

LARGE FILING SEPARATOR SHEET

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Kathleen Yost

17-2295

Republic Wind

09-12-2019

Ohio Power Siting Board

I would like to address the more than 14,000 abandoned wind turbines currently sited in the US. There are at least 3 abandoned project sites in California and 5 in Hawaii, with more scattered throughout many other states. The wind companies promise at the beginning to have a bond to cover decommissioning and removing turbines that are no longer viable, but after many sales to different investment groups, that promise is not being kept and these eyesores are what the residents need to live with for years to come, possibly decades.

The bases of these turbines are 25 -30 feet deep. They need to blast through bedrock to build the bases. What is that going to do to our aquifers and wells? I have read testimony from people living in other areas with turbines and they have stated that it has affected their wells, sometimes the water is almost black. Living in the country, we only have our wells to bring clean, fresh water into our homes.

For the past 20 years or so, Seneca County has been actively trying to reintroduce the bald eagle into this area. And we have done a terrific job! We now have dozens of nesting pairs. Wind companies like to say that cats kill more birds in the US than turbines and I'm sure that's true. But cats kill robins, sparrows, starlings and other small birds that are not endangered. Cats do not kill eagles, hawks, owls and other large birds. Turbines also kill bats, which are beneficial to our area farmers, and even family gardeners, so they can use less and spend less on pesticides. Seneca County has many nature preserves for the very purpose of providing habitat for a variety of native wildlife and plants, and at least 2 of these are in the footprint of the turbines. All those years of nurturing these birds will be for naught.

Many rural areas of our county are zoned for agricultural, residential and some commercial use. What is the purpose of local zoning laws if industrial use turbines are allowed on thousands of acres? I can assure you, none of the people living in these areas ever thought they would be living in an industrial zone. Some people have mentioned the Whirlpool facility in Findlay, Hancock County, Ohio and the fact that they have half a dozen or more turbines. Whirlpool is already zoned industrial and their turbines are half or less the size of the ones proposed for our mainly agricultural townships. And the people in that township have since voted against more turbines being built. Thankfully, they had that choice.

And none of the above points even addresses the fact that it costs more in ores and minerals and other production costs to produce each turbine than will ever be produced in electricity. None of the wind turbines would be economically viable without government subsidies. These turbines are not the green dream or savior that they are made out to be.

Please consider all of these points, along with others made here today, and decline to approve these industrial wind turbines in Seneca County.

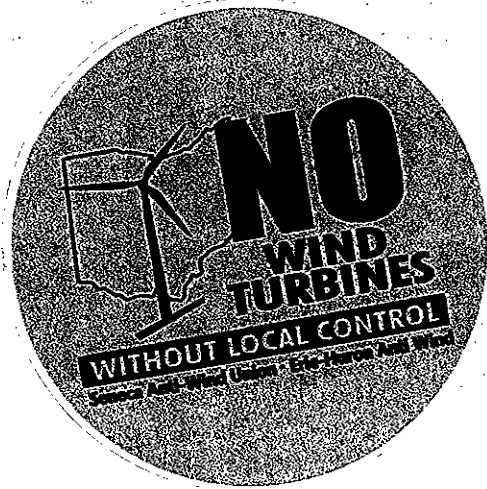
Kathleen Yost 3206 S County Rd 7, Seneca Twp, Tiffin, OH 44883 419-937-2517

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Lori Riedy

My name is Lori Riedy and I own Russell's Flowers, Garden Center & Gifts at 9910 St. Rt. 269, Bellevue in Erie County. I am here to voice my absolute opposition to the wind turbines that are slated for Sandusky, Seneca, Erie & Huron Counties. All four counties that surround the city of Bellevue.

There are many reasons why I am against them. The bats, the eagles, the bird migration, the infrasound, the shadow flicker, the fact only the land owners that have them on their actual property are the only ones that will benefit financially from them, but my biggest concern is the effect they will have on this very sensitive region that we live in known as the Karst Region.

Bellevue has the largest sinkholes in the state of Ohio by perimeter, area & volume. We have the most extensive Karst Region and this has been documented. My business involves using tens of thousands of gallons of water being pumped from our well to water 8 greenhouses full of plants, mum plots, etc. Without our well we would be out of business. Not only are they trying to put wind turbines here but they want to erect the largest ever built, 655', two which are to be located directly behind my property within less than a quarter of a mile. The amount of excavation that will have to be done to later pour hundreds of tons of concrete in for the bases to hold these turbines is just unbelievable. There is absolutely a very high probability that greater sinkholes and solution cavities will be disrupted or filled in. Underground streams and drainage that have formed through our limestone layers will be irreparably damaged. Our wells may be contaminated if not destroyed all together. There was a report done after the 2008 Flood in Bellevue which closed down our State Route 269, where my business is located, for more than 3 months. I cannot imagine what would happen if these turbines are allowed to be built. This was designated as an EPA protected area because of the sensitive region that we are located in. Why would we allow anyone to come in and disturb our area for something that has already proven to have negative effects and no quantitative benefits? They have no idea what type of area they are dealing with and then add to that they want to put the largest turbines ever constructed on top of it in an area with high population. They have slated a very high concentration of turbines in a very populated area which makes no sense.

This whole process will have a negative effect on many of the people who live in this area and I would plead that they not be allowed to locate here in Bellevue.

Thank you.



Casey Didion

Any sound decision is made by conducting an impartial cost-benefit-analysis. The factors to be analyzed in considering these local wind farms fall into two categories: 1) Environmental Considerations and 2) Economic Impact.

The Environmental analysis centers on the undisputed amount and location of karst in our region. In its simplest terms, karst's unstable terrain allows for high connectivity between land surface and the water table. What does this mean? Pollution. Of our wells. Of our drinking water. Of our Lake. Because they promote major nutrient loading from farm chemical runoff creating a direct route to Lake Erie and causing the notoriously harmful algae bloom in the lake. ODNR independently documented and discussed these at length in a 2013 publication which concluded that Bellevue's karst sites are the largest in the state. This report was conducted years before the influence or pressure of the 'wind farm craze' and cautioned of the 'high susceptibility of pollution' and instability of erecting structures in karst regions. Yet, interestingly, windmill proponents now offer their own, self-funded "reports" to assure us there is no risk to local water sources.

But with windmills exerting more than 1,000 pounds of pressure per square foot – what if they are wrong? What if ONDR's was right? How will a polluted water table serving entire communities be remediated? Who will residents call for assistance the day it happens? Who will shoulder the cost? There is no cheap or easy fix if these fragile subterranean features are damaged.

The environmental risks may pass muster in our cost-benefit-analysis if they were outweighed by the economic benefit. But to be blunt, it isn't even close. To summarize:

- These windfarms do not result in more energy choices to consumers
- These windfarms do not result in lower energy costs to consumers
- Only a handful of local property owners stand to benefit from land leases
- By their own admissions in their application – these windmills are expected to generate only 41 permanent jobs
- And what's most telling – the economic projections themselves were filed under seal. Why? Because they simply don't make economic sense for the citizens of our area, but rather line the pockets of the developers and lease holders

Finally, we must consider safety in completing our analysis. In 2014, legislators took note of the noise and dangers of *much shorter* wind towers and approved HB 483, which set the distance of blade tips 1125' from a property line. Now, in the frenzy to promote and approve much taller windmills, proponents seek shorter distances and want to measure from a *structure* as opposed to a property line.

Step back and run the analysis: Irreparable environmental harm to local residents, including flooding and the contamination of our drinking water; further pollution to Great Lake Erie; Safety concerns of reduced setbacks.....weighed against a non-profitable private business venture, which generates few permanent jobs and results in no direct benefit to local residents. I encourage you to deny the pending application.

Respectfully submitted,

Casey Didion

Diane Hudok

Your Honor,

My husband Joe and I live in Eden Township in rural Seneca County. We oppose the construction of RepublicWind.

IWTs here are so wrong on so many levels. There are many facts and much anecdotal evidence that you will be hearing today-tonite from others for this conclusion. I am asking that when you listen, please listen also with your heart.

There are trade offs when you live out of town out in the country. Those who live in the country have traded pizza delivery, cable TV, and reliable cellphone-WiFi service for fireflies at dusk, eagles in flight, starry night skies and barred owls in the woods. We have longer distances to schools, work, grocery stores, doctors, and church but shorter time in actual traffic. One tractor and one car is a traffic jam in the country. We've traded the nonstop noise of the city for the throaty growl of our neighbors' tractors at planting and harvest. We've learned to sniff the air or check which way the breeze blows before hanging out laundry. We have sky "scapes" instead of skyscrapers, and we like it that way.

To us, a wind farm project is NOT a farm. We know farms. This is an industrial project that is systematic organized vandalism of our beloved rural area.

The proposed IWTs *here* make us fear for our health, our homes, our community ethos, and the rural beauty that surrounds us.

IWTs *here* would be monstrous metal structures testifying to short sightedness and greed. OKing construction of this wind project oks destruction of this rural area.

AND THAT IS NOT OK. OR JUST OR FAIR.

Thank you,

Diane Hudok

Diane Hudok

6300 TR 151

Eden Township, rural Seneca Co

9-12-19



September 12, 2019

My name is William Seaman. I am a resident of Lyme Township in Huron County. My family has farmed, owned property and lived in Lyme Township for 172 years.

Lyme Township is adjacent to Seneca County and Sandusky County, and I reside in the view shed of the Republic Wind project and also the Emerson Creek Wind project.

Thank you for the opportunity to speak at this public hearing today.

My comments today are directed to the seven voting members on the Ohio Power Siting Board – Sam Randazzo, Dorothy Pelanda, Lydia Mihalik, Laurie Stevenson, Amy Acton, Mary Mertz and Gregory Murphy. These are the individuals who ultimately will approve or deny APEX's certificate for the Republic Wind project.

I am not a young person, so hopefully the many years I've lived have given me some wisdom.

In my 39 years of employment with the Federal government I have seen, up close and personal, public policies that are destructive, unnecessarily expensive and downright wrong. And often these public policies start out with the best of intentions.

First and foremost, we can all agree that we want Ohio to be a better place to live. We want an environment safe for ourselves, our children and our grandchildren. We want our natural resources protected. We also want our economy to grow and prosper.

For the record, Ohio has the 7th largest economy in the United States, and the 27th largest in the world.

The backbone of our robust economy is our electrical grid. Reliable, robust reasonably priced electricity is essential to keeping businesses currently based in Ohio here, and attracting new businesses from other parts of the US and overseas.

The arrival of big wind to our area – with projects in Seneca, Sandusky, Huron and Erie County – does NOT make our electrical grid more reliable, more robust or cheaper.

A study released by the University of Chicago in April 2019 shows that states with renewable portfolio standards inevitably have higher rates for electricity. Higher costs for energy reduce Ohio's ability to attract businesses. Companies expand or come to Ohio, in part, because we have a reliable electrical grid. Intermittent energy sources are not what Ohio needs.

Every single watt of power produced by an industrial wind turbine must be backed up by another power source - nuclear, natural gas, coal, etc. This doesn't sound like a recipe for simplicity.

Germany, despite 29,000 operating wind turbines in a nation the size of Montana, has not reduced its carbon emissions at all. There is growing resistance to wind development in Germany – with installations down 80% this year. How does Germany handle the shortfalls from wind? They fire up their coal powered plants and are building a natural gas pipeline to Russia. Their cost of electricity is the highest in Europe, and two and a half times higher when compared to the United States.

This does not appear to be a sound energy policy.

The arrival of big wind to our area also endangers human health, animal health and our environment.

Setback distances, under currently Ohio law, are grossly inadequate. The operating manual for one model of turbines states the minimum safety zone around an industrial wind turbine is 1640 feet, which is several hundred feet longer than our current setback rules. In Hillsdale County in Michigan, the regulation is 1 mile from any home. The French Ministry of Health recommends 4,291 feet setbacks. In Bavaria, the setbacks are 10 times the height of a wind turbine. [In the Emerson Creek Wind project that would make the setbacks 6,550 feet. In the Republic Wind project that would make the setbacks 5,860 feet.]

In addition to the threat of being struck by ice throws or various parts from a wind turbine because of inadequate setback distances, our state health officials should be concerned about the cumulative negative effects of noise, shadow flicker and

infrasound from industrial wind turbines. Has this topic been discussed or researched at the Ohio Department of Health? If it has not been studied or discussed, why not? There is substantial data already there due to the extensive history of wind power in Europe.

By now we should all be aware to the threats to our water, by siting wind turbines in areas where the karst is prevalent, which is smack dab in the Republic Wind project, and also in parts of the Emerson Creek Wind project. Lake Erie must be protected as a top priority by the Ohio EPA. Siting wind turbines in the most fragile Great Lake, and siting wind turbines in the karst does not sound like sound public policy to me.

Despite mounting contra evidence around the globe, however, we continue to see more wind development in Ohio. There is money to be made, and federal tax credits to be received by crony capitalists who live nowhere near a wind turbine.

At the heart of this is the marginalization of the rural residents in Northwest Ohio. If these projects were anywhere near Indian Hill, Madeira, Powell, New Albany, Upper Arlington, Hilliard, Maumee, Shaker Heights, Hunting Valley, Chagrin Falls or Hudson they would be dead upon arrival. Wind developers hope our marginalized rural communities do not have the energy or means to fight.

These projects are not wanted, despite what APEX Clean Energy (an ironic title) says. For example, in Huron County only 38 families in five townships will potentially host a wind turbine in the Emerson Creek Wind project. I am sure the numbers are similarly small in Seneca and Sandusky County.

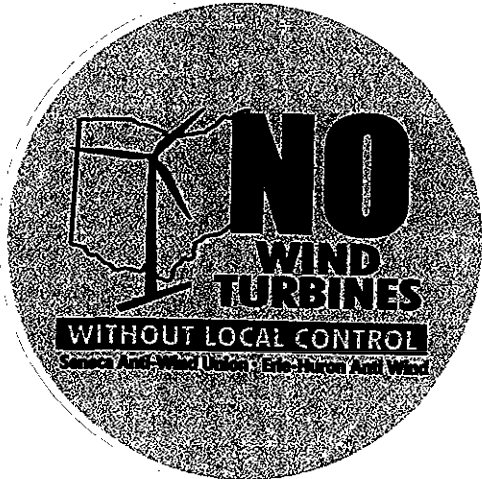
38 families

should not be allowed to set public policy for the 60,000 residents of Huron County. And if you are keeping track, only 1 ~~of~~ person out of those 38 families is an elected official, a township trustee in Lyme Township, who should resign his position due to a clear conflict of interest.

38 families are not my rulers, any more than people from New York and California get to tell me who will win the next presidential election.

Please deny the certificate for the Republic Wind project, and send a message of sound energy policy and common sense to those who would desecrate our rural

landscapes and threaten our economy, our environment and our health. Protect all the citizens of Ohio, not just those who live in our suburbs and cities.



Jim Feasel

Public Hearing Testimony
Republic Wind 17-2295-EL-BGN
September 12, 2019

Jim Feasel
1121 East County Rd 16
Tiffin, Ohio 44883
Seneca County

I am opposed to this project being built in Seneca County for public safety reasons.

The seven voting members of the Power Siting Board will determine whether Republic Wind receives a certificate to build. Yet, for the most part, these voting members are insulated from the details surrounding the project. On the off chance that the voting members will hear my words today I would like to address my remarks directly to them.

By now, everyone on the staff should be aware of the fact that wind turbines, already built in Ohio and surrounding areas, have experienced failures, throwing several pound blade fragments, hundreds of feet farther than the setback distances used in the design of this Republic project. The evidence of this is on file at the Siting Board's office. This evidence is signed and stamped by professional engineers.

This evidence proves beyond a shadow of a doubt that many of the turbines in this project are far too close for public safety. On average 3,800 wind turbine blade failures occur each year. These include, three BRAND NEW turbines in the US(1), that have suffered catastrophic failure already this year, and 2 more new turbines this year in other countries, proving that NEW technology is still NOT reliable, and cannot be counted on to solve the safety problem. Yet the staff report makes no mention of the safety risks designed into this project.

Also on file at the Board's office are safety manuals for the turbines proposed to be installed. Although deemed proprietary information, it is widely believed that the safety distances recommended by the turbine manufacturers are far greater than the setback distances allowed in the design of this project. Whether this is true or not true, it is inexcusable that this information be withheld from the public who will be directly exposed to any possible hazards. The safety recommendations in these manuals can be made public without exposing trade secrets. There is absolutely no excuse for not doing so.

The process that the OPSB staff is using to approve wind projects shows complete and utter disregard for public safety. And this disregard comes with the full knowledge of the staff, and hopefully by now, every voting member on the Board. It is not a matter of opinion. It is not a matter of lacking information. It is not a matter of misinformation. Rather, it is a matter of the complete failure of this agency to adhere to its number one directive, that being to protect public safety.

Being the judge over whose property rights are most important is NOT what this Board was created for.

Judging the safety, and need, of energy projects IS what this Board was created for.

Determining whether more tax money for local schools would be a good thing is NOT the duty of this Board,

Making determinations on public safety IS the duty of this Board.

