapter 30 Determination

An agricultural drainageway enters at the southeast corner of the property and runs north along the east side of the property exiting in the northeast corner. In April of 2023 Green Lake County staff performed a navigability determination on the drainageway and found it to be non-navigable. The determination was sent to the Wisconsin Department of Natural Resources for review and concurrence. The Wisconsin Department of Natural Resources concurs with the determination (See Appendix C) and has declared that the drainageway is not regulated as a public watercourse. Permits are not required to work in, near, or to alter the drainageway.

5 PROPOSED OPERATIONS

The following plan of operation has been developed to efficiently utilize the site's natural and agricultural resources, protect human health and the environment, and minimize long-term operational costs. See A-5: Proposed Site & Phasing, Appendix A.

5.1 ACCESS, BUFFER ZONE, SITE PREPARATION & EROSION CONTROL

The site will be accessed from CTH K, approximately 375' west of the intersection with Searle Rd. The existing entrance will be widened to accommodate operations at the site, and will be constructed of crushed stone and paved with asphalt to the inner boundary of the required 100' buffer zone to minimize tracking of debris onto CTH K. The 100' buffer zone will be established from all exterior property boundaries and the right of way of CTH K. No mineral extraction will occur inside of the buffer zone and a screening berm will be constructed in this area. An additional 50' along the north end of the site will not be extracted to provide space for a stormwater basin and facilitate maintenance access to the basin.

The screening berm will serve multiple functions. The berm acts as a safety barrier from mining operations. It also provides an aesthetic buffer from site operations by providing a visual barrier and dampening sounds from day-to-day operations. The berm will also be utilized as topsoil and overburden storage for later use in the reclamation stages of the operation. The berm will range from 10' to 15' in height and have a maximum 3H:1V slope. As construction of the berm is completed, it will be seeded down to establish vegetation and stabilize the berm. Two staggered rows of Norway Spruce trees will be planted on the top third of the exterior side of the screening berm on the southern 40-acre parcel and the rest of the berm will be seeded with native grasses and wildflowers to enhance the screening capability and visual aesthetics of the berm.

The site will be developed incrementally to minimize disturbed areas and allow existing agricultural operations to continue as long as practicable. Topsoil and overburden will be stripped to access the limestone formation. Removed topsoil and overburden will be separated and used to construct the screening berm surrounding the property. Clay soils will be further separated from the overburden and stockpiled for pond liner material for the site stormwater pond and the pond to be built during the reclamation phases of the site. Fill material hauled to the site will also be stockpiled for use in the reclamation process and clay materials hauled to the site will be stockpiled with the onsite clay for use in pond construction. Upon commencement of mining at the site, approximately 10 acres will be stripped to the limestone formation. The overburden from the initial 10 acres will supply the material needed to construct the screening berm around the property.

Surface water runoff from neighboring properties enters the site at three locations. Runoff from lands south of CTH K enter the site through a drainage ditch near the south-east corner of the property. Runoff from lands west of the site enter at two locations on the west property line to the north and south of the center of the property. The three external runoff points will be diverted into a storm sewer network that will run along the west and east property lines and convey the runoff to a stormwater basin that will be constructed in the 150' buffer area on the north end of the site. Surface water flows inside the screening berm but outside the active extraction area will be conveyed through temporary ditches and diversions to either the stormwater basin or to temporary basins and allowed to dissipate naturally. It is anticipated that surface water from precipitation in the active extraction area will infiltrate into the exposed rock, as is common in limestone quarries operating above the water table. If there is a limiting factor such as a clay seam below the terminal elevation of the quarry floor or a major precipitation event that makes allowing the water to dissipate naturally impractical, the surface water from the active area will be pumped to the stormwater basin. All surface water management practices will adhere to the requirements of the site's Wisconsin Pollutant Discharge Elimination System permit and utilize the Pollution Prevention Best Management Practices contained in Appendix F, as well as erosion controls outlined in the Wisconsin Department of Natural Resources, "Wisconsin Construction Site Erosion Control Field Guide". These best management practices will be utilized as needed to prevent sediment loss and stabilize soil during all phases of the site's operational lifespan. Such measures include the utilization of seeding, mulching, stormwater ponds, sediment traps, grassed swales, and crushed stone checks.

5.2 Aggregate Removal & Processing

Extraction of the limestone will begin in the north-east quadrant of the site in area 1-A. The extraction operation will progress incrementally through phase 1 and then through phase 2 ending extraction in the south-west quadrant of the site.

The limestone will be intermittently drilled and blasted. This process involves drilling holes into the limestone and loading the holes with a blasting agent. The blasting agent is detonated by trained and licensed blasters. The blasts are designed to displace the rock from the solid formation, fragmenting it to a size that permits efficient crushing and sizing of the rock. All blasting is performed in accordance with Wisconsin Administrative Code chapter SPS 307 and 30 CFR, Part 56, Sub Part E of the Mine Safety and Health Administration Code.

The limestone will be extracted to a maximum depth of 10' above the groundwater elevation at the site at the time of commencement, to be determined through observations from four monitoring wells that will be installed at the site, and at least 5' above the St. Peter sandstone that lies directly below the limestone formation. The more restrictive elevation of the two will be used. This will ensure that the extraction operation maintains an adequate buffer above groundwater, also allowing for groundwater level fluctuation, and prevent the exposure of the sulfide cement horizon (SCH) which is known to be present at the top of the St. Peter Formation. The location of the SCH is easily identified through test drilling. Test drilling of phases 1-A through 1-D will be performed prior to the initial blast at the site to determine the elevation of the SCH, and periodic test drilling will be performed thereafter as extraction progresses through subsequent phases to ensure the buffer is maintained. Based on local well data, the limestone formation terminates at approximately 900' AMSL, which puts the floor of the quarry at range of 26' to 47' above the St. Peter sandstone and the SCH. It is estimated that the terminal elevation for extraction will range from 947' AMSL at the south end of the extraction area to 926' AMSL at the north end of the extraction area based on data from local well logs.

Portable processing plants will be brought in intermittently to crush and size the blasted limestone into stockpiles of finished products. Portable processing equipment and stockpiles will be staged within the area of extraction and placed to accommodate the working face of the quarry. A list of equipment that could be utilized on-site for aggregate processing is included in Appendix E- Aggregate Processing & Construction Equipment.

5.3 PORTABLE ASPHALT & CONCRETE BATCH PLANT OPERATION

There may be local projects from time to time that require enough pavement material to stage a portable asphalt or concrete batch plant at the site. These plants will be operated in accordance with the Wisconsin DNR regulations that pertain to them. There will be no permanent asphalt or concrete production plants at the site.

5.4 SUPPORT STRUCTURES

There will be no permanent buildings or structures at the site. All the processes conducted at the site utilize completely portable equipment. A gate and proper signage will be at the entrance of the site. A portable scale house and scale will be positioned near the site entrance to weigh products as they leave the site. A portable sanitary station will be provided for employees/customers.

As the site is developed it may be determined that a water supply well is needed to supply water for dust suppression, supplemental water for washing aggregates, or portable pavement plants. A licensed well driller will be hired to construct the well in compliance with Wisconsin Administrative Code and Wisconsin Department of Natural Resources requirements.

5.5 HOURS OF OPERATION

The hours of operation at the site will align with agricultural schedules in the area to take advantage of optimum daylight during the construction season. Working hours for processing and material hauling will be from 5:30am to 6:00pm, Monday through Friday and 6:00am to 3:00pm on Saturdays. Blasting will only be performed between 9:00am and 3:30pm, Monday through Friday. Maintenance and equipment repair as well as set-up and tear-down of processing equipment may be performed outside of these times as they generally only require the use of hand tools and minimal amounts of support from heavy equipment.

All operations at the site will occur intermittently based on market demand. It is projected that the site will produce an average of 100,000 to 150,000 tons of finished product a year requiring an average of two processing sessions with a duration of three weeks or less time depending on the products required. The yearly tonnage estimate provides for an average of two trucks per hour hauling product from the site in a 10-hour workday.

6 HUMAN HEALTH & ENVIRONMENTAL PROTECTIONS

Several different features have been incorporated into this plan to protect human health and the environment. They are outlined below.

6.1 SAFETY

The safety aspects of nonmetallic mining are regulated by the Occupational Safety and Health Administration as well as the Mine Safety and Health Administration. The physical safety features proposed for the Retzlaff property are the installation of berms, a locking gate, and proper signage around the site. Posted notices and signs will increase awareness and improve safety. These include:

1. Notice of the required site-specific safety training and KKCI safety policies for those entering the site.

2. Signs with "No Trespassing" and "Danger Active Quarry" posted on the gate, berms, and perimeter of active operations.

KKCI promotes a safety culture within the company. All employees receive new miner training when hired and annual safety refresher training which is required by MSHA. The safety culture is also reinforced through company-wide safety meetings to educate employees on the use of new equipment they may not be familiar with, changes in safety policies, and to identify and correct any areas that need improvement. On-site crews conduct pre-shift team meetings to discuss the tasks that will be performed during their shift, identify potential safety hazards associated with the tasks, and develop a plan to avoid or correct identified hazards.

All site visitors, vendors, and customers are required to receive site specific safety training before entering the site. Any outside contractors performing work at the site are required to have received all MSHA mandated training in addition to site specific safety training.

6.2 AESTHETICS

The site will be developed below the existing grade. A screening berm will be constructed and maintained around the site which will provide a view of natural vegetation from outside the quarry, rather than the quarry operation. Two rows of Norway Spruce trees will be planted towards the top of the berm on the southern 40-acre parcel to enhance the screening effect. The berm will be planted with native grasses and flowers to add visual appeal to the berm and provide a food source for pollinators.

6.3 NOISE

Sound is produced by the various pieces of equipment required to operate the site. The sounds from the operation will be similar to other sounds routinely generated in the area by nearby agricultural operations, industrial operations, and highway traffic. The screening berm around the site will drastically reduce sound levels from site operations. Surrounding the processing area with material stockpiles also effectively dampens sounds from the operation. The use of modern processing equipment contributes to reduced sound levels because most of the units that comprise the plant do not have an engine, instead they are powered by an electric generator. It is common to have only two engines on a processing plant, one on the primary crusher because it requires a lot of power and can function as a stand-alone piece for certain products, and one engine to power the generator which in turn powers the screen units, secondary and tertiary crushers, and all the conveyors. The mobile equipment units that support the plant and load the products into trucks are equipped with mufflers and kept in good running order, which also helps reduce sound levels.

6.4 Air Quality

Dust control is of the utmost importance. Excessive dust generation can create safety issues such as obscured visibility of site operations and potential health impacts if the respirable particles are comprised of silica. The mineral deposit at the Retzlaff property is a limestone formation which is not a siliceous (comprised of silica) mineral. Limestone generally has a quartz content of 5% to 10% or less and is comprised mostly of calcium carbonate and magnesium. Quartz is the most common form of silica in Wisconsin. Industrial sand is comprised of 95% quartz or higher, and igneous rocks such as rhyolite or granite have a quartz content of 20% to 60%. The quartz content of glacial sand and gravel deposits can vary widely depending on which lobe of the glacier they originate from and what other mineralization was mixed into the deposit as the glaciers receded. The low quartz content of limestone means that respirable dust generated from limestone mining operations have a very low likelihood of causing silicosis and other lung diseases associated with the inhalation of respirable crystalline silica particles. KKCI has prepared a Fugitive Dust Control Plan for the K Quarry (Appendix G) which utilizes Wisconsin Department of Natural Resources best management practices for dust control and fugitive dust prevention.

6.5 Groundwater & Surface Water Quality

Limestone extraction at the site will terminate a minimum of 10' above the groundwater level observed at the site upon commencement. **There will be no mining at, into, or below the water table**. The extraction will terminate above groundwater level, meaning there will be no groundwater dewatering occurring and no risk of lowering the local water table or the available amount of water in local wells. Limestone extraction will terminate a minimum of 5' above the sulfide cement horizon (SCH) at the top of the St. Peter sandstone formation, which will prevent the exposure of sulfide mineralization. Exposing and dewatering the SCH can potentially cause the water that is drawn out of it to become acidic and release high amounts of metals which may also be present in the SCH. There will be no chemical processing of aggregates at the site. Blasting will be performed using an ANFO based emulsion which is a highly viscous waterproof compound that prevents degradation, migration and leaching of nitrates to groundwater.

Surface water runoff from the surrounding agricultural lands will not be permitted to flow into the extraction area. This water will be diverted into a storm sewer network where it enters the property and conveyed to the stormwater basin on the north end of the site, which will reduce both the sediment and nutrient loading of the water before it is discharged from the pond. On-site surface water will not be permitted to flow into the extraction area and will be diverted to the stormwater basin on the north end of the property or to temporary basins to reduce the sediment and nutrient loadings of the surface water. Surface water inside the extraction area will be allowed to dissipate naturally or in the case of an extreme precipitation event or a limiting factor below the terminus of the quarry, will be pumped to the stormwater basin. Wisconsin Department of Natural Resources WPDES permitting for the site requires water quality testing and monitoring if surface water from the extraction area is pumped to the stormwater basin. This ensures that water discharged from the site is clean and does not pose a threat to humans or wildlife.

A complete copy of the Pollution Prevention Best Management Practices Plan is included in Appendix F. This plan identifies potential contaminants and provides best management practices for protection and prevention.

6.6 Blasting

Blasting will be conducted on an intermittent basis, and likely only occur 2 to 4 times a year. All blasting at the site will be performed by licensed professional blasters and result in safely conducted blasts with ground vibration and airblast inside the regulatory safety limits and no damage occurring to surrounding properties. Each blast is recorded by a calibrated seismograph, logged, and made available upon request. The seismograph monitors ground vibration and airblast levels to ensure compliance with State and Federal limits.

7 POST MINING LAND USE & RECLAMATION PLAN

Based upon the amount of limestone reserves on the Retzlaff property, it is expected that the resources will supply area communities for at least seventy years.

When the available resources on the Retzlaff property are fully extracted, the site will be restored for agricultural use to the pre-mining ratio of agricultural and non-agricultural (See A-4: Existing Agriculture, Appendix A) use consistent with the A-1 Farmland Preservation zoning classification of the property. The details of the plan are presented below.

7.1 SITE GRADING & PREPARATION

Grading and site preparation will occur incrementally throughout the life of the quarry. Once the footprint of the quarry is large enough to contain all material stockpiles and allow enough room for processing equipment to continue mineral extraction (approximately Phase 1-F) interim reclamation will begin. The overburden from precedent and subsequent phases, and excess fill from projects in the area will be utilized to raise inactive areas of the quarry to the final elevations shown in A-7: Reclamation Grading Plan, Appendix A. Interim reclamation will progress with extraction, as space requirements allow, through Phase 2 with final reclamation occurring after mineral extraction at the site is complete. The reclaimed site will generally consist of a gently sloping grade towards the pond and slopes no steeper than 3H:1V covering the portions of the highwall that extend above 978'AMSL. The surface water that enters the reclaimed site will be directed to the pond. The pond will be lined with a minimum of 2' of clay materials that were separated during overburden stripping. The pond floor will have a minimum of 4' of separation from bedrock. Any clay materials that were hauled to the site and stockpiled will also be utilized for pond construction. The main body of the pond will range from 25' to 36' in depth and have 3H:1V slopes. The north end of the pond will be substantially shallower, ranging from 8' to 2' in depth. The pond will have a permanent pool elevation of approximately 976' AMSL and utilize the outfall structure from the extraction phase of the site.

7.2 OVERBURDEN & TOPSOIL PLACEMENT

The overburden that was stripped from the site and used to construct the screening berms or placed in temporary stockpiles as well as imported fill material, will be dispersed and graded to a minimum of eight inches below the grades shown on A-7 Reclamation Grading Plan, Appendix A to accommodate for topsoil placement above the proposed pond water elevation.

The topsoil from the site will be spread across the site at a minimum thickness of eight inches to reach the final grades established in the Reclamation Plan.

7.3 SITE REVEGETATION & EROSION CONTROL

The agricultural acreage of the site will be planted as grass hay/pasture ground. It will be seeded with an equine pasture mix consisting of 40% Orchardgrass, 20% Tetraploid Perennial Ryegrass, 15% Kentucky Bluegrass, 15% Timothy, and 10% Intermediate Ryegrass, or the closest equivalent available at the time of seeding. The seed will be planted with a seed drill to a depth of ¼ to ½ inch at a rate of 25 pounds per acre. Soil tests will be performed prior to seeding to determine the type and appropriate application rate for any fertilizer that may be needed.

The pond slopes will be seeded with Canada Wild Rye to stabilize the slopes and provide protection from erosion until the water level reaches the permanent pool elevation. The Canada Wild Rye will be planted with a seed drill to a depth of ¼ to ½ inch at a rate of 10 pounds per acre. As the water level in the pond reaches the elevation of the shallow area on the north end of the pond, the area will be prepared and planted with a wetland emergent mix of seed to be drilled or broadcast at a rate of 4 pounds per acre, to promote a wetland filter area at the outfall of the pond.

Seeding will be conducted in spring, early summer, or fall. Seeding during mid to late summer as well as during exceedingly hot or dry weather will be avoided to maximize the successful germination and survival of the plantings. Mulch and erosion matting will be utilized as necessary to protect the plantings from erosion.

The reclamation work at the site will utilize the existing erosion control measures in place from the extraction phase of the site, as well as additional erosion control BMPs as needed. Additional BMPs may include but are not limited to silt fence, ditch checks, Water diversion berms or channels, mulching, erosion matting, and temporary seeding.

7.4 INTERIM RECLAMATION

Interim reclamation at the site will begin as soon as space allows (approximately Phase 1-F). Interim reclamation reduces the amount of time required to reach full reclamation of the site and reduces total reclamation costs. Interim reclamation will begin along the outer edges of the extraction, filling along the highwall and working inward towards the middle of the site following behind extraction as it progresses. Interim reclamation will stop during Phase 2-C to allow adequate room for operations in the final areas of Phase 2 to be extracted. Areas of interim reclamation that meet the final reclamation elevation and vegetation requirements will be reviewed and inspected as they are completed. If the regulatory authority approves the interim areas as complete, they will be treated as fully reclaimed and financial assurance for the approved acreage will be released.

7.5 ESTIMATED COST OF RECLAMATION

The following cost estimate is provided to establish the proper amount of financial assurance required for the site. The amount of financial assurance will be periodically reviewed and adjusted to meet the regulatory authority's requirements. The total acreage to be disturbed is 79.17 acres of which 58.62 acres will be reclaimed back to agricultural use, and 20.55 acres will be reclaimed to non-agricultural use in accordance with the pre-existing ratio of ag/non-ag acreage on the property. The work and materials required to complete reclamation and the cost per acre for each item are shown in the table on page 16.

It is estimated that there will be approximately 1,600,000 cubic yards of overburden on-site, 85,500 cubic yards of which is topsoil. Approximately 1,440,000 cubic yards of fill material will be hauled into the quarry to reach final reclamation grades.

Fill material sites for excess dirt from civil construction sites are becoming increasingly difficult to locate. Nonmetallic mineral extraction sites are an ideal location to dump excess clean fill materials, as they generally allow for an easily accessible dumping area, they have Wisconsin Department of Natural Resources permits, and they have stormwater and erosion control best management practices in place. Currently KKCI charges customers a per load fee to dump clean fill at sites that can utilize the material for reclamation, and frequently refuses fill material so that reclamation work does not encroach on actively mined areas. Customers with large projects that will generate a substantial amount of excess fill material are generally allowed to dump free of charge or for a reduced fee, provided that the customer levels the fill brought to the site with their own equipment and grades it to KKCI's specifications. KKCI also performs civil construction and frequently hauls excess fill from projects to local aggregate sites and levels the material with its own equipment in exchange for no charge dumping or a reduced dumping fee. As such, if the regulatory authority had to hire a contractor to reclaim the site, imported fill material and the leveling of imported fill material would not be a cost. If the regulatory authority chose to do so, they could generate revenue by charging a small fee to dump and require contractors to level the fill material with their own equipment.

Reclamation Cost Summary Table

Activity/Material	Cost Unit	Total Units	Cost Per Unit	Total Cost	Cost Per Acre
Redistribute & Grade Overburden	Cubic Yard	1,514,500.00	$1.25	$1,893,125.00	$23,912.15
Redistribute & Grade Topsoil	Acre	58.87	$1,891.75	$111,367.32	$1,891.75
Seed & Seeding Hay Ground	Acre	58.87	$103.95	$6,119.54	$103.95
Pond Slope Seed & Seeding	Acre	12.50	$370.00	$4,625.00	$370.00
Wetland Emergent Seed & Seeding	Acre	1.50	$1,826.67	$2,740.01	$1,826.67
Fertilizer Contingency	Acre	58.87	$135.89	$7,999.84	$135.89
Erosion Control Contingency	Acre	79.17	$94.74	$7,500.57	$94.74
Scale Removal	Lump Sum	1	$750.00	$750.00	$9.47
TOTALS				$2,034,227.28	$28,344.62

7.6 Criteria for Measuring Reclamation Success

Reclamation of the agricultural acreage at the site will be considered complete once it achieves 70% overall vegetative cover. Vegetative cover will be verified by throwing out a square with a 3' by 3' opening (constructed of grade lathe or other suitable material) at randomly selected locations across the site and observing the percent vegetative cover inside the square. At least 2 locations per 5 acres of agricultural acreage will be observed for a total of 12 observations, and the total average of all observations will determine the total percentage of vegetative cover.

Reclamation of the non-agricultural acreage at the site will be considered complete when the water elevation of the pond is within 5' of the permanent pool elevation. Based on the calculated runoff volume of the acreage that drains to the property, it will take approximately 4 years for the pond to fill to the permanent pool elevation with average precipitation.

When KKCI believes the site has been satisfactorily reclaimed, the regulatory authority will be brought in to perform a field inspection and verification.

8 Conclusion

Kopplin & Kinas Company's existing resources will not continue to supply an economical source of construction aggregates to meet local demands. A commercial-grade limestone deposit is present on the Retzlaff property located on CTH K in the Town of Brooklyn. The property contains aggregate suitable, and needed, for local construction. The proposed plan of operation protects human health and the environment and allows for the economic extraction of this resource.

9 Standard of Care

This plan was prepared using generally accepted geologic and hydrogeologic information and practices and is based upon information available at the time of preparation. The scope of this plan is limited to the specific locations described herein.

10 Reclamation Plan Compliance Certification

I hereby certify, as a duly authorized representative or agent, that the reclamation at this nonmetallic mining site will be carried out in accordance with the approved reclamation plan submitted by Kopplin & Kinas Company, Incorporated. I also certify that, as a condition of this permit, financial assurance will be provided as required by NR 135.40 upon granting of this permit and before mining begins. I further certify that the information contained herein is true and accurate and complies with local and statewide nonmetallic mining reclamation standards established in NR 135, Wisconsin Administrative Code.

Donald E. Kinas, Jr. — 3-1-24
President, Kopplin & Kinas Co., Inc. — Date

Christopher D. Retzlaff — 3-1-24
Current Landowner — Date

Ruth M. Retzlaff — 3-1-24
Current Landowner — Date

11 REFERENCES

Bedrock Geologic Map of Wisconsin, by M.G. Mudrey, B.A. Brown, J.K. Greenberg, Wisconsin Geological and Natural History Survey, 1982

Quarternary Geology of Columbia, Green Lake, and Marquette Counties, Wisconsin, by Thomas S. Hooyer, William N. Mode, Lee Clayton, Wisconsin Geological and Natural History Survey, 2021

Web Soil Survey, Green Lake County, United States Department of Agriculture, 2023

Well Construction Reports, Well Construction Information System, Wisconsin Department of Natural Resources, 2023

Surface Water Viewer, Wisconsin Department of Natural Resources, 2022

L-THIA Great Lakes Watershed Management System, Purdue University, 2023

Wisconsin Historical Aerial Image Finder, Wisconsin State Cartographer's Office, 2023

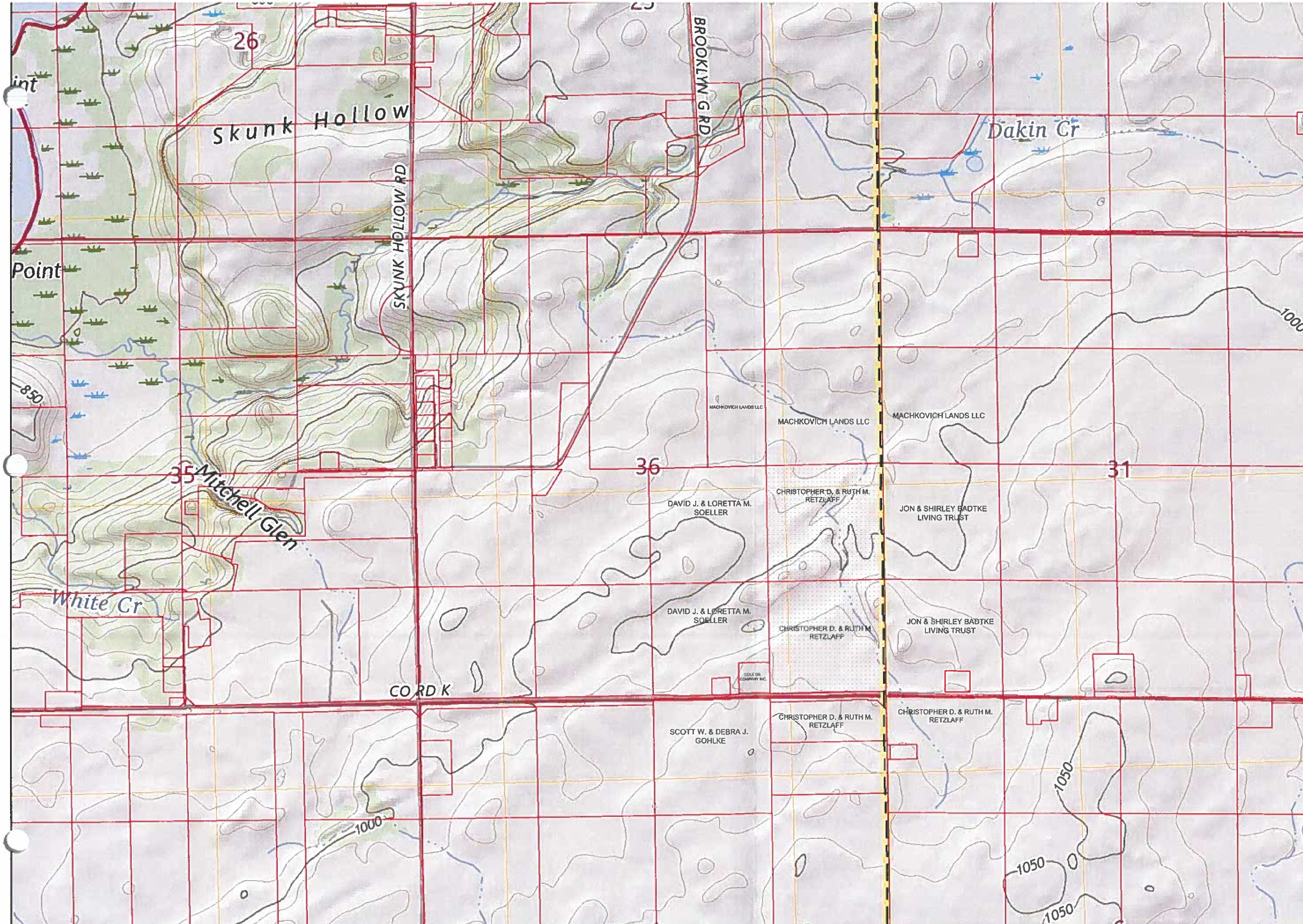
Wisconsin Land Economic Inventory Survey Collection, University of Wisconsin Madison Library, 2023

USGS Maps, United States Geological Survey, 2023

Green Lake County Geographic Information System, Green Lake County, 2023

APPENDIX A – MAPS

A-1 – USGS Quadrangle/Property Overlay



Notes:

HATCHED AREA REPRESENTS THE RETZLAFF PROPERTY

REV:	DESCRIPTION:	BY:	DATE:

STATUS: FINAL

KOPPLIN & KINAS CO., INC.
GREEN LAKE, WISCONSIN

PREPARED FOR:

PREPARED BY:
KOPPLIN & KINAS CO., INC.
W1266 NORTH LAWSON DRIVE
GREEN LAKE, WI 54941
(920)294-6451 HTTPS://KKCI.US

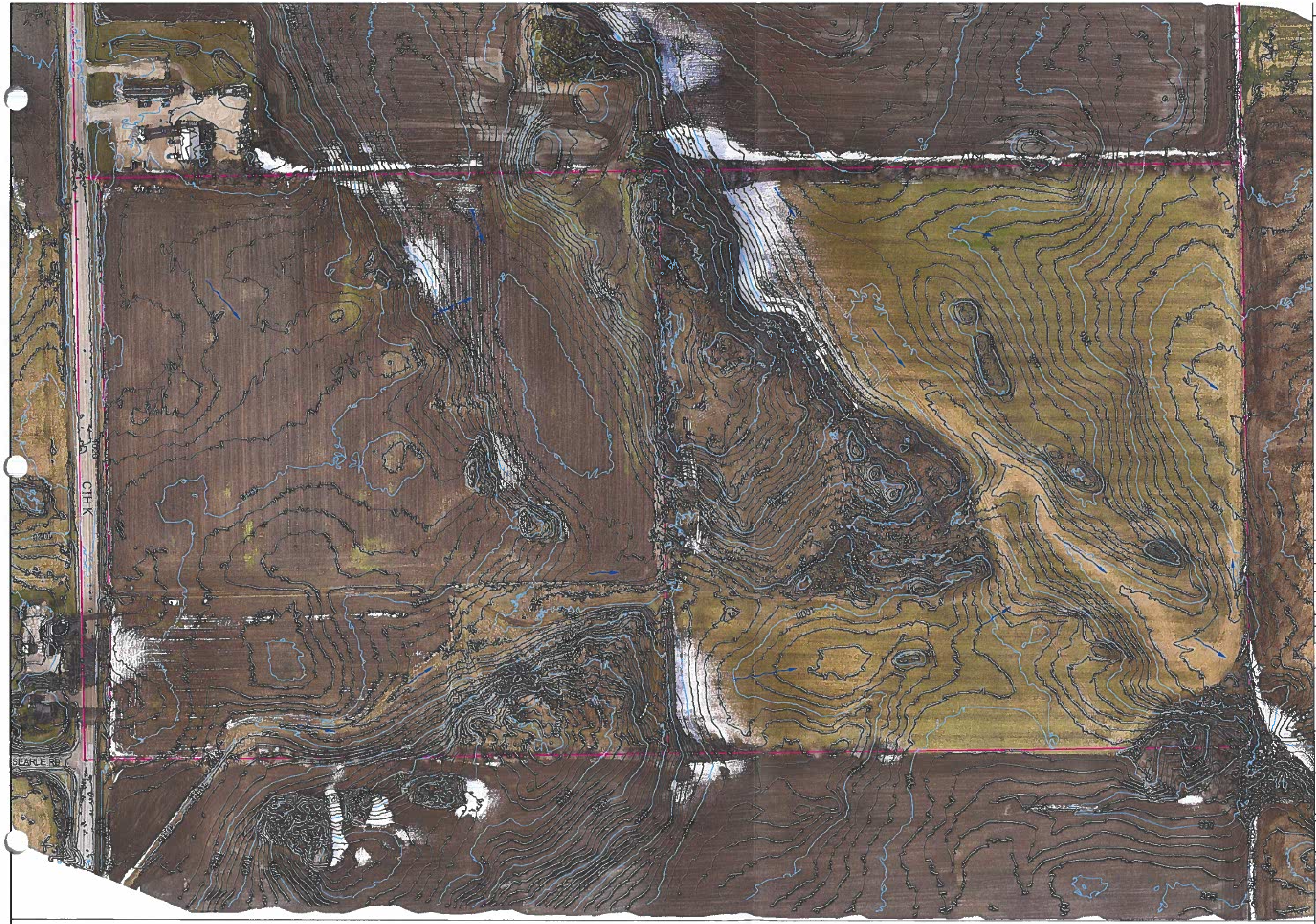
SITE:
K QUARRY
NE/SE & SE/SE,SEC. 36, T16N,R13E

TITLE:
USGS 7.5 MINUTE QUADRANGLE PARCEL OVERLAY

SCALE:	DATE:	DRAWN:
1=1000	12/09/2023	MCM

SHEET NUMBER:	REVISION:
21	

A-2 – Existing Ground



Notes:

1' CONTOURS

DRAINAGE DIRECTION

0 100 200

REV:	DESCRIPTION:	BY:	DATE:

STATUS: FINAL

KOPPLIN & KINAS CO., INC.
GREEN LAKE, WISCONSIN

PREPARED FOR:

PREPARED BY:
KOPPLIN & KINAS CO., INC.
W1266 NORTH LAWSON DRIVE
GREEN LAKE, WI 54941
(920)294-6451 HTTPS://KKCI.US

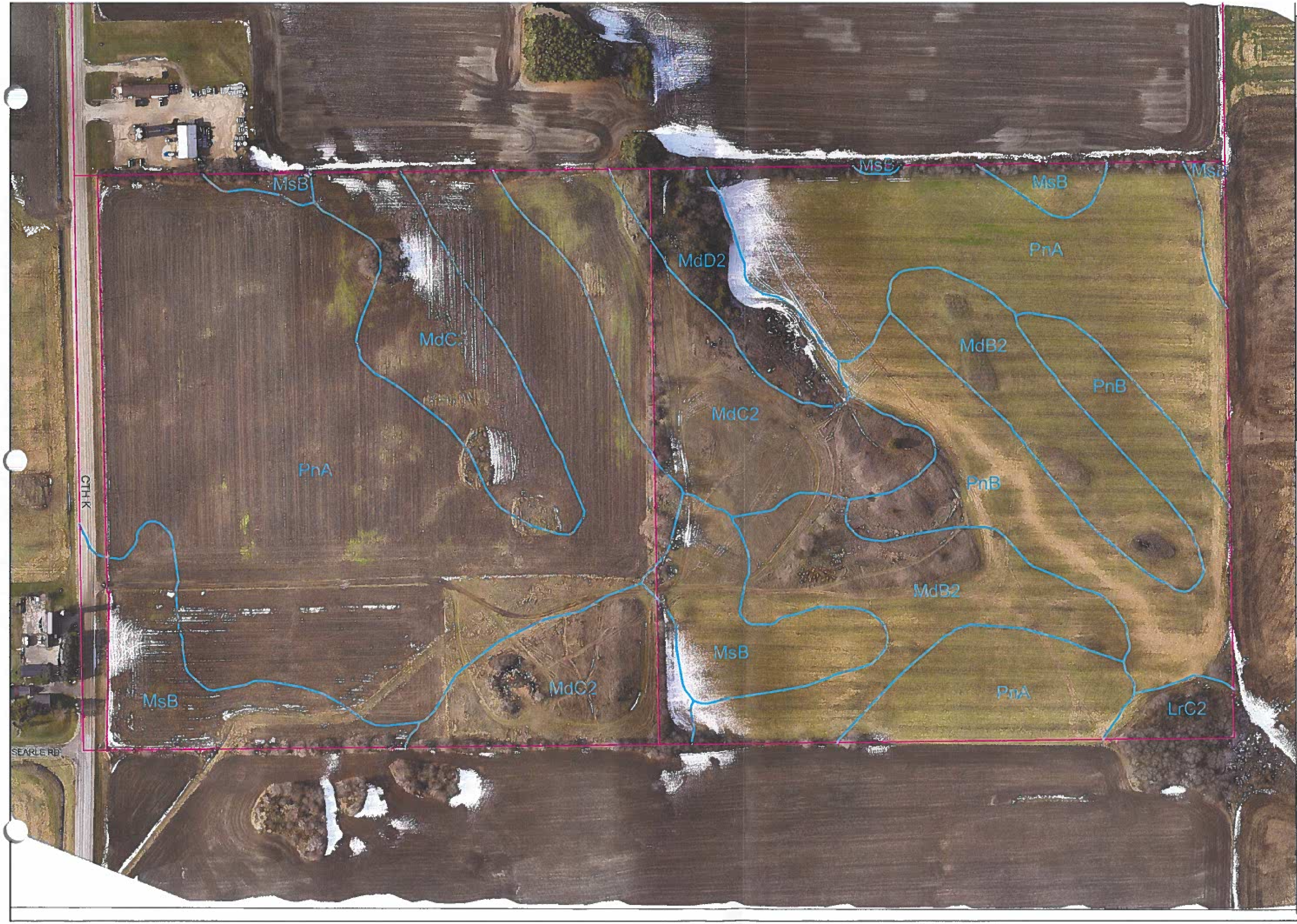
SITE:
K QUARRY
NE/SE & SE/SE,SEC. 36, T16N,R13E

TITLE:
EXISTING GROUND
AERIAL SURVEY 12/08/2023

SCALE:	DATE:	DRAWN:
1=200	12/09/2023	MCM

SHEET NUMBER:	REVISION:
22	

A-3 – Soil Map



Notes:

LrC2	LeRoy silt loam, 6 to 12 percent slopes, eroded
MdB2	Markesan silt loam, 2 to 6 percent slopes, eroded MLRA 95B
MdC2	Markesan silt loam, 6 to 12 percent slopes, eroded
MdD2	Markesan silt loam, 12 to 20 percent slopes, eroded
MsB	Mendota silt loam, 2 to 6 percent slopes
PnA	Plano silt loam, till substratum, 0 to 2 percent slopes
PnB	Plano silt loam, till substratum, 2 to 6 percent slopes

REV:	DESCRIPTION:	BY:	DATE:

STATUS: FINAL

KOPPLIN & KINAS CO., INC.
GREEN LAKE, WISCONSIN

PREPARED FOR:

PREPARED BY:
KOPPLIN & KINAS CO., INC.
W1265 NORTH LAWSON DRIVE
GREEN LAKE, WI 54941
(920)294-6451 HTTPS://KKCI.US

SITE:
K QUARRY
NE/SE & SE/SE SEC. 36, T16N,R13E

TITLE:
USDA SOILS OVERLAY
AERIAL SURVEY 12/08/2023

SCALE:	DATE:	DRAWN:
1=200	12/09/2023	MCM

SHEET NUMBER: 23

REVISION:

A-4 – Existing Agriculture

Notes:

REV:	DESCRIPTION:	BY:	DATE:

STATUS: FINAL

KOPPLIN & KINAS CO., INC.
GREEN LAKE, WISCONSIN

PREPARED FOR:

PREPARED BY:
KOPPLIN & KINAS CO., INC.
W1266 NORTH LAWSON DRIVE
GREEN LAKE, WI 54941
(920)294-6451 HTTPS://KKCI.US

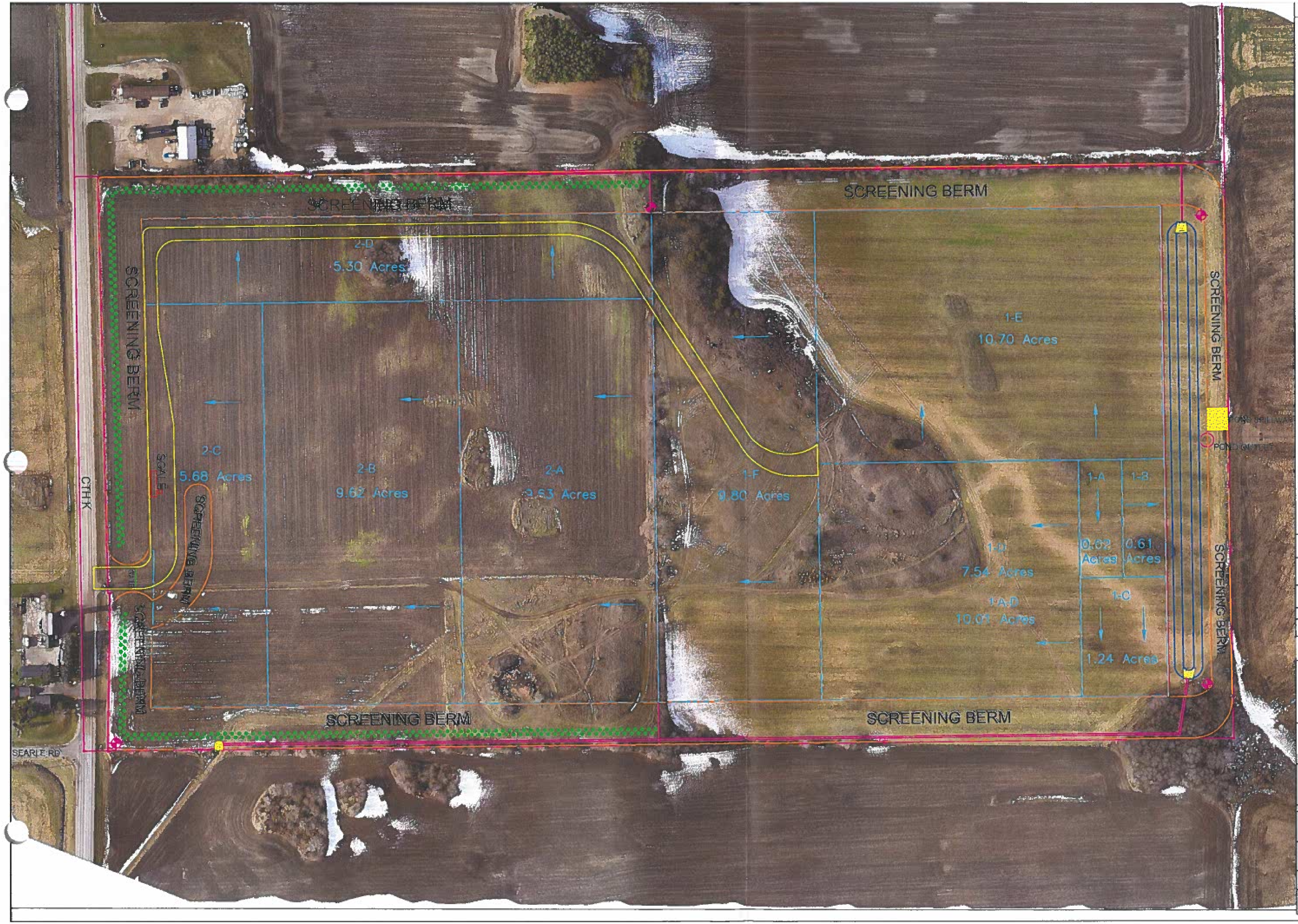
SITE:
K QUARRY
NE/SE & SE/SE,SEC. 36, T16N,R13E

TITLE:
AGRICULTURAL AREA
AERIAL SURVEY 12/08/2023

SCALE:	DATE:	DRAWN:
1=200	12/09/2023	MCM

SHEET NUMBER:	REVISION:
24	

A-5 – PROPOSED SITE & PHASING



Notes:

EROSION CONTROL: STORMWATER BASIN TO BE CONSTRUCTED PRIOR TO ANY OTHER LAND DISTURBING ACTIVITY.

SILT FENCE TO BE INSTALLED AROUND PERIMETER OF SITE WHERE NECESSARY TO PREVENT SEDIMENT FROM LEAVING THE SITE.

ADDITIONAL EROSION CONTROL BMPS ARE TO BE DEPLOYED AS NECESSARY.

POND: POND OUTFALL ELEVATION TO MATCH LOW POINT ON NORTH PROPERTY LINE, APPROXIMATELY 976' AMSL. EMERGENCY SPILLWAY ELEVATION TO BE 2' HIGHER THAN PERMANENT POOL, APPROXIMATELY 978' AMSL.

-GROUNDWATER MONITORING WELL

N

0 100 200

REV:	DESCRIPTION:	BY:	DATE:

STATUS: FINAL

KOPPLIN & KINAS CO., INC.
GREEN LAKE, WISCONSIN

PREPARED FOR:

PREPARED BY:
KOPPLIN & KINAS CO., INC.
W1266 NORTH LAWSON DRIVE
GREEN LAKE, WI 54941
(920)294-6451 HTTPS://KK.CLUS

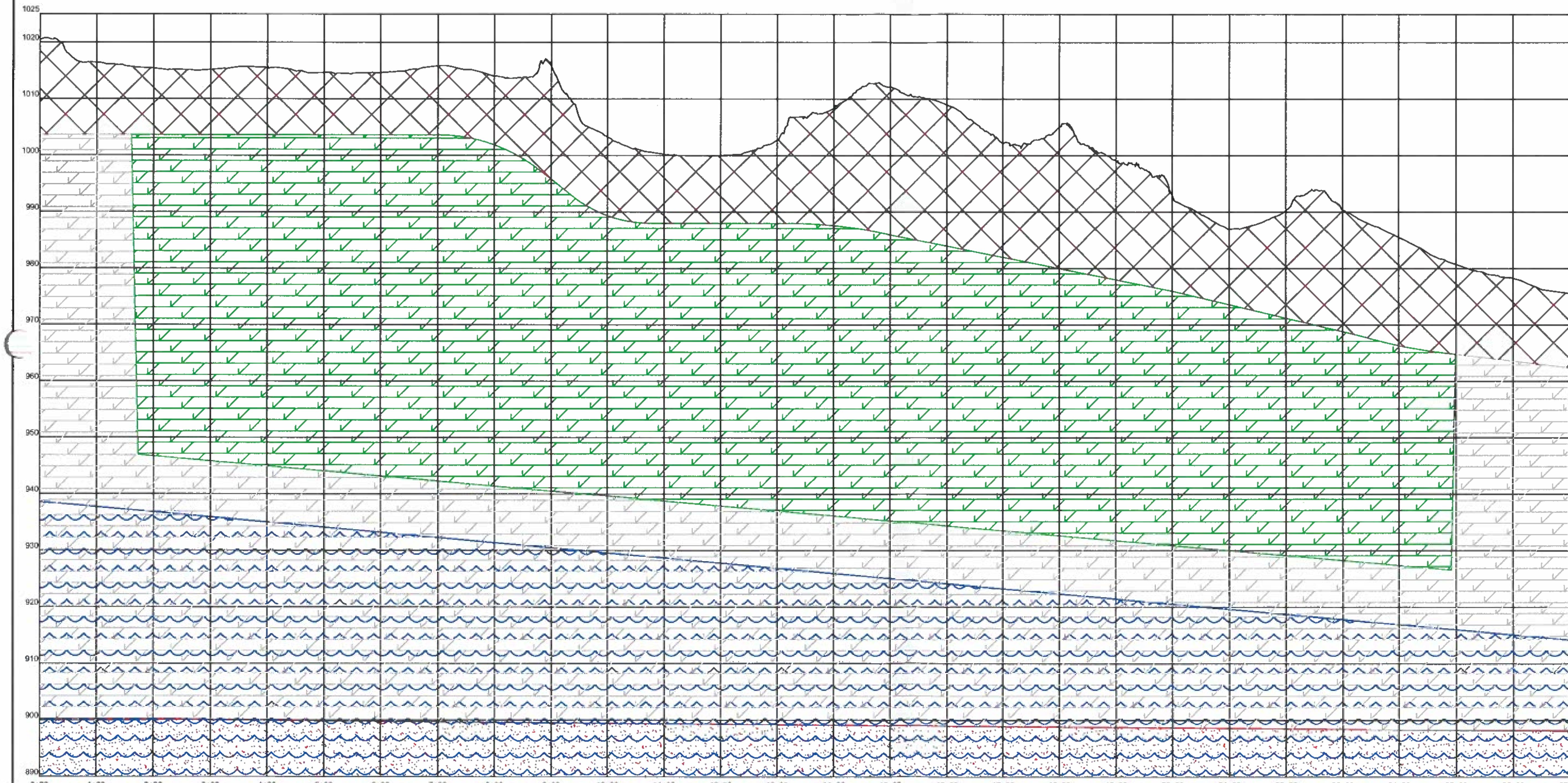
SITE: K QUARRY
NE/SE & SE/SE SEC. 36, T16N,R13E

TITLE: SITE DEVELOPMENT MINING SEQUENCE

SCALE:	DATE:	DRAWN:
1"=200	12/09/2023	MCM

SHEET NUMBER:	REVISION:
25	

A-6 – Geologic Cross-Section



LEGEND:

	OVERBURDEN
	LIMESTONE - TO BE EXTRACTED
	LIMESTONE - NOT EXTRACTED
	SANDSTONE
	GROUNDWATER

GEOLOGIC CROSS-SECTION FOLLOWS GREEN LINE SOUTH TO NORTH

REV:	DESCRIPTION:	BY:	DATE:

STATUS: FINAL

KOPPLIN & KINAS CO., INC.
GREEN LAKE, WISCONSIN

PREPARED FOR:

PREPARED BY:
KOPPLIN & KINAS CO., INC.
W1266 NORTH LAWSON DRIVE
GREEN LAKE, WI 54941
(920)294-6451 HTTPS://KKCI.US

SITE:
K QUARRY
NE/SE & SE/SE,SEC. 36, T16N,R13E

TITLE:
GEOLOGIC CROSS-SECTION
CENTER OF SITE - SOUTH TO NORTH

SCALE:	DATE:	DRAWN:
100H/10V	12/09/2023	MCM

SHEET NUMBER:	REVISION:
26	

A-7 – Reclamation Grading Plan

Notes:

EROSION CONTROL: ENTIRE SITE IS TO BE GRADED TO DRAIN TO THE POND.

DITCH CHECKS, DIVERSION BERMS, AND ADDITIONAL EROSION CONTROL BMPS ARE TO BE DEPLOYED AS NECESSARY.

POND: POND OUTFALL ELEVATION TO MATCH LOW POINT ON NORTH PROPERTY LINE, APPROXIMATELY 976' AMSL. RECLAIMED POND TO UTILIZE OUTFALL STRUCTURE FROM SITE STORMWATER BASIN. EMERGENCY SPILLWAY ELEVATION TO BE 2' HIGHER THAN PERMANENT POOL, APPROXIMATELY 978' AMSL.

REV:	DESCRIPTION:	BY:	DATE:

STATUS: FINAL

KOPPLIN & KINAS CO., INC.
GREEN LAKE, WISCONSIN

PREPARED FOR:

PREPARED BY:
KOPPLIN & KINAS CO., INC.
W1266 NORTH LAWSON DRIVE
GREEN LAKE, WI 54941
(920)294-6451 HTTPS://KK.CO.US

SITE: K QUARRY
NE/SE & SE/SE SEC. 36, T16N,R13E

TITLE: RECLAMATION
AERIAL SURVEY 12/08/2023

SCALE:	DATE:	DRAWN:
1=200	12/09/2023	MCM

SHEET NUMBER:	REVISION:
27	0

APPENDIX B – LOCAL WELL CONSTRUCTION REPORTS

State of Wisconsin
Department of Natural Resources
Box 7921
Madison, Wisconsin 53707

NOTE: JUN 15 1977
White Copy – Division's Copy
Green Copy – Driller's Copy
Yellow Copy – Owner's Copy

WELL CONSTRUCTOR'S REPORT

Form 3300-15 Rev. 12-76

COUNTY: Fond du Lac
CHECK (✓) ONE: [X] Town [ ] Village [ ] City — Name: Metomen

2. LOCATION: ¼ Section N.W. Section 6 Township 15-N. Range 14-E
OR – Grid or Street No. Street Name: Searl Rd.
AND – If available subdivision name, lot & block No.

3. NAME [X] OWNER [ ] AGENT AT TIME OF DRILLING CHECK (✓) ONE: Roy Voss
ADDRESS: R. 2
POST OFFICE: Ripon, Wis.

4. Distance in feet from well to nearest: (Record answer in appropriate block)

Building | Sanitary Bldg. Drain (C.I., Other) | Sanitary Bldg. Sewer (C.I., Other) | Floor Drain Connected To: (C.I. Sewer, Other Sewer) | Storm Bldg. Drain (C.I., Other) | Storm Bldg. Sewer (C.I., Other)

Street Sewer (San., Storm) | Other Sewers (C.I., Other) | Foundation Drain Connected to: (Sewer, Clearwater Dr., Sewage Sump, Clearwater Sump) | Sewage Sump (C.I., Other) | Clearwater Sump | Septic Tank | Holding Tank | Sewage Absorption Unit (Seepage Pit, Seepage Bed, Seepage Trench)

VACANT LOT

Privy | Pet Waste Pit | Pit: Nonconforming Existing (Well, Pump, Tank) | Subsurface Pumproom Nonconforming Existing | Barn Gutter | Animal Barn Pen | Animal Yard | Silo With Pit | Glass Lined Storage Facility | Silo w/o Pit | Earthen Silage Storage Trench Or Pit

Temporary Manure Stack | Watertight Liquid Manure Tank | Solid Manure Storage Structure | Subsurface Gasoline or Oil Tank | Waste Pond or Land Disposal Unit (Specify Type) | Other (Give Description)

5. Well is intended to supply water for: Residence

6. DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
8 3/4	Surface	75			
6	75	215			

7. CASING, LINER, CURBING AND SCREEN

Dia. (in.)	Material, Weight, Specification & Method of Assembly	From (ft.)	To (ft.)
6	New, Black Steel	Surface	75
	18.97 lbs.per.ft.		
	ASTM-A-53		
	P.E.		
	Interlake Inc.		

8. GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
Cuttings & Drillmud	Surface	7
Neat Cement	7	75

9. FORMATIONS

Kind	From (ft.)	To (ft.)
Gravel & Clay	Surface	20
Limerock & Shale	20	65
Limerock	65	215

10. TYPE OF DRILLING MACHINE USED

[ ] Cable Tool [ ] Rotary-air w/drilling mud [ ] Rotary-w/drilling mud [X] Rotary-hammer w/drilling mud & air [ ] Rotary-hammer & air [ ] Reverse Rotary [ ] Jetting with [ ] Air [ ] Water

Well construction completed on 5 - 4 1977

Well is terminated 12 inches [X] above [ ] below final grade

Well disinfected upon completion [X] Yes [ ] No

Well sealed watertight upon completion [X] Yes [ ] No

11. MISCELLANEOUS DATA

Yield Test: 1 Hrs. at 10 GPM

Depth from surface to normal water level 100 Ft.

Depth of water level when pumping 105 Ft. Stabilized [X] Yes [ ] No

Madison laboratory on 6 - 7 1977

...ation hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, seals, method of ...t used in grouting, blasting, etc., should be given on reverse side.

FL 1290

Signature: [signature] Registered Well Driller

Complete Mail Address: Brandon, Wisconsin

WELL CONSTRUCTOR'S REPORT — WISCONSIN STATE BOARD OF HEALTH — Wel 6

1. COUNTY	CHECK ONE	NAME
Greenlake	☐ Town ☐ Village ☐ City	Greenlake

2. LOCATION (Number and Street or ¼ section, section, township and range. Also give subdivision name, lot and block numbers when available.)

NE, NE NE, Sec. 1 T16N R13E
NE, NE, Sec. 1, T 15 N, R 13 E

3. OWNER AT TIME OF DRILLING
Edward Manske
Edward Manske

4. OWNER'S COMPLETE MAIL ADDRESS
Rt. 2, Ripon, Wisconsin

5. Distance in feet from well to nearest: (Record answer in appropriate block)

BUILDING	SANITARY SEWER C.I.	SANITARY SEWER TILE	FLOOR DRAIN C.I.	FLOOR DRAIN TILE	FOUNDATION DRAIN SEWER CONNECTED	FOUNDATION DRAIN INDEPENDENT	WASTE WATER DRAIN C.I.	WASTE WATER DRAIN TILE
6								

CLEAR WATER DRAIN C.I.	CLEAR WATER DRAIN TILE	SEPTIC TANK	PRIVY	SEEPAGE PIT	ABSORPTION FIELD	BARN	SILO	ABANDONED WELL	SINK HOLE
		80			90			100	

OTHER POLLUTION SOURCES (Give description such as dump, quarry, drainage well, stream, pond, lake, etc.)

6. Well is intended to supply water for:
Farm

7. DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
7 7/8	Surface	48'6"			
5 7/8	48'6"	158			

8. CASING, LINER, CURBING, AND SCREEN

Dia. (in.)	Kind and Weight	From (ft.)	To (ft.)
6	Std. steel	Surface	48'6"

9. GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
Drill cuttings	Surface	15
Cement	15	48'6"

10. FORMATIONS

Kind	From (ft.)	To (ft.)
clay	Surface	3
gravel & hardpan	3	20
limerock	20	124
sandstone	124	158

Well construction completed on Nov. 19 1965

Well is terminated 8 inches ☒ above ☐ below final grade

Well disinfected upon completion ☒ Yes ☐ No

Well sealed watertight upon completion ☒ Yes ☐ No

11. MISCELLANEOUS DATA

Yield test: ½ Hrs. at 20 GPM

Depth from surface to normal water level 38 ft.

Depth to water level when pumping 98 ft.

Water sample sent to Madison laboratory on: Nov. 23 1965

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, seals, type of casing joints, method of finishing the well, amount of cement used in grouting, blasting, subsurface pumprooms, access pits, etc., should be given on reverse side.

SIGNATURE
Richard Berkholtz
Richard Berkholtz, President — Registered Well Driller

COMPLETE MAIL ADDRESS
BERKHOLTZ CO. INC.
1170 Forest Lane, Brookfield, Wisconsin

Please do not write in space below

COLIFORM TEST RESULT	GAS — 24 HRS.	GAS — 48 HRS.	CONFIRMED	REMARKS
				200' 1377099

2502

plot

Well Construction Report
WISCONSIN UNIQUE WELL NUMBER LX386

Drinking Water and Groundwater - DG/5
Department of Natural Resources, Box 7921
Madison WI 53707
Form 3300-077A

Property Owner	HERSCHBERGER, ART
Phone #	(414)295-6220
Mailing Address	W208 CTY RD K
City	RIPON
State	WI
Zip Code	54971
County	Green Lake
Co. Permit #	
Notification #	
Completed	07-03-1997
Well Constructor (Business Name)	SAMS ROTARY DRILLERS INC
Lic. #	370
Facility ID # (Public Wells)	
Well Plan Approval #	
Address	PO BOX 150 RANDOLPH WI 53956-0150
Approval Date (mm-dd-yyyy)	
Hicap Permanent Well #	
Common Well #	
Specific Capacity	0.1

1. Well Location Fire # (if avail.)

Town of BROOKLYN

Street Address or Road Name and Number: CTY HWY K

Subdivision Name | Lot # | Block #

Latitude / Longitude in Decimal Degree (DD) °N °W | Method Code GPS008

		Section	Township	Range
SW	SE			
or Govt Lot #		36	16 N	13 E

2. Well Type New Well

of previous unique well # constructed in

Reason for replaced or reconstructed well ?

Construction Type Drilled

3. Well serves 1 # of BUSINESS

Private,potable

Heat Exchange____# of drillholes

Hicap Well ? No

Hicap Property ? No

Hicap Potable ?

4. Potential Contamination Sources - ON REVERSE SIDE

5. Drillhole Dimensions and Construction Method

Dia. (in.)	From (ft.)	To (ft.)
8.75	Surface	103
6	103	177

Upper Enlarged Drillhole / Lower Open Bedrock

- Rotary - Mud Circulation ....
- Yes Rotary - Air ....
- Rotary - Air & Foam ....
- Drill-Through Casing Hammer
- Reverse Rotary
- Cable-tool Bit ____in. dia...
- Dual Rotary ....
- Yes Temp. Outer Casing 10in. dia
- Removed? ____depth ft. (If NO explain on back side)

8. Geology

Geology Codes		8. Geology Type, Caving/Noncaving, Color, Hardness, etc...	From (ft.)	To (ft.)
	Z	CLAY @ GRAVEL	Surface	3
	L	LIMEROCK	3	120
	N	SANDROCK	120	177

6. Casing, Liner, Screen

Dia. (in.)	Material, Weight, Specification Manufacturer & Method of Assembly	From (ft.)	To (ft.)
6	STD BLK PIPE 280 WALL WLD JTS A53 SAWHILL	Surface	103

Dia. (in.)	Screen type, material & slot size	From (ft.)	To (ft.)

9. Static Water Level

85 ft. below ground surface

10. Pump Test

Pumping level 120 ft. below surface

Pumping at 2 GP M for 1 Hrs.

Pumping Method ?

11. Well Is

24 in. above grade

Developed ? Yes

Disinfected ? Yes

Capped ? Yes

7. Grout or Other Sealing Material

Method TREMIE PUMPED

Kind of Sealing Material	From (ft.)	To (ft.)	# Sacks Cement
CEMENT	Surface	103	21 S

12. Notified Owner of need to fill & seal ?

Filled & Sealed Well(s) as needed?

13. Constructor / Supervisory Driller	Lic #	Date Signed
SVJ		07-15-1997
Drill Rig Operator	**Lic or Reg #**	**Date Signed**
RH		07-15-1997

APR 8 1975

MAR 26 1975

WELL CONSTRUCTOR'S REPORT
FORM 3300-15

NOTE
WHITE COPY – DIVISION'S COPY
GREEN COPY – DRILLER'S COPY
YELLOW COPY – OWNER'S COPY

STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESOURCES
Box 450
Madison, Wisconsin 53701

COUNTY: Green Lake | CHECK ONE: [X] Town [ ] Village [ ] City | NAME: Brooklyn

2. LOCATION – ¼ Section: S.E. | Section: 36 | Township: 16N | Range: 13E
OR Grid or street no. | Street name: Hwy K
AND If available subdivision name, lot & block no.

3. OWNER AT TIME OF DRILLING: Richard G. Hahn
ADDRESS: Route # 3
POST OFFICE: Ripon, Wis.

4. Distance in feet from well to nearest: (Record answer in appropriate block)

BUILDING	SANITARY SEWER C.I.	SANITARY SEWER TILE	FLOOR DRAIN C.I.	FLOOR DRAIN TILE	FOUNDATION DRAIN SEWER CONNECTED	FOUNDATION DRAIN INDEPENDENT	WASTE WATER DRAIN C.I.	WASTE WATER DRAIN TILE
6	36							

CLEAR WATER DRAIN C.I.	CLEAR WATER DRAIN TILE	SEPTIC TANK	PRIVY	SEEPAGE PIT	ABSORPTION FIELD	BARN	SILO	ABANDONED WELL	SINK HOLE
		61			73	67		26	

OTHER POLLUTION SOURCES (Give description such as dump, quarry, drainage well, stream, pond, lake, etc.)

5. Well is intended to supply water for: Farm

6. DRILLHOLE

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
8	Surface	75			
6	75	190			

7. CASING, LINER, CURBING, AND SCREEN

Dia. (in.)	Kind and Weight	From (ft.)	To (ft.)
6	New, black steel	Surface	75
	18.97 lbs. per ft.		
	P.E.		

9. FORMATIONS

Kind	From (ft.)	To (ft.)
Gravel & Clay	Surface	22
Limerock & Shale	22	64
Limerock	64	115
Sandstone	115	190

8. GROUT OR OTHER SEALING MATERIAL

Kind	From (ft.)	To (ft.)
Cuttings & Drillmud	Surface	8
Neat Cement	8	75

10. TYPE OF DRILLING MACHINE USED
[ ] Cable Tool [ ] Direct Rotary [ ] Reverse Rotary
[X] Rotary – air w/drilling mud [ ] Rotary – hammer with drilling mud & air [ ] Jetting with [ ] Air [ ] Water

Well construction completed on 2 - 26 19 75

Well is terminated 12 inches [X] above [ ] below final grade

Well disinfected upon completion [X] Yes [ ] No

Well sealed watertight upon completion [X] Yes [ ] No

11. MISCELLANEOUS DATA
Yield test: 24 Hrs. at 10 GPM
Depth from surface to normal water level 79 ft.
Depth to water level when pumping 84 ft.

Water sample sent to Madison laboratory on: 2 - 27 19 75

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, seals, type of casing joints, method of finishing the well, amount of cement used in grouting, blasting, sub-surface pumprooms, access pits, etc., should be given on reverse side.

SIGNATURE: [signature] Registered Well Driller
COMPLETE MAIL ADDRESS: Brandon, Wisconsin

Please do not write in space below

COLIFORM TEST RESULT	GAS 24 HRS.	GAS 48 HRS.	CONFIRMED	REMARKS

REV. 3-71

Well Construction Report
WISCONSIN UNIQUE WELL NUMBER UW527

Drinking Water and Groundwater - DG/5
Department of Natural Resources, Box 7921
Madison WI 53707

Form 3300-077A

Property Owner	KEMNITZ, GLORIA
Phone #	
Mailing Address	W241 CO TRK K
City	RIPON
State	WI
Zip Code	54971
County	Green Lake
Co. Permit #	
Notification #	32619568
Completed	05-26-2009
Well Constructor (Business Name)	CENTRAL WELL DRILLING INC
Lic. #	4231
Facility ID # (Public Wells)	
Well Plan Approval #	
Address	PO BOX 405 400 S WOODWARD ST BRANDON WI 53919-0405
Approval Date (mm-dd-yyyy)	
Hicap Permanent Well #	
Common Well #	
Specific Capacity	1.3

1. Well Location

Town of	GREEN LAKE
Fire # (if avail.)	W241
Street Address or Road Name and Number	CO RD K
Subdivision Name	
Lot #	
Block #	
Latitude / Longitude in Decimal Degree (DD)	°N °W
Method Code	
NW NE or Govt Lot #	
Section	1
Township	15 N
Range	13 E

2. Well Type Replacement

of previous unique well # constructed in

Reason for replaced or reconstructed well ? OLD WELL NOT TO CODE

Construction Type Drilled

3. Well serves 1 # of

Private,potable

Heat Exchange____# of drillholes

Hicap Well ? No

Hicap Property ? No

Hicap Potable ?

4. Potential Contamination Sources - ON REVERSE SIDE

5. Drillhole Dimensions and Construction Method

Dia. (in.)	From (ft.)	To (ft.)
8.75	Surface	67
6	67	178
5	178	218

Upper Enlarged Drillhole	Method	Lower Open Bedrock
Yes	Rotary - Mud Circulation	Yes
Yes	Rotary - Air	Yes
	Rotary - Air & Foam	
	Drill-Through Casing Hammer	
	Reverse Rotary	
	Cable-tool Bit ____in. dia...	
	Dual Rotary	
	Temp. Outer Casing ____in. dia	
	Removed? ____depth ft. (If NO explain on back side)	

8. Geology

Geology Codes				8. Geology Type, Caving/Noncaving, Color, Hardness, etc...	From (ft.)	To (ft.)
T	-	C	-	BROWN CLAY	Surface	8
-	-	L	I	MARKESAN LOAM	8	18
-	-	L	-	LIMEROCK	18	44
-	C	-	-	CERVICE	44	46
-	-	H	-	SHALE	46	64
-	-	L	-	LIMEROCK	64	96
-	Q	N	-	SOFT AND CAVING SANDROCK	96	218

6. Casing, Liner, Screen

Dia. (in.)	Material, Weight, Specification Manufacturer & Method of Assembly	From (ft.)	To (ft.)
6	NEW BLACK STEEL ASTM A-53B P.E. MITTAL CANADA	Surface	67
5	NEW BLACK STEEL IPSCO P.E. ASTM A-53B W/K-PACKER	66	178

Dia. (in.)	Screen type, material & slot size	From (ft.)	To (ft.)

7. Grout or Other Sealing Material

Method TREMIE PUMPED

Kind of Sealing Material	From (ft.)	To (ft.)	# Sacks Cement
CEMENT	Surface	67	12 S

9. Static Water Level

85 ft. below ground surface

10. Pump Test

Pumping level 100 ft. below surface

Pumping at 20 GP M for 3 Hrs.

Pumping Method ?

11. Well Is

18 in. above grade

Developed ? Yes

Disinfected ? Yes

Capped ? Yes

12. Notified Owner of need to fill & seal ?

Filled & Sealed Well(s) as needed? Yes

13. Constructor / Supervisory Driller	Lic #	Date Signed
SS		05-26-2009
Drill Rig Operator	Lic or Reg #	Date Signed

Wel 6

WELL CONSTRUCTOR'S REPORT TO WISCONSIN STATE BOARD OF HEALTH

See Instructions on Reverse Side

1. County Fondulac — Town ☒ Village ☐ City ☐ Ripon (Check one and give name)
2. Location Sec 31 SW¼ of NE¼ T16N R14E (Name of street and number of premise or Section, Town and Range numbers)
3. Owner ☒ or Agent ☐ John Leinbach (Name of individual, partnership or firm)
4. Mail Address Ripon (Complete address required)
5. From well to nearest: Building 8 ft; sewer ___ ft; drain ___ ft; septic tank 50 ft; dry well or filter bed ___ ft; abandoned well 200 ft.

RECEIVED
JAN 28 1959
ENVIRONMENTAL SANITATION

6. Well is intended to supply water for: Home

7. DRILLHOLE:

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
10	0	42			
6	42	200			

8. CASING AND LINER PIPE OR CURBING:

Dia. (in.)	Kind and Weight	From (ft.)	To (ft.)
~~4~~	Steel 19.45	0	42
6	" "	"	"

9. GROUT:

Kind	From (ft.)	To (ft.)
Slurry Cement	0	42

10. FORMATIONS:

Kind	From (ft.)	To (ft.)
Clay	0	5
Sand	5	18
Limestone	18	50
Sandstone	50	200
water bearing		

Construction of the well was completed on: Dec 31 1958

The well is terminated 10 inches ☒ above, below ☐ the permanent ground surface.

Was the well disinfected upon completion? Yes X No ___

Was the well sealed watertight upon completion? Yes X No ___

11. MISCELLANEOUS DATA:

Yield test: 12 Hrs. at 20 GPM.