Deciding whether some more income for leaseholders would help their financial condition is NOT this Board's job,

Deciding how best to protect public safety IS this Board's job.

Protecting the world against climate change is NOT in this Board's mission statement

Protecting Ohio citizens by properly locating energy projects IS this Board's defined mission.

I could go on but it should not be necessary.

I ask that every voting member on this Board think long and hard about your decision. You will live with your vote on your conscious for a long, long, time. Can you live with supporting a project that you know will put public safety at risk?

I ask the members of the Board to remember when deciding, that, as a society, we only accept risk to safety if there is an offsetting benefit that cannot be attained by any other method with lower risk. Every benefit this wind project purports to bring can be attained with lower risk by other methods. Solar, would be one such alternate method.. Your vote, will become part of your permanent legacy. It COULD be used to help guide the renewables industry towards safer and more sensible projects, while protecting public safety at the same time. If I had a vote, that is how I would use it.

Perhaps, in the near future, local citizens will obtain some control with a vote in these projects, by gaining the right to a referendum on them. At that point WE, the public, can decide if any benefits that may come with a wind project are worth the costs and risk of turning our area into a heavy industrial zone. In some areas they may well be. In others they will not. Only the local residents can make that decision correctly.

When local control is re-established then, WE, the local public, will undoubtedly be VERY motivated to watch out for public safety. It is our safety that is on the line here, and that of our families, and our children, our neighbors, and our loved ones. Until that time comes, and the ills of this process are healed, we must rely on YOU, the voting members of this Board, to protect our safety. I respectfully ask that you DO NOT LET US DOWN.

(1) as per Wind Power Monthly, a wind industry newsletter.

Roger Walters

FOR FULL DISCLOSURE, I MANAGE LAND LEASED TO APEX, and THERE IS ZERO PROBABILITY THAT WE WILL EVER SEE A TURBINE ON THIS LAND.

OIL AND GAS LEASES HAD BEEN A FACT OF LIFE IN THIS AREA.

LEASES HAVE AND CONTINUE TO PROVIDE SOME STABILITY TO FARM INCOME AFFECTED BY WEATHER AND MARKET CALAMITIES.

ALTERNATIVE ENERGY WILL PROVIDE SOME ADDITIONAL STABILITY TO RURAL COMMUNITIES.

THE WIND PROJECT WILL BENEFIT LANDOWNERS, SCHOOLS, TOWNSHIPS, AND COUNTIES.

ALL OF THE ARGUING ABOUT WIND LED US TO TAKE A ROAD TRIP TO THE VAN WERT -

PAULDING AREA LAST YEAR. WE ARE ALL DIFFERENT. PERSONALLY, I WOULD RATHER SIT

ON MY PORCH AND WATCH THAT SLOWLY SPINNING TURBINE BLADE THAN LOOK AT CELL

TOWERS OR THE NEW POWER POLES ON 224 EAST OF TIFFIN .

WHILE WALKING UNDER TURBINES NORTH OF PAULDING WE FOUND NO DEAD BIRDS.

I HAD TO ASK MY WIFE IF SHE COULD HEAR THE BLADES TURNING.

TRAFFIC 2 MILES AWAY, THE FARMERS GRAIN AUGER 1500 FEET AWAY, EVEN THE BIRDS

AROUND US-ALL MADE MORE NOISE THAN THE TURBINE.

Proposed Republic Wind Farm Opposition Testimony
Republic Wind, LLC, OPS B# 17-2295 EL-BGN

#14
Gail Moyer
My name is Gail Moyer, and I reside at 3040 South State Route 67, Tiffin, OH 44883, Bloom Township, and have lived there since 1981. I was born and raised in Bellevue, Ohio where I met my husband, Keith, who grew up in Flat Rock, OH. We were married in Ebenezer United Methodist Church in Flat Rock, and owned property in Flat Rock when the application for the Republic Wind Farm was originally initiated.

I would like to state that I am opposed to the proposed Republic Wind Farm for many reasons including excessive noise levels, harmful levels of shadow flicker, harmful effects from infrasound, dangers of ground water impacts and well water contamination due to karst in the area, negative impact to our local airports, Life Flight service, property values, nature preserves, local bald eagles and other wildlife, the siting of a wind turbine very close to Flat Rock Children's home, and the overall improper siting of the over 600 foot tall industrial wind turbines in a densely populated rural environment.

However, today I will focus my remarks on Ohio Administrative Code 4906-4-08 Health and safety, land use and ecological information, Section 4 Land Use Plans, Part (d) which states: assess the compatibility of the proposed facility and the anticipated resultant regional development with current regional plans. I am basing my remarks on the Seneca County Comprehensive Plan Update 2001 and the Sandusky County Comprehensive Plan Update 2013. I have a written copy of excerpts from these documents as well as a copy of my statements concerning these excerpts to give to the court recorder.

The Comprehensive/Regional Plans are long-range plans used to guide growth and development according to Ohio Revised Code 713.23. They are statements of development policy for the counties and work best with public support and understanding, as well as far-sighted leadership by public agencies to support the vision and goals of the respective plans. All decisions should be made in light of the strong history of private rights enjoyed by citizens of our country. Sandusky and Seneca County residents have chosen to allow most land-use control to be exercised at the township level in order to ensure that these controls are responsive to the needs and wishes of residents. The plans do not advocate the expansion of these controls at the expense of property rights or the reduction of local authority.

In order to promote positive economic growth countywide, there should be a co-operative understanding between all agencies, citizens, and public officials so that all parties can be involved in new industry proposals.

Economic development must be considered within a land use framework in order to have maximum benefit on the regional and local economies while having minimum negative impacts on the environment, service capacity, and character of the area. Furthermore, the use of economic development agreements through intergovernmental coordination should be promoted.

Sandusky County's housing goal is to ensure adequate supply of housing to meet the diverse needs of Sandusky County households, promoting housing developments in a safe, quiet environment that is healthy, convenient, and attractive, ensures stable property values, and affords opportunities for all citizens.

Sandusky County desires to establish conservation, restoration, and preservation methods to assist in the retention of natural amenities and scenic beauty and encourage site design that protects the natural terrain and groundwater, preserves or restores significant vegetation and scenic views, and protects areas that are sensitive to change: wetlands, riparian corridors, other environmentally sensitive areas and habitats. One such area is the Shelley Wetland located at the intersection of CR 177 and York Twp. Rd, 292, less than 1 ½ miles from a proposed wind turbine over 600 foot tall.

Seneca County provides an example of the value of open space and natural resources to its residents. Throughout the County's past, the natural environment has played an important role in defining Seneca's identity. Seneca County prides itself on its rural character and agricultural resources. Citizens want to maintain the rural character of the County by preserving farmland and other natural features.



To protect the County's rural character, growth management techniques need to be used to encourage compact development in existing urban areas, plan ahead for growth, and prevent further environmental degradation of the land. We need to encourage growth that builds upon existing municipalities and supports new residential, commercial, and industrial growth only within identified urban growth boundaries where public infrastructure is available.

We need to preserve prime farmland recognizing agriculture as a viable economic resource. We need to develop and implement an aggressive program to preserve agricultural uses in those areas identified for permanent agricultural preservation. Citizens and officials alike acknowledge that the encroachment of development on farmland is a critical county issue.

We need to protect sensitive environmental areas such as wetlands, woodlands, steep slopes, endangered species habitats, native species habitats, and flora and fauna from the impacts of developments. We need to restrict development in critical resource areas such as in the 100 year flood plain and in perennial stream buffers. We need to maintain and preserve natural open space corridors that are important to wildlife and plant life habitats.

Again, these ideas are not my original thoughts. They are all part of the documents that were accepted as guides for the Seneca County Regional Planning Commission and the Sandusky County Comprehensive Plan. They can be found on their websites. These plans were created to advise elected officials on actions relevant to growth and change.

I request that the Ohio Power Siting Board reject the application for license to erect an industrial wind farm submitted by Republic Wind, LLC, OPSB# 17-2295-EL-BGN as it is NOT compatible with the current Seneca County Regional Plan or Sandusky County Comprehensive plan and will negatively impact our farmland and airports, and decimate our rural open spaces and sensitive environmental areas.

Thank you.

My name is Dennis Schreiner, I live in Groton Township of Erie County.

My comments will primarily address Margin of Safety:

Due to the lack of local control under current Ohio law, I will offer testimony showing the need for the Ohio Power Siting Board to place public safety as a top priority when considering projects such as these. It should be incumbent on the wind project developer to prove their equipment is safe, not for the public to show it is not safe!

The OPSB is charged (in part) with promulgating regulations to ensure the safety of all Ohioans.

Reductions in Safety

A. Reduction in Physical Personnel Safety. Setbacks should be established so as to minimize any increased risk of an undesirable event due to the proposed Industrial Wind Generating Facilities.

There have been Industrial Wind Turbine Accidents – incidences of turbine blade failure here in Ohio

- Timber Road II (Paulding Wind Farm) April 24th 2012 – Turbine in service for about 2 years. This was a Manufacturing Defect – The developer, stated in their May 14th 2010 application that project setbacks between turbine sites and permanent residences (min of 914 feet) and property lines (minimum of 505 feet) should protect the public from the already minimal risk of blade throw. In the Incident Report, Turbine Manufacturer Vestas, established an emergency clearance distance of 500 meters (1649 feet). In summarizing the blade damage, Vestas reported that the largest fragment they “recovered” was more than 6.6 pounds and was found 764 feet from the tower base. A Van Wert County Hoaglin Township Trustee documented fragments 1158 feet and 1561 feet from the tower.
- April 4, 2018 – Hog Creek Wind Farm in Hardin County – Blade Shear. No report filed – reporting of incidents are not a requirement. Speculation is that high wind and lightening caused the blade failure.
- August 25th, 2018 – Blue Creek Wind Farm in Van Wert County - a 10-foot section broke and traveled 825 feet. Safety systems failed – continued to rotate for 10 minutes then separated. Debris was thrown 300 feet further than the property line setback distance.

It is a matter of Public Safety and non-participating Property Owner Rights that IWTs be no closer than the Manufacturer required 1640 feet or the distance calculated in a credible Blade Throw analysis, whichever is the greater. Please do not allow Ohio to become the laughing stock of the Nation and World with respect to setbacks since virtually everyone is increasing setbacks to address the effects of blade failures, noise (especially low frequency noise) and shadow flicker. Setback distances of a mile or more from an occupied structure are not uncommon.

B. Reduction in Ecological Safety

The extreme disruption of the subsoil in and around Karst features alone should give the OPSB reason to pause and ask what controls will be in place to protect our drinking water. There is also a concern with the dissolution of carbonate rocks exposed to slightly acidic groundwater in the Republic Wind Project. I urge that independent 3rd party reviews be conducted by persons agreeable to both the State of Ohio and the developer if the project moves forward.

C. Reduction in the Level of Safety provided to Preserve and Protect Wildlife

The Republic Wind project is within the range of the federal and state endangered Indiana bat and federal and state threatened northern long-eared bat. The primary threat to these bats is a collision with an operational industrial wind turbine. The Applicant has proposed a curtailment regime to minimize impacts to bats and other avian species in the project area during operation of the facility. The OPSB Staff believes that the Applicant's proposal may be inadequate and inconsistent with the recommendations of past wind projects. The Seneca project site and adjacent parcels encompass habitat with confirmed use by listed species. The Applicant expects collision risk to bats in the project area "to be consistent with other wind energy projects in agricultural landscapes in the Midwestern U.S." and estimates 1,039 to 2,332 bat deaths per year. However, the ODNR anticipates the mortality rate may be greater as this site has approximately four times the amount of forested area as other operating projects in agricultural landscapes in Ohio. The OPSB Staff report details all of the actions and if the project is approved, I believe that some sort of verification is conducted. If needed, enforcement actions should be provided with sufficient financial penalty to ensure literal compliance with Staff Recommendations.

D. Reduction in Political Sustainability due to Loss of Local Control

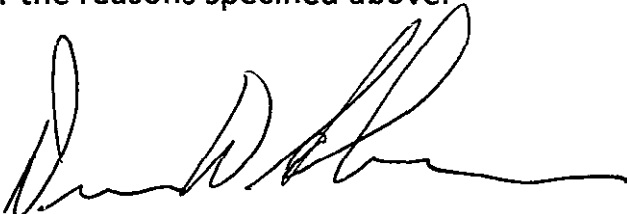
Ohio Law removes local control over the siting of Green Energy Industrial Complexes in land zoned for Residential/Agricultural use bypassing local zoning procedures for facilities under OPSB control. The short sightedness of preventing local control has divided our communities. The Ohio Chamber of Commerce states a local referendum sets a dangerous precedence. In this age of information, continually telling people their opinions do not matter or they do not deserve a seat at the decision-making table will be politically unsustainable. Politicians are elected to serve the people. Elections and referendums allow the people a voice with their vote!

E. Other Reductions in Margin of Safety

- Intermittent wind generation disrupts the entire electrical grid resulting in Blackouts as evidenced in Loss of Power in Chicago, New York, Washington State, and Texas.
- Chemical Hazards exist with IWTs such as the 450 plus gallons of lubrication oil in the unit that often leaks.
- With the current setbacks – road safety is reduced in Ohio. Maybe the roads should be Posted as being hazardous to travel!
- The margin of safety is reduced for EMS and other Emergency services. IWTs interfere with “lifeFlight”, weather radar, the reception of Emergency broadcasts and other radio signals. Autonomous farm vehicle navigation systems can be affected if within 2.4 miles of an Industrial Wind Turbine.
- Lacking IWT Incident Reporting Criteria and Rulemaking – the assurance Public Safety Margin is reduced. Turbine Failures are not Rare or Isolated Incidences with little to no consequence. IWT failure rate is 1 failure per turbine per year. One in 20 turbine blades will experience a blade failure or separation during their lifetime. Five Industrial Wind Turbines have suffered catastrophic failure and subsequent collapse so far in 2019. What reasoning can the OPSB apply that would allow the construction of these much taller IWTs in Ohio without knowing that the cause has been determined and that corrective actions have been taken to prevent recurrence?

Conclusion

The Responsible siting of IWTs would preclude Seneca and Sandusky County as a host county. I recommend denial of this project for the reasons specified above.

Respectfully,


Kip Siesel

IUOE Local 18 Business Representative

2412 S. Reynolds Rd Toledo Ohio 43614

On behalf of the Operating Engineers Local Union 18, I am here to support the approval of the Republic Wind Farm project.

The members of Local 18 and the state of Ohio have benefitted greatly from the wind farm projects built in Northwest Ohio over the past several years. There have been several phases and years of work for our members as a result of these projects, and the Republic Wind Farm will help contribute to the creation of jobs. In turn high paying wages, health care benefits and training programs can continue to grow because of the wind industry.

The areas in which these projects have already been constructed have seen numerous benefits in the Townships and the Counties involved. If approved the Republic Wind Farm will not only create jobs but you can expect an economic impact, additional tax money, and clean energy for Ohio as a result from the project.

The members of Local 18 have the experience to build this project safely and on time from their involvement on the other wind farm projects. They also have been provided the proper training required to build a project of this size safely and on time. The ongoing maintenance of the Republic Wind Farm would also continue to employ our members during the project's existence.

We encourage the Ohio Power Siting Board to support the jobs of the Men and Women of Local 18 by approving the Republic Wind Farm application.

Senate Energy and Public Utilities Committee,

Hundreds of rural landowners throughout the townships that encompass the Republic Wind, LLC have entered into legally binding contracts with Apex Clean Energy for the installation of wind turbines. I am one of those landowners in Thompson Township as evidenced by a deed hanging on my wall granted to my ancestors in 1832 signed by President Andrew Jackson.

There are many such family century farms that in good faith signed these agreements knowing full well any construction of wind turbines would be approved and regulated by the Ohio Power Siting Board (OPSB) (Case No. 17-2295-EL BGN.)

This Ohio farmland has seen many developments over the years, with paved roads, electric and telephone poles, radio and cell towers all of which were acceptable with rural land owners.

The contracts for the wind turbines should be no different and these private property rights cannot be interfered with by the State of Ohio by passing House Bill 6 with an amendment that would allow neighboring residents to have a referendum which would approve or reject any certification by the OPSB. (Zoning laws are already in place, if passed by the townships, for land control for the public good.)

Our forefathers set forth in the U.S. Constitution Article I Section 10, clause 1 which made it clear that the States are prohibited from passing laws "impairing the obligation of contracts".

The Ohio Constitution under Article I Section 19 states "Private property shall ever be held inviolate." That means owners of private property can enter into a legal agreement without fear of it being interfered with in any way by the State. The Ohio Constitution further states under Article II Section 28 that there can be no retroactive laws or any "laws impairing the obligation of contracts".

I can state with reasonable legal certainty that the amendment in HB 6 to have township residents vote by referendum as to whether or not they approve the legal contracts allowing wind turbines, after approved by the OPSB, will not be upheld by the Courts.

As you are aware, this is not an eminent domain issue and before any private property rights are infringed upon by legislative enactment, the U.S. Supreme Court in Energy Reserves Corp v Kansas Power and Light (1983, 459US400) has set forth three criteria that must be considered.

1. The law can not substantially impair a contractual relationship
2. The State must have a significant and legitimate purpose.
3. It must be reasonable and appropriate for all its intended purposes.

With 45 years of legal experience, I am certain that the proposed legislation in HB 6 does not pass this test and should not be favorably voted on by the Senate.

Ronald R. Smith
Attorney at Law and Assistant Prosecuting
Attorney, Retired
June 18, 2019

My name is Jim Schumacher. I am a resident of Venice Township and within the proposed Seneca Wind Project area. My family has been a member of this community for over 57 years. I have been involved in farming all my life. I strongly support the Republic Wind project.

This project will:

Help provide economic boost to our area especially, our schools, our libraries, our county and Local communities. Our schools will get a much-needed funding to continually improve the education of our students. These students are the future. We should give them what is needed for them to excel in the world today. This economic boost to our schools could help relieve the financial burden that our homeowners and property owners are asked to bare. *This is a win win for everyone.*

This project will help provide clean energy and diversify our electric energy needs. We cannot just depend on energy sources of the past. We have a natural resource of abundant wind in this area and we should use this resource for help in our electric energy needs for the future.

Many people in the area will benefit with jobs during construction and operation of the Republic Wind Project. These are jobs that will help many families and businesses.

This project will produce clean energy that does not pollute the air or contribute to global warming. We all need to protect the environment for future generations.

FOX

Being a resident of Thompson Township, in Seneca County, I oppose the development of the Republic Wind Project.

I am recently retired. My husband and I built our house 41 years ago. We raised our family in the peaceful countryside, not far from Bellevue. Our home is an investment in our future. Or so we thought. We have maintained and improved our house and property. We never assumed our home could be devalued due to our close proximity to Industrial Wind Turbines. Nor did we imagine that our health and safety may be compromised by the development of these projects. We do believe that landowners should be able to do what they want with their property, as long as there is no potential to compromise the well-being and safety of others.

I have been involved in education for 43 years, having been an early childhood teacher for over 30 of those years. I do know the negative effects that light flicker and constant, as well as intermittent noise can have on children. Some children, especially those with sensory disorders (whether diagnosed or undiagnosed) may cry, scream, hit, complain of headaches, cover their ears and/or crawl under a desk or table – trying to get away from the sight or sound that is making them uncomfortable in their own skin. These behaviors that I have witnessed over the years are real, not imagined. It has been shown that living with noise pollution can have adverse cognitive as well as behavioral and emotional effects on children.

As an educator, it was my obligation to help provide a safe learning environment in my classroom by acting to reduce known stressors on my students. I provided soft lighting, in order to minimize the use of overhead fluorescent bulbs. I utilized paper towels instead of air dryers. If needed also encouraged students to wear headphones to lessen effects of nuisance noise. By supporting the health and welfare of all students I was enabling each to work and grow to their full potential.

The same basic theory holds true for adults. In order to live a healthy productive life, stressors need to be eliminated or greatly reduced, not enhanced. Industrial wind turbines situated in close proximity to residents are known to produce negative health and safety concerns resulting from the swoosh and hum of blades and engines, infrasound, vibrations, shadow flicker, and ice/debris throw. No longer can it be said that noise pollution and shadow flicker are mere annoyances. These can, and have adversely impacted the health and safety of people. That is why in many parts of our country, as well as in Europe and Canada, discussions are taking place recommending more restrictive setbacks from industrial wind turbines in order to reduce the chance of ill-effects.

I sought out and continue to seek information regarding wind turbines to better understand what I've become a part of. One difference that holds true for me is that I am still pursuing information both pro and con; while most wind turbine lease holders were pursued. I'm not bound by a gag order prohibiting me from expressing my thoughts and concerns. With regard to wind turbine projects, can there ever be an accurate report on citizen health and safety impact due to wind lease agreement

OPSB Public Hearing Republic Wind LLC

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holder's code of confidentiality; their inability to express adverse health, safety, and property concerns without the possibility of negative ramifications being taken against them?

Industrial wind turbines do have the potential to be devastating and cause damage that can be harmful and costly. It is not acceptable to allow a wind turbine project in an area based on the fact that fewer people are at risk due to rural areas being less populated than urban areas. Nonetheless, these areas are populated. It is not acceptable to consider the well-being and safety of some citizens as a major priority, but not value all citizens the same. A trade-off of quality of life should not be justified.

Members of the OPSB, you have the means to promote safety measures. It's time to update the one true safety measure of industrial wind turbines. That is setbacks. You have the means to greatly increase setbacks to reduce negative impacts for the health and safety of all life, especially non-participating residents residing in and near proposed wind projects.

Please err on the side of caution for the health and safety of all living things.

Respectfully,

Jane Fox
8236 St. Rt. 269 N,
Bellevue, Oh 44811

Thompson Township
Seneca County



My name is Sally Norman. I live at 6647 Young Rd., Lyme Township, Huron County, Ohio. I do not live in the Republic Wind Project, but I do live across Route 269 South of Bellevue and am about ½ mile away, and my property abuts Emerson Creek Wind.

I have many reasons to voice my opinion against these Industrial Wind Turbines, but I will keep it short and to a minimum.

At this hearing I would like to address the effect this project, if approved, would have on the well water surrounding the project. Due to the Karst, which originates in Seneca County, any disruption of the Karst could have disastrous effects on the well water of the area I live in. We rely on our well as the sole provider of our water supply as do many others in our area. What will happen if our wells are destroyed or contaminated by the building of these giant industrial wind complexes. I refuse to call them wind farms, because they are about as far from being a farm as they could be. Will the developer or subsequent owners of the project guarantee our future water supply at no cost to us?

We built our dream home about 1½ miles to the south of Bellevue on 3 ¼ acres of land. We did so for the beautiful, quiet, rural residential area, after living on Route 20 in Bellevue for 20 years. We did not sign up to be surrounded by these monstrous 600 to 655 foot tall wind turbines, which is what will happen if these projects are approved.

I often take pictures of the beautiful sunrises and sunsets from my back yard, which will no longer be possible with the landscape covered with 600 foot turbines to the west and 655 foot turbines to the north, east and south of my home. *Many sleepless early mornings, I look to the east and I see the beautiful starlit sky above rows of our blue spruce and pines. The constellation Orion is so beautiful. But with the flashing red nighttime lights on these gigantic turbines, those sights will be forever lost.*

Our home is one of our most important investments, and despite the claims of the wind companies, we will almost certainly lose value in our home and property. Will the wind companies and their successors guarantee our home values?

Industrial turbines may have their place, but it is NOT in populated rural areas and situated so closely to homes.

I ask that the Ohio Power Siting Board not approve any of these projects. Let them be located in areas where no one lives for miles and miles.

Thank you.

Sally Norman
6647 Young Rd.
Bellevue OH 44811, Lyme Township, Huron County

Tami Andrews
11178 E. US Hwy 224
Attica, OH 44807
Venice Township

re: Docket # 17-2295-EL-BGN, Republic Wind



To the Ohio Power Siting Board: Thank you for offering this opportunity for residents to speak. *I am opposed to this project.*

For those of you that remember the TV show "The Golden Girls", I would like to borrow from Sophia Petrillo, one of the four main characters. Picture it! Downtown Columbus, summer of 2019. Traffic. Shops. Tall buildings. Traffic. Restaurants. Busy sidewalks. Traffic.

You decide to spend part of your lunch hour in a brisk walk to help you meet your daily goal of 10,000 steps. You have enough time to walk 4 blocks. You enjoy the sights as you walk and do a little window shopping on your way. Suddenly, at the end of your 4-block walk, you are confronted with a 60-story . . . machine!! 4 city blocks away!

Picture it! You are a citizen of rural eastern Seneca County. The current setback for wind turbines from property lines is approximately 1330 feet, which, according to a conversion chart at "convertunits.com", is 4 city blocks (for Midwest U.S). You now are facing this real possibility—an Industrial Wind Turbine is planned for 4 city blocks from your property. Easy walking distance.

You are not a country bumpkin and realize that machines break down. What happens when a 60-story machine breaks down? You know how to do quality research and discover that when these machines break down, it's not a pleasant scenario. There

have been documented blade throws of varying distances, as some of your neighbors have shared. Some, like one in Ontario, have flown the equivalent of 5.6 city blocks.

You are not a hayseed. Other neighbors share the information they found in their research that shows that these machines catch on fire. (You have watched the episode of “Dirty Jobs” where Mike Rowe goes up in a nacelle to clean out all of the accumulated grease and oil, to help prevent such fires. Sadly, you learn that Mike Rowe will not be a part of any wind turbine in Seneca County.) You know that these massive machines could be located in fields of potentially dry crops near or around your property. You also know that your local fire departments, as wonderful as they are, have no capability to fight a 60-story fire.

You are not a rural rube. You know that machines can make noise, and you figure that a 60-story machine 4 city blocks away with turning blades could do just that. One of your neighbors finds a recording of turbine noise from a homeowner living near an actual turbine, and you hear the actual, unpleasant noise they make. The World Health Organization has determined safe and unsafe decibel levels. Sadly, there will be homes in this project in the unsafe levels due to the location of the turbines near them. Others do excellent research on the sound you can’t hear—infrasound. One neighbor does his research at the National Institutes of Health, where he looks into Soviet research in the 70’s on infrasound. He then travels to Germany to talk with a scientist whose research he studied. Another neighbor translates an article written in German about the dangers of infrasound. Rural rubes indeed!

Because you did not check your IQ at the county border when you moved to rural Seneca County, you surmise that 60-story machines could interfere with aircraft. More

research supports this. These machines have prohibited crop dusting in some areas. They WILL prevent Life Flight from being able to land in some areas—for the ultimate effect on your health and safety.

Because your neck did not turn red the minute you moved to your rural area, you theorize that 60-story machines will have some effect on your property value. Several neighbors have looked into this and found that property values in areas overrun with these machines have gone down, in some places, anywhere from 12% to 55%. You start to question now why you are asked to make such sacrifices, when all you wanted to do was live out in the country in Seneca County.

Because “hick” is not a word that describes you, you marvel at the combined research conducted and knowledge gained and wisdom shared by all of your neighbors in the same boat as you. And you realize that not once—*not ever*—at any meetings where you all have gathered, has anyone ever said, “Let’s spend these untold hours and hours of time away from our families and daily lives in research, ^{and tedious work} because we want to prevent our lease-holding neighbors from making extra money.” It is all about—and has always *only* been about—protecting the health, safety, and property values for you and your neighbors.

You realize that you cannot remain silent. You must speak, and share and share and share. The sacrifice you are being forced to make, against your will, is too great. You need to be heard.

And so, in closing, I ask one thing. Please *hear* us. Really, really *hear* us.

Thank you for this opportunity to speak tonight.

Both Walliser

9/12/19

Hello,

I would like to thank the Ohio Power
Sitting Board for traveling up here to Tiffin
to hold this forum.

I am here not only for my friends and
family who could potentially live under
an industrialized wind turbine but as a concerned
citizen.

There are pros and cons to any issue we
may confront. I believe the cons to industrialized
wind turbines are far worse than the pros known.

The industrial wind turbine folks say our
townships will receive a small, X amount of
dollars per year. That each property owner
who signs a lease will receive a small, X
amount of dollars per year. This small
amount of monies does not balance out all
of the negative consequences.

There is documented dangers, side effects, that
these industrialized wind turbines create. No humans,
live stock or wildlife should be forced to live
near these dangers.

Our rural areas are to populace. Our health
and quality of life should come first.

I do have a few questions that I still
have yet to be answered. If these industrialized
wind turbines are given the go ahead the who's
gonna pay for all the damages to our rural roads
caused by their huge machinery? Who is gonna

* How many of the property owners that will ^{old} receive a check would still be in favor if the money was taken away?

* Who's gonna pay to fix someone's contaminated well? pay to inspect every single turbine to ensure that all aspects of the infrastructure is up to code? Who is going to pay for the ongoing inspections that each turbine will require? Who is going to pay to investigate any complaint filed in regards to adverse side effects people, livestock, the wildlife? Who is going to pay the damages caused by the side effects? Who is going to pay for the demolition of these turbines when they become obsolete? * *

In closing, I must say I am an environmentalist. I truly believe we need to lessen our dependence on fossil fuels. I truly believe we need to develop more green energy including turbines. However, the key to success for these turbines is location, location, location. These industrialized wind turbines should not be near our homes, our schools, our towns, or our parks and nature preserves.

Thank you,

Beth Walliser
45 Thomas St.
Jefferson, Ohio 44883
(419) 618-0727





Republic Wind Opponent Testimony

By, Chris Aichholz



Figure 1 – Scenic photo of Bowen Nature Preserve’s vast prairie and wetland areas

My name is Chris Aichholz I am a life-long resident of Seneca County and I would like to talk to you today about one of the major reasons I am in opposition of the Republic Wind Project as proposed. As Eagle Scout, an avid outdoorsman, and advocate for conservation I was appalled to see Republic Wind’s plan to completely inundate Bowen Nature Preserve with 600 foot tall industrial wind turbines. According to the coordinates that APEX/Republic Wind submitted to the Federal Aviation Administration (FAA), they plan to put 21 IWT’s within 2.5 miles of Bowen Nature Preserve (*see Figure 2*).

Per the website “Birding in Ohio” their description of the preserve is, “The Bowen Nature Preserve is a 65-acre nature preserve with 58 acres of restored grassland/prairie, a restored wetland, hardwood and pine woodland areas, abundant wildlife, a variety of wildflowers, picnic tables and resting benches, and a combination of 2.7 miles of hiking and equestrian trails.

The preserve became a reality in 2007 with a gift of 58 acres of land from Jonathan E. Bowen. In 2008, six acres of woodland was donated to the park district through his parents, Yvonne J. and Norman Bowen.

The Bowen name was well known in West Lodi because Jonathan’s great-grandfather was Dr. Adelbert Bowen. Jonathan lived on this farm in his early years with his parents and grandparents. After his grandparents, Merle and Louise Bowen, died, he acquired the farm. As manager of this property, Jonathan developed the grasslands and reinstalled a wetland to encourage the development of wildlife.”

Also listed on the Birding in Ohio website there is a section where qualified birders note 42 different bird species some of which include: wood duck, great blue heron, turkey vulture, coopers hawk, red tailed hawk, yellow warbler, and yellow-rumped warbler. This shows this preserve is highly attractive area for birds.

This is completely unnecessary and defies all logic when it comes to safe and sensible siting of industrial wind turbines. If this project is allowed to proceed as proposed the Ohio Power Siting Board would be egregiously going against almost every core reason for establishing a nature preserve such as Bowen nature preserve. This is why I believe the experts at the Seneca County Park District have come out in opposition of these proposed IWT locations. The Seneca County Park District is intervening in the Republic Wind Project all in an effort to try and protect our preserves. They have asked for a *more than reasonable 2.5 mile buffer to protect this preserve from being completely rendered useless.*

The Seneca County Park District also submitted a letter as well (Source #2) that was written by Park Director Sarah Betts it states that, "less than 10% of Seneca County exists as natural areas, which are found in fragments across the landscape of the County. Adding industrial sized turbines in close proximity to nature preserves would cause additional extreme vertical fragmentation of the landscape and further fragmentation of habitats on a landscape and macro-landscape scale (for wildlife migrating through from Canada to South American countries). Protecting nature preserves, these natural gems, and safe corridors between them is crucial for the wildlife that use them for access to their most essential components of life; food, water, shelter, and space."

She also says, "We have been entrusted by the public with the care of Seneca County Nature Preserves, and are bound by our mission statement to act in the best interest of the parks, wildlife, and patrons. Therefore, we feel it is our duty to request a minimum turbine-free buffer of 2.5 miles to be incorporated around all SCPD Nature Preserves for any industrial turbine project proposed in Seneca County. We believe this proposed buffer zone allows both SCPD and the industrial wind turbine projects to meet the needs of their respective stakeholders, and strongly urge you to consider adopting this proposed buffer zone.

This preserve was entrusted to the County Park District by generous individuals to care and protect it, it has been taken care of by countless volunteers and Park District Employees, the preserve has been enjoyed by the people of not only this area but out of area visitors, and finally the preserve is home to many birds, insects, animals, native grasses and flowers, and it would be an absolute shame if it was not protected from completely unnecessary and reckless siting of many industrial wind turbines.

In addition this preserve and all of our preserves under The Seneca County Park District are funded by the taxpayers and property tax. In November 2016 the Park District was able to pass their first tax levy to help support and build/grow our existing preserves. After voters approved the county's first ever parks levy big changes have happened for the park district. They previously managed their 10 parks with a budget of less than \$50,000 per year and had only two part time employees. The rest of the parks needs and operations were covered all by volunteers. The Park District used to operate out of a small office in the basement of a downtown Tiffin building. With the levy they now generate around \$571,000 per year for the district. Lee Martin who was co-chair of the levy said when the levy passed that, "those funds are transformational" and "they're going to really allow us to become the park district that we would like to be." Since the passing of the levy the district has since been able to hire a Director, a Natural Resource Coordinator, a Naturalist and Naturalist Assistant, a part-time pre-school teacher, a part-time business manager, and a seasonal maintenance crew. (source #4)

The reason I bring this all up is that I also would like to highlight another risk to our County Park District. The Republic Wind Project will negatively impact property values in the area. This in turn will negatively impact the amount of funding that the park district is currently receiving.