Depth from surface to water-level: 60 ft.

Water-level when pumping: 70 ft.

Water sample was sent to the state laboratory at: Oshkosh (City) on Jan 6 1959

Signature Wallace Clark (Registered Well Driller) — Oshkosh R3 (Complete Mail Address)

Please do not write in space below

Rec'd ___ No. ___

Ans'd ___

Interpretation ___

	10 ml	10 ml	10 ml	10 ml	10 ml
Gas—24 hrs.					
48 hrs.					
Confirm					
B. Coli					

Examiner ___

FL 4329

Well Construction Report | **CP187**
WISCONSIN UNIQUE WELL NUMBER

Drinking Water and Groundwater - DG/5
Department of Natural Resources, Box 7921
Madison WI 53707
Form 3300-077A

Property Owner: ERIC GODFREY		Phone #: (414)748-6789	
Mailing Address: PRAIRIE RD			
City: RIPON	State: WI	Zip Code: 54971	
County: Fond du Lac	Co. Permit #	Notification #	Completed: 06-22-1990

Well Constructor (Business Name): SLAGER LARRY J	Lic. #: 140	Facility ID # (Public Wells)
		Well Plan Approval #
Address: P O BOX 405 BRANDON WI 53919		Approval Date (mm-dd-yyyy)
Hicap Permanent Well #	Common Well #	Specific Capacity: 0.8

1. Well Location
Town of RIPON
Fire # (if avail.)
Street Address or Road Name and Number
Subdivision Name | Lot # | Block #

Latitude / Longitude in Decimal Degree (DD)		Method Code
43.82346 °N	-88.88129 °W	GPS008

SW	SW	Section	Township	Range
or Govt Lot #		30	16 N	14 E

2. Well Type New Well
of previous unique well # constructed in
Reason for replaced or reconstructed well ?
NEW HOME

Construction Type Drilled

3. Well serves 1 # of
Private,potable
Heat Exchange____# of drillholes

Hicap Well ? No
Hicap Property ? No
Hicap Potable ?

4. Potential Contamination Sources - ON REVERSE SIDE

5. Drillhole Dimensions and Construction Method

Dia. (in.)	From (ft.)	To (ft.)
8.75	Surface	62
6	62	220

Upper Enlarged Drillhole / Lower Open Bedrock

Yes Rotary - Mud Circulation ....
Rotary - Air ....
Rotary - Air & Foam ....
Drill-Through Casing Hammer
Reverse Rotary
Cable-tool Bit ____in. dia...
Dual Rotary ....
Temp. Outer Casing ____in. dia
Removed? ____depth ft. (If NO explain on back side)

8. Geology

Geology Codes			**8. Geology** Type, Caving/Noncaving, Color, Hardness, etc...	From (ft.)	To (ft.)
		C	CLAY	Surface	6
	B	L	LIMEROCK (BROKEN)	6	30
		L	LIMEROCK	30	220

6. Casing, Liner, Screen

Dia. (in.)	Material, Weight, Specification Manufacturer & Method of Assembly	From (ft.)	To (ft.)
6	NEW BLK STL 18.97#/FT 1780 PSI ASTMA 53 GR BP.E. VENEZUELA	Surface	62
Dia. (in.)	Screen type, material & slot size	From (ft.)	To (ft.)

9. Static Water Level
64 ft. below ground surface

10. Pump Test
Pumping level 82 ft. below surface
Pumping at 15 GP for 3 Hrs.
Pumping Method ?

11. Well Is
12 in. above grade
Developed ? Yes
Disinfected ? Yes
Capped ? Yes

7. Grout or Other Sealing Material
Method PRESSURE

Kind of Sealing Material	From (ft.)	To (ft.)	# Sacks Cement
MUD @ CUTTINGS	Surface	6	
CEMENT	6	62	11

12. Notified Owner of need to fill & seal ?
Filled & Sealed Well(s) as needed?

13. Constructor / Supervisory Driller	Lic #	Date Signed
LJS		06-22-1990
Drill Rig Operator	Lic or Reg #	Date Signed

WELL CONSTRUCTOR'S REPORT TO WISCONSIN STATE BOARD OF HEALTH
See Instructions on Reverse Side

RECEIVED JAN 31 1950 BUREAU SAN. ENG.

1. County Green Lake — Town [X] Village [ ] City [ ] Brooklyn (Check one and give name)

2. Location 'NE, NW N. E. of [crossed out] Sec. 36 Township 16 north Range 13 E
(Name of street and number of premise or Section, Town and Range numbers)

3. Owner [X] or Agent [ ] August Quick
(Name of individual, partnership or firm)

4. Mail Address Ripon Route 2
(Complete address required)

5. From well to nearest: Building 25 ~~32~~ ft; sewer 45 ft; drain 50 ~~85~~ ft; septic tank ~~none~~ 55 ft;
dry well or filter bed 75 ft; abandoned well 200 ft.

6. Well is intended to supply water for: Home & Farm

7. DRILLHOLE:

Dia. (in.)	From (ft.)	To (ft.)	Dia. (in.)	From (ft.)	To (ft.)
8	0	75			
6	75	140			

8. CASING AND LINER PIPE OR CURBING:

Dia. (in.)	Kind	From (ft.)	To (ft.)
6	Standard Weight		
	steel pipe	0	75

9. GROUT:

Kind	From (ft.)	To (ft.)
Drill cuttings	0	18
cement	18	75

10. FORMATIONS:

Kind	From (ft.)	To (ft.)
clay gravel	0	15
Limestone	15	55
Sand-stone	55	140

Construction of the well was completed on:
Dec. 29 1949

The well is terminated 8 inches
[X] above, below [ ] the permanent ground surface.

Was the well disinfected upon completion?
Yes X No

Was the well sealed watertight upon completion?
Yes X No

11. MISCELLANEOUS DATA:

Yield test: 1 Hrs. at 30 GPM.

Depth from surface to water-level: 52 ft.

Water-level when pumping: 55 ft.

Water sample was sent to the state laboratory at:
Oshkosh (City) on Jan. 18 1950

Signature R. J. Schafer & Sons (Registered Well Driller) — Fremont Wis. (Complete Mail Address)

Please do not write in space below

Rec'd JAN 20 1950 No. 00505

Ans'd

Interpretation Safe

	10 ml	10 ml	10 ml	10 ml	10 ml
Gas—24 hrs.	O	O	O	O	O
48 hrs.	O	O	O	O	O
Confirm					
B. Coli					

Examiner

4429

300'
1377058

Well Construction Report
WISCONSIN UNIQUE WELL NUMBER SQ446

Drinking Water and Groundwater - DG/5
Department of Natural Resources, Box 7921
Madison WI 53707

Form 3300-077A

Property Owner: MACHKOVICH, STEVE
Phone #:

Mailing Address: W235 PRAIRIE RD

City: RIPON | State: WI | Zip Code: 54971

County	Co. Permit #	Notification #	Completed
Green Lake			08-20-2004

Well Constructor (Business Name)	Lic. #	Facility ID # (Public Wells)
DANIEL J STEFFES	6109	

Well Plan Approval #: 24-1-0031

Address: BADGER WELL DRLG
FOND DU LAC WI 54935

Approval Date (mm-dd-yyyy): 07-07-2004

Hicap Permanent Well #	Common Well #	Specific Capacity
	2	2.7

3. Well serves # of IRRIGATION
Private, non-potable Irrigation
Heat Exchange____# of drillholes

Hicap Well ? Yes
Hicap Property ? Yes
Hicap Potable ?

1. Well Location Fire # (if avail.)

Town of BROOKLYN

Street Address or Road Name and Number

Subdivision Name	Lot #	Block #

Latitude / Longitude in Decimal Degree (DD)		Method Code
°N	°W	GPS008

NE	NE	Section	Township	Range
or Govt Lot #		36	16 N	13 E

2. Well Type New Well YJ585 replaces this well
of previous unique well # constructed in

Reason for replaced or reconstructed well ?

Construction Type Drilled

4. Potential Contamination Sources - ON REVERSE SIDE

5. Drillhole Dimensions and Construction Method

Dia. (in.)	From (ft.)	To (ft.)
16	Surface	62
12	62	465

Upper Enlarged Drillhole / Lower Open Bedrock

Yes Rotary - Mud Circulation .... No
Rotary - Air ....
Rotary - Air & Foam ....
Drill-Through Casing Hammer
Reverse Rotary
Cable-tool Bit ____in. dia...
Dual Rotary ....
Temp. Outer Casing ____in. dia
Removed? ____depth ft. (If NO explain on back side)

8. Geology

Geology Codes				8. Geology Type, Caving/Noncaving, Color, Hardness, etc...	From (ft.)	To (ft.)
K	-	I	-	BLACK DIRT	Surface	3
-	-	Y	P	HARDPAN STONES SAND	3	34
-	-	L	-	LIMESTONE	34	87
-	-	N	-	SANDSTONE	87	115
-	-	N	L	SANDSTONE LIMESTONE	115	197
-	-	N	-	SANDSTONE	197	465

6. Casing, Liner, Screen

Dia. (in.)	Material, Weight, Specification Manufacturer & Method of Assembly	From (ft.)	To (ft.)
12	ASTM A53B IPSCO PARAGON 12.750 X .375 EL 21 PLAIN END	Surface	62

Dia. (in.)	Screen type, material & slot size	From (ft.)	To (ft.)

7. Grout or Other Sealing Material

Method TREMIE PIPE PUMPED

Kind of Sealing Material	From (ft.)	To (ft.)	# Sacks Cement
NEAT CEMENT GROUT	Surface	62	45 S

9. Static Water Level
38 ft. below ground surface

10. Pump Test
Pumping level 225 ft. below surface
Pumping at 500 GP M for 1 Hrs.
Pumping Method ?

11. Well Is
24 in. above grade
Developed ? Yes
Disinfected ? Yes
Capped ? Yes

12. Notified Owner of need to fill & seal ?

Filled & Sealed Well(s) as needed?

13. Constructor / Supervisory Driller	Lic #	Date Signed
DJS		08-20-2004
Drill Rig Operator	**Lic or Reg #**	**Date Signed**

Wisconsin Geological and Natural History Survey
DIVISION OF EXTENSION
UNIVERSITY OF WISCONSIN-MADISON

BOREHOLE GEOPHYSICAL LOG

WGNHS ID 24000136 SITE NAME Machkovich 2
WUWN SQ446 COUNTY Green Lake DATE 5/24/2013 LOGGED BY PM Chase

LATITUDE 43.818841 LOCATION Ripon, WI - NE1/4, NE1/4, Sec 36 T16N R 13E
LONGITUDE -88.888482 LOC METHOD GPS LOC CONF 30m/100ft

ELEVATION 988 WELL DEPTH 415 CASING DEPTH 61
ELEV. METHOD 10mDEM2017 DEPTH TO WATER 95 CASING STICK UP 1

Comments:

LOGS COLLECTED:

- [X] Gamma
- [X] Caliper
- [X] Single Point Resistivity
- [X] Self Potential
- [X] Normal Resistivity
- [X] Fluid Temperature
- [X] Fluid Conductivity
- [ ] Flow Meter- HeatPulse
- [ ] Flow Meter- Spinner (up is negative; down is positive)
- [ ] Optical Borehole Imager
- [ ] Acoustic Borehole Imager
- [ ] OTHER

Unless noted, (1) all depths are in feet; (2) well depth, casing depth, and depth to water are interpreted from geophysical log; and (3) datum is the top of casing. For more information or to obtain collected data not shown, please contact: data@wgnhs.wisc.edu

File Created on: 2/3/2014
By: AMB

APPENDIX C – WISCONSIN CHAPTER 30 DETERMINATION

State of Wisconsin
DEPARTMENT OF NATURAL RESOURCES
625 E County Rd Y
Oshkosh, WI, 54901

Tony Evers, Governor
Adam N. Payne, Secretary
Telephone 608-266-2621
Toll Free 1-888-936-7463
TTY Access via relay - 711

May 5, 2023

Caleb Edwards
Green Lake County Planning and Development
571 County Road A
Green Lake, WI 54941
[sent electronically]

INF-NE-2023-24-01327

RE: Request for a Navigability Determination Concurrence, for a Tributary to Dakin Creek, located on the Retzlaff Property, in the Town of Brooklyn, Green Lake County.

Dear Caleb::

We have reviewed the navigability determination submitted to the department by Green Lake County after county staff visited this site on April 18, 2023. The site is located in the SE 1/4, SE 1/4 of Section 36, Township 16N, Range 13E. In Wisconsin, the Supreme Court has defined a navigable waterway as one which has a defined bed and banks and carries enough water to float a canoe or other watercraft during the spring high water periods. Based on this definition and the conditions observed at your site, the department concurs with your assessment that the stream on this property has been determined to be non-navigable and so is not regulated as a public watercourse.

While we acknowledge that the wealth of evidence you provided indicates that this reach is non-navigable for Ch. 30 jurisdiction, please do take into consideration that this watershed collects water from roadway ditches and an agricultural area, and it eventually drains into a navigable waterway and trout stream (Dakin Creek), so any development plans along this reach should carefully consider any activities which may alter or impact the watershed and runoff, and the water quality further downstream.

According to Chapter 30, Wis. Stats., permits are not needed for work in and near this waterway. Information on these regulations and application materials are available on the DNR waterways website at https://dnr.wisconsin.gov/topic/Waterways.

Certain activities may also require permits from the local county zoning department and/or the federal office Army Corps of Engineers (ACOE). It's beneficial for the property owner to reach out and contact those offices before beginning any construction at this site.

If you have any questions about your determination, please call me at (920) 267-1739 or you can reach me by email at Dale.Rezabek@wisconsin.gov.

Sincerely,

Dale H Rzbk

Dale Rezabek
Water Management Specialist (Shoreland)

Email cc: U.S. Army Corps of Engineers
Lane Loveland, WDNR WMS NMM
Eric Stadig, WDNR WMS
Alison Masek, WDNR WMS
Brad Latza WDNR Conservation Warden

Enclosure: Map of navigability determination concurrence

APPENDIX D – PRODUCT LIST

Kopplin & Kinas Co., Inc. Product List

Shot Rock

Rip-Rap- Various Sizes

Breaker Run

Dense Base- Various Sizes

Clear Stone- Various Sizes

Screenings

Ag-Lime

Asphalt & Concrete Aggregate

Recycled Concrete

Recycled Asphalt

Crushed Chips- Various Sizes

Crushed Granular Fill

APPENDIX E – AGGREGATE PROCESSING & CONSTRUCTION EQUIPMENT

Kopplin & Kinas Co., Inc.

Aggregate Processing & Construction Equipment

Site Development

Dozers
Scrapers
Excavators
Haul Trucks
Graders

Processing & Material Transport

Drill Rigs
Crushing Units (Primary, Secondary, Tertiary)
Screening Units
Washing Units
Conveyors
Wheeled Loaders
Skid-Loaders
Service Trucks
Crane
Haul Trucks
Generators
Pumps

Aggregate & Product Transport

Truck Scale
Scale House
Dump Trucks
Forklifts

Equipment for Environmental Control

Tractor & Seed Drill
Roller
Water Truck
Sweeper

KOPPLIN & KINAS CO., INC.
GREEN LAKE, WISCONSIN

APPENDIX F – POLLUTION PREVENTION BEST MANAGEMENT PRACTICES

Kopplin & Kinas Company Inc.
Pollution Prevention Best Management Practices

1 Introduction & Purpose

Kopplin & Kinas Company Incorporated (KKCI) is an aggregate production and heavy/civil construction company serving the communities of Green Lake and the surrounding counties since 1926.

KKCI's business is reliant upon an available supply of sand and crushed stone to complete their projects and service their customers. Crushed stone and sand and gravel are intermittently excavated from local stone and glacial deposits. They are processed and delivered using one or more combinations of stripping, excavating, crushing, screening, washing, and load-out equipment.

KKCI has prepared the following plan to identify potential pollutants at these work sites and minimize their exposure to sensitive waters of the State through employee education, sound planning, and the best management practices (BMPs) described herein.

2 Responsibility & Training

It is the responsibility of all employees to recognize and respond to potential environmental concerns. Pollution prevention plans are reviewed annually by executive and field personnel and updated as needed to protect surface water and groundwater resources. Field crews are trained in the importance of pollution prevention at routine tailgate safety meetings. Topics for discussion include good housekeeping practices, safe petroleum product handling, and proper maintenance and inspection procedures.

Erosion control measures outside of plant and equipment work areas may be identified by field personnel. In these situations, company officials are notified so that site specific BMPs can be implemented.

3 Potential Pollutants & Best Management Practices

There are two general types of pollutants at every crushed stone or sand and gravel facility. These include: (1) Sediment, and (2) petroleum products such as fuels and/or lubricants. The following section describes potential pollutant sources and BMPs for prevention of their release to sensitive waters of the State.

4 BMPs for Soil Erosion & Sediment Control

Site preparation activities at new nonmetallic mine sites or previously undisturbed portions of an existing nonmetallic mine site can release sediments, allowing their capture into storm water. These activities include topsoil and/or overburden stripping, berm construction, and the establishment of an access drive. Soils containing a high percentage of silt or clay, and those located near waterways or on steep slopes pose the highest risk for erosion and sediment runoff, particularly during periods of high precipitation.

Proper site planning is the best approach to prevention. For new and existing sites, KKCI will implement the following BMPs as necessary for storm water control under changing site conditions:

- Develop the site incrementally, preserving vegetation (where Possible) along the perimeter of the excavation.
- Divert surface water away from disturbed areas.
- Prevent tracking of sediment from the entrance of the site. This can be done several ways: (1) Restricting on-road vehicles to stabilized areas, (2) Diverting surface water runoff from the roadway into the facility, (3) Constructing a gravel tracking pad, or (4) Inspecting and cleaning up any residual material tracked onto adjacent roadways.
- Contain surface water runoff within the overall excavation (below grade) so sediments in surface water will be captured and filtered before they are discharged to groundwater.
- Construct berms with stable slopes (typically 3:1 or less), away from sensitive wetlands or waterways.
- Stabilize berm areas upon construction with perennial vegetative cover, mulching as needed.
- Evaluate runoff at outfalls, near wetlands and waterways, or areas of steep slopes to evaluate the need for additional erosion controls such as those outlined in the Wisconsin Construction Site Erosion Control Field Guide, and Wisconsin DOT handbook. These controls may include but are not limited to the temporary erection of silt fence, sediment traps, straw bales or natural or synthetic matting or netting, or the permanent construction of sediment retention ponds.

5 BMPs for Material Processing & Loading

Aggregate processing requires the physical reduction, sizing and/or washing of natural earth materials. Portable processing equipment is used to produce various sized material stockpiles. The equipment is used intermittently at KKCI's facilities to produce the needed construction aggregates. In general, processing is conducted below grade within the area of extraction. KKCI may elect to implement the following BMPs as necessary to minimize risk from sediment to storm water and nearby surface water bodies during processing and loading:

- Consider environmental impacts when selecting plant sites. Site all processing equipment away from surface water bodies; preferably below grade within the area of extraction.
- Maintain internal drainage of the site for the duration of the processing cycle.
- Construct berms or dikes around processing equipment and/or wash ponds if surface water runoff is not adequately contained onsite.
- Use conveying equipment to stockpile sand and crushed stone products away from major transportation routes within the facility.
- Manage bulk storage piles following the BMPs described in Wisconsin DNR publication "Storage Pile Best Management Practices" WT-468-96, When placed outside of the internally drained limits of the excavation.
- Size wash ponds to have sufficient storage capacity for wash out purposes, as well as a 25-year storm event.
- Routinely remove fine material generated from crushing, screening, or conveying operations to prevent buildup and off-site tracking.
- Loadout within the area of extraction, being careful to avoid spilling from trucks.

6 BMPs for Maintenance of Roads, Erosion Controls, & Wash Ponds

Roadways, temporary and permanent erosion control structures, and wash ponds need to be maintained to ensure optimum performance. Routine Maintenance is scheduled on an as needed basis and may include any one or more of the following:

- Refresh the tracking pad and/or sweep sediment from paved roadways.
- Remove silt fence, straw bales, or other temporary erosion controls when surface soils have been stabilized.
- Clean out sediment from retention and/or wash ponds as needed and store in a secure area of the site within the area of extraction.

7 BMPs for Mobile Fueling of Generators, Engines, and Heavy Equipment

Fuel is delivered to KKCI work sites as it is in other rural areas. A local supply truck arrives during working hours to fuel necessary equipment and fuel transfer tanks. BMPs associated with fueling may include:

- Assisting delivery drivers as needed to provide safe and effective transfer of fuels.
- Monitoring fuel deliveries at all times to prevent overfilling.
- Providing spill containment and recovery equipment in the event of a spill.

8 BMPs for Maintenance & Repair of Equipment

Petroleum fluids such as oil lubricants and grease can impact sensitive waters of the State. The Following BMPs have been provided as a means of prevention:

- Avoid overfilling gearboxes and crankcases.
- Follow manufacturer's specifications when greasing bearings and wear surfaces.
- Repair leaking seals on mechanical equipment.
- Prevent spills during oil changes.
- Maintain an adequate supply of absorbent material and spill kits for routine maintenance and petroleum spills.
- Properly store and secure petroleum products to avoid their contact with storm water.
- Store waste oil in spill proof containers for offsite disposal.
- Discard soiled towels in receptacles provided.
- Fully service and inspect engines and gearboxes in the off-season to eliminate leaking seals, fuel lines, and gaskets; annual repairs such as these are to be conducted in the shop or other appropriate facility.

APPENDIX G – FUGITIVE DUST CONTROL PLAN

Fugitive Dust Control Plan for the K Quarry
Section 36, Town of Brooklyn
Green Lake County, Wisconsin

The control of fugitive dust is required under section NR 415.04, Wisconsin Administrative Code, for all affected facilities. Section NR 415.075(2), Wis. Adm. Code, has specific requirements for fugitive dust control for rock quarries and industrial sand mines. **The standard for fugitive dust emission quantification is by visual observation. If visible dust emissions are observed, they need to be suppressed.**

1 SITE ROADWAYS

A. The dust on the site roadways shall be controlled by applications of water. Applications of water shall be performed when conditions exist that will likely produce fugitive dust (long periods of low precipitation, low humidity, high winds, high site traffic) and whenever fugitive dust is observed. After application, a follow-up observation shall be performed to ensure the effectiveness of the control measures.

B. All paved travel ways shall be swept whenever there is an accumulation of debris or fugitive dust is observed. Any material spillage on roads shall be cleaned up immediately. After control measures are taken, a follow-up observation shall be performed to ensure the effectiveness of the control measures.

C. Speed limits shall be kept within the quarry and haul roads to 10 miles per hour or less. Speed limits shall be posted on haul roads. (Section NR 415.075, Wis. Adm. Code)

D. Fugitive emissions from haul roads will not exceed 20% opacity at the source. (Section NR 415.075, Wis. Adm. Code). Even though some equipment and activities are allowed up to 20% opacity at the source, no visible emissions of dust should ever be allowed to cross the property boundary.

E. A screening berm with a windbreak of trees planted on it will be constructed surrounding the site.

2 Processing Plant

A. The drop distance at each transfer point shall be reduced to the minimum the equipment can achieve.

B. Water spray nozzles or bars at transfer points and points of high dust generation shall be utilized when necessary.

C. Plant equipment and enclosures shall be inspected on a regular basis (daily, weekly, monthly, or per manufacturer's recommendation) for physical integrity. Any equipment or seal leaks shall be repaired as soon as practicable and not later than 48 hours after being identified.

3 Storage Piles

A. Stockpiling of all nonmetallic minerals shall be performed in a manner that minimizes drop distances and control potential dust problems.

B. Loading and stockpiling areas shall be watered as needed to control fugitive dust.

4 Truck Traffic

A. Vehicles shall be loaded in a manner that prevents their contents from dropping, leaking, blowing, or otherwise escaping. This shall be accomplished by loading so that no part of the load shall come in contact within six inches of the top of any sideboard, side panel or tail gate. Trucks shall be covered or secured to prevent the escape of materials likely to become airborne during transport, prior to any transportation off site. (Section NR 415.075, Wis. Adm. Code)

B. Excess dust and/or spillage of material off-site shall be cleaned up and returned to the facility or properly disposed of.

5 Drilling & Blasting Activities

A. All drilling activities will be performed using a collar and dust collection system or other means to reduce fugitive emissions. Fugitive emissions from drilling will not exceed 20% opacity at the source. (Section NR 415.075, Wis. Adm. Code)

B. All blasting shall use blast hole stemming materials that have been approved by the Department or the Department of Commerce. (Section NR 415.075, Wis. Adm. Code)

6 Employee Responsibilities for Implementation of Plan

All employees are required to take action to prevent fugitive dust if they observe any site activity or site condition that is likely to cause it. Employees are required to immediately notify a supervisor if excessive fugitive emissions are observed. This will include a description of the source of the excessive emission. The supervisor will be responsible for directing dust control measures and ensuring the measures taken are adequate.

7 List of dust control Equipment

The following is a list of equipment that will be onsite or readily obtainable for control and cleanup to reduce fugitive dust.

A. Water trucks
B. Frontend loader/trucks (cleaning up spillage)
C. Brooms/hand tools
D. Road sweeper

8 Excessive Fugitive Dust Plan

If excessive dust is generated at the facility, the operation creating the dust problem shall be shut down immediately and will not resume until the problem is corrected. An investigation as to the cause of the excessive dust shall be conducted, and if necessary, the Fugitive Dust Control Plan will be revised to avoid any future fugitive dust emissions.

The Sky is Falling: Misconceptions About Mining in Green Lake County

Michael C McConnell

Kopplin & Kinas Company, Incorporated

Contents

The Sky is Falling: Misconceptions About Mining in Green Lake County

> Did you ever hear of Chicken Little, how she disturbed a whole neighborhood by her foolish alarm? Well, Chicken Little was running about in a gentleman's garden, where she had no business to be: she ran under a rosebush, and a leaf fell on her tail; so she was dreadfully frightened, and ran away to Hen Pen. "O Hen Pen," said she, "the sky is falling!" "Why, Chicken Little, how do you know it?" "O, I heard it with my ears, I saw it with my eyes, and part of it fell on my tail." "Come then," says Hen Pen, "let us run as fast as we can." (Chandler, 1840).

The Remarkable Story of Chicken Little bears an uncanny similarity to the hysteria that takes place when a new non-metallic mine is proposed. The role of Chicken Little is generally manifested by local environmental groups who are certain that a new pit or quarry will bring irreparable harm to the community and end life as we know it. Hen Pen, Loose Goose, and Turkey Lurkey are incarnated by a small faction of residents, and sometimes non-residents, who blindly follow the activist groups, believing the unfounded story of pending doom solely because their "friend" said it was so. The role of Fox Lox is where this similarity becomes more abstract. Fox Lox in this scenario is represented by mob mentality rather than a physical being, more specifically outrage culture caused by environmental alarmism. Outrage culture does not bring the neighborhood fowl to an untimely death as Fox Lox did to the birds in the story, but rather it kills reason and rational thought amongst the affected members of the community. The effect of outrage can be so profound, that even when presented with fact and scientific evidence that shows the anti-mining narrative is based on myths and misconceptions, those consumed by outrage will claim that the information is invalid or not even be able to acknowledge it at all (in one ear and out the other).

A frequent statement is “anywhere but here”, which seems like an honest compromise until you arrive at the next “here” only to “hear” this phrase again. Unfortunately, “anywhere” does not exist. Mineral deposits are not accessible “anywhere”, and even if they were, that “anywhere” would almost certainly be a different group’s “here”.

The intent of this document is to address concerns that commonly arise during the permitting of a new mine, and to clear up the misconceptions about mining in Green Lake County, Wisconsin.

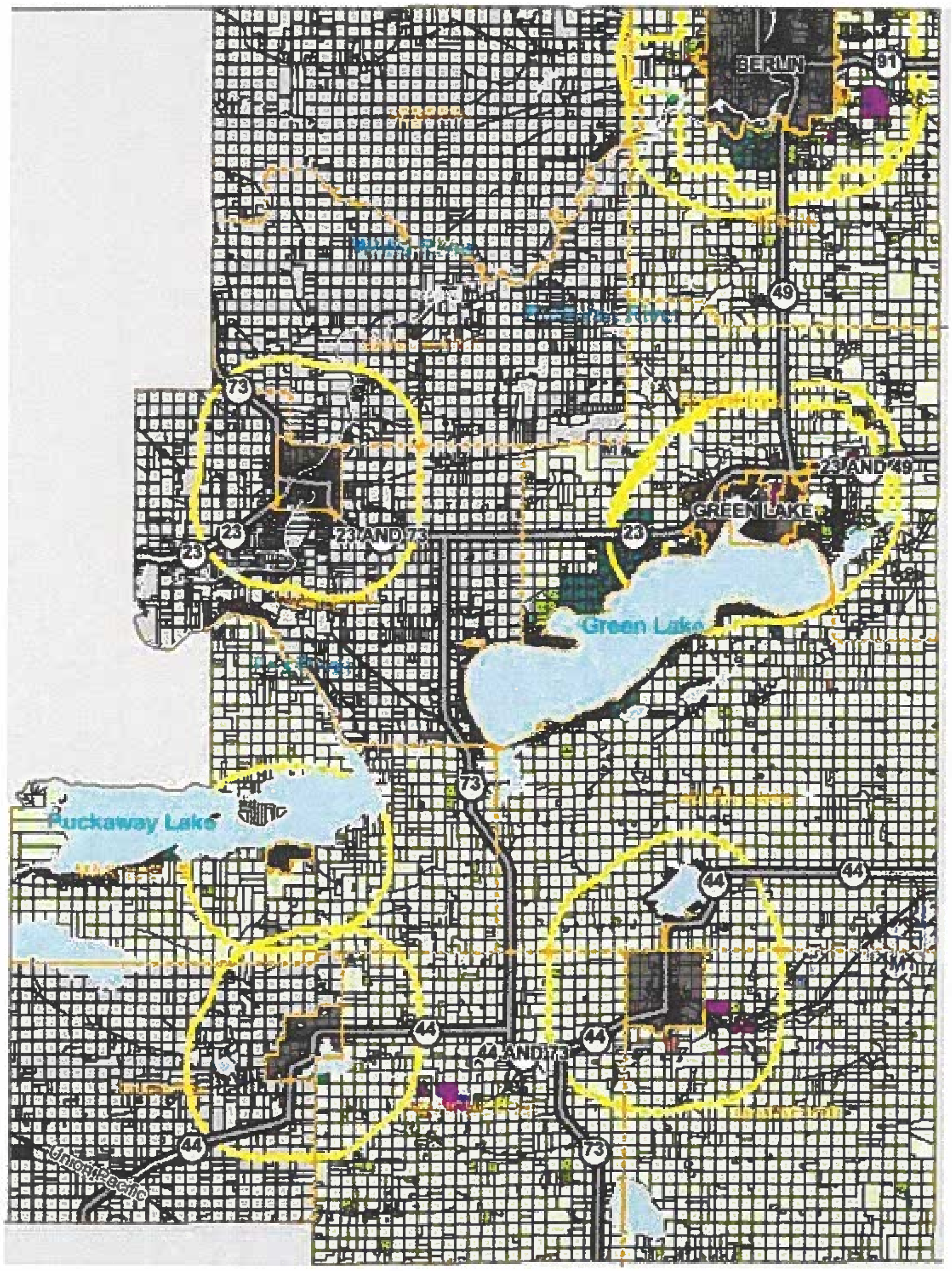
Mining and the Green Lake County Zoning Ordinance

The zoning ordinance of Green Lake County establishes fourteen zoning districts (Ch. 350-24). Non-metallic mineral extraction is only allowed in three of these districts and is only allowed as a conditional use. The three districts are the A-1 Farmland Preservation District, the A-2 General Agriculture District, and the M-1 Mineral Extraction District.

A-1 Lands in Green Lake County

According to the Comprehensive Plan of Green Lake County, ninety-two- and one-half percent of the unincorporated area in Green Lake County falls under the Farmland Preservation designation. Non-metallic mining is allowed as a conditional use in the A-1 Zoning District. Mineral extraction sites in the A-1 District are required to be reclaimed back to agricultural use, which is the main distinction between mineral extraction in the A-1 District versus the other two districts. The map in Figure 1 shows the extents of the A-1 District in Green Lake County, The A-1 District is shown in pale-yellow.

Figure 1.

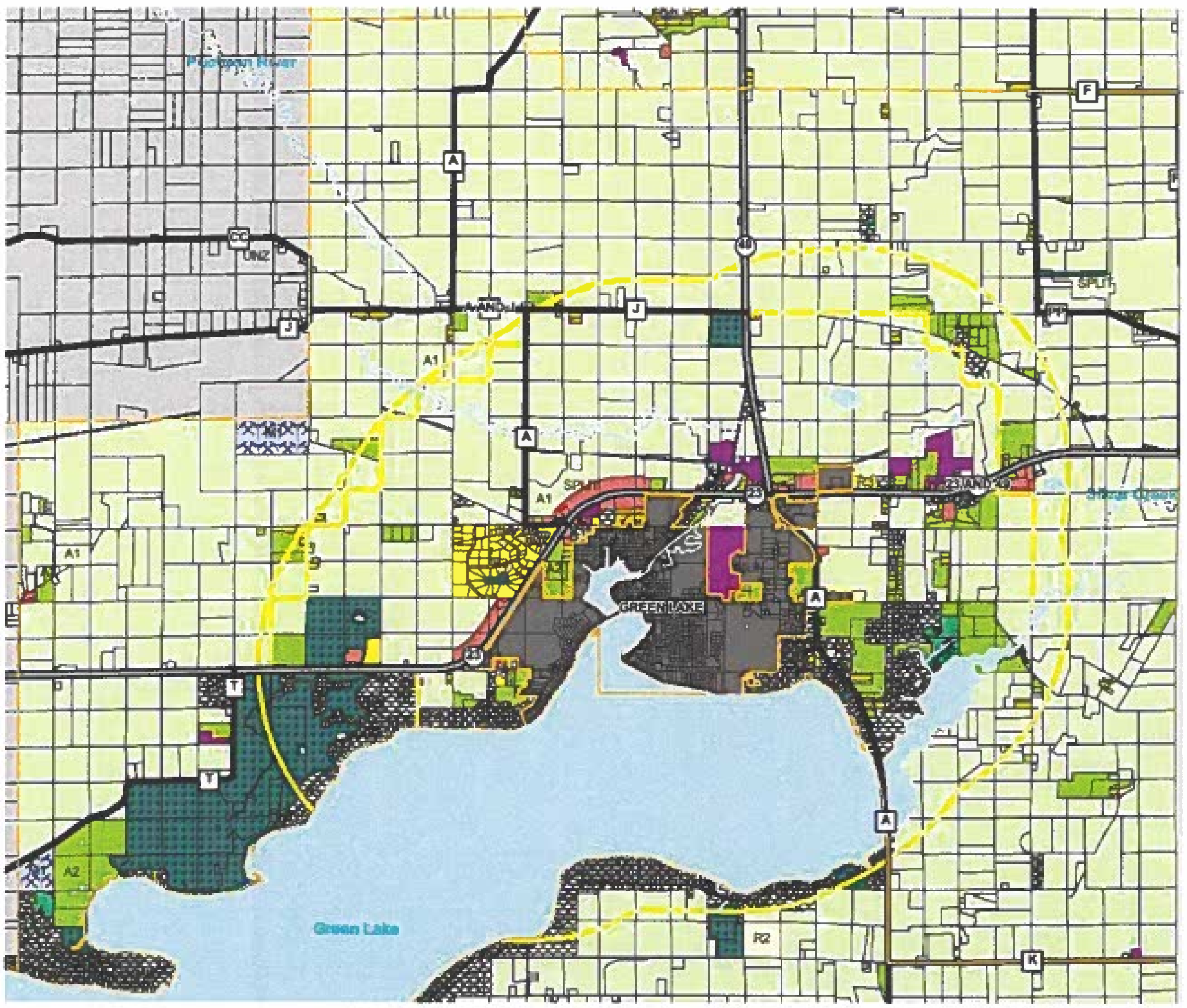


Note. Zoning district overlay map, Green Lake County GIS Web Application.

A-2 Lands in Green Lake County

Non-metallic mining is allowed as a conditional use in the A-2 General Agriculture District. The A-2 district in Green Lake County is generally made up of small, irregularly shaped parcels, mostly under forty acres in area. The district is predominantly made up of rural residences, marsh, and forest land. Figure 2 illustrates the scarcity, and irregular size and shape of the A-2 District in the Township of Brooklyn. The A-2 District is shown in green.

Figure 2.



Note. Zoning district overlay map, Green Lake County GIS Web Application.

M-1 Lands in Green Lake County

There are approximately 1,302.15 acres of land in Green Lake County that are zoned M-1 Mineral Extraction District. Approximately 1,155.06 acres of M-1 land are part of currently active non-metallic construction aggregate and industrial sand mines. There are approximately 147.09 acres of M-1 land not currently part of an active mine.

85.39 acres of the 147.09 total acres are contained in parcel number 004-00793-0000 and are reclaimed acreage from an industrial sand mine. The remaining 61.7 acres are contained on three different parcels in two townships.

Parcel number 010-00056-0000 is in the Town of Mackford. It contains 11.77 M-1 acres. If the site was previously mined, it has been reclaimed. Establishing a 100' buffer from adjacent properties, the actual minable acreage is approximately 4.75 acres.

Parcel number 012-00467-0000 is in the Town of Manchester. It contains 10 M-1 acres and is a split zoned parcel with the 30 acres zoned A-1. There has been activity on this parcel in the past, but it is unclear if it was aggregate mining or a borrow site for fill material. Establishing a 100' buffer from adjacent properties, the actual minable area is approximately 7 acres.

Parcel number 012-00278-0000 is in the Town of Manchester. It contains 40 M-1 acres. The parcel has an unnamed stream which flows along the eastern 1/3 of the parcel and contains approximately 15.5 acres of mapped wetlands. If the site was previously mined it has been reclaimed. Establishing a 100' buffer from adjacent properties, maintaining a 300' buffer from the stream, and avoiding the mapped wetlands, the actual minable area is approximately 7 acres.

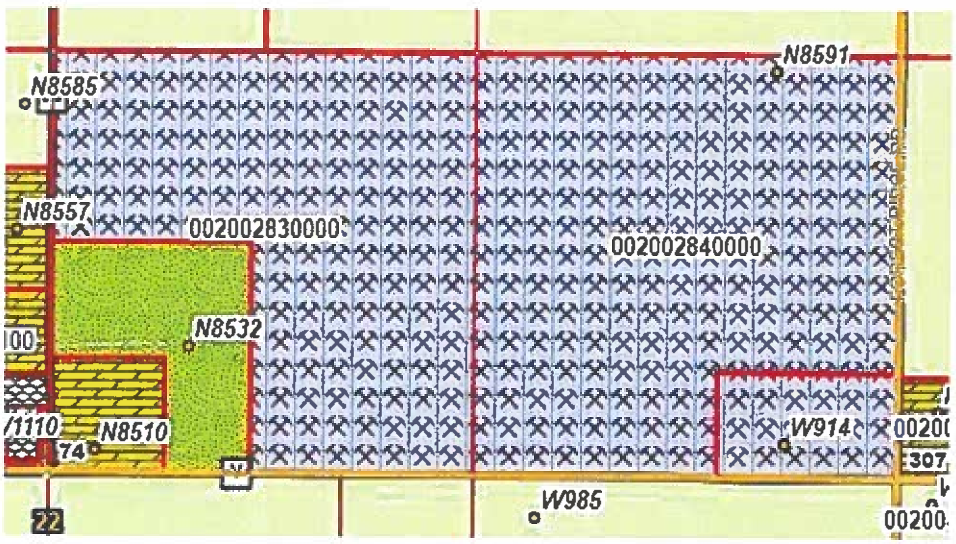
If the three parcels were not previously mined and have marketable reserves, they still do not contain enough minable acreage to be of any practical use and are not economical to mine. Figures 3-1 through 3-14 show the M-1 District parcels in Green Lake County.

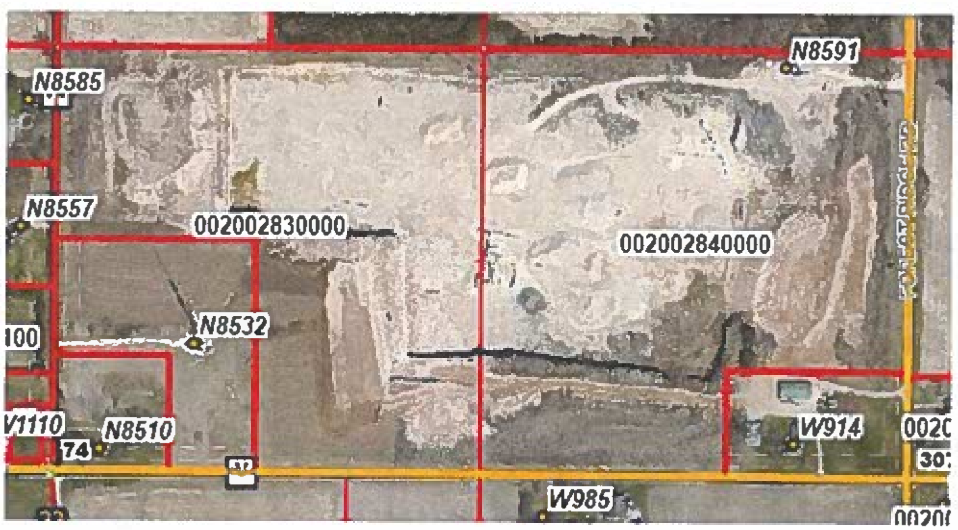
Figure 3-1

Parcels: 002-00283-0000, 002-00284-0000, 002-00284-0100

Total M1 Acreage: 69.98

Operator: Ridge Stone Products





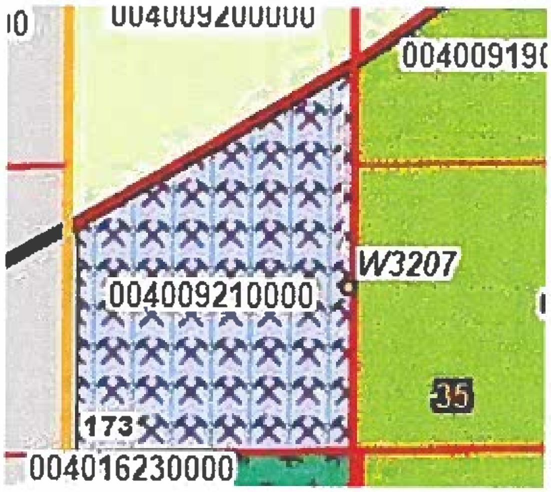
Note. Overlay & Aerial map, Green Lake County GIS Web Application.

Figure 3-2

Parcels: 004-00921-0000

Total M1 Acreage: 40

Operator: Kopplin & Kinas Co., Inc.



Note. Overlay & Aerial map, Green Lake County GIS Web Application.

Figure 3-3

Parcels:004-00793-0000

Total M1 Acreage: 85.39

Operator: Badger Mining Corporation- Reclaimed

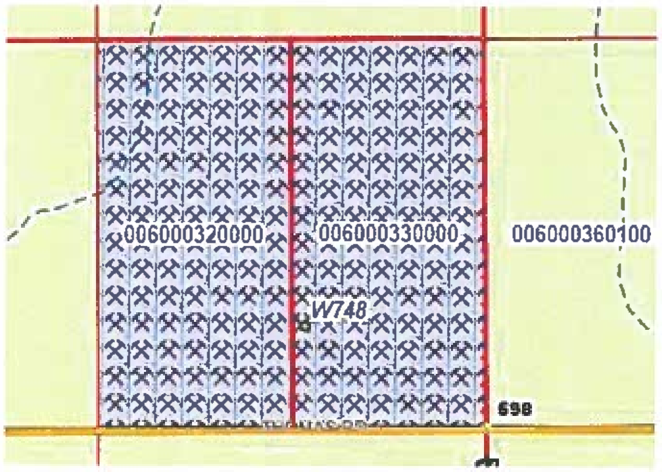
Note. Overlay & Aerial map, Green Lake County GIS Web Application.

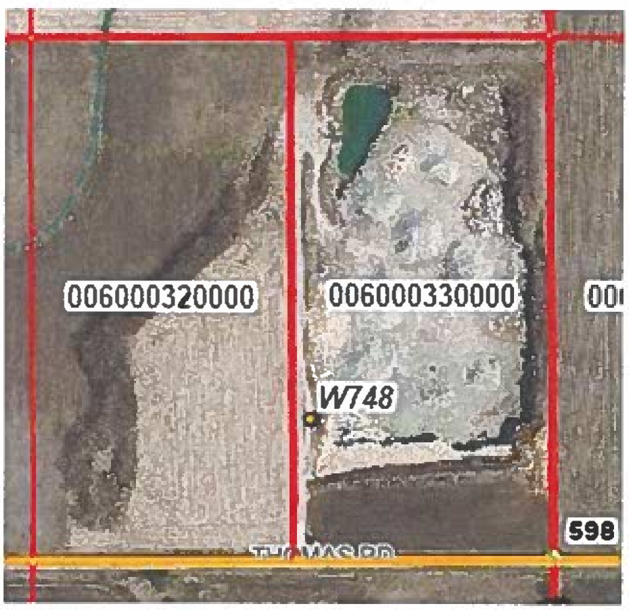
Figure 3-4

Parcels: 006-00032-0000, 006-00033-0000

Total M1 Acreage: 40

Operator: Egbert Materials





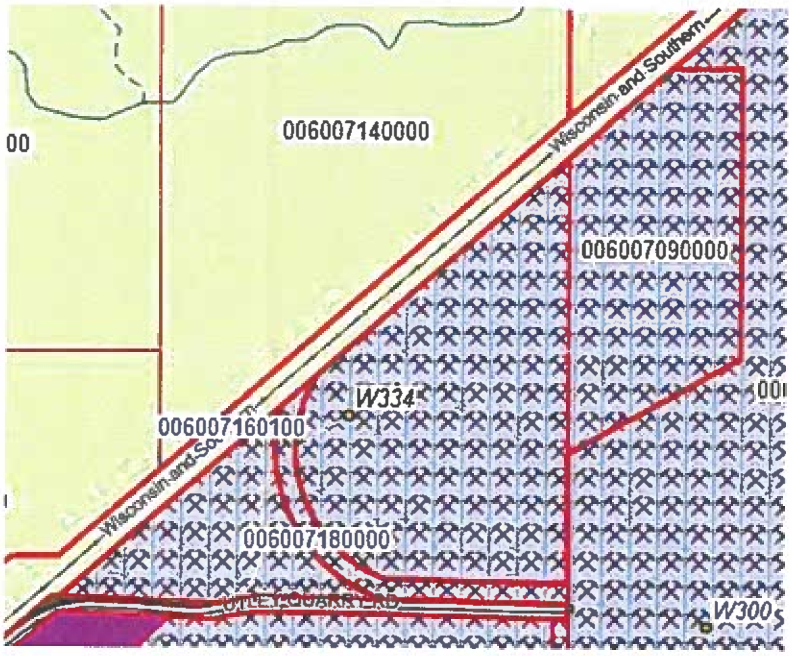
Note. Overlay & Aerial map, Green Lake County GIS Web Application.

Figure 3-5

Parcels: 006-00717-0000, 006-00709-0000

Total M1 Acreage: 44.5

Operator: Michels Road & Stone



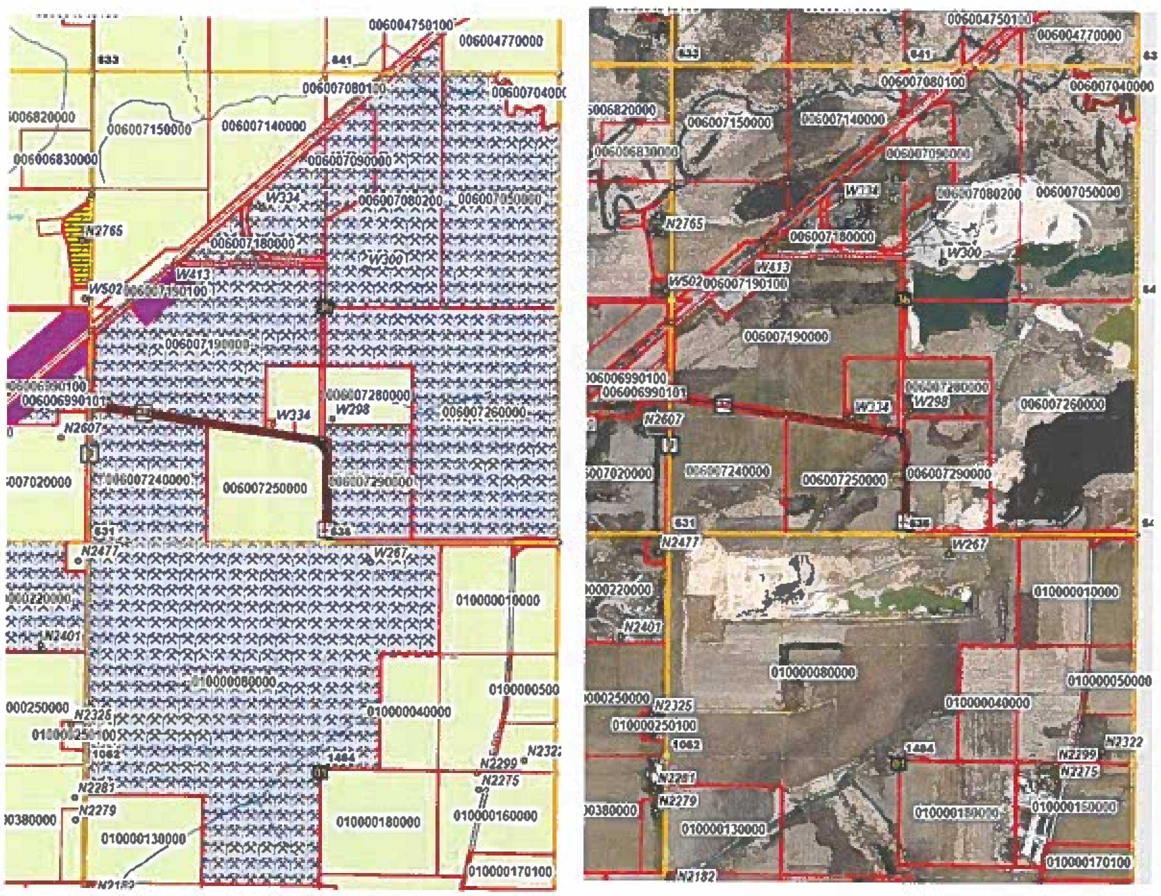
Note. Overlay & Aerial map, Green Lake County GIS Web Application.

Figure 3-6

Parcels: 006-00718-0000, 006-00708-0200, 006-00705-0000, 006-00699-0101, 006-00719-0000, 006-00726-0000, 006-00729-0000, 006-00724-0000, 010-00008-0000

Total M1 Acreage: 672.38

Operator: Badger Mining Corporation



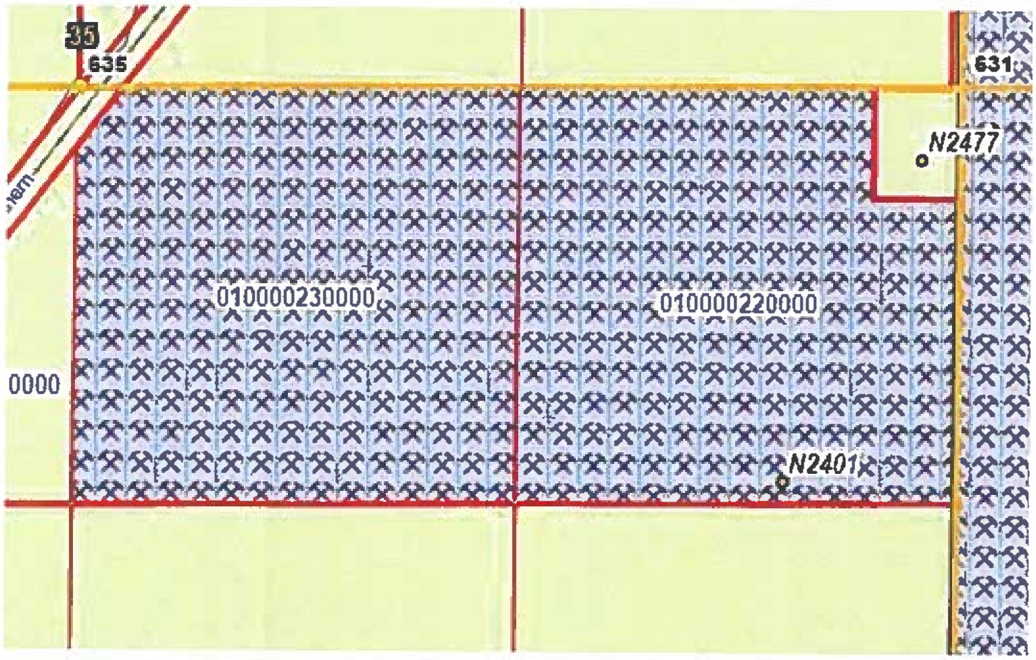
Note. Overlay & Aerial map, Green Lake County GIS Web Application.

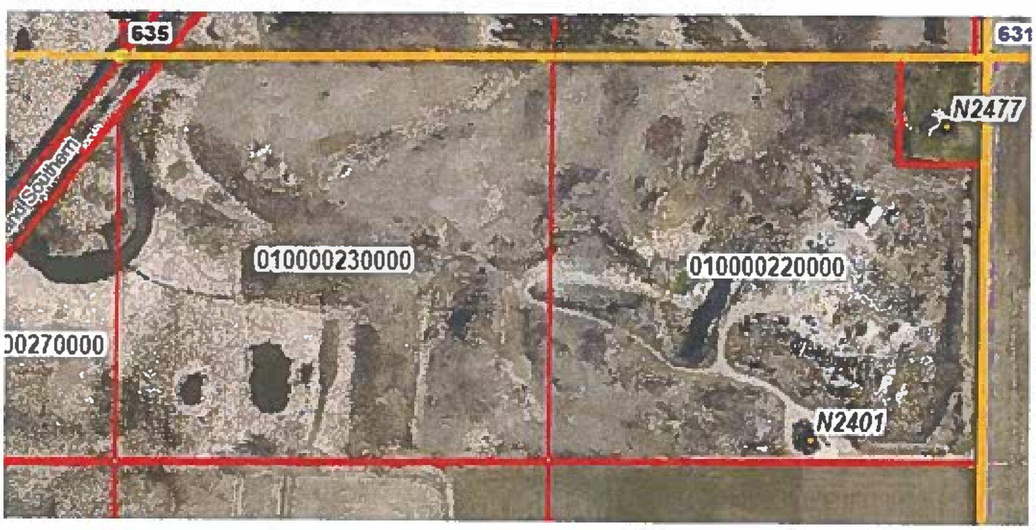
Figure 3-7

Parcels: 010-00023-0000, 010-00022-0000

Total M1 Acreage: 75.8

Operator: Kinas Materials, LLC.





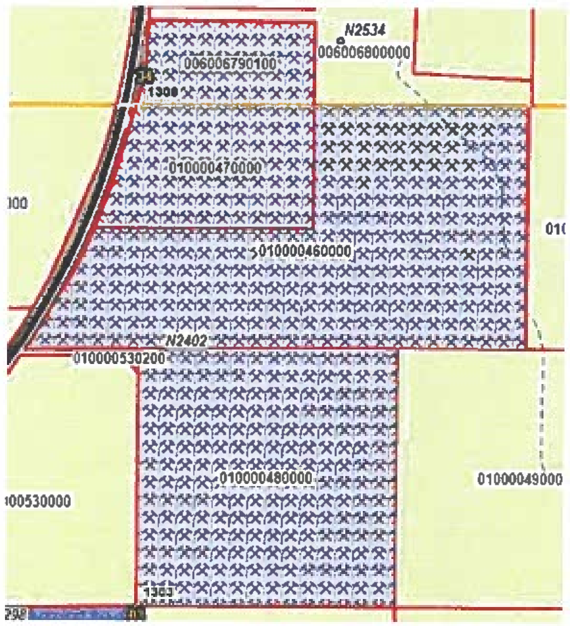
Note. Overlay & Aerial map, Green Lake County GIS Web Application.

Figure 3-8

Parcels: 006-00679-0100, 010-00047-0000, 010-00046-0000, 010-00048-0000

Total M1 Acreage: 116.36

Operator: A.F. Gelhar Co., Inc.



Note. Overlay & Aerial map, Green Lake County GIS Web Application.

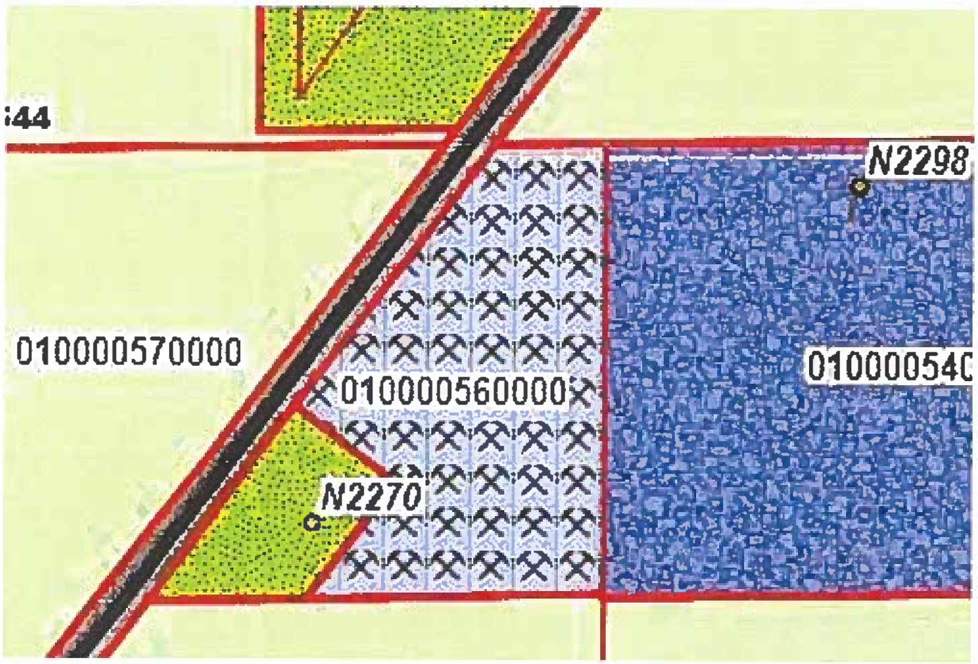
Figure 3-9

Parcels: 010-00056-0000

Total M1 Acreage: 11.77

Operator: None-Possibly a borrow source for the adjoining landfill,

Owned by the City of Markesan



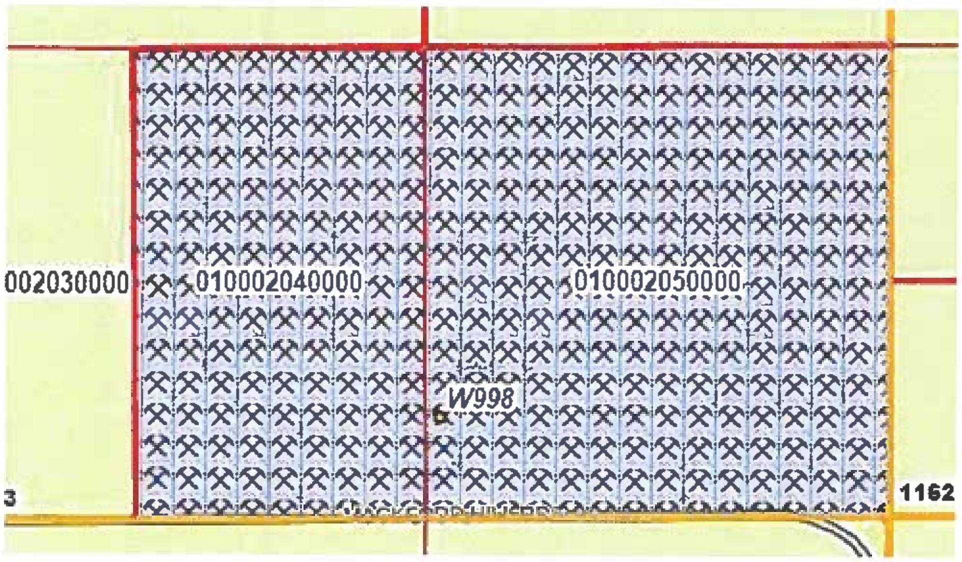
Note. Overlay & Aerial map, Green Lake County GIS Web Application.

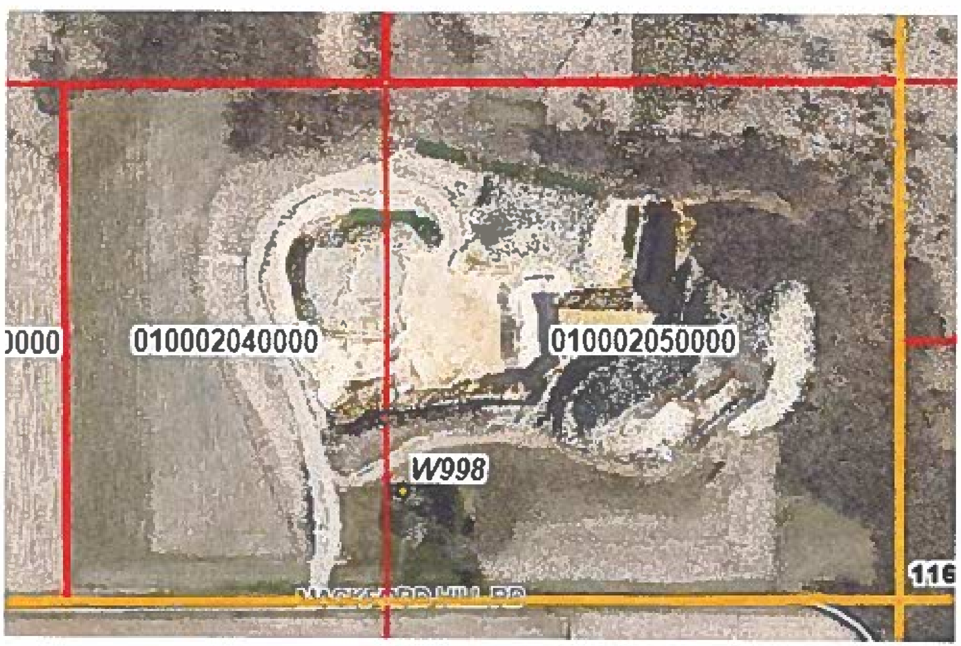
Figure 3-10

Parcels: 010-00204-0000, 010-00205-0000

Total M1 Acreage: 65

Operator: A.F. Gelhar Co., Inc.





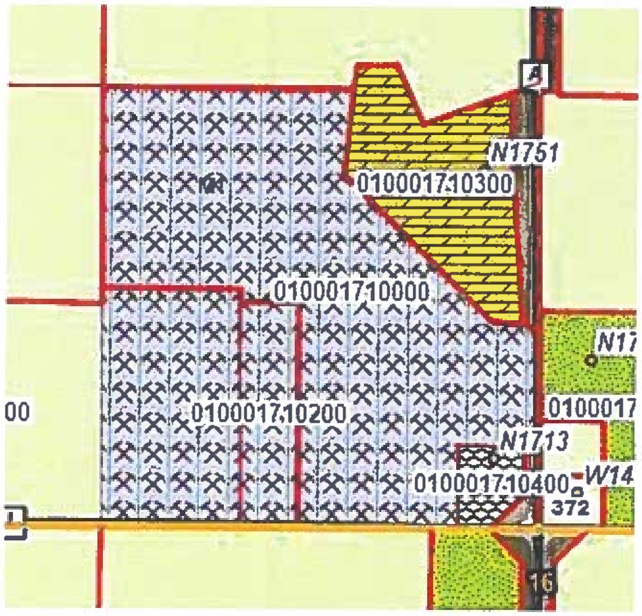
Note. Overlay & Aerial map, Green Lake County GIS Web Application.

Figure 3-11

Parcels: 010-00171-0000

Total M1 Acreage: 23.97

Operator: Sam Gaastra & Sons, Inc.



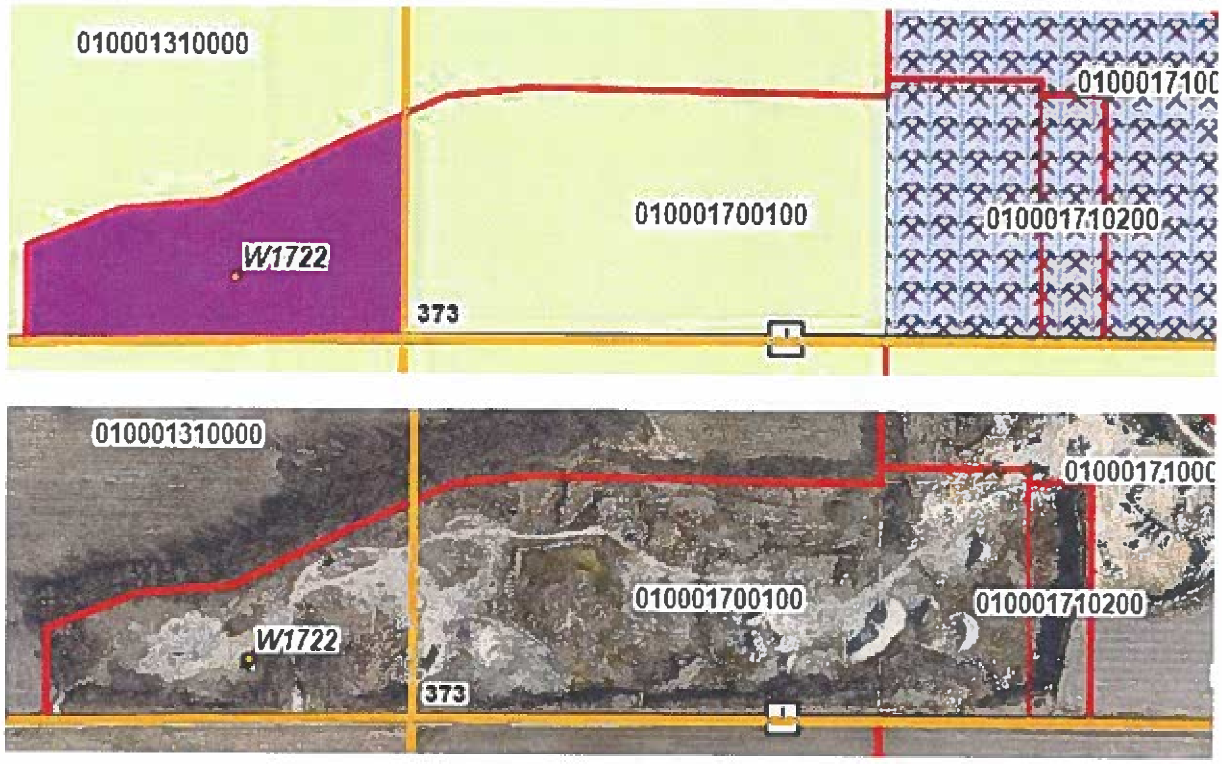
Note. Overlay & Aerial map, Green Lake County GIS Web Application.

Figure 3-12

Parcels: 010-00170-0100(**Split Zoning-M1 & A1**), 010-00171-0200

Total Acreage: 7

Operator: Michels Road & Stone



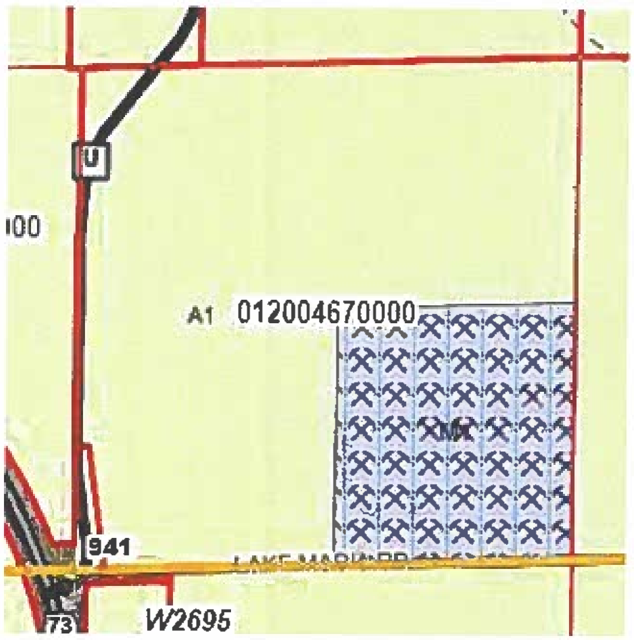
Note. Overlay & Aerial map, Green Lake County GIS Web Application.

Figure 3-13

Parcels: 012-00467-0000 (**Split Zoning-M1 & A1)**

Total Acreage: 10

Operator: None- Possible borrow pit/un-reclaimed



Note. Overlay & Aerial map, Green Lake County GIS Web Application.

Figure 3-14

Parcels: 012-00278-0000

Total M1 Acreage: 40

Operator: None- Reclaimed if previously mined, has a stream & mapped wetland.

Note. Overlays & Aerial map, Green Lake County GIS Web Application.