This project aims to place 600 ft tall IWT's as close to 1330ft to non-participants homes. Set-aside the fact that the Ohio Power Siting Board has documented cases of blade failures in which a wind turbine has thrown chards of blade over 1800ft there are many negatives with living close to these massive industrial wind turbines. There will be many people who will see a dozen or so IWT's within a two mile radius of their homes. This will lead to excessive sound levels,

shadow flicker amounts, the negative impact to their area nature preserves, potentially unsafe hazards from wind turbine failures, how could anyone question that there would not be some level of negative impact to peoples home and property's value. Republic Wind will employ many so called "experts" on this topic that without a doubt has little to no experience with Seneca County. Republic Wind has cited studies that have little specific relevance to what we are facing here in our county.

I on the other hand have spoken with several real estate agents in the area who own or are employed by some of the area's most premier real estate agencies. These folks are without a doubt experts on the local real estate market and therefore their insights are far and away more relative to this topic than the people Republic Wind have and will utilize. They have contacted me personally and through our Seneca Anti-Wind Union Facebook page regarding the proposed IWT projects. They wanted to know where certain properties fell in the IWT projects, how close their clients would be to the nearest IWT, and other information regarding leases and good neighbor agreements. Several of them made it abundantly clear that their clients did not want a home that would be anywhere close to the proposed IWT's. These are local real-world cases that already prove that these potential IWT projects are already having a negative impact to real estate values.

For the purposes of my testimony today I have asked two separate area real estate agents to provide me with a few remarks regarding the negative impacts that they have seen already and what they expect to see should the Republic Wind Project be built. To protect these individuals they have both asked me to refrain from using their names or agencies. However, should the OPSB Staff or Administrative Law Judge request that information I am sure they would be happy to provide their remarks privately to you.

The first real estate agent's statement said, "As a local Real Estate Agent I see no positive impact on the Real Estate Community if wind turbines are to become part of our landscape. We, as Realtors, must do our due diligence when showing properties in these areas by letting our clients know of the potential upcoming projects. More times than not buyers do not want to take the chance of purchasing a home that may lose its value and have an obstruction to look at each day. A home is supposed to increase in value, right?

I would have a hard time selling a property or even a lot if there were huge turbines hindering the beautiful landscape that we have here in Northwest Ohio. Not to mention selling a lot only to find that they can't build due to restrictions of the turbines. Imagine....purchasing your dream lot prior to the turbine proposal and then by the time you save money to build you can't because of turbine restrictions! Curb appeal is a big selling factor in homes, do you not agree? If you drive by a home you look at the surroundings to see what you will look at each day, right? Homes that sit by large power lines and railroad tracks have a harder time selling. Do we really want to add another deterrent into this equation? And then let's think of the future when these are not the most viable source of energy, what happens to the turbines and the landscape around them?

Because of this proposal Sellers are holding off selling their homes in this area. Why? Because they know that because of this proposal they may not get what the full value their home could offer. We currently have a shortage of homes already in the area and could use these potential Sellers homes.

We do need sources of energy, this I will not disagree with, but I don't feel this is the way to go. We have been given a gift of our beautiful land, let's keep it that way."

My second statement comes from an owner of one of the area's premier real estate agencies who said, "In regards to your question of the proposed wind turbines affecting home values in our area we can speak to the following. The current market situation favors the seller and even with the scarcity of homes many of our home buyer clients are very reluctant to, or are not willing at all to look at homes that would be close to any of the proposed wind turbines.

Although it's too early to put a percentage or dollar figure to the effect this has on a seller's home value, it stands to reason that limiting the potential buyer pool for a seller's home would have a negative effect on the home's value. If a purchaser client is looking for a home in one of the proposed wind turbine installation areas this is one of their 1st questions. How close would they be to one of the projects?"

In addition to these actual real estate agencies statements I have had around ten people contact me about certain properties or homes wanting to know how close IWT's would be from them because they did not want them near them. I have sent several people maps and even links to OPSB case files. This again is just further proof of the negative impact the Republic Wind project will have on homes and properties in or near their project's footprint.

APEX/Republic wind has cited the Berkeley National Laboratory studies in relation to IWT's impact to property values. This study is very biased and useless when comparing the situation the people in the Republic Wind Project footprint will face.

The main problem with this study is that it only 10% of the total sales transactions that they used had any view of IWT's. Of that 10% only 2.1% of the homes used in the study had a view that they rated greater than minor. This study was highly dominated by home sales that had no IWT's near them. There may be tons of homes utilized in this study but hardly any of them are even important or relative to Seneca County and homes in the Republic Wind project. I think it is critical to compare apples to apples.

Ben Hoen who authored the Berkeley Study that Republic Wind has cited said the following regarding IWT's and his study via an interview in 2009, "You know we are very cautious about what happens close to the turbines. We really don't know what's going on there (e.g., 1,250 ft from turbines). I just spoke in Illinois about this. You might know about a Property Value Guarantee. It's a dicey situation and complicated, but I think homes that are very close, there is just too much unknown right now; that seems reasonable. I think one of the things that often happens is that (wind) developers put our report forward and say look property values aren't affected, and that's not what we would say specifically. On the other hand, they have little ground to stand on if they say we won't guarantee that. I think for homes that are close we have a lot more ambiguity and real issues. If we are talking about views that's one thing, if we are hearing it or shadow flicker that might be really regular, the kind of things that happen at night. ...

"I'm not a lawyer and I'm not the developer, these [PVGs] are just options in the tool kit. I don't know whether it's reasonable to put together, I have looked at one, I don't know if there is a better way to write it or whether the one I read from Illinois is good or bad. They have to be thought about, they all probably have cost implications, so the developer is not going to give away the house if they were too generous; on the other hand if they are not generous enough they don't have any impact. That's just one of the tools available, there are neighbor agreements that may be more applicable whether folks nearby get compensation, if they are not a participating land owner. One of the things I've always hoped is somebody would offer one or the other and see what landowners would do." (source #3)

The Republic Wind Project has many fatal flaws in my opinion many of which I did not even broach in my lengthy testimony today. Above all APEX/Republic Wind has been very deceptive to the people of Seneca County and our leaders. They have been incorrect too many times in their representations for it to be accidental.

Among many other things they have worked to publicly discredit me and others. They have tried to convince local area leaders that anything I say should not be "given much weight". Dalton Carr of APEX/Republic Wind scorned me in an email for taking interest in the Republic Wind project because of where my home was located in relation to the projects footprint. He said, "There may also be some confusion here – Apex is developing the Republic Wind Project, which is more than 7 miles from Mr. Aichholz at its closest point. I'm sensing some frustration regarding Republic Wind and its

support, but I'm hard-pressed to give much weight to an outside source." He then went on to say, "I'm not sure of the interest Mr. Aichholz has in regard to the Republic Wind community." Mr. Carr was right that my family's home is seven miles from the project area but I wasn't aware that prevented me from having interest in one of the largest industrial projects that has ever been brought to our county. The local leaders on this email where Mr. Carr laid out allegations of, "political hostility", "industrial threats or bullying" was quite substantial. The mayor of Tiffin, County Commissioners, top personnel where my wife is employed, and others were all included and saw this email that went against me personally. This email is available for the members of the OPSB or its staff should you need it.

Another example of this type of behavior goes back to April 2018 when I sent a list of questions about the project to my County Commissioners and one of the Commissioners at the time Holly Stacy forwarded it on to John Arehart III (APEX). She stated, "I know this is not your project, I just wanted you to see a sampling of what we are hearing/receiving from the activity of "Seneca Wind", S Power, whatever their project is called, and Mr. John Moran." She then continues on about the dysfunction of the Seneca Wind project.

In a reply to her John Arehart III starts off by saying that "we are not happy with how this project (Seneca Wind) is being handled either". He then says, "In the meantime, I know of Mr. Aichholz and he is working with Mr. Zeman. The questions he asks are the same as they proposed on our project. The same I've answered for them multiple times and dispelled multiple times. Unfortunately, this new project is not making my job easy. I am happy to answer any of the questions that he poses as they are largely unfounded and an effort to create unrest."

Prior to this email I had NEVER sent any email to my Commissioners or anyone from the wind industry. I had never met Mr. Zeman like Mr. Arehart alluded to nor did I know Mr. Arehart even though he claimed to "know of me". This is the type of behavior that many of us local people have come to see from Republic Wind. As previously mentioned I would be happy to send these emails to the OPSB and any members of your staff should you request them.

In closing today I would like to state that the Republic Wind Project as proposed is an all-around bad deal for Seneca County, its residents, the County Park District, The Bowen Nature Preserve. Therefore I am asking the Ohio Power Siting Board to deny Republic Wind's application and asking you to NOT grant them a Certificate of Environmental Compatibility and Public Need.

Thank You

Sources

1. Wikipedia – Nature preserves - https://en.wikipedia.org/wiki/Nature_reserve
2. Seneca County Park District's Director Sarah Betts Letter - http://dis.puc.state.oh.us/TiffToPDF/A1001001A19A29B02558A00289_1.pdf
3. Ben Hoen interview - <https://www.wind-watch.org/documents/ben-hoen-on-need-for-property-value-guarantee/>
4. <https://www.wtol.com/article/text/news/seneca-county-approves-first-ever-parks-levy/512-fb05164d-49ae-4ddb-85a0-0fb21649608d>

With respect to the Ohio Siting Board, I would like to start by reading your mission statement.

"Our mission is to support sound energy policies that provide for the installation of energy capacity and transmission infrastructure for the benefit of the Ohio citizens, promoting the state's economic interests, and protecting the environment and land use."

That is a strong powerful statement, "protecting the environment and land use". If you permit these wind turbines to be built over one of the most expansive karst in the state you will fall short of your mission statement.

There are many reasons to oppose the proposed wind turbines in Seneca, Sandusky, Erie, and Huron counties. I have not separated the counties because the karst that underlays those counties are one and the same.

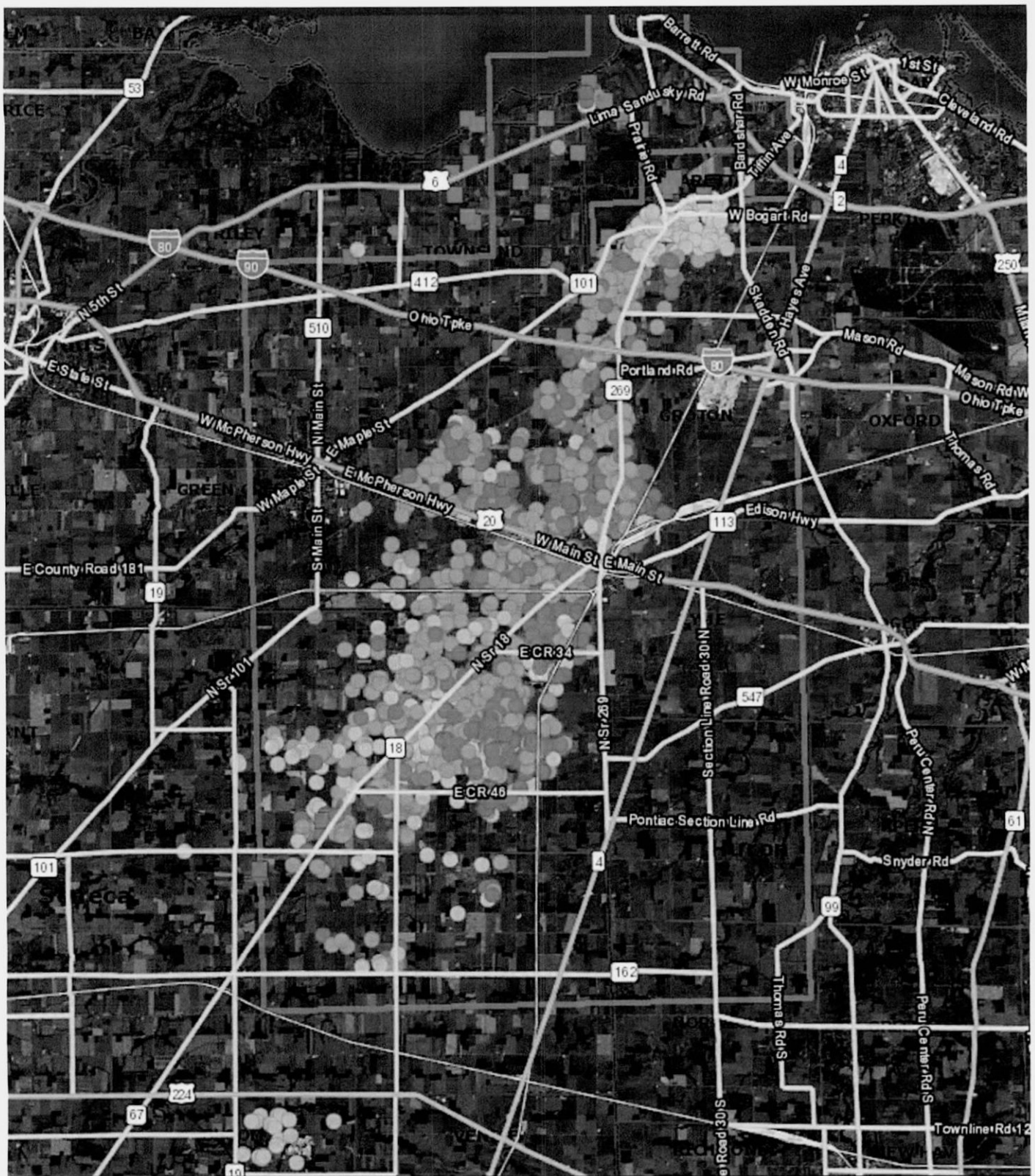
According to the American Geological Institute, "Karst areas are among the world's most diverse, fascinating, resource-rich, yet problematic terrains. They contain the largest springs and most productive groundwater supplies on Earth. .. many critical processes in karst occur underground, requiring monitoring of groundwater flow and exploration. They are also the landscapes most vulnerable to environmental impacts. Their groundwater is the most easily polluted.

Karst regions require special care to prevent contamination of vulnerable groundwater supplies and to avoid building in geologically hazardous areas. Living in karst environments may result in destabilization of the delicate equilibrium between surface and underground components of karst resulting in alteration of drainage patterns and increasing incidents of catastrophic sinkhole collapse, particularly in areas of unplanned urban growth. "

One of the best resources is our own Department of Natural Resources, which have studied the karst regions in Ohio and especially the four county area where the turbines are proposed to be built. The ODNR have multiple resources available to the public to learn about the karst area .If that were not enough, they have done a remarkable job putting an interactive karst map on their website that shows how extensive the karst area is.

There are hundreds if not thousands of articles explaining that building over a karst can be catastrophic. (I have brought two different resources for your viewing pleasure.) They explain the fragility of a karst system, how the aquifer system works within the karst system and the high risk of collapse and contamination to an ecosystem.

The aquifer that is within the karst area directly flows into Lake Erie. We already have seen the algae blooms that is what happens when farm chemicals, animal waste, and other pollutants make their way into a very delicate ecosystem.



Above is a screen shot of ODNR's interactive karst map. This screen shot includes Seneca, Sandusky, Erie, and Huron Counties. Underneath all those dots are either a field verified karst, suspected karst, and natural springs. This map is wonderful, as it shows the magnitude of the karst area that covers our four counties. Apex would like them to be divided by area but that is impossible because the four county area is one big karst! The next page shows one dot of the many dots above.

With the interactive program, from the ODNR, you can see that each dot has the potential to be massive. Each dot is interconnected in ways that you can't see from a dot on a map.

Interactive Karst Map from the ODNR



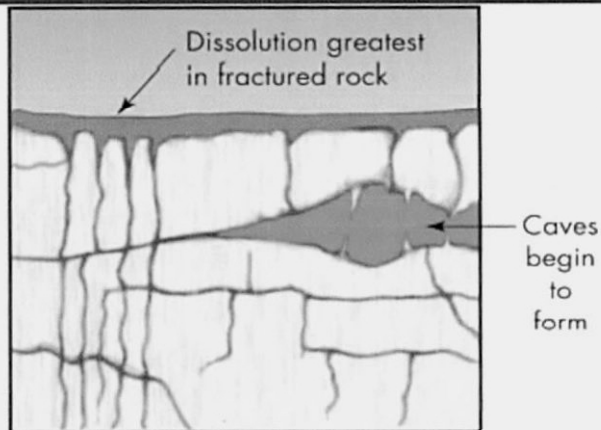
① Approximate location for 3 of the proposed wind turbines. ☆ Indicate private wells that draw off the karst above. The gray and brown areas are a screen shot of ODNR's interactive karst website. As you can see from this photo above the karst is extensive. Most of the karst is unseen from the surface. The aquifer system connects to other karst in the area.



This area is directly over the karst from the previous page. The surface water is a much smaller part of the actual karst. The blue dot also on the previous page reflects the location that these pictures were taken. The road closes yearly because of rain, this brings in some pretty amazing birds and has become an eBird hotspot for birders. Eagles have been spotted visiting the karst/aquifer area.

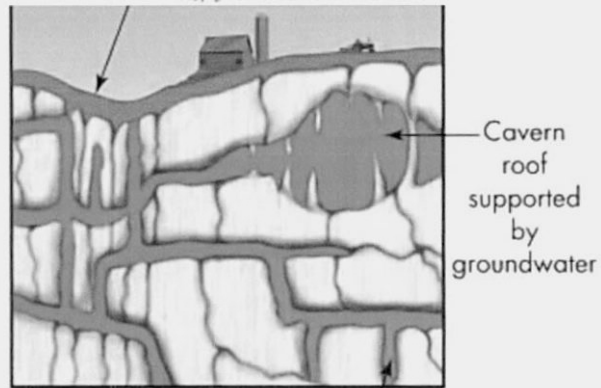
Sinkholes

- Groundwater dissolves soluble rock, creating fractures and caves.
- Dissolving continues to form larger caves and fractures.



(a)

Copyright © 2008 Pearson Prentice Hall, Inc.



(b)

Fractures enlarged by dissolution

Copyright © 2008 Pearson Prentice Hall, Inc.

You can visually see in the illustration above the fractures in the karst and how the underground aquifer system works. You can also visually see what makes our area so unstable.

The following are excerpts from the Fremont News Messenger article that was written by Daniel Carson and published Aug. 2, 2019. I have enclosed the article within this packet. Ms. Montague, APEX Clean Energy spokesperson, was interviewed via email and she stated that a “series of steps were laid out to detect karst and avoid groundwater sources.” Had APEX checked with the ODNR they would have found extensive research regarding the karst region and how the ground water is affected when the karst is disturbed.

“APEX is developing projects in the Oklahoma and Texas that have karst features.” Kenneth S. Johnson, William J. Bangsund, Neal A. Hines published an article regarding the risk in siting wind turbines in Blaine County, Oklahoma. “Catastrophic collapse of a wind turbine is clearly unacceptable, and minor settlement could also be a risk. Differential settlement by even 3 cm across a 15-m-wide turbine foundation could lead to the turbine tilting out of tolerance...”

I have done extensive research on the “developing projects”, that is stated above, but have not found one turbine located over a karst in Oklahoma. There were some that were planned in 2017 but have never come to fruition. APEX is welcome to correct me if I am wrong.

“If a turbine location is determined to be in a potential karst area, additional testing is conducted,”

Our Ohio Department of Natural Resources has done an outstanding job of mapping Ohio’s karst areas. I have enclosed in your packet a copy of the ODNR publication. As you can see by that publication, karst have been studied in Ohio since the 1980’s. There is so much information on karst that I was able to gain multiple government sources stating that building over a karst can be catastrophic! Why would Apex choose one of the largest most vulnerable areas in Ohio to place 600 feet turbines on?

“The typical and expected foundation of the turbine models under consideration in northern Ohio wind projects extend to a maximum depth of approximately 10 feet, which she described as not significant enough to impact groundwater. Turbines are intentionally sited away from wells and other water sources.”

Well Ms. Montague you do not understand how a karst and aquifer work. The soil filters the groundwater, it then filters through the karst into the aquifer system. ODNR states, “The many passageways formed in karst terrain allow for high connectivity between the land surface and the water table”. The pilings that Apex will have to put in to stabilize the turbine can be up to 30 feet deep with multiple pilings on one turbine. Imagine the damage that will do to the karst system and aquifer system. You visually can see by the illustration provided what will happen if you start disturbing the karst and the aquifer system it supports. Also, existing turbines are 400 feet tall, ours will be 655 feet tall, you cannot compare foundations or make the claim the same type will work. That is physics, when something goes up the foundation must be larger.

Our own Department of Natural Resources has wonderful information for all of us. All academia versed in karst specifically mention how unstable the limestone is and how easily it is to destroy or contaminate an aquifer system. We have some of the best experts in the country, specifically the ODNR, versed in karst and aquifer systems and yet we are not listening to them. Sinking pilings into the ground will only fracture the karst even further and compromise the drinking water by letting groundwater go directly into the aquifer. You see how massive our karst is and it supplies fresh drinking water to thousands of residents within the four county area. How much will it cost to repair the damage that these turbines will do to the aquifer system? Once an ecosystem is destroyed you can not bring it back. This is a project that is so massive that it is beyond my comprehension, how this has even gotten this far in the process with the locations that they have proposed. This is much bigger than just putting up turbines this is our homes, our water sources, you can not put a monetary amount on that. We are talking the entire four county area is at critical risk. It's concerning to me that we are taking something that could be detrimental to our quality of life, water, and compromising its integrity. It's also concerning that we are talking about the money this project will bring. What will the cost be if hundreds if not thousands of wells are contaminated? What will the cost be if the 600+ turbines subside? I guarantee it will cost the state more money than these wind turbines will ever contribute to the great State of Ohio.

I respectfully ask that you deny the application of 17-2295-EL-BGN, Republic Wind Farm for the reasons stated above.

Deborah J. Didion

6040 County Road 113

Bellevue, Ohio 44811

Literature Cited

The following are websites that you can learn more about karst and aquifers and the impact they can have when disturbed.

http://www.geo.hunter.cuny.edu/~fbuon/GEOL_231/Lectures/Karst%20Landforms.pdf

<https://www.usgs.gov/news/earthword-karst>

<https://karstwaters.org/educational-resources/water-quality/>

<https://www.americangeosciences.org/sites/default/files/karst.pdf>

<https://geosurvey.ohiodnr.gov/portals/geosurvey/PDFs/Karst/karstmap.pdf>

https://geosurvey.ohiodnr.gov/portals/geosurvey/PDFs/OpenFileReports/OFR_2013-1.pdf

<https://karst.iah.org/karst>

http://www.gepgis.eu/en/wp-content/uploads/2013/08/Znacilnosti-kraskih-vodon_www_eng.pdf

<http://www.geosociety.org/gsatoday/archive/25/1/pdf/i1052-5173-25-1-38.pdf>

Valerie Myers, 1858 C.R. 270, Clyde, OH 43410; ^{York Twp} own property (farmland at the NW corner of Seneca County Rd. 34 and Thompson Twp. Rd 80. (Thompson Twp))

Testimony Regarding Case 17-2295-EL-BGN: Republic Wind Farm

I am speaking in opposition to the Republic Wind Farm.

Hello. My name is Valerie Myers, and my husband and I own approximately 150 acres of farmland in Thompson Township, Seneca County. This farm is within one to two miles of four of the proposed wind turbines and within 3-5 miles of another seven turbines. All of these turbines, along with several other Republic Wind turbines, sit in the Bellevue-Castalia Karst Plain, an area that is characterized by underground aquifers, caves, and sinkholes. The ODNR karst map identifies 12 areas of karst depression on our farm alone, and as the owners since 1974, we can verify the presence of several sinkholes.

The main problem of farmland that has sinkholes is that in extremely wet conditions, the water from the underground aquifers rises up through the sinkholes and creates areas of flooding. We have one particularly large, depressed area with two sinkholes that would for years flood during spring rains, then dry up in time for planting, or, at worst, cause the loss of 1-4 acres that remained wet, something that only happened 4 times in the first 20 years.

Before we understood the nature of karst terrain, my husband contacted the Seneca County Soil and Water Conservation District and asked about whether there was a way to plug some of the sinkholes to prevent the rising water from flooding our property. He was told that plugging sinkholes was something he definitely should not do...that it was an unacceptable soil and water practice, so we never plugged the sinkholes!

Unfortunately, as construction of various facilities around the area has occurred, sinkholes **have** been plugged to prevent flooding on these new building sites. One particular building complex north of our property was allowed to plug several known sinkholes. Since that construction, the flooding in our sinkholes has gotten much greater than we had ever seen before, including the loss of about 95 crop acres last year, and, with the extremely wet conditions experienced this spring, all 150 crop acres.

To understand why this happens, consider an analogy provided to me by an ODNR karst expert. The karst plain is like a sponge. The aquifers that flow underneath the ground are like the channels in the sponge. If you put pressure on one end of the sponge, the water is going to travel through the other channels and escape through the surface openings. Think of washing your car. After you've dipped the sponge in the water, you squeeze on the sponge to force the water out. If sinkholes and aquifers are plugged in one part of our karst "sponge," the water will be forced out the other sponge channels, ^{openings,} which are the sinkholes that exist all over our area.

A large percentage of Republic wind turbines are to be built into the karst plain. According to Apex's geotechnical report from Hull Engineering, "karst areas may include sinkholes, solution cavities and cave systems. These voids may need to be grouted in order to provide adequate foundation support."

That is, Apex will be plugging sinkholes and aquifers that flow in and around the turbine foundation. Thus, our karst "sponge" may be "squeezed" in several turbine sites, causing higher surface water in areas already containing sinkholes and potentially decreasing water flow in aquifers into which wells have been dug. This has potentially serious consequences for our farms and for the city of Bellevue, which is already subject to flooding.

We need the OPSB to take into consideration the unique terrain that our farms and towns are built on and to ensure that the water systems that underlie our land are not disrupted. This is not just a property rights issue. The impact of turbines that disrupt our underwater aquifers is a critical issue for the whole community of people who live on the Bellevue-Castalia Karst Plain!

In addition, although I did not plan to speak to the issue of decreased property values, I would like to point out that as farmland becomes wetter, the value of that land decreases, so there is a large potential to impact people's property values if sinkholes and aquifers are grouted.



My name is Evelyn Snavely and I 'm a Landowner of this area. We are not going to receive a Wind Turbine on our farm, but there will be several in our Area.

I am a supporter of Republic Wind. I feel that the Schools, County, and Townships in our Area will benefit greatly from this Wind Project, and it will be an Economic Boon for Seneca County.

I also don't have a problem with the look of the Turbines. I think they are awesome to look at and know that our safety will be first in construction of these Turbines.

Vote YES, approve this permit, and bring this great project to Seneca County.

Evelyn Snavely

Linda Schuback
5921 N. Twp 169
Green Springs

Adams Twp.
In Republic Wind Project

Members of the Ohio Power Sitting Bd,
thank you for allowing me to
address you regarding my support
of Republic Wind Project. My
name is Linda Schuback and
I am a life long resident of
Seneca Cty.

As someone who has lived
in the Republic Wind area for
50 years, I can tell you there
is plenty of wind blowing all year
long. Why not harvest this
natural source of energy? This
project will produce enough
energy to power over 62,000 homes.
This enough for all of Seneca Cty.

This project will be a step
forward in fighting climate change.
by providing ~~to~~ renewable energy
to electricity grid.

Wind energy production does
not produce any toxic fumes or
by products

The wind is free - let's use
it. Please approve the Republic Wind
permit application. Thank you for
hearing my support of this project

September 12, 2019

Hello,

I am Kim Root and I live in Thompson Township in Seneca County. I am here to support the Republic Wind Project. I believe just as our ancestors gave to us the progress of automobiles, phones, electricity, running water and so many other conveniences that we have at our hands now this is a time for us to give and prepare for our future generations that will be coming after us. The wind turbine project is only preparing us and future generations to have another secure resource in addition to our fossil fuels for energy.

I am sure there was opposition back in the day when automobiles, phones, electricity, running water, etc. came into existence at their birth but think about taking all those things away from us now. Where would we be if our ancestors didn't have the foresight to see into the future the things we now take for granted? I believe wind turbines fall into this same category. Where will we be if the wind project is not able to go forward?

And in all reality aren't we seeing history repeat itself. The windmill to generate energy is not a new idea. Our ancestors actually came up with it.

Thank you!



Kim Root

Property Owner in Flat Rock, OH

Owner of 100 acre farm

Not receiving a wind turbine on our property

September 12, 2019

I live within the Republic wind Farm in Seneca County. My property has been in my family for generations. I've lived here 75 Years now. This wind project has been in development for at least 10 years.

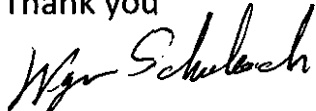
I've been here for all of it, and I'm ready to see the project built. I know what this wind farm will do for the community.

This community means everything to me, - my livelihood, - my family, and we are here for the long-run.

There are many reasons why my family and I support the wind turbines, but one of the reasons for my being here today is to express my absolute detest for how the opposition has dismantled Apex Clean Energy's, and my family's mission not only to provide additional income to my family farm. But I feel this project is a vary positive change for our county. Not only will the turbines bring in money to our suffering economy, but it will provide jobs to residents, who will spend that money right here in this County.

Please seriously consider granting this permit and help bring this money to our area.

Thank you

A handwritten signature in black ink, appearing to read 'Wynn Schubach', written in a cursive style.

Wynn Schubach

5921 North Township Road 169

Green Springs, Ohio 44836

Seneca County, Adams Township

419-618-1584

Barbara Baldosser

My name is Barbara Baldosser. I am a resident of Adams Township. I am here in support of the Republic Wind project. My husband's family has lived and farmed in this township for 80 plus years and the care of the land has always been a priority as well as the welfare of the township.

Adams Township is an entity without any industry and relies solely on Real Property taxes to fund our schools. This wind project is an opportunity to fund the education system for our children and our grandchildren without adding a greater financial burden on the tax payers of this township, be it a farmer, landowner or house owner. It also provides an opportunity to upgrade our infrastructure.

Yes, landowners, who are not all farmers, will recognize some financial compensation if they have a wind turbine on their property or are signed into the project as a neighbor. This is how capitalism works. Is it wrong for a landowner to determine how the property which he owns and controls is to be used in a way he or she desires? We are talking about a renewable fuel in a time when it is becoming clearer across the globe that it is necessary to have renewable fuels to benefit to our community.

I have researched wind turbines and find many studies that are cited, but not scientifically proven to be accurate, that are being used to support arguments against this project. *It's interesting how we pick and choose to ignore studies by reputable University's and scientists because they don't say what we want them to say.*

I find a wind turbine more esthetically pleasing to look at then say a cell tower or an electric tower. As for setbacks, extremely tall electric poles have been erected on right-of-ways along a major highway in this county. There is no setback for these poles and if a storm happens that is strong enough to bring down a wind turbine it more than likely it will bring down these poles also, and they are very close to many homes and buildings.

If you are a person who has had the benefit of travel in the U. S or abroad you know that wind turbines have been around for a long time across the world and they have not affected the ability to live a long and good life.

In summary, I do support the Republic Wind project for the good I can see it doing for our schools, the good for our community, the good for our township, and the good for our overall economy. This is a clean source of energy for all.

Thank you for listening to my point of view.

Barbara Baldosser



My wife and I live inside the proposed project area and we are in opposition of Republic Wind Farm (Case No. 17-2295-EL-BGN) for several reasons. Infrasound, constant sound levels, blade throw, and shadow flicker are some of our reasons. These are health and safety issues that will decrease the quality of life of those living within and around the footprint of this project. The World Health Organization has deemed constant sound levels above 40 dB will lead to diminished health.

What else could ruin the quality of life for residents? Well contamination would most certainly ruin quality of life and our property. Regarding turbine foundations the OPSB staff report states, "An alternative that could be used is a rock anchored pile-supported foundation. Also the report states, "The Applicant has noted that 27 of the proposed 64 wind turbines are situated in areas exhibiting karst features. Where the Applicant conducts future geotechnical studies that identify Karst features, those areas would be avoided for siting wind turbines." So why is it ok for 27 turbines to be sited on top of karst and not 28 or more? To the logical person it sounds like siting turbines on karst is a problem. Karst is not stable ground and therefore APEX would likely have to use their alternative foundation method of anchored pile foundations. Using this alternative method could cause wells in our area to be contaminated.

Driving piles to anchor turbines in the Chatham, Ontario region which lies just across Lake Erie is believed to have contaminated wells there. In July of this year charges have been filed against industrial wind companies, the environment minister, and his staff. The Ontario Court of Justice in Chatham-Kent determined there were "reasonable and probable grounds" for these charges.

According to *Chatham Daily News*, a group of citizens banded together after the announcement of a wind farm being constructed in their area back in 2018. Many of these citizens expressed concerns that the vibrations of the construction and operation of the wind turbines would cause damage to private water wells in their area. Sounds familiar doesn't it? Well, more than a year later, it seems that this may have been the case. Hopefully our group of citizens don't have the same fate. It is simple for us not to face the same fate as our neighbors to the north. You the Ohio Power Siting Board can deny APEX's application for this industrial wind farm. We ask as Seneca County residents that you deny APEX's application.