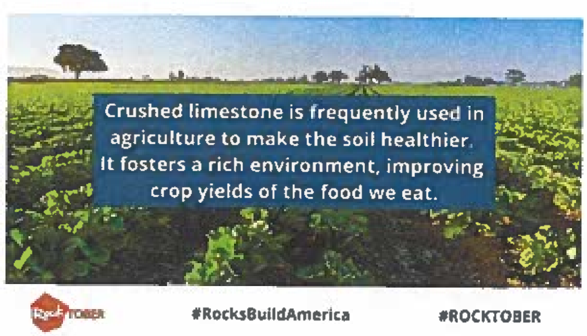
The Comprehensive and Farmland Preservation Plans of Green Lake County

Both the Comprehensive and Farmland Preservation Plans of Green Lake County state the need for adequate infrastructure, adequate roadways, and economic development.

Mined aggregate is an essential component of both infrastructure and roadways and also contributes to and is necessary for economic development. Every new factory or commercial building and every new house that is built requires concrete, and two of the main ingredients of concrete are stone and sand. The driveways, parking lots, roadways, and infrastructure that service all of these need, at a minimum, periodic maintenance and repair, and occasionally replacement and reconstruction, this all requires mined aggregates.

The Farmland Preservation Plan of Green Lake County recognizes that although mining will result in the loss of some farmland, it is necessary to support agricultural infrastructure. Modern agricultural operations also require an extensive infrastructure, both on and off the farm. Maintaining and updating agricultural facilities as well as expansions of existing operations all require mined aggregate. Agriculture uses mined aggregates for more than just construction and transportation purposes. Free-stall barns are commonly bedded with processed sand, and finely crushed limestone is applied to croplands to improve the soil.

Figure 4.



Agricultural equipment is growing in size and weight to increase efficiency and production rates so that the farms can maximize their production. The increased load on local roads increases the need for roadway improvements and thus an increased need for construction aggregates. In June of 2023 Wisconsin State Senate Bill 247 was signed into law and became 2023 Wisconsin Act 13. 2023 Wisconsin Act 13 provides one-hundred fifty million dollars in funding for the Agricultural Roads Improvement Program (ARIP). ARIP provides funding assistance for the improvement of small, deficient, weight restricted "Class B" roads and small bridges, that if improved, would provide agricultural haul routes that reduce deferred or repeated trips, providing more feasible haul routes. ARIP provides road improvement funding to towns that would not be able to afford or prioritize funding for roads that are less traveled by the public but are vital to local agriculture. Adequate agricultural infrastructure is vital to the success of the Farmland Preservation Plan of Green Lake County, and mined aggregates are vital to that infrastructure.

Figure 5.

The local availability of mined aggregate has a direct effect on infrastructure needs and the economic development of a community through transportation costs. On average it costs an additional one dollar and sixty-three cents per ton for every ten minutes added to a dump truck haul. For example, if you compare a ten-minute haul from the aggregate source to a thirty-minute haul, you will see a cost increase of just under forty-nine thousand dollars for fifteen-thousand tons of stone hauled ($1.63/ton per 10 min.; 20min. longer = $3.26/ton; 15,000 tons x

$3.26 = $48,900). For large projects this can mean hundreds of thousands of dollars in extra transit costs. The increase in cost can slow development, deter industry from moving to an area, and cause maintenance and updates to infrastructure to fall far behind the schedule they should be performed at.

Another aspect of economic development the mining industry in Green Lake County contributes to is providing jobs for the citizens of the county. The direct employment impact of one small construction aggregate mine is relatively small, providing for two to four additional employees, but the indirect contribution is far reaching. The indirect employment opportunities start at the mine with truck drivers, equipment sales and service, and various forms of technical support personnel. Opportunities that are not centered around the mine include jobs in infrastructure construction, building construction, all the way to those employed by industries that move to the area because of the appeal of lower construction costs and infrastructure that can meet or exceed their businesses' needs.

Non-metallic Mineral Extraction & Conditional Use Permitting

Section 350-56(2) of the Code of Green Lake County establishes standards that a conditional use must meet to be approved or approved with conditions. These standards ensure that a proposed conditional use does not pose a danger or nuisance to neighboring people or properties and is capable of being served by any applicable public services it would require. Section 350-27(e) establishes additional standards that a non-metallic mineral extraction operation is required to adhere to in order to be granted a conditional use permit in the A-1 zoning district. These additional standards ensure that the proposed mineral extraction operation will not be detrimental to neighboring agricultural lands and that the extraction site is reclaimed back to agricultural use.

The non-metallic mineral extraction sites in Green Lake County adhere to these standards every single day. If this was not the case, the Green Lake County Land Use Planning & Zoning Department, the Green Lake County Circuit Court, the Wisconsin Department of Natural Resources, and the Mine Safety and Health Administration would all be overwhelmed with claims from aggrieved neighbors and possibly even the employees of the mine. Every mineral extraction site in Green Lake County has its own unique framework that it operates under. This framework is made up of conditions of permits, agreements with property owners, agreements with the neighbors and neighborhoods they are located near, government regulation, and the individual policies and standards that the mining companies have developed and put in place on their own accord. The framework that these sites operate under ensures that each site conforms to the standards set forth by section 350-56(2) (and 350-27(e) if located in the A-1 District) of the zoning code. It also ensures the safety of the people who work at and live near these sites as well as protects the properties and environment surrounding the sites. Safety is a priority at all the mineral extraction operations in Green Lake County. The safety culture at these sites ensures the safety of the surrounding people and properties.

In November of 2017 Wisconsin Assembly Bill 479 was signed into law as 2017 Wisconsin Act 67. 2017 Wisconsin Act 67 created Section 59.69 (5e) which limits local government discretion related to the issuance of conditional use permits and defines both "conditional use" and "substantial evidence". 2017 Wisconsin Act 67 requires the county zoning board to grant a conditional use permit if the applicant meets or agrees to meet all of the requirements and conditions specified in the county ordinance or imposed by the board, and that the county's decision to approve or deny the permit must be based on substantial evidence, meaning facts and information, not personal preference or speculation.

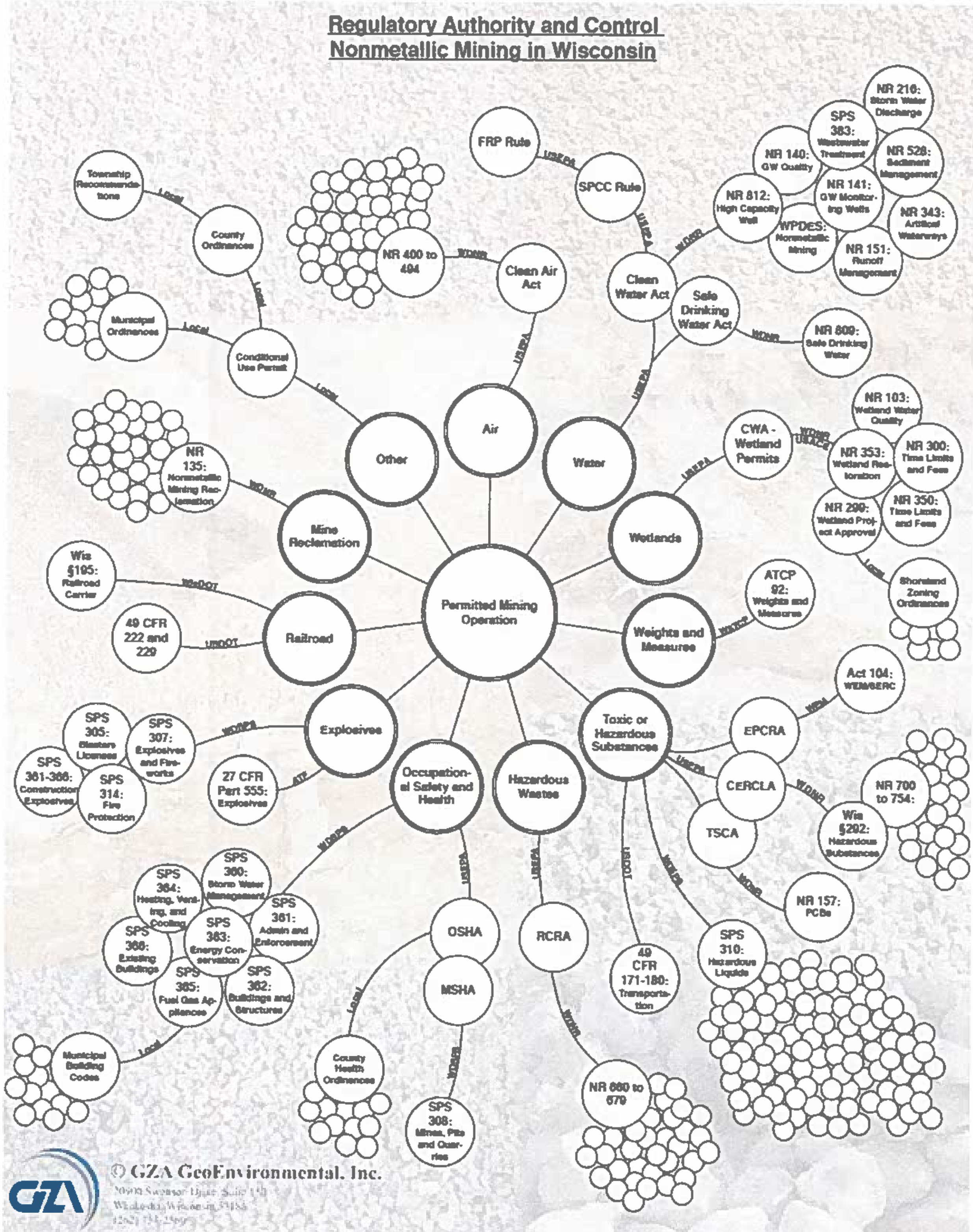
Conclusions on Conformity with the Land Use Ordinances of Green Lake County

Non-metallic mineral extraction is allowed only as a conditional use, and that conditional use is only allowed in three of the fourteen zoning districts established by the zoning ordinance of Green Lake County. Without re-zoning parcels, the only zoning district that contains lands viable for opening a new aggregate source in the zoned territories of Green Lake County is the A-1 Farmland Preservation District. If conditional use permits for non-metallic mining in Green Lake County are going to be denied on the basis that it is not an appropriate land use in the A-1 District, then the Land Use Planning and Zoning Committee is essentially creating a moratorium by proxy on new mineral extraction operations.

The development of local aggregate sources is essential to the success of both the Comprehensive Plan of Green Lake County and the Farmland Preservation Plan of Green Lake County. Tourism, residents, and industry all require functioning infrastructure and safe, adequately constructed roadways. Aggregates are literally the building block of these. Aggregates also lay the foundation for modern agricultural enterprise. If farming is going to continue to grow and prosper in Green Lake County, it will do this through updating and innovating. Developing local aggregate sources will help make this a certainty.

The existing mineral extraction sites in Green Lake County conform to the zoning ordinances that govern their permits. The operations also adhere to an extremely long list of regulations and legislation placed on them by the government entities that oversee them, as shown in Figure 6. The track record of mining in Green Lake County is substantial evidence that mineral extraction operations conform to the standards and requirements of the Green Lake County zoning ordinance.

Figure 6.



Note. Infographic from *Quarry Regulatory Control and Permitting* Krumenacher, 2021.

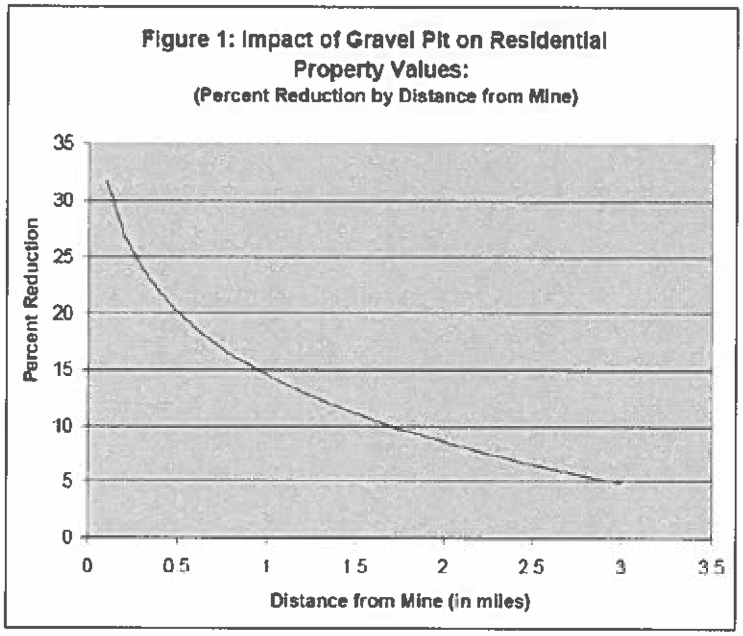
Mining & Property Devaluation

The claim that mining will have a negative effect on property values in the area surrounding a mine has become a common tactic that opposition groups use to bolster their argument that a proposed mineral extraction site does not meet the standards and requirements set forth in zoning ordinances for granting conditional use permits.

The Magic Curve

The claims of negative property value impacts almost universally rely on an unconventional regression model found in a short eight page working paper drafted by Diane Hite in 2006. The model in Hite's paper was originally created to calculate the negative property value impact of environmental disamenities, specifically sanitary landfills, on surrounding properties. In 2006 George Erickcek of the W.E. Upjohn Institute drafted a report in which he applied Hite's "model" to a proposed mining operation in Kalamazoo County Michigan. These documents are often called the "Hite Study" or "Erickcek Study", however these are not studies, they are non-peer-reviewed working papers that rely on an unproven theoretical model. Erickcek claims that upon commencement of mining surrounding properties will suffer an immediate loss in value based on proximity to the mine, and then appreciate at the same rate as properties not near the operation. Erickcek's paper contains the curve in Figure 7 which compares proximity to the mine to the assumed percent reduction in property value that would occur and appears to be a version of Hite's curve from her paper shown in Figure 8. The curve in Figure 7 is also almost universally shown in every report claiming a direct relationship between proximity and property value.

Figure 7.



Note. Curve from Erickcek, 2006.

Figure 8.

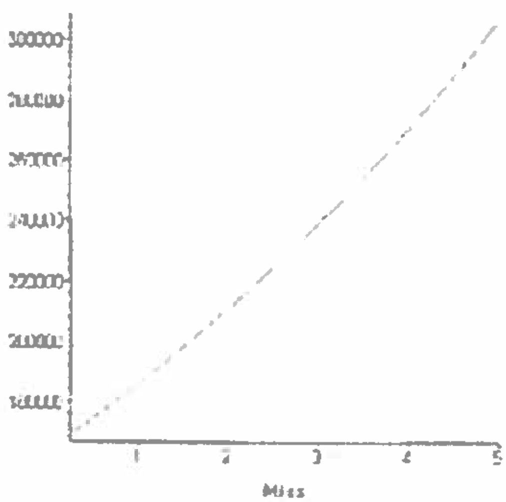


Figure 1: Predicted Price as Function of Distance from Gravel Pit

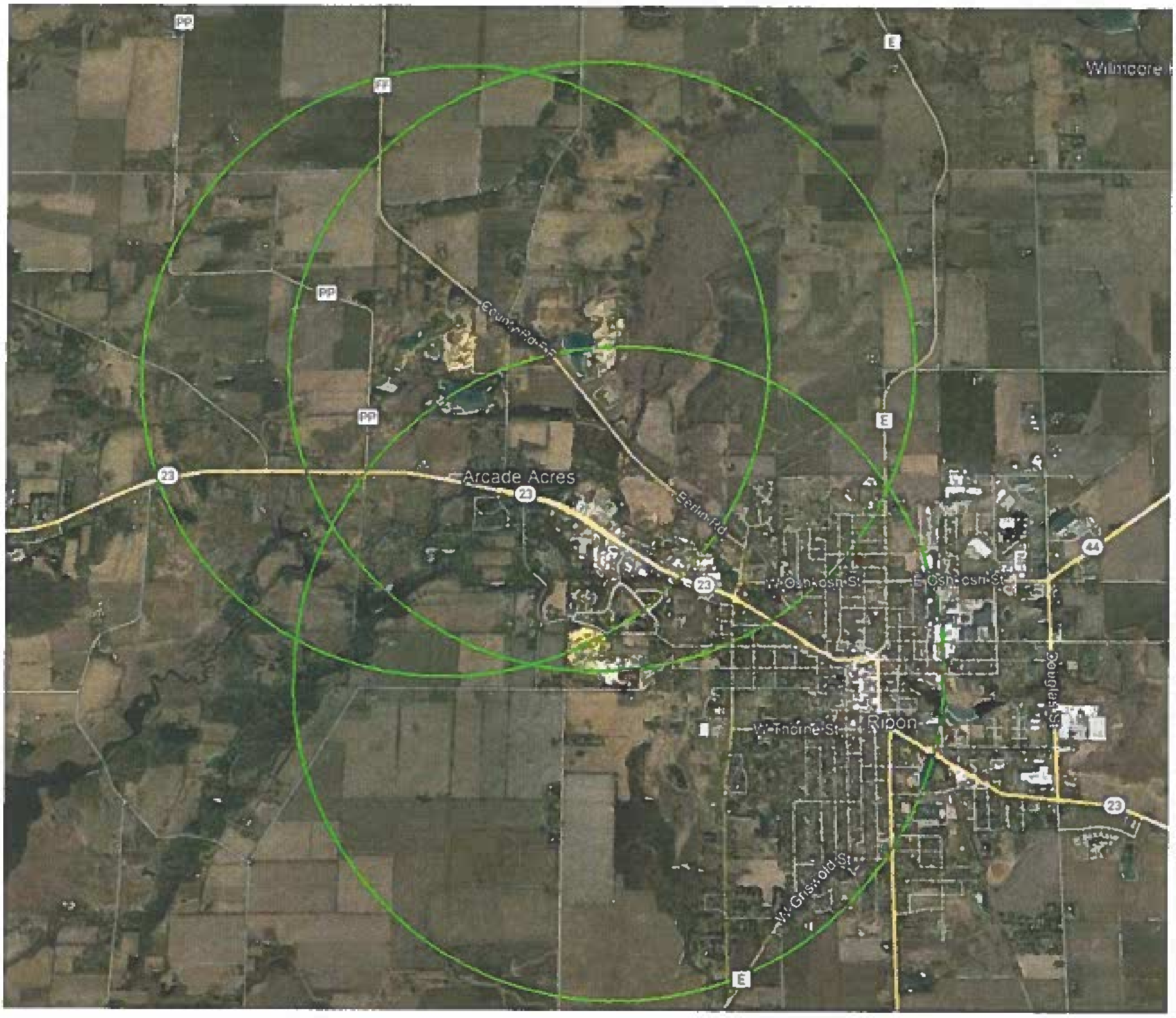
Note. Curve from Hite, 2006.

Erickcek's paper has been disproven by multiple firms including The Great Lakes Appraisal Company, Econsult Solutions, Inc., and The Phoenix Center for Advanced Legal and Economic Public Policy Studies. The Great Lakes Appraisal Company found Erickcek's work to be "unprofessional at best and likely misleading and reckless". The Phoenix Center tried to reproduce Hite's theory in 2018 and was unable to replicate the negative impact. They found some instances where the opposite was true, property values were lower at greater distances from the mine, not higher, and conclude that no negative property value impact is occurring. Studies exist from the pre-Hite/Erickcek era as well that find no negative impact on property values from neighboring mining operations. In 1981 the U.S. Bureau of Mines published a study titled *Social, Economic, and Legal Consequences of Blasting in Strip Mines and Quarries* which found no tie between properly developed mines and property values. In 1987 Joseph Rabianski and Neil Carn of the Department of Real Estate at Georgia State University found no significant impact from mining on property values, Anne Dorrian and Clifford Cook of the Department of Economics at Ohio Wesleyan University came to the same conclusion in 1996.

A Local Perspective

The lack of negative impact on property values from mining can be seen right across the eastern Green Lake County line in the City of Ripon. Ripon has one active mine within its city limits and two active mines operating northwest of the city. Additionally, the two sites outside of the city have or have had asphalt production plants staged at them. This puts most of the homes in Ripon within one- and one-half miles of at least one mine, with some being inside the radius of two or all three. The green circles in Figure 9 illustrate a one- and one-half mile radius from the center of each of the three mines.

Figure 9.



Note. Image from Google Earth, 2023.

The situation, or more accurately lack thereof, in Ripon can be seen through a laymen's eyes without magical curves or studies from various academic institutions. Using the website Zillow.com, data from recent property sales can be easily retrieved as well as comparable sales, time on market, and previous sales of the property. The spreadsheet in Figure 10 shows sales data from thirty-three homes in the Ripon area with proximity to the nearest mine ranging from four hundred seventy-five feet to just over two miles.

Figure 10.

ADDRESS	BEDROOMS	BATHROOMS	SQUARE FT.	SOLD FOR	DAYS ON MARKET	$/SQ. FT.	PROXIMITY/MI
825 WINDSOR CT.	4	4	4,019	$ 475,000.00	43	$ 118.19	0.82
242 MORAINE DR.	4	3.1	3,735	$ 545,000.00	41	$ 145.92	0.138
845 WINDSOR RD.	4	3	3,168	$ 449,000.00	62	$ 141.73	0.73
148 STONEY RIDGE RD.	3	2.1	3,071	$ 385,000.00	55	$ 125.37	0.09
220 N DOUGLAS ST.	4	3	2,989	$ 260,000.00	72	$ 86.99	1.82
N7883 ANGLE RD.	4	3	2,588	$ 285,000.00	?	$ 110.12	2.03
1017 EUREKA ST.	3	2.2	2,484	$ 309,500.00	79	$ 124.60	1.29
1034 NEWBURY ST	4	3	2,472	$ 295,000.00	63	$ 119.34	1.34
N7860 ANGLE RD.	3	2	2,460	$ 293,000.00	12	$ 119.11	2.06
W14173 PLANTE DR.	2	2	2,361	$ 290,000.00	171	$ 122.83	0.4
694 KENSINGTON DR.	4	3	2,350	$ 300,000.00	29	$ 127.66	0.73
W13879 SKYLINE CIR.	3	2	2,104	$ 320,000.00	20	$ 152.09	1.06
W13861 SKYLINE CIR.	3	3	2,036	$ 270,000.00	191	$ 132.61	1.04
768 S DOUGLAS ST.	4	2	1,890	$ 181,000.00	43	$ 95.77	1.98
731 CHESTER CT.	3	2	1,874	$ 360,000.00	?	$ 192.10	0.73
510 HOPE AVE.	4	2	1,762	$ 220,000.00	37	$ 124.86	1.59
N8615 ARCADE GLEN RD.	3	1	1,738	$ 184,900.00	56	$ 106.39	0.55
609 CAMBRIDGE DR.	3	2.5	1,650	$ 324,500.00	?	$ 196.67	0.84
N9005 S KORO RD.	3	2	1,600	$ 289,900.00	60	$ 181.19	0.19
412 ARDMORE AVE.	3	3	1,560	$ 205,000.00	?	$ 131.41	1.53
413 SANDMAR DR.	3	2	1,500	$ 275,000.00	378	$ 183.33	1.63
742 SUNRISE DR.	2	3	1,482	$ 265,000.00	?	$ 178.81	1.87
201 STONE HILL CT.	3	2	1,481	$ 389,000.00	?	$ 262.66	0.1
526 ARDMOORE AVE	3	2	1,470	$ 235,000.00	50	$ 159.86	1.65
W14256 HIGHLAND TER.	3	1	1,461	$ 185,500.00	?	$ 126.97	0.47
629 HARVEY ST.	3	2	1,368	$ 255,000.00	31	$ 186.40	1.71
632 SUNRISE DR.	3	2	1,350	$ 233,000.00	51	$ 172.59	1.85
N8610 ARCADE GLEN RD.	3	2	1,300	$ 150,000.00	52	$ 115.38	0.55
N8623 COMORN RD.	3	1	1,288	$ 185,000.00	46	$ 143.63	0.46
N8605 ARCADE GLEN RD.	3	2	1,152	$ 185,000.00	?	$ 160.59	0.55
W13252 SCANDI ST.	3	1	1,100	$ 181,000.00	49	$ 164.55	2.1
W14247 GINGER ST.	3	1	936	$ 140,000.00	?	$ 149.57	0.52
W14347 BROOKWOOD CT.	2	1	800	$ 147,683.00	23	$ 184.60	0.55

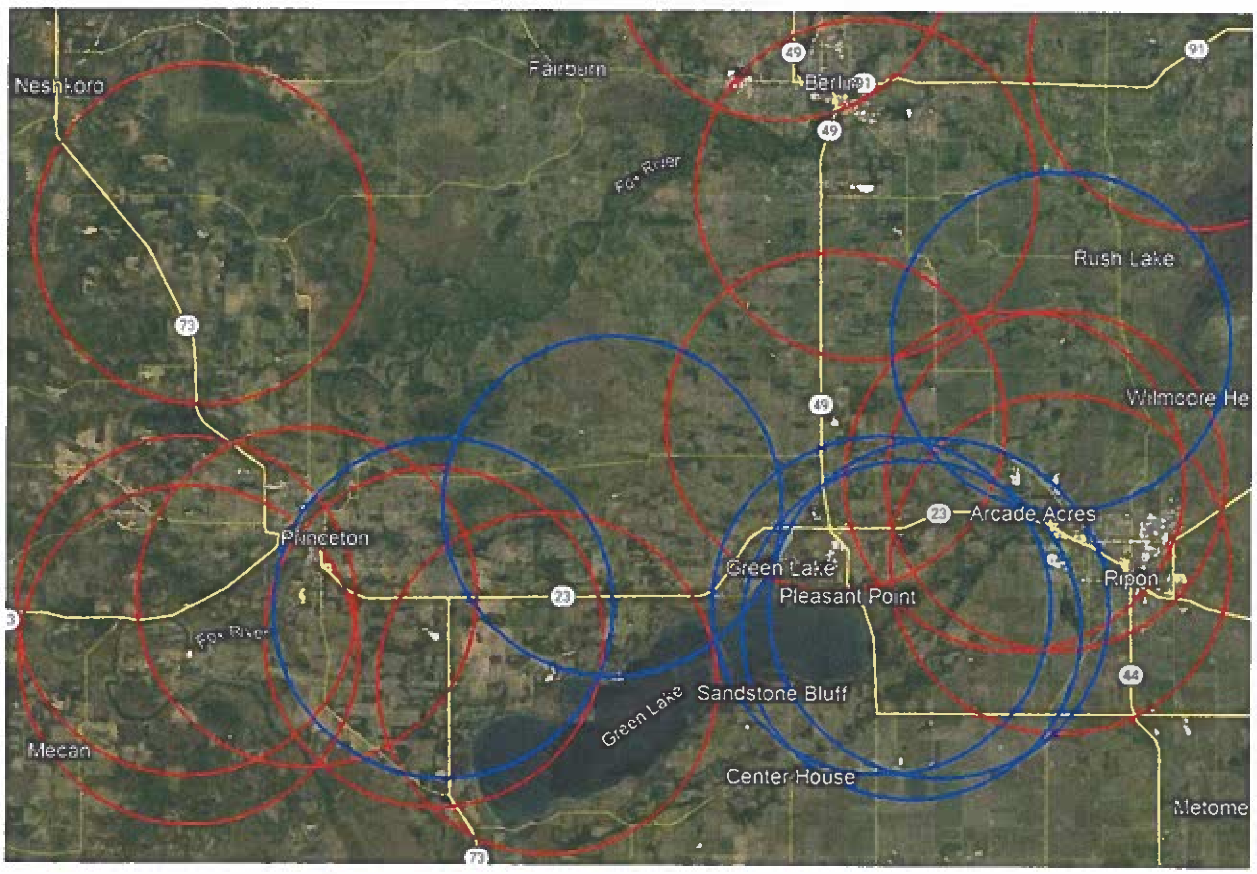
Note. Data in spreadsheet from Zillow.com

The data does not show any disparities in sales prices for homes closer to a mining operation. Of the homes which data on days on market were available for, only three spent more than ninety days on the market, of the three homes, the home farthest away from a mine spent the longest time on the market. There is no significant impact on property value due to proximity to mining operations occurring in the City of Ripon. Homes in Ripon are selling for what the local market will bear and two pits and a quarry have nothing to do with it.

A Regional View

If the curve in Figure 7 was correct, the City of Ripon would not be the only municipality dealing with devalued property. The problem would be apparent all the way around Big Green Lake, west through the City of Princeton and north through the City of Berlin as well. The image in Figure 11 shows a three-mile radius around active mineral extraction sites in red and reclaimed or inactive sites in blue.

Figure 11.



Note. Image from Google Earth, 2023.

There is no mining induced disparity in values for the properties inside the radii shown in Figure 11. It also begs the question that if the Erickcek model calculates the effect of opening one mine on property values, would properties within three miles of several mines endure a five to thirty-five percent loss for each mine? If this were true, it would be a major crisis across the entire region and the issue would be at the forefront of public policy decision making in Green Lake and Fond du Lac Counties.

Conclusions on Property Values

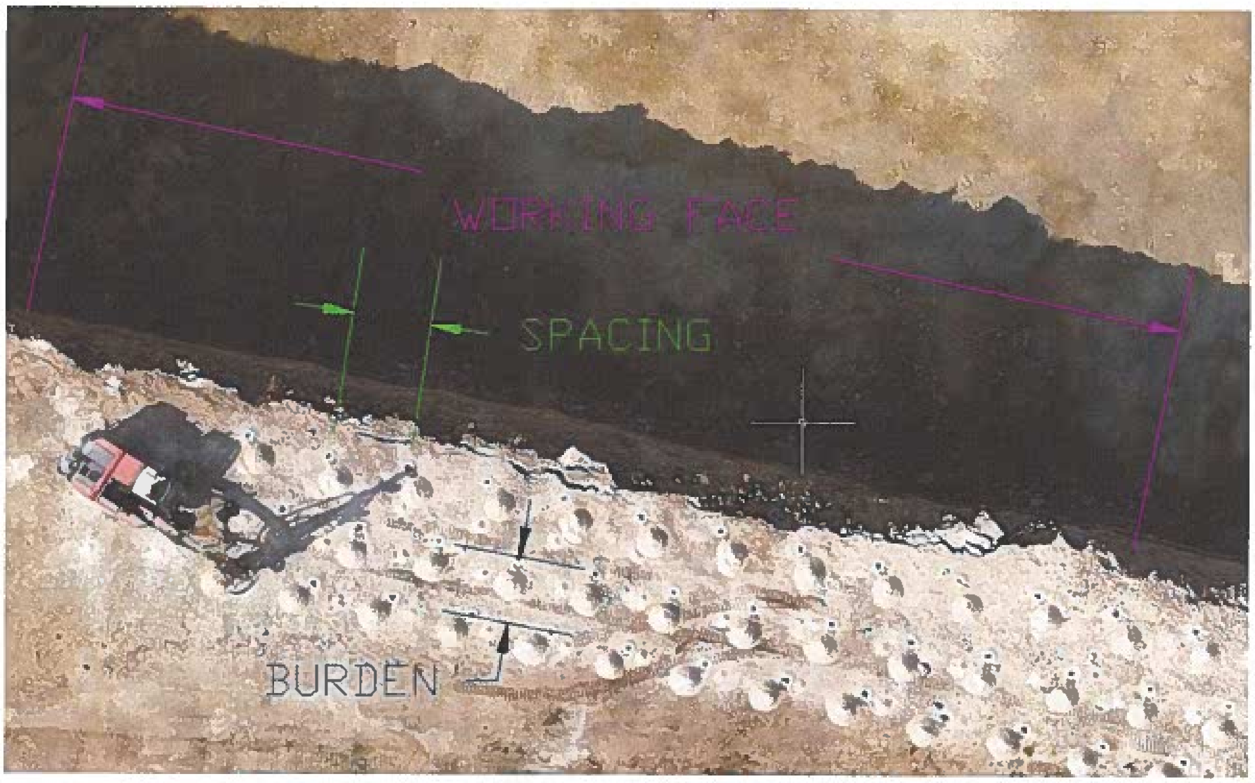
Owning property is one of the most significant investments the average person can make, so it is understandable that protecting the value of that property would be of the utmost importance. Concerns over a new mineral extraction site having a negative impact on neighboring property values have been brought up during the permitting process of many proposed sites. While the questions this concern brings are honest ones, the "go to" answer that those opposed to mining always lead with is not an honest answer. The Erickcek devaluation model is a poorly conceived work of fiction which continues to gain traction from being repeatedly claimed as fact. The model's misuse by real estate appraisal firms looking to make an easy dollar by drafting valuation reports to be used as propaganda by anti-mining groups is becoming more and more common and is extremely dishonest and even dangerous. These reports further the disconnect between the mining industry and the communities they serve and operate in.

A working knowledge of statistics and advanced mathematics is not needed to see that properties near active mineral extraction operations in Green Lake County and the surrounding area are not experiencing a loss in value due to mining. These homes are being sold for fair prices which are based on the size, age, and condition of the property and not how near or far they are from a mining operation.

Blasting

Blasting is the first stage of processing the rock at a quarry. An air-rotary drill is used to drill holes in the rock along and into the working face of the quarry. The holes are spaced apart at pre-determined distances known as burden and spacing as shown in Figure 12.

Figure 12.



The holes are drilled to depths based on the height of the working face to provide uniform fragmentation at the working level on the floor of the quarry. Some quarries have smooth uniform seams in the stone at the working level which determine the drilling depth, such as the quarry floor shown in Figure 13, note the dark circles on the floor that form a grid pattern, these are marks from the drill at the bottom of the hole that become visible when the floor gets wet. Some quarries do not have smooth uniform seams at the working level and require what is known as sub-drilling. Sub-drilling is drilling the holes to a depth below the working level, usually two feet below it, so that the floor can be built up with gravel and finer material from the blast to produce a smooth working surface and facilitate drainage away from the working area like the quarry floor in Figure 14.

Figure 13.

Figure 14.

Once the holes are drilled, the blasting crew fills them with a measured amount of blasting agent and detonation materials, and then top the hole off with stemming material (crushed stone or drill cuttings) to the depth determined in the design of the blast. Stemming material is used to confine the explosion inside the hole to prevent "fly-rock". The holes are linked together and electronically detonated. One blast in a quarry is actually a series of small explosions with millisecond delays between them. This allows for reduced vibration and air blast while still efficiently breaking up the rock for further processing. The delays also allow control over the direction of the blast so that it can be sent out into the quarry instead of up into the air or back into the solid face of the highwall, both of which could cause potentially dangerous situations. The images in Figure 15 illustrate the delays, duration, and direction of a blast at the Upper Mashuda Quarry in Green Lake County.

Figure 15.

Pre-Blast

Start of Blast

Note. There were some high spots of rock on the floor that were also blasted in this session.

0.51 Seconds into Blast

0.84 Seconds into Blast

1.35 Seconds into Blast

2.03 Seconds into Blast

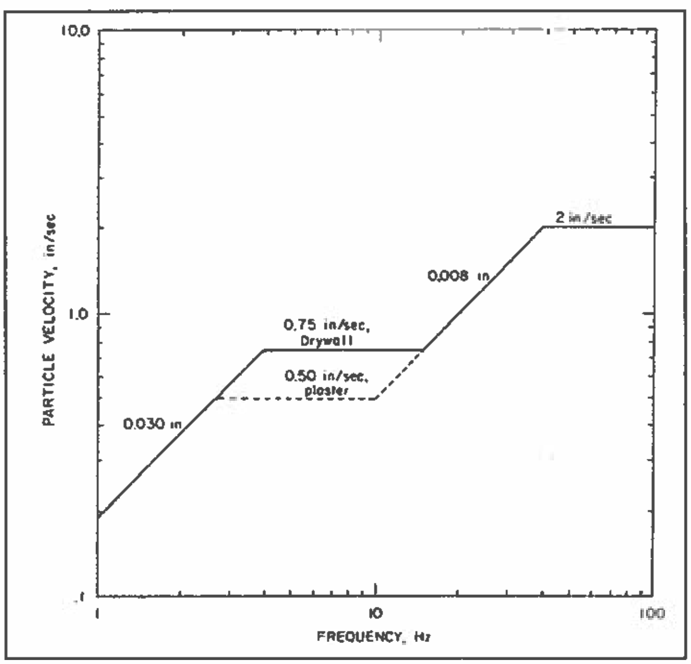
Note. The last hole has detonated by this point.

3.21 Seconds into Blast

Blast Design

The modern quarry blast is a highly engineered process, with multiple factors to consider with each blast design. The closest structure to the blast dictates the airblast and ground vibration limits for each blast and because of this, the amount of explosive energy that can be used. Airblast is the air overpressure from an explosion and is measured in decibels. This is not the same decibel scale used to measure the intensity of audible noise (dBA), it is a linear logarithmic measurement (dB(L)) used to measure the ratio between normal atmospheric pressure and the increased air pressure from the blast. Airblast generally isn't audible as it is at frequencies below what humans can hear. Ground vibration is just that, vibration through the ground, which is measured in inches per second and frequency in hertz. Chapter SPS 307.44 of the Wisconsin Administrative Code sets the limit for airblast for surrounding structures at one hundred thirty-three decibels and uses what is commonly known as the "Z-Curve" which was developed by the U.S. Bureau of Mines, shown in Figure 16 to set the limit on ground vibration.

Figure 16.



Studies by the U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement have determined that risk of damage from airblast does not occur until approximately one hundred forty decibels. Studies on ground vibration by the U.S. Bureau of Mines concluded that if peak particle velocities are under the limits set forth in the "Z-Curve" no damage to structures will occur. Other factors that are included in engineering a blast include the density of the rock, height of the working face, the volume of rock to be blasted, atmospheric conditions, and the preferred sizing of the blasted rock. These parameters are all used to formulate a blast that is first and foremost under the allowable airblast and vibration limits, but also efficiently break the rock. The blasters perform pre-blast surveys of the working face of the quarry to determine minimum burdens and spacing as shown in Figures 17 and 18, as well as using data from previous blasts at the site and similar sites.

Figure 17.

Overview

Site name:
Bench name:
Blast name:
Recording date: 8/16/2023 12:16 PM
3D Model: Mashuda_#3-2023poly.jm3
Blast Site: Mashuda_#3-2023polyholes_FINAL.sm

Blast Site geometry

Face Plane dip direction:	11.0 °	Min bench height:	54.33 ft
Face Plane dip angle:	84.6 °	Mean bench height:	59.44 ft
Floor Plane elevation:	807.0 ft	Max bench height:	61.64 ft
Floor Plane dip direction:	n.a.	Distance (Delimiters):	482.11 ft
Floor Plane dip angle:	0.0 °	Distance (delimiting planes):	658.94 ft

Design parameters

Burden:	10.0 ft	Borehole inclination:	0.0 °
Number of rows:	1	Borehole subdrilling:	2.0 ft
Row distance:	8.20 ft	Side spacing:	9.84 ft
Row shift:	0.0 ft	Rock density:	0.0 tn. sh./cu. yd

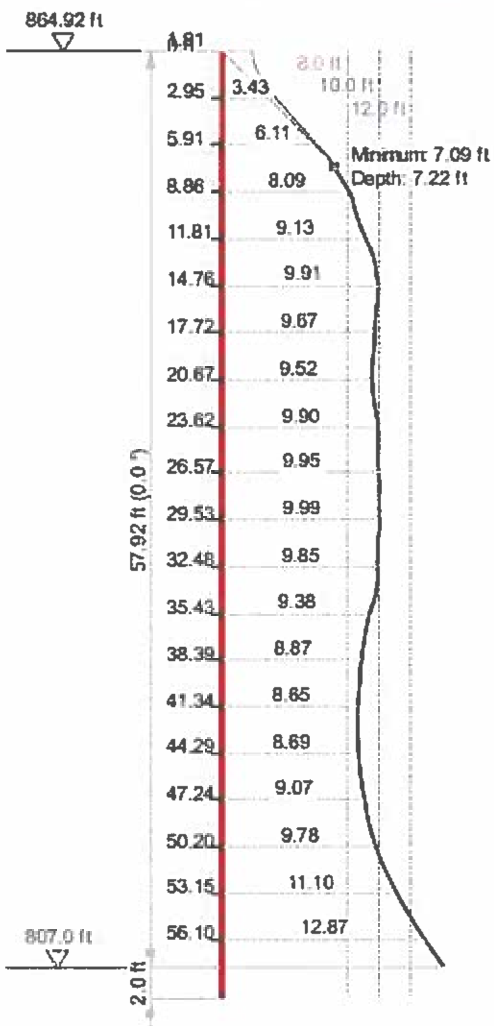
Drill Pattern analysis

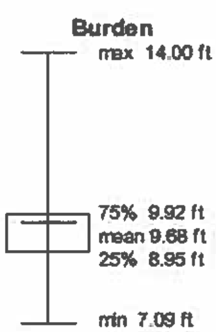
Number of rows:	3	Min subdrilling:	2.0 ft
Number of boreholes:	165	Mean subdrilling:	2.0 ft
Min side spacing:	7.6 ft	Max subdrilling:	2.0 ft
Mean side spacing:	10.9 ft	Total drilling length:	10166.62 ft
Max side spacing:	12.6 ft		
Min inclination:	0.0 °		
Mean inclination:	0.0 °		
Max inclination:	0.0 °		

Note. Image shows data for blast design from the blast in Figure 15.

Figure 18.

2 (Scale 1:130) Minimum Burden





Inclination: 0.00 °
Length: 59.92 ft
Diameter: 3.94 in
Area: 1191.0 sq. ft (of profile)
Position: u: -38.30 ft, v: 0.07 ft
E: 2210946.60 ft
N: 666216.12 ft
H: 864.92 ft
Subdrilling: 2 ft

Depth [ft]	Min. burden [ft]
0.0	0.000
3.3	3.276
6.6	6.553
9.8	8.406
13.1	9.638
16.4	9.765
19.7	9.534
23.0	9.820
26.2	9.937
29.5	9.986
32.8	9.849
36.1	9.218
39.4	8.783
42.7	8.628
45.9	8.850
49.2	9.479
52.5	10.765
55.8	12.654
59.1	-3.281

Note. Image shows data for hole number 2 of 165 for the blast shown in Figure 15.

The blast engineers use what is known as the scaled distance equation which calculates the weight of explosives that can be detonated in one eight millisecond window and keep the ground vibration under the safety limits at the surrounding structures. The modern quarry blast is a highly engineered process that is created through the use of many scientific, mathematic, and geologic principles as well as on the ground experience.

Safety & Environmental Precautions

Safety and environmental concerns about blasting are commonly brought up during the permitting phase of a new mineral extraction site. These concerns are generally brought by a lack of understanding of the process. Blasting at a quarry is one of the most safety-centric parts of the aggregate production process.

During a blasting session the blasters are responsible for the safety of every person at the mine as well as those in the immediate area surrounding the mine. Every part of the process is measured and monitored. Before the blast is detonated the blasters make sure that everyone on site is accounted for and is in the designated safety area before the blast occurs. The blasters also secure a safe perimeter around the site to ensure that no one inadvertently enters the blast area. An audible warning is sounded before the blast is detonated, and no one is allowed to enter the site after the blast until the blaster in charge assesses the blast and clears the site for re-entry.

Seismographs are deployed at structures near the site to record the real-time ground vibration and airblast to ensure compliance with the safety limits. The report in Figure 19 shows the seismograph data from the nearest structure for the blast at the Upper Mashuda Quarry in Green Lake County shown in Figure 15.

Figure 19.

Instantel

Event Report

Date/Time	Tran at 12:30:58 August 30, 2023
Trigger Source	Geo: 0.030 in/s, Mic: 130.0 dB(L)
Range	Geo: 10.000 in/s
Record Time	3.0 sec at 1024 sps
Job Number:	1

Serial Number	BA11290 V 10.72-8.17 BlastMate III
Battery Level	6.3 Volts
Unit Calibration	August 11, 2023 by Instantel
File Name	M290K6D4.3M0

Notes

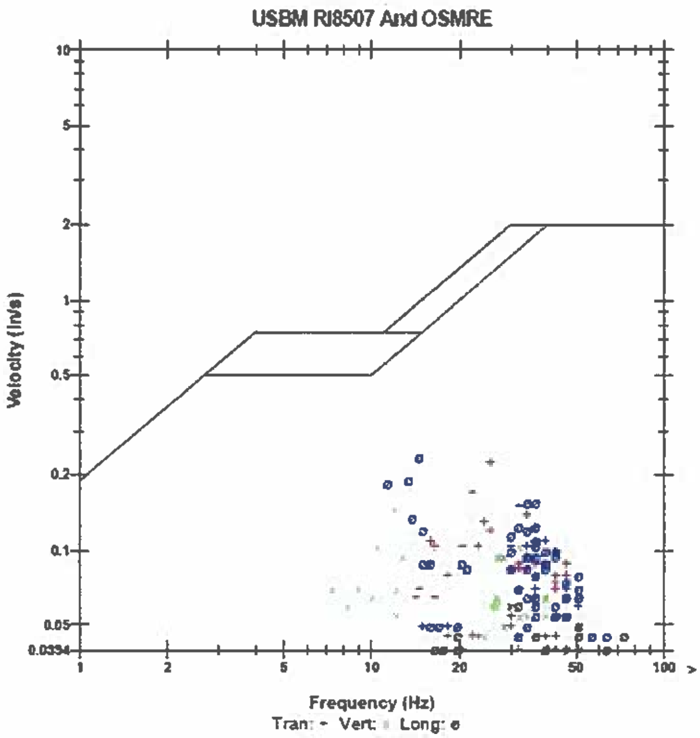
Client:	Kopplin & Kinas
Location:	Mashuda
Seis Location:	Farmhouse
User:	Mike

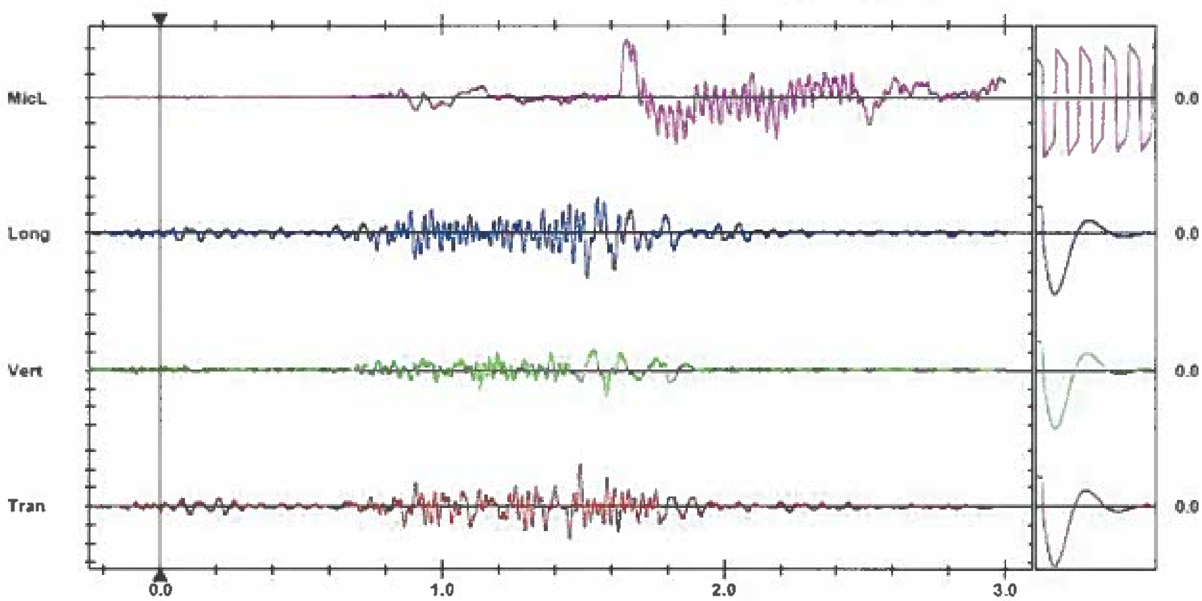
Extended Notes
Clear 66 N 10

Microphone	Linear Weighting
PSPL	124.1 dB(L) at 1.655 sec
ZC Freq	6.4 Hz
Channel Test	Passed (Freq = 20.1 Hz Amp = 573 mv)

	Tran	Vert	Long	
PPV	0.225	0.145	0.235	in/s
ZC Freq	26	12	15	Hz
Time (Rel. to Trig)	1.490	1.582	1.517	sec
Peak Acceleration	0.106	0.053	0.106	g
Peak Displacement	0.001	0.002	0.002	in
Sensor Check	Passed	Passed	Passed	
Frequency	7.8	7.6	7.3	Hz
Overswing Ratio	3.7	3.5	4.7	

Peak Vector Sum 0.240 in/s at 1.517 sec





Time Scale: 0.20 sec/div Amplitude Scale: Geo: 0.100 in/s/div Mic: 0.002 psi(L)/div
Trigger =

Sensor Check

Printed: August 30, 2023 (V 10.74)

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The seismograph data in Figure 19 shows that the peak particle velocities (PPV), measured in inches per second, are below the regulatory limit as well as the peak airblast shown as PSPL measured in dB(L). Just over eighty-thousand tons of rock were blasted in this session and zero damage occurred to surrounding properties or mine property. The ability to blast large quantities of rock in a single session makes blasting an intermittent occurrence. On an average year most rock quarries in Green Lake County will only blast two or three times a year, with blasts that are complete within several seconds, causing no damage to neighboring properties.

The compounds used for blasting are another common concern that is brought up in the discussion about blasting. A popular misconception is that quarries use dynamite to blast the rock, they do not. The modern quarry generally uses ANFO (ammonium-nitrate/fuel-oil) based compounds to blast the rock. ANFO based explosives are far less hazardous and more cost effective for quarry blasting than dynamite. ANFO based emulsions are normally used for quarry blasting in Green Lake County. Emulsions are viscous waterproof compounds which prevent the degradation and leaching of the product if it comes in contact with water. This ensures that the compound remains in the drill-hole and is converted into gas upon detonation which expands and breaks the rock. Emulsions allow for the use of less explosives to blast more rock at a lower energy than straight ANFO products.

Conclusions on Blasting

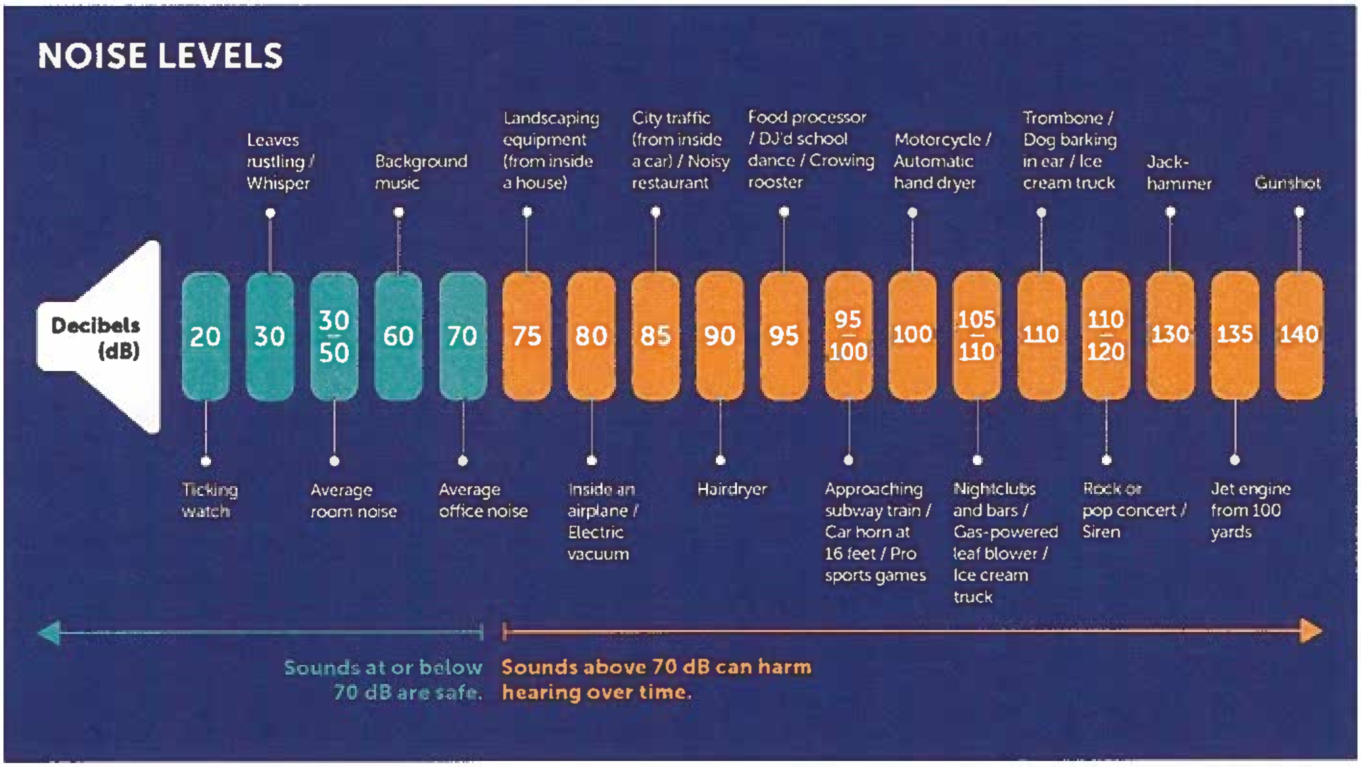
Blasting at a mineral extraction site is a technical, engineered process. Blasters utilize advanced technologies to ensure that it is performed in a safe, highly controlled manner. The methods and products used keep vibration and airblast at safe levels and prevent nitrates from leaching to groundwater. Blasting is performed at every active quarry in Green Lake County and is done so without damaging surrounding properties or contaminating groundwater.

Noise

The mineral extraction sites in Green Lake County all utilize mechanical processes that produce various sounds and at varying levels. Most of the sites process mined materials on an intermittent basis, except for the industrial sand sites, which for the most part, operate continuously. All the active stone quarries in Green Lake County drill, blast, and process stone on an intermittent basis which is determined by the demand for aggregate. Most of the quarries have daily dump truck traffic hauling out of the sites and delivering aggregates to customers. The amount of truck traffic varies from site to site and can range anywhere from several trucks per day to several trucks per hour. All these activities generate varying levels of sound. The intensity of sound outside of an extraction site is generally controlled by placing screening berms around the property which are extremely effective at dampening the sounds generated during operation. As the extraction area is increased in size, the processing equipment is set-up below grade on the floor of the quarry adding another layer to dampen the sound. Processing equipment is generally set up in between the working face of the mine and the stockpiles of processed products, which also contributes to sound reduction.

Sound functions similarly to ground vibration and airblast in that it lessens in intensity and dissipates with distance from the source. Sound, as it relates to human hearing capability, is measured in decibels on a weighted scale (dBA). Zero dBA is the bottom threshold of human hearing and one-hundred thirty dBA is the threshold for pain. The chart in Figure 20 shows examples of sounds at various intensities in decibels.

Figure 20.



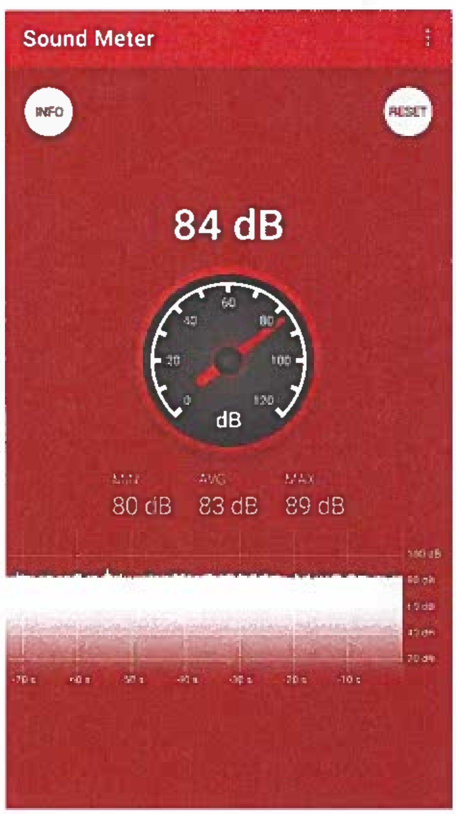
Note. Infographic from Hearing Health Foundation, Online.

Sound level readings were taken at two Kopplin & Kinas Co., Inc. mineral extraction sites during processing operations in July of 2023. The first site is the Morris Quarry which is located at STH 49 and McConnell Road in the Town of Brooklyn. The aerial photo in Figure 21 shows the locations of the sound level readings taken.

Figure 21.

Reading #1 is shown in Figure 22 and was taken on the quarry floor approximately one-hundred feet from the processing equipment.

Figure 22.

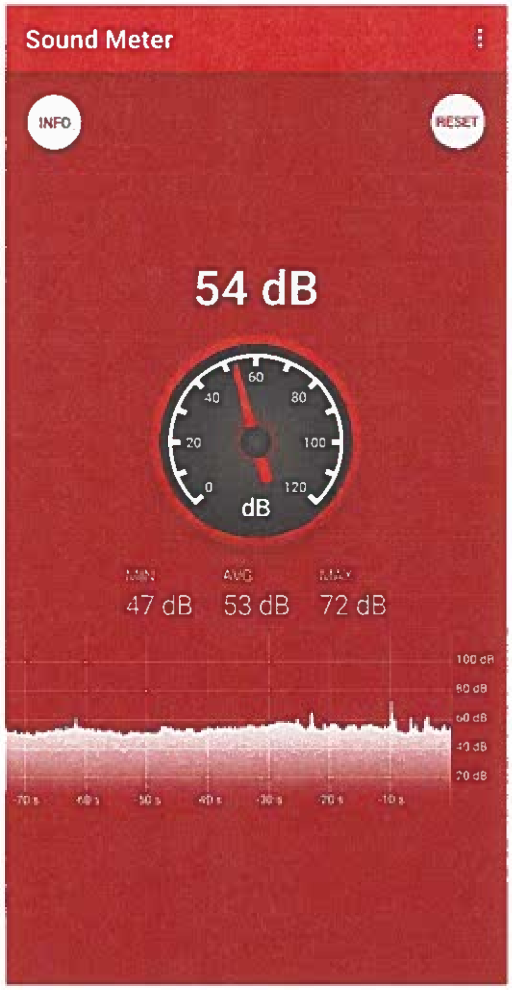


Reading #2 is shown in Figure 23 and was taken in between the highwall and the safety berm approximately two-hundred fifty feet from the processing equipment.

Figure 23.

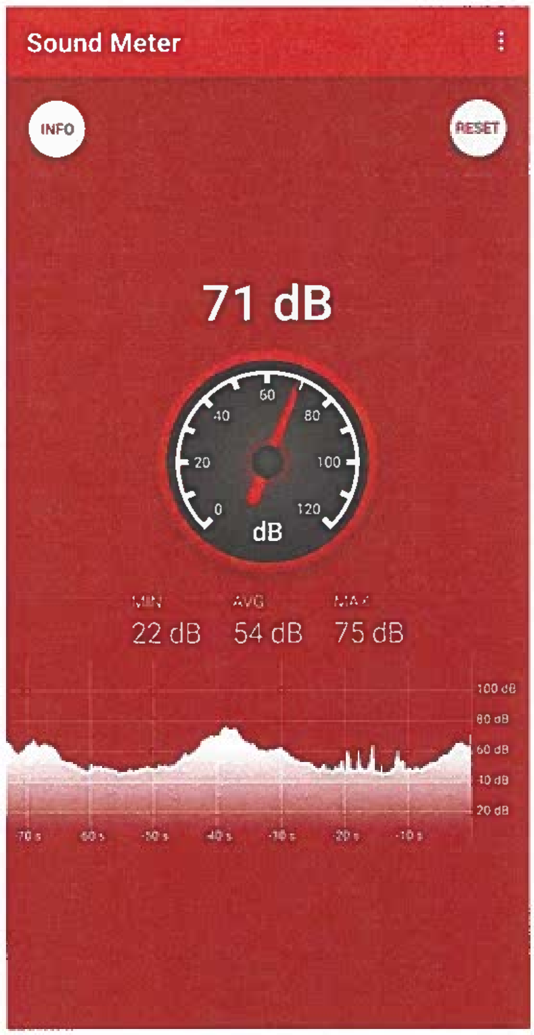
Reading #3 is shown in Figure #24 and was taken in between the safety berm and the exterior screening berm, approximately eight-hundred twenty-five feet from the processing equipment.

Figure 24.



Reading #4 is shown in Figure 25 and was taken outside the exterior screening berm along STH 49, approximately one-thousand one-hundred twenty-five feet from the processing equipment.

Figure 25.



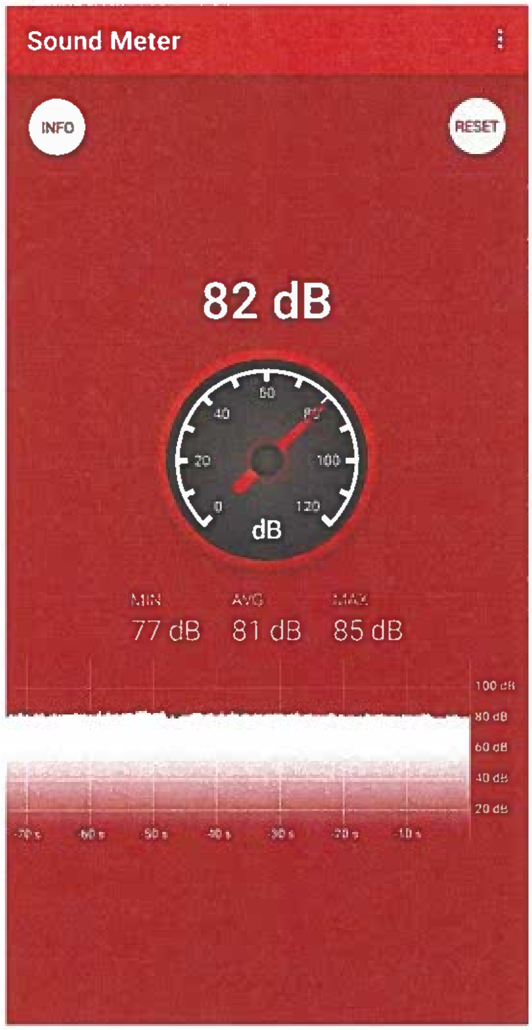
Readings #1 and #2 show similar results as would be expected. The time lapse graphs on readings #1 and #2 show steady high intensity sound readings with a reduction in the average decibel reading by three decibels at reading #2 due purely to the sound traveling over a distance and slightly losing intensity. Reading #3 shows a drastic reduction in the average sound level by twenty-seven decibels from reading #2. The reduction is caused by both the distance from the sound source and sound dampening from the eight-foot-tall safety berm along the top of the highwall. The time lapse graph on reading #3 shows a fairly steady, low intensity reading at this location which is a mixture of ambient sound and the sound of the processing equipment and is at an average of fifty-three decibels. Comparing this average to the sound level examples shown in Figure 20, the sound level falls in between average room noise and background music, normal conversation averages at sixty decibels for another level of reference. The peaks on the graph are from traffic on STH 49 and several birds that chirped during the reading. Reading #4 shows similar average and maximum levels to reading #3. The graph, however, does not show a steady readout, it rolls up and down due to traffic on STH 49 and the small peaks are from birds chirping once again during the reading. The twenty-foot-tall screening berm at this location provides enough sound dampening that extreme focus was necessary to discern the processing equipment sound from the ambient sound of the area.

The second site where sound level readings were taken is the Upper Mashuda Quarry on STH 73 in the Town of Princeton. The aerial photo in Figure 26 shows the locations of the sound level readings taken.

Figure 26.

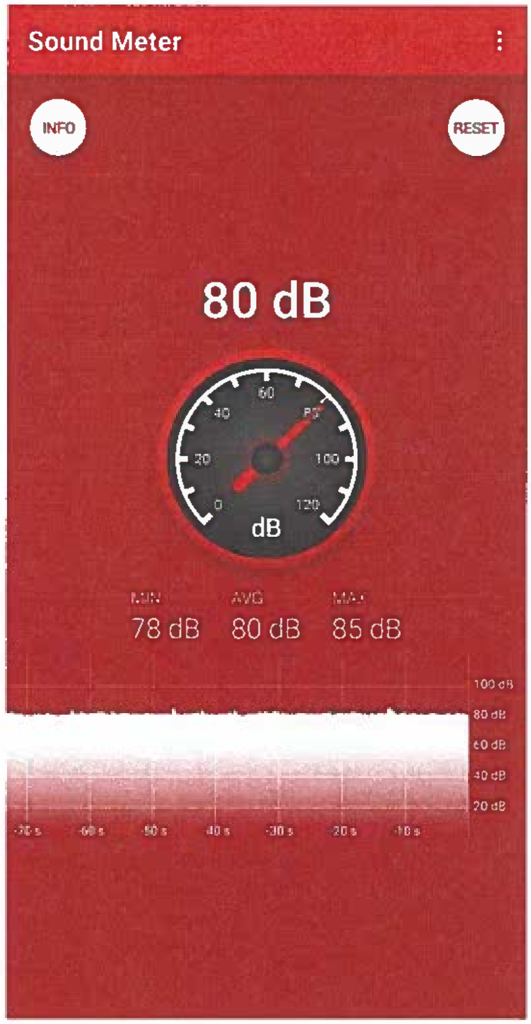
Reading #1 is shown in Figure 27 and was taken on the quarry floor approximately one-hundred feet from the processing equipment.

Figure 27.



Reading #2 is shown in Figure 28 and was taken in between the highwall and the safety berm approximately four-hundred seventy-five feet from the processing equipment.

Figure 28.



Reading #3 is shown in Figure 29 and was taken outside the safety berm in the hay field, approximately eight-hundred seventy-five feet from the processing equipment.

Figure 29.

Reading #4 is shown in Figure 30 and was taken along STH 73, approximately one-thousand three-hundred seventy-five feet from the processing equipment.

Figure 30.

Once again readings #1 and #2 are very similar with only a one decibel reduction in the average reading from reading #1 to reading #2. Both time lapse graphs also show steady high intensity sound. Reading #3 shows a twenty-decibel reduction with an average sound level of sixty decibels, and the time lapse graph showing steady low intensity sound. At the reading #3 location a high level of focus was required to discern between sounds from processing equipment and the ambient sounds of the area. Reading #4 was taken along STH 73 on the highway side of the hill that is utilized for screening in leu of a man-made berm. The hill crests approximately ten feet higher than the base of the safety berm that runs along the highwall. The results of reading #4 are extremely similar to reading #4 from the Morris Quarry. Traffic on STH 73 created all of the high intensity sound readouts, and it was not possible to discern between the ambient sounds of the area and the sounds of mineral processing at the quarry.

Screening berms and natural topography are an effective measure to mitigate the sounds of a mineral extraction operation. All of the non-metallic mineral extraction sites in Green Lake County utilize some form of screening to serve this purpose and others. Wind, temperature, and atmospheric conditions all affect how far and what direction sound will travel, but proper mine development with screening prevents the sounds emitted from an extraction site from becoming a nuisance.

Dust

Almost all ground engaging activities are capable of producing dust. Earthmoving, road construction, agriculture, and driving vehicles on unpaved roads or driveways all have a high probability of generating dust, as do non-metallic mineral extraction operations.

Dust Control

Dust can be generated by a mineral extraction operation by many of the different processes used at the site. Removal of overburden, drilling, blasting, crushing, screening, conveying, loading, and transporting products will all generate dust if control measures are not taken. Dust is controlled in several ways; the most common and effective way is through the application of water to the source of the dust. Water is applied to the travel-ways of the extraction site by water trucks and the discharge points of processing equipment can be outfitted with spray nozzles to knock down dust generated during processing. Product drop heights from conveyors are kept at minimal distances to keep dust down at transfer points. Screening berms and vegetation are also very effective at preventing dust from leaving the site and becoming fugitive or nuisance dust.

Dust Regulation

Dust generated by a non-metallic mineral extraction operation is regulated by both the federal and state governments to ensure a safe working environment at the site and to prevent fugitive or nuisance dust from entering surrounding properties. The Mine Safety and Health Administration (MSHA) regulates the dust at mineral extraction sites, and the Wisconsin Department of Natural Resources (WDNR) regulates dust emissions from mineral extraction sites. MSHA performs random inspections of non-metallic mineral extraction operations and conducts dust level monitoring frequently as part of their inspection. If an operation is not adequately controlling dust, MSHA will shut down the operation, order corrective action, and issue expensive citations. The WDNR enforces compliance with state air quality regulations and will also shut down and fine non-compliant operations. MSHA's dust monitoring detects the presence and amount of respirable crystalline silica in the dust as well as the amount of other respirable particles in the dust. Overexposure to respirable particles of crystalline silica can lead to the lung disease silicosis as well as lung cancer. Silica in Wisconsin comes in the form of quartz which is a commonly occurring mineral. The different minerals that are extracted in Green Lake County have varying quartz contents. The high-grade industrial sand that is extracted in southern Green Lake County is essentially pure quartz. The glacial sand which can be found in deposits around the county is made up of less than ninety-five percent quartz. The rhyolite extrusions that can be seen at Utley, Berlin, and Marquette (these are commonly misnomered as granite, rhyolite is the volcanic equivalent of granite) have a quartz content of twenty to sixty percent. The mined limestone formations in the county are dolomitic limestone and contain the least amount of quartz, ranging from less than five to ten percent quartz, and are mostly comprised of calcium carbonate and magnesium. The active non-metallic mineral extraction operations in Green Lake County all implement dust control measures to ensure the safety of their employees and to remain in compliance with government regulations. By ensuring the safety of their employees these operators are also ensuring the safety of neighbors near the site.