Jason & Marsha Bowers

Republic, Ohio

References:

<https://windsor.ctvnews.ca/epa-charges-tied-to-chatham-kent-wind-projects-1.4524947>

<https://www.narcity.com/news/ca/on/canadian-wind-companies-charged-for-allegedly-contaminating-drinking-water-in-ontario>



My name is Melissa Clapp. I live in the area where the proposed Republic Wind project is and I oppose Republic Wind. Currently where I live if the Republic Wind project is approved I will have wind turbines across the street and wind turbines behind my house. The Ohio Power Sitting Board's mission statement is to support sound energy policies that provide for the installation of energy capacity and transmission infrastructure for the benefit of Ohio citizens, promoting the state's economic interests and protecting the state's environment and land use. The OPSB website states wind farms must be designed to avoid unreasonable adverse shadow flicker at non participating residences within 1,000 meters of any turbine. What do you consider unreasonable shadow flicker? I personally consider any shadow flicker unreasonable.

Also the OPSB website says that non participating residences within one mile of the project boundary must not exceed nighttime average sound levels by five decibels. According to a sound study submitted to the OPSB in June this year there will be homes that experience sound levels considered dangerous by the World Health Organization. How can you guarantee that the sound levels be kept within safe limits? Also there is a high probability Ohio residents living near wind turbines can become ill from the unsafe noise levels. I believe that non participating residences should not have to listen to any sound noise from wind turbines.

Bellevue and it's surrounding area is situated on karsts. Even if wind turbine foundations do not go down into the ground to disturb the karst, the pilings that will stabilize and support the wind turbines will go down into the karst levels. There is a high probability the pilings for the turbines will ruin some people's well water. If this happens how will this be for their benefit? There is also a high probability the wind turbines can cause sinkholes to form and cause flooding. How can public safety be maintained if this happens?

OPSB there is proof in your files of wind turbines having blade throw and what the safety setback distance is for wind turbines. Knowing this information, how can you allow this project to go thru knowing this project does not follow public safety protocols for blade throw. How can the high

probability of blade throw damage to animals, humans and property benefits Ohio citizens? If damage occurs to my property from wind turbines, who will pay for this? Most insurance companies do not cover damage from wind turbines.

Life flight has limits on how high in the air they can fly and how close to a wind turbine they can land. There is an intersection a 1/2 mile down the road from my house where there have been accidents and even someone killed. The wind turbines would be located between my house and this intersection. How can the public safety of Ohio motorists be guaranteed when life flight has limits on how close they can land to a turbine? The OPSB also states that it's mission is to protect the environment. If this is true how many birds and bats have been killed by wind turbines? If the OPSB wants to protect the environment how can you allow turbines to kill any wildlife.

There has been a study showing the possible side effects on children who are exposed to continuous noise. The study shows that children who are constantly stimulated do not develop all their brain vessels, which then causes developmental delays. This issue is personal to me since I am a mother to young children. I have two girls, one is six the other is two. Both of my girls were premies and born six weeks early. Both of my girls had issues with their breathing when they were born. My older daughter has overcome her breathing issues while my younger daughter still struggles with it. My youngest has been diagnosed with reactive airway disease. She gets bronchitis very easily and was hospitalized last Christmas when she had pneumonia and rsv at the same time. My older daughter has trouble with her eyes floating and loses her vision. You see my children do not need to be exposed to anything else that can hinder their development or put their health at risk.

Recently there has been a cardiologist in Iowa who has shown there is a possible connection between wind turbines and affecting the electrophysiology of the heart. My dad had congestive heart failure and atrial defibrillation. If he was still alive he would be living near these wind

turbines. I would not have wanted him to be exposed to something that could possibly give him heart disease or worsen it. If all the possible issues in this speech are not enough to be concerned about, I also have to live with the fact that the wind turbine issue is personal. You see I have family members and friends who have signed lease agreements with the wind companies. I also have family members who are for wind turbines. This issue has caused heated discussions, unpleasant and uncomfortable conversations, strife and division in my family.

You are forcing wind turbines on us without giving us a say. OPSB how can you support any energy policy without protecting the citizens of Ohio first. Every member of the OPSB has family and friends who are precious to them. How would you feel if your family and friends were being forced to live near unwanted wind turbines. Before you go to vote I want every member of the OPSB to picture their family and friends, then decide would I want my family and friends to live with wind turbines knowing the possible negative effects caused by them.

How will shadow flicker, turbine noise, blade throw and pilings driven into the karst benefit Ohio citizens? OPSB if you care about supporting sound safe energy that benefits Ohio citizens, protecting the environment and protecting public safety you will not allow these turbines in Ohio! The answer to wind turbines is NO!



Testimony for public hearing for Republic Wind LLC case 17-2295-EL-BGN

I am Dominic Miller, I live at 1582 St. Rt. 4 Bellevue, Ohio, Huron County, Sherman TWP.

I do not live in the footprint of Republic Wind, but I do live in the footprint of Emerson Creek Wind, and am within 4 miles of the nearest Republic Wind turbine.

Tonight, I am going to talk about weather radar interference from Industrial Wind Turbines. This information was taken from an article written by Anthony Watts on April 29, 2018, titled "NOAA/NWS document: wind turbines affect weather radar, create false storm impressions"

HOW ROTATING WIND TURBINE BLADES IMPACT THE NEXRAD DOPPLER WEATHER RADAR

Rotating wind turbine blades can impact the radar in several ways. Wind turbines can impact the NEXRAD radar base data, algorithms, and derived products when the turbine blades are moving and in the radar's line of sight (RLOS); and, if turbines are sited very near to the radar their large nacelles and blades can also physically block the radar beam or reflect enough energy back to the radar to damage the radar's receiver hardware.

Turbines in RLOS can reflect energy back to the radar and visually contaminate the reflectivity, velocity, and spectrum width data. Forecasters look for certain "signatures" in the data that indicate the severity of the storms. The wind farm clutter can sometimes look just like showers and thunderstorms, or can alter the appearance of a storm such as hook echoes. This visually corrupted data adds uncertainty to the analysis and could cause forecasters to delay or miss a severe weather warning or to warn unnecessarily.

The base reflectivity, velocity, and spectrum-width data are also used by many algorithms in the radar processor to detect certain storm characteristics, such as mesocyclones, relative storm motion, hail, turbulence, etc. Corrupted base data can cause the radar algorithms to generate false alerts or to miss alerts. The radar also generates many additional products using this base data, such as wind profiles and rainfall estimates. Wind turbine clutter can impact the accuracy of these derived products.

You may wonder why we can't filter out this clutter since we know where the wind farms are located. The NEXRAD has a sophisticated clutter removal scheme. Since weather is usually in motion, the scheme was designed to filter returns that have essentially no or very low motion. This is effective for removing the returned signals from terrain, buildings, and other non-moving structures. However, the radar sees rotating wind turbine blades as targets having motion, hence processes these returns as weather. At this time, there is no filtering scheme available to identify and remove wind turbine clutter while preserving real weather returns.

Wind turbine clutter has not had a major negative impact on forecast or warning operations, **YET**. However, with more and larger wind turbines coming on line, radars in some parts of the country will have multiple wind farms in their line of sight. Cumulative negative impacts should be anticipated – which, at some point, may become sufficient to compromise the ability of radar data users to perform their missions.

Most, if not all of us, that live in the footprints of these Industrial Wind projects live in rural areas that do not have any tornado warning sirens they can hear. We rely on TV, radio, or cell phones to get warnings for severe weather. Any delays or inaccurate forecasts could prove to eventually have deadly consequences. The more Industrial Wind Projects that are built in an area will cause a bigger area that has scrambled signals and blocks the area behind the turbines from radar. We have the possibility of being in the midst of Republic Wind, Emerson Creek, Emerson Creek West, Buck Springs, Seneca Wind, and Honey Creek Wind projects. If all these are built, the weather forecasting for the entire area will be thrust back to pre-Doppler era accuracy.

This falls back into the hands of You, the OPSB, that are required to site these projects in a safe manner. This and all the other issues brought up here tonight all end up in the same overflowing basket of **Public Safety**. If you were to site these projects it would make a large part of Ohio, not a very safe place to live. This part of Ohio is **OUR** home. It is where **WE** live. We have all worked our entire lives to make our homes and this area a place that we are extremely proud of. Please do not destroy it. Please do not approve Republic Wind or any other project in this area. Thank you for your time and listening to my opinion.

Dennis Alt

OHIO POWER SITING BOARD PUBLIC HEARING

FOR REPUBLIC WIND # 17-2295-EL-BGN

My name is Dennis Alt, I live at 1448 St. Rte.4, Bellevue, Ohio. I live on the Seneca – Huron county line, and will be within several miles of a Republic Wind Turbine.

I would like to thank the OHIO POWER SITING BOARD members present today for the opportunity to address my concerns of the Republic Wind project.

My concerns are the negative effect of Noise and the effect it has on public safety. Noise is measured in dba (decibels) and has a wide range as to our hearing the noise. Some people can hear very low audible sounds, and some people can't, while others can hear all of them. You might ask why, and this has to do with exposure to certain noise levels at extended periods of time. Also all individuals have small but different anatomy structures, so this explains some differences in noise tolerance and recognition of different noise levels.

The great State of OHIO doesn't have a State Plan, which means not a plan approved by the Federal Occupational Safety and Health Agency. This means Ohio follows Federal safety standards for private sector workplace employees, but not State workers, they have their own standards. The standard of noise decibels starts around 10 to 15 decibels all the way up to 140 and above, noise can and will damage your ability to hear sounds. Also according to CDC noise can harm more than your ears and the ability to hear sounds, it has conducted studies and found links to exposure to loud noises or high decibels, can affect your other body systems. It has found links in 14% of hearing loss individuals to have higher blood pressure and cholesterol levels. Both of these conditions are some of the leading causes of deaths, strokes, and heart attack in the USA. This has also been found to be true by the World Health Organization (WHO), especially with long continuous exposure time. The longer the time exposed the greater the chance of doing lasting damage. The federal Standard with regard to this is not more than

eight hours of continuous exposure, at 90dba, which is city traffic. Most people don't want to hear city traffic noise in the country. The higher the number, decibels, the shorter the exposure time allowed. This means your body needs a longer time away from the noise to undo the harmful effects. Apex's new model turbine has listed as making 110 dba of noise, and this could be continuous for days.

How does one escape the noise, build a wall 30ft. deep and 10ft. tall and insulate it, as one study suggested, not feasible. This makes as much sense as pulling down shades to block flicker.

In Apex's application for sound propagation they show numerous houses that will be impacted by decibels of 35dba to 55dba and because a turbine will not shut down after eight hr. run time, these houses will be impacted beyond the WHO limits for health safety.

The people of Germany have found the noise generated by Industrial Turbines to be a health risk to the people around them. Max Planck a leading independent researcher came to find long exposure to continuous noise levels leads to sleep disruption, which causes stress, which leads to hypertension and other heart related problems. You might ask why this is so important, Germany was on the leading edge of Industrial Wind Turbine farms and development. They have been able to collect the data because of the number of Turbines and also the years in use. Germany is also heavily populated, much like the area of the Republic Wind Farm. Max's research has found that the noise travels much farther than suggested, and that the more Turbines the greater the distance, they amplify the sound.

In the USA, Number Three Wind, has been told to comply with The WHO recommendations, in noise. IT has been suggested they change setbacks standards to 1.5 miles from residences, and to shut down the Turbines for the entire night if conditions warrant.

Will Industrial Turbines be shut during the night so affected people can get a good night's sleep, or will they be forced to become midnight shift workers without being asked, I hope not! Will the State of Ohio make Wind farms follow Federal standards on noise, they call them Industrial. Will I be made to install an alarm to notify me of over exposure to continuous noise levels. Will the OPSB look

to the West and see the problems other States have had to address. Will all of these be addressed, maybe. Will I or others be compensated for illness caused by the noise of the Turbines? Maybe. Will I or others become a marginal minority because of the turbine noise? Don't know. Will we the Citizens of Ohio become test dummies so the answers to 655ft. turbines can be known, I hope not! I urge the OPSB to follow the guidelines for the safety of all residents and not approve the application for Republic Wind.



Robert
Manz

REPUBLIC WIND HEARING – September 12, 2019

OPSB Case: 17-2295-RL-BGN

I am Robert Manz, residing at 225 East Township Road 42, Tiffin, Ohio 44883, Eden Township.

I am totally opposed to placement of ANY industrial wind turbines in the proximity of our homes as this area's population density is NO place for industrial machines like those proposed. As members of the Ohio Power Siting Board, you have been very diligent in turning and acknowledging those who speak before you. But, how much of what is said do you actually hear? There is no doubt anyone in your positions can "zone out" after a few speakers. I ask that you hear the pleas before you as your decision will affect the lives of all of this area's residents. I respectfully ask of you to ponder what this decision will entail.

Other speakers have noted the detriments machines of this nature will bring. I simply desire to point out what I hope are obvious facts.

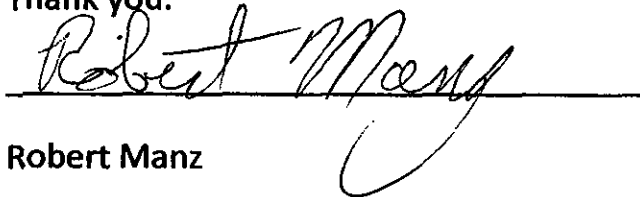
You, as a board member, moved into an area knowing the negatives of that vicinity. Those of us in Seneca and surrounding counties did the same. However, now we have an out-of-state entity attempting to change our entire life style by making it an industrial zone. How would you feel if such a thing happened where you live?

This project would create noise, flicker, and night lights along with road and bridge alterations upon people who should not have any such things placed upon them.

Most of those who speak in favor of the proposed project are leaseholders, possibly a worker's union rep seeking short term jobs and others with a monetary interest, while those opposed to this project are merely asking to be able to maintain the lifestyle we sought when we purchased or built our homes.

This board has a responsibility to the citizens of Ohio – not to out-of-state companies with no other interest than to use us to make some money. Please, put yourself in our position. I respectfully ask you to vote NO on Republic Wind.

Thank you.

A handwritten signature in cursive script, reading "Robert Manz", is written over a horizontal line.

Robert Manz

225 East Township Road 42

Tiffin, Ohio

Zachary West

**Ohio Power Siting Board
Local Public Hearing: Republic Wind
Case Number: 17-2295-EL-BGN
Zachary K. West
Pleasant Township, Seneca County
September 12, 2019**

My name is Zachary West. I am a third generation Seneca County resident from Pleasant Township. I spent the last twelve years throughout Ohio pursuing a higher education including graduate school, medical school, and residency training. I am now a board certified internal medicine physician, licensed to practice in the State of Ohio, with a graduate degree in public health. My roots are in this area and I have always considered Seneca County to be my home. It was always my goal to return here, practice medicine, and perhaps start a family of my own. However, it was throughout twelve grueling years of my intense training that I and others were left unaware of the nefarious threat of wind projects in Seneca County. I would observe that it was during those same twelve years, that an absolute decision on the matter of wind turbines in this county could have been given to the people.

My professional oath charges me with the responsibility to preserve the health and well-being of others and to aid in the general welfare of my community. As contributing member to the overall health of my community, I wish to express my concerns as it pertains to the proposed industrial wind project.

A growing body of evidence exists with regards to the health effects of industrial wind turbines. The World Health Organization (WHO) defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity".¹ The effects of wind turbines on health can broadly be classified into three categories: ecological impacts, emergency services impacts, and direct threats to public health and safety.

The ecological impacts of industrial wind turbines can involve issues stemming from the regional karst formations and the potential impacts on water drainage and well water supply during the construction of wind turbines. The Bellevue-Castalia Karst Plain occupies portions of northeastern Seneca County, northwestern Huron County, southeastern Sandusky County, and western Erie County and the area is believed to contain more sink-holes than any of Ohio's other karst terrains.² Karst and the associated sinkhole formations serve as a direct conduit to the water table and are a high risk for pollution.³ Likewise, houses with a water well in a karst area have a high risk of surficial contamination from anything that enters a sinkhole, including E. coli, fertilizer, pesticide, and other waste.³ The World Health Organization (WHO) considers safe water supplies and good water management to be fundamental to global health.⁴ Unfortunately, wind turbine projects have already effected the safe drinking water supply for various communities. On July 12, 2019, the Ontario Court of Justice in Chatham-Kent determined there were "reasonable and probable grounds" to believe environmental offences had been committed under the Environmental Protection Act by the environment minister, ministry staff and three industrial wind companies as the charges stem from contamination of residential well water for those residing near an industrial wind project.⁵

Another ecological impact with an indirect effect to the health of our community involves the native bat population. Insectivorous bats have been found to be worth more than three billion USD annually due to their destruction of agricultural pests.⁶ Likewise, bats are known to assist in pollination and seed disbursement. Unfortunately, with the global increase of industrial wind facilities, collisions with industrial wind turbines are now the leading cause of mass mortality events.⁷ Disruption to the local bat population poses a potential risk to local food supply and pestilence control.