Water Quality

Concerns about water quality as they relate to non-metallic mineral extraction generally focus on the quality of water that will be discharged from the site. Most of the non-metallic mineral extraction sites in Green Lake County have been developed above the water table. Sites above the water table only have to manage surface water, whereas sites that are developed below the water table have to contend with both surface and ground water.

Surface Water Management

Surface water at a mineral extraction site comes in the form of stormwater and from pumped water if the site needs to mechanically dewater. The way non-metallic mineral extraction sites handle surface water puts them into one of two classifications for their required WDNR Wisconsin Pollutant Discharge Elimination System (WPDES) permit, internally or externally drained. The internally drained classification means that the site can capture and contain or infiltrate the full amount of stormwater that falls on all disturbed areas of the site from a twenty-five-year, twenty-four-hour storm event, which in Green Lake County would be approximately four and four tenths' inches to four and seven tenths' inches of rain. A site is considered externally drained if it cannot contain the twenty-five-year, twenty-four-hour rain event or if the site discharges pumped water from dewatering or process water. The WDNR requires monthly, quarterly, or annual water quality testing for the different types of discharges, as well as flow monitoring and temperature monitoring for externally drained sites. The type and frequency of monitoring is dependent upon where mine water is discharged and the results of water quality testing. Non-metallic mineral extraction operations put measures in place to prevent the in-flow of overland stormwater runoff into the extraction area because it is generally advantageous to not take on any more water than necessary. Some sites construct stormwater basins to capture and treat runoff and use the water for dust control or wash processes. The active areas of a site may also have basins or sumps to contain the stormwater that is received and reuse it in the same manner. Stormwater basins are an accepted best management practice (BMP) and are frequently prescribed by the USDA Natural Resources Conservation Service, the Wisconsin Department of Natural Resources, and the Green Lake County Land Conservation Department to control runoff flow rates and reduce sediment and nutrient loadings that are sent downstream.

Mine Water Quality Vs. Stream Water Quality

In September and October of 2023, water samples were collected and analyzed from two quarries in eastern Green Lake County and from three tributaries that flow into the east end of Big Green Lake. The samples were analyzed for the eight metals listed in the US EPA Resource Conservation and Recovery Act (RCRA 8), Nickel, Coliform, E-Coli, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrate + Nitrite, and pH. The quarry samples were pulled from the stormwater sump at the Egbert Materials Pahl Quarry on Thomas Road in the Town of Green Lake. Samples were also pulled from the stormwater sump and the closed-circuit wash pond at the Kopplin & Kinas Company's Morris Quarry on McConnell Road in the Town of Brooklyn. Two streams were sampled in the Town of Brooklyn: Silver Creek, upstream of the bridge on Spaulding Hill Road and Dakin Creek upstream of the cross-culvert on Skunk Hollow Road. One stream was sampled in the Town of Green Lake: White Creek, upstream of the bridge on Spring Grove Road. The results are shown in Figure 31.

Figure 31.

TESTS	WI DNR WATER QUALITY STANDARDS (UNITS ug/L UNLESS INDICATED OTHERWISE)	MORRIS QUARRY (PRAIRIE DU CHIEN GROUP) FLOOR STORMWATER SUMP	MORRIS QUARRY (PRAIRIE DU CHIEN GROUP) WASH PROCESS POND	EGBERT MATERIALS QUARRY (SINNIPEE GROUP) FLOOR STORMWATER SUMP
RCRA 8 METALS + NICKEL				
ARSENIC ug/L	10	1.7	1.1	1.01
BARIUM ug/L	2000	48.2	28.3	34.4
CADMIUM ug/L	5	< 2.7	< 2.7	< 0.09
CHROMIUM ug/L	100	< 2.3	< 2.3	< 3
LEAD ug/L	15	< 0.8	< 0.8	2.79 "J"
MERCURY ug/L	2	< 0.1	< 0.1	< 0.086
NICKEL ug/L	100	< 6.6	8.85 "J"	< 3.9
SELENIUM ug/L	50	< 1.1	< 1.1	< 5.7
SILVER ug/L	50	< 2.5	< 2.5	< 2.1
GENERAL				
COLIFORM mpn	N/A	276 mpn	53.7 mpn	921 mpn
E-COLI mpn	N/A	10.2 mpn	< 1 mpn	14.4 mpn
BOD mg/L	N/A	< 2 mg/L	< 2 mg/L	< 2 mg/L
COD, UNFILTERED mg/L	N/A	13.94 mg/L "J"	< 10.3 mg/L	14.0 mg/L "J"
NITRITE + NITRATE mg/L	10 mg/L	< 0.43 mg/L	1.51 mg/L	< 0.43 mg/L
pH su	N/A	7.26	7.65	7.53

Notes: "J" Flag: Analyte detected between LOD & LOQ.

TESTS	WI DNR WATER QUALITY STANDARDS (UNITS ug/L UNLESS INDICATED OTHERWISE)	SILVER CREEK (UPSTREAM FROM BRIDGE ON SPAULDING HILL RD)	WHITE CREEK (UPSTREAM FROM BRIDGE ON SPRING GROVE RD)	DAKIN CREEK (UPSTREAM FROM CULVERT CROSSING SKUNK HOLLOW RD)
RCRA 8 METALS + NICKEL				
ARSENIC ug/L	10	0.801	0.373	0.239 "J"
BARIUM ug/L	2000	57.4	67.4	55.6
CADMIUM ug/L	5	< 0.09	< 0.09	< 0.09
CHROMIUM ug/L	100	< 3	< 3	< 3
LEAD ug/L	15	4.67	4.53	4.69
MERCURY ug/L	2	< 0.086	< 0.086	< 0.086
NICKEL ug/L	100	5.58 "J"	< 3.9	< 3.9
SELENIUM ug/L	50	< 5.7	< 5.7	< 5.7
SILVER ug/L	50	< 2.1	< 2.1	< 2.1
GENERAL				
COLIFORM mpn	N/A	> 2420 mpn	770 mpn	>2420 mpn
E-COLI mpn	N/A	1990 mpn	6.20 mpn	488 mpn
BOD mg/L	N/A	< 2 mg/L	< 2 mg/L	< 2 mg/L
COD, UNFILTERED mg/L	N/A	< 10.3 mg/L	< 10.3 mg/L	< 10.3 mg/L
NITRITE + NITRATE mg/L	10 mg/L	1.82 mg/L	10.3 mg/L	9.37 mg/L
pH su	N/A	7.77	7.82	7.81

Notes: "J" Flag: Analyte detected between LOD & LOQ.

The results of the RCRA 8 Metals plus nickel analysis show the water quality for all six sample sites to be far below the limits set forth in the WDNR water quality standards for both drinking water and chronic toxicity criteria for aquatic organisms. Most of the metals analyzed show results under the limit of detection (LOD), which is the lowest concentration or amount of an analyte that can be identified, measured, and reported with confidence that the concentration is not a false positive value. Results that are reported as under the LOD are preceded by the less than symbol (<). Results that are followed by a "J" flag fall in between the LOD and the limit of quantitation (LOQ). The LOQ is the lowest concentration of an analyte that can be determined with acceptable repeatability and accuracy. When a result falls between the LOD and LOQ it means that there is enough of an analyte present to have certainty that it is not a false positive result, but the concentration of the analyte is not reported with the high confidence in repeatability and accuracy of a result that has a concentration exceeding the LOQ.

The results of the general water quality analysis show some differences between the quarry samples and the stream samples in several of the analytes tested. The coliform and E-Coli counts are generally higher in the stream samples. This result is expected as the streams are encountered by a large volume of wildlife and take on agricultural runoff that likely has been in contact with some form of waste produced by livestock, whereas the quarry waterbodies are only exposed to wildlife visiting the ponds and do not take on any agricultural runoff. The BOD and COD results for all six sites are low, which is an indicator that they are not polluted waters. BOD measures the amount of oxygen required by microbes to aerobically decompose organic matter present in a sample and COD measures the amount of oxygen required to chemically oxidize both organic and inorganic matter present in a sample. High BOD and COD equate to less available oxygen in the water for aquatic life. COD is always higher than BOD because it accounts for both organic and inorganic matter present in the sample where BOD only accounts for organic matter. Natural surface water generally has a BOD of less than 5mg/L and a COD of less than 20mg/L. The results of the nitrite + nitrate analysis show the stream samples having a higher nitrate concentration than the quarry samples. Two of the stream samples produced results near the WDNR drinking water limit, with White Creek just over the limit at 10.3mg/L and Dakin Creek just under at 9.37mg/L. The pH of the water at all six sites ranges from 7.26 to 7.62, which means the water is just on the alkaline side of neutral.

The wash process pond at the Morris Quarry was sampled to determine if closed circuit washing would cause increased concentrations of metals and nitrates in the pond. Closed circuit washing means that same pond was used to both supply the water that washes the aggregate and receive the sediment laden water that exits the wash plant. A floating turbidity barrier was used to keep the water intake separated from the sediment discharge. Over 25,000 tons of material were washed utilizing the pond in this configuration. The results of the wash pond analysis don't show any major increases in the concentration of analytes compared to the floor stormwater sump. Arsenic and barium were slightly lower, and nickel and nitrates were slightly higher than the sump sample. Well water was used to maintain the pond level because a portion of the process water leaves the plant with the finished products. The slight increase in nitrate concentration could have come from the supplemental groundwater. The WDNR Well Water Quality Viewer shows that water from three of the four wells sampled in the section the quarry is located in produced nitrate test results ranging between 5.1mg/L and 10.0mg/L as shown in Figure 32.

Figure 32.

Statistics Report ×

(1 of 1) Clear

NITRATE (mg/l as N) for S3 T16N R13E

Range	Number	Percent	Summary
None Detected	0	0%	Minimum: 0.2
... 2.0	1	25%	
2.1 - 5.0	0	0%	Median: 7.4
5.1 - 10.0	3	75%	Average: 6.1
10.1 - 20.0	0	0%	
20.1 ...	0	0%	Maximum: 9.4
Total Samples:	4		
> 10mg/l N	0	0%	Exceeds Health Standard

Note. Figure 32. from WDNR Well Water Quality Viewer, Online

The results of the water quality analysis show that the surface and process water from an active quarry can be as clean, if not cleaner, than the natural watercourses flowing in the surrounding area.

Sulfide Mineralization

The exposure of sulfide mineralization to air and water causes the oxidation of metals contained in the sulfide. The reaction generates sulfuric acid which turns the water acidic and acts as a vehicle for the metals, releasing and carrying them in the water. The product of the reaction is commonly known as acid mine drainage (AMD). A visual indicator that acid mine drainage is occurring is the discoloration on the bottoms of drainageways and ponds. As iron precipitates out of the acid solution it settles on the bottom of the drainageway or pond in the form of yellow, orange, or red sediment. AMD is a common occurrence in metal and coal mining and can be found in tailings piles or ponds, mine waste rock dumps, and coal spoils. Indicators of AMD can be seen in Figures 33 and 34.

Figure 33.

Note. Indicators of AMD in and around a tailings pond at a Minnesota iron ore mine.

Figure 34.

Note. Indicators of AMD in a drainageway at an Illinois coal mine.

AMD is treated with limestone. Limestone is mostly comprised of calcium carbonate which neutralizes the acid. Limestone is used in both passive and active treatments for AMD. Passive treatments include limestone lined basins to treat acidic water and working limestone into tailings and rock waste to neutralize the acid. Active treatments involve using a lime slurry in a water treatment plant which raises the pH of the water, causing the metals to precipitate out of the solution for separation. Metal free, neutral pH water is discharged from the treatment facility.

Green Lake County does not have any metallic or coal mining occurring, the potential for AMD to occur comes from a different source. The common sulfides found in Green Lake County are Pyrite and Marcasite, and they may be seen in small amounts in several of the rock formations found in the county. Concentrated sulfide mineralization can be found in the Sulfide Cement Horizon, which lies immediately below the base of the Platteville limestone formation. If the SCH is exposed, it can react and cause AMD. A quarry in the Fox River Valley exposed the SCH and created AMD due to the exposure, see Figure 35. The quarry was utilized in several studies concerning groundwater quality and the SCH and has been closed to prevent further exposure and stop the reaction, see Figure 36.

Figure 35.

Note. Indicators of AMD next to the submerged area of the quarry.

Figure 36.

Note. Closed Quarry

The SCH can be identified by test drilling and avoided through proper mine planning and development. The SCH does not pose a threat if it is not exposed or dewatered. Sulfides may be present in the limestone formations as well, but acid production is neutralized by the limestone itself. Composite samples of the Sinnipee Group formations (Galena, Decorah, Platteville) were taken during test drilling for the Skunk Hollow Quarry in Section 36 of the Town of Brooklyn and sent to ALS Laboratories in Reno, Nevada to have acid base accounting (ABA) testing performed. ABA tests determine the acid producing potential, neutralizing potential, and sulfide content of rocks and soils. ABA testing is a standard procedure in coal and metallic mining planning so that mine operators can develop plans to mitigate AMD. The results of the ABA testing showed that the limestone at Skunk Hollow contains 0.12% to 0.19% sulfide mineralization, has a very low acid producing potential, and a very large neutralization potential. If all the sulfide available at the site was converted to acid, only 1% of the available calcium carbonate at the site would be required to neutralize it.

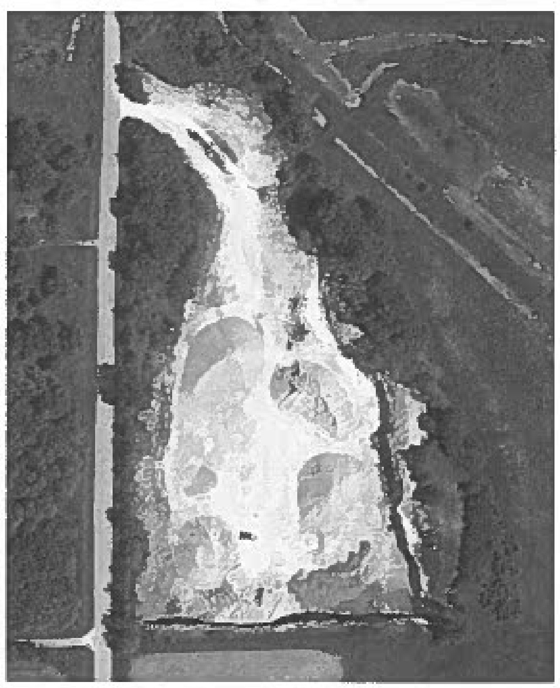
Reclamation

Reclamation is the process of turning mined areas back into land that can be used for purposes other than mining. A mine can be transformed into a lake or pond, filled and leveled to become agricultural land, and even transformed into golf courses, parks, or residential developments.

Wisconsin Chapter NR 135 sets the requirements for reclamation as well as what is required as part of a reclamation plan. Every non-metallic mineral extraction operation in Green Lake County has a reclamation plan on file with the county. Reclamation quite frequently begins while a property is still being mined because it reduces the amount of time needed to reach final reclamation and it reduces operating and reclamation costs.

The following figures show examples of reclamation performed by Kopplin & Kinas Co., Inc. in the last few years.

Figure 37.



Note. Priske Quarry, Fall River, WI, Pre-reclamation.

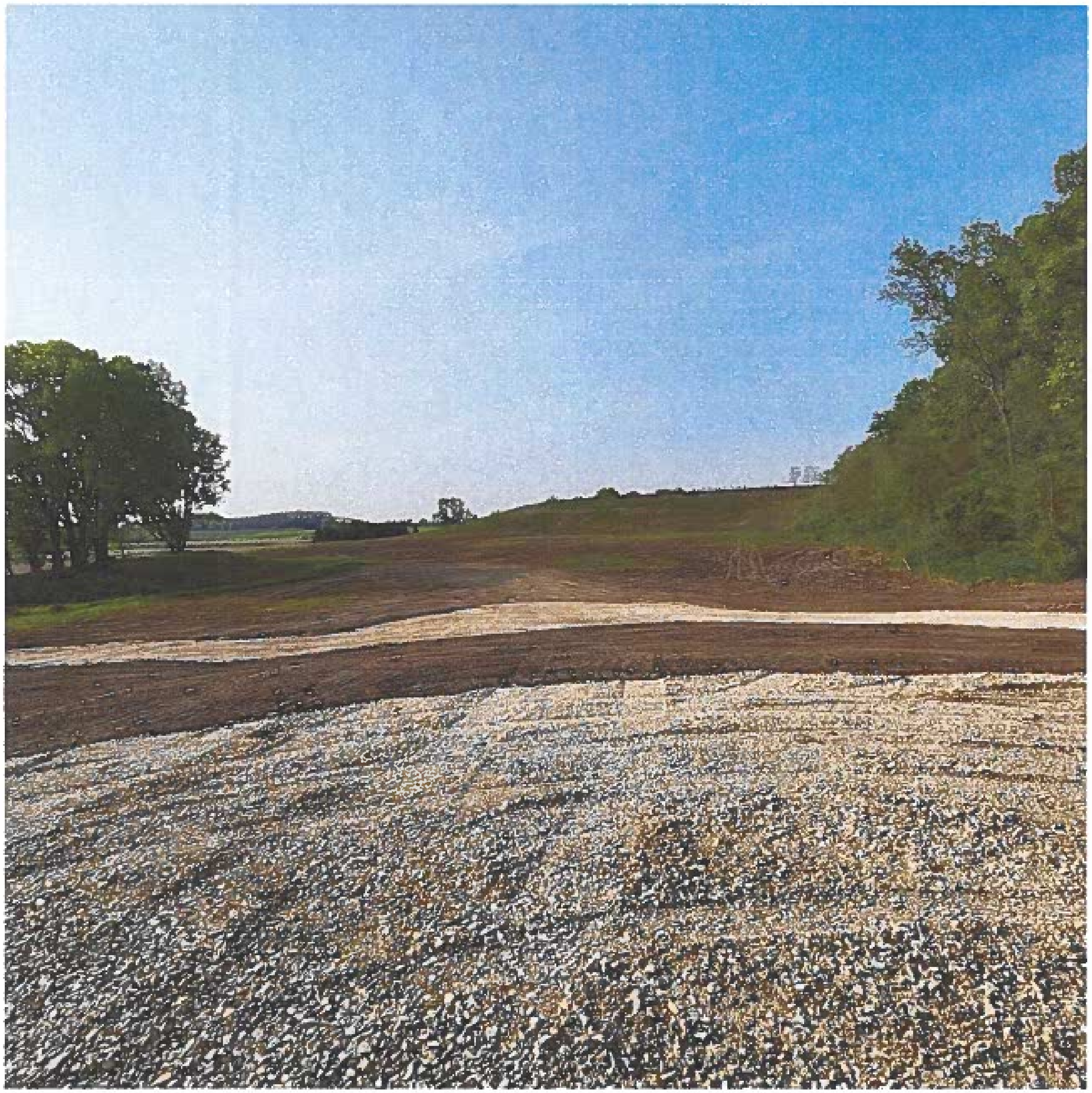
Figure 38.

Note. Highwalls have been sloped off, imported fill has been leveled across floor.

Figure 39.

Note. Slopes have been finish graded and seeded, floor prep in progress.

Figure 40.



Note. Floor has been finished and prepped for seeding, paths and look-out pad have been graveled.

Figure 41.

Note. Floor has been seeded.

Figure 42.

Note. Final Reclamation.

Figure 43.

Note. Final Reclamation

Figure 44.

Note. Final Reclamation.

Figure 45.

Note. Final Reclamation.

Figure 46.

Note. Undisclosed location per landowner's request. Active quarry in 2010. Reclamation has started. Reclamation will be completed utilizing only imported fill.

Figure 47.

Note. Reclamation progressing. 2017

Figure 48.

Note. Reclamation almost complete in 2020.

Figure 49.

Note. Final reclamation completed in 2022.

Mining Makes a Good Neighbor

U.S. mining respects the communities in which we operate and the environment in which we live.

Our commitment to the environment means investing heavily in the development of advanced technologies that minimize mining's footprint. It also means operating under a comprehensive set of standards, which include every major U.S. environmental law, as well as state laws and the industry's own strict sustainability practices.

Being a community partner means restoring more than 3.0 million acres of mined lands since 1978 for beneficial uses including recreation areas, farms, economic development parks, golf courses, schools, housing developments, wildlife habitat and wetlands. No mining project is complete until we fully restore the lands on which we operate.

No mining project is complete until we fully restore the lands on which we operate.

Visit the National Mining Association at www.nma.org
for more information.

NMA

MINERALS MAKE GOOD NEIGHBORS

Mi Ne Ra Ls
M A K E
L I F E

People are at the core of U.S. minerals mining. We respect and care for the health and safety of our employees, the well-being of the communities in which we operate and the environment in which we live.

COMMITTED TO OUR EMPLOYEES

Employees are the cornerstone of U.S. minerals mining, and their health and safety is our top priority.

- U.S. mining has lower injury rates than many other industrial sectors—but we can and are doing more.[1]
- CORESafety, mining's new health and safety initiative, seeks to reduce the rate of employee injury even further, cutting it in half by 2015.[2]

SCHOOL

COMMITTED TO OUR COMMUNITIES

U.S. minerals mining strives to give back to the communities whose support is vital to our work.

- We support local communities through volunteer efforts and millions of dollars in charitable contributions every year.
- In addition, minerals mining generates tens of billions of dollars in much-needed revenue for federal, state and local governments …[3]
- … While stimulating the local economy by providing community residents with high-earning jobs that pay 79% more than the average private sector job.[4]

COMMITTED TO THE ENVIRONMENT

U.S. mining is dedicated to being a responsible environmental steward and invests heavily in the development of new technologies and processes to minimize environmental impacts.

- U.S. mining operates under a comprehensive set of standards that includes every major U.S. environmental law.[5]
- In 2012, U.S. mining introduced the Environmental Management System, a roadmap providing all minerals mining companies, regardless of size, the tools necessary to navigate regulatory processes and continually improve environmental performance.[6]
- U.S. mining is committed to restoring the lands on which we operate, and always has a plan and funding for restoration in place before mining begins.

[1] [illegible]
[2] [illegible]
[3] [illegible]
[4] [illegible]
[5] [illegible]
[6] [illegible]

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Federal Environmental Laws that Govern U.S. Mining

NMA THE AMERICAN RESOURCE

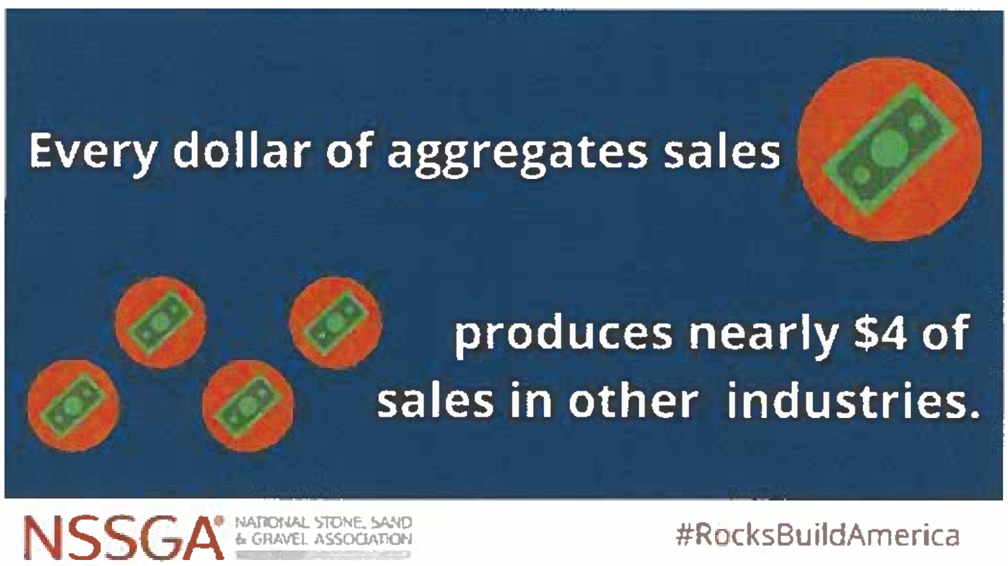
More than three dozen federal environmental laws and regulations cover all aspects of mining. The following list includes some of those major laws. In addition, each state has laws and regulations that mining companies must follow.

- National Environmental Policy Act - requires an interdisciplinary approach to environmental decision making.
- Federal Land Policy and Management Act - prevents undue and unnecessary degradation of federal lands.
- Clean Air Act - sets air quality standards.
- Federal Water Pollution Control Act (Clean Water Act) - directs standards for surface water quality and controlling discharges to surface water.
- Safe Drinking Water Act - directs standards for quality of drinking water supplied to the public (states are primary authorities) and regulating underground injection operations.
- Resource Conservation and Recovery Act (formerly the Solid Waste Disposal Act) - regulates generation, storage and disposal of hazardous waste (Subtitle C; authorized state programs) and manages solid, non-hazardous waste (Subtitle D; approved state programs).
- Comprehensive Environmental Response, Compensation, and Liability Act - Imposes liability on persons responsible for releases of hazardous substances.
- Toxic Substance Control Act - requires regulation of chemicals that present an unreasonable risk of injury to health or environment, including an unreasonable risk to a potentially exposed or susceptible subpopulation, under the conditions of use. In addition, manufacturers (including importers) are required to report certain production and use information on chemicals in commerce over certain threshold quantities.
- Emergency Planning and Community Right-to-Know Act – requires reporting on certain hazardous chemicals to state and local emergency planning committees, as well as certain chemicals under the Toxics Release Inventory program.
- Endangered Species Act - lists threatened plants and animals; protection plans mandated.

- Migratory Bird Treaty Act - protects nearly all bird species.
- Surface Mining Control and Reclamation Act - regulates coal mining operations and reclamation.
- Uranium Mill Tailings Radiation Control Act – directs standards for the protection of the public health, safety, and the environment from hazards associated with uranium recovery activities.

Other laws that impact mining include:

- the Rivers and Harbors Act,
- the Federal Mining Law,
- the National Historic Preservation Act,
- the Law Authorizing Treasury's Bureau of Alcohol, Tobacco and Firearms to Regulate Sale, Transport and Storage of Explosives, and
- the Federal Mine Safety and Health Act.


Every dollar of aggregates sales
produces nearly $4 of
sales in other industries.
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Phoenix Center Policy Paper Number 53:

Quarry Operations and Property Values: Revisiting Old and Investigating New Empirical Evidence

George S. Ford, PhD
R. Alan Seals, PhD

(March 2018)

Phoenix Center Policy Paper No. 53

Quarry Operations and Property Values: Revisiting Old and Investigating New Empirical Evidence

George S. Ford, PhD†
R. Alan Seals, PhD•

Abstract: A large literature exists on the impact of disamenities, such as landfills and airports, on home prices. Less frequently analyzed is the effect of rock quarries on property values, and what little evidence is available is dated and conflicting. This question of price effects is a policy relevant one, with one study in particular used frequently to support "not in my backyard" campaigns against new quarry sites. In this POLICY PAPER, we revisit the literature and conduct a new analysis of the price effects of quarries, estimating the effect of quarries on home prices with data from four locations across the United States and a wide range of econometric specifications and robustness checks along with a variety of temporal circumstances from the lead-up to quarry installation to subsequent operational periods. We find no compelling statistical evidence that either the anticipation of, or the ongoing operation of, rock quarries negatively impact home prices. Our study likewise highlights a number of shortcomings in the empirical methodologies generally used to estimate the effect of disamenities on real estate prices. First and foremost, many existing studies are naïve as to the empirical conditions necessary to identify a causal relationship and do not establish credible strategies to estimate the counter-factual outcome. Second, the inclusion of "distance to the site" regressors in hedonic models is shown to be an unreliable statistical method. Using the method of randomized inference, the null hypothesis of "no effect" of placebo quarries is rejected in as much as 93% of simulations.

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† Chief Economist, Phoenix Center for Advanced Legal & Economic Public Policy Studies. The views expressed in this paper are the authors' alone and do not represent the views of the Phoenix Center or its staff.

• Adjunct Fellow, Phoenix Center for Advanced Legal & Economic Public Policy Studies; Associate Professor of Economics and Director of Graduate Studies – Auburn University.

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I. Background

Odds are that underneath your feet is a construction material made of sand, crushed stone, and gravel. These construction materials are an essential ingredient into nearly every construction project, from residential housing, office buildings, retail outlets, entertainment structures, to the roads that connect them.[1] Sand, rock and gravel are literally the foundation of economic development, but their extraction process can generate dust, noise, vibration, and truck traffic. While modern technologies and methods have greatly reduced quarries' impact, the environmental and economic consequences of quarry operations receive considerable attention, often in the form of "not in my backyard" (or "NIMBY") campaigns opposing quarry expansions or new sites. Choosing a quarry site is a delicate task. While a quarry may be best located far from residential density on NIMBY concerns, it also needs to be near the final point of demand due to its high transportation cost. Quarries must balance the need to be both "near" and "far," so they are typically found on the outskirts of cities and towns.

A key NIMBY complaint in the siting and expansion of quarries is the effect of the operations on nearby home values. According to Census data, housing amounts to about 70% of the average American's net wealth, so naturally homeowners are sensitive to any adverse effect, real or imagined, on property values.[2] Despite NIMBY opposition, nearly all the evidence on quarry operations finds no price effect. Frequently mentioned studies include Rabianski and Carn (1987) and Dorrian and Cook (1996), both of which find no relationship between appreciation rates of property values near to and far from quarries.[3] An

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1 *2014 Minerals Yearbook, Construction Sand and Gravel*, U.S. Geological Survey (2014) at p. 1 (available at: https://minerals.usgs.gov/minerals/pubs/commodity/sand_&_gravel_construction/myb1-2014-sandc.pdf) ("Construction sand and gravel is a traditional basic building material and is one of the earliest materials used by humans for dwellings and later for outdoor areas such as paths, roadways, and other constructs. Despite the relatively low, but increasing, unit value of its basic products, the construction sand and gravel industry is a major contributor to and an indicator of the economic well-being of the Nation").

2 *Wealth, Asset Ownership, & Debt of Households Detailed Tables: 2013*, U.S. Census Bureau (2017) (available at: https://www.census.gov/data/tables/2013/demo/wealth/wealth-asset-ownership.html).

3 A.M. Dorrian and C.G. Cook, *Do Rock Quarry Operations Affect Appreciation Rates of Residential Real Estate*, Working Paper (1996); J. Rabianski and N. Carn, *Impact of Rock Quarry*

(Footnote Continued. . . .)

even earlier study conducted for the U.S. Bureau of Mines in 1981 also found no consistent relationship between quarry operations and the prices of nearby homes.[4] There are a number of consulting reports on the question, and none report price attenuation attributable to a quarry.[5]

Opposition to quarries based on home valuations relies universally on a report by Professor Patricia Hite (2006).[6] This brief, 250-word study (hereinafter the "*Hite Report*") analyzes data from a few thousand homes sales (apparently in the mid-to-late 1990s) around a single quarry in Delaware, Ohio. Using an unconventional regression model and data on transactions occurring decades after the quarry opened, the *Hite Report* finds a positive relationship between home prices and distance from the quarry. Based on that evidence, the *Hite Report* concludes that quarries reduce home values. Yet, the *Hite Report*'s methods and data do not support a causal interpretation.

As economic development marches on, new quarries will be required to satisfy the demand for basic building materials. In light of the mostly dated and conflicting evidence on the effect of quarries on housing prices, this POLICY PAPER offers new evidence, and a review of old evidence, on the relationship between housing prices and rock quarries. First, given its frequent use by NIMBY opposition to quarries, we revisit the *Hite Report*, analyzing home sales data

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Operations on Value of Nearby Housing, Prepared for the Davidson Mineral Properties (August 25, 1987).

4 M. Radnor, D. Hofler, *et al.*, *Social, Economic and Legal Consequences of Blasting in Strip Mines and Quarries*, U.S. Bureau of Mines (May 1981) (available at: http://www.cdc.gov/niosh/nioshtic-2/10006499.html).

5 *See, e.g.*, *Study of Impact of Proposed Quarry on The Real Estate Values of Surrounding Residential Property in Raymond, New Hampshire*, Crafts Appraisal Associates Ltd. (April, 2009) ("The evidence does however suggest that the overall marketplace does not react to an influence such as a quarry with a measurable negative reaction as it relates to sale price."); *Martin Marietta New Design Quarry: Analysis of Effect on Real Estate Values*, Stagg Resources Consultants, Inc. (November 17, 2008); *A Property Valuation Report: Affect [sic] of Sand and Gravel Mines on Property Values*, Banks and Gesso, LLC (October 2002); *Impacts of Rock Quarries on Residential Property Values in Jefferson County, Colorado*, Banks and Gesso, LLC (May 1998); R.J. McKown, *Analysis of Proposed Sand & Gravel Quarry: Granite Falls, WA*, Schueler, McKown & Keenan, Inc. (September 25, 1995).

6 D. Hite, *Summary of Analysis: Impact of an Operational Gravel Pit on House Values: Delaware County, Ohio*, Working Paper (2006). We assign the date "2006" as is conventional, but that year is merely the recording stamp date on the document when it was filed in some type of proceeding. We do not know whether a more detailed analysis was provided at some point. We have never seen such a document cited and were unable to locate it.

around the same Delaware-Ohio quarry. Despite replicating both the location and methods of the *Hite Report*, our regression analysis finds that prices *fall* — not rise — as distance from the quarry increases. This result conflicts with that appearing in the *Hite Report*, so we look for more evidence by analyzing data on homes sales near a quarry outside of Murfreesboro, Tennessee, over the same time interval. Again, we find prices *fall* as distance from the quarry increases.

We are reluctant, however, to claim this evidence implies quarries raise home prices. Rather, we conclude, based on the method of randomized inference and other tests, that the *Hite Report*'s method is unreliable. Using a simulation of pseudo-treatments, we find that the null hypothesis that home prices rise or fall in distance from a *randomly selected location* is rejected in no less than 67% of cases at the 10% nominal significance level. Estimating price-distance relationships, especially without explicitly considering selection bias, is a highly-unreliable statistical procedure. The nature of real estate markets do not permit the effect of quarries to be identified with such naïve empirical tests.

Second, using data on home sales near a relatively new quarry in Gurley, Alabama, we augment the Hite-style analysis with a difference-in-differences estimator, which quantifies the price-distance relationship both before-and-after operations begin. By exploiting the timing of the quarry buildout and the location of home sales with respect to the quarry, we can credibly identify a causal relationship, at least in theory. Unlike the analysis for Delaware and Murfreesboro, home prices rises in distance from the Gurley quarry site, but do so *before* the quarry becomes operational. After operations begin in 2013, the positive effect of distance is attenuated, again suggesting a positive effect of quarries on housing values.

One critique of our Gurley analysis is that market participants shift price forecasts downward in response to the prospect of a quarry so that the deleterious effects of the quarry could be realized before the quarry opens. Quarry site approvals normally take a decade or so, providing ample time for anticipatory responses to valuation fears. To address this concern, we analyze transactions near a recently approved quarry in Madera County, California. Using a difference-in-differences estimator in conjunction with Coarsened Exact Matching, we test for the anticipatory effect of the proposed quarry on nearby housing prices located along the major roadways serving the site. We find no evidence the quarry reduced housing prices. If anything, relative home prices rose near the quarry site.

While our evidence suggests that quarries do not reduce, but may increase, home prices, our analysis suggests more than anything that the identification of the effect of quarries on prices is a very difficult problem, facing many conceptual and practical obstacles. We do not resolve all these difficulties. That said, we can conclude the evidence strongly implies the *Hite Report* and its methods are unreliable. Further analysis is, as usual, encouraged.

This paper is outlined as follows. First, we discuss the empirical requirements of quantifying a plausibly causal relationship between property values and quarry operations. Second, we revisit the *Hite Report*, estimating the price-distance relationship for the same quarry in Delaware, Ohio, and replicating the analysis for a quarry near Murfreesboro, Tennessee. Using a simulation method, we demonstrate the futility of estimating the price effects of quarries using the method proposed in the *Hite Report*. Third, we turn to the estimation of causal effects using the difference-in-differences estimator for quarry sites in Gurley, Alabama, and Madera County, California. Across multiple methods, we find, if anything, that home prices near quarries rise, not fall. In all, however, we believe our analysis best supports the hypothesis of "no effect" of quarries, or the announcement of quarries, on home prices. Conclusions are provided in the final section.

II. Empirical Framework

Disamenities such as landfills, airports, windfarms and prisons may plausibly reduce the prices of nearby homes. Such effects have been widely studied.[7] Modern empirical methods for observational data based on the Rubin Causal Model, however, suggest that much of the work may offer biased estimates of such disamenities because much it looks only at prices after the "treatment," making it difficult to address selection bias.[8] To conclude that a disamenity reduces home values, the researcher's interest must be in the *causal effect* of an amenity or disamenity on property values. Using only post-treatment prices is problematic since the locations of amenities and disamenities are not randomly selected, and

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[7] Other disamenities that may affect property values, airports and waste disposal, are frequently opposed by homeowners. *See, e.g.*, J.P. Nelson, *Airport and Property Values: A Survey of Recent Evidence*, 14 JOURNAL OF TRANSPORT ECONOMICS AND POLICY 37-52 (1980) (available at: http://www.bath.ac.uk/e-journals/jtep/pdf/Volume_X1V_No_1_37-52.pdf); J.B. Braden, X. Feng, and D. Won, *Waste Sites and Property Values: A Meta-Analysis*, 50 ENVIRONMENTAL AND RESOURCE ECONOMICS 175-201 (2011).

[8] Excellent resources on the modern methods of causal inference for economic analysis include G.W. Imbens and J.M. Wooldridge, *Recent Developments in the Econometrics of Program Evaluation*, 47 JOURNAL OF ECONOMIC LITERATURE 5-86 (2009); J.D. Angrist and J. Pischke, MOSTLY HARMLESS ECONOMETRICS: AN EMPIRICIST'S COMPANION (2008); and J.D. Angrist and J. Pischke, MASTERING 'METRICS: THE PATH FROM CAUSE TO EFFECT (2015).

disamenities are typically located away from residential density to minimize impact and to placate NIMBY resistance.

The non-random selection of a quarry site greatly complicates the quantification of a quarry on housing prices due to selection bias. Finding that housing prices rise at increased distance from a quarry may merely reflect the economics of site choice (i.e., real estate is cheaper per unit in less densely populated areas on the outskirts of town) rather than any causal effect on property values. Also and consequently, empirical work may be frustrated by the lack of housing density near the site, rendering small sample sizes, which may, in turn, lead to the undue influence of outliers. Many quarries, especially new ones, have almost no housing within a mile or two of the site (the typical distance within which negative effects are claimed), as shown in the maps provided in the Appendices. And, given the lengthy approval process, if a quarry does affect housing prices, then such effects may occur prior to operations by an "announcement effect." In conducting empirical work on quarries and housing prices, the researcher must address, and deal with the theoretical and empirical consequences of, the non-random nature of site location.

A. *Quantifying the Effect of a Quarry on Housing Prices*

Resistance to new quarry sites (or the expansions of old ones) based on property values rests exclusively on the *Hite Report*. In that report, the effect on prices is quantified by comparing the mean, quality-adjusted transactions prices around the quarry outside of Delaware, Ohio, as the home's distance from the quarry increases. This "experiment," however, has little hope of accurately measuring the effect of quarries on home prices.

To better grasp the nature of the problem, let there be two types of residential locations: (1) locations proximate to and potentially affected by quarry operations (labeled *N*, for "near"); and (2) locations distant from and entirely unaffected by quarry operations (labeled *F*, for "far"). Also, let there be two periods: the period prior to ($t = 0$) and after ($t = 1$) the initiation of quarry operations. For now, assume the approval process is instantaneous and that the quality and type of homes in the two locations are very similar (or, that such differences can be accounted for by statistical methods).

Prior to quarry operations homes sell for the average price P_0^N if near the future location of the quarry and P_0^F otherwise. (A numerical example is provided later.) For various reasons, these prices need not be equal. After quarry operations begin, the average, quality-adjusted prices for houses are P_1^N and P_1^F. The differences in the prices across time (P_1 - P_0) are δ^N and δ^F. Other things constant, the effect of the quarry operations can be measured as,

$$\Delta = \delta^N - \delta^F = \left(P_1^N - P_0^N\right) - \left(P_1^F - P_0^F\right), \tag{1}$$

where Δ is the difference-in-differences ("DiD") estimator.[9] The DiD estimator looks for a difference in outcomes after the treatment that is difference than the differences in outcomes before the treatment (thus, explaining the term difference-in-differences). Under certain conditions, the DiD estimator plausibly measures the causal effect of the quarry.

Many studies of the effect of amenities or disamenities on housing values looks only at the difference between *near* and *far* locations in the *post-treatment* period, or the difference in P_1^N and P_1^F (or δ_1). This post-treatment approach is the one used in the *Hite Report*, where all the data is from sales decades after the quarry operations began. If, however, there is a difference in prices before the quarry operations begin, this post-operations difference is clearly not a measure of the effect of proximity to the quarry. A numerical example may prove helpful.

B. *A Numerical Example*

Before a quarry opens, assume the average, quality-adjusted price for a home near the quarry site is $80,000, but the average price is $100,000 for homes far from the future quarry site. Thus, there is a $20,000 or 20% difference in prices prior to quarry operations, perhaps reflecting the lack of locational rents for homes far from residential density. Plainly, since quarry operations have not begun, this difference cannot be attributed to the quarry. In fact, the quarry site may have been chosen because of the lower property values or lack of residential housing in the area.

As a benchmark case, say that the quarry operations once initiated have *no effect* on property values and the sales prices of homes are unchanged after quarry operations begin ($80,000 and $100,000, respectively). If a researcher were to

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9 *See, e.g.*, B.D. Meyer, *Natural and Quasi-Experiments in Economics*, 13 JOURNAL OF BUSINESS & ECONOMIC STATISTICS 151-161 (1995); J.D. Angrist and A.B. Krueger, *Empirical Strategies in Labor Economics*, in HANDBOOK OF LABOR ECONOMICS Vol. 3A (eds., O. Ashenfelter and D. Card) (1999); S. Galiani, P. Gertler, and E. Schargrodsky, *Water for Life: The Impact of the Privatization of Water Services on Child Mortality*, 113 JOURNAL OF POLITICAL ECONOMY 83-123 (2005); D. Card, *The Impact of the Mariel Boatlift on the Miami Labor Market*, 13 INDUSTRIAL AND LABOR RELATIONS REVIEW 245-257 (1990).

simply compare prices based on distance from the quarry after operations begin, then a difference of 20% would be found. Yet, that difference existed prior to the quarry's opening, and thus the quarry did not *cause* that difference, implying any causal claim made about that difference is mistaken. The truth (by assumption) is that the quarry had *no effect*. The DiD estimator (Δ) is, in fact, zero, correctly identifying the causal effect of the quarry [= (80,000 – 80,000) – (100,000 – 100,000)].

Assume instead that the quarry does reduce prices for nearby homes. Let the post-quarry average prices be $70,000 near and $100,000 far from the quarry, other things constant.[10] Prices near the quarry fall by $10,000 and those far from the quarry are unchanged. The DiD estimator accurately quantifies the effect of the quarry, which is a $10,000 reduction in value [= (70,000 – 80,000) – (100,000 – 100,000)]. Looking at data after the quarry operations begin, alternately, which is the *Hite Report*'s approach, would find an effect size of $30,000 [=70,000 – 100,000], or three times the true effect. Selection bias accounts for the $20,000 error in the estimated effect.

Ideally, then, to properly identify the causal effect of a quarry operation, the researcher must observe prices both before and after the quarry may reasonably be expected to affect housing prices (among other considerations such as the similarity in pricing trends prior to the treatment). The analysis of transactions occurring well after the quarry opens offers little hope for quantifying the effect of the quarry, absent unique circumstances. Certainly, the empirical demands are considerable, and the identification of the causal effect must be explicitly set forth and proper empirical methods applied.

C. *Key Assumptions for Estimating Causal Effects*

With regard to the location of homes and quarries, we do not have the luxury of experimental data. Rather, the data is observational and the data generation process occurs over many decades. The observational nature of the data is crucial: quarry site and housing locations are non-random and not independent of economic activity near the site or each other. Thus, research on the price effects of quarry sites must pay careful attention to selection bias, which is caused by the non-random process by which sites are chosen to avoid residential density but still

10 For instance, a large condominium complex may have built near the quarry. The researcher must adjust for the difference in average prices resulting from this changing mix of household types).

(Footnote Continued. . . .)

remain close to the point of demand for aggregates (i.e., sand, stone and gravel). Thus, the "treatment" and "outcome" are related through observed and potentially unobserved factors.[11]

As explained by Imbens and Wooldridge (2009), when estimating the causal treatment effect in observational studies the researcher must be alert to two key concepts stemming from selection bias: (1) unconfoundedness (or the conditional independence assumption) and (2) covariate overlap (or common support).[12] Unconfoundedness implies that, conditional on observed covariates *X*, the treatment assignment probabilities are independent of potential outcomes. If we have a sufficiently rich set of observable covariates, then regression analysis including the variables *X* leads to valid estimates of causal effects. Since the *X* must be observed to be included in the regression model, this approach is often referred to as *selection on observables*. It is difficult to know and impossible to test whether the observed and included *X* are sufficient to guarantee unconfoundedness (so the regression error and treatment are uncorrelated), though some guidance is available through pseudo-treatment tests (as applied later).

The conditional independence assumption (or *unconfoundedness*) implies that the observed factors included in the statistical analysis fully account for all the differences in the types of homes sold both near and far from the quarry (or other site of interest).[13] In quantifying the effect of education on income, for instance, it is not enough to simply compare the incomes of persons with and without a college education. Work ethic, for instance, affects both the probability that a person will obtain a college degree and his or her future income. A hard-working person may earn a higher income even without a college education. If work ethic cannot be observed, then a comparison of average incomes across those with and without a college degree does not measure the true value of a degree. The difference is a positively biased estimate of the payoff of education.

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[11] In regression analysis, this problem appears as a correlation between the regression residual and the treatment variable.

[12] *Supra* n. 8.

[13] That is, the regression model includes all the regressors needed to make the conditional *near* and *far* prices equal prior to the treatment.

(Footnote Continued. . . .)

The second factor to consider for the measurement of the causal effect is covariate overlap, which Imbens and Wooldridge (2009) observe is, after unconfoundedness, the "main problem facing the analyst."[14] This condition implies that the support of the conditional distribution of X for the control group overlaps completely with the conditional distribution of X for the treatment group. That is, the covariate distributions for the treated and untreated groups are sufficiently alike, thereby lending credibility to the extrapolations inherent to regression analysis between groups. If the characteristics of untreated observations (home *far from* the quarry) are very different from the treated observations (homes *near to* the quarry), then the projections from the controls to the treated units will be a poor one.

Say, for instance, that a sample used to assess the effect of an experimental cancer treatment includes only persons over 65 years old in the experimental treatment group (or simply treatment group) and only persons below 45 years old in the non- treatment group (or control group). The purpose of the control group is not simply a counterweight to the treatment group. Rather, the control group measures the outcomes for the treated group if that group did not receive the treatment. To fix ideas, what we actually want to estimate is what would the treatment group have looked like had they not been treated, which is the sole purpose of a control group. It is unreasonable to expect, we believe, that the survival outcomes of 45 year-old persons provides an approximation of survival outcomes of persons 65 years and over that did not receive the experimental treatment. To extrapolate this discussion to the case of housing values, if the control group includes almost all homes in a golf course community with swimming pools and the treatment group—the properties near some dis-amenity—includes mostly one-bedroom condominiums, then the difference in sale prices between the two is a nearly meaningless statistic. Regression models are powerful tools, but they cannot make up of for such large differences in characteristics across treatment and control groups (even if observable and included in the regression model as explanatory variables), which is important given that the control group is being "projected" onto the treatment group.

A number of statistical techniques are used to address confoundedness and covariate imbalance in observational studies. In a housing study, for instance, a researcher may choose the control group by finding a group of homes comparable to the treatment group—that is, similar square footage, amenities, lot sizes—from a population of homes unaffected by the treatment. This approach, which we

[14] Imbens and Wooldridge, *supra* n. 8 at 43.

employ here, ensures that the characteristics of homes in the treatment and control groups are sufficiently similar, adding credibility to the control group as a suitable "stand in" for the treatment group if it had not received the treatment.

The *Hite Report* is silent on both of these key assumptions, and there is good reason to suspect the analysis fails on both counts. All the pricing data is for home sales occurring long after the quarry operation began and the regression model is quite basic, so the experiment is almost certainly plagued with selection bias. As for covariate overlap, from what few descriptive statistics are provided in the *Hite Report* we observe that the range of home prices within 0.5 miles of the quarry has a minimum of $80.1 and a maximum of $178.9 (in thousands). In contrast, the range of prices for homes further from the quarry is $60 to $798.6. This difference in the maximum prices is sizable, suggesting that the homes near the quarry may be very much unlike those far from the quarry, thus risking biased results of the effect of distance.

III. Revisiting the *Hite Report*

In NIMBY campaigns challenging quarry development, the *Hite Report* is the sole empirical analysis supporting the claim that quarries reduce housing prices. Subsequent works by Erickcek (2006), the Center for Spatial Economics (2009), Smith (2014), among others, conduct no new empirical analysis, choosing instead to extrapolate the *Hite Report*'s results to different locations (a questionable practice on its own).[15]

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[15] G.A. Erickcek, *An Assessment of the Economic Impact of the Proposed Stoneco Gravel Mine Operation on Richland Township*, W.E. Upjohn Institute for Employment Research (August 15, 2006) (available at: http://www.stopthequarry.ca/documents/US%20Study%20on%20the%20impact%20of%20pits%20quarries%20on%20home%20prices.pdf); *The Potential Financial Impacts of the Proposed Rockfort Quarry*, Center for Spatial Economics (February 26, 2009) (available at: http://wcwrpc.org/FinancialImpacts_RockfortQuarryCanada.pdf); G. Smith, *Economic Costs and Benefits of the Proposed Austin Quarry in Madera County*, Report (October 23, 2014) (available at: http://www.noaustinquarry.org/wp-content/uploads/2016/08/Austin-Quarry-Economics-Report.pdf). Other works relying on the *Hite Report* (directly or indirectly) include, *e.g.*, M. Conklin, *et al.*, *The Quarry Proposed by St. Marys Cement Inc. for a Location Near Carlisle, Ontario Should Not be Permitted: Proponents' Brief*, 5 STUDIES BY UNDERGRADUATE RESEARCHERS AT GUELPH (2011) (available at: https://journal.lib.uoguelph.ca/index.php/surg/article/view/1338/2345); *Business Suirvey and Economic Assessment of Locating a Quarry and Asphalt and Cement Plants within Aeortech Park*, Group ATN Consulting, Inc. (October 13, 2014) (available at: http://stopthefallriverquarry.com/wp-content/uploads/2015/10/GATN_Aerotech_Park_FINAL_Report_Oct_13_2015-2.pdf); M.A. Sale,

(Footnote Continued. . . .)

This uniform reliance on the *Hite Report* is somewhat surprising. On the face of it, the report is a seven-page document consisting of 1.5 pages of double spaced text (about 250 words) along with a few tables and figures. It is more an "abstract" than it is a "study." Moreover, even a brief review of the *Hite Report* points to a number of serious problems that should give any researcher pause. First, there are almost no details regarding model specification and few details on the data used. Not even descriptive statistics are provided. Second, the choice of model specification is entirely ad hoc, treating nearly identical variables (distance) differently with respect to functional form and using a non-standard and unnecessary estimation procedure. Such inconsistent, unconventional and inconvenient choices are symptomatic of ends-driven analysis. Third, no explanation is provided as to how the chosen model and analysis of transactions occurring decades after the quarry operations began might identify the effect of *that particular* quarry (or any new quarry) on housing prices. Selection bias is clearly a concern, but it is neither mentioned nor addressed. Fourth, no analysis is provided to suggest that the homes near the quarry are sufficiently similar to those distant from the quarry to provide reliable estimates of the effect of distance (i.e., covariate overlap). Comparing prices of the homes in rural areas on the outskirts of town to those near the local university risks confusing the vagaries of real estate development with the impact of the quarry.

Setting aside the question of causality for the moment, whether the relationship estimated in the *Hite Report* can be replicated is an important first step in evaluating the report's credibility and the suitability of the methods used to answer this policy-relevant empirical question. To that end, we collect data on home sales within five-miles of the same quarry in Delaware, Ohio, evaluated in the *Hite Report*.[16] It appears the data from the *Hite Report* was from the 1990's (though it is impossible to be certain given the lack of detail), so we collect data on

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Quarry Bad for Area, THE NEWS & ADVANCE (September 28, 2008) (available at: http://www.newsadvance.com/opinion/editorials/letters-to-the-editor-for-sunday-september/article_ca388ca4-14c7-534b-9b17-1b78d1cecc40.html).

16 Data is obtained from www.agentpro247.com. For all our analysis, we limit the prices to greater than $25,000 and less than $1,000,000, and look only at the "full" sales of single-family homes not in distress. The National Lime & Stone Quarry near Delaware, Ohio, is located near Latitude 40.281005 and Longitude -83.135828.

(Footnote Continued. . . .)

sales over the ten-year period 1998 through 2007.[17] These data appear to immediately follow that used in the *Hite Report* but precedes the housing market crash in 2008 and the broader economic malaise that followed.[18] For further analysis, we also collect data on sales near a quarry outside of Murfreesboro, Tennessee, over the same ten-year period.

A. *A Review of Empirical Methods*

To reproduce the *Hite Report*'s analysis, we obtain transactions prices on 2,114 single-family homes between 1998 through 2007 that are located within five miles of the National Lime & Stone Quarry near Delaware, Ohio. Using latitude and longitude coordinates, distance from each home to the center the quarry (*D*) is calculated. Other explanatory variables used the *Hite Report* include, for each transaction, the sale date (*DATE*), the distance to Delaware City (*DDC*), the house-to-lot size (*H2L*), the number of bathrooms (*BATH*), and the number of total rooms (*TOTR*). We measure the sale date as the year of sale; the *Hite Report* does not indicate how the sale date is measured.[19]

The regression model of the *Hite Report* takes the following general form,

$$p_{it} = \exp(\delta_1 \ln D_i + \beta_0 + \sum_{j=1}^{k} \beta_j X_{j,i}) + \varepsilon_{i,t}, \tag{2}$$

where p_{it} is the transaction price (in thousands) for home i at time t, ln$D$ is the natural log of distance from the quarry (in miles), and X_j are the k regressors listed above (with coefficients β_j as coefficients).[20] For reasons unexplained in the *Hite Report*, only the distance from the quarry is transformed by the natural log

[17] *See also* D. Hite, *The Impact of the Ajax Mine on Property Values*, ARMCHAIRMAYOR.CA (March 5, 2015) (available at: https://armchairmayor.ca/2015/03/05/letter-the-impact-of-the-ajax-mine-on-property-values) (stating that the analysis was completed in 1996-1998).

[18] Our data source does not offer data in the early-to-mid 1990s, so we cannot replicate the same time period as the *Hite Report*. We are trying to obtain such data for further analysis.

[19] It is preferred to measure *DATE* as a fixed effects, as this specification requires prices to rise monotonically over time.

[20] The variables in the model are listed at *Hite Report, supra* n. 6 at p. 3. A similar specification is used in D. Hite, *A Hedonic Model of Environmental Justice*, Working Paper (February 14, 2006) (available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=884233).

transformation; distance from the city center (*DCC*) and the other regressors are not transformed. The specification seems purely ad hoc.

Equation (2) is non-linear in the parameters and must be estimated by Non-Linear Least Squares ("NLS"). This specification is highly irregular in econometric practice. Normally, hedonic models of housing prices are estimated by Ordinary Least Squares ("OLS"). A regression model quite similar to Equation (2) and very common in hedonic analysis is,

$$\ln p_{i,t} = \delta_1 \ln D_i + \beta_0 + \sum_{j=2}^{k} \beta_j X_{j,i} + \upsilon_{i,t}, \qquad (3)$$

where the dependent variable is the natural log of price and where the *X*s might be transformed to logs as well.[21] While Equation (3) is typical of hedonic price functions, we are unable to find the estimation of Equation (2) anywhere in the literature. In fact, we were unable to locate a single instance where even the author of the *Hite Report* estimates a hedonic price function using Equation (2), but plenty of instances where Equation (3) is used.[22] As detailed later, a test of functional form can inform us as to whether the natural log transformation of the dependent variable is a better approach and infinitely more common.

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21 Note that Equation (3) is not simply the log transformation of Equation (2) because of the additive error term in Equation (2).

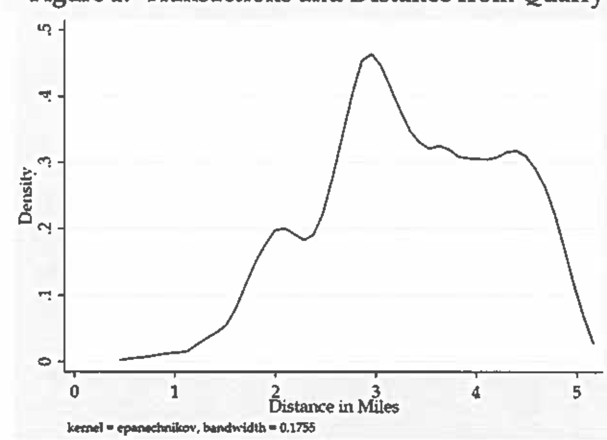
22 *See, e.g.*, D. Hite, W.S. Chern, F. Hitzhusen and A. Randall, *Property Value Impacts of an Environmental Disamenity*, 22 JOURNAL OF REAL ESTATE FINANCE AND ECONOMICS 185-202 (2010) (draft available at: https://ssrn.com/abstract=290292); D. Hite, A. Jauregui, B. Sohngen, and G. Traxler, *Open Space at the Rural-Urban Fringe: A Joint Spatial Hedonic Model of Developed and Undeveloped Land Values*, Working Paper (November 1, 2006) (available at: https://ssrn.com/abstract=916964); D.M. Brasington and D. Hite, *A Mixed Index Approach to Identifying Hedonic Price Models*, 38 REGIONAL SCIENCE AND URBAN ECONOMICS 271-284 2008 (August 5, 2006) (available at: https://ssrn.com/abstract=928252); E. Affuso, C. de Parisot, C. Ho, and D. Hite, *The Impact of Hazardous Wastes on Property Values: The Effect of Lead Pollution*, 22 URBANI IZZIV 117-126 (2010) (available at: https://ssrn.com/abstract=1427544); D. Hite, *Factors Influencing Convergence of Survey and Market-Based Values of an Environmental Disamenity*, Mississippi State University Agricultural Economics Working Paper No. 2001-011 (November 29, 2001) (available at: https://ssrn.com/abstract=292447); C. Ho and D. Hite, *Economic Impact of Environmental Health Risks on House Values in Southeast Region: A County-Level Analysis*, Working Paper (2005) (available at: https://ssrn.com/abstract=839211); D. Hite, *A Hedonic Model of Environmental Justice*, Working Paper (February 14, 2006) (available at: https://ssrn.com/abstract=884233).

The coefficient of primary interest in the *Hite Report* is δ_1, which measures the percent change in the transaction price for a percentage change in distance from the quarry (D), but only *after* the quarry operations began (see Eq. 1). In this specification (and also for Eq. 3), this elasticity is constant across the full range of distance. With data on 2,812 sales, the *Hite Report* estimates the coefficient δ_1 to be 0.125, where the positive sign indicates the average sale price of homes is higher the further away the homes are from the quarry (statistically significant at the 1% level). The *Hite Report* concludes, as do subsequent reports that adopt the result, that this positive coefficient implies quarries reduce the price of nearby homes. As detailed above, the positive sign on the coefficient δ_1 cannot reasonably be interpreted in this manner since the data is for sales occurring long after quarry operations began, among other concerns.

B. *National Lime & Stone Quarry in Delaware, Ohio*

Replication is the essence of science. Even if the estimated price-distance relationship from Equation (2) lacks a causal interpretation, it is worth evaluating whether the *Hite Report's* findings can be confirmed. We do so by estimating Equation (2) using data on 2,114 transactions in the same area over the period 1998-2007. Figure 1 offers the kernel density of the distribution of transactions by distance from the quarry. The thinness of the market very near the quarry is plain to see, which is also apparent from a map of the area surrounding the quarry (see Appendix 1).

Figure 1. Transactions and Distance from Quarry



Regression results from Equation (2) are summarized in the first column of Table 1, along with descriptive statistics for the full sample and the sample divided into homes closer to the quarry than two miles and those further than that distance. The model has a Pseudo-R^2 of 0.25, which is very close to that reported in the *Hite Report* (0.254).[23] Five of the seven estimated coefficients (including the constant term) are statistically different from zero at the 1% level or better.

Table 1. Regression Results and Descriptive Statistics
National Quarry near Delaware, Ohio

	Coef (t-stat)	Mean (St. Dev)	*N* = 0 Mean (St. Dev)	*N* = 1 Mean (St. Dev)
ln*D* (δ_1)	-0.1413***	1.166	1.227	0.518
	(-4.00)	(0.304)	(0.230)	(0.224)
DATE	0.0450***	2002.7	2002.5	2004.4
	(11.13)	(2.952)	(2.969)	(2.125)
DDC	0.0409***	2.876	2.859	3.050
	(5.92)	(2.139)	(2.207)	(1.207)
H2L	-0.102	0.1498	0.148	0.1668
	(-0.81)	(0.1110)	(0.111)	(0.102)
BATH	0.0419	1.806	1.788	1.995
	(1.09)	(0.584)	(0.597)	(0.384)
TOTR	0.1398***	5.099	5.065	5.099
	(7.59)	(1.016)	(1.031)	(1.016)
Constant	-85.71***	...	...	...
	(-10.57)			
Pseudo-R^2	0.250			
Obs.	2,114	2,114	1,930	184

Statistical Significance: *** 1%, ** 5%, * 10%

Despite using exactly the same regression model and data on sales around the same quarry, we find that the transaction prices of homes *decrease* (not increase) as the distance from the quarry increases. The negative coefficient (-0.141) is similar in size *but different in sign* from that found in the *Hite Report* (0.125) and is statistically significant at the 1% level. The estimated coefficient implies a 1% increase in distance reduces home average, quality-adjusted home prices by about 0.14%. Since the coefficient is less than unity, the price-distance relationship is subject to diminishing marginal returns.[24] Figure 2 illustrates the relationship

23 The Pseudo-R^2 is the squared correlation coefficient between the predicted value of the regression and the dependent variable.

24 For any fixed change in mileage, the percentage change falls as distance increases.

between sale prices and distance from the quarry, revealing sizable reductions in average prices as distance from the quarry increases.

Figure 2. Price-Distance Relationship

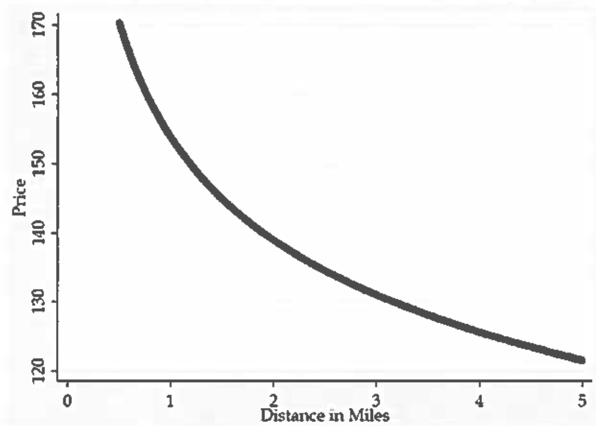


Table 2 summarizes the average predicted prices and price effects at varying distances from the quarry. Interpretation of the table is straightforward. A home sold 3 miles from the quarry will have a price 22% lower that of a home sold within 0.5 miles of the quarry, or 16% lower than the average home sold within 1.5 miles of the quarry. At two miles, the differences are 18% and 11%; at five miles, the differences are 28% and 22%. These are sizable effects.

Table 2. Home Values by Distance from Quarry

	Distance in Miles from Quarry							
	0.5	1.0	1.5	2.0	2.5	3	4.0	5.0
Avg. Price ('000)	169.8	153.9	145.4	139.6	135.2	131.8	126.5	122.6
Reduced Value (from 0.5 miles)	...	-9%	-14%	-18%	-20%	-22%	-25%	-28%
Reduced Value (from 1.5 miles)	...	...	...	-11%	-14%	-16%	-19%	-22%

These estimates and their predicted effect on prices are based on the estimation method (Eq. 2) used in the *Hite Report*. There are other equation specifications and estimation methods that are more consistent with standard practice in the analysis of housing prices (hedonics). In order to assess the robustness of the result, we offer alternative analyses below.

1. *Alternative Estimation Approaches*

As discussed above, Equation (2) is a non-standard method to estimate the relationship of interest. Normally, a researcher would avoid the non-linear Equation (2) and use the natural log of price to estimate Equation (3) by OLS. Statistical testing (such as the Box-Cox test of functional form) may be used to evaluate whether the linear or log-form of the dependent variable is preferred.[25] Other advantages of Equation (3) over Equation (2) is that the linear equation is amenable to estimation by Median Regression ("MReg") and Robust Regression ("RReg"), both of which are less sensitive to outliers in the data than is NLS or OLS.[26] Outliers are common in home sales data, so it is sensible to evaluate the effect on the estimates by these alternative estimation procedures, especially when the results are used in a policy relevant setting that may have significant financial implications.[27] We summarize the results from both methods.

Modern research on housing prices increasingly accounts for the spatial nature of real estate markets using new spatial methods.[28] We estimate the price-distance

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[25] W.E. Griffiths, R.C. Hill and G.G. Judge, LEARNING AND PRACTICING ECONOMETRICS (1993) at pp. 345-7.

[26] *See, e.g.*, R. Koenker, QUANTILE REGRESSION (2005); B.S. Cade and B.R. Noon, *A Gentle Introduction to Quantile Regression*, 1 FRONTIERS IN ECOLOGY AND THE ENVIRONMENT 412-420 (2004) (available at: http://www.econ.uiuc.edu/~roger/research/rq/QReco.pdf); O.O. John, *Robustness of Quantile Regression to Outliers*, 3 AMERICAN JOURNAL OF APPLIED MATHEMATICS AND STATISTICS 86-88 (2015); P.J. Rousseeux and A.M. Leroy, ROBUST REGRESSION AND OUTLIER DETECTION (2005); R. Andersen, MODERN METHODS FOR ROBUST REGRESSION (2008); T.P. Ryan, MODERN REGRESSION METHODS (2008).

[27] C. Janssen, B. Söderberg and J. Zhou, *Robust Estimation of Hedonic Models of Price and Income for Investment Property*, 19 JOURNAL OF PROPERTY INVESTMENT & FINANCE 342-360 (2001); S.C. Bourassa, E. Cantoni and M. Hoesli, *Robust Hedonic Price Indexes*, 9 INTERNATIONAL JOURNAL OF HOUSING MARKETS AND ANALYSIS 47-65 (2016).

[28] Including papers by the *Hite Report*'s author. *See, e.g.*, D.M. Brasington and D. Hite, *Demand for Environmental Quality: A Spatial Hedonic Analysis*, 35 REGIONAL SCIENCE AND URBAN ECONOMICS 57-82 (2005) (draft available at: https://ssrn.com/abstract=491244); *see also* J.M. Mueller and J.B. Loomis, *Spatial Dependence in Hedonic Property Models: Do Different Corrections for Spatial Dependence Result in Economically Significant Differences in Estimated Prices?*, 33 JOURNAL OF AGRICULTURAL AND RESOURCE ECONOMICS 212-231 (2008) (available at: http://ageconsearch.umn.edu/bitstream/42459/2/MuellerLoomis.pdf); L. Osland, *An Application of Spatial Econometrics in Relation to Hedonic House Price Modeling*, 32 JOURNAL OF REAL ESTATE

(Footnote Continued. . . .)

relationship using a Spatial Regression Model ("SReg"). To do so, a spatial weighting matrix (*W*) is computed and spatially-weighted lags of the dependent and independent variables are included in the regression as well as an adjustment for autocorrelated errors.[29]

Table 3. Alternative Estimation Methods
National Quarry near Delaware, Ohio

	OLS Coef (t-stat)	*MReg* Coef (t-stat)	*RReg* Coef (t-stat)	*SReg* Coef (t-stat)	*OLS-CEM* Coef (t-stat)
ln*D*	-0.2726***	-0.2021***	-0.1220***	-0.1558 ***	-0.147***
	(-7.31)	(-14.21)	(-5.59)	(-2.65)	(-3.00)
DATE	0.0433***	0.0342***	0.0367***	0.0440***	0.0453***
	(12.45)	(15.76)	(16.58)	(12.86)	(6.30)
DDC	0.0273***	0.0460***	0.0551***	0.0679***	0.0483***
	(3.90)	(8.64)	(15.00)	(5.09)	(3.31)
H2L	0.0794	-0.1131	-0.2591***	-0.1779	0.1812
	(0.68)	(-1.47)	(-3.74)	(-1.48)	(0.94)
BATH	0.0485	0.0997***	0.1499***	0.0166	-0.0092
	(1.46)	(5.41)	(7.94)	(0.56)	(-0.10)
TOTR	0.1540***	0.1523***	0.1508***	0.1497***	0.2047***
	(8.97)	(14.00)	(14.12)	(9.11)	(6.44)
Constant	-82.47***	-64.31***	-69.52***	-77.07***	-86.77***
	(-11.82)	(-14.80)	(-15.67)	(-11.25)	(-6.02)
Spatial Terms (χ^2)				242.3***	
Pseudo-R^2	0.246	0.216	0.243	0.265	0.214
Obs.	2,114	2,114	2,114	2,114	1,461

Statistical Significance: *** 1%, ** 5%, * 10%

RESEARCH 289-320 (2010) (available at: http://pages.jh.edu/jrer/papers/pdf/past/vol32n03/03.289_320.pdf).

[29] D.M. Drukker, H. Peng, I.R. Prucha, and R. Raciborski, *Creating and Managing Spatial-Weighting matrices with the* spmat *Command*, 13 STATA JOURNAL 242-286 (2013); D.M. Brasington and D. Hite, *Demand for Environmental Quality: A Spatial Hedonic Analysis*, 35 REGIONAL SCIENCE AND URBAN ECONOMICS 57-82 (2005) (draft available at: https://ssrn.com/abstract=491244). We truncate the distance at 0.5 miles.

(Footnote Continued. . . .)

Results for the alternative estimation methods are summarized in Table 3.[30] Across all four alternatives, the price-distance relationship is negative and statistically different from zero at the 1% level or better. Plainly, the negative price-distance relationship is robust to estimation method. The price-distance elasticity is a good bit larger for OLS and MReg, but similar to that estimated by Equation (2) for both the RReg and SReg methods (in the full sample). Note that more of the regressors are statistically significance in MReg and RReg, suggesting these estimation alternatives are worth consideration.

2. *Coarsened Exact Matching*

Thus far, we have paid no attention to whether homes near the quarry are like those far from the quarry (i.e., covariate overlap). What evidence is available in the *Hite Report* suggests that in her sample the types of homes sold near the quarry may have been be very different than those sold at a distance from it. While distance from the quarry is a continuous variable, we can consider covariate overlap by comparing the characteristics of homes near to and those far from the quarry, using a two-mile cutoff. In Table 1, we do observe some meaningful differences between homes within two miles of the quarry and those further away especially in the year sold and the number of bathrooms and total rooms.[31] To ensure we are comparing like homes, we apply Coarsened Exact Matching ("CEM") to the data and match on these three variables.[32] All 184 transactions within two miles of the quarry are matched to 1,277 (of 1,930) homes further than

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30 The Box-Cox test statistic for the Delaware County data is 64.1, which is statistically significant at better than the 1% level. The test statistic is distributed $\chi^2(1)$ with a critical value of 2.71 at the 10% level. The natural log transformation, consistent with Equation (3), is preferred to the specification estimated in the *Hite Report*. Or, we might say the problem is not so much in the estimation by NLS rather than OLS but that the natural log transformation of the dependent variable is the better specification.

31 Standardized differences (the absolute value of the means difference divided by the square root of the summed variances) are used. *See* Imbens and Wooldridge, *supra* n. 8 at p. 24. The rule of thumb for a large difference is a standardized difference exceeding 0.25. For the DATE variable, the standardized difference is 0.51, and about 0.30 for bathrooms and total rooms.

32 S.M. Iacus, G. King. G. Porro, *Causal Inference without Balance Checking: Coarsened Exact Matching*, Working Paper (June 26, 2008) (available at: https://ssrn.com/abstract=1152391), later published *Causal Inference without Balance Checking: Coarsened Exact Matching*, 20 POLITICAL ANALYSIS 1-24 (2012) (available at: https://gking.harvard.edu/files/political_analysis-2011-iacus-pan_mpr013.pdf).

(Footnote Continued. . . .)

two miles from the quarry. The weights created by the CEM procedure are then used to estimate Equation (3) by weighted OLS.

Results for the CEM-weighted regression are reported in the final column of Table 3. The estimated coefficients are comparable in most respects to the other models.[33] Most significantly, the price-distance relationship remains negative (-0.147) and statistically different from zero. While we do not present the results in the table, we note that when estimated using the non-linear Equation (2) with CEM-weighted data the price-distance relationship is negative (-0.053) but not statistically significant, a difference we will return to later.

C. *Rogers Group Quarry near Murfreesboro, Tennessee*

It is reasonable to expect that the relationship of home prices to distance from a quarry might vary by location. Earlier research suggests this is so in other contexts.[34] To further evaluate the results reported in the *Hite Report*, we collect data on home sales around the Rogers Group Quarry near Murfreesboro, Tennessee.[35] Transaction data is again collected for years 1998 through 2007 and the sample includes 2,311 transactions. Given differences in data availability, we replace the total number of rooms with square footage (*SQFT*). Distance from the city center (*DCC*) is measured from Murfreesboro. We apply the same methods as before, estimating Equation (2) by NLS and then Equation (3) by OLS, MReg, RReg, and SReg. Results are summarized in Table 4. We do not observe large differences between the characteristics of home sold near to and far from the quarry, so we do not apply CEM for this quarry.

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33 CEM-weighting often alters the coefficients and their significant levels since the data is better matched.

34 *See supra* n. 7 and citations therein.

35 The quarry is located at coordinates: 35.884699, -86.530625.

Table 4. Regression Results and Descriptive Statistics
Rogers Quarry near Murfreesboro, Tennessee

	NLS Coef (t-stat)	*OLS* Coef (t-stat)	*MReg* Coef (t-stat)	*RReg* Coef (t-stat)	*SReg* Coef (t-stat)
ln*D*	-0.0655***	-0.0383***	-0.0320***	-0.0327***	-0.0222
	(-4.99)	(-2.63)	(-3.01)	(-3.78)	(-0.72)
DATE	0.0522***	0.0443***	0.0407***	0.0404***	0.0444
	(27.09)	(20.36)	(31.73)	(35.55)	(23.05)
DDC	-0.0035*	-0.0006	-0.0007	-0.0011	-0.0012
	(1.85)	(-0.26)	(-0.44)	(-0.84)	(-0.15)
H2L	-0.6590	0.6404	-2.170***	-2.676***	0.3311
	(-1.11)	(0.42)	(-4.47)	(-5.84)	(0.42)
BATH	0.1395***	0.1666***	0.1811***	0.1759***	0.1344***
	(17.65)	(13.44)	(24.06)	(28.87)	(12.17)
SQFT	0.00026***	0.00021***	0.00032***	0.00033***	0.00018***
	(17.40)	(5.82)	(25.01)	(29.27)	(9.10)
Constant	-100.3***	-84.59***	-77.57***	-76.87***	-77.84***
	(-17.40)	(-19.52)	(-30.57)	(-33.79)	(-20.17)
Spatial Terms (χ^2)					385.2***
Pseudo-R^2	0.692	0.590	0.529	0.678	0.605
Obs.	2,311	2,311	2,311	2,311	2,311

Statistical Significance: *** 1%, ** 5%, * 10%

The fit the regressions (R^2 is around 0.60) is much higher than for the Delaware data, but the negative coefficients on distance are seen again. For the NLS model, the price-distance relationship is -0.0655 and the coefficient is statistically different from zero at better than the 1% level. Across the alternative specifications and estimation methods, the price-distance relationship is consistently negative and statistically different from zero, save one exception. Only in spatial regression is the price-distance relationship not statistically significant, though the coefficient is negative and similarly sized to the other models.

Additional evidence also leads to questions about the negative views of quarries. If quarries were a disamenity, then we might expect people to avoid living around them. Figures 3A-3C in Appendix 3 demonstrate population movements for Rutherford County, Tennessee, with emphasis on the Rogers Group quarry. Population is measured using U.S. Census Bureau population data for years 1990, 2000, and 2010. These figures show population density increasing dramatically over this time period in the same census block as the Rogers Group quarry. These population movements toward the quarry in conjunction with the econometric results further indicate the Murfreesboro quarry is not a great disamenity, if a disamenity at all.

D. *Randomized Inference and the Implausibility of the Model*

Our analyses of home prices near the quarries in Delaware, Ohio, and Murfreesboro, Tennessee, find a negative and statistically significant relationship between home prices and distance from a rock quarry in most specifications and estimation methods. Consequently, we find no evidence that supports the findings of the *Hite Report*, despite using the same model and, in one instance, the same quarry from that earlier study. We fear, however, that these estimated relationships are mainly the consequence of the *Hite Report*'s poor experimental design than they are a measure of any real effect of the quarry. Indeed, we question whether the quantification of the effect of a disamenity or amenity can be plausibly estimated by a price-distance relationship. In Delaware County, for instance, it is not hard to find a statistically-significant price-distance relationship (using Eq. 2) from just about anywhere: the Church of the Nazarene off Highway 101 ($\delta_1 = -0.058$, $t = -2.79$); The Greater Gouda gourmet grocery on North Sandusky Road ($\delta_1 = 0.268$, $t = 6.92$); and the Foot & Ankle Wellness Center off South Hook Road ($\delta_1 = -0.043$, $t = -2.99$).

Given patterns in real estate development, it seems plausible that a positive or negative price-distance relationship would be observed from almost any location. A sensible way to evaluate the reliability of the distance-based hedonic regressions is to apply the method of randomized inference (a type of pseudo-treatment).[36] In this procedure, the location of a "disamenity" or "amenity" is randomly chosen in the geographic area under study. Given the random assignment of location, we might expect the price-distance relationship to be statistically significant in proportion to the alpha-level of the statistical test (say, a 10% significance level) due to random variation. That is, a valid statistical test conducted at the 10% level

[36] R.A. Fisher, THE DESIGN OF EXPERIMENTS (1935); P.R. Rosenbaum, OBSERVATIONAL STUDIES (2002); M.D. Cattaneo, B.R. Frandsen, and R. Titiunik, *Randomization Inference in the Regression Discontinuity Design: An Application to Party Advantages in the U.S. Senate*, 3 JOURNAL OF CAUSAL INFERENCE 1–24 (2015); T. Fujiwara and L. Wantchekon, *Can Informed Public Deliberation Overcome Clientelism? Experimental Evidence from Benin*, 5 AMERICAN ECONOMIC JOURNAL: APPLIED ECONOMICS 241–255 (2013).

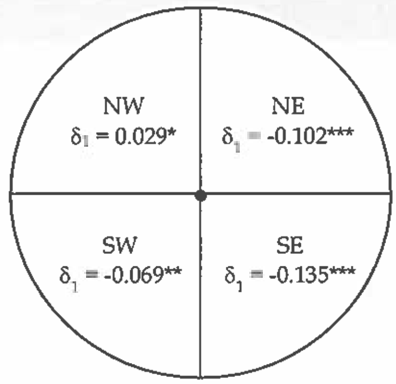
will reject the null hypothesis 10% of the time even if the null is true (e.g., Type I error).

We conduct such tests using the following simulation. First, a random location (latitude, longitude) within the Delaware area is chosen (see Appendix 4 for an illustration of the process). Second, the distances from this location to all home sales is computed. Third, we replace in the regression model the variable measuring distance from the quarry (D) with this alternate distance measure (D'). Fourth, we estimate a regression of price on the same variables as above, obtaining the coefficient, t-statistic and its probability on δ_1. Fifth, this process is repeated 1,000 times. Finally, from these 1,000 simulations, we can compute how often the null hypothesis of "no effect" is rejected.

At the threshold significance level of 10%, the null hypothesis is rejected in a whopping 67% of the simulations for the data from Delaware County, sometimes with positive and sometimes negative coefficients. Conducting the same simulation for Murfreesboro, the rejection rate is an even larger 93%. Given the random selection of locations in the simulation, this result is a powerful indictment against the sort of model employed in the *Hite Report*. A researcher may pick just about any location and find a statistically-significant price-distance relationship. We conclude based on this analysis that the addition of a distance variable to a hedonic model in an effort to identify the effect of a quarry on home prices is a poor experimental design with grossly inaccurate inference tests, especially when using asymptotic critical values for hypothesis testing and only data on post-operation transactions. In fact, we suspect many of the hedonic studies using distance from disamenities may be similarly unable to identify an effect of interest, but leave that question to future research.

Another problem with estimating the price-distance relationship is that unlike square footage, distance from a quarry is not unidimensional but occurs on a coordinate plane. A house may be located to the east or to the west, to the north or to the south, of a quarry, and moving closer to or away from the town center, a university, a landfill, or any other site that may influence prices. To see this, we divide the transaction data near Murfreesboro into four quadrants around the quarry (northeast, northwest, southeast, and southwest) and estimate a price-distance relationship unique to each quadrant (using Eq. 2). Results are summarized in Figure 3.

Figure 3. Price-Distance Relationship
Quadrants around Murfreesboro Quarry



From Figure 3, we see that the price-distance relationships are not equal across quadrants but rather differ substantially by the direction of the movement away from the quarry. From Table 4, we know that the average price-distance relationship from this quarry is negative (and statistically significant). Yet, from Figure 3, we see that the price-distance relationship is positive in the Northwest quadrant, but negative in all other quadrants. All the estimated price-distance relationships are statistically different from zero at the 10% level or better. It appears, therefore, that there is no "price-distance relationship" but many "price-distance relationships" from any given site. We believe these results are more evidence of the spurious nature of the price-distance relationship estimated using hedonic models of housing prices.

In light of our randomized inference procedure and additional evidence, we conclude, for now, that the type of model and experimental design used in the *Hite Report* is entirely unsuited to the task of identifying the price impact of quarries. Our results from replication efforts, which consistently find a negative price-distance relationship, are no less implicated by the defect than those of the *Hite Report*. Identifying the effects of quarries on housing prices requires a different experimental design, and careful attention to selection bias, covariate overlap, and the numerous ramifications of thin markets around the site. We attempt to offer some better evidence below.

E. *Spurious Regression and the Search for Results*

In light of the evidence that a statistically significant price-distance relationship is found for no less than seven-out-of-ten randomly chosen locations, we conclude the *Hite Report's* experimental design is incapable of quantifying the effect of quarries on house prices. The results from such models are spurious. Consequently, we expect that the price-distance relationship will be sometimes positive, sometimes negative, sometimes statistically significant and sometimes not for any given quarry. Statistical significance is the flip of a coin heavily weighted toward the rejection of the null hypothesis. Our analysis also shows that the choice of estimation method may alter the estimated coefficient and its significance, a common trait of spurious regression.

The fact different quarries and different estimation methods produce different results advises caution in conducting and assessing such studies, especially in a policy-relevant context when economic development is at stake. Inference errors may be inadvertent, or an advocate may exploit the spurious nature of the relationship by searching for a location, model specification, and time period to produce an outcome supporting a favored policy position. We can demonstrate the risks of such an ends-driven search by looking at more recent data for Delaware, Ohio, using data on prices for the five-year period 2012 through 2016 (1,429 transactions). The models and variables are measured in the same way as above.

Table 5 summarizes the results from a few estimation methods. For expositional purposes, we present only on the price-distance relationship. Using the unconventional Equation (2) from the *Hite Report*, we find that the price-distance relationship for this period is positive—a statistically significant result (by asymptotic convention). The result is opposite of that estimated for the data from the 1998-2007 period, even though the location is the same. Without any constraint on the choice of time period to analyze, an unscrupulous advocate is free to choose data from different periods in search of results to support his or her position.

Table 5. Results Delaware Quarry, Years '12-16

	NLS Coef (t-stat)	*OLS* Coef (t-stat)	*MReg* Coef (t-stat)	*RReg* Coef (t-stat)	*SReg* Coef (t-stat)
ln*D*	0.1285***	0.0192	-0.0065	0.0412	0.0780
	(3.45)	(0.52)	(-0.32)	(1.63)	(1.10)
Spatial Terms (χ^2)					41.28***
Pseudo-R^2	0.392	0.332	0.263	0.377	0.347
Obs.	1,429	1,429	1,429	1,429	1,429

Statistical Significance: *** 1%, ** 5%, * 10%

Model selection and variable choice may also be used in an ends-drive search for results. As shown in Table 5, estimating Equation (3), a standard functional form for hedonic regressions, the positive coefficient is now a sixth the size of that estimated by Equation (2) and is no longer statistically different from zero at standard levels.[37] Also, Median, Robust and Spatial Regression do not find statistically significant price-distance relationships. In fact, the only model that produces a statistically-significant positive effect is the non-standard regression equation used in the *Hite Report*. Moreover, if we replace the *TOTR* variable with the *SQFT* variable in the NLS model, the price-distance relationship shrinks to 0.02 (one-sixth the size) and the coefficient is no longer statistically significant. Again, a researcher may pick-and-choose model specification, along with time period analyzed and regressors, to obtain a desired result. Skepticism is warranted for any analysis of the price effects of quarries (and amenities or disamenities generally) absent robustness analysis across time and model specifications.

Table 6. Results Delaware Quarry, Years '98-07 & '12-16

	NLS Coef (t-stat)	*OLS* Coef (t-stat)	*MReg* Coef (t-stat)	*RReg* Coef (t-stat)	*SReg* Coef (t-stat)
ln*D*	0.10028	-0.1361***	-0.0963***	-0.0501***	-0.1059**
	(0.11)	(-5.04)	(-6.33)	(-2.89)	(-2.10)
Spatial Terms (χ^2)					41.28***
Pseudo-R^2	0.302	0.262	0.219	0.288	0.151
Obs.	3,543	3,543	3,543	3,543	3,543

Statistical Significance: *** 1%, ** 5%, * 10%

As another check on robustness (or a lack thereof), we combine the data from 1998-2007 and 2012-2016, excluding those years when the housing market and economy generally were in turmoil (2008-2011). Results on the price-distance relationship are summarized in Table 6. Now, Equation (2) estimated by NLS reports a statistically insignificant (but positive) coefficient for the price-distance relationship. The other estimation methods, however, all confirm the negative and statistically significant relationship consistent with the results in Tables 1 and 3. It appears, therefore, whether or not quarries affect prices hinges on model selection and dates selected, which simply demonstrates the spurious nature of these sorts of experiments. Plainly, care must be given to model selection, and robustness analysis should be thorough and explicit. And, in light of the randomized

[37] The Box-Cox test indicates a preference for the transformation ($\chi^2 = 40.7$).

inference and quadrant analysis above, the utility of the price-distance relationship for quantifying the effects of quarries and disamenities should be regarded as defective, at least until further research demonstrates otherwise.

The analyses presented here, we believe, offers compelling evidence that the *Hite Report*'s experimental design is a flimsy method, easily manipulated to produce nearly any desired result through the selection of location, model specification, estimation technique, and the time period analyzed. The *Hite Report*'s findings cannot be reliably replicated and conflicting results are readily obtained. The spurious nature of the price-distance relationship from such experiments is clearly demonstrated, and the defective approach allows for nearly any result imaginable. Using data long after a quarry opens poses no limits on the selection of time period, enhancing the risk of the exploitation of spurious regression for economic and political advantage.

IV. A Difference-in-Difference Approach

As detailed above, to quantify the effect of a quarry on home prices the researcher ideally needs pricing data both before and after quarry operations begin.[38] With this data, statistical analysis can determine how the relationship between price and distance from the quarry *changes* after the quarry opens, thus quantifying, under some well-known assumptions, a plausible causal effect.

There are some potential shortcomings with a simple before-and-after analysis, however. New quarries take years to get approval and normally we expect equity prices to reflect new information quickly, so price effects may precede that event. In this section, we offer two before-and-after analyses of the effect of a quarry on home prices. First, we evaluate pricing activity around the Vulcan quarry in Gurley, Alabama, which began operations in 2013. Gurley is a rural area not far from the city of Huntsville, Alabama. Consistent with the analysis above, we use the general format of the *Hite Report* (and several

[38] Another possible identification strategy involves exploiting policy experiments with respect to residential distance from a quarry. For example, if some states required houses to be a certain distance away from a quarry while other states did not, then a credible counter-factual could be constructed allowing the researcher to estimate the effect of quarry distance on home prices. A regression discontinuity design could be used to identify the price-distance relationship if regulations required potential home buyers to be informed of the quarry for homes within a certain distance. Homes just inside and just outside this cut-point would could be used as treatment and control units to identify the causal price-distance relationship.

(Footnote Continued. . . .)

alternatives) to test for a *change* in the price-distance relationship after the quarry opens.

Second, we evaluate the price effects of the contested Austin Quarry in Madera, California, which was approved in 2016.[39] Located in the southwest corner of the intersection of Highway 41 and Highway 145, the site is proximate to two subdivisions, one located on Highway 145 and the other on Highway 41. Thus, not only are the subdivisions proximate to the quarry, but both are expected to deal regularly with the quarry's traffic flow. Though first proposed in 2010, media coverage and public protest did not begin until 2013, at which time the new quarry might be expected to affect home prices through an announcement effect.[40] A control group is chosen using CEM from homes sales in subdivisions not too far from the quarry site but beyond the range of influence. We find no statistically significant effect of the quarry in either model, though in both cases the estimated coefficients indicate, if anything, the quarry raises property values.

A. *The Empirical Model*

For these analyses, we employ the standard regression model for the DiD estimator. Using a log-linear form common to hedonic regressions, the regression equation is,

$$\ln p_{it} = \Delta T \cdot N_i + \delta_0 N_i + \beta_0 + \sum_{j=2}^{k} \beta_j X_{j,i} + \upsilon_{it} \,, \tag{4}$$

where T is dummy variable equal to 1.0 after the treatment and N_i is a dummy variable for homes near the quarry site (or a continuous measure of distance from the quarry). The estimated coefficient δ_0 measures the difference in average sale prices for homes near the quarry (or the effect of distance from it) *prior to the treatment*. After the treatment, the difference in price between homes near and far from the quarry is $\Delta + \delta_0$. The difference between the two effects is Δ, which is the DiD estimator, as defined in Equation (1), or $\Delta = \delta_1 - \delta_0$. The t-test on the coefficient

39 J. Rieping, *Controversial Quarry Up for Vote*, MADERA TRIBUTE (July 16, 2016) (available at: http://www.maderatribune.com/single-post/2016/07/16/Controversial-quarry-up-for-vote); M.E. Smith, *Austin Quarry Approved in 3-2 Vote*, SIERRA STAR (July 20, 2016) (available at: http://www.sierrastar.com/latest-news/article90713132.html).

40 Lexus-Nexus search conducted on February 20, 2018. B. Wilkinson, *Concerns Over Truck Traffic on Road*, SIERRA STAR (February 21, 2013).

Δ is, therefore, a direct test of the statistical significance of the effect of a quarry on home prices.

As an alternative, we estimate,

$$\ln p_{it} = \Delta T \cdot N_i + \beta_0 + \sum_{j=2}^{k} \beta_j X_{j,i} + \lambda_t + \nu_{it} \ , \tag{5}$$

where the continuous *DATE* variable is replaced with year fixed effects (λ_t), which is a somewhat standard treatment of time in the DiD regression. Due to collinearity with the fixed effects, the $\delta_0 N$ term is no longer included in the regression, but the interpretation of Δ is unchanged.

For consistency with the earlier analysis, we also estimate the model specification of the *Hite Report*, adding as a regressor the interaction of a treatment dummy variable for years 2013 and later (*T*). The regression model is,

$$p_{it} = \exp(\delta_0 \ln D_i + \Delta \ln T \cdot D_i + \beta_0 + \sum_{j=2}^{k} \beta_j X_{j,i}) + \varepsilon_{it} \ , \tag{6}$$

where the variables are defined the same way as the Murfreesboro analysis (i.e., total rooms is replaced with square footage). The coefficient δ_0 quantifies the price-distance relationship prior to the initiation of quarry operations in 2013. Starting in 2013, the price-distance relationship is measured by $\delta_0 + \Delta = \delta_1$, where Δ measures the *change* in the slope of the price-distance relationship. If the quarry reduces home values near the quarry, then Δ should be positive and statistically significant. Equation (6) is estimated by NLS.

B. *Vulcan Quarry in Gurley, Alabama*

As with the earlier analysis, data is obtained on home sales within a five-mile radius of the quarry location in Gurley, Alabama. The quarry began operations in 2013, and our data spans 2005 through portions of 2017. The sample includes 593 transactions, but we note only 83 are for sales prior to 2013.[41] Since there is no "city

[41] The low samples are likely the consequence of the rural nature of the market and data collection in such areas. We cannot exclude the possibility the sample is peculiar in some respect.

center" in the area, the *DCC* variable is measured as the distance from the WalMart Supercenter in the nearby town of Big Cove.

Table 7. Regression Results and Descriptive Statistics
Vulcan Quarry in Gurley, Alabama

	NLS-Eq. 6 Coef (t-stat)	*OLS-Eq. 4* Coef (t-stat)	*OLS-Eq. 5* Coef (t-stat)	Mean (St. Dev)
ln*D*	0.0876	0.2723***	0.3679**	3.445
	(0.97)	(3.64)	(2.20)	(0.987)
T·ln*D*	-0.1205**	-0.0543	-0.1587	2.936
	(-2.41)	(-1.07)	(-0.88)	(1.50)
DATE	0.0162*	0.0191*	…	2014.1
	(1.67)	(1.85)		(2.30)
DDC	-0.0456***	-0.0529***	-0.0512***	4.484
	(-5.85)	(-5.99)	(-5.80)	(2.27)
H2L	-1.2185	-0.2457	0.1868	0.063
	(-0.79)	(-0.11)	(0.08)	(0.029)
BATH	0.1752***	0.2672***	0.2655***	2.875
	(6.92)	(8.84)	(8.71)	(0.932)
SQFT	2.2E-04***	2.0E-04***	1.9E-04***	2,870.3
	(5.97)	(3.22)	(3.11)	(1,139.8)
Constant	-27.99	-27.57	10.61***	…
	(-1.43)	(-1.32)	(36.57)	
λ_t	No	No	Yes	…
Pseudo-R^2	0.641	0.602	0.608	…
Obs.	593	593	593	593

Statistical Significance: *** 1%, ** 5%, * 10%

Results are summarized in Table 7.[42] Many of the coefficients are statistically significant and similar to those estimated using the Murfreesboro data. First, for Equation (6) estimated by NLS, we find that housing prices rise as distance from the quarry increases (the coefficient on ln*D* is positive), but this positive effect is observed *prior to the beginning of quarry operations*. After the quarry opens, the positive (though statistically insignificant) price-distance relationship is attenuated; the estimated Δ coefficient is -0.103 and the null hypothesis of "no effect" for the DiD estimator is rejected at the 5% level. Prior to 2013, the price-

42 Since we do not observe large differences in the characteristics of homes near to and far from the quarry, we do not apply CEM.

distance elasticity is 0.088 (δ_0), but after 2013 it is -0.033 (δ_1), a small effect that is statistically indistinguishable from zero (F-stat = 0.16, prob = 0.69).

Turning to Equation (4), the price-distance relationship is again positive (and much larger than with NLS) but is now statistically significant prior to the beginning of quarry operations. The Δ coefficient is -0.054, which while negative is no longer statistically different from zero at standard levels. The positive price-distance relationship is attenuated after the quarry began operating, but not to a statistically significant degree. The results are similar for Equation (5). Though not summarized in the table, we note that for MReg and RReg neither of the quarry-distance coefficients is statistically different from zero. The SReg results, also not presented in the table, are not wholly unlike the OLS estimates of Equation (4); the coefficient δ_0 is positive (0.331, t = 4.45) and statistically significant, but the Δ coefficient is negative (-0.055, t = 0.98) and not statistically different from zero.

The lack of robustness to specification leads us to conclude that the most likely effect of the quarry is no effect at all. Also, we acknowledge that the defects in the *Hite Report*'s empirical strategy is as relevant here as before: our randomized inference simulation computes a rejection rate on δ_0 of 65% and for Δ of 67% (at a nominal 10% significance level). While we recognize the limitations of the data and the methods, on whole the results are entirely at odds with the claim that quarries reduce housing prices. If anything, the effect is the opposite.

C. *Austin Quarry in Madera County, California*

Quarry sites often take years for approval. Our model of the Gurley quarry presumed that prices do not reflect the quarry operations until after the quarry is operational. A reasonable argument may be made, however, that home prices might adjust before the quarry opens when the local population becomes aware of the future quarry site. We consider that possibility now.

The Austin Quarry in Madera, California, was approved in September 2016 despite a substantial NIMBY effort.[43] A search of news outlets reveals that public attention to proposed quarry initiated in early 2013 and was very active is

43 M. Smith, *Supervisors Approve Austin Quarry 3-2*, SIERRA STAR (September 12, 2016) (available at: http://www.sierrastar.com/news/local/article101492412.html).

(Footnote Continued. . . .)

subsequent years.[44] Thus, we define the treatment dummy *T* as having values of one in years after 2013 (and also consider other years). Data is collected for the ten years preceding the treatment date, so the data spans 2007 through 2016.

The Austin Quarry site is well outside of town, but there are two subdivisions proximate (less than three miles) to the site: Bonadelle Racheros-Madera Ranchos and Bonadelle Rancheros Nine. Both subdivisions abut the major highways (Highways 41 and 145) servicing the quarry site. If any homes are to be affected by the quarry, then these are the most likely candidates, and they represent our treatment group. The dummy variable *N* takes a value of 1 for these subdivisions (zero otherwise). Visual inspection of the area points to a number of subdivisions in the vicinity that are neither on the major highways serving the site nor within ten miles of the site: Madera Estates, Madera Country Club, Lake Madera Country Club, Chuk Chanse, Valley Lake Ranchos, Madera Acres, Madera Knolls, and Madera Highlands. A control group will be selected from home sales in these subdivisions.

Estimation of the DiD estimator employs Equation (5). Regressors include the age of the home at the sale data (*AGE*), square footage (*SQFT*), the number of bedrooms (*BED*) and bathrooms (*BATH*), a dummy variable indicating whether the home a two story home (*STRY*), a dummy variable indicating the presence of a fireplace (*FIRE*), a dummy variable indicating whether the home has a swimming pool (*POOL*). Year fixed effects are included.

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[44] B. Wilkinson, *Concerns Over Truck Traffic on Road*, SIERRA STAR (February 32, 2013); G. Smith, *Economic Costs and Benefits of the Proposed Austin Quarry in Madera County* (October 23, 2014) (available at: http://www.noaustinquarry.org/wp-content/uploads/2016/08/Austin-Quarry-Economics-Report.pdf); M.E. Smith, *Progress Continues on Austin Quarry*, SIERRA STAR (February 10, 2016) (available at: http://www.sierrastar.com/news/article87816032.html); B. Wilkinson, *Group Opposes Proposed Rock Quarry*, SIERRA STAR (November 12, 2014) (available at: http://www.sierrastar.com/news/article87802492.html); D. Joseph, *Quarry Issues Need to be Addressed*, SIERRA STAR (December 3, 2014) (available at: http://www.sierrastar.com/opinion/article87803072.html).

Table 8. Descriptive Statistics
Austin Quarry in Madera County, California

Variable	ALL Mean (St.Dev)	*N*=0 Mean (St.Dev)	*N*=1 Mean (St.Dev)	Stan. Diff.
AGE	16.13	16.50	15.21	0.075
	(12.16)	(12.22)	(11.95)	
SQFT	1811.6	1706.7	2072.9	0.518*
	(522.7)	(490.6)	(509.5)	
BED	3.32	3.27	3.43	0.179
	(0.59)	(0.54)	(0.70)	
BATH	1.99	1.83	2.38	0.639*
	(0.68)	(0.66)	(0.56)	
STRY	0.024	0.016	0.043	0.115
	(0.15)	(0.12)	(0.20)	
FIRE	0.632	0.730	0.390	0.515*
	(0.48)	(0.44)	(0.49)	
POOL	0.068	0.033	0.159	0.311*
	(0.25)	(0.17)	(0.36)	
Price	215.4	195.0	266.3	
Price/*SQFT*	120.8	116.4	131.9	
Obs.	887	633	254	

Descriptive statistics for the treatment and control pool are provided in Table 8. The homes are similar in some respects, but large standardized differences (> 0.25) are found for square footage, the number of bathrooms, and the presence of a fireplace or pool.[45] CEM based on *SQFT*, *BATH*, *FIRE*, and *POOL* reduces the standardized differences to acceptable levels for all the regressors. We are able to match 229 of 254 homes in the treated group to 450 of 633 homes in the control pool, for an estimation sample of 679 home sales.

45 Imbens and Wooldridge, *supra* n. 8.

Table 9. Regression Results and Descriptive Statistics
Austin Quarry in Madera County, California

	OLS Coef (t-stat)	*CEM-OLS* Coef (t-stat)	*CEM-MReg* Coef (t-stat)	*SReg* Coef (t-stat)
N (δ_0)	0.1166**	0.1277**	0.1194***	0.1913**
	(2.47)	(2.08)	(4.99)	(2.11)
T·N (Δ)	0.1663***	0.1005	0.1161***	0.0878
	(2.95)	(1.21)	(3.14)	(1.32)
AGE	0.0017	0.0087***	-0.0003	-0.0055*
	(1.20)	(3.47)	(-0.35)	(-0.35)
SQFT	1.7E-04***	1.3E-04**	3.0E-04***	2.0 E-04***
	(3.40)	(2.05)	(12.68)	(4.39)
BED	0.0349	0.01205***	0.0450**	-0.0542
	(0.90)	(2.63)	(2.49)	(1.54)
BATH	0.0288	-0.0439	-0.0777***	-0.0218
	(1.08)	(-0.60)	(-2.60)	(-0.61)
STRY	-0.0878	-0.0408	0.0043	-0.1378
	(-0.70)	(-0.33)	(0.05)	(-1.29)
FIRE	0.0770**	0.0650*	0.0422***	0.0305
	(2.43)	(1.73)	(2.94)	(0.88)
POOL	0.1833***	0.1577***	0.0853***	0.2346***
	(3.71)	(4.03)	(3.68)	(3.63)
Constant	11.21***	10.92***	11.35***	11.62***
	(98.08)	(70.30)	(20.67)	(83.17)
λ_t	Yes	Yes	Yes	Yes
Spatial Terms (χ^2)				27.17***
Pseudo-R^2	0.482	0.491	0.361	0.186
Obs.	887	679	679	887

Statistical Significance: *** 1%, ** 5%, * 10%

Regression results are summarized in Table 9. For comparison purposes and to illustrate the important effects of covariate balance, estimates for both the full and CEM-weighted samples are provided. The models fit the data well for both samples. For the full sample, which we caution does not rely on balanced data, the estimated δ_0 coefficient (0.117) indicates that prices in the treated group were about 12% higher [exp(δ_0) - 1] in the pre-treatment period. After the treatment, the prices were even higher (Δ = 0.166), a statistically significant result of about an 18% increase. The remaining coefficients are sensibly sized and many are statistically different from zero. A swimming pool, for instance, raises price by about $38,000.

Turning to the CEM-weighted model, the price difference before the treatment is a bit larger (δ_0 = 0.128), and the difference is statistically significant at standard levels. As in the full sample, the DiD estimator Δ is positive (0.100), but now it is not statistically significant. For the balanced sample, we cannot reject the null hypothesis that the quarry's announcement effect is zero, though the coefficient is relatively large and the t-statistic is much larger than 1.00. In contrast, for the CEM-weighted MReg, prices are higher in the treated area during both the pre-treatment and treatment period, and both coefficients are statistically different from zero at better than the 1% level.

In the final column of Table 9, we summarize the results from SReg using the full sample. The spatial terms are statistically significant at the 1% level. The results are comparable to the others. Prices are higher in the treated area before the treatment, but we do not see a statistically significant change is seen after the treatment. The DiD estimator Δ is positive and relatively large (0.09), but statistically significant only at the 20% level.

Table 10. Regression Results, Annual Treatment Effect
Austin Quarry in Madera County, California

	2013 Coef (t-stat)	2014 Coef (t-stat)	2015 Coef (t-stat)	2016 Coef (t-stat)
$T{\cdot}N$ (Δ)	0.2721*** (2.65)	0.0018 (0.01)	0.0322 (0.42)	0.3949 (1.41)

Statistical Significance: *** 1%, ** 5%, * 10%

Finally, we can estimate the Δ coefficient for each year beginning with our chosen treatment date (2013), thereby assessing whether that choice is influencing the estimate.[46] The results by year are summarized in Table 10. Large positive coefficients are observed in years 2013 and 2016 (the latter close to being statistically significant), and smaller positive coefficients for the other years. These results are consistent with those reported in Table 9.

Notably, we do not estimate a price-distance relationship in these equations. Distance from the quarry site is not a regressor. Unlike the distance-based model, the rejection rates for randomized inference (assigning the homes in the treatment group randomly from those in the sample) are very close to the nominal level of the test (11% rejection rate versus 10% nominal test level). The statistical reliability

46 The coefficients are year specific and do not quantify the average after the treatment year, as do the results from Table 9.

of this approach is much superior to the price-distance approach used in the *Hite Report*.

Taken together, we conclude from these results indicate that the effect of the quarry may very well be zero, at least in the form of an announcement effect. If there is any effect, it is positive. Whether or not the quarry will affect prices, either positively or negatively, after operations begin (assuming they do) is unknowable at this time. In light of the evidence presented here and in prior research, the expectation must be that there will be little to no effect on home prices and, if anything, that effect may be positive.

V. Conclusions

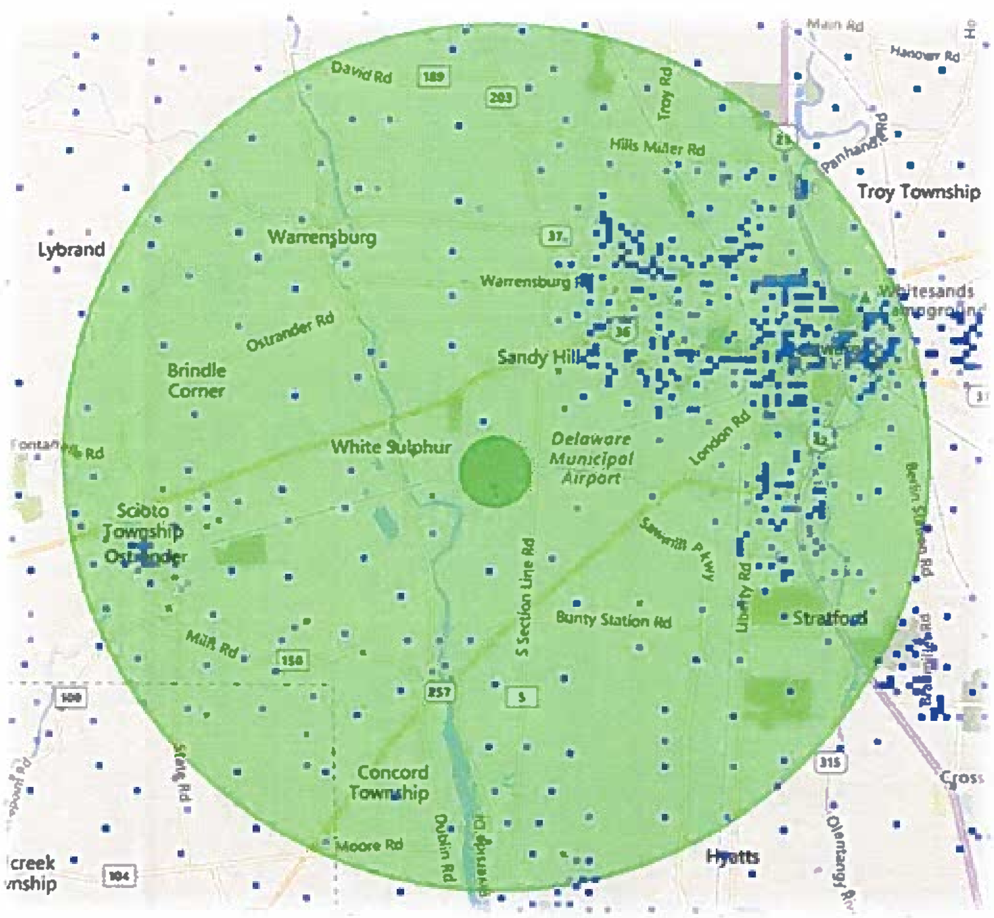
We estimate the effect of rock quarries on home prices with data from four quarry locations across the United States, a wide range of econometric specifications and robustness checks, and a variety of temporal circumstances from the lead-up to quarry installation to subsequent operational periods. We find no compelling statistical evidence that either the anticipation of, or the ongoing operation of, rock quarries negatively impact home prices. While our study extends the literature on estimating the effects of "disamenities," primarily as a critique of existing methods, the empirical problem is difficult and likely requires advanced research methods beyond what we provide here. The primary obstacle to estimating these effects is the lack of data and that lack of data is actually driven by the quarry site selection process, which limits our ability to infer a causal relationship. Thin markets and a subsequent lack of sales data are a serious problem since quarries are today (and typically in the past) located, by design, away from residential density.

Our study highlights a number of shortcomings in the empirical methodologies generally used to estimate the effect of disamenities on real estate prices. First and foremost, the vast majority of studies do not (or even attempt to) identify the causal effect of disamenities. That is, existing studies are naïve as to the empirical conditions necessary to identify a causal relationship and do not establish credible strategies to estimate the counter-factual outcome—i.e., how the real estate around quarries would have looked, on average, without a landfill or other disamenity. To evaluate the credibility of existing studies and their methodologies, we first employ permutation tests to examine whether or not the existing methodologies yield higher than expected rejection rates of the null hypothesis. We accomplish this by randomly assigning a location in our sample space with a "disamenity" (i.e., a placebo quarry) and then estimate the effect on surrounding home prices. The null hypothesis of "no effect" of the placebo quarries is rejected in no less than 7 out of 10 simulations, and at a rate as high as 9 out of 10 simulations.

In an attempt to produce a meaningful counter-factual we employ a difference-in-differences estimation strategy which exploits the timing and placement of a quarry. We use this strategy in two different contexts: (1) before and after operations of a quarry in Gurley, Alabama; and (2) before and after local debate (and subsequent approval) of a quarry in Madera County, California. The first exercise estimates the effect of quarry operations on home prices and the second exercise estimates the anticipatory effect of a quarry on home prices. Neither exercise yields evidence of a negative impact on home prices. Given a number of data concerns and model limitations (since our interest is primarily in replication), further research is advised.

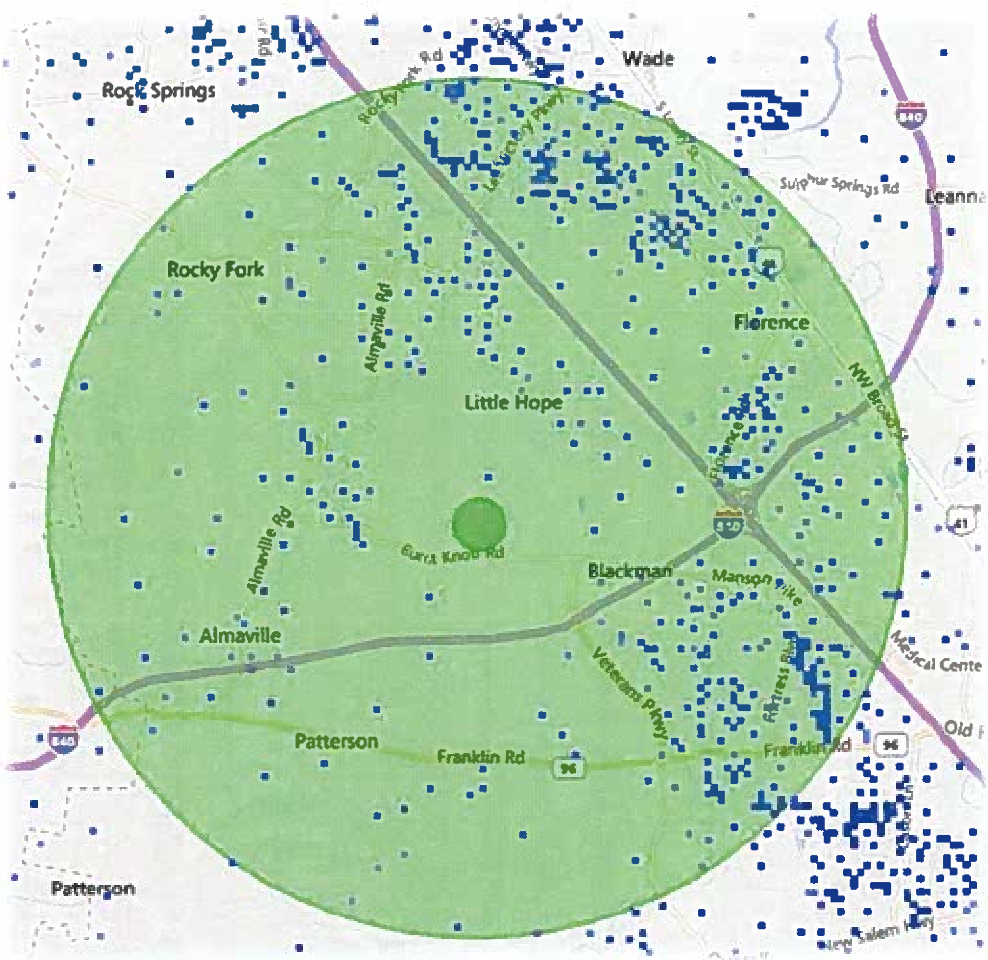
APPENDIX 1. MAP OF NATIONAL LIME & STONE QUARRY NEAR DELAWARE, OHIO

Notes: The small, inner green circle marks the National Lime & Stone Quarry near Delaware, Ohio. The larger green circle is a five-mile radius around the quarry location. The blue dots mark areas of population density using 2010 census data. Map generated using censusviewer.com.



APPENDIX 2. MAP OF ROGERS GROUP QUARRY NEAR MURFREESBORO, TENNESSEE

Notes: The small, inner green circle marks the Rogers Group Quarry near Murfreesboro, Tennessee. The larger green circle is a five-mile radius around the quarry location. The blue dots mark areas of population density using 2010 census data. Map generated using censusviewer.com.



APPENDIX 3. CENSUS BLOCK POPULATION GROWTH NEAR ROGERS GROUP QUARRY NEAR MURFREESBORO, TENNESSEE

Notes: Figures 3A-3C demonstrate population movements for Rutherford County, TN, with emphasis on the Rogers Group quarry. Population is measured using U.S. Census Bureau population data for years 2000, 2010, and 2016. Darker blues imply greater population.

Fig. 3A: Rutherford County, TN, 1990 Population Density

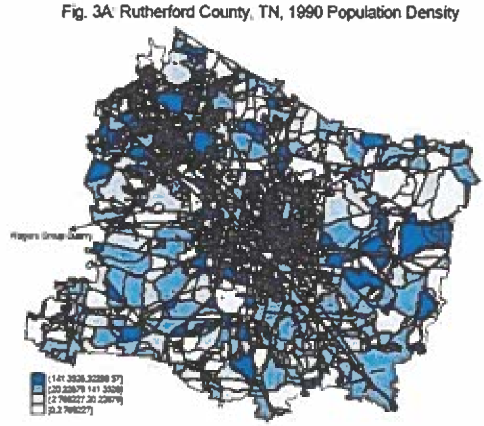


Fig. 3B: Rutherford County, TN 2000 Population Density

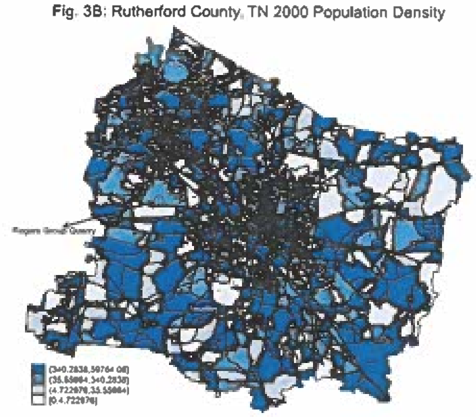
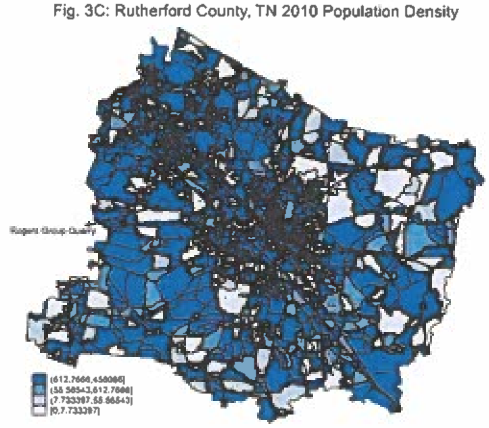
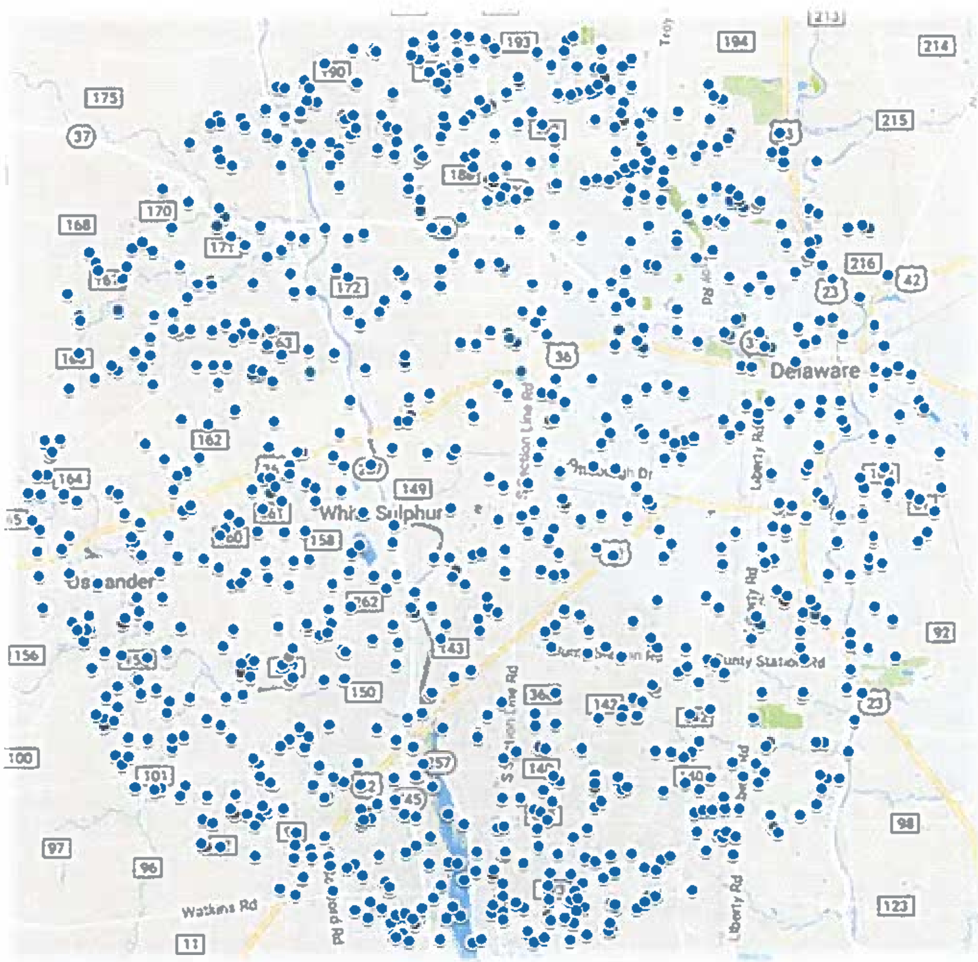


Fig. 3C: Rutherford County, TN 2010 Population Density



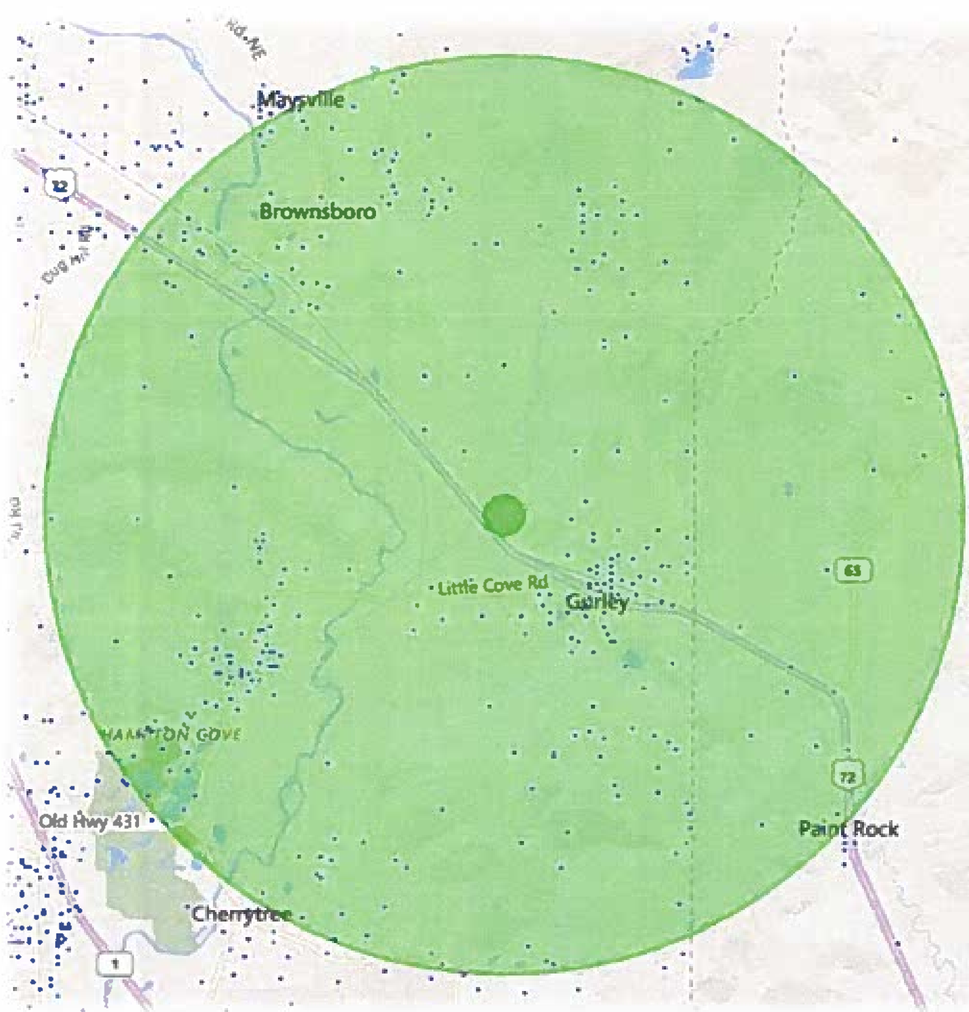
APPENDIX 4. ILLUSTRATIVE MAP OF RANDOM LOCATIONS USED FOR RANDOMIZED INFERENCE ANALYSIS FOR DELAWARE COUNTY

Notes: The blue dots represent the random locations chosen by the randomized inference simulation for Delaware County, Ohio. Map generated using Google maps.



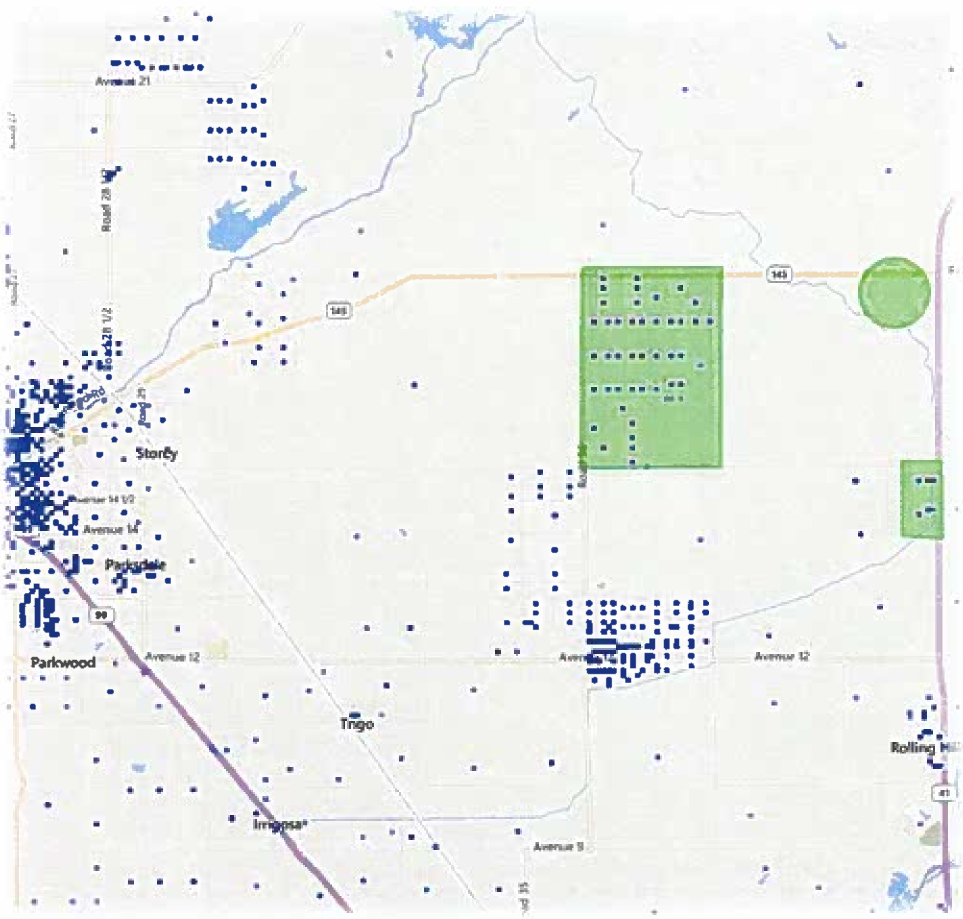
APPENDIX 5. VULCAN QUARRY NEAR GURLEY, ALABAMA

Notes: The small, inner green circle markets the Vulcan Quarry near Gurley, Alabama. The larger green circle is a five-mile radius around the quarry location. The blue dots mark areas of population density using 2010 census data. Map generated using censusviewer.com.



APPENDIX 6. MAP OF AUSTIN QUARRY SITE IN MADERA COUNTY, CALIFORNIA

Notes: The green circle marks the site of the proposed Austin Quarry in Madera County, California. The immediate two areas of population to the South and West of the quarry site—marked in green rectangles—are the "treated" areas. The blue dots mark areas of population density using 2010 census data. The control group is chosen from areas further west and north of Highway 145 toward Madera. Map generated using censusviewer.com.



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Phoenix Center Policy Paper Number 57:

What is the Effect of Rock Quarries on Home Prices? An Empirical Analysis of Three Cities

George S. Ford, PhD

(May 2022)

Phoenix Center Policy Paper No. 57
What is the Effect of Rock Quarries on Home Prices? An Empirical Analysis of Three Cities

George S. Ford, PhD†

Abstract: For many Americans, a home is their most valuable asset. Naturally, the threat of a reduction in home values causes concern, which leads to opposition to several sorts of economic development projects and essential infrastructure. Opposition to rock quarries is one example. Evidence on the effects of quarries on home values is scant; the studies are often limited to a single city, leading to questions about generalizability, and use home sales occurring long after the quarry begins operations, introducing selection bias. In this POLICY PAPER, I apply multiple empirical methods to data on homes sales from three cities in Ohio. I find no evidence to suggest quarries reduce home values. I also offer evidence to suggest that the typical approach to quantify such effects—a home's distance from the quarry—may be unreliable given the idiosyncrasies of real estate markets.

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† Chief Economist, Phoenix Center for Advanced Legal & Economic Public Policy Studies. The views expressed in this paper are the authors' alone and do not represent the views of the Phoenix Center or its staff.

I. Introduction

Hedonic models of home prices seek to explain sales prices by accounting for housing characteristics (e.g., square footage, acres, and so forth) and other factors that affect home values. Typically included in the set of covariates is the distance from a city's center or its central business district ("CBD"), or several such districts, with the expectation that home prices fall as distance from these employment centers rises.[1]

Along the same lines, researchers sometimes include the distance to an amenity or disamenity—a beach, an airport, a landfill—to quantify the effect of proximity to such establishments on home values.[2] For instance, rock quarries are sometimes subject to "not in my backyard" ("NIMBY") resistance due to their alleged effect on home values. Yet, research on the effect of rock quarries on home values is scarce. Opposition to quarries based on home valuations relies almost universally on Hite (2006), a brief report analyzing data from a few thousand homes sales around a single quarry in Delaware, Ohio.[3] Using an unconventional regression model and data on transactions within five miles of the quarry occurring decades after the quarry opened, the report finds a positive relationship between home prices and distance from the quarry. In contrast to Hite (2006), Rabianski and Carn (1987), Dorrian and Cook (1996), Bureau of Mines (1981), Grant (2017) and various other reports find no consistent relationship between

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[1] The "monocentric" assumption originated in the works of W. Alonso, LOCATION AND LAND USE: TOWARD A GENERAL THEORY OF LAND RENT (1964); E.S. Mills, STUDIES IN THE STRUCTURE OF THE URBAN ECONOMY (1972); R.F. Muth, CITIES AND HOUSING: THE SPATIAL PATTERN OF URBAN RESIDENTIAL LAND USE (1969).

[2] *See, e.g.*, J.P. Cohen and C.C. Coughlin, *Spatial Hedonic Models of Airport Noise, Proximity, and Housing Prices*, FEDERAL RESERVE BANK OF ST. LOUIS WORKING PAPER No. 2006-026 (2006) (available at: https://research.stlouisfed.org/wp/more/2006-026); M. Rahmatian and L. Cockerill, *Airport Noise and Residential Housing Valuation in Southern California: A Hedonic Pricing Approach*, 1 INTERNATIONAL JOURNAL OF ENVIRONMENTAL SCIENCE AND TECHNOLOGY 17–25 (2004) (available at: https://doi.org/10.1007/BF03325812); M. Thayer, H. Albers, and M. Rahmatian, *The Benefits of Reducing Exposure to Waste Disposal Sites: A Hedonic Valuation Approach*, 7 JOURNAL OF REAL ESTATE RESEARCH 265-282 (1992); R.B. Palmquist, *Estimating the Demand for the Characteristics of Housing*, 66 REVIEW OF ECONOMICS AND STATISTICS 394-404 (1984); P. Graves, J.C. Murdoch, M.A. Thayer and D. Waldman, *The Robustness of Hedonic Price Estimation: Urban Air Quality*, 64 LAND ECONOMICS 220-233 (1988).

[3] For a discussion of the Hite (2006) model, *see* G.S. Ford and R.A. Seals, *Quarry Operations and Property Values: Revisiting Old and Investigating New Empirical Evidence*, PHOENIX CENTER POLICY PAPER NO. 53 (March 2018) (available at: https://www.phoenix-center.org/pcpp/PCPP53Final.pdf).

property values and proximity to a quarry.[4] Two recent studies offer conflicting evidence. Malikov, Sun and Hite (2018) look again at home prices around the quarry in Delaware, Ohio, and report price attenuation for homes nearer the quarry. Ford and Seals (2018) estimate plausibly causal effects for two quarries using Difference-in-Differences ("DiD") and find no effect of the quarry on home prices. Also, Ford and Seals (2018) study the Delaware quarry and find no effect of the quarry on home values, though the available data precluded a DiD analysis for this quarry.[5]

In this POLICY PAPER, I return to the question of the effect of rock quarries on home prices, although many of our findings are also relevant for any other sorts of spatially-centered disamenities. Given the idiosyncrasies of real estate markets across cities, there is little reason to suspect the results on a single quarry can be generalized to other cities. Here, I use data on three cities in Ohio, including, once more, the city of Delaware. Estimates of the effects are based on Ordinary Least Squares regression ("OLS"), Robust Regression ("RREG"), Quantile Regression ("QREG"), Spatial Regression ("SREG"), and Semiparametric Regression ("SPR"). As in most studies of disamentities and rock quarries, all home sales occur after the quarry began operations, so selection bias may be an issue. Like Hite (2006) and Malikov, Sun and Hite (2018), I am unable to make causal claims. Nonetheless, this sort of evidence is routinely used to address the effect of quarries on home values, so it is worth undertaking such analysis.

To establish expectations, I begin with an analysis of the geographic scope of quarry blasting, since blasting is a root cause of the disamenity nature of a quarry. This analysis, based on standard methods, reveals a narrow geographic impact of blasting (less than one-half mile across a wide range of charge strengths). For the three quarries, I find no attenuation of prices based on proximity to the quarry. I likewise evaluate the statistical validity of distance-from-site variables in econometric models. As in Ford and Seals (2018), Randomized Inference reveals that these sorts of models can produce very high rejection rates for the distance-

[4] A.M. Dorrian and C.G. Cook, *Do Rock Quarry Operations Affect Appreciation Rates of Residential Real Estate*, Working Paper (1996); J. Rabianski and N. Carn, *Impact of Rock Quarry Operations on Value of Nearby Housing, Prepared for the Davidson Mineral Properties* (August 25, 1987); M. Radnor, D. Hofler, et al., *Social, Economic and Legal Consequences of Blasting in Strip Mines and Quarries*, U.S. Bureau of Mines (May 1981); A. Grant, *Estimating the Marginal Effect of Pits and Quarries on Rural Residential Property Values in Wellington County, Ontario: A Hedonic Approach*, Master's Thesis, University of Guelph (June 2017).

[5] Ford and Seals (2018) also demonstrate that the positive results in Hite (2006) may be due to the unconventional estimation method.

from-site variable, suggesting distance-from-site models tend to over-reject the null hypothesis (of no effect). These empirical distributions of distance-from-site coefficients are typically quite wide, encompassing even very large distance-from-site coefficients. Some analysis of the data used in Malikov, Sun and Hite (2018), which is, in part, publicly available, is also provided, revealing sign changes on the distance-from-quarry coefficient under plausible circumstances.

II. Background

There exists a large literature on the effect of disamenities, like airports and landfills, on home values. Rock quarries have received less attention, though "not in my backyard" ("NIMBY") resistance to quarries or quarry expansions is commonplace. Opponents of the quarries, normally residents in the city or county of operation, must rely on scant evidence to support their positions on home valuations. Two analyses are typically offered to support resistance: (1) a six-page description of results from a consulting report by Hite (2006); and (2) a more thorough study of the same quarry (using later data) by Malikov, Sun, and Hite (2018).[6] Only the latter study provides a detailed accounting of the data and analyses, though much of the NIMBY resistance relies on Hite (2006). These reports, like most studies of (dis)amenities, rely on the "distance-from-site" methodology in a hedonic framework. To counter the NIMBY claim, quarry advocates sometimes rely on Ford and Seals (2018), among other studies, which finds no effect (either mere correlation or causal) of quarries on home prices.

Data on sales prices used by Hite (2006) and Malikov, Sun, and Hite (2018) are for sales occurring long after the quarry began operations; the quarry in Delaware, Ohio, opened in 1904. Malikov, Sun and Hite (2018) use data on home sales across the entire county, so much of the sample is for sales many miles from the quarry; the data also span multiple cities. Since quarries are not randomly sited and are often located in rural areas where land prices, home prices, and housing density are low, there is the obvious problem of selection bias.[7] While Malikov, Sun, and Hite (2018) use a sophisticated econometric approach, nothing in the model

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[6] A summary presentation of results for a student project by Sun (2018) on the effects of a surface mine (for gold and silver), for which there is no accompanying paper and no detailed description of the data or methods, is sometimes cited, though mineral mines use very different techniques than do rock quarries. B. Sun, *An Econometric Analysis of the Effect of Mining on Local Real Estate Values*, Unpublished Presentation (Undated).

[7] With the founding literature on home prices suggests prices fall as distance from the city center increases, it is little surprise that home prices may be lower around rock quarries located on the edge of town.

addresses selection bias so there can be no claim of a causal impact, and the authors never formally make a causal claim (though infer it).[8] In large part, the study appears to be more a presentation of a novel econometric methodology (semiparametric quantile spatial regression) than an attempt to quantify the causal effect of a quarry on home values. That is, the study is of academic interest more than of policy interest. Also, Ford and Seals (2018) find no effect of the Delaware quarry on homes prices, and I confirm that result here.

When looking at a single quarry, the generalizability of the result to other quarries is questionable. As demonstrated by Ford and Seals (2018), and again here, the coefficient on a distance-from-site covariate, which tend to statistically significance, may simply reflect the idiosyncrasies of individual real estate markets. Here, I look at three quarries to shed light on the generalizability of the findings.

A. *The Challenge and Advantages of Causal Analysis*

Though common in the literature, distance-from-site models have several serious shortcomings. First, there is selection bias. Available data for home sales often covers periods long after the amenity or disamenity is in place, precluding reliable causal estimation by methods such as Difference-in-Differences ("DiD").[9] Since the location of an amenity or disamenity is presumably not random, the risk of spurious correlation in distance-from-site relationships is high. Does the quarry reduce home prices, or are quarries located in areas where home prices are low? Studies like Hite (2006) and Malikov, Sun, and Hite (2018) cannot say, and my analysis here suffers from the same problem.

Disamenities are often placed away from population centers and where land prices (and thus home prices) are lower. Rock quarries often occupy hundreds of acres, so they are often places where land prices are lower, subject to the desirability of the geography. Public policy also influences site selection and (dis)amenities are sometimes clustered, thus making identification of a single (dis)amenity difficult. For instance, the quarry in Delaware, Ohio, sits on the edge of the city, adjacent to the municipal airport and an outdoor shooting range. Second, the available data on home characteristics varies among county assessors, so omitted variables may be a problem. Third, real estate markets are complex;

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[8] The same holds for the Hite (2006) study.