The threat of impeding access to air ambulance service exists with the proposed industrial wind projects. Trauma-related injuries are one of the leading causes of death in America.⁸ Expeditious treatment has long been a tenet of trauma care and patients have been shown to have improved survival (including a 57.0% decrease in mortality) when transported by air ambulance as compared to ground ambulance.⁹ Access to emergency services for the Seneca County region continues to improve as a result of the work of multiple organizations. The region is serviced largely by Mercy Health Life Flight and the nearest adult level one trauma centers are located in Toledo, Ohio. In the unfortunate event such services are needed, it has become a common occurrence that patients be air-lifted from the scene. It has been concluded there indeed are factors with the wind turbine project that would impact air ambulance services and that the need may arise to utilize a Predesignated Landing Zone (PDLZ) requiring that patients be transported from the scene to an area safe for landing. Ultimately, there exists the potential for delay in the care of patients with the introduction of wind turbines and that delay can have detrimental consequences.

The turbine structure itself poses a potential direct threat to the health and safety of county residents. Turbine fires pose a potential challenge to the regions first responders and I express a genuine concern on the adequacy of current emergency response teams to address such incidents. Turbine fires have already been attributed with starting wildfires causing hundreds of acreage of damage.¹⁰

Wind turbine blade failures occur an estimated 3800 times annually.¹¹ The current Ohio minimum setback distance as outlined in the Ohio Revised Code is measured at 1125 feet.¹² Wind turbine failures in the State of Ohio have documented blade throw failures with debris fields measuring 1561 feet.¹³ A discrepancy, therefore, presently exists between the state minimum setback distance and the recorded distance of blade throws posing a potential direct threat to the health and safety of those in vicinity at the time of a turbine failure. According to the United States Census Bureau, Seneca County has a population density of 103 person per square mile.¹⁴ By comparison, Van Wert County, host to the Blue Creek Wind Project, Ohio's largest wind project, has a population density of 70.3 person per square mile.¹⁵ Furthermore, Paulding County, host to the greatest number of current (or planned) wind turbines has a population density of a mere 47.1 person per square mile.¹⁶ The discrepancies in size between areas like Van Wert or Paulding Counties versus Seneca County means a greater number of citizens are subjected to the negative health and safety effects.

Finally, the noise generation from industrial wind turbines is currently being reviewed as a potential threat to health and well-being. Wind turbine noise includes audible, infrasound, and low-frequency sound. I share in the concerns expressed by the World Health Organization (WHO) in its 2018 report as it pertains to noise and the impacts on health. WHO acknowledges that wind turbines can generate infrasound or lower frequencies of sound in addition to audible noise. Furthermore, WHO maintains the standard methods of measuring sound may not capture the low-frequency sound and amplitude characteristic of wind turbine noise.

While the body of data accessing the incidence of adverse health impacts as it pertains to infrasound is limited, such a limitation should not be interpreted as to imply exposure as being safe. Preliminary research is revealing the potential effects of infrasound as it pertains to cardiac, brain, and auditory tissues. Symptoms including stress, headache, dizziness, nausea, nuisance, annoyance, motion sickness and sleep disturbance have been reported as being caused by wind turbines. All of these symptoms are real to the patient afflicted and stand to greatly impact their overall health and quality of life. The debate on this matter might remain unsettled, but it will be those healthcare providers, like me, that are tasked with caring for the people subjected to the wind turbines and the consequences of the actions by the wind developer. The entities and governing bodies tasked with the review and siting of wind turbine projects must take into consideration human health and safety. WHO makes the recommendation that "proper public involvement, communication, and consultation of affected citizens living in the vicinity of the industrial wind turbines **during the planning state** of future installations is expected to be beneficial as part of the health and environmental impact assessments." I personally and professionally agree with such a statement and request acknowledgement by the Ohio Power Siting Board as it pertains to health and safety.

Article 1, Section 1 of the Ohio State Constitution states "All men are, by nature, free and independent, and have certain inalienable rights, among which are those of enjoying and defending **life** and liberty, acquiring, possessing, and protecting property, and seeking and obtaining **happiness and safety**."¹⁸ These same rights certainly extend to the citizens of Seneca County.

The diagnosis is an uninvited and unwarranted malignant wind project. The treatment is the rejection of Republic Wind.

Thank you for your time.

Zachary K. West DO, MPH
Pleasant Township, Seneca County



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J. Dian West

**Ohio Power Siting Board
Local Public Hearing: Republic Wind
Case Number: 17-2295-EL-BGN
J. Dian West
Pleasant Township, Seneca County
September 12, 2019**

I stand here before you to express just a few of my concerns with the Republic Wind project.

To begin my story, I must share that I did not become aware of this project until December 2017. Just prior to the public disclosure of the project, my mom had been involved in an automobile accident. As a result of medical negligence and fortitude of unfortunate events, my mother succumbed to her injuries and the resulting medical negligence after 145 days. It was during the darkest of hours surrounding her unexpected death that the public filing was completed for Republic Wind. I can remember hearing of a wind project and was astonished the very notion of building such an entity in Seneca County.

I began my independent research into wind turbines. My higher level of education affords me a curious mind. Evenings turned into weeks, weeks into months, and now I find a year and a half later, I continue to learn about wind energy, the details of this project, and the implications. What presented to me initially was the gut wrenching question of why was this project hidden behind a dark curtain for so many years? Only those who stood to financially gain would know about this project. The very same neighbors I had gone to school with and my parents interacted with, had kept a very dark secret; a secret which ultimately impacts more than just them. While they get financial gains, the rest of us are left with all the negative impacts from the wind project. Where was my say in the determination of whether to bring a project into my community? Where is the local control? Where is the democratic process in deciding the future of our community?

Shut out. Condemned if we speak out. Targeted as if we do not want "green energy". In today's current state of affairs, I would say we, the anti-wind folks have been the target. We have nothing to gain and everything to lose. We are misunderstood and significantly underestimated.

My childhood home, which is now my home, is less than a quarter mile outside the Republic Wind boundary edge and a mile from the closest turbine. Yet I get no local vote, no local say at the township level, no local say at the county level. I tried to file as an intervenor since my family will deal with the negative effects of this project. However, as a result of the current flawed process, and because I live outside the project boundary line, the very same wind project developer up for consideration denied me that opportunity. Not surprising considering it is the same developer that spend years working behind the scenes to sign leases and actively has worked to block any and all attempts at local control, including a vote by the people.

I stand before each of you this evening to ask for you to not just hear my voice, but to truly listen. There is a difference. I am second generation and my three sons are third generation to this same community. Professionally, my education affords me a license by the Ohio State Nursing Board as a registered nurse. I also maintain a Master of Business Administration in human resources, marketing, and health care administration. My career consists of being a registered nurse for twenty years in the intensive coronary care unit at Fremont Memorial Hospital. I know firsthand how important time can be post sudden serious illness or life threatening accident. Time matters and time can make the difference between life, death, or disability. Our local hospitals are not trauma rated. We have been blessed for many years with

air ambulance service from through Promedica Air, Lifeflight, and Cleveland Metro. The ability to air lift patients from the scene of accidents we largely take for granted. Air support from the scene affords prompt medical interventions. With wind turbines placed throughout the many townships, this will present the inability and interference to fly when the ceiling is decreased due to weather. Also depending on the location of the accidents, the air ambulance may have to land miles away from the turbines, thus requiring duplicate transfer by ground to the helicopter. This process takes time, something that can make the difference between life and death. I ask does anyone care about this? The Seneca County area is too populated for wind turbines of the projected size and number. Hindrance to medical support should never be compromised due wind turbines. Where is the local say or control in this? My life or the lives of my family members would be put in jeopardy with this wind turbine project.

I ask about the safety from fire by our local fire departments as it relates to wind turbines. The Republic Wind project projected to be built in Seneca County also presents the issue of what to do when a wind turbine fire occurs. You may be saying to yourselves, such an event cannot occur. I challenge you to research such events. Beneath these monstrosities are acres of fields and homes; innocent homes that belong to folks like me who had no say in if they even wanted wind turbine projects. Do we really believe that our local volunteer township fire departments have the equipment to handle hundreds of acres of fires or a fire 600 feet in the air?

I have raised my three sons in Pleasant Township, just as I and my siblings grew up amongst the area farmers and their families. I choose to raise my three sons in the same setting. Tractors, pigs, horses, cows and field and fields of crops situated amongst the homes of numerous families. We choose to live where the crops suck up the rain drops and dance in the sunshine. We appreciate the hard working farmers. We value the country life. Wind turbines have no place in Seneca County.

Some in this room may have had the pleasure of knowing my mom. She was homemaker, mother, grandmother, and left widowed at far too young an age. She would take care of the elderly in the community affording them the opportunity to stay in homes for as long as they could. Despite her display of care, compassion, and consideration of others, many of those same families she helped are the ones who brought the divisive issue of wind turbines to our community. My mom loved to talk and could start a conversation with just about anyone. Although she is not able to be here in person, I assure you she would have no trouble getting up here and making her opinion on this matter plainly known.

My deceased parents would not approve of this project. I do not approve of this project. My entire family does not approve of this project. Neither should you.

Thank you,

J. Dian West RN, MBA
Pleasant Township, Seneca County



DAN WHITE

I would like to share some statistics from the public comments filed with the Ohio Power Siting Board in this project. I have here a list of all comments filed through September 9th, and I have an extra copy that I will leave with the board following my testimony today.

First, I will state that roughly an equal number of people have filed comments supporting and opposing this project. But beyond that the similarities stop.

One of the first things noticeable when reviewing comments is that some comments on both sides have been filed repeatedly. Of comments opposing the project, six were filed in duplicate - meaning the same letter signed by the same person filed two separate times with the OPSB.

But there is a much more noticeable pattern of duplicate filings among comments in support of the project. Overall, 24 comments in support have been filed in duplicate with the OPSB. Four comments in support have been filed in triplicate. And one comment in support - the same letter signed by the same person - was filed four times in a five month period.

Another statistic that I want to point out to this Board is that fewer than half of the comments in support of this project are from Seneca County residents. By comparison, 90% of the comments in opposition are from people who live in this county. And if you add residents of neighboring Sandusky and Huron Counties that figure rises to 95%.

I understand why a union employee might not object to this project. For them, Republic Wind is a paycheck for a few months, and then they get to go home. They are not forced to carry the burden for the next 20-30 years like those of us who live here will be.

A final pattern I want to point out is the overwhelming prevalence of form letters among comments in support of the project. In fact, 93% of all public comments in support of this project are form letters. By comparison, only 23% of comments in opposition are form letters.

One of the dangers of relying heavily on form letters is that you end up with situations such as the gentleman from Crosby, Texas who submitted a form

letter stating he is "a resident of the area surrounding the Republic Wind Project." I suppose it depends how you define "the area surrounding Republic", but at over 1200 miles away I think Crosby, Texas is rather a stretch.

I would also like to point out that it is much easier to simply sign your name to a letter that someone else wrote and that someone else will submit on your behalf than it is to take the time and effort to find your own words and figure out how to navigate the OPSB system to submit your comment yourself. There is a level of time, effort and investment in the many heartfelt comments in opposition that is lacking the form letters of support.

In closing, I would like to make the following comments:

To Whom It May Concern:

Seneca County is (really) my home, and I have an interest in decisions that impact our future.

Wind energy is a complex subject, but I've educated myself over the last few years to understand exactly what this project means for my family, my community, and our legacy. I'm not alone, as I've seen widespread opposition to this project from my neighbors and family. Most don't want it, and I share their opinion. As for me and my family, we will welcome the denial of this project and the avoidance of all damage that this wind project would bring.

We've been voicing our concerns on this project for over a year. Now that the Ohio Power Siting Board is finally here, I urge you to hear the overwhelming opposition from the foundation of this community - the people who (really) live here!

Thank you.



Don Vogt 13740 TR 136, Bellevue, OH 44811
Seneca Co Thompson Twp. - Surrounded on 3 sides
by turbines

I'm here solely as a concerned citizen not living in the drawn footprint of the Republic Wind Project but surrounded by up to 12 turbines within a 2 mile radius of our home. We moved here 7 years ago not just for the change of employment but to enjoy the beauty of the country life here in North-central Ohio that mimicked the rural area of Indiana where I grew up. I don't have precise statistics for you, but many of my neighbors and peers have already provided them for you. I want to take this opportunity to express a more human perspective as a person who has read studies on varying negative aspects of the installation of the wind turbines. Studies relayed to us from agencies^{like} in Van Wert County have shown the decrease of property values that accompany the building of wind farms. Ten years ago I lost 80% of my hearing^{in my left ear}, so research on the negative effects of infrasound caused by the blade rotation is ~~am~~ concerning to me and should also be to others susceptible to hearing loss. You've also heard testimony on setbacks being too close to property lines and the concerns of building 400 foot turbines on potentially unstable bedrock topped with large karst formations.

In the early stages of our fight to protect our land here in Seneca County, I attended the meetings on both sides and decided to see for myself. I happened to be taking my son on a college visit to Purdue University in West Lafayette, Indiana near where I grew up. Just north of West Lafayette there are three little towns in White County that are replicas of our hometowns of Attica & Republic. Near Brookston, Chalmers, and Reynolds, there stands a gigantic mass of wind turbines that stand at just over 300 feet - half the height of the proposed turbines in the Republic Wind farm. This sounds a little crazy and maybe a little creepy, but I decided I was going to find someone living amongst the turbines so I could hear from a direct source who was impacted by the wind farm. In the middle of the countryside I spotted a lady carrying in her groceries, so I pulled in the lane and struck up a conversation with her that lasted a good 2 hours. What I heard horrified me but backed up much of the statistics and research on the negative aspects that you have heard today. As we talked, the noise was overtly noticeable and did interrupt our conversation only because it caused me to lose my focus in disbelief. Her rented property was once a scenic piece of

land, and there was a fire pit that was prevalent in the back yard. I asked how they liked their outdoor space noticing the irritating shadow flicker, and the woman replied that they didn't use it any more as within a $\frac{1}{2}$ mile of the house there was a substation where the very noticeable Hum went on 24/7/365. It made it unbearable for her to be outside for extended periods of time. She cited irritation levels that were heightened in her 3 dogs, but what saddened my heart was that she was a single mother raising an autistic child who, before the turbines, was making so much positive progress but became overly agitated ~~and~~ when the turbines came. In addition, her landowner allowed power lines to cross the property but had to use a portion of his initial payment to restructure the water source to the home. It seemed by both her & the property owner that the construction of the turbines caused the re-routing of the water table. I left the home just as the flashing red light on the tops of the turbines began pulsing at dusk, and I admit I was deeply affected in ways I can't express in words. I'm not against green energy but I am against property right infringement, property devaluation, and the infringement of the right to live a life ~~unburdened~~ unburdened by unnecessary health risks. Many of us here,

4.

The effects
are real as I
found out

including myself are imploring you as The Power
Siting Board to err on the side of caution and
make a decision that protects up who live in
and near The Republic Wind Project and in
other wind turbine projects in Ohio. Going ahead
and approving the Republic project puts up in
adverse situations that negatively impact
our lives in various ways just as it had for this
woman and her son in Indiana. I know
She's only one person, but isn't that enough?

that should be

Thank you

Paul Jones

September 12, 2019 At Tiffin University

1. Vote for Bernie – free napkins free table settings free work days no one will ever have to go to work. Oops sorry – Notes from Bernie rally at Heidelberg this weekend.

2. Recently I was having coffee in the early morning hours with an ex friend who questioned my reasons to speak for No Wind Turbines in Seneca County. He had three valid points and they are as follows:

One – The Seneca East School System needs the tax revenue from those turbines. -

Two – How can you a Pillar of the Community be against renewable energy? Planet Earth is being destroyed.

Three – A man has the right to build or lease whatever he wants on his own land!

I visited SE schools a couple of weeks ago.

A. Mr. Jones, The other day I heard one of mom's friends call you – "A dumb hillbilly from Kentucky" are you? Am I what? Dumb or from Kentucky?

I know you are not dumb, but are you from Kentucky.

B. Are you Mr. Jones? Yes, I am young lady. Grandma said you were one of her favorite teachers...

C. Mr. Jones sign on to one of the spare Mac Book Pros, I want to airdrop you a document and you check the parameters of my paper. My research paper on the Lifestyle of the Aborigines in Southern Australia. Check my thesis and see if it is too ambiguous. If it needs some clarification, suggest the means About this time I thought. I could be having lunch at Sawmill Creek Resort in Sandusky. My daughter

Sawmill Creek Resort – Golf Course – Hotel –restaurant and 50 undeveloped acres of land.

Seneca East Schools – over a million dollars carryover into the new school year.

Only five schools in our area rated a bronze metal in educational merit.

Edison, Huron, Vermilion, and Ontario. Announced Principal Vogt at a recent board meeting. Only 2 percent made gold and 11 percent made silver. We are in the top 16 percent in the state of Ohio

Enrollment is up – Open enrollment Dr. Laura Kagy, the staff, school board, and employees deserve a thank you . We do not need wind turbines lording over the school Open enrollment would certainly be affected.

6. Testimonials I understand – about 2nd hand information in a court of law.
Called Father Hoyles

7. Against renewable energy. That is not true. I wish that the effort put into turbines would be used instead for Solar power. At least until technology improves the performance of 660 wind turbines.