[9] *See, e.g.*, J.D. Angrist and J. Pischke, MOSTLY HARMLESS ECONOMETRICS: AN EMPIRICIST'S COMPANION (2009); J.D. Angrist and J. Pischke, MASTERING METRICS: THE PATH FROM CAUSE TO EFFECT (2014); S. Cunningham, CAUSAL INFERENCE: THE MIXTAPE (2021); G.S. Ford and R.A. Seals, *supra* n. 3.

home values rise or fall from nearly any location, irrespective of the presence of an amenity or disamenity. Ford and Seals (2018) show that the null hypothesis (no effect) for a distance-from-site coefficient from nearly any location in a city is rejected at rates far exceeding the alpha level of the test. This finding forces the question about how unusual the estimated distance-from-site coefficient really is, irrespective of its statistical significance.

While I do not conduct a DiD analysis of home values here, a concise review of DiD analysis sheds light on why the distance-from-site approach is prone to bias. It also reveals the condition that must be satisfied for the results of such analysis to render a plausibly causal effect. Let us consider a hypothetical scenario. Say a quarry receives approval to begin operations on the outskirts of town. For several reasons, quarries are typically and intentionally located away from housing density where land prices are low. Before even the planning phase of the quarry, assume the average (quality-adjusted) price for a home near the quarry site is $95,000, and the average price is $100,000 for homes far from the future quarry site. This 5% price difference cannot be due to the quarry because the lower average price is present prior to the quarry even being proposed (by assumption).

After the quarry initiates operations, homes are bought and sold, and the prices are observed. Assume, for now, that the quarry has *no effect* on property values (and average prices do not change). If a researcher looked only at post-operations prices, then a 5% price difference is observed, though, by assumption, this price difference is not due to the quarry as the difference preceded the quarry. Nonetheless, this difference may be attributed falsely to the quarry. (The same would be true if home prices near the quarry were initially 5% higher than those far away).

The *true* effect of the quarry on home prices is revealed by the Difference-in-differences estimator,

$$\delta = (P_1^N - P_0^N) - (P_1^F - P_0^F), \tag{1}$$

where δ is the DiD estimator, P is price before (0) and after (1) the quarry begins operations for houses near (N) and far (F) from the quarry. In this "no effect" case, the DiD estimator is zero [(95,000 - 95,000) - (100,000 - 100,000) = 0], correctly identifying the causal effect of the quarry. Using only post-operation prices, the calculated statistic from empirical analysis is,

$$\Delta = P_1^N - P_1^F, \tag{2}$$

where Δ equals δ only when $P_0^N - P_0^F = 0$, which seems unlikely given the economics and policies related to siting a quarry. In this hypothetical, the Δ coefficient equals -$5,000, which is not the effect of the quarry. Thus, when a quarry's effect on home prices draws conclusions from an estimate of Δ and not δ, no plausible claim of a causal effect is possible.

As an alternative scenario assume that the quarry reduces prices for nearby homes to $90,000 (a reduction of $5,000), with more distance home prices remaining constant. Looking only at post-quarry transactions materially overstates the effect size [90,000 - 100,000 = -10,000], with selection bias accounting for a $5,000 overstatement. The DiD estimator, contrariwise, accurately quantifies the effect of the quarry [(90,000 – 95,000) – (100,000 – 100,000) = -5,000]. Absent special circumstances, an analysis restricted to home sales after the quarry becomes operational cannot quantify reliably the effect of the quarry on home prices.

Conducting a DiD study on home values and quarry operations, while desirable if not necessary, is complicated by the fact many quarries near housing density are decades old and new quarries are almost always located in more rural areas where housing density is low. Even in instances where a new quarry site is selected, obtaining adequate price data on home sales near a quarry site is challenging given low housing density. I do not conduct a DiD analysis here; instead, I use the traditional hedonic models. As such, I can make no causal claims. Still, my analysis speaks to the issue using the methods commonly relied upon and addresses the reliability of existing estimates of a quarry's effects and to the use of distance-from-site covariates generally.

B. *Forming Expectations*

Central to the distance-from-site analysis is that the effects of the (dis)amenity are larger the closer is the home to the (dis)amenity, with presumably stronger effects near the quarry that dissipate over distance. It makes sense, therefore, to consider the practical distances over which a rock quarry's operations may be felt. Local resistance to rock quarries often focuses on the use of explosives that create ground vibrations and sound waves ("overpressure"), both of which can cause annoyance if not damage to property if sufficiently intense. (Other concerns include truck traffic and the water table.) Advances in blasting technology and operator care over the last thirty years has greatly diminished these effects, even if such advances have not reduced NIMBY resistance. An analysis on the geographic scope of blasting may shed light on the distances over which a quarry's operations may influence home values.

The geographic scope of the blasting on a quarry's neighbors is measured by ground vibrations and overpressure. Ground vibration is measured in terms of Peak Particle Velocity ("PPV"), which measures the movement of particles at the surface. Such vibrations may be felt at nearby homes and may cause cosmetic damage (e.g., drywall). A typical (empirical) equation for PPV is,

$$PPV = 160\left(\frac{D}{\sqrt{W}}\right)^{-1.6}, \tag{3}$$

where D is the distance from the charge in meters and W is the charge mass (maximum pounds per 8 millisecond delay).[10] While the parameters of the equation may vary by circumstances (e.g., vibration frequency, rock characteristics, the water table), the listed parameters are recommended absent field blast data at a particular site. The Bureau of Mines' standard for drywall damage is 0.75 inches per second.[11] Home damage is a serious concern, but there is also the potential for human annoyance. Studies suggest that the human perception for blast vibration ground motion is about 0.03 inch/s (0.80 mm/s) and that complaints are unusual below 0.08 inches/s (2.03 mm/s).[12] In a study of

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[10] The parameter selection is based on the INTERNATIONAL SOCIETY OF EXPLOSIVES ENGINEERS BLASTER'S HANDBOOK (18th Edition) (2011) at p. 567; *see also*, R. Kumar, D. Choudhury, and K. Bhargava, *Determination of Blast-Induced Ground Vibration Equations for Rocks Using Mechanical and Geological Properties*, 8 JOURNAL OF ROCK MECHANICS AND GEOTECHNICAL ENGINEERING 341-349 (2016) (available at: https://www.sciencedirect.com/science/article/pii/S167477551600024X).

[11] D.E. Suskind, M.S. Stagg, J.W. Kopp, and C.H. Dowding, *Structure Response and Damage Produced by Ground Vibration from Surface Mine Blasting*, United States Bureau of Mines RI-8507 (1980), Appendix B.

[12] *See, e.g.*, Suskind *et al.*, *id.*; T. Ongen, G. Konak, and D. Karakus, *Vibration Discomfort Levels Caused by Blasting According to Gender*, 7 ENVIRONMENTAL AND EARTH SCIENCES RESEARCH JOURNAL 109-115 (2020) (available at: https://www.iieta.org/journals/eesrj/paper/10.18280/eesrj.070303); B.T. Lusk, *An Analysis and Policy Implications of Comfort Levels of Diverse Constituents with Reported Units for Blast Vibrations and Limits: Closing the Communication Gap*, Ph.D. Thesis the Faculty of the Graduate School of the University of Missouri-Rolla in Mining Engineering (2006); Q. Yao, X. Yang, and H. Li, *Comparative Analysis on the Comfort Assessment Methods and Standards of Blasting Vibration*, 17 JOURNAL OF VIBROENGINEERING 1017-1036 (2015); A.K. Raina, M. Baheti, A. Haldar, M. Ramulu, A.K. Chakraborty, P.B. Sahu, C. Bandopadhayay, *Impact of Blast Induced Transitory Vibration and Air-Overpressure/Noise on Human Brain—An Experimental Study*, 14 INTERNATIONAL JOURNAL OF ENVIRONMENTAL HEALTH RESEARCH 143-14 (2004); A.K. Raina, A. Haldar, A.K. Chakraborty, P.B. Choudhury, M. Ramulu, and C. Bandyopadhyay, *Human Response to Blast-Induced Vibration and Air-Overpressure and Indian Sceranio*, 63 BULLETIN OF ENGINEERING GEOLOGY AND THE ENVIRONMENT 209-214 (2004); K. Medearis, *The Development of Rational Damage Criteria for Low-Rise Structures Subjected to Blasting Vibrations*, Final Report for the National Crushed Stone Association (1976).

human perception of blasting at a rock quarry, Ongen, Konak, and Karakus (2020) report perception occurring only at a PPV of 0.03 inches/s (0.80 mm/s), no annoyance at a PPV of 0.033 inches/s (0.84 mm/s), and slight annoyance at a PPV of 0.09 inches/s (2.27 mm/s).[13]

In addition to ground vibration, a blast produces a shock wave. This overpressure—the pressure (above normal atmospheric pressure) caused by a shock wave— may be felt and heard. Overpressure is measured in linear decibels ("dBL").[14] To limit structural damage to property, the U.S. Bureau of Mines sets a threshold of 133 dBL.[15] Again, the threshold for human annoyance may be different than that for structural damage. The U.S. Bureau of Mines sets the annoyance threshold at 120 dBL. In Australia and New Zealand, the Environmental Council sets the annoyance threshold at 115 dBL.[16] In studying sonic booms, NASA found that none of participants viewed as annoying a sonic boom producing a dBL of 121 and only 10% of respondents were annoyed by a boom of 128 dBL.[17] To avoid annoyance, NASA recommended a sonic boom should not exceed 125 dBL. Overpressure may be estimated using the formula,[18]

$$P = 164.8\left(\frac{D}{\sqrt[3]{W}}\right)^{-0.0696}. \tag{4}$$

Using these two formulae, it is possible to establish the distance from a quarry at which nearby residences and businesses may experience either structural damage or annoyance.

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13 Ongen, *et al., id.*

14 dBL is a linear scale and thus different from the logarithmic scale typically used for sound.

15 D. E. Suskind, V.J. Stachura, M.S. Stagg, and J.W. Kopp, *Structure Response and Damage Produced by Airblast from Surface Mining*, United States Bureau of Mines RI-8485 (1979).

16 *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration*, Australian and New Zealand Environment Council (1990).

17 *Environmental Impact State for the Kennedy Space Center*, National Aeronautics and Space Administration (1979) at pp. 5-40.

18 Parameters are based on conversations with J. Straw, Vice President and Area Manager, GeoSonics, Inc. (https://www.geosonicsvibratech.com), which are based on testing at quarry locations. A typical charge weight for quarry operation is 78.75 kg/ft^3.

Table 1. Miles from Blast for Threshold PPVs and Overpressures

	PPV inch/s			Overpressure dBL		
W	0.75	0.08	0.03	133	125	115
50 kg	0.038	0.155	0.286	…	0.036	0.122
75 kg	0.047	0.190	0.350	…	0.042	0.140
100 kg	0.054	0.219	0.404	…	0.046	0.154
125 kg	0.060	0.245	0.452	0.020	0.050	0.166
150 kg	0.066	0.268	0.495	0.021	0.053	0.177
175 kg	0.071	0.290	0.535	0.023	0.056	0.186
200 kg	0.076	0.310	0.572	0.024	0.059	0.194

Table 1 summarizes the two measures for varying blast charges at different levels of PPV and Overpressure. For PPV, the values are 0.75 for drywall damage and 0.08 for annoyance and 0.03 for human detection. For overpressure, the values are 133 dBL for structural damage, 125 dBL based on NASA's threshold for annoyance, and 115 based on the Environmental Council's threshold for annoyance. The potential for damage is quickly exhausted (less than one-tenth of a mile), mild human annoyance is exhausted at less than one-third mile from the quarry, and human perception at about one-half mile. Overpressure does not appear to be problem for damage or annoyance at distances greater than two-tenths of a mile. The claim that a rock quarry affects homes prices up to ten miles, as reported by Malikov, Sun and Hite (2018) seems incredible, at least with respect to the influence of blasting.

C. *Randomized Inference*

Hedonic regression analysis with distance-from-site variables quantifies the relationship between home prices and distance from some location of interest. Usually, only a few distance-from-site variables are included in hedonic models. Yet, real estate markets are complex and may include a wide array of (dis)amenities. It is possible, if not likely, that in many cities a statistically-significant coefficient on a distance-from-site covariate will be observed from many locations, not simply the location(s) of a researcher's interest. Thus, rejecting the null hypothesis at a particular location using the traditional asymptotic approach (e.g., a t-test) may overstate how unusual is the price-to-distance relationship. Moreover, failing to account for all amenities, disamenities, or market idiosyncrasies (the latter being very difficult), the distance-from-site coefficient at one location may simply reflect the influence of another location.

Randomized Inference can shed some light on this problem. Randomized inference is a statistical technique that randomly assigns a treatment, in this case distance from a randomly-selected location, for the purpose of creating a reference distribution under the null hypothesis of "no effect."[19] How unusual a particular measured distance-from-site effect may be quantified by comparing the estimated coefficient (or its t-statistic) for a particular distance-from-site coefficient to this reference distribution. For instance, say the regression analysis indicates that a 10% increase in distance from a quarry reduces home prices by 5%, and this relationship has a one-tailed p-value of 0.05, allowing for the rejection of the null hypothesis of no effect. If, however, the effect of distance is also 5% for 30% of randomly-selected locations in a city, then the "true" one-tailed p-value would be 0.30 (or 60% in a two-tailed test), which does not permit a rejection of the null hypothesis (*i.e.*, the 5% effect is not very rare).

Property values rise and fall across the area of a city for a host of reasons, so testing for a price difference from a given location is prone to find prices rising or falling. Ford and Seals (2018), using data from Delaware, Ohio, find that a statistically significant coefficient on a distance-from-site variable is almost certain to appear. Selecting one thousand locations at random within a city, Ford and Seals (2018) find the null hypothesis of "no effect of distance" was rejected in 93% of cases at the 10% level. A statistically-significant positive or negative distance-from-site coefficient is almost guaranteed. Of course, the observed rejection rate may vary by city, model specification, variables included, and the estimation method.

I apply Randomized Inference for the cities in our sample. One thousand locations are randomly chosen, and a hedonic regression is used to estimate the distance-from-site coefficient. The distance-to-quarry coefficient can then be compared to this null-reference distribution to determine whether the coefficient indicates an "unusual" relationship by computing the one-tail p-values. Or, the estimated distance-to-quarry coefficient can be evaluated against the 90% or 95% confidence interval of the reference distribution, thus mimicking the traditional approach of using 10% or 5% significance levels.

19 R.A. Fisher, THE DESIGN OF EXPERIMENTS (1951).

III. Data

Data on home sales are obtained for three cities in Ohio of similar size: the cities of Delaware, Findlay, and Lima.[20] These data are obtained from the relevant county assessor's webpage. Prices from arms-length transactions of single-family homes within five miles of the quarry (as in Hite 2006) and on ten acres or less are included in the samples.[21] Data are obtained for years 2010 through 2021. Some summary statistics are provided in Table 2.[22] Prices and home sizes in Delaware are much higher than in the other cities, and home prices are correlated with median income.

Table 2. Cities in Sample

City	Sample Size	Average Price	Average Sqft	Average Price/Sqft	Population (2019)	Median Income (2019)
Findlay	2,843	154,227	1,600	95.4	41,335	51,002
Delaware	2,439	234,378	1,901	124.9	40,568	69,087
Lima	1,169	86,049	1,351	64.6	37,117	35,779

Delaware and Findlay are an interesting pair. The Delaware quarry is the only one analyzed in Hite (2006) and Malikov, Sun, and Hite (2018), and is also studied in Ford and Seals (2018). Like Delaware, the quarry in Findlay is in the Southwest corner of the city and sits adjacent to the municipal airport (a disamenity frequently studied in the literature). We might expect, therefore, similar results for the distance-from-site covariate in both cities. Note, however, that given these quarries' proximity to these other disamentities (an airport in both and an outdoor

20 The locations of the quarries are: Findlay (41.013530, -83.690632); Delaware (40.281032, -83.136392); and Lima (40.751028, -84.083442). Delaware is in Delaware County; Findlay is in Hancock County; and Lima is in Allen County.

21 A valid sale is an "arm's length, open market transaction as of a specific date whereby there is a willing buyer and seller, each acting in what he/she considers his/her best interest; a reasonable time is allowed for exposure in an open market; payment is made in terms of cash or comparable financial arrangements; and the price represents the normal consideration for the property sold unaffected by special or creative financing or sales concessions granted by anyone associated with the sale (https://wedge1.hcauditor.org/page/Glossary)." Valid sales are typically by Warranty Deed and these samples are restricted to Warranty Deeds or comparable deeds. Deeds such as Quit Claim and Survivorship Deeds are excluded since these deeds, while valid transfers, are not arms-length transactions. A minimum price of $10,000 is imposed and mobile homes are excluded.

22 Population and income data available at: https://datausa.io. Also see home value statistics from Zillow: Findlay (https://www.zillow.com/findlay-oh/home-values); Delaware (https://www.zillow.com/delaware-oh/home-values); Lima (https://www.zillow.com/lima-oh/home-values).

shooting range in Delaware), it is impossible to say which "disamenity" might be correlated with lower home prices. Normally, we expect airports and shooting ranges to be sited away from higher-value housing, so low prices may simply reflect the choice of site rather than any causal effect on home prices. By most standards, the proximity to another disamenity (or two) would disqualify the city for analysis, but these prior studies on the Delaware quarry have ignored this possibility.

As is standard in hedonic models of home prices, data is collected on a variety of home characteristics. Some county assessors provide more detail than others and the lack of some characteristics may lead to omitted variables bias and fail to address selection bias. Home and area characteristics included, when possible, are square footage, acreage, indicators for the number of bedrooms and (full and half) bathrooms, basement square footage, an indicator for single-story homes, indicators for the number of fireplaces (one, two, or three or more), the age of the home at the sale date, an indicator for homes remodeled in the ten years prior to the sale, the distance (in miles) to the city center and the rock quarry, indicators for the assessor's grade of the quality of construction materials and the condition of the home, indicators for the type of garage (attached, detached, finished, unfinished), and sale-year fixed effects. Demographic data on median income, the share of the White population, and the share of vacant homes is also used.[23]

IV. Regression Model

Home prices are affected by many factors, so I proceed with multivariate regression analysis. As is standard, the regression model takes the general form,

$$P_{it} = \Delta M_i + \beta X_{it} + \alpha Z_{it} + \tau_t + \varepsilon_{it} \ , \quad (5)$$

where P_i is the sale price of home i at time t, M_i is the home's distance in miles from the rock quarry, X_{it} is a vector of home- and transaction-specific characteristics such as square footage, acres, and distance from the city center, Z_{it} is a vector of area characteristics such as median income, τ_t is a year fixed effect, and ε_{it} is the econometric disturbance term. As home prices vary considerably, the dependent variable is the natural log of price. Standard errors are clustered at the census tract level when feasible. The same model is used for OLS, RREG, and QREG.

Housing markets are an archetype case of spatial correlation—the price of a home depends, in part, on the prices of nearby homes (which also affect the

23 Data available at: https://docs.safegraph.com/docs/open-census-data.

valuation for mortgage approval). In OLS, the assumption is that the disturbances (ε) are independent, so the presence of spatial relationships requires an alternative estimation approach. Failing to account for these spatial relationships represents a form of omitted variables bias (though there are other justifications for spatial regression), which may or may not bias the coefficients.[24] For all cities in this analysis, Moran's test indicates the presence of spatial correlation. So, in addition to the traditional regression analysis, I perform spatial regression including a spatially-lagged dependent variable and spatial errors (a Spatial Durbin Model, or "SDM"). Spatial analysis is based on a row -normalized spatial weight matrix (W) where distance is truncated at three miles. The spatial regression model is,

$$\begin{aligned} P_{it} &= \Delta M_i + \beta X_{it} + \alpha Z_{it} + \tau_t + \theta WP + \mu_{it} \\ \mu_{it} &= \lambda_t W \mu_{it} + \varepsilon_{it} \end{aligned} , \quad (6)$$

where WP is the spatial lag of price and μ_{it} is the spatial error term. With a spatial regression model, the effect of a variable has a direct, indirect, and total effect, though here the sign on the Δ coefficients are of primary interest. For comparison purposes, I also estimate the Spatial Lag Model ("SAR"),

$$P_{it} = \Delta M_i + \beta X_{it} + \alpha Z_{it} + \tau_t + \theta WP + \mu_{it} , \quad (7)$$

and the Spatial Error Model ("SEM"),

$$P_{it} = \Delta M_i + \beta X_{it} + \alpha Z_{it} + \tau_t + \lambda W \varepsilon_i + \mu_{it} . \quad (8)$$

I also estimate a semiparametric relationship between home prices and quarry-distance,

$$P_{it} = g(M_i) + \beta X_{it} + \alpha Z_{it} + \tau_t + \theta WP + \nu_{it} , \quad (9)$$

where $g(M_i)$ permits a non-parametric and flexible relationship between prices and quarry distance. Since g(Mi) is not a parameter, the semi-parametric results are graphed (though confidence intervals may be computed). The other covariates enter parametrically and include the WP regressor (the spatial lag).

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24 *See, e.g.*, J. LeSage and R.K. Pace, INTRODUCTION TO SPATIAL ECONOMETRICS (2008); M.D. Ward and K.S. Gleditsch, SPATIAL REGRESSION MODELS (2018).

Outliers are a potential problem in home sales data due to the idiosyncrasies of transactions and perhaps coding problems. I have tried to limit such problems by looking only at arms-lengths transactions, but it may be worth evaluating the effect of potential outliers. I mark outliers as those transactions with a Cook's D exceeding $4/N$.[25] RREG and QREG are also employed to limit the effect of outliers.

A. *Findlay, Ohio*

I begin my analysis with Findlay, Ohio, in Hancock County. The county assessor provides extensive data on home characteristics. Like Delaware, the quarry in Findlay is in the Southwest corner of the city and adjacent to the municipal airport. Presumably, if the distance-to-quarry coefficient truly measures the effect of the quarry, then the Δ coefficients should be similar across the two cities. For Findlay, there are 2,843 homes sales meeting the sample restrictions over the 2010-2021 period. There are two distance-from-site covariates (measured in miles) including distance from the city center and distance from the rock quarry. About 5.6% of sales are identified as outliers based on Cook's D; these outliers are marked with a dichotomous indicator.

Four models are estimated including two by OLS (with one including the outlier indicator), one by RREG and another by QREG. Given the large number of covariates, a detailed summary of the estimates is placed in Appendix A (for all models and cities). The estimated coefficients are mostly as expected. Home prices rise in square footage and acreage, fall in age, and rise over time. Prices are higher as the condition of the home is better.

Table 3. Summary of Regression Results, Findlay

Variable	Model A OLS	Model B OLS	Model C RREG	Model D QREG
ln(Quarry Dist.)	-0.030	-0.033	-0.031***	-0.042***
ln(City Center Dist.)	0.011	0.001	0.032***	0.034***
ln(sqft)	0.386***	0.409***	0.484***	0.482***
ln(acres)	0.041	0.086**	0.067***	0.059***
Outlier Indicator	No	Yes	No	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Standard Errors	Clustered	Clustered	...	Robust
Observations	2,843	2,843	2,843	2,843
R^2	0.645	0.723	0.838	...

Stat. Sig. * 10% ** 5% *** 1%

[25] R.D. Cook, *Detection of Influential Observations in Linear Regression*, 19 TECHNOMETRICS 15-18 (1977).

Table 3 provides a summary of the results for a few key parameters. As expected, the coefficient on square footage is positive, large, and statistically significant at better than the 1% level; prices rise with larger lots. A positive coefficient is estimated for the distance-from-city center covariate, but the coefficient is statistically different from zero only in RREG and QREG. Turning to the quarry, the quarry-distance variable has negative coefficients across the board suggesting home prices fall as distance-from-the-quarry increases. The quarry-distance coefficients are statistically different from zero only in Models C and D. Home prices, conditioned on many variables, tend to be lower as distance from the quarry increases.

Table 4. Summary of Spatial Regression Results, Findlay

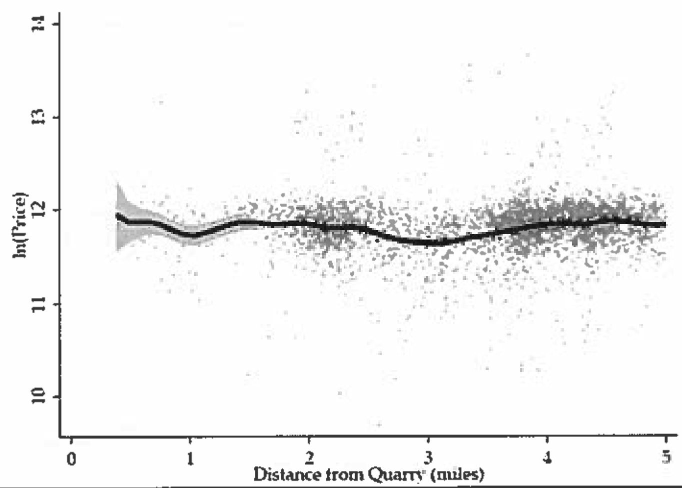
Variable	Model E SDR	Model F SDR	Model G SAR	Model H SEM
ln(Quarry Dist.)	-0.030	-0.036	-0.009	-0.056**
ln(City Center Dist.)	-0.027	-0.042**	-0.001	0.011
ln(sqft)	0.345***	0.366***	0.341***	0.361***
ln(acres)	0.038**	0.085***	0.015	0.107***
Spatial Lag	0.912***	0.907***	0.880***	...
Spatial Error	0.941***	0.953***	...	3.012***
Outlier Indicator	No	Yes	No	No
Year Fixed Effects	Yes	Yes	Yes	Yes
Standard Errors	Robust	Robust	Robust	Robust
Observations	2,843	2,843	2,843	2,843

Stat. Sig. * 10% ** 5% *** 1%

Turning the spatial regression model, Moran's test statistic is 144.3, which is statistically significant at the 1% level. As expected, the data are spatially related. A summary of Spatial Regression results is provided in Table 4; standard errors are robust to heteroskedasticity. Again, the coefficients on the quarry-distance covariate are negative and of similar size to the non-spatial models, but now most of the coefficients are statistically insignificant. Only in the SEM variant is the quarry-distance coefficient statistically different from zero (at the 5% level). In the spatial models, home prices are mostly uncorrelated with distance from the quarry.

I turn now to semiparametric regression where the relationship between prices and quarry distance is non-parametric. For ease of interpretation, the distance from the quarry covariate is measured in miles (not its natural log). Results are illustrated in Figure 1, which includes the confidence interval. Consistent with the regression analysis, prices tend to fall as distance from the quarry increases, though the effect is small. The low housing density near the quarry is apparent in the scatter plot and the large confidence interval around the estimated relationship when near the quarry. While some statistically significant coefficients are found, across all the models there is very little evidence to suggest the quarry is affecting home prices.

Figure 1. Semiparametric Regression, Findlay



Following Ford and Seals (2018), an empirical distribution of a distance-from-site coefficient is crafted using Randomized Inference. One thousand locations are chosen randomly, and then the distance-from-site coefficient is estimated.[26] The quarry-distance covariate is excluded (but replaced by the distance from the random site) but all other variables are included in the regression, so the model most closely resembles Model A from Table 3 with a coefficient on the quarry-distance variable of -0.030 with a p-value of 0.285. The 95% confidence interval on the simulated coefficient distribution is -0.095 to 0.074, a wide range that easily encompasses the coefficient value of -0.030. The -0.03 coefficient cuts off 26.1% of the empirical distribution (a one-tail cutoff, a two-tail p-value of 52.2%). Across all simulations, the null hypothesis for the coefficient on simulated locations is rejected 11.8% of the time at the 10% level for tract-clustered errors, which is close to the alpha level. For robust standard errors, the rejection rate is 33.6%, more than three-times the alpha level. The choice of standard errors is important. These rejection rates are well below that reported in Ford and Seals (2018), suggesting randomized inference may produce different rejections rates in different cities (confirmed *infra*) and for models with different covariates (our model has many more covariates than in Ford and Seals 2018). For instance, removing the census-

26 The maximum distance from the city center in the sample is six miles, so the random locations are chosen within five miles of the city center.

level variables from the model increases the rejection rates to 16.9% for clustered and 58.2% for robust standard errors.

B. *Delaware, Ohio*

Like Hite (2006), Malikov, Sun, and Hite (2018), and Ford and Seals (2018), data on home prices from the city of Delaware, Ohio, are analyzed. The sample include 2,439 home sales subject to the established criteria. Like Findlay, the quarry is in the Southwest corner of the city and adjacent to the municipal airport, which perhaps should disqualify this city from analysis (there are two treatments). The outdoor shooting range just North of the quarry may represent a third treatment. Nonetheless, the city of Delaware has been studied before, so it worth looking at again.

Table 5. Summary of Regression Results, Delaware

Variable	Model I OLS	Model J OLS	Model K RREG	Model L QREG
ln(Quarry Dist.)	-0.019	-0.022	0.011	0.009
ln(City Center Dist.)	0.066**	0.049	0.063***	0.070***
ln(sqft)	0.557***	0.596***	0.530***	0.535***
ln(acres)	0076***	0.081***	0.090***	0.075***
Outlier Indicator	No	Yes	No	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Standard Errors	Clustered	Clustered	…	Robust
Observations	2,439	2,439	2,439	2,439
R^2	0.705	0.736	0.881	…

Stat. Sig. * 10% ** 5% *** 1%

Table 5 summarizes both the OLS, RREG and QREG results. About 6.4% of observations are marked as outliers. Prices rise in distance from the city center, square footage, and acreage. The Δ coefficients on the quarry-distance covariate are of mixed sign across model types but none are statistically different from zero and all are quite small. Homes prices are uncorrelated with distance from the quarry.

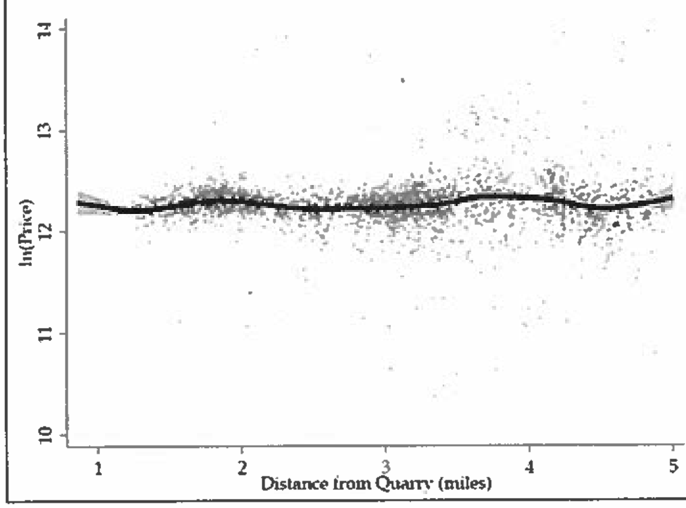
Table 6. Summary of Spatial Regression Results, Delaware

Variable	Model M SDR	Model N SDR	Model O SAR	Model P SEM
ln(Quarry Dist.)	-0.078*	-0.081**	-0.025	-0.034
ln(City Center Dist.)	0.088***	0.038*	0.014	0.072***
ln(sqft)	0.555***	0.582***	0.522***	0.551***
ln(acres)	0.067***	0.073***	0.070***	0.068***
Spatial Lag	-0.271***	-0.133	0.293***	...
Spatial Error	0.903***	0.915***	...	0.582***
Outlier Indicator	No	Yes	No	No
Year Fixed Effects	Yes	Yes	Yes	Yes
Standard Errors	Robust	Robust	Robust	Robust
Observations	2,439	2,439	2,439	2,439

Stat. Sig. * 10% ** 5% *** 1%

Turning to the Spatial Regressions summarized in Table 6, Moran's test statistic is 120.7, which is statistically significant at the 1% level. For the spatial models, the coefficients on the quarry-distance covariate are always negative and statistically different from zero in the two OLS models. If anything, there is a decay in home prices as distance from the quarry increases.

Figure 2. Semiparametric Regression, Delaware



Semiparametric regression, illustrated in Figure 2, offers little more insight than does the regression analysis. Consistent with much of the regression analysis, there is no apparent relationship on prices as distance from the quarry increases, and the thin market near the quarry produces a wide confidence interval.

Randomized Inference is conducted using Model I to determine whether the coefficient is truly unusual. One thousand random locations are selected within seven miles of the city center including locations more than five miles from the quarry. The 95% confidence interval on the empirical coefficient distribution is -0.064 to 0.184, a very wide range that easily encompasses the coefficient value of -0.019 from Model I. The coefficient is not unusual at all, but the t-test indicates the same. Across all simulations, the null hypothesis for the coefficient on simulated locations is rejected 16.1% of the time at the 10% level for tract-clustered errors. For robust standard errors, the rejection rate is 38.5%. As in Ford and Seals (2018), rejection rates for distance coefficients are above the alpha level, though not as high as the earlier study reports.

C. *Lima, Ohio*

If the three quarries analyzed here, the quarry in Lima is closest to the city's center. Of the three cities, Lima has the smallest population and lowest median income, the lowest home prices, and the smallest homes. A sample of 1,169 home sales meeting the sample criteria are included in the analysis. Results are summarized in Table 7 for OLS, RREG, and QREG models. About 4.4% of sales are identified as outliers.

Table 7. Summary of Regression Results, Lima

Variable	Model Q OLS	Model R OLS	Model S RREG	Model T QREG
ln(Quarry Dist.)	0.019	-0.025	-0.110**	-0.018
ln(City Center Dist.)	0.085	0.081	0.074**	0.082*
ln(sqft)	0.490***	0.439***	0.537***	0.469***
ln(acres)	0.136**	0.124**	0.054	0.093**
Outlier Indicator	No	Yes	No	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Standard Errors	Clustered	Clustered	...	Robust
Observations	1,169	1,169	1,169	1,169
R^2	0.342	0.421	0.606	...

Stat. Sig. * 10% ** 5% *** 1%

For Lima, three of the four quarry-distance coefficients are negative but only one is statistically significant (RREG). The one positive coefficient is not statistically different from zero. In Lima, there is little-to-no evidence of the quarry being correlated with lower home prices. Prices rise as distance from the city center increases (with two of four coefficients statistically significant) and as home and lot sizes increase.

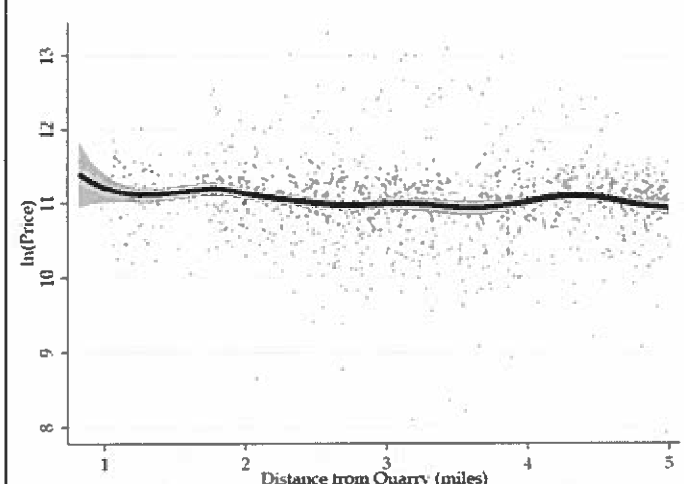
Table 8. Summary of Spatial Regression Results, Lima

Variable	Model U SDR	Model V SDR	Model W SAR	Model X SEM
ln(Quarry Dist.)	-0.065	-0.116	-0.073	-0.011
ln(City Center Dist.)	0.147*	0.158**	0.101**	0.182**
ln(sqft)	0.477***	0.424***	0.475***	0.484***
ln(acres)	0.141***	0.128**	0.138***	0.142***
Spatial Lag	0.520***	0.607***	0.589***	...
Spatial Error	0.234	0.132	...	0.621***
Outlier Indicator	No	Yes	No	No
Year Fixed Effects	Yes	Yes	Yes	Yes
Standard Errors	Robust	Robust	Robust	Robust
Observations	1,169	1,169	1,169	1,169

Stat. Sig. * 10% ** 5% *** 1%

Results from the spatial regression (summarized in Table 8) are comparable. Moran test is 35.5 with probability less than 0.01. For the Spatial Regressions, the quarry-distance covariates are negative but never statistically different from zero at standard levels. Spatial models have very similar coefficients to the non-spatial models with the exception of the two distance variables (as might be expected).

Figure 3. Semiparametric Regression, Lima



Semiparametric regression, illustrated in Figure 3, shows declining prices as distance from the quarry increases, a result consistent with the regression analysis. Confidence intervals are again wide nearer the quarry. There is nothing in the figure, or in the regression results, to suggest that the quarry reduces home prices.

Nor do we expect that the quarry increases home prices but view the negative coefficients as largely an artifact of distance-from-site covariates. Indeed, Randomized Inference on Model Q produces an empirical distribution with a wide range. The 95% confidence interval of the distance coefficients is -1.45 to 1.38, whereas the coefficient on quarry-distance from Model Q is 0.02. The overall rejection for clustered errors is only 74.6% and 81.5% for robust standard errors. Plainly, the generalizability of distance-from-site models is suspect.

V. Analysis of Prior Evidence

A sketch of the data from the Malikov, Sun and Hite (2018) are available online.[27] The data do not permit a reproduction of the paper's results, so only a limited analysis of the data is permitted. For instance, parcels and their locations are not identified, precluding spatial analysis (though OLS and spatial regression produce similar results above). The data covers the entire county (not just Delaware city) and spans years 2009 through the third-quarter of 2011. The data does not include a distance-from-city-center variable or the year of sale indicators, which are omitted variables. There are 5,500 observations in the sample.

Using county level data includes homes quite distant from the quarry (as high 15 miles). In Hite (2006) and here, distance from the quarry was limited to five miles. Presumably, the effects, if any, of the quarry would be limited to a few miles, as suggested by the analysis above. So, I estimate the model when limiting the distance to the quarry to five miles (Model Z). Standard errors are clustered at the block-group level, since a variable in the dataset is block-group level. Results are summarized in Table 9.

Table 9. Summary of Regression Results

Variable	Model Y	Model Z
ln(Quarry Dist.)	0.068***	-0.124***
ln(sqft)	0.693***	0.662***
ln(acres)	0.089***	0.122***
Outlier Indicator	No	No
Year Fixed Effects	No	No
Standard Errors	Clustered	Clustered
Observations	5,500	1,173
R^2	0.658	0.514
Stat. Sig. * 10% ** 5% *** 1%		

27 Data available at: http://qed.econ.queensu.ca/jae/2019-v34.1/malikov-sun-hite.

For the full sample (Model Y) of the Malikov, Sun, and Hite (2018) study, the coefficient on the quarry-distance variable is positive and statistically different from zero. When limiting the date to home sales within five-miles of the quarry (Model Z), the coefficient is negative and statistically different from zero. A review of the data indicates that the average home size rises sharply at about six miles, so it appears there is an anomaly in the real estate market far from the quarry that may be driving the positive coefficient.[28] The results from a distance-from-site hedonic model appear very sensitive to model specification and the data used.

VI. Conclusion

For many Americans, a home is their most valuable asset. Naturally, the threat of a reduction in home values causes concern. Opposition to rock quarries, which are typically located in rural areas with low housing density, is motivated, in large part, by a fear of a loss in home values. Yet, the geographic scope of a quarry's activities is narrow and usually less than one-half mile. Modern quarrying methods have greatly reduced the influence of quarry operations on surrounding areas. Evidence supporting the effect of a quarry on home values is scant, which is something I attempt to rectify here with the most extensive study to date. Evidence from three cities for thousands of home sales reveals no robust effect of quarries on home values.

Like most prior studies, I do not estimate plausibly causal effects. Ideally, Difference-in-Differences methods, or some other causal model, would be used, as in Ford and Seals (2018). An impediment to causal analysis is the difficulty in obtaining sufficient samples of home sales around new quarry sites given their mostly rural locations. Correlation studies are most frequently cited before regulators, so these results are useful in that respect. However, I stress that this study, as well as the commonly cited Hite (2006) study, as well as Malikov, Sun and Hite (2018), need not offer plausibly causal estimates of the effect of quarries on home sales.

I note that efforts to establish the effect of a (dis)amenity on home prices is not merely an academic exercise. Such studies may be relied upon for public policy decisions restricting property rights of landowners and potentially affecting millions of dollars in economic activity. Distance-from-site regressions, as I demonstrate here, are unreliable and often plagued by selection bias. Results are often sensitive to the richness of the model, the estimation method, and the

[28] The average square footage within five miles of the quarry is 1,901. Between five and ten miles from the quarry, the average home size is 2,887.

geographic scope of the data. A serious effort to assess the robustness of any estimate, using different methods, models, data, and inference procedures (including Randomized Inference), seems prudent if not essential.

APPENDIX:

Variable Definitions

Variable	Description
ld_quarry	Natural log of distance from quarry in miles.
ld_center	Natural log of distance from the city center in miles
lsqft	Natural log of home's square footage.
lacres	Natural log of home's lot size in acres.
basementshare	Percentage of square footage in basement.
onestory	House has one story.
lage	Natural log of age of home.
remodel10	Home remodeled in the 10 years prior to sale.
airc	Home has central air conditioning.
bedroomsN	Home as N bedrooms. "m" indicates "or more."
fullbathN	Home has N full bathrooms. "m" indicates "or more."
halfbathN	Home has N half bathroom. "m" indicates "or more."
fireplaceN	Home has N fireplaces. "m" indicates "or more."
gradeN	Grade of N for housing construction.
condN	Condition N of household.
garage_	AF (attached finished); AU (attached unfinished); DF (detached unfinished); DU (detached unfinished); BA (basement attached); CP (carport); N indicates count of garages.
lmedinc	Natural log of median income in census block group.
white	Share of white population in census block group.
vacant	Share of vacant homes in census block group.
outlier	Outlier indicator.

Table A-3. Findlay, Ohio				
	Model A	Model B	Model C	Model D
ld_quarry	-0.0299	-0.0325	-0.0313***	-0.0417***
ld_center	0.0107	0.00132	0.0318***	0.0335**
lsqft	0.386***	0.409***	0.484***	0.482***
lacres	0.0414	0.0864***	0.0666***	0.0586***
basementsh~e	0.215***	0.220***	0.188***	0.183***
onestory	0.0193	0.00819	-0.0019	0.00453
lage	-0.0477**	-0.0555***	-0.105***	-0.103***
remodel10	0.123**	0.0918	0.0647**	0.0868**
airc	0.174***	0.132***	0.109***	0.126***
bedrooms2	0.0109	-0.0757	0.00393	-0.0112
bedrooms3	0.0503	-0.0464	0.0372	0.0186
bedrooms4	0.0825	-0.0259	0.0308	0.0147
bedrooms5m	-0.0455	-0.0956	-0.0124	-0.0486
fullbath2	0.159***	0.149***	0.115***	0.114***
fullbath3	0.280***	0.298***	0.159***	0.157***
fullbath4m	0.246	0.421**	0.336***	0.395***
halfbath1	0.0553***	0.0535***	0.0478***	0.0388***
halfbath2m	0.246***	0.293***	0.120***	0.111***
fireplace1	0.0812***	0.0655**	0.0409***	0.0540***
fireplace2m	0.108**	0.130*	0.0617***	0.0397
gradeB	-0.416***	-0.328**	-0.252***	-0.243***
gradeC	-0.554***	-0.489***	-0.386***	-0.375***
gradeD	-0.655***	-0.557***	-0.482***	-0.484***
condG	0.584**	-0.0595	-0.0667	0.116
condA	0.578**	-0.1	-0.0905*	0.114
condF	0.352	-0.19	-0.129**	0.0185
garage_AF	0.123***	0.0976***	0.0496***	0.0674***
garage_AU	0.0892**	0.0673***	0.0309***	0.0470***
garage_DF	0.0852	0.105	0.0196	0.0256
garage_DU	0.0646	0.0952*	0.0166	0.00765
garage_BA	0.0882	0.314**	-0.0222	-0.00473
garage_CP	-0.119	0.135	-0.0807	-0.109
lmedinc	0.0984*	0.0971**	0.0837***	0.0675***
white	0.302**	0.323**	0.144***	0.208***
vacant	-0.151	-0.141	-0.0632	-0.0834
outlier		-0.776***		
_cons	7.136***	7.908***	7.737***	7.631***
Year Fixed Effects	Yes	Yes	Yes	Yes
N	2,843	2,843	2,843	2,843
R2	0.645	0.723	0.838	
Sig. Level: * 10% ** 5% *** 1%				

Table A-3. Findlay, Ohio

	Model A	Model B	Model C	Model D
ld_quarry	-0.0298	-0.036	-0.00921	-0.0562**
ld_center	-0.0268	-0.0416*	-0.00144	0.011
lsqft	0.345***	0.368***	0.341***	0.361***
lacres	0.0384**	0.0854***	0.0145	0.107***
basementsh~e	0.190***	0.195***	0.200***	0.193***
onestory	0.0216	0.0119	0.0191	0.0111
lage	-0.0189*	-0.0294***	-0.0187*	-0.0265**
remodel10	0.138***	0.108**	0.133***	0.116***
airc	0.156***	0.116***	0.171***	0.101***
bedrooms2	0.00348	-0.0825**	0.0127	-0.0899**
bedrooms3	0.0428	-0.053	0.0526	-0.0602
bedrooms4	0.0679	-0.0399	0.0840*	-0.0506
bedrooms5m	-0.0506	-0.100*	-0.0376	-0.107*
fullbath2	0.134***	0.125***	0.140***	0.118***
fullbath3	0.252***	0.269***	0.254***	0.270***
fullbath4m	0.225***	0.393***	0.246***	0.362***
halfbath1	0.0439***	0.0428***	0.0480***	0.0423***
halfbath2m	0.241***	0.289***	0.239***	0.284***
fireplace1	0.0630***	0.0489***	0.0627***	0.0453***
fireplace2m	0.103***	0.122***	0.107***	0.103***
gradeB	-0.391***	-0.300***	-0.407***	-0.285***
gradeC	-0.505***	-0.437***	-0.527***	-0.422***
gradeD	-0.602***	-0.501***	-0.629***	-0.479***
condG	0.510***	-0.107	0.508***	-0.0987
condA	0.504***	-0.146*	0.491***	-0.123
condF	0.274***	-0.241***	0.260***	-0.209**
garage_AF	0.100***	0.0770***	0.0962***	0.0869***
garage_AU	0.0800***	0.0595***	0.0812***	0.0618***
garage_DF	0.0735	0.0974	0.0796	0.0864
garage_DU	0.0691	0.0976**	0.0716	0.0982***
garage_BA	0.0977	0.317***	0.0871	0.336***
garage_CP	-0.12	0.134*	-0.132	0.137*
lmedinc	0.0343	0.0364	-0.00608	0.111***
white	0.160*	0.176**	0.189**	0.183
vacant	-0.164	-0.153	-0.16	-0.147
outlier		-0.760***		-0.742***
_cons	-2.541**	-1.769*	-1.706***	8.189***
Year Fixed Effects	Yes	Yes	Yes	Yes
lprice	0.912***	0.907***	0.880***	
e.lprice	0.941***	0.953***		3.012***
var(e.lprice)	0.105***	0.0818***	0.107***	0.0814***
N	2,843	2,843	2,843	2,843

Sig. Level: * 10% ** 5% *** 1%

Table A-5. Delaware, Ohio

	Model I	Model J	Model K	Model L
ld_quarry	-0.0194	-0.0222	0.0106	0.00898
ld_center	0.0661**	0.0489	0.0629***	0.0702***
lsqft	0.557***	0.596***	0.529***	0.535***
lacres	0.0758***	0.0805***	0.0895***	0.0754***
onestory	0.0775**	0.0860**	0.0765***	0.0853***
lage	-0.0358**	-0.0314*	-0.0481***	-0.0422***
remodel10	0.0439***	0.0508***	0.0602***	0.0405***
airc	0.0437	0.0191	-0.0221**	0.016
fullbase	0.149***	0.150***	0.145***	0.151***
partbase	0.118***	0.113***	0.129***	0.136***
bedrooms2	0.0283	-0.260***	0.156**	0.251***
bedrooms3	0.140**	-0.183**	0.192***	0.315***
bedrooms4	0.117**	-0.215**	0.174**	0.300***
bedrooms5m	0.0981*	-0.186**	0.0941	0.234***
fullbath2	0.0361	0.0406	0.0715***	0.0665***
fullbath3	0.144**	0.144**	0.157***	0.153***
fullbath4m	0.190**	0.212**	0.186***	0.165***
halfbath1	0.0297	0.0297	0.00161	0.00818
halfbath2m	0.217***	0.261***	0.133***	0.157***
fireplace1	0.0346*	0.0330*	0.0348***	0.0324***
fireplace2	0.157**	0.166**	0.0703***	0.0731*
fireplace3m	0.396***	0.513***	0.301***	0.341***
lmedinc	0.101*	0.112*	0.0703***	0.0780***
white	0.0902	-0.0233	0.0952*	0.0558
vacant	0.0482	0.0143	-0.185**	-0.309***
garage1	0.0983**	0.0728**	0.0287**	0.0569***
garage2	0.109**	0.0869**	0.0445***	0.0687***
garage3	0.108**	0.123***	0.131***	0.152***
garage4m	0.195***	0.233***	0.146***	0.148***
outlier		-0.378***		
_cons	6.272***	6.356***	6.978***	6.652***
Year Fixed Effects	Yes	Yes	Yes	Yes
N	2,439	2,439	2,439	2,439
R2	0.705	0.736	0.881	
Sig. Level: * 10% ** 5% *** 1%				

Table A-6. Delaware, Ohio

	Model I	Model J	Model K	Model L
ld_quarry	-0.0778*	-0.0810**	-0.0246	-0.0337
ld_center	0.0879***	0.0383*	0.0139	0.0716***
lsqft	0.555***	0.582***	0.522***	0.551***
lacres	0.0669***	0.0730***	0.0696***	0.0677***
onestory	0.0633***	0.0745***	0.0705***	0.0653***
lage	-0.0294***	-0.0246***	-0.0278***	-0.0287***
remodel10	0.0408**	0.0478***	0.0398**	0.0417**
airc	0.0415**	0.0163	0.0493**	0.0423**
fullbase	0.139***	0.133***	0.133***	0.137***
partbase	0.109***	0.0992***	0.106***	0.108***
bedrooms2	0.0514	-0.248**	0.0651	0.0492
bedrooms3	0.176	-0.162	0.185	0.175
bedrooms4	0.156	-0.192	0.161	0.151
bedrooms5m	0.148	-0.15	0.141	0.141
fullbath2	0.0312	0.0416**	0.0387**	0.0340*
fullbath3	0.134***	0.134***	0.133***	0.141***
fullbath4m	0.198***	0.225***	0.190***	0.199***
halfbath1	0.0265	0.0311**	0.0291*	0.0267
halfbath2m	0.202***	0.252***	0.208***	0.203***
fireplace1	0.0291**	0.0286**	0.0328***	0.0308**
fireplace2	0.152***	0.161***	0.160***	0.154***
fireplace3m	0.390***	0.515***	0.398***	0.389***
lmedinc	0.125***	0.120***	0.0589**	0.103***
white	0.0953	0.0323	0.222**	0.105
vacant	0.0685	0.077	0.122	0.0323
garage1	0.0920***	0.0743***	0.104***	0.0928***
garage2	0.0958***	0.0804***	0.112***	0.0974***
garage3	0.126***	0.143***	0.124***	0.128***
garage4m	0.217***	0.247***	0.215***	0.221***
outlier		-0.405***		
_cons	9.345***	7.987***	3.256***	6.264***
Year Fixed Effects	Yes	Yes	Yes	Yes
lprice	-0.271***	-0.133	0.293***	
e.lprice	0.903***	0.915***		0.582***
var(e.lprice)	0.0652***	0.0573***	0.0660***	0.0660***
N	2,439	2,439	2,439	2,439
Sig. Level: * 10% ** 5% *** 1%				

Table A-7. Lima, Ohio

	ModeQ	Model R	Model S	Model T
ld_quarry	0.0185	-0.0254	-0.110**	-0.0178
ld_center	0.0854	0.081	0.0738	0.0822
lsqft	0.490***	0.439***	0.537***	0.469***
lacres	0.136**	0.124**	0.0539	0.0931**
basementshare	0.262**	0.317**	0.292**	0.294
onestory	0.00474	0.0125	0.123***	0.0622
lage	-0.290***	-0.269***	-0.294***	-0.267***
remodel10	0.0369	0.0134	0.126**	0.0521
airc	0.0383	0.0843**	0.185***	0.124***
fullbase	0.00846	-0.0221	-0.0231	-0.0262
bedrooms2	0.0905	0.256	-0.000842	0.0675
bedrooms3	0.128	0.282	-0.0157	0.0549
bedrooms4	-0.0346	0.0509	-0.0484	-0.00189
bedrooms5m	0.388	0.169	0.15	0.268*
fullbath2	0.022	0.0201	0.0736*	0.0611
fullbath3	-0.148	0.268	-0.0671	-0.136
fullbath4m	0.362	0.503	-0.0121	0.44
halfbath1	0.0109	0.0289	0.0863**	0.0623*
halfbath2m	-0.303**	-0.741**	-0.126	-0.286
fireplace1	0.0494	0.0535	0.0937**	0.0438
fireplace2m	0.0548	0.0399	0.104	0.0627
gradeB	-0.0611	0.656	-0.733**	-0.29
gradeC	-0.378	0.438	-1.033***	-0.58
gradeD	-0.655	0.141	-1.343***	-0.898**
garage1	0.0153	0.0115	0.0552	0.0584*
garage2	0.0512	-0.00986	0.0112	0.0174
garage3	0.258*	0.0308	0.106	0.116
lmedinc	0.185*	0.247**	0.365***	0.240***
white	-0.097	-0.0152	0.0495	0.0301
vacant	-0.347	-0.446*	-0.389**	-0.375*
outlier		1.203***		
_cons	7.132***	5.773***	5.339***	6.657***
Year Fixed Effects	Yes	Yes	Yes	Yes
N	1,169	1,169	1,169	1,169
R2	0.333	0.432	0.591	

Sig. Level: * 10% ** 5% *** 1%

Table A-8. Lima, Ohio

	Model U	Model V	Model W	Model X
ld_quarry	-0.0654	-0.116	-0.0728	-0.0109
ld_center	0.147*	0.158**	0.101	0.182**
lsqft	0.477***	0.424***	0.475***	0.484***
lacres	0.141***	0.128***	0.138***	0.142***
basementsharee	0.253	0.315*	0.26	0.245
onestory	-0.00787	-0.00536	0.00659	-0.0185
lage	-0.278***	-0.253***	-0.284***	-0.275***
remodel10	0.0176	-0.00967	0.0164	0.0221
airc	0.0174	0.0587	0.0253	0.017
fullbase	0.0219	-0.00563	0.0194	0.0195
bedrooms2	0.101	0.27	0.0998	0.101
bedrooms3	0.154	0.311*	0.153	0.149
bedrooms4	0.00679	0.0949	0.000812	0.00597
bedrooms5m	0.407	0.194	0.402	0.401
fullbath2	0.00796	0.00387	0.0166	0.00293
fullbath3	-0.159	0.261	-0.145	-0.173
fullbath4m	0.454	0.599	0.463	0.415
halfbath1	0.000382	0.0165	0.00212	0.00102
halfbath2m	-0.309	-0.752***	-0.315	-0.303
fireplace1	0.0408	0.0411	0.0396	0.0488
fireplace2m	0.0432	0.0249	0.0482	0.0452
gradeB	-0.0228	0.693*	-0.0338	-0.027
gradeC	-0.318	0.5	-0.333	-0.33
gradeD	-0.551	0.252	-0.57	-0.569
garage1	0.0114	0.00475	0.0193	0.00653
garage2	0.0508	-0.00981	0.0521	0.0486
garage3	0.241	0.0132	0.251	0.229
lmedinc	0.123*	0.183***	0.119*	0.148**
white	-0.103	-0.00632	-0.129	-0.0813
vacant	-0.242	-0.343	-0.228	-0.287
outlier		1.211***		
_cons	3.384	1.947	2.293*	7.409***
Year Fixed Effects	Yes	Yes	Yes	Yes
lprice	0.401**	0.407**	0.512***	
e.lprice	0.326	0.396*		0.585***
var(e.lpri~)	0.371***	0.324***	0.372***	0.373***
N	1,169	1,169	1,169	1,169

Sig. Level: * 10% ** 5% *** 1%

Property Value Impacts of the SGI Charmian Quarry and Processing Facility in Hamiltonban Township, Adams County PA

Status: Final Report
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Submitted to:

K&L Gates LLP
Market Square Plaza, 18th Floor
17 North Second Street
Harrisburg, PA 17101

ESI ECONSULT SOLUTIONS INC.

economics | policy | strategy

1435 WALNUT STREET, 4TH FLOOR, PHILADELPHIA, PA 19102 | 215-717-2777 | ECONSULTSOLUTIONS.COM

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About Econsult Solutions, Inc.

This report was produced by Econsult Solutions, Inc. ("ESI"). ESI is a Philadelphia-based economic consulting firm that provides businesses and public policy makers with economic consulting services in urban economics, real estate economics, transportation, public infrastructure, development, public policy and finance, community and neighborhood development, planning, as well as expert witness services for litigation support. Its principals are nationally recognized experts in urban development, real estate, government and public policy, planning, transportation, non-profit management, business strategy and administration, as well as litigation and commercial damages. Staff members have outstanding professional and academic credentials, including active positions at the university level, wide experience at the highest levels of the public policy process and extensive consulting experience.

1. Introduction

Specialty Granules, LLC (SGI) is a national manufacturer of mineral granules for the residential and commercial roofing markets. The SGI Charmian plant was established in 1923 in Hamiltonban Township, Adams County. The location had also been used for mining prior to SGI's ownership. Most of the granules SGI produces are used to manufacture asphalt-based roofing shingles and it is the only granule production facility serving asphalt shingle manufacturers in the Northeast. The Charmian plant produces enough granules to protect approximately 1 million homes (both new and re-roofing) per year with asphalt shingles. The next-closest granule products plants to the northeast market are in Wisconsin and North Carolina.

SGI has applied for a new surface mining permit to continue its currently permitted and operating metabasalt quarry operations through development of an approximately 112-acre mining area referred to as the Northern Tract adjacent to and northeast of the existing Pitts Quarry area. SGI has asked Econsult Solutions, Inc. to estimate the impact, if any, that the quarry has on nearby property values. This report details our analytical approach and findings of our analysis.

2. Background

A common complaint raised by opponents to the development of new quarries or the expansion of existing quarries is the potential impact on near-by residential property values.

It is well recognized that residential property values may be impacted by a variety of factors, including the characteristics of the property itself (e.g., lot size/land area, building square footage, structure condition), general economic and employment conditions (e.g., recession vs. expansion cycles), and characteristics of the surrounding area. The industry standard method used in real estate economics to evaluate the relative importance of each attribute, or variable, on property values involves hedonic regression models (also referred to as hedonic pricing models). Hedonic modeling starts with actual reported sales prices from arms-length transactions and provides, through a set of multiple statistical analyses, estimates of the average impact that any property attribute (e.g., lot size or square feet of residence) or neighborhood attribute (e.g., location in relation to some other land use) contributes to property values seen in market transactions while controlling for the impact of other variables. As discussed below, ESI prepared a hedonic regression model that used actual sale prices reported in Adams and Franklin Counties to evaluate the potential impact of proximity to or distance from the SGI Charmian Facility.

In addition to modeling, we conducted a literature search of the effect of quarries on property value. There is extensive literature applying hedonic regression models to study the effects of certain perceived environmental disamenities on residential property values. The results of the studies with regards to the impact that proximity to landfills, hazardous waste sites, and power plants have on residential property values are mixed depending on each individual circumstance. In contrast, there is relatively limited literature as to whether a negative property value effect results from quarries. In addition, many of the studies that do exist are non-peer-reviewed.

The most commonly cited study of potentially negative residential property value impacts of quarries was a relatively short paper prepared by Professor Patricia Hite of a quarry near Delaware, Ohio.[1] However, as discussed in more detail below, the results of the Hite paper have recently been called into question.[2]

The Hite paper found a positive relationship between residential property values and distance from the Delaware, Ohio quarry, which would imply a negative impact on residential property values – as one moves closer to the quarry, residential property values decline. Additional studies that purported to find a negative impact of quarries, including Erickcek (2006), the Center for Spatial Economics (2009),

[1] D. Hite, Summary of Analysis: Impact of an Operational Gravel Pit on House Values: Delaware County, Ohio, Working Paper (2006) (available at: http://www.accpg.org/docs/Gravel%20Pit%20Interim%20Zoning/Storey%20Pit/exhibit_b.pdf)

[2] See: Ford and R. Seals, Quarry Operations and Property Values: Revisiting Old and Investigating New Empirical Evidence , The Phoenix Center (March 2018) (available at: http://www.phoenix-center.org/pcpp/PCPP53Final.pdf) for a criticism of the Hite paper.

and Smith (2014)[3] among others, did not conduct their own econometric modelling, but rather extrapolated the results of Hite's report to different locations. As such, these additional studies do not supply any additional support for the notion that quarries have a negative impact on property values. In contrast, as discussed below, two recent studies did not find a negative impact of quarries.

A recent paper from the Phoenix Center (2018)[4] points out many of the shortcomings of the Hite paper, including the length of the paper (250 words), no details regarding the modeling methodology used and little information on data used in the analysis. The Phoenix Center attempted to replicate the results of the Hite study using data from the same quarry and the same methods as the original paper (e.g., using price rather than the log of price[5] and using non-linear least squares[6]). The Phoenix Center study found that reported transaction prices of residential properties decreased as the distance from the quarry increased. The coefficient for distance from the quarry from the regression model (-.141) was similar in size but had the opposite sign from the results reported in the Hite paper (.125). These coefficients represent the average impact of a given housing or neighborhood attribute on property valuations, while controlling for the impact of other variables. Thus, one model utilizing non-standard methodology purported to find a decrease in property values near the Ohio quarry, while a second model prepared using better documented and more accepted methodology showed an increase in property values near the Ohio Quarry.

In additional to attempting to replicate the results of the Hite study, the Phoenix Center analysis also analyzed the data using a variety of model specifications[7]. The Phoenix Center analysis looked at a variety of alternative specifications to test the impact of distance from the quarry on property values. Across all alternative model specifications, the price-distance relationship was negative, that is, controlling for other variables, properties further away from the quarry tended to have lower prices and that relationship was statistically significant. The negative price-distance relationship is robust to estimation method and distance specifications.

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[3] G.A. Erickcek, An Assessment of the Economic Impact of the Proposed Stoneco Gravel Mine Operation on Richland Township, W.E. Upjohn Institute for Employment Research (August 15, 2006) (available at: http://www.stopthequarry.ca/documents/US%20Study%20on%20the%20impact%20of%20pits% 20quarries%20on%20home%20prices.pdf); The Potential Financial Impacts of the Proposed Rockfort Quarry, Center for Spatial Economics (February 26, 2009) (available at: http://wcwrpc.org/FinancialImpacts_RockfortQuarryCanada.pdf);
G. Smith, Economic Costs and Benefits of the Proposed Austin Quarry in Madera County, Report (October 23, 2014) (available at: http://www.noaustinquarry.org/wp-content/uploads/2016/08/Austin-Quarry-Economics- Report.pdf).

[4] G. Ford and R. Seals, Quarry Operations and Property Values: Revisiting Old and Investigating New Empirical Evidence , The Phoenix Center (March 2018) (available at: http://www.phoenix-center.org/pcpp/PCPP53Final.pdf)

[5] "Log of price" involves translation of a series of prices into their respective natural-log value, which makes it easier to evaluate the average percentage change.

[6] The functional form of the model chosen by Hite is highly irregular in hedonic house price models. The model is non-linear which required the use the non-linear least squares estimation technique to estimate the model, rather the ordinary least squares estimation technique which is standard practice in the hedonic house price literature. The Phoenix Center paper was unable to find an instance in the literature where the specification used by Professor Hite is used and in addition, they were able to find a number of other studies by Professor Hite where ordinary least squares techniques and the more common functional forms were used rather than the non-linear least squares technique.

[7] A "model specification" is part of the process of building a statistical model: specification consists of selecting an appropriate functional form for the model and choosing which variables to include.

The Phoenix Center study also undertook a similar analysis for properties surrounding the Rogers Group Quarry near Murfreesboro, Tennessee. Across all model specifications the price-distance relationship was negative, controlling for other variables, properties a further distance from the quarry tended to have lower prices and statistically significant.

In addition, Grant (2017)[8] analyzed the impacts of quarries on property values in Wellington County, Ontario. The analysis found a small positive impact associated with being close to a quarry, meaning prices were slightly higher near the quarry .

[8] A. Grant, Estimating the Marginal Effect of Pits and Quarries on Rural Residential Property values in Wellington County, Ontario: A Hedonic Approach. (June 2017). (available at: https://atrium.lib.uoguelph.ca/xmlui/bitstream/handle/10214/10903/Grant_Alison_201706_MSc.pdf?sequence=3&isAllowed=y)

3. Property Value Impact of SGI's Quarry in Hamiltonban, Adams County PA

To determine the residential property value impact of SGI's Quarry in Hamiltonban, ESI undertook a rigorous statistical analysis of 561 arms-length residential property transactions in Adams and Franklin Counties located within three miles of the quarry over the 2000 to 2019 period.[9] Data on reported property transactions was obtained from the Adams County Tax Services Department and the Franklin County Geographic Information Services Department.[10] This data set is large enough to allow for statistically significant findings.

3.1. Analytical Approach

Hedonic regression models are an industry-standard technique used to statistically estimate the effects of property characteristics on residential property values. Hedonic modeling can provide estimates of the average impact that any housing or neighborhood attribute contributes to property valuations while controlling for the impact of other variables. Hedonic modeling offers valuable information about the relative contribution of property characteristics, such as proximity to the SGI quarry, to the value of real property controlling for the other variables that impact prices.

The hedonic regression model used is as follows:

$$House\ Value_i = f(S, N, T, Quarry)$$

Where:

S is the vector of structural characteristics of the house, including total square feet of the house, and lot size.

N is a vector of neighborhood socioeconomic characteristics measured at the Census Tract level. These include household income and percentage of houses that are owner occupied and other demographic variables.

***T** is a vector of indicator variables for year of sale to control for overall market conditions in each year.*

Quarry is distance of the quarry to each of the individual houses

[9] We also did the analysis using data from all 35,310 arms-length transactions in Adams and Franklin Counties. We found the results to be similar to the model results using data from within three miles of the quarry.
[10] The property transaction data and property characteristics data was purchased from the appropriate departments in each county in May 2019.

This hedonic model allowed us to isolate the impact of being close to the quarry on the value of residential properties located near the quarry, while controlling for the impact of other variables.

The regression model was estimated using data from 561 arms-length transactions of single-family homes in Adams and Franklin counties that are located within 3-miles of the SGI facility. The property transaction data was carefully screened and cleaned to remove non-arms-length sales such as transactions between family members. In addition, transactions with missing or unusual characteristics were also excluded. Specifically, we excluded transactions that involved structures that were less than 500 or more than 5,000 square feet in size, had sales prices that were less than $10,000 or greater than $5,000,000, or that were missing the sale date, sale price, square footage, or acreage data.

The transactions span the 2000 to 2019 period which covers the period before and after the housing crash in 2007. The impact of the housing crash and other market-wide temporal influences on house prices was accounted for by including a series of time variables that are equal to 1 if a transaction occurred in a given year, and 0 otherwise. This allowed us to control for the impact of factors, such as the housing market crash, that would impact all residential properties that transact in a given year.

Each transaction was geo-coded (assigned a unique latitude and longitude) based upon its address and assigned a spatial location. The data was read into ArcView GIS along with a shapefile of the location of the quarry. For each transaction, the distance to the SGI quarry was calculated using Geographic Information System (GIS) tools. Given the size of the quarry we calculated the distance of each residential parcel to three different locations on the quarry site. The locations include:

1. crusher and processing facility,
2. the area where current quarrying is occurring, and
3. the proposed expansion site.

The sites are illustrated in Figure 1.

Figure 1: Quarry Locations

The regression model used the natural log of residential property price as the dependent variable, which is the most commonly used specification in the hedonic house price literature. By using the natural log of price, rather than price itself, as the dependent variable, the coefficients have the interpretation of being the percent change, rather than dollar change, in the price of the residential property as a result of a change in the independent variables. For example, if the size of th lot were to increase by one unit (acre), the residential property value would increase by X.X percent. In addition, using the natural log of house prices assumes a nonlinear relationship between the price of the residential property and their inherent attributes (e.g. square footage or lot size). The implicit price is not a constant, but a function of the quantity of the attribute being bought – the value of additional square foot of house size or acre of lot size depends on the how big the house or the lot is.

3.2. Findings

Figure 2 summarizes the results of the hedonic regression model. The regression model was estimated using four different distance measures – once for each of the distance variables described above as well as for the minimum value of the three distance variables.

Figure 2: Regression Results

	Model 1		Model 2		Model 3		Model 4	
Log of distance to processing facility	-0.049							
Log of distance to the current quarry			-0.056					
Log of distance to the proposed quarry					-0.086			
Log of the minimum distance to the quarry							-0.033	
Living area	0.001	***	0.001	***	0.001	***	0.001	***
Living area squared	0.000	***	0.000	***	0.000	***	0.000	***
Lot size	0.032	***	0.032	***	0.032	***	0.032	***
Percent of owner-occupied homes (Census Tract)	-0.140		-0.045		-0.096		-0.169	
Population density (Census Tract)	0.001		0.001		0.001		0.001	
Median hold income (000's $)	0.018		0.018	*	0.020	*	0.020	
Adams County	0.050		0.035		-0.008		0.048	
Sale year 2001	0.076		0.072		0.078		0.077	
Sale year 2002	0.144		0.142		0.146		0.147	
Sale year 2003	0.406	***	0.405	***	0.408	***	0.408	***
Sale year 2004	0.557	***	0.554	***	0.552	***	0.560	***
Sale year 2005	0.719	***	0.716	***	0.720	***	0.722	***
Sale year 2006	0.697	***	0.695	***	0.700	***	0.699	***
Sale year 2007	1.148	***	1.149	***	1.142	***	1.146	***
Sale year 2008	0.864	***	0.861	***	0.865	***	0.866	***
Sale year 2009	0.769	***	0.771	***	0.764	***	0.772	***
Sale year 2010	0.954	***	0.954	***	0.957	***	0.954	***
Sale year 2011	0.748	***	0.746	***	0.747	***	0.750	***
Sale year 2012	0.823	***	0.821	***	0.820	***	0.826	***
Sale year 2013	0.792	***	0.787	***	0.791	***	0.796	***
Sale year 2014	0.565	***	0.563	***	0.568	***	0.568	***
Sale year 2015	0.747	***	0.746	***	0.744	***	0.748	***
Sale year 2016	0.790	***	0.785	***	0.789	***	0.792	***
Sale year 2017	0.805	***	0.801	***	0.806	***	0.807	***
Sale year 2018	0.941	***	0.938	***	0.937	***	0.944	***
Sale year 2019	0.977	***	0.976	***	0.979	***	0.978	***
Intercept	8.971	***	8.923	***	8.885	***	9.002	***
Observations	561		561		561		561	
R-squared	0.2532		0.2535		0.2539		0.2530	

**** statistically significant at the 1% level, ** at the 5% level, and * at the 10% level*

In a hedonic regression model, the average impact of a given housing or neighborhood attribute on property valuations, while controlling for the impact of other variables, is given by the coefficients from the regression model. The coefficients from our analysis are presented in Figure 2.

The effect of the quarry on house values is obtained from the estimated coefficients on the quarry variables in the regressions. The coefficients give the % change in residential property values, given a unit change in the distance from the quarry. For example, the estimated coefficients from the model variables indicates what the average % change in residential property prices for each additional mile further from the quarry, controlling for other housing characteristics.

The model results indicate that the coefficients on the distance variables range from -0.033 to -0.086. Translated, for each mile that a house is located further away from the quarry, residential property prices **decrease** by between 3.3 percent and 8.6 percent.

For example, the average sales price for houses located nearby the quarry is $156,000 and the median value is $164,000. If those houses were moved so that they were one mile away from the quarry, their value would decrease between 3.3 percent and 8.6 percent. For the average house, this would amount to a reduction in value of between $5,070 and $13,400 and for the median house a reduction of between $5,330 and $14,100.

The t-values of each variable indicate the strength of the statistical association between residential property values and the independent variables, in this case distance to the quarry. A value greater than 1.96 or less than -1.96 indicate a "statistically significant" (i.e. strong and non-random) relationship. The t-values for the quarry distance variables range from -0.40 to -0.89, which indicates that the relationship between residential property values and distance to the quarry is weak and that the quarry does not have a statistically significant impact on nearby property values.

The r-squared of the regression models in Figure 2 is similar in size to the r-squared values from the Hite study and the analysis undertaken by the Phoenix Center. This means that models presented in Figure 2 have a similar "fit" as the models estimated by Hite and the Phoenix Center.

In addition to using data from within three miles of the quarry, we also estimated the models using data for all transactions in Adams and Franklin Counties over the 2000 to 2019 time period.[11] Across all distance specifications the price distance relationship was negative and statistically significant. To examine the potential for the distance relationship to be non-linear in nature, we classified properties into one of the following distance bands, less than one mile, one to two miles, two to three miles, and greater than three miles. Across the less than one, one to two miles, and two to three-mile distance bands, the regression coefficients from the models were not statistically significant.

Based on our analysis, we find that the SGI quarry has not had a negative impact on nearby property values based upon actual reported sale price data and analysis that controls for other property

[11] The regression models using data from the entire county used 35,310 observations.

variables. The results are robust to the data used (properties only within three miles of quarry vs from both counties) and distance specification (linear distance vs. distance bands). Given the fact that the intensity of the operations of the quarry is not going to change, the continued operations of the quarry should not have a negative impact on near-by property values.

BLASTING IN OHIO'S QUARRIES AND SURFACE COAL MINES

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Ohio Department of Natural Resources
Division of Mineral Resources Management
minerals.ohiodnr.gov

Columbus 614.265.6633
New Philadelphia 330.339.2207

On a typical workday in Ohio, over a quarter million pounds of explosives are safely detonated in quarries and surface coal mines.

The word "blasting" often conjures up visions of destruction - mushroom clouds, gigantic craters, high-rise buildings collapsing, bridges falling and cars exploding. However, on a typical workday in Ohio, over a quarter million pounds of explosives are safely detonated in quarries and surface coal mines. The Ohio Department of Natural Resources, Division of Mineral Resources Management is the agency responsible for regulating the environmental effects of mining and blasting. This article will address some of the commonly asked questions and misconceptions regarding blasting.

Why is blasting necessary?

Blasting is the most cost effective way to fracture rock so that it can be excavated by earth-moving equipment. This, in turn, reduces the costs of building materials, such as gravel and concrete, energy produced from coal, and many other products derived from estone, coal and other minerals.

Is dynamite still used?

People living near quarries and coal mines often express concern about "the dynamiting going on over there." In fact, dynamite, a nitroglycerin-based explosive, is rarely used today in Ohio's quarries and surface coal mines. The most widely used explosives are ANFO, emulsions, and ANFO/emulsion blends. ANFO is a mixture of ammonium nitrate (AN) and fuel oil (FO). The AN is in the form of a prill (small, bead-like pellet), which absorbs the fuel oil. An emulsion is essentially a waterproof version of ANFO. Both are far less hazardous than dynamite and break more rock per unit of cost.

How far do fractures extend from a blasthole?

Blastholes are normally drilled vertically and arranged in a grid pattern. Typical blasthole diameters range from two to seven inches in quarries and five to nine inches in surface coal mines, with typical depths from 10 to 70 feet. Upon detonation, fracturing of rock generally occurs no greater than 20 to 30 feet from any blasthole, depending largely upon hole diameter and the densities of the rock and explosive. A common misconception is that fracturing extends far beyond the mine property - even miles from the blast site. If this were true, the blastholes could be placed much farther apart than the commonly used spacing of six to 18 feet in quarries and 12 to 25 feet in surface coal mines, and blasting would be much more economical since less drilling and explosives would be necessary.

Another common misconception associated with blasting is that significant fracturing occurs far below the bottom of a blasthole. In fact, most of the gas pressure forces created by the detonation of the explosive radiate outward along the length of the cylindrical blasthole. Depending upon the hole diameter, type of explosive and nature of the rock, gas-pressure forces below the bottom of the blasthole are comparatively minimal and fracturing of rock is generally limited to several feet. In most surface coal mines, a buffer of only three to five feet between the bottom of the blastholes and the top of the coal seam adequately protects the coal (which is brittle to begin with) from being fractured and contaminated by the rock material immediately above it. Failure to protect the coal from fracturing can increase the cost of cleaning the coal and significantly reduce the mine operator's profits.

What causes ground vibration and how is it measured?

When a blast detonates, some of the explosive energy not utilized in breaking rock travels through the ground in all directions as wave motion, similar to the ripple created in a pond when a stone hits the water. This wave motion, or ground vibration, travels mainly along the surface at speeds of 5,000 to 20,000 feet per second, depending upon the density and thickness of the rock and soil. Its energy decreases rapidly with distance from the blast and normally decays to levels undetectable by humans beyond several thousand feet. Because explosives are expensive and vibration represents wasted energy, it is to the blaster's advantage to utilize as much of the energy as possible in fragmentation, thereby minimizing vibration.

Blasting seismographs are used to measure ground vibration in terms of particle velocity, which is the speed at which each particle in the ground oscillates as the wave motion passes. This would be similar to measuring the speed of a fishing bobber in a pond as it moves up and down when a ripple passes under it. Particle velocity is measured in inches per second, but beyond several hundred feet from a blast the actual movement of the ground, or displacement, is generally only a tiny fraction of an inch, about the thickness of a piece of paper, or less. So it is important to understand that a particle velocity reading expressed in inches per second refers to the speed at which the ground moved, and not the amount of movement.

How is ground vibration controlled?

Blasters control ground vibration mainly by limiting the weight of explosives detonated within any instant of time. They do this by using millisecond delay detonators (blasting caps) to separate the firing time of each hole from adjacent holes. In a typical 50-hole blast, the result would be 50 smaller and separate explosions instead of one large blast. A common misconception is that the number of blastholes determines the resulting intensity of vibration. However, given the same charge-weight per delay and the same distance to a house, a 100-hole blast can be designed to produce no more vibration than a 10-hole blast.

What is airblast and how is it measured?

When a blast detonates, some energy is lost to the atmosphere in the form of noise and/or concussion. This phenomenon is caused by the venting of gases through cracks and fissures and the upward and outward movement of the rock on top and in front of the blastholes. The resulting increase in the air pressure is commonly called airblast. Like ground vibration, airblast levels decrease rapidly with distance from the blast. However, airblast travels only at the speed of sound, around 1,100 feet per second, depending upon air temperature, and can be greatly influenced by wind direction and speed, and by an occasional atmospheric temperature inversion which can bend it back toward the earth and focus its energy several miles away.

Airblast is usually measured with a special microphone connected to the same type of seismograph that measures ground vibration. The most common units of airblast measurement are pounds per square inch (psi) and the decibel (dB), which is based on a logarithmic sound-pressure scale related to human hearing. The threshold of hearing begins at zero decibels. An increase of six decibels represents a doubling of air pressure. As an example, an airblast measured at 126 dB would have twice the air pressure of an airblast at 120 dB. (See Figure 1 - Airblast Effects.)

How is airblast controlled?

Airblast is controlled mainly by the use of stemming material (drill cuttings or crushed stones that are shoveled back into the blasthole after the explosives have been loaded to a predetermined depth from the surface), and by not loading explosives into portions of holes with cracks, voids or mud seams. These techniques minimize the escape of gases and confine the explosive energy where it is needed to efficiently break rock.

What are the ground vibration and airblast limits?

Seismographic monitoring is required if the explosive charge-weight per delay will exceed the maximum allowed by a specific formula, based on the distance to the nearest dwelling. When a seismograph is used to record a blast at any dwelling, the airblast must not exceed 133 dB (in Figure 1), and the ground vibration must not exceed the frequency-dependent limits, or "Z-curve" (in Figure 2). The Z-curve is a sliding scale that allows higher particle velocities at higher frequencies, up to a maximum of 2.0 in/sec.

Ohio's limits are based on extensive research by the former United States Bureau of Mines (USBM), which evaluated the effects of blast-induced ground vibration and airblast on residential structures. The limits were designed to prevent the most cosmetic type of damage–hairline cracks in drywall and older plaster-on-lath–even if the blasting is repeated on a daily basis for many years. The limits provide even greater protection to foundation walls, concrete slabs, wells and buried utilities.

Who may conduct blasting?

Only a certified blaster may conduct blasting in Ohio's quarries and surface coal mines. To become certified, a blaster must obtain 2 years of blasting crew experience including on-the-job training, attend 40 hours of classroom training, and pass an exam covering blast design, safety, vibration control and monitoring, and state and federal blasting regulations. Once certified, a blaster must attend 24 hours of continuing education during every 3-year renewal period.

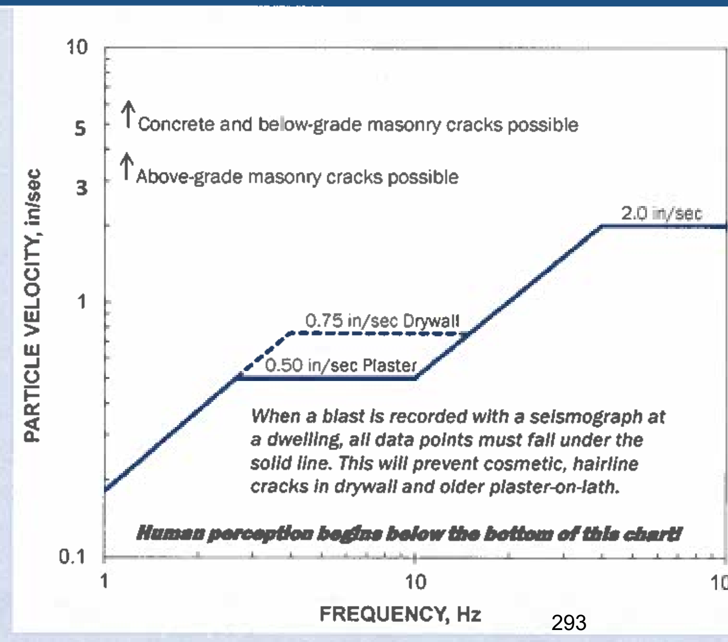
If the dishes rattle, is my home being damaged?

Even when blast vibrations are far below the legal limit, highly perceptible vibration can be experienced inside the home; windows and dishes might rattle, knickknacks and pictures might move or fall if not securely fastened, and hanging lamps might sway. These effects can be generated by ground vibration or airblast acting separately or together, and can last from one to three seconds or more, depending upon the distance from the blast, geologic influences and other factors. Despite these sometimes startling effects, there is no direct correlation between how a blast "feels" or sounds and its potential for causing structural damage to a home. In fact, cultural stresses (e.g., doors slamming, kids jumping, people pounding nails) and natural stresses (e.g., sunlight, wind, rain, temperature and humidity fluctuations and changes in soil moisture) can place greater stresses on a home than legal blast vibrations.

Figure 1. Airblast Effects

dB	psi	
180	3.0	Conventional structures severely damaged Plaster cracks at 176 dB
170	1.0	Most windows break at 171 dB
160	0.3	
150	0.1	Some windows may break at 151 dB
140	0.03	Exceeded by strong wind gusts in Ohio
130	0.009	ODNR/DMRM limit is 133 dB
120	0.003	Startling to people inside homes
100	$3x10^{-4}$	
80	$3x10^{-5}$	
60	$3x10^{-6}$	Conversational speech

Figure 2. Ground Vibration Limits for Ohio Coal and Industrial Minerals Permits



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Article

Geochemical Characterization of Trace MVT Mineralization in Paleozoic Sedimentary Rocks of Northeastern Wisconsin, USA

John A. Luczaj [1,*], Michael J. McIntire [2] and Megan J. Olson Hunt [3]

1 Department of Natural & Applied Sciences (Geoscience), University of Wisconsin-Green Bay, Green Bay, WI 54311, USA
2 Department of Natural & Applied Sciences (Chemistry), University of Wisconsin-Green Bay, Green Bay, WI 54311, USA; mcintirm@uwgb.edu
3 Department of Natural & Applied Sciences (Statistics), University of Wisconsin-Green Bay, Green Bay, WI 54311, USA; olsonhum@uwgb.edu
* Correspondence: luczajj@uwgb.edu; Tel.: +1-920-465-5139

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Abstract: Disseminated Mississippi Valley-type (MVT) mineralization occurs throughout northeastern Wisconsin, USA, and is recognized as the source of regionally extensive natural groundwater contamination in the form of dissolved arsenic, nickel, and other related metals. Although considerable attention has been given to arsenic contamination of groundwater in the region, limited attention has been focused on characterizing the bedrock sources of these and other metals. A better understanding of the potential sources of groundwater contamination is needed, especially in areas where groundwater is the dominant source of drinking water. This article describes the regional, stratigraphic, and petrographic distribution of MVT mineralization in Paleozoic rocks of northeastern Wisconsin, with a focus on sulfide minerals. Whole-rock geochemical analysis performed on 310 samples of dolomite, sandstone, and shale show detectable levels of arsenic, nickel, cobalt, copper, lead, zinc, and other metals related to various sulfide mineral phases identified using scanning electron microscopy. MVT minerals include pyrite, marcasite, sphalerite, galena, chalcopyrite, fluorite, celestine, barite, and others. We describe the first nickel- and cobalt-bearing sulfide mineral phases known from Paleozoic strata in the region. Arsenic, nickel, and cobalt are sometimes present as isomorphous substitutions in pyrite and marcasite, but discrete mineral phases containing nickel and cobalt elements are also observed, including bravoite and vaesite. Locally abundant stratigraphic zones of sulfide minerals occur across the region, especially in the highly enriched Sulfide Cement Horizon at the top of the Ordovician St. Peter Sandstone. Abundant quantities of sulfides also appear near the contact between the Silurian Mayville Formation and the underlying Maquoketa and Neda formations in certain areas along and east of the Niagara escarpment. This article illustrates how a detailed geochemical and mineralogical investigation can yield a better understanding of groundwater quality problems.

Keywords: Wisconsin; Paleozoic; vaesite; bravoite; sulfide; nickel; cobalt; arsenic

1. Introduction

Mississippi Valley-Type (MVT) lead-zinc ore deposits are carbonate-hosted accumulations of sulfide and associate minerals that are dominated by sphalerite, galena, iron sulfides, and other associated minerals. They typically occur in Phanerozoic dolostone (with some in limestone or sandstone) located on the flanks of sedimentary basins, orogenic forelands, or foreland thrust belts [1–3]. MVT ore deposits are located throughout the world, but were named for deposits that occur along the

Mississippi River Valley in North America. Large, well-studied deposits occur in the United States and Canada [1–5], Europe (especially Ireland and Poland) [3,5–7], and elsewhere. Modern interpretations of the origin of MVT ore deposits generally include large-scale brine migration driven within platform carbonates by large-scale tectonic events [3].

The upper Mississippi Valley region of southwest Wisconsin, eastern Iowa, and northwestern Illinois, USA (Figure 1) contains a historic Mississippi Valley-type (MVT) ore district [8]. Although the lead mineralization in the region was discovered during the late 17th century, these deposits did not receive major attention until the early 19th century. It was in this region that the first large "metals rush" in the United States took place in what is known as the Upper Mississippi Valley Zinc-Lead Ore District. Galena, and later sphalerite, were the two principal minerals of interest in small ore bodies located near folds and faults hosted by Paleozoic carbonate rocks [8]. The likelihood of a hydrothermal origin for these deposits was recognized by the mid-20th century by Heyl *et al.* and McLimans [8,9]. Research by Sverjensky, Garven, Bethke, Rowan and others during the 1980s and 1990s led to the general acceptance that these deposits were the result of northward basin-scale brine migration from the Illinois basin [1,2,10,11]. The economic viability of these deposits faded during the later 20th century, and the last mine in the district closed in 1979.

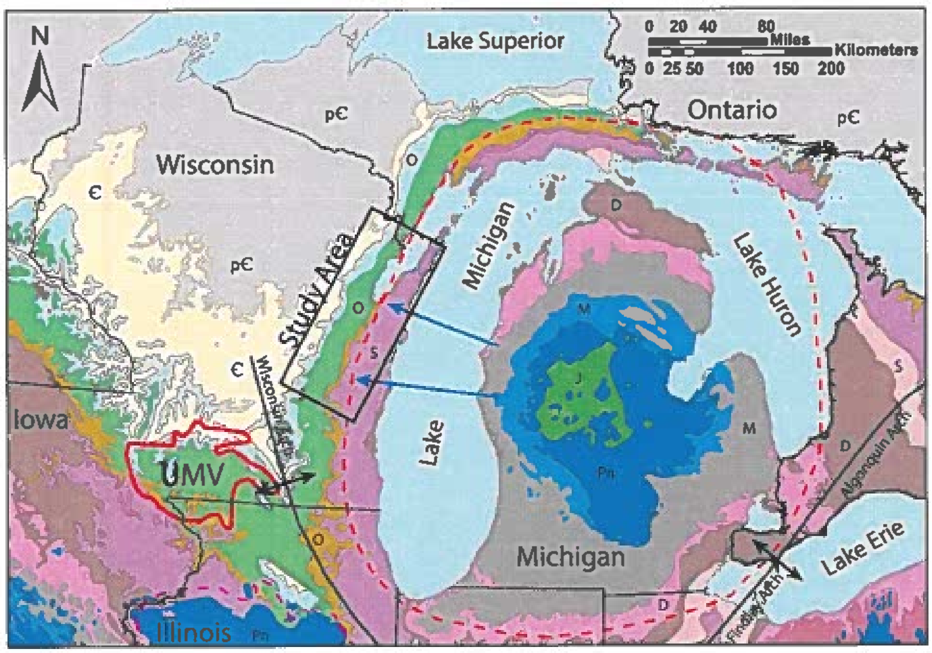

Figure 1. Bedrock geologic map of the western Great Lakes region of North America showing the locations of major geologic structures near the states of Wisconsin and Michigan. Geologic rock systems are as follows: pЄ = Precambrian, Є = Cambrian, O = Ordovician, S = Silurian, D = Devonian, M = Mississippian, Pn = Pennsylvanian, J = Jurassic. Red dashed lines denote the Illinois and Michigan structural basins. Black lines with double arrows indicate the positions of structural arches. "UMV" indicates the location of the Upper Mississippi Valley Lead-Zinc Ore District as defined by Heyl *et al.* [8]. Blue arrows indicate inferred flow paths of hydrothermal fluids originating in the Michigan basin. Base map modified after [12,13].

Similar MVT mineralization is also present throughout eastern Wisconsin, which was initially thought to represent outlying deposits of the main ore district [14,15]. Limited exploration for MVT mineralization took place in southeastern Wisconsin during the early 1980s through subsurface coring program in eight southeastern Wisconsin counties by Mobil Mineral Resources, Inc. [16]. However, extensive Pleistocene glacial overburden, coupled with a limited understanding of the distribution and character of geologic structures and the absence of economic petroleum deposits, has hampered efforts to fully characterize the region's subsurface geology. This article focuses on a broad region of Paleozoic-hosted MVT mineralization in northeastern Wisconsin located about 250 km (150 miles) northeast of the Upper Mississippi Valley Zinc-Lead ore district and the Illinois basin (Figure 1).

During the 1970s and 1980s, Paleozoic rocks in Wisconsin received further attention from carbonate sedimentologists who focused on Ordovician rocks as a potential ancient analog for the formation of low-temperature dolomite. This model, known either as the "Dorag" model or the mixing-zone model, involved interaction between fresh water and seawater along a coastal mixing zone in southern Wisconsin [17]. Despite an early call for a hydrothermal origin for the dolomite [18], the low-temperature interpretation continued to be favored by most sedimentologists who worked in the region. In fact, the Dorag model became a paradigm for dolomitization models elsewhere, and remained so throughout much of the 1980s and 1990s (e.g., [19–21]).

The geochemical interpretations for the origin of the dolomite and MVT mineralization in eastern Wisconsin were in stark contrast with one another until conclusive data were presented that supported a hydrothermal origin for both [22,23]. This hydrothermal system was interpreted to be a distinct, unrelated flow system from the one that formed the Upper Mississippi Valley ore district. Subeconomic MVT mineralization extends throughout the entire region of eastern Wisconsin into the Upper Peninsula of Michigan. Luczaj [22,23] used petrographic, isotopic, and fluid-inclusion data to propose a common hydrothermal origin for the MVT mineralization, pervasive epigenetic dolomitization, and K-silicate mineralization in the region. His research mainly focused on an evaluation of the mixing-zone *versus* hydrothermal epigenetic dolomitization models for the formation of pervasively dolomitized strata in the region.

1.1. Geologic Setting of the Study Area

The study area in eastern Wisconsin region lies on the western edge of the ancestral Michigan basin and is located to the east of the Wisconsin arch and to the south of the Superior Craton (Figure 1). As much as 500 to 800 m of Lower and Middle Paleozoic quartz sandstone, dolostone, and shale are present (Figures 2 and 3), and the strata thicken and dip gently toward the Michigan basin (Figure 4) where they are overlain by younger Paleozoic and Mesozoic sedimentary rocks.

Numerous gentle folds, faults, and fractures are observed in Paleozoic rocks in the region, despite a geographic position near the middle of the North American craton away from orogenic belts. Dip-slip and strike-slip faults are present within the study area, based upon water well records and quarry exposures, but few are directly observed because they are concealed by extensive Pleistocene glacial drift [23–25]. The carbonate rocks throughout the study area are completely dolomitized over all stratigraphic intervals. Faults and joints were certainly preferred conduits for mineralizing groundwater because sulfide minerals are preferentially precipitated along these surfaces throughout most of the study area. Stratigraphic reconstructions and organic maturity data suggest that the thickness of eroded sediments in eastern Wisconsin was probably much less than 1–1.5 km at any time during the burial history of these rocks [23].

1.2. Origin of the MVT Mineralization in Eastern Wisconsin

Luczaj [22,23] proposed the existence of a regional hydrothermal system in eastern Wisconsin that was active during the Late Devonian–Mississippian periods. The precise timing is not well defined, but could be earlier than the Late Paleozoic system responsible for mineralization of the Upper Mississippi Valley Zinc-Lead ore district [26]. The rocks in eastern Wisconsin preserve a pervasive hydrothermal signature and contain abundant epigenetic dolomite, subeconomic MVT mineralization, and minor authigenic K-silicate mineralization. Fluid-inclusion, stable isotopic, and petrographic evidence suggests that the MVT mineralization, K-silicate mineralization, and dolomitization in eastern Wisconsin are genetically related to the same regional hydrothermal system that operated at temperatures between about 60 and 120 °C, with sulfide mineralization likely occurring between about 80 and 110 °C [22,23]. This ancient system was responsible for precipitation and replacement of a suite of MVT sulfide minerals that includes pyrite and marcasite (FeS_2), galena (PbS), sphalerite (ZnS), chalcopyrite ($CuFeS_2$), fluorite (CaF_2), and other related minerals. It is this hydrothermal system that also precipitated the arsenic, nickel, and cobalt-bearing sulfide minerals in the region, including unusually enriched sulfide cement horizons (SCH) in sandstones such as the St. Peter Sandstone of the Middle Ordovician Ancell Group (Figure 2).

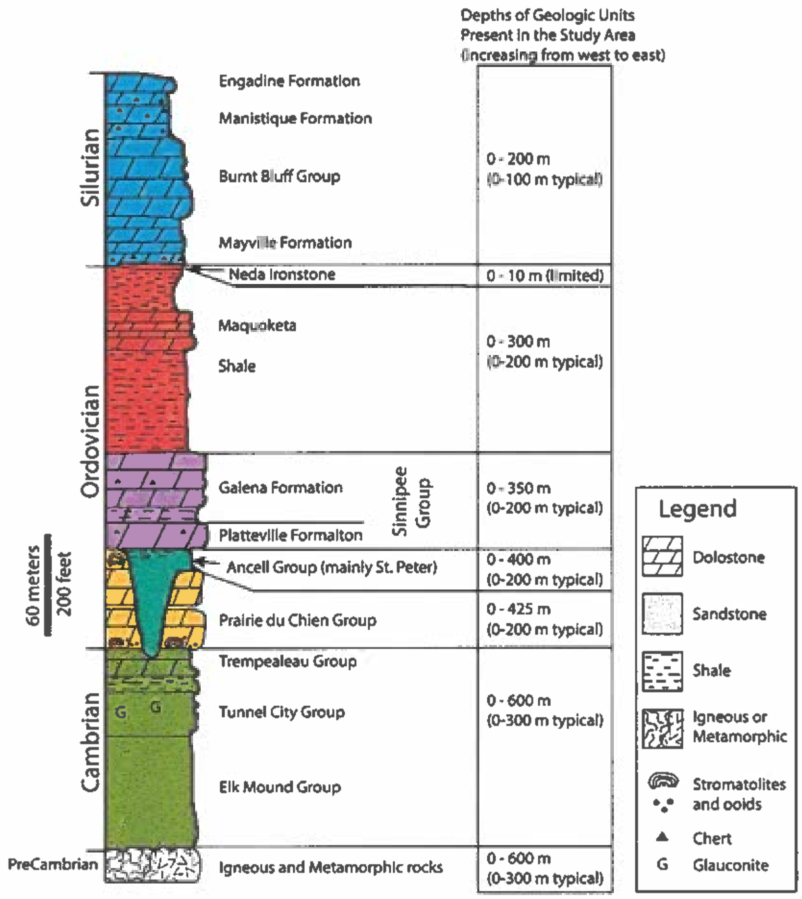

Figure 2. Simplified stratigraphic column for Paleozoic rocks in northeastern Wisconsin, USA [13]. Pleistocene sediments and younger Silurian and Devonian strata for southeastern Wisconsin are not shown here for simplicity, but can be found elsewhere [27,28].

The sequence of mineralization in the study area is somewhat variable, but generally consists of early dolomite and quartz, followed by K-feldspar and MVT mineralization, followed by late calcite. Dolomite precipitation continues throughout the main stage of sulfide mineralization. However, unlike many MVT-related dolomites, the dolomite of eastern Wisconsin is almost exclusively planar (non-saddle). Only a few small vugs with examples of saddle dolomite have been observed in the study area, and cathodoluminescence suggests they have the same cement stratigraphy as some of the planar dolomite [23]. Some late-stage euhedral planar dolomite crystals are up to 1 cm in diameter.

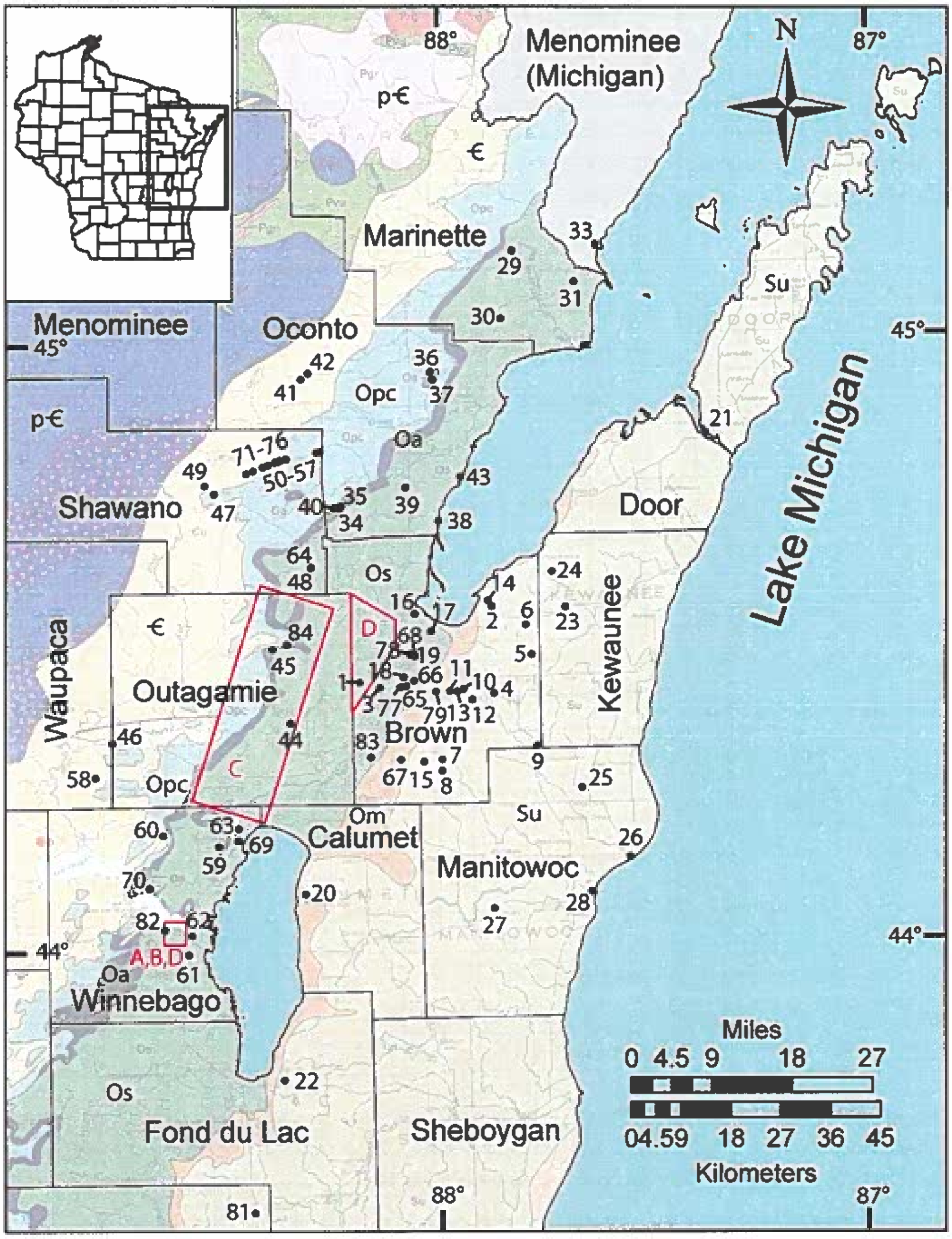

Figure 3. Map with sample locations (outcrops, quarries, drill cores, well cuttings) throughout the study area in northeastern Wisconsin. Thin lines and names indicate county boundaries. Inset map shows the study area location in the state of Wisconsin, USA. Red areas with letters indicate groundwater studies performed in the region (A is reference for Gotkowitz *et al.* [29], B is Thornburg and Sahai [30], C is Burkel and Stoll [31], and D is Schreiber *et al.* [32]). Additional references for region-wide studies include Riewe *et al.* [33] and Johnson and Riewe [34], as well as a cancer study by Knobeloch *et al.* [35] that focused on Winnebago and Outagamie counties. Base map after Mudrey *et al.* [36] shows the following units: p€ = Precambrian, € = Cambrian sandstones, Opc = Ordovician Prairie du Chien Group, Oa = Ordovician Ancell Group, Os = Ordovician Sinnipee Group, Om = Ordovician Maquoketa-Neda formations, and Su = Silurian dolostones.

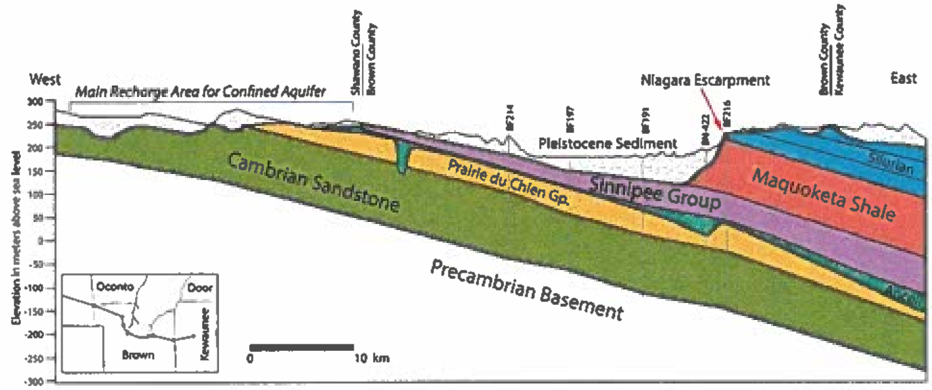

Figure 4. West to east geologic cross-section through portions of Shawano, Brown, and Kewaunee counties near Green Bay, Wisconsin. Paleozoic strata typically dip southeastward between about 5 and 7.5 m/km toward the ancestral Michigan basin. Vertical lines with labels indicate well codes for selected existing and backup wells in the Green Bay region of Brown County. Vertical exaggeration is 45 times. Modified after [13].

1.3. Relevance to Water Quality Issues

Dissolved arsenic has been recognized as a significant water quality problem that affects millions across the world and can lead to health problems including lung, bladder, and skin cancers. Bangladesh, for example, is widely known for having high dissolved arsenic resulting from sulfide mineralization, with the situation being described as a public health emergency (e.g., [37]). Three main regions in Wisconsin exhibit elevated levels of arsenic in groundwater [13,35]. Since its discovery in the late 1980s as part of a routine feasibility study for a landfill proposed in Winnebago County [33], the problem of arsenic contamination in the region's groundwater has received significant attention, with most work occurring in Winnebago and Outagamie counties (Figure 3). Eastern Wisconsin's MVT mineralization is recognized as the source of regionally extensive groundwater contamination in the form of dissolved arsenic, nickel, and other related metals [13]. The focus of previous research in the region [29–34,38–40] was to characterize the distribution and release mechanisms of arsenic in well waters and aquifer host rocks (mainly Ancell Group), primarily in parts of the eastern Wisconsin counties of Winnebago, Outagamie, and Brown (Figure 3). Geochemical mechanisms proposed for arsenic release include oxidation of arsenic-bearing sulfide minerals (most significant), reductive dissolution of iron (hydr)oxides, and release of sorbed arsenic from mineral surfaces [29,30,39].

Arsenic (As) concentrations vary from less than 1 µg/L to over 15,000 µg/L [33,41] in the study area, which contains several tens of thousands of private water wells and hundreds of municipal and other high capacity wells. In some townships (roughly 100 km^2), 20%–40% of the wells tested above the 10 µg/L health standard set for As in drinking water by the United States Environmental Protection Agency [13]. Although wells are less commonly tested for nickel and cobalt, these metals were also observed in some wells at elevated concentrations, especially in Winnebago and Outagamie counties. An evaluation of publicly available data through the Wisconsin Department of Natural Resources [41] indicates that in four counties in the study area (Winnebago, Outagamie, Brown, and Green Lake), cobalt exceeded the Wisconsin groundwater quality enforcement standard of 40 µg/L in 5.4% to 8.8% of the wells tested. Nickel showed a similar pattern, with six counties in the study area (Winnebago, Outagamie, Brown, Marinette, Fond du Lac, and Manitowoc) exceeding the Wisconsin groundwater quality enforcement standard of 100 µg/L in 1.8% to 5.7% of the wells tested. The National Uranium Resource Evaluation (NURE) [42,43], an older dataset from 1976 to 1979, also showed elevated dissolved Ni, Co, and As in the study area. Most of the wells with exceedances draw water from the Cambrian-Ordovician sandstone aquifers, especially the Ancell Group. Even municipal wells in Brown County 240–320 m deep have been impacted by elevated As, Co, and Ni during aquifer storage and recovery (ASR) tests or when valve leaks occurred that allowed oxygenated surface water into the Cambrian aquifer [44–46].

The most seriously impacted well studied in the region was one in northeastern Outagamie County and was drawing from the Ancell Group (St. Peter Sandstone). The well had the following chemistry (tested 1991–1992): pH = 2.05, As = 4300 μg/L, Co = 5500 μg/L, Cd = 220 μg/L, Cr = 84 μg/L, Ni = 11,000 μg/L, Al = 15,000 μg/L, and Pb = 400 μg/L [13,41]. The incidence of As, Co, and Ni in drinking water wells across the study area demonstrates the need for a better understanding of the link between groundwater quality and MVT mineralization in the region.

Additional work by Knobeloch and others [35] (Figure 3) on the health implications of arsenic in the study area has indicated an increased prevalence of skin cancer in the region. In 2004, the Wisconsin Department of Natural Resources designated a "Special Well Casing Pipe Depth Area" for all of Outagamie and Winnebago counties, which included special requirements for drilling methods, disinfection methods, and grouting requirements [13]. Arsenic is a major priority among regulators and local health departments in the region. Less attention has been paid to counties to the north, and they do not have special well casing requirements, despite their nearly identical geology.

The chemistry of a groundwater system is controlled in large part by the composition of its host rock [47]. Sulfide minerals in eastern Wisconsin Ordovician carbonate rocks coat the walls of joints, bedding planes, faults, and macropores in these dolostones [23]. In Cambrian and Ordovician sandstones, sulfides are observed as isolated nodules, stringers, and sometimes as continuous zones of cementation, especially in the Ancell Group. Oxidation of these sulfide minerals has been shown to be the major source of arsenic and other metals of concern in eastern Wisconsin [29,30,39]. This occurs most often near recharge areas where the aquifers are shallow (Figure 4) or in areas of intense drawdown where the aquifer becomes partially dewatered.

While an initial stratigraphic and petrographic framework was known for bedrock mineralization in Winnebago and Outagamie counties, limited data were available regarding the whole-rock and trace element composition of the bedrock, especially in areas to the north in Marinette, Oconto, and Shawano counties (Figure 3). A better understanding of potential sources of groundwater contamination is needed, especially in these rural areas where domestic well supplies are the dominant source of drinking water.

Although the MVT minerals are unlikely to be mined within the study area, they will continue to affect groundwater quality indefinitely. Groundwater is an important source of drinking water in Wisconsin. The percentage of the population that consumes water produced by private or municipal wells ranges from 18% to 100% of the population in each county. Overall, approximately 55% of the population in the study area uses groundwater, with most surface water users limited to a few of the larger municipalities in Brown, Winnebago, and Outagamie counties [48]. Many municipalities in the study area that currently use surface water have wells that penetrate the Cambrian-Ordovician sandstones in the region (Figure 4) that are kept as a backup in the event of a pipeline malfunction.

This article presents an analysis of the regional, stratigraphic, and petrographic distribution of MVT mineralization in Paleozoic rocks of northeastern Wisconsin and had two main objectives. The first was to document the origin and characteristics of the MVT-related mineralization in eastern Wisconsin. This included field and laboratory mineralogical observations along with a regional whole-rock geochemical study of bedrock from several Paleozoic stratigraphic units, with a focus on heavy metals composition. In this context, we present the first evidence in northeastern Wisconsin of discrete nickel- and cobalt-bearing mineral phases, along with a complete list of MVT-related minerals known from the region. A second objective was to provide a regional foundation for current and future groundwater studies in the region in order to better understand the causes of dissolved arsenic and other metals in the groundwater of northeastern Wisconsin. We hope this work will provide a baseline for future economic geologists and groundwater specialists in this region and in others with similar geology.

2. Materials and Methods

The study area includes several counties in northeastern Wisconsin, comprising approximately 13,000 km^2 (Figure 3). The sources of rock samples from the study area included quarries, outcrops, well cuttings, and limited drill cores. Design of a sampling strategy for geochemical characterization was affected by two major limitations. First, the distribution of outcrop and core samples was not random in either the stratigraphic or regional sense due to extensive Quaternary glacial deposits throughout the entire study area. Outcrops are more common near escarpments formed where Silurian and Ordovician dolostones overlie weaker shale or sandstone. Quarry locations are preferentially distributed near the base of the Silurian Mayville Formation, near the base of the Platteville Formation, and near the base of the Prairie du Chien Group carbonates (Figure 2). This outcrop distribution inevitably led to a biased stratigraphic sampling. A second limitation was that physical access to samples near quarry high walls is restricted for safety reasons. We made reasonable attempts to sample multiple stratigraphic levels wherever possible, including sets of well cuttings and drill cores.

2.1. Sample Collection

For whole-rock geochemical analysis, we collected and designated two principal categories of samples. Samples that were representative of the stratigraphic horizon or those that were taken at random are designated as "Matrix" specimens. Online Supplementary Materials Table S1 contains location numbers and sample descriptions. In contrast, sampling that was deliberately biased in an attempt to analyze the most sulfide-rich materials along fractures, bedding planes, and the SCH are designated as "Enriched".

The Paleozoic stratigraphic section (Figure 2) was divided into six principal stratigraphic units for the purpose of collection and analysis. These are the Cambrian sandstones, the Prairie du Chien Group (PDC) carbonates, the Ancell Group sandstone and shale, the Sinnipee Group carbonates, the Maquoketa Shale/Neda Ironstone, and the Silurian carbonates. Numerous samples were obtained from each of these stratigraphic units.

2.2. Scanning Electron Microscopy with Energy Dispersive Spectroscopy (SEM-EDS)

Samples of polished rock slabs, crystal-lined vugs, and well-cutting chips were carbon-coated before analysis. Samples were analyzed with a TESCAN Scanning Electron Microscope (SEM), model VEGA TS 5136SB with an excitation voltage of 30 kV. Elemental analysis was conducted using Energy Dispersive Spectroscopy (EDS) on a Genesis Spectrum EDAX detector. SEM images were obtained using backscattered electrons (BSE). This technique was used to explore the chemistry and petrographic distribution of metal sulfide minerals and associated minerals in over 30 selected samples.

2.3. Whole-Rock Geochemistry and Data Analysis

Matrix samples submitted for whole-rock analysis were typically 1–2 kg, except for drill cores and cuttings, which typically had a mass of at least 0.02 kg. Specimens indicated as "Enriched" were as large as possible, but generally were at least 0.2 kg. Digestion of 208 whole-rock samples was performed in 2007–2008 by ALS Chemex of Thunder Bay, Ontario, Canada, using Conventional 35-element Inductively Coupled Plasma–Atomic Emission Spectroscopy (ICP-AES) (ALS Method ME_ICP41) after Aqua Regia Digestion in a graphite heating block. Subsequent analysis of an additional 102 samples was performed in 2013 by ALS Minerals of Vancouver, British Columbia, Canada using two methods. Specifically, conventional 51-element ICP-AES (ALS Method ME_MS41) and ultra-low detection ICP-AES (ALS Method ME-MS41L) were performed after Aqua Regia Digestion in a graphite heating block. The results of these analyses yielded whole-rock concentrations for 35 or 51 different elements (depending on analysis), including arsenic (As), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb), zinc (Zn), molybdenum (Mo), and vanadium (V). Lower detection limits for some of the elements analyzed improved between 2008 and 2013, but this mostly affected elements that were not the focus of this study. Additional "overlimit" analyses, conducted with standard laboratory methods, were required for certain samples in which sulfur (S), iron (Fe), and phosphorous (P) exceeded instrument limits. ALS Minerals is accredited by the Standards Council of Canada and reports analytical precision of ± 10% for the methods used in this study. Quality control procedures included sample duplicates during sample crushing, and sample blanks in every analytical run.

Sample numbers, localities, analytical methods, and whole-rock geochemistry for a selected list of elements are presented in Online Supplementary Materials Table S1. Raw whole-rock geochemistry data for all samples are presented in Tables S2A and S2B.

Correlations were estimated between $\log_{10}$-transformed concentrations for selected elements. Elemental concentrations that were below detection limits were set to 0.55 times their detection limit for a given element to avoid missing data after log transformation [49]. Both Pearson's r and Spearman's ρ (a non-parametric measure of correlation) were calculated as a sensitivity analysis due to some remaining non-linearity between some pairs of elements even after transformation, with both measures available in Supplementary Materials Tables S2C and S2D. R version 3.3.0 for Windows was used for all analyses and the construction of plots.

3. Results

3.1. Field and Core Observations

Observations made at quarries and outcrops clearly indicate that the regional distribution of MVT mineralization extends throughout the study area northward into the state of Michigan. The most abundant minerals found in vugs and fractures tended to be dolomite and calcite, with quartz present locally. Sulfide mineralization was dominated by pyrite and marcasite, but sphalerite, chalcopyrite, and galena were also observed in hand specimens. Additional macroscopic minerals included fluorite, celestine, strontianite, and barite.

The distribution of sulfide minerals (and related weathering products) in the host sedimentary rocks was heterogeneous, but stratigraphically predictable. Throughout northeastern Wisconsin, the stratigraphic unit with the most sulfide mineralization was the top of the Ordovician Ancell Group (dominated by the St. Peter Sandstone in this portion of the state). This zone of naturally enriched iron sulfide mineralization, known as the Sulfide Cement Horizon (SCH), occurs across eastern Wisconsin from the Illinois border in the south to the Michigan border in the north ([13,23], this study). In the study area, the SCH was exposed on the quarry floors or in sump trenches at several quarries in Shawano, Oconto, Marinette, Outagamie, and Winnebago counties and areas southwest of the study area (Figure 5). No distinct ore deposits made any one part of the study area more concentrated than another. Cores and cuttings also show that the SCH is present down dip to the east of the outcrop belt, from near the surface in quarries to depths of several hundred meters (Figures 2 and 4). Nodules and intergranular cements of pyrite and marcasite were abundant where this group of rocks is rarely exposed. In one quarry near the city of Oshkosh in Winnebago County, a pink coating of amorphous material similar to erythrite (hydrated cobalt arsenate) and annabergite (hydrated nickel arsenate) was observed as a weathering product near the SCH in the St. Peter Sandstone, and was confirmed by SEM-EDS analysis. Another quarry in Green Lake County (southwest of the study area) contained primarily calcite and sphalerite cement in the SCH. A thin (~10–50 cm) layer of dark brown shale above the St. Peter Sandstone was interpreted to be the Glenwood Shale and was present at many locations. It contained abundant fine-grained sulfides, including pyritized arthropod and bryozoan fossils in some quarries.

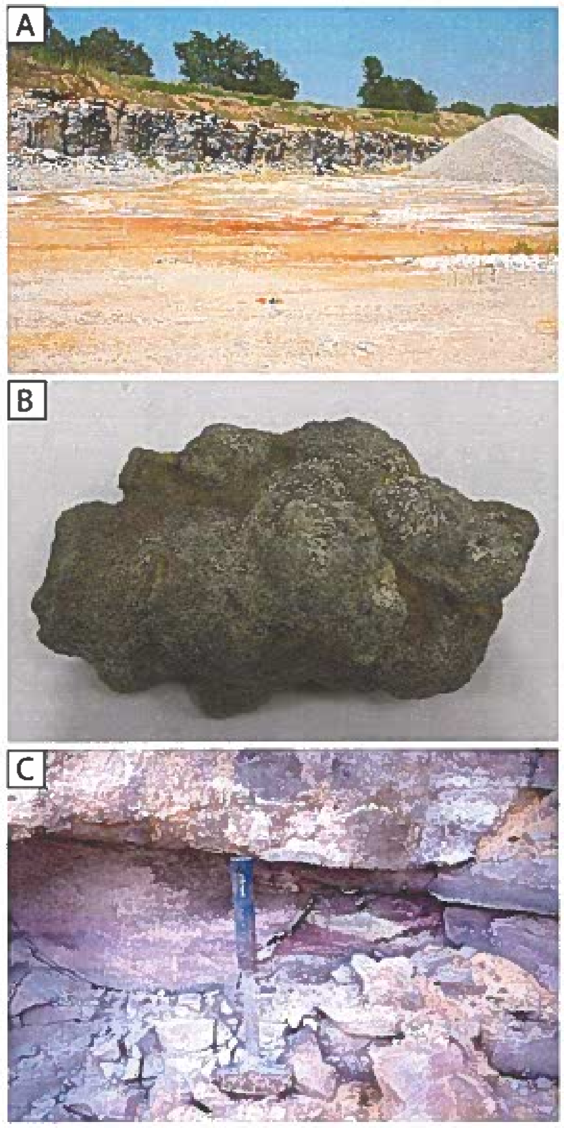

Figure 5. Exposures of the Sulfide Cement Horizon (SCH) in the upper portion of the St. Peter Sandstone (Ancell Group): (**A**) Discolored floor of a dolostone quarry showing the chemical alteration present at the top of the SCH at Location 34 in Oconto County. The quarry wall is the overlying Platteville Formation of the Sinnipee Group (human for scale). (**B**) A typical nodule of pyrite and/or marcasite-cemented quartz sandstone from the SCH at Locality 84 in Outagamie County (96-OUT-1), about 9 cm wide here. (**C**) Pink coating on Sulfide Cement Horizon at Locality 82 in Winnebago County (hammer for scale).

The next most mineralized stratigraphic zone occurred near the contact between the Silurian Mayville Dolomite and the underlying Ordovician Maquoketa Shale and Neda formations (Figure 6). Where present, the Upper Ordovician Neda Ironstone and related strata appeared to have sulfides associated with the upper extent of those units. In places, the mass of sulfides was striking, with large (10–40 cm thick) accumulations of pyrite easily identified, especially in central Brown County along portions of the Niagara Escarpment. This sulfide mineralization typically extended upward into the lower few meters of the Silurian Mayville Dolomite. In at least one case, a local aggregate producer had problems with the "aesthetic" quality of its product due to rust stains from the weathering of pyrite fragments in asphalt and concrete products. This interval was best exposed in quarries and natural outcrops along Scray Hill in the towns of Ledgeview and Glenmore in central Brown County. Significant, but lesser amounts of pyrite were present at this contact and within the upper part of the Maquoketa Formation where the Neda Formation is not present.

Figure 6. View of an approximately 70 cm tall section present in a bedrock sump trench at the Scott Construction Ulmen Quarry in central Brown County, Wisconsin (Location 13). Sulfides occur at the contact between the Silurian Mayville Formation (top 30 cm) and the Ordovician Neda-Maquoketa formations (lower 40 cm) and are responsible for the Fe-oxide staining.

The Ordovician Sinnipee Group carbonates contained significant quantities of metal sulfides, even at stratigraphic intervals farther away from the SCH in the Ancell Group. Sulfide mineralization was locally abundant along bedding planes, in vertical fractures and joints, and as vug fillings and intercrystalline cements. The mineralization was recognized throughout the Sinnipee Group, and some vertical fractures were mineralized by pyrite, K-silicates, and calcite cements throughout over 15 m of vertical exposure.

Some mineralization occurred within the Prairie du Chien Group and the Cambrian sandstones. Chalcopyrite, quartz, pyrite, and sphalerite were observed in the Prairie du Chien Group, with one notable location in western Outagamie County (Location 46) containing smoky quartz, amethyst, galena and malachite. Pyrite and marcasite nodules were observed in drill cores and cuttings from the Cambrian sandstones, with chalcopyrite, sphalerite, and galena observed locally. The top of the Jordan Sandstone (the uppermost Cambrian unit in northeastern Wisconsin) has also been observed to host zones enriched in pyrite and marcasite [34].

The carbonate units with the least amount of sulfide mineralization were the Silurian dolostones, which represent the youngest strata in the study area. Cores, abundant quarry exposures, and outcrops of the Silurian dolostones indicate that most sulfides are restricted to the lower few meters of the Mayville Formation. However, trace amounts of iron sulfides were present in various forms throughout the Silurian section. The presence of iron-stained vertical joints suggests that this unit, which is regionally karsted, has had much of its sulfide mineralization removed through near-surface weathering during the Cenozoic Era.

3.2. Petrographic Analysis Using SEM with EDS

Samples of polished rock slabs, polished thin sections, crystal-lined vugs, and well-cuttings chips were analyzed to determine minerals present, to outline mineral paragenesis, and to identify whether or not separate mineral phases were present that could be identified as the source of certain heavy metals present in regional groundwater.

Separate mineral phases containing Fe, Zn, Pb, Cu, and other metals were observed in samples from many locations, especially where parts of the middle and lower Ordovician section are exposed (Figures 7–10). Typically, pyrite and marcasite (FeS_2) were the dominant sulfide phases present. Pyrite exhibited several crystal habits, including cubes, octahedrons, and pyritohedrons up to 1 cm in length. Marcasite occured as bladed—and sometimes cockscomb—habits with a greenish or bluish metallic, iridescent coating of unknown origin. Sphalerite (ZnS) was the next most commonly observed sulfide phase, with generally rounded, irregular crystals up to 5 cm. Galena (PbS) was far less common, and was typically found as small cubic crystals a few millimeters in size, but crystals up to 1 cm were also found in the southern part of the study area. Chalcopyrite crystals are 1 to 3 mm in size and display a typical disphenoid crystal form.

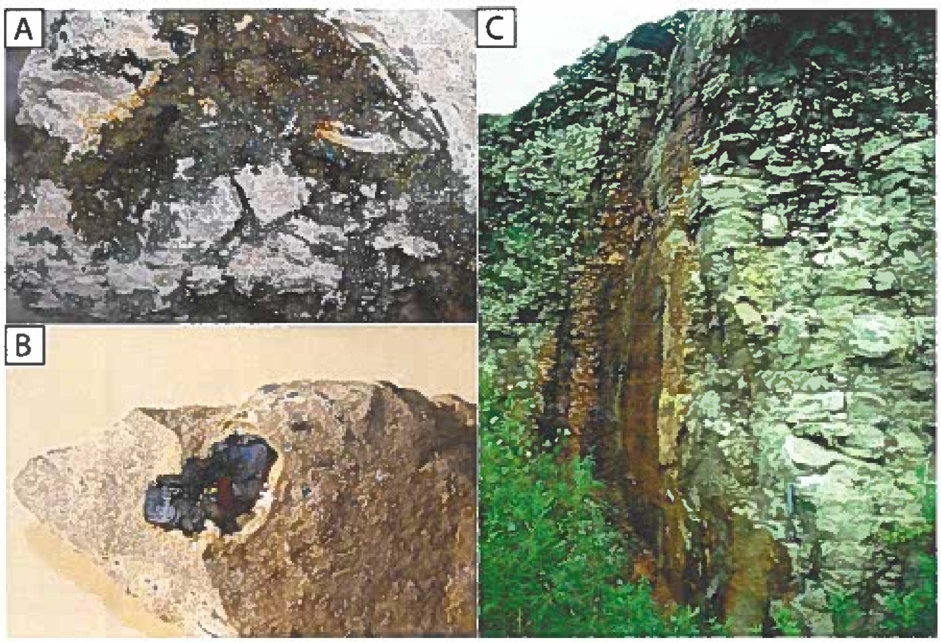

Figure 7. Photographs of selected MVT minerals in Ordovician carbonate strata from northeastern Wisconsin. **(A)** Fe-sulfide cemented dolostone breccia at Locality 48. View is approximately 12 cm across. **(B)** Dolostone hosted galena and sphalerite with hydrothermal dolomite from Locality 82 in Winnebago County. Vug is 2 cm across. **(C)** A small strike-slip fault with several centimeter-wide filling of iron sulfides) at Locality 59 in Winnebago County (note hammer for scale).

Two copper-bearing minerals were observed in the study area. The crystal morphology and EDS spectrum of the most common Cu-bearing phase suggests that it is chalcopyrite ($CuFeS_2$). This has been observed at several locations in Oconto, Winnebago, and Outagamie counties (Figures 3 and 9). Botryoidal and fibrous malachite has been observed in growths up to 3 mm long at one location in western Outagamie County in association with pyrite and chalcopyrite (Figure 9). Malachite has also been observed in association with chalcopyrite south of the study area at the Morris Pit in Green Lake County, Wisconsin [50].

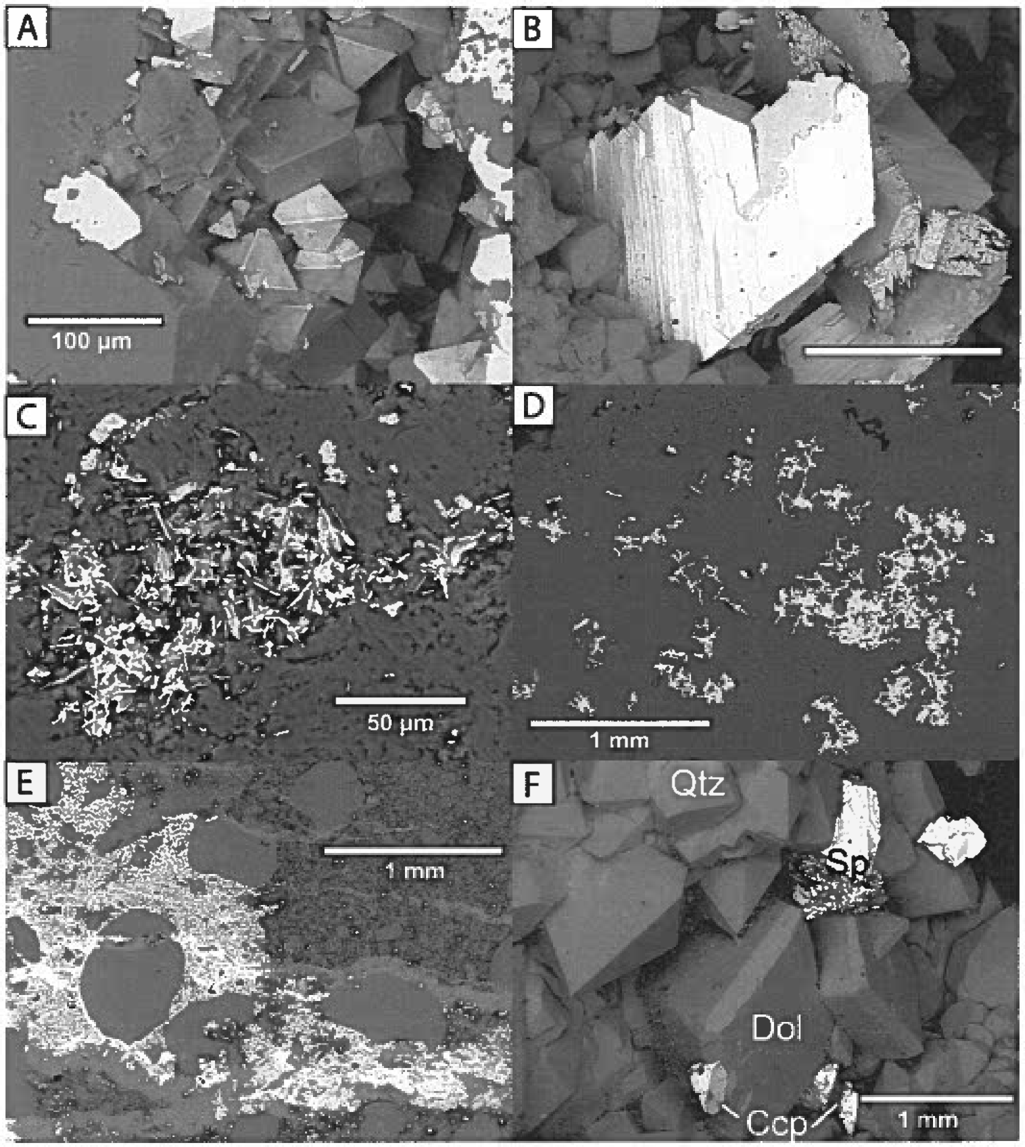

Figure 8. SEM-BSE images of polished sections and vug-filling cements illustrating the character of Mississippi Valley-type mineralization in northeastern Wisconsin: (**A**) Octahedral pyrite is intergrown with dolomite in vug from Locality 59 in Winnebago County (96-WIN-2). Left and right edges are flat, polished surfaces. (**B**) Bladed marcasite (bright) on dolomite (gray) from Locality 48 in Shawano County (07-SH-MCK-5). (**C**) Fine bladed marcasite and cubic pyrite intergrown with dolomite from Locality 48 (07-SH-Mck-0) in Shawano County. (**D**) Polished section showing dolomite (gray) and later pyrite (bright) filling pores and replacing parts of the dolomite at Locality 3 in Brown County (07-BN-LQ-1). (**E**) Fracture-filling cements from a quartz sandstone layer in the lower Platteville Formation at Locality 29 in Marinette County (Sample 07-MT-FP-2). Round gray grains are detrital quartz sand. Bright white areas in fracture are pyrite cement, whereas medium gray cements are calcite. Gray spotted areas coprecipitated with pyrite are an unknown authigenic K-Al-Silicate mineral cement, possibly illite or K-feldspar. (**F**) Late dolomite intergrown with chalcopyrite and sphalerite and associated with quartz from Locality 46 (07-NL-45E) in Outagamie County.

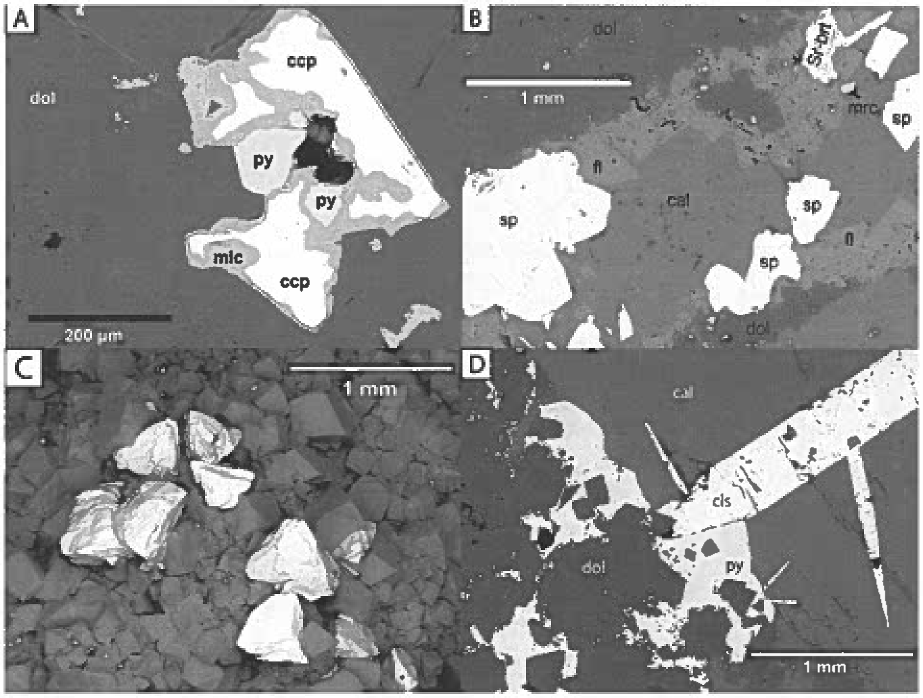

Figure 9. SEM-BSE images of Cu, Cr, Sr, and Ba-bearing minerals from the study area: (**A**) polished thin section from Locality 46 in the Oneota Formation (lower Prairie du Chien Group) of western Outagamie County; (**B**) highly variable mineralogy in a few millimeter-wide fracture from Locality 33 in Menominee County, Michigan; (**C**) chalcopyrite (bright) on dolomite (gray) from Locality 39 in Oconto County; and (**D**) an assemblage of dolomite, celestine, pyrite and late calcite from the Platteville Formation at Locality 3 in Brown County. Labeled minerals are dolomite (dol), calcite (cal), botryoidal malachite (mlc), pyrite (py), chalcopyrite (ccp), sphalerite (sp), strontium-barite (Sr-brt), marcasite (mrc), fluorite (fl), and celestine (cls).

The vast majority of pyrite and marcasite analyzed from the region had no detectable peaks for Ni, Co, or As using SEM-EDS techniques. However, detections of Ni, Co, and As in sulfide minerals were made in some cases (Figure 10; Table 1). Detection of a discrete As peak was limited to one specimen, with values of ~2 to 4 weight percent (~0.5 to 1 mole percent), based on EDS analysis. Although this is higher than the As concentration described by Thornburg and Sahai [30] for As-bearing pyrite in which isomorphic substitution of As was interpreted, it is still likely that the As occurs in a similar form here, and not in a discrete mineral phase such as arsenopyrite.

Despite its occurrence in southern parts of Wisconsin [8,14,51,52], millerite (NiS) has not been documented in this study area of northeastern Wisconsin. Additional references to minor amounts of millerite, bravoite, violarite, honessite, cobaltite and smaltite are given for the Upper Mississippi Valley lead-zinc district in southwestern Wisconsin by Heyl *et al.* [8,52].

Detection of numerous microscopic crystals of sulfide minerals enriched in Ni and Co was made in samples from Brown and Oconto counties (Figure 10; Table 1). These microscopic occurrences are the first examples of Ni- and Co-bearing minerals found in northeastern Wisconsin. Crystals contain widely varying proportions of Ni-Co-Fe, based on SEM-EDS analysis. Figure 11 shows normalized mole percent values for the sulfide minerals containing Ni, Co, and Fe listed in Table 1. Nickel proportions up to 89 mole percent and cobalt proportions up to 24.6 mole percent suggest that the occurrence of these elements is not simply restricted to isomorphous substitution within pyrite, as appears to be the case with arsenic from a few locations in the study area [30]. Based upon crystal morphology and SEM-EDS composition, bravoite and vaesite are the most likely mineral species present for the Ni and Co-rich crystals.

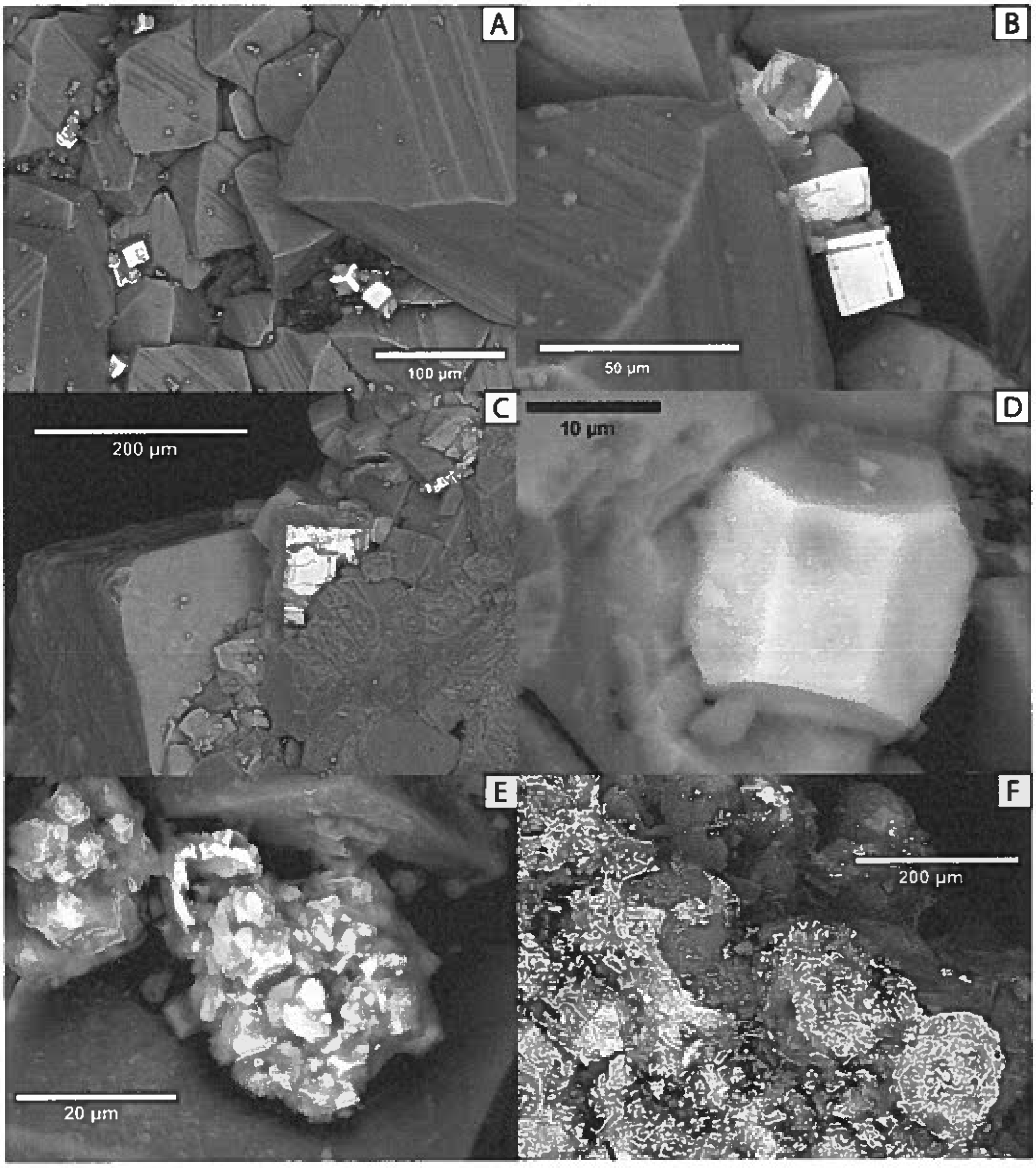

Figure 10. SEM-BSE images of selected Ni, Co, and As-bearing MVT minerals from three localities in the study area in northeastern Wisconsin. SEM-EDS data for (**A–E**) are shown in Table 1: (A,B) Locality 39 in Oconto County; (C–E) Locality 83 in Brown County; and (**F**) Locality 82 in Winnebago County. (A) Cubic bravoite $(Ni, Co, Fe)S_2$ on coarse dolomite (Sample 07-OCO-MTV-2; crystals 3-8). (B) Three crystals of cubic bravoite (2a–c) associated with nickelian pyrite (2d) (Sample 07-OCO-MTV-2; crystals 2a, 2b, 2c, and 2d). (C) Bright cubic crystal (center) with regions of both bravoite and vaesite associated with fluorite (medium gray, left) and dolomite (dark gray, lower right) (Sample AP-24; 510-515 ft; crystal 2). (D) Bravoite crystal $(Ni, Co, Fe)S_2$ showing both cubic and pyritohedron forms (Sample AP-24; 510-515 ft; crystal 4). (E) Arsenic-bearing nickelian pyrite in finely crystalline masses. Sample AP-24; 520-525 ft; crystal cluster A. (F) Amorphous pink coating of Co-Ni-As-Zn-bearing material (Figure 5) that is likely a sulfate or an arsenide, possibly erythrite (Sample 97-WIN-3).

Table 1. Concentrations of elements in selected crystals of Ni-Co-Fe-As-sulfide minerals from Brown and Oconto Counties. Values are reported in weight % generated from the EDAX Software. Sample AP-24 refers to the Village of Wrightstown Test Well in Brown County (Locality 83). Designations 1a, 1b, *etc.* refer to analysis points broadly from the core to the rim of crystal 1. Sample 07-OCO-MTV-2 refers to the Montevideo quarry in Oconto County (Locality 39). Dashes indicate no detection by the software.

Sample; Crystal	Ni	Co	As	Fe	C	O	Mg	Si	S	Cl	Ca
AP-24; 510-515 ft; 1a	30.69	9.91	-	6.22	18.19	11.49	-	-	20.44	-	3.05
AP-24; 510-515 ft; 1b	28.70	6.32	-	4.62	16.30	14.16	-	-	26.13	1.61	2.15
AP-24; 510-515 ft; 1c	27.55	1.59	-	2.80	16.78	13.07	-	-	37.46	-	0.76
AP-24; 510-515 ft; 1d	32.10	1.42	-	2.77	21.33	7.13	-	-	33.72	-	1.54
AP-24; 510-515 ft; 2	35.31	1.49	-	2.75	-	10.98	-	-	49.48	-	-
AP-24; 510-515 ft; 3	24.55	9.98	-	5.67	17.97	14.04	1.46	0.82	20.80	2.12	2.59
AP-24; 510-515 ft; 4	17.75	3.41	-	4.01	27.59	16.35	2.37	-	26.36	-	2.15
AP-24; 520-525 ft; A1	1.84	0.75	2.27	13.08	43.34	24.47	3.06	0.45	7.89	0.66	2.18
AP-24; 520-525 ft; A2	3.16	1.36	4.09	19.41	35.64	20.57	3.44	0.50	7.36	0.59	3.90
07-OCO-MTV-2; 1	20.25	1.41	-	4.21	19.68	23.93	1.77	-	27.06	-	1.68
07-OCO-MTV-2; 2a-1	18.99	0.90	-	3.95	25.00	25.00	-	-	25.36	-	0.80
07-OCO-MTV-2; 2a-2	15.76	1.20	-	5.55	26.04	28.08	1.06	-	21.20	-	1.11
07-OCO-MTV-2; 2b	19.05	1.29	-	3.99	22.83	26.25	-	-	26.58	-	-
07-OCO-MTV-2; 2c	17.12	1.26	-	4.71	20.19	32.61	-	-	23.21	-	0.90
07-OCO-MTV-2; 2d	2.47	-	-	29.70	-	31.84	2.08	-	32.45	-	1.47
07-OCO-MTV-2; 3	18.66	1.23	-	4.21	25.53	26.01	1.48	-	21.06	-	1.83
07-OCO-MTV-2; 4	17.66	1.61	-	4.57	32.29	20.54	1.74	-	19.23	-	2.35
07-OCO-MTV-2; 5	20.80	1.50	-	4.99	32.73	20.87	1.63	-	15.48	-	2.00
07-OCO-MTV-2; 6	22.24	1.65	-	4.97	32.35	20.34	1.64	-	14.48	-	2.33
07-OCO-MTV-2; 7	21.19	1.38	-	3.75	26.49	20.64	-	-	26.54	-	-
07-OCO-MTV-2; 8	15.00	1.24	-	4.37	29.88	27.63	-	-	20.90	-	0.98
07-OCO-MTV-2; 9	15.27	1.13	-	4.25	20.90	30.33	2.89	0.65	22.91	-	1.67

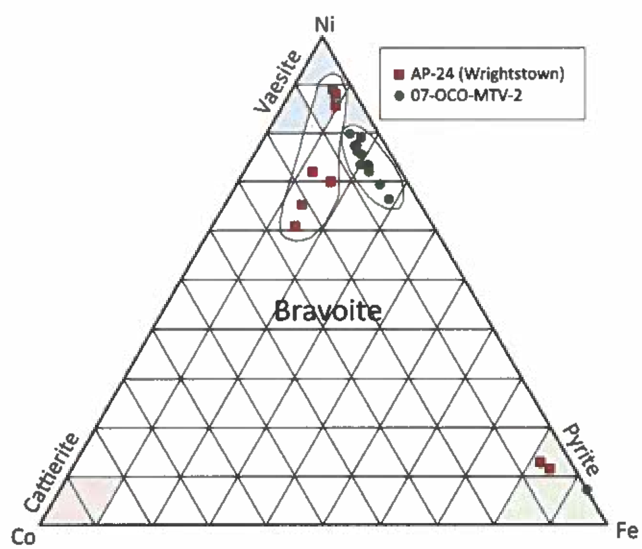

Figure 11. Ternary plot of mole percent normalized compositions indicating the relative proportions of nickel, cobalt, and iron for various members of the pyrite group. Data are for samples listed in Table 1. Red squares are for samples AP-24 (Locality 83), and green circles are for 07-OCO-MTV-2 (Locality 39). Region of bravoite, along with end members pyrite, vaesite, and cattierite are shown, as described by Kerr [53].

The precise mineralogy of these Ni and Co phases is challenging to determine due to the size of the crystals (tens of micrometers). Crystal morphology varied from indistinct to cubic to cube-pyritohedron forms (Figure 10), which is possible in the solid solution series of the pyrite group. In cases where the crystal approaches the NiS_2 end-member composition, the mineral vaesite (NiS_2) is the most likely candidate [53]. Other crystals with elevated Co and Fe are best described as bravoite ($(Ni\text{-}Co\text{-}Fe)S_2$). In the absence of X-ray data, strict identification of these minerals is not possible, but their compositions are shown in Figure 11.

In contrast to the above metals, none of the samples examined with the SEM displayed separate mineral phases for arsenic, such as arsenopyrite. While the presence of arsenopyrite cannot be ruled out in these rocks, it seems likely that As is substituting for Fe as a trace element in the iron sulfides, as has been suggested by Thornburg and Sahai [30]. For a limited sample set, they concluded that As was present in isomorphous substitution with pyrite/marcasite, which can be released by oxidation and subsequently sorb onto ferric oxyhydroxides.

Some fractures and vugs contained a complex microscopic array of minerals in the MVT assemblage (e.g., Figure 9B). In one 2 mm-wide fracture intercepted by a drill core, sphalerite, galena, fluorite, dolomite, marcasite, Sr-barite, and calcite were observed in close association with each other.

With only one exception near the Wisconsin–Michigan border (Locality 33), all galena observed in northeastern Wisconsin falls south of an east–west regional fault that is possibly associated with a crustal boundary in the Precambrian basement rocks known as the Spirit Lake Tectonic Zone [25]. The reason for this distribution is unknown, but it might be related to the metals concentrations in Precambrian bedrock through which hydrothermal deep groundwater likely passed [54,55].

3.3. Paragenetic Sequence of Mineralization

Table 2 lists the diagenetic minerals observed in Paleozoic sedimentary rocks in the region. Although no single diagram can precisely synthesize the full complexity of the mineral paragenesis in the study area, Figure 12 illustrates the general mineralization sequence in northeastern Wisconsin.

Table 2. Complete list of Mississippi Valley-type and associated diagenetic minerals observed in Paleozoic rocks of northeastern Wisconsin.

Mineral Group	Minerals Observed [1]
Carbonates	Dolomite, calcite, strontianite, malachite (rare)
Sulfates	Barite, celestine, Sr-barite, gypsum; anhydrite[2] (minor)
Sulfides (and related)	Pyrite, marcasite, sphalerite, chalcopyrite, galena, bravoite, vaesite, nickelian-pyrite, As-bearing-pyrite, erythrite?
Phosphates	Apatite/fluorapatite
Silicates	Quartz, K-feldspar, illite?, amethyst[3], smoky quartz[3]
Halides	Fluorite

[1] Additional rare MVT and alteration minerals not observed in this study can be found in [40] for one quarry in Winnebago County; [2] Anhydrite was identified in one sample with the assistance of David Tuschel using Raman spectroscopy at HORIBA Scientific in Edison, New Jersey, USA; [3] Amethyst and smoky quartz were observed at Locality 46 in western Outagamie County.

In general, pervasive dolomitization and silicate mineralization are the earliest events. Early quartz appears to have formed at temperatures $\leqslant$ ~50 °C, due to the presence of all-liquid fluid inclusion assemblages entrapped within quartz overgrowths. Later quartz and the majority of the dolomite were formed from a Na-Ca-Mg-Cl brine at temperatures of ~80–100 °C as temperatures warmed [23]. Iron sulfides occurred throughout much of the sequence, but the main stage of MVT mineralization included sphalerite, galena, chalcopyrite, pyrite, marcasite, and Ni-Co-Fe-sulfide minerals (Figures 8–10). The MVT mineralization was intergrown with two episodes of dolomite, with most MVT minerals closely associated with late planar dolomite (Figures 7 and 8). Middle and late-stage dolomite, as well as MVT minerals, appear to have formed by similar brines at temperatures of 80–110 °C during what appears to be peak heating. Siderite was not documented in the region, although some dolomite was ferroan. The timing of K-silicates (K-feldspar and possibly illite), relative to other diagenetic phases, is difficult to determine in cases where it occurs as cements within quartz arenites. However, some of it is clearly coeval with abundant iron sulfide mineralization in vertical fractures observed in the northern part of the study area (Figure 8E).

New evidence (Figure 9) suggests that at least some of the sulfate minerals precipitated during the MVT stage of mineralization. Sr-barite, barite, and celestine were observed with fluorite, sphalerite, and pyrite in some samples, likely forming during the waning stages of mineralization. Other late-stage minerals include beef-vein and intergranular gypsum, as well as late-stage calcite. Conditions of calcite mineralization are not well known, but at least some late calcite in Silurian rocks contains all-liquid inclusions, suggesting a lower temperature of entrapment [23]. Strontianite was also found in the region as a relatively late mineral, but its precise location in the sequence is not well-constrained.

The order of mineralization shown in Figure 12 should be used with caution. As a regionally derived diagram, local or stratigraphic variations may not be expressed fully. Many minerals are also found as isolated occurrences or with only one other mineral. Nevertheless, the diagram presents the only complete synopsis of the paragenetic sequence of mineralization in the study area.

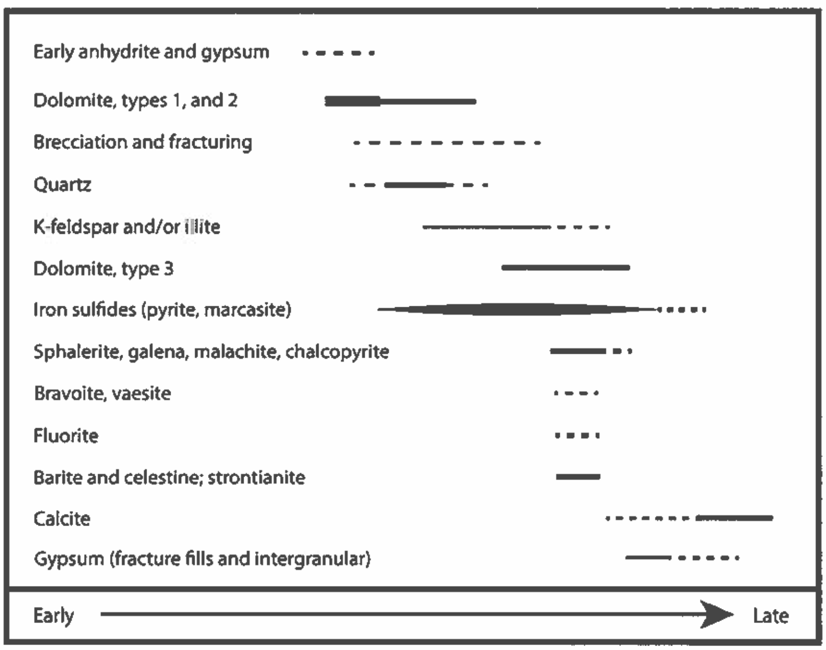

Figure 12. Generalized paragenetic sequence for Paleozoic rocks in northeastern Wisconsin.

3.4. ICP-AES Analytical Results and Discussion

Analytical results for all 310 samples are presented in Online Supplementary Materials Tables S1 and S2. The main purpose for analyzing the whole-rock chemistry of these strata was to look for regional and stratigraphic trends in the character of the mineralization, with a focus on heavy metals. Table 3 presents descriptive statistics for selected metals in all samples in the study that were designated as "Matrix" and "Enriched." Table 4 illustrates the typical (median) whole-rock concentrations for selected metals in representative "matrix" samples of bedrock from the region. Averages were not calculated because the data were heavily skewed right, as is common when measuring concentrations. Metals concentrations varied widely, from below detection limits to far above the median concentrations for the host rocks, which was consistent with observations of hand specimens and thin sections.

Table 3. Minimum, minimum *detected*, median, maximum, and the interquartile range of concentrations for iron and trace metals in Paleozoic whole-rock samples from northeastern Wisconsin. For Fe, the unit is percentage, while all other elements are measured in mg/kg (ppm). Reported values are for all samples in the study (matrix and enriched, n = 310). ND is a value below the detection limit for that respective element.

	Fe (%)	As	Cd	Co	Cr	Cu	Mo	Ni	Pb	V	Zn
Minimum [1]	0.06	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Minimum *detected* value	0.06	0.40	0.001	0.40	1.0	0.9	0.05	0.7	0.38	1.0	0.6
Median	0.57	4.00	ND	1.66	4.0	5.0	0.10	3.0	4.00	6.0	3.0
Maximum	28.4	499	4.20	133	152	1620	25.0	1110	584	353	3720
Interquartile range	0.89	9.00	0.01	2.58	4.9	9.5	0.90	8.0	7.41	6.0	6.0

[1] Some analyses from early in the study were below the detection limits for many metals due to the analytical methods available.

Table 4. Median metal concentrations (interquartile range in parentheses) for ***matrix*** samples from Paleozoic rock strata of northeastern Wisconsin (sample sizes in parentheses next to strata names). For Fe, the unit is percentage, while all other elements are measured in mg/kg (ppm). A Precambrian data point was excluded from this table due to having only one observation in that geologic unit.

Rock Unit	Fe (%)	As	Co	Cr	Cu	Mo	Ni	Pb	V	Zn
Silurian (33)	0.16 (0.21)	4.00 (6.00)	1.00 (0.50)	2.0 (2.0)	2.0 (2.0)	ND (0.00)	ND (1.0)	4.00 (3.60)	1.0 (2.0)	ND (3.0)
Maquoketa-Neda (11)	8.52 (13.31)	132 (151)	13.00 (24.50)	7.0 (7.0)	48.0 (7.0)	2.00 (3.34)	24.0 (25.1)	50.00 (55.15)	22.0 (64.0)	14.0 (11.0)
Sinnipee Group (111)	0.59 (0.25)	2.00 (5.00)	1.00 (1.20)	3.0 (3.0)	3.0 (2.8)	ND (0.29)	2.7 (3.3)	3.60 (3.85)	5.0 (3.0)	2.0 (4.5)
Ancell Group (18)	1.24 (1.07)	5.71 (4.16)	4.89 (6.99)	8.2 (13.8)	13.5 (12.9)	0.25 (0.79)	11.8 (31.6)	6.14 (8.86)	8.1 (14.4)	7.8 (8.4)
PDC Group (75)	0.40 (0.17)	3.00 (6.00)	1.70 (1.25)	3.0 (3.0)	6.0 (8.0)	ND (0.24)	2.0 (3.0)	2.00 (2.95)	9.0 (5.9)	3.0 (6.5)
Cambrian (19)	0.67 (0.68)	1.02 (7.35)	3.17 (8.69)	12.0 (4.6)	6.9 (13.4)	1.17 (1.11)	5.2 (8.0)	1.56 (5.07)	6.0 (7.2)	2.4 (1.4)

Based on field observations and elemental analysis, three specific stratigraphic horizons showed the most significant mineralization. These were the top of the Ancell Group, the Ordovician-Silurian contact, and, to a lesser extent, the Sinnipee Group dolostone. All three of these zones typically contained elevated metals concentrations, especially in "enriched" samples from the SCH, or along mineralized bedding planes, faults, or fractures. Figure 13 shows box-plots (on the $\log_{10}$ scale) for selected metals from Table 3. Elevated metals occurred in several Cambrian and Ordovician units, but the Silurian dolostones generally exhibited lower concentrations. Additional box-plots for these and other metals are presented in Supplementary Materials Figure S3. It is important to note that all stratigraphic units show some potential for locally elevated metals concentrations, including the Prairie du Chien Group and the Cambrian sandstones, which serve as an important regional aquifer system along with the Ancell Group [56,57].

Table 5 presents Spearman's ρ correlations, estimated for a subset of $\log_{10}$-transformed metals concentrations relevant to the study. Figure 14 shows scatter plots for selected metals concentrations, again on the $\log_{10}$ scale. While most pairs of elements in Table 5 show moderate correlations, the highest values occurred for Ni *vs.* Fe, Ni *vs.* Co, Pb *vs.* Fe, Co *vs.* Fe, and Cr *vs.* V. This result is consistent with the SEM-EDS observations of As-, Ni-, and Co-bearing sulfide minerals, suggesting that they are likely related to the same mineralization event.

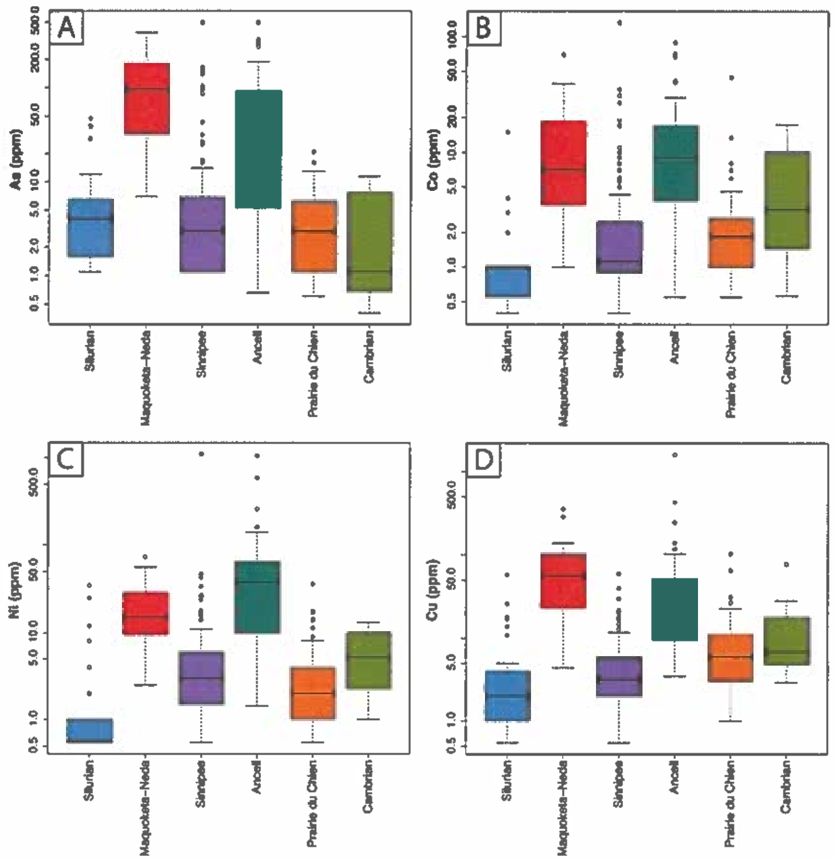

Figure 13. Box-plots on the $\log_{10}$ scale for selected metals ((**A**) As, (**B**) Co, (**C**) Ni, and (**D**) Cu) for 309 samples (single Precambrian point excluded), separated by major stratigraphic units (Figures 2 and 4). Metals concentrations are highest in the Maquoketa-Neda and the Ancell Group, while the Silurian dolostone units tend to have the lowest concentrations for most metals. Colors correspond to those used in Figures 2 and 4.

Table 5. Estimated Spearman's ρ correlations amongst $\log_{10}$-transformed variables for selected elements. For all but one of the estimates (Zn *vs.* Fe of enriched samples), *p*-values were smaller than 0.02, with most < 0.0001. An expanded analysis showing Pearson's *r*, Spearman's ρ , and all *p*-values is presented in Supplementary Materials Tables S2C and S2D.

Log_{10}-Transformed Variables	Spearman's ρ All Samples	Spearman's ρ Enriched Samples	Spearman's ρ Matrix Samples
Cr *vs.* V (O-S subset) [1]	0.940	-	-
Ni *vs.* Fe	0.744	0.587	0.642
Ni *vs.* Co	0.718	0.690	0.654
Pb *vs.* Fe	0.619	0.676	0.470
Co *vs.* Fe	0.612	0.449	0.529
K *vs.* B	0.594	0.694	0.578
Co *vs.* As	0.588	0.554	0.495
Cr *vs.* V	0.541	0.769	0.503
As *vs.* Fe	0.522	0.579	0.313
Cu *vs.* Fe	0.499	0.379	0.392
Ni *vs.* As	0.437	0.540	0.201
Zn *vs.* Fe [2]	0.326	0.156	0.354

[1] This row represents a subset of 17 enriched and matrix samples from Kittell Falls, Fonferek's Glen, and Ulmen Quarry along a portion of the Niagara Escarpment in central Brown County. Outcrops occur along the Ordovician-Silurian Contact. [2] The *p*-value for the correlation of Zn *vs.* Fe for enriched samples was 0.324.

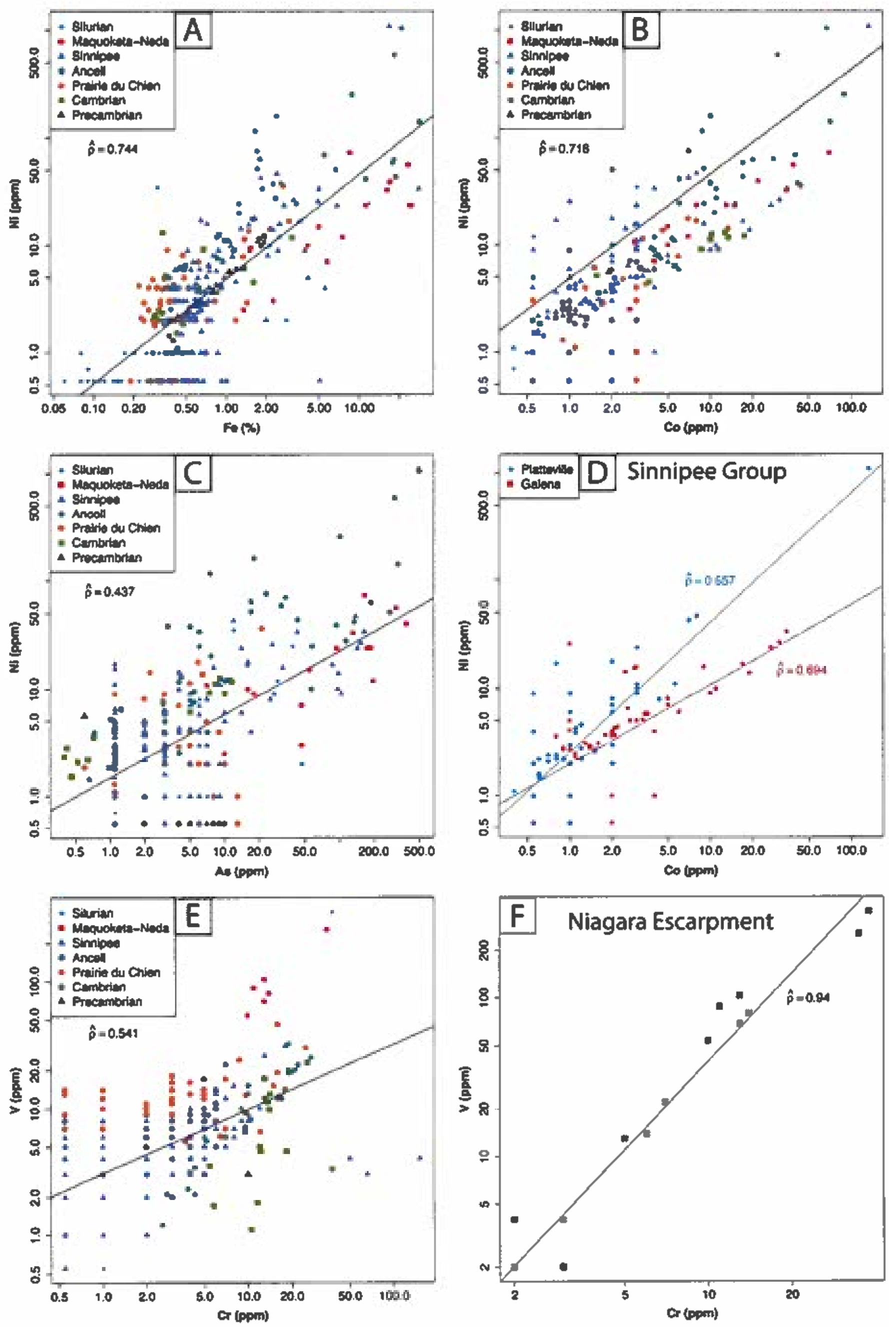

Figure 14. Scatter plots (log_{10} axes) of selected metals from whole-rock ICP-AES analyses on rock specimens from northeastern Wisconsin. Legends indicate the particular stratigraphic unit sampled. **(A)** Nickel (Ni) *vs.* iron (Fe) for all samples, separated by stratigraphic unit; **(B)** Nickel (Ni) *vs.* cobalt (Co) for all samples, separated by stratigraphic unit; **(C)** Nickel (Ni) *vs.* arsenic (As) for all samples, separated by stratigraphic unit. Several samples exhibited elevated Ni, consistent with the presence of observed Ni-bearing minerals (see text); **(D)** Nickel (Ni) *vs.* cobalt (Co) for the two formations of the Sinnipee Group in northeastern Wisconsin (Platteville and Galena); **(E)** Vanadium (V) *vs.* chromium (Cr) for all samples in the study, separated by stratigraphic unit. Note the V-enriched samples (red squares and blue diamond in upper right area of plot) from central Brown County; **(F)** Vanadium (V) *vs.* chromium (Cr) for all samples from three localities along a portion of the Niagara Escarpment in central Brown County.

Strong correlations for Ni *vs.* Fe ($\hat{\rho}$ = 0.744), Ni *vs.* Co ($\hat{\rho}$ = 0.718), and Co *vs.* Fe ($\hat{\rho}$ = 0.612) suggest that these three elements are related to the same mineralization event (Figure 14). Ni and Co are well correlated in all sample subsets (Table 5), suggesting that these elements are more closely related. They are likely principally occurring as isomorphic substitutions in pyrite, or as separate Ni-Co-enriched sulfide minerals. This interpretation is consistent with the discovery of discrete, but microscopic, Ni-Co-Fe sulfide minerals vaesite and bravoite in the study area (Figures 10 and 11). Correlations between Ni, Co, and Fe are higher than correlations for Ni and As ($\hat{\rho}$ = 0.437) or Co and As ($\hat{\rho}$ = 0.588). This is consistent with mineralogical observations in which As is typically in separate sulfide mineral phases from Ni and Co (Figure 10). This is an important observation suggesting that water quality evaluations for wells in the study area should probably include analyses for Ni and Co more regularly, instead of only As.

Smaller correlations between Zn and Fe and between Cu and Fe are most likely due to the fact that those metals also precipitate as separate sulfide mineral phases, such as sphalerite and chalcopyrite, and are independent of the presence of pyrite or marcasite in any particular sample. The same would be expected between Pb and Fe, but there is a moderate correlation between these two elements ($\hat{\rho}$ = 0.676 for enriched samples). Because galena is far less commonly observed in the study area than sphalerite, chalcopyrite, pyrite, or marcasite, the correlation between Pb and Fe may represent isomorphic substitution of Pb in pyrite or marcasite rather than the discrete presence of galena.

The correlation between K and B ($\hat{\rho}$ = 0.694 for enriched samples) was unexpected, and is not well understood because boron could not be detected using SEM-EDS techniques. However, it is possible that B is substituting in the structure of authigenic feldspar or illite (e.g., Figure 8E), both of which are present in the region [23]. These minerals could be the source of elevated boron levels reported for the Cambrian-Ordovician aquifer across the study area [58].

Correlations between Ni and As estimated separately by stratigraphic units (Supplementary Materials Table S2D) showed samples from the Maquoketa-Neda, the Ancell Group, and the Cambrian Sandstones were well correlated ($\hat{\rho}$ = 0.762, 0.722, and 0.797, respectively). The plot of Ni *vs.* As (Figure 14C) showed that some samples contained elevated Ni concentrations relative to As. These are best represented by some Ancell Group samples from three Oconto County quarries (Duame Quarry, Chase Quarry, and Montevideo Quarry) and one Sinnipee Group sample from the Vulcan Quarry in Winnebago County. Elevated nickel relative to arsenic is consistent with the existence of Ni-bearing minerals such as vaesite and bravoite that were observed in Oconto County (Figures 10 and 11). Ni and As in the Silurian units appeared moderately correlated ($\hat{\rho}$ = 0.501), while in the remaining units (Sinnipee and Prairie du Chien groups), they did not correlate as strongly ($\hat{\rho}$ = 0.381 and −0.158, respectively).

Relatively strong correlations between Ni and Co persisted even for some finer stratigraphic divisions, such as individual formations within the Sinnipee Group. Specifically, for the Galena and Platteville formations, $\hat{\rho}$ was 0.694 and 0.657, respectively (Figure 14D). As and Co were less strongly correlated for the Galena and Platteville formations, yielding $\hat{\rho}$ values of 0.572 and 0.385, respectively. Again, this is consistent with the observation of Ni and Co-bearing mineral phases as described above.

A moderate correlation ($\hat{\rho}$ = 0.541) existed for V and Cr in all samples over all stratigraphic intervals (Figure 14E), but this correlation improved notably for the enriched sample subset ($\hat{\rho}$ = 0.769) (Table 5). However, for a subset of samples from the mineralized zone near the Ordovician-Silurian contact in central Brown County (17 samples along a small portion of the Niagara Escarpment), a particularly high correlation between V and Cr was observed ($\hat{\rho}$ = 0.940) (Table 5; Figure 14F). In these samples, a slight enrichment of V, Sc, Tl, and La was also observed. The precise cause is unknown, but it might relate to the presence of oolitic hematite of the Neda Formation along this part of the escarpment. Although there is a general affinity of V for iron-bearing rocks, most of the samples with high V concentrations are dolostone samples from near the contact. Another stratigraphic difference noted is that iron sulfide-rich samples from the Maquoketa-Neda contact and the Silurian dolostones just above this contact are depleted in Ni, relative to samples from the Ancell and Sinnipee groups

(Figure 14A). Although depleted in Ni, they are slightly enriched in V, Sc, Tl, and La relative to the Ancell and Sinnipee Group samples (Table S1). These differences are likely the result of diagenesis by hydrothermal groundwater. The Maquoketa Shale (Figures 2 and 4) is a regional confining unit that likely isolated the Silurian dolostone units above from the Ordovician sandstones and carbonates below during mineralization. This local anomaly occurs near the only exposure of the Neda Ironstone, which suggests that mineralizing groundwater may have scavenged certain elements locally from the Neda Ironstone instead of being supplied by groundwater migrating through other strata.

Cu concentrations were highest in Oconto County (Ancell Group) and near the Ordovician-Silurian contact in central Brown County (Maquoketa-Neda units). This is consistent with the identification of chalcopyrite in field specimens from Oconto County Prairie du Chien Group samples.

Tuttle *et al.* [59] demonstrated that redistribution of minor and trace elements can occur in rocks with sulfide mineralization due to weathering processes and groundwater flow. While it is likely that remobilization of trace elements may have occurred in the study area, a systematic assessment of this was not performed. Extensive Late Pleistocene glaciation has removed bedrock-derived soil horizons, and most soils have developed on transported materials. In most cases, bedrock samples were obtained from relatively fresh host rocks in quarries, drill cores/cuttings, and excavated road cuts to keep sample weathering effects to a minimum. The most likely bedrock units to have been affected by weathering are the Silurian dolostones (Figure 2), which show extensive karst development [25] and relatively low trace element concentrations (Table 4).

4. Discussion

The origin of the SCH is not well understood, but the fact that the most prevalent sulfide mineralization in eastern Wisconsin is located at the top of the St. Peter Sandstone is well recognized. Enrichment of this zone might be the result of sulfate reduction due to organic carbon near the contact between the Ancell and Sinnipee groups, but this is absent at many locations in the study area. Alternatively, its location at the top of the St. Peter Sandstone is consistent with the possibility of a sour gas cap during mineralization. The presence of sour (H_2S-rich) natural gas migrating with deep groundwater discharging out of the Michigan basin (e.g., [23]) could explain the observed regional and stratigraphic spatial distribution of sulfides at the top of this unit. Precipitation of sulfide minerals would be expected to occur at the site of gas exsolution from brines migrating updip or from a metals-bearing fluid mixing with a preexisting sour gas cap. Further analysis is beyond the scope of this study, but work on the sulfur-isotopic characteristics of the sulfide mineralization is ongoing and may help to resolve this.

Previous work on whole-rock chemistry in the region was limited to a small number of samples because those studies were mostly focused on detailed water quality research in a few locations (Figure 3). Results of the whole-rock analyses from this study were compared with reported metals concentrations for the Ancell Group of Winnebago and Outagamie Counties and other localities in northeastern Wisconsin [29,38,40,60,61]. This procedure allowed generalized comparisons to be made between rocks in the southern part of the study area to those in the northern portion. Additional unpublished data were obtained from Dave Johnson [45] for 69 selected well cuttings from Cambrian rocks in Brown County. In those samples, nickel, arsenic, and cobalt concentrations were generally low, but values of up to 22.5 ppm for Ni, 105 ppm for As, and 93 ppm for Co were detected in different samples, with six samples containing cobalt above 25 ppm [45]. This likely indicates the presence of As, Ni, or Co-bearing minerals at those locations.

Arsenic concentrations relative to iron in this study were compared to those from the studies mentioned above. In general, whole-rock arsenic concentrations varied between 0 ppm and 500 ppm for all studies. However, for three samples reported in previous studies from Winnebago and Outagamie counties, As concentrations ranged between 500 and 743 ppm. While a few samples reported by

Gotkowitz *et al.* [29,40] had higher maximum Co concentrations than those in this study, a comparison of As *vs.* Co data also shows general overlap between the studies.

There were some differences noted between the studies. First, Cr concentrations in 308 of 310 samples in this study were below 40 ppm. The two exceptions were for cuttings samples in a municipal well in central Brown County with Cr concentrations of 66 and 152 ppm. In contrast, 18 of 21 samples analyzed in previous studies [29,40,61] were reported to have Cr concentrations between 100 and 764 ppm, regardless of location, with most concentrations above 200 ppm. Because the locations of some of these data overlap those in our study, these high Cr values seem anomalous and may be due to sample contamination. One value reported by Gotkowitz *et al.* [29,40] for an unmineralized sample of St. Peter Sandstone had a Cr concentration above 500 ppm, even though the sample had no sulfur and less than 1% Fe. Because of this anomalous behavior of Cr, we did not attempt to draw any conclusions about the difference in Cr between our studies and previous studies as they relate to rock geochemistry. It is possible that samples in the previous studies were submitted to a laboratory that crushed the samples with high Cr-steel, which is an alloy known for its toughness and which would be a suitable material for crushing rocks. In this study, contamination of the two higher Cr cuttings samples from this study by drilling equipment cannot be ruled out.

A comparison of Ni, As, and Fe shows general agreement between most samples analyzed in our study and those of Gotkowitz *et al.* [29,40] and Pelczar [38] (Figure 14A,B). In most samples, As is enriched relative to Ni. However, in some samples, Ni appears elevated relative to arsenic (Figure 14C), which is consistent with the presence of Ni-bearing minerals such as vaesite and bravoite.

It is unknown whether northeastern Wisconsin holds economic concentrations of MVT minerals in Paleozoic bedrock. A lack of significant local enrichment, compared to the former ore district in southwestern Wisconsin, could be due to a number of factors. It is likely that a diffuse hydrothermal fluid flow system was responsible for mineralization in the study area. This is consistent with pervasively dolomitized carbonate rocks in which 100 percent of the host-rock limestone has been replaced, along with a regionally prevalent SCH. However, occasional instances of acidic, metals-rich groundwater in water wells reported in the region suggest alteration of enriched sulfide deposits might occur in local areas. Such instances are observed mainly in areas near the Ancell Group outcrop belt (Figure 3) where oxygenated water interacts with the SCH or other sulfides due to natural conditions or aquifer drawdown [29,30,32,34,40]. Farther east (*i.e.*, down dip) from the outcrop belt (Figure 4), oxidizing conditions are less likely to occur, so limited information about the existence of mineralized zones can be inferred from groundwater chemistry alone. Extensive glacial sedimentary cover, poor knowledge of geologic structures such as folds and faults, and geochemical conditions favoring the stability of sulfide minerals, make detection of larger concentrations of sulfide minerals unfavorable in much of the region. Structural style, as well as hydrothermal fluid composition and intensity may also be factors.

It is useful to consider the potential impact of this mineralization on groundwater quality in the region outside of Winnebago and Outagamie counties where special well casing requirements are established. While the upper Ancell Group is likely to be the most significant source of metals due to the abundance of sulfides and the fact that porous media flow dominates, water quality in all units below the Silurian dolostones should be studied more carefully in the future. Because the distribution of sulfide minerals is highly heterogeneous, their locations and intensities along fractures, faults, bedding planes, and in vugs are difficult to predict locally. Fracture and bedding plane-dominated flow are likely to amplify the interaction between groundwater and sulfide minerals under the right redox conditions. In addition, certain stratigraphic zones of dolostone with high intercrystalline porosity, such as one about 6 m (20 feet) above the base of the Platteville Formation, also contain abundant Fe-sulfides locally (Figure 7A). For these reasons, the average concentrations of metals within the specific units are probably not so important. Rather, the complex distribution of sulfide minerals, redox conditions, and fluid flow pathways likely has a much larger influence on water quality in the carbonate units.

Additional MVT-related groundwater quality issues persist in this region that are relevant to this discussion. High dissolved fluoride (up to 3 mg/L) and exceptionally high strontium concentrations (over 10 mg/L) are present in groundwater throughout parts of the study area, especially in the Cambrian and Ordovician strata [13,56,58]. It is likely that these two ions are related to the presence of fluorite, celestine, and strontianite in the bedrock. Fluorine was not part of the whole-rock chemical analysis package used in this study, but microscopic and macroscopic fluorite was observed in strata from the region. Strontium whole-rock concentrations were generally low (< 200 ppm in 304 of 310 samples), with the highest concentration observed at 731 ppm. However, microscopic and macroscopic celestine and strontianite occur in the study area and are the likely sources of high dissolved strontium [13,51,58]. The fact that high whole-rock Sr concentrations were not observed in this study further emphasizes the important conclusion that many of the minerals having negative impacts on water quality in the region are widespread, but heterogeneously distributed.

5. Conclusions

This article provides an improved understanding of the bedrock chemistry in northeastern Wisconsin, USA and places it in the context of groundwater quality problems facing the region resulting from sulfide mineralization. Field, laboratory, and SEM-EDS observations; regional whole-rock geochemical sampling; and a stratigraphic analysis were conducted on Paleozoic bedrock. This study provides the first detailed description and whole-rock geochemical analysis of MVT-bearing rocks in northeastern Wisconsin.

Four major conclusions can be drawn from the study. First, we document that an expanded region of sulfide mineralization, previously described in Winnebago and Outagamie counties, extends northward into Brown, Shawano, Oconto, and Marinette counties. This includes both the highly enriched sulfide cement horizon (SCH) at the top of the Ancell Group, as well as disseminated metal sulfides in other parts of the section. It is now clear that the SCH stretches throughout most of eastern Wisconsin and into the upper peninsula of Michigan.

Second, the study provides the first qualitative and quantitative assessment of the stratigraphic distribution of sulfide mineralization and metals concentrations in Paleozoic bedrock in the region. On a local scale (meters to kilometers), the distribution of MVT minerals is heterogeneous because they occur in vugs, fractures, and along particular bedding planes. The two units with the highest metals concentrations are the Ordovician Ancell Group and the Maquoketa-Neda formations. Somewhat lower concentrations of metals generally occur in the Cambrian sandstones, the Sinnipee Group dolostones, and the Prairie du Chien dolostones. The lowest metals concentrations are typically found in the Silurian dolostones in the eastern part of the study area.

We also present the first descriptions of discrete Ni and Co-bearing mineral phases in northeastern Wisconsin, along with a complete list of MVT-related minerals known from the region, which is more extensive than previously recognized. Field and SEM-EDS investigations have documented the existence of previously unknown minerals for the region, including vaesite, bravoite, malachite, possibly erythrite, and others.

Finally, the results of this study provide a regional foundation for current and future groundwater studies in the region in order to better understand the sources of dissolved arsenic and other metals in the groundwater of northeastern Wisconsin. Based upon the bedrock geochemistry, the potential for groundwater quality problems from arsenic and other metals is greater than previously recognized for counties in the northern portion of the study area. In addition, the discovery of new minerals (bravoite and vaesite) explains the origin of dissolved nickel and cobalt that has been observed in groundwater above State of Wisconsin health standards for over 25 years. We hope this work will provide a baseline for future economic geologists and groundwater specialists in this region and in others with similar geology.

Supplementary Materials: The following are available online at www.mdpi.com/2076-3263/6/2/29/s1, Table S1: Sample numbers, locations, descriptions, and selected whole-rock geochemistry for 310 samples. Table S2A: Full raw analytical results for the whole-rock ICP-AES analyses of samples from 2007 to 2008. Table S2B: Full raw analytical results for the whole-rock ICP-AES analyses of samples from 2013. Table S2C: Expanded table showing estimated Pearson's *r* and Spearman's *ρ* correlations amongst $\log_{10}$ -transformed variables for selected elements in all samples. Table S2D: Table showing estimated Pearson's *r* and Spearman's *ρ* correlations amongst $\log_{10}$ -transformed Ni *vs.* As, listed by stratigraphic interval (Precambrian excluded). Figure S3: Box-plots for selected metals from both the full set of samples and the "matrix" subset of samples.

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Abbreviations

The following abbreviations are used in this manuscript:

MVT	Mississippi Valley-type
ICP-AES	Inductively Coupled Plasma—Atomic Emission Spectroscopy
SEM-EDS	Scanning Electron Microscopy—Energy Dispersive Spectroscopy
SCH	Sulfide Cement Horizon
PDC	Prairie du Chien Group

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Matthew E. Kirkman, Director
Land Use Planning & Zoning Department
Green Lake County, Wisconsin
Via email: mkirkman@greenlakecountywi.gov
April 17, 2024

Re: Consideration of the proposed "K" Quarry; Inclusion of Decision Form document in Packet

Dear Director Kirkman,

The Green Lake Conservancy, Inc., a non-profit land trust, submits for the public record in connection with the scheduled May 2 hearing, the decision list prepared by legal counsel for the Board of Adjustment in the matter involving the prior similarly proposed Skunk Hollow quarry. The list incorporates statutory, ordinance and regulatory considerations that must be taken into account in determining whether a Conditional Use Permit should be issued to an applicant for a non-metallic quarry in Green Lake County.

Sincerely,

Robert E. Burke, Esq., Board Member

For the Conservancy Board

Copy: Melissa Curran, Conservancy President

Attachment: Board of Adjustment Decision Form dated December 22, 2024

In re Appeal of CUP Issued to Kinas
Green Lake Board of Adjustment
Date of Hearing: December 22, 2022

DECISION FORM

Decision:

_______ Uphold/Sustain the Appeal (requires 2-0 vote)

_______ Deny the Appeal (may be a 1-1 vote on other motion OR 2-0 vote on this motion) with the effect being to allow CUP issued by Land Use Planning and Zoning Committee to proceed

_______ Deny the Appeal, issue permit and impose conditions (requires 2-0 vote)

Findings if Permit is Granted (Opposite Findings for Permit Denial):

1. The operation does or will comply with subch. 1 of Wis. Stat. ch. 295 related to nonmetallic mining reclamation.

2. The operation does or will comply with Chap. 323 of the County's ordinances related to nonmetallic mining reclamation.

3. The operation and location of the mine is consistent with the purposes of the farmland preservation zoning district, which is "to promote areas for uses of a generally exclusive agricultural nature in order to protect farmland and to allow participation in the state's farmland preservation program."

4. The operation and location of the mine in the farmland preservation zoning district are reasonable and appropriate, considering alternative locations outside the farmland preservation zoning district.

5. The operation is reasonably designed to minimize the conversion of land around the extraction site from agricultural use or open space use.

6. The operation does not substantially impair or limit the current or future agricultural use of surrounding parcels of land that are zoned for or legally restricted to agricultural use.

7. The operation will not have a negative effect upon the health, safety, and general welfare of occupants of surrounding lands.

8. The operation will be designed, constructed, operated, and maintained so as to be harmonious and be appropriate in appearance with the existing or intended character of the general vicinity and that such a use will not change the essential character of the same area.

9. The operation will not be hazardous or disturbing to existing or future neighboring uses.

10. The operation will not be detrimental to property in the immediate vicinity or to the community as a whole.

11. The operation will be served adequately by essential public facilities and services, such as highways, streets, police and fire protection, drainage structures, and schools, and that the persons or agencies responsible for the establishment of the proposed use shall be able to provide adequately any such service.

12. The operation will have vehicular approaches to the property which shall be so designed as not to create an interference with traffic on surrounding public or private streets or roads.

Additional Findings:

Conditions Board may Consider Imposing:

1. No additional expansion or addition of structures, mined area, and/or uses relating to this conditional use permit shall occur without review and approval through future conditional use permit(s).

2. Any outdoor lighting shall comply with Section 350-23 of the County Zoning Ordinance.

3. That the owners/applicants are responsible for obtaining permits and licenses from any other regulatory agency, including Wisconsin Historical Society.

4. Hours of Operation are from Monday-Friday from 5:30am to 6:00pm and Saturday from 6:00am to 3:00pm. Same-day blasting required and may only occur Monday-Friday 9:00am-3:00pm.

5. Blasting contractor must utilize best management practices, so as to best eliminate nitrate residuals that can lead to ground water contamination.

6. All mining equipment should have mufflers (when applicable).

7. Operator to implement all aspects of the required by WDNR Erosion Control & Stormwater Management Plan and forward copies of the early Spring and early Fall inspections to LUP&Z Dept.

8. Operator to implement all aspects of the required by WDNR Stormwater Pollution Prevention Plan (SWPPP) permit and forward a copy of the Annual Facility Site Compliance Inspection Report to LUP&Z Dept.

9. Owner must receive a Non-metallic Mining Reclamation Permit.

10. The site shall be reclaimed from east to west as the quarry progresses from east to west. Reclamation fill material must be exempt from WDNR solid waste regulations (See NR500.08).

11. Owner to study the proposed site for the presence of shallow groundwater by installing five small diameter groundwater monitoring wells. One well to be centrally located and the other four to be along

the four property lines and within the 100ft buffers. The study must show that the flow of groundwater supplying Mitchel Glen, Powell Springs and White Creek will not be decreased.

12. The elevation and flow of groundwater within and from the proposed mining site shall be determined. This shall be accomplished by installing three groundwater monitoring wells, one in the NW corner, one in the NE corner, and the other in the SE corner of the proposed site. Each well to be constructed from the anticipated terminal depth of the quarry to the ground surface.

13. No non-metallic mining shall occur within five feet of the elevation of the aquifer as determined through ground water monitor well data.

Additional Conditions:

TOWN BOARD ACTION

Dear Land Use Planning and Zoning Committee:

Please be advised that the Town Board of Brooklyn, County of Green Lake, took the following action on – (Date) April 9th 2023.

Owner/Applicant: Christopher Retzlaff **Applicant:** Michael McConnell (Kopplin & Kinas Co. Inc.)

Site Location: Highway K

General legal description: Parcels 004-00789-0000 & 004-00792-0000, NE ¼ of SE ¼ and SE ¼ of SE ¼ of Section 36, Town of Brooklyn, ±80 acres.

Request: Non-metallic Mining Permit for a limestone quarry to produce construction aggregates.

Planned public hearing date for the above requests: May 2, 2024

_____ **Town Does Not object to and Approves of request**

X **No action taken**

_____ **Objects to and requests denial of request**

NOTE: If denial – please enclose Town Resolution of denial

- Reason(s) for objection:

____

____

____

______________________________ April 9th 2023

Town Representative **Date Signed**

NOTES: Due To Conflicts of interest The Town was Advise By our Legal Attorney not Take Any Action

Please return this form to the Land Use Planning & Zoning Office by: April 19, 2024

DETERMINATION OF THE LAND USE PLANNING AND ZONING COMMITTEE

Public Hearing Date: May 2, 2024

Owner: Christopher D. & Ruth M. Retzlaff

Agent: Michael McConnell, Kopplin & Kinas Co. Inc.

Parcels: #004-00789-0000 & 004-00792-0000, Highway K & Searle Road, Town of Brooklyn.

Request: Conditional Use Permit for a limestone quarry.

Land Use Planning and Zoning Committee:

____
Curt Talma, Chair

____
Harley Reabe

____
William Boutwell

____
Chuck Buss, Vice Chair

____
Gene Thom

Date signed: May 2, 2024

Committee vote: Ayes ____ Nays____ Abstain____ Absent____

☐ **Approve**

☐ **With the conditions (listed on page 2-3)**

☐ **Deny.**

☐ **Modify as follows:**

Conditions of Approval:

General Conditions:

1. No additional expansion or addition of structures, mined area, and/or uses related to this conditional use permit shall occur without review and approval through future conditional use permit(s).
2. The site shall obtain a fire number prior to the start of mining operations.
3. Any outdoor lighting shall comply with Section 350-23 of the County Zoning Ordinance.
4. Any restroom facilities/POWTS located on site must be compliant with Wisconsin Administrative code SPS 381-387 or SPS 391 as applicable.
5. Hours of Operation are Monday-Friday from 5:30am to 6:00pm and Saturday from 6:00am to 3:00pm. Blasting may only occur Monday through Friday 9:00am to 3:00pm.
6. All mining equipment must have mufflers (when applicable).
7. That the owners/applicants are responsible for obtaining permits and licenses from any other regulatory agency.
8. Owner must obtain and follow an Erosion Control and Storm Water Management Plan from the Wisconsin Department of Natural Resources.
9. Owner must receive and follow a Non-Metallic Mining Reclamation Permit from Green Lake County.
10. Owner must remain current with annual Non-Metallic Mining fees and Financial Assurance requirements.
11. No excavation or blasting of materials shall occur within a 100ft. buffer of all property lines, excluding the property line separating parcels 004-00792-0000 and 004-00789-0000. Construction, maintenance, or removal of the following features shall not be considered excavating or blasting for the purpose of this condition: quarry entrance, exterior berms, stormwater basin, and diversion of unnamed stream (WBIC 5027058).
12. The Green Lake County Land Use Planning and Zoning Department shall be contacted prior to the use of a wash plant on site. All byproducts of the wash process shall be disposed of in a manner following the current applicable regulations and so as not to contaminate ground or surface water quality.
13. Any well, constructed or abandoned on site, must be in compliance with NR 141, and done in a manner that prevents substantial contamination of groundwater quality.
14. The elevation of groundwater within the proposed mining site shall be determined. This shall be accomplished by installing four groundwater monitoring wells, two in the northern edge, one on the western edge, and the other in the southeast corner of the proposed site. Each well to be constructed into the groundwater table.
15. No material shall be removed below the aquifer or within 10 feet of the high groundwater elevation as determined in condition 14 of this permit.
16. No material extraction shall occur within five feet of any feature that could substantially harm human health, groundwater quality, surface water quality, or neighboring properties.
17. The Green Lake County Land Use Planning and Zoning Department must be contacted immediately if mining operations disturb a feature that could pose a serious risk to human health, groundwater, surface waters, or neighboring properties.

18. The Green Lake County Land Use Planning and Zoning Department shall be notified at least 24 hours prior to any blasting operations.
19. Information about blasting seismograph data as required by Wisconsin State Administrative Code SPS 307.31(4)(18) shall be made public upon request by a member of the public, or an employee of: Green Lake County, the State of Wisconsin, or the United States Federal Government.

Public Hearing **May 2, 2024**

Item IV: Reclamation Permit Public Hearing

Attn: Land Use Planning & Zoning Committee:

Owner:
Christopher D & Ruth M Retzlaff

Applicant:
Kopplin and Kinas CO INC

The following review checklist is to work as a guide to explain the reclamation standards for a reclamation plan. NR 135.20 requires that the county publicly notices and allows the public an opportunity for a public hearing regarding the reclamation plan. As long as the reclamation plan meets all of the requirements it must be approved according to NR 135.17(1). According to Section 323-17.A.(2)(a) of the Nonmetallic Mining Reclamation ordinance, the Green Lake County Land Use Planning and Zoning Department shall consider the reclamation-related testimony in the zoning-related hearing in deciding on a permit application. The Land Use Planning & Zoning Committee is not the approval body in this case.

Reclamation Plan Review Checklist

This checklist is based on a restatement of reclamation plan requirements of NR135.19 and the County's Non-Metallic Mining Ordinance # 323.

Applicant: ______Kopplin and Kinas CO INC ________________________________

Site Location: ___ NE and SE ¼ of the SE ¼ of Section 36, T16N, R13E, Town of Brooklyn._________

__x___ New Mine Automatic Permit # _____23___________

__x___ Yes _____ No Does the plan provide adequate detail on how reclamation will be conducted?
___x__ Yes _____ No Does the plan meet the uniform statewide reclamation standards?
__x___ Yes _____ No Can the target post-mining land use(s) be achieved?

_____ Approve Plan
_____ Plan returned for additional information (See Checklist)

Reviewed by: ____Max Richards_________________ Date: ______________________

Reviewed by: _____Matt Kirkman__________________ Date: ___________________________

NR 135.19(1) PLAN REQUIRED. An operator who conducts or plans to conduct nonmetallic mining on or after August 1, 2001, shall submit to the regulatory authority a reclamation plan that meets the requirements of this section and complies with the standards of Subch. II. To avoid duplication, the reclamation plans may, by reference, incorporate existing plans and materials that meet the requirements of Chapter NR 135.

- **Site Information:**

NR 135.19(2) SITE INFORMATION. The reclamation plan shall include information sufficient to describe the existing natural and physical conditions of the site, including, but not limited to:

- **Maps:**

  NR 135.19(2)(a) Maps of the nonmetallic mining site including the general location, property boundaries, the aerial extent, geologic composition and depth of the nonmetallic mineral deposit, the distribution, thickness and type of topsoil, the approximate elevation of ground water, the location of surface waters, and the existing drainage patterns.

  Note: Some of or all of the information required above may be shown on the same submittal, i.e. the site map required by par. (a) may also show topography required by par. (c).

  - **General Location:**
    Found in Appendix Map A-1 (USGS Quadrangle/Property Overlay), Explained in section 4.1 (Location and Land Use)
  - **Property Boundaries:**
    Found in Appendix Maps A-1 (USGS Quadrangle/Property Overlay), A-2 (Existing Ground), A-3 (Soil Map), A-4 (Existing Agriculture), A-5 (Proposed Site & Phasing), A-6 (Geologic Cross-Section), and A-7 (Reclamation Grading Plan). Explained in section 4.1 (Location and Land Use)
  - **Aerial Extent:**
  - *Found in Appendix Maps A-1 (USGS Quadrangle/Property Overlay), A-2 (Existing Ground), A-3 (Soil Map), A-4 (Existing Agriculture), A-5 (Proposed Site & Phasing), A-6 (Geologic Cross-Section), and A-7 (Reclamation Grading Plan)*
  - **Geologic Composition and Depth of the Mineral Deposit:**
    Found in Appendix Map A-6 (Geologic Cross-Section), supported by Appendix B- (Local Well Construction Reports), Explained in section 4.4 (Geology & Description of the Mineral Resources)
  - **Distribution, Thickness, and Type of Topsoil:**
    Found in Appendix Map A-3 (Soil Map), Explained in section 4.3 (Distribution, Thickness, and Types of Soil)
  - **Approximate Elevation of Ground Water:**
    Found in Appendix Map A-6 (Geologic Cross-Section), supported by Appendix B- (Local Well Construction Reports), Explained in section 4.5 (Surface Water, Wetlands, and Groundwater), 4.6 (Local Well Construction Summary)
  - **Location of Surface Waters:**
    Found in Appendix Map A-1 (USGS Quadrangle/Property Overlay), Explained in section 4.5 (Surface Water, Wetlands, & Groundwater), 4.9 (Wisconsin Chapter 30 Determination), and in Appendix C- (Wisconsin Chapter 30 Determination)
  - **Existing Drainage Patterns:**
    Found in Appendix Map A-2 (Existing Ground), Explained in sections 4.5 (Surface Water, Wetlands, & Groundwater), and 5.1 (Access, Buffer Zone, Site Preparation, & Erosion Control)
  - **Existing Topography:**
    Found in Appendix Map A-2 (Existing Ground)

NR 135.19(2)(c) Existing topography as shown on contour maps of the site at intervals specified by the regulatory authority.

Note: Some of or all of the information required here may be combined to avoid duplication, e.g. a single map may show anticipated post-mining topography required by par.(c) as well as structures and roads as required by par. (d).

- **Location of Manmade Features:**

NR 135.19(2)(d) Location of manmade features on or near the site.
Found in Appendix Map A-4 (Existing Agriculture), Explained in section 3 (Background)

- **Previously Mined Areas: (IF APPLICABLE)**

NR 135.19(2)(e) For existing mines, a plan view drawing showing the location and extent of land previously affected by nonmetallic mining, including the location of stockpiles, wash ponds, and sediment basins.
Found in Section 3 (Background)

- **Biological Information:**

NR 135. 19(2)(b) Information available to the mine operator on biological resources, plant communities, and wildlife use at and adjacent to the proposed or operating mine site.
Explained in section 4.7 (Agricultural Vegetation & Wildlife)

- **Post-mining Land Use:**

NR 135.19(3) POST-MINING LAND USE. (a) the reclamation plan shall specify a proposed post-mining land use for the nonmetallic mine site. The proposed post-mining land use shall be consistent with local land use plans and local zoning at the time the plan is submitted, unless a change to the land use plan or zoning is proposed. The proposed post-mining land use shall also be consistent with any applicable state, local, or federal laws in effect at the time the plan is submitted.
Found in Section 7 (Post Mining Land Use & Reclamation Plan) and Appendix Map A-7 (Reclamation Grading Plan)

Note: A proposed post-mining land use is necessary to determine the type and degree of reclamation needed to correspond with that land use. The post-mining land use will be key in determining the reclamation plan. Final slopes, drainage patterns, site hydrology, seed mixes, and the degree of removal of mining-related structures, drainage structures and sediment control structures will be dictated by the approved post-mining land use.

NR 135.19(3)(b) Land used for nonmetallic mineral extraction in areas zoned under an exclusive agricultural use ordinance pursuant to subch. III of ch. 91., Stats., shall be restored to agricultural use.
Found in Sections 4.7 (Agricultural Vegetation and Wildlife), 7 (Post Mining Land Use & Reclamation Plan), Appendix Maps A-4 (Existing Agriculture), and A-7 (Reclamation Grading Plan)

Note: Section 91.46 (6), Stats., contains this requirement. Section 91.01 (2), Stats., defines the term "agricultural use."

- **Reclamation Measures**

NR 135.19(4) RECLAMATION MEASURES. The reclamation plan shall include a description of the proposed reclamation, including methods and procedures to be used and a proposed schedule and sequence for the completion of reclamation activities for various stages of reclamation of the nonmetallic mining site. The following shall be included:

- **Earthwork and Grading:**

NR 135.19(4)(a) A description of the proposed earthwork and reclamation, including final slope angles, high wall reduction, benching, terracing, and other structural slope stabilization measures.
Explained in section 7.1 (Site Grading & Preparation) Shown in Appendix Maps A-5 (Proposed Site & Phasing), A-6 (Geologic Cross Section), and A-7 (Reclamation Grading Plan)

- **Topsoil:**

NR 135.19(4)(b) The methods of topsoil or topsoil substitute material removal, storage, stabilization, and conservation that will be used during reclamation.
Explained in Sections 4.3 (distribution, Thickness, and Types of Soils), 5.1 (Access, Buffer Zone, Site Preparation, & Erosion Control), 7.1(Site Grading and Preparation), 7.2 (Overburden & Topsoil Placement), 7.3 (Site Revegetation & Erosion Control) Shown in Appendix Maps A-3 (Soil Map), A-5 (Proposed Site & Phasing), and A-7 (Reclamation Grading Plan)

- **Topography:**

NR 135.19(4)(c) A plan or map which shows anticipated topography of the reclaimed site and any water impoundments or artificial lakes needed to support the anticipated future land use of the site.
Explained in section 7.1 (Site Grading & Preparation), Shown in Appendix Map A-7 (Reclamation Grading Plan)

- **Structures:**

NR 135.19(4)(d) A plan or map which shows surface structures, roads, and related facilities after the cessation of mining.
Explained in Sections 5.3 (Portable Asphalt & Concrete Batch Plant Operations) and 5.4 (Support Structures) Shown in Appendix Map A-7 (Reclamation Grading Plan)

- **Cost:**

NR 135.19(4)(e) The estimated cost of reclamation for each stage of the project or the entire site if reclamation staging is not planned.
Explained in section 7.5 (Estimated Cost of Reclamation) and Shown in Reclamation Cost Summary Table.

- **Revegetation Plan:**

  NR 135.19(4)(f) A revegetation plan which shall include timing and methods of seed bed preparation, rates and kinds of soil amendments, seed application timing, methods and rates, mulching, netting and any other techniques needed to accomplish solid and slope stabilization.
  Explained in section 7.3 (Site Revegetation & Erosion Control)

- **Revegetation Standards:**

  NR 135.19(4)(g) Quantifiable standards for revegetation adequate to show that a sustainable stand of vegetation has been established which will support the approved post-mining land use. Standards for revegetation may be based on the precent vegetative cover, productivity, plant density, diversity or other applicable measures.
  Explained in section 7.6 (Criteria For Measuring Reclamation Success)

- **Erosion Control:**

  NR 135.19(4)(h) A plan and, if necessary, a narrative showing erosion control measures to be employed during reclamation activities. These shall address how reclamation activities will be conducted to minimize erosion and pollution of surface and groundwater.
  Explained in section 7.3 (Site Revegetation & Erosion Control) Shown in Appendix Map A-7 (Reclamation Grading Plan)

- **Interim Reclamation: (OPTIONAL)**

  NR 135.19(4)(i) A description of any areas which will be reclaimed on an interim basis sufficient to qualify for the waiver of fees pursuant to s. NR 135.41 and which will be subsequently disturbed prior to final reclamation. Descriptions shall include an identification of the proposed areas involved, methods or reclamation to comply with the standards in Subch. II and timing of interim and final reclamation.
  Explained in Section 7.4 (Interim Reclamation)

- **Criteria for Successful Reclamation**

  NR 135. 19(5) The reclamation plan shall contain criteria for assuring successful reclamation in accordance with s. NR 135.13.
  Explained in sections 7.1 (Site Grading and Preparation) and 7.6 (Criteria for Measuring Reclamation Success) Shown in Appendix Map A-7 (Reclamation Grading Plan)

- **Certification of the Reclamation Plan**

  NR 135.19(6) CERTIFICATION OF RECLAMATION PLAN. The operator shall provide a signed certification that reclamation will be carried out in accordance with the reclamation plan. If the operator does not own the land, the land owner or lessor, if different from the operator or owner, shall also provide a signed certification that they concur with the reclamation plan and will allow its implementation.
  Found in Section 10 (Reclamation Plan Compliance Certification)

- **Financial Assurance**
  Initial active acres will be assured and $28,344.62 per acre. Future Financial Assurance numbers will be subject to change.
  NR 135.40(1-13)

- **Submitting the Plan**

  NR 135.19(7) APPROVAL. The regulatory authority shall approve, approve conditionally, or deny the reclamation plan in writing in accordance with s. NR 135.21(1). Conditional approvals shall be issued according to s. NR 135.21(2), and denials of permit applications shall be made according to s. NR 135.22.

Please type or use black ink

Return to: Green Lake County
Planning & Zoning Department
571 County Road A
Green Lake, WI 54941

GENERAL APPLICATION

Fee $450.00 (not refundable) Date 02/29/2024

Zone Change from ________ to ________

Conditional Use Permit for ________

Other NMM Reclamation Permit

PROPERTY OWNER / APPLICANT

Name Christopher D. & Ruth M. Retzlaff

Mailing Address W14445 Retzlaff Dr, Ripon, WI 54971

Phone Number (920) 229-2853

Signature [signatures] Date 02/29/2024

AGENT IF OTHER THAN OWNER

Name Michael C McConnell, Kopplin & Kinas Co., Inc.

Mailing Address W1266 N Lawson Dr., Green Lake, WI 54941

Phone Number (920) 294-6451

Signature [signature] Date 02/29/2024

PROPERTY INFORMATION

Town of Brooklyn Parcel Number 004-00789-0000, 004-00792-0000 Acres 80

Lot ___ Block ___ Subdivision ________

Section 36 Town 16 North Range 13 East

Location of Property CTH K & Searle Rd

Legal Description The Northeast Quarter of the Southeast Quarter (NE 1/4 SE 1/4) and the Southeast Quarter of the Southeast Quarter (SE 1/4 SE 1/4) of Section Thirty Six (36),Township Sixteen (16) North, Range Thirteen (13) East, Town of Brooklyn, GreenLake County, Wisconsin.

Current Zoning Classification A-1 Current Use of Property Ag/Non-Ag

Detailed Description of Proposed Use Limestone quarry. See attached documentation.

PLEASE PROVIDE A DETAILED SITE PLAN WITH THE APPLICATION

Fees: Zone Change $375
Conditional Use Permit $375.00
Variance $375.00
Special Exception $375.00
NMM Reclamation Permit $450

PZP-010 (04/09)

Item #4: Owner: Christopher D. & Ruth M. Retzlaff, **Agent:** Michael McConnell, Kopplin & Kinas Co. Inc., **Location:** County Highway K and Searle Road, **Parcels:** 004-00789-0000 & 004-00792-0000. **Legal Description:** NE ¼ of SE ¼ and SE ¼ of SE ¼ of Section 36, T16N, R13E, Town of Brooklyn, ±80 acres. **Request:** The owners are requesting a Non-metallic mining reclamation permit for a limestone quarry.

Please refer to pages 43 through 324 of this packet for information regarding details of Item #4 of this public hearing.