The materials needed to build a base for a turbine

The roads to carry the equipment, the dastardly effect that building them will have on Seneca County. Wind turbines in their current stage of development are not going to save our planet.

8. A person should have the right to build anything they wish on their own land.
I disagree. Rattlesnake Farm –

Billy Graham in 1966 at Cu Chi home of the 25th Infantry on Christmas Eve.

My son called last night – invited me to go to Munich Germany and then on to Florence, Italy he leaves in a couple of weeks. Nah! He's going but he won't take me with him.

Vice-President of Niagara Corp in Dallas Texas. Not bad for having a father who is a dumb hillbilly from Ky. - Excuse me Bluegrass American.

Please don't show up at Heidelberg this weekend looking for the Bernie Sanders rally. I lied. Thank you.

Before I begin I would like to point out that there are many individuals that are here today ^{and live in the footprint} that would like to speak in opposition of this project, but are legally unable to because they will be speaking in Columbus in the future. Also, even though many here don't live in the footprint, it doesn't mean they won't be affected by these wind turbines any less since several of us live very close to this and the surrounding projects.

Stephanie Miller

My name is Stephanie Miller and I am a resident of Reed Township in Seneca County. My home is located in the proposed Seneca Wind Project and in the viewshed of the Republic Wind Project. Though the arguments of opposition to these wind turbines are considerable here, one hits very close to home for myself and my family. Should something happen to us or another resident within our county lines, I worry about the accessibility of emergency personnel, the safety of those involved and those precious crucial seconds.

Twelve years ago, this past August, I was in a horrible car accident that almost took my life. This accident occurred in Venice Township, which is about 4/5 miles from my home, and I had to be life-flighted from the scene. The location of my accident was proposed to have three wind turbines located right there.

From my understanding of the research that I have done on life flight, the ability for them to land and aid those in need is not guaranteed and will be compromised by a variety of obstacles. The height of these turbines and the air pressure they create are just two of the obstacles. Due to the air pressure around these turbines, I have read that life flight may have to land anywhere from 2 to 6 miles or more away from the actual site of the emergency. This a huge distance when these wind turbines are wide spread and located in clusters, which make it difficult for emergency personnel to get close. Also, this past November, the Director of Operations Life Flight in Toledo released a comment that they do not have specific regulations regarding wind turbines. However, they do have to follow FAA regulations that govern how Helicopter Air Ambulance helicopters in the United States operate. Pilots must be able to clear all obstacles by 300 feet during the day or by 500 feet at night, while still staying 500 feet below the cloud "ceiling" above them. This becomes a major obstacle when life flight is necessary to save a person's life.



These turbines proposed in the Republic Wind Project are much higher than the other wind turbines in Ohio. Therefore, there is much more of an issue surrounding the approximately 600 foot turbines purposed in this project when it comes to life flight. I have been in contact with local life flight personnel and all I have been told is to not worry because life flight and the local fire department will be in contact with one another if something were to happen so that a decision can be made as to how to proceed. However, it is in these situations where life flight is needed, that EVERY second counts. Through discussions with local fire department personnel, *they too are looking for answers to these same questions.* There is not time when something happens to discuss a plan with the necessary local emergency personnel in these life or death situations. If this had been the case 12 years ago, I may not be here today with my family and I don't want this to become a reality for someone else.

In conclusion, the citizens living in and around this proposed project need to be heard. Most importantly, it is time we stop to listen to the concerns of our local airports and those that are experts in flight when it comes to these wind turbines. The wind companies only tell what we want to hear regarding these emergency situations and not the entire truth. It is time for us to take the citizens in the surrounding area's safety into concern and make sure these wind turbines don't become an unwanted part of the next 30+ years of our lives.

Bob Rine I have 450 Acres in the curve out because of the
Indiana long eared bat, Does this cause my report to
Good Evening, not count? *Bob Rine* 419-217-3768

I am Bob Rine of Adams township in Seneca County and I thank you for allowing me to speak.

I am really excited about the possibility of the windturbines generating power in my community!!

I am the 5th generation that has been raised on the same parcel of land with the same passion for the land that I try to instill in the generation to come. We embrace both the successes and challenges of managing a family farm. We hope to pass our land on in better condition than we found it. We have to be flexible and open to change to keep our operation viable. I plant cover crops and no till my crops in an effort to be a good steward of the land. This has certain costs to me, yet I believe it is the right thing to do. We utilize 3 phase for our farm operation and it is supplied by Toledo Edison on one end and north central electric on the other. Keeping my farm operational is not just about me or my family, it trickles down to the dozen or so local businesses that work with our family farm.

I see the windturbines as being similar. No source of energy is perfect or without cost. I think this type of power shows a positive cost/benefit ratio and is in keeping with the spirit of leaving things better we found them. There has been quite a struggle in the development of this idea, but the right thing is not always easy is it? That is why I have remained committed to this process. Energy costs are high for my business and I am certain many others. Having a renewable source that brings revenue to my community is a win/win.

Monday through Friday finds me teaching Physics and Math. I like numbers and facts. We have to make a decision based on facts and not emotion or fear. I am not aware that many of the studies mentioned are peer-reviewed quality. I am fully aware of the costs of a great education and very clear that my tax dollars cannot climb higher to provide that. If this project could only offset a portion of the rural tax burden that would be huge!

Earlier this week I had a plane fly cover crops on 600 acres. I discussed with the pilot how the turbines might affect that moving forward. He replied that he must follow FAA rules regarding flight patterns, but they would not be prohibitive to this farming practice in general. This is an adjustment I can make. This is my choice as a land owner. My decision.

I have researched this topic and fully understand what a wind farm would mean for this community. I believe it would be very positive addition to our neighborhood. Let's move forward responsible to ourselves and generations to come.

Thank you again for your time!

A handwritten signature in black ink, appearing to read "Chad Rine". The signature is fluid and cursive, with a small "11/15/14" written above the first part of the name.

✓

DUSTIN AUSTIN TESTIMONY

I come to you today as long time Seneca county resident, a Thompson Township resident whose family has resided in this county for over 170 years. My home that I own is located on the family farm which has been in our family for over 131 years! Over the years I have heard generations of family members tell stories about the land, and give insights of the farming operations and geology of the farm. This is very important, since we are here today to talk about the industrial wind farms purposed for this area.

I have grave concerns over these projects, as they will greatly impact my family, home, and surrounding area where I reside. I have three major concerns with this project that I hope the Ohio Power Siting Board takes in to account.

One is the impact these wind turbines will have on the water system in this county. You see many people, actually, many of my neighbors, rely on their wells for their main and only water source for their home, barns and animals. Many families today cannot afford another water source, or to have one brought in. Especially, since most wells are a free water source, helping to make it financially easier for families to pay their other monthly bills.

In one community in Chatham-Kent, Ontario, there are major problems with water wells being contaminated with black shale sediment. This has affected over 200 homes, which was first noticed during construction and operations of the North Kent Wind project. This is believed to have been caused by what is called pile driving, along with different types of vibrations from the operations of turbines. Why would we want to take the chance of affecting our precious water sources in this county which families desperately rely on?

Secondly, with this being said, it is very important for the OPSB to consider the large karst area in Seneca County. With a large amount of sink holes in this county, it is very important to consider what lies below the surface and I can only pray that this is highly researched and considered before allowing these wind projects. On our family farm, there are five sink holes, and a 6th one in the process of opening up. This is very concerning for my family, as we do not know how many more sink holes could/would open during and after construction of these large wind turbines. The vibrations caused from these large industrial wind turbines is sure to have negative side effects here, just like as they have in other communities. The fact of the matter is, new sinks holes could open, and the current sink holes could open even larger, making this a very serious problem. I urge you to look at the two maps I am including with my statement attached here! According to a report "EVALUATING KARST RISK AT PROPOSED WINDPOWER PROJECTS" by William J Bangsund; of Barr Engineering Co & Kenneth J Johnson; Oklahoma Geological Survey, "Karst can lead to a wind turbine tilting and even toppling". I ask you all, is this something you would want to topple near your home and family? Especially, since the wind companies are pushing for shorter setbacks from homes!

Lastly, I want to urge the OPSB to consider our local parks which would also be negatively affected by these wind projects. We need to protect our area wildlife as they are essential to farming operations, with the many benefits they bring, such as bats. An estimated 600,000 birds are killed annually by wind turbines, so why would we want to participate in this slaughter? Some of the most beneficial birds being bats, which eat large numbers night-flying insects which include mosquitoes; and they pollinate seeds

and fruits we eat. Furthermore, our eagle population has finally returned and these large turbines threaten the species' once again. Bird watching is a real thing in this area, which brings tourists to the area.

In the Public Utilities Commission mission statement, they assure all residential and business consumers access to adequate, safe and reliable utility services at fair prices! I sure hope you all keep this mission statement in mind along with the words "safe and reliable" when voting on this project! These large industrial wind turbines are neither safe nor reliable, if you take a look at these wind turbines in other projects, in other areas.

Why would we want to risk all of this for wind turbines which are really not green at all? The major negative impacts far outweigh any minute monetary benefits these turbines would bring. I urge the Ohio Power Siting Board to deny the certificate and do not let these industrial wind farms into Seneca County!!

Respectfully,

Dustin Austin
Thompson Twp



Cathy Limbird

Hello, my name is Cathy Limbird. I live at 16418 East Reed Township Road 9 in Reed Township in Seneca County where multiple Industrial Wind Turbines are proposed to be built in the Republic Wind project.

I am talking to you today because I oppose the wind turbine projects. There are a multitude of reasons why I oppose them, but I am focusing on what I think is the most important reason to me. I have growing concerns of the health effects that the Industrial Wind Turbines can cause. I have worked in health care as a registered nurse for over 30 years. Because of my background as a nurse, my focus has always been trying to better the quality of my patients' lives. I feel that the effects of the turbines will decrease the quality of life in those living by them.

The term Wind Turbine Syndrome is the clinical name that has been given to the multiple ~~of~~ symptoms that are experienced by many people who live near the wind turbines.

These symptoms are:

- sleep disturbances

- headache

- tinnitus

- ear pressure

- dizziness

- vertigo—refers to the sensation of
spinning, or the room moving

- nausea

- visual blurring

- rapid heart rate

- irritability

- problems with concentration and memory

panic episodes and anxiety associated with sensations of internal pulsation or quivering, which can arise while awake or asleep

Wind turbine syndrome seems to be triggered by the organs of motion, position and balance which is located in your ear. The low frequency noise and the infrasound that the wind turbine produces send scrambled signals to the brain centers that control these symptoms. There are many accounts of people who live by the turbines that have developed such intense symptoms that they literally had to move from their homes.

Infrasound is the noise produced by the turbines that a human ear can not hear. It occurs when large masses are in motion, for example, the rotation of the wind turbine blades. Infrasound, especially the larger the wind turbine is, can be measured miles from the turbine. Wind developers deny any health effects from the infrasound and the low frequency noise of the turbines. Unfortunately, some people think that if you can't hear the noise, it can't hurt you. There has been much research done on this subject in the medical field and saying that what you can't hear will not hurt you, is absolutely false.

As troubling as Wind Turbine Syndrome is, my concern grew even more when I found research done by a cardiovascular physician in Germany. The wind turbines have been around there for over 20 years. He has been focusing on the acute human health effects of infrasound.

It was found that infrasound does have a distinct effect on heart muscle tissue. They found a clear reduction of the heart muscle strength when exposed to infrasound. When your heart muscle

decreases in its strength your heart will not pump as effectively as it should, thus decreasing the heart's function and causing a multitude of cardiac problems.

This study is alarming to me. Wind turbines do not belong around areas where people live. No one should have to endure health effects from wind turbines. There is nothing, absolutely nothing that says wind turbines must be sited next door to people's homes. Siting of these turbines that are over 600 feet high is a crucial problem. Please keep them out of our counties where our population is too large. They do not belong here.

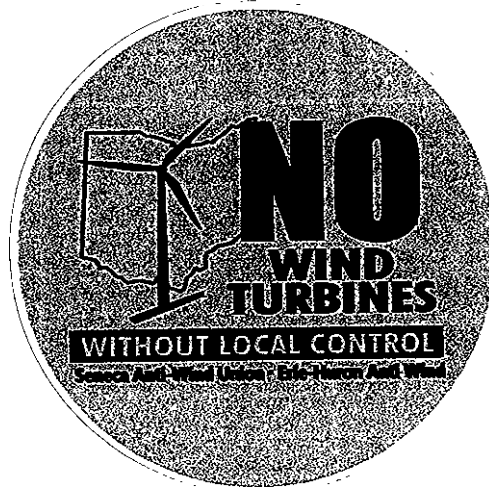
I am also very concerned about Life Flight being able to reach emergencies in our area if the wind turbines were to be built here. As a registered nurse who has worked over 30 years in a rural hospital emergency department, I am very aware of the importance of the golden hour a trauma victim has immediately after being involved in an injury accident. We live in an area that is 60 miles away from a Level 1 trauma center. Without Life Flight, we here in our rural area will take huge steps backwards when it comes to treating trauma victims in a timely manner to save their lives. Not only are we in the middle of farm country where accidents can and do happen, but we have a great deal of tourist traffic, especially in the summer months.

At the end of the day, you will all go home. I do not know if there are wind turbines lurking in your future or not, but I want you to remember that the decision that this board makes is going to impact thousands of people. Our quality of life is resting in your hands. Please do not subject us to all of the negative impact that wind turbines have. Let us ^{continue to} please live our lives in our beautiful and peaceful rural areas.....unchanged from the way it is now.

Thank you,

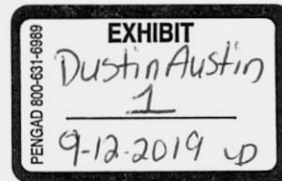
Cathy Limbird

Cathy Limbird
16418 East Reed Township Road 9
Attica, Ohio 44807
419-426-6055
forkeepsphotos@yahoo.com



DUSTIN

STIN EX1



This map is the Karst Interactive Map by ODNr Division of Geological Survey.

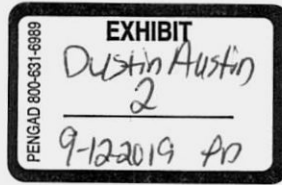
The red arrow shows a sink hole that is not on the ODNr map but it is in fact a large sink hole. (I added the red dot, the red circle and the red arrow)

The red dot in the orange arrow is a sinkhole that appears to be opening up currently. (I added this red dot, orange circle and orange arrow)

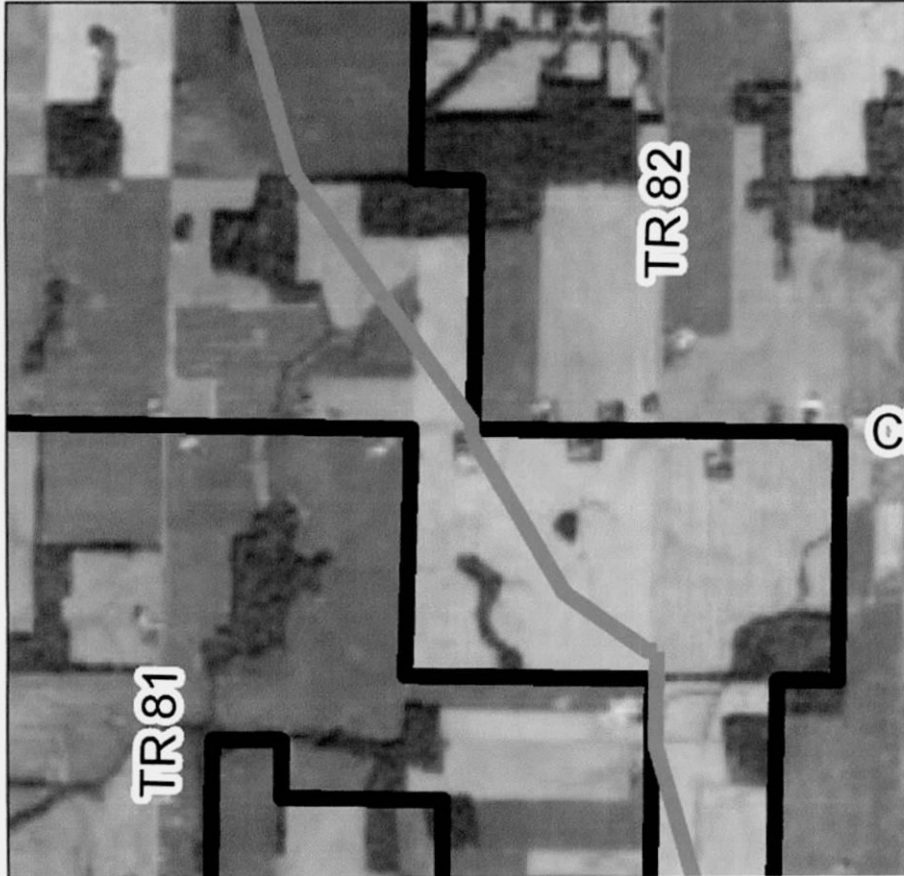
Please note the sink hole across from this possible new sink hole, which are on both sides of the !

The two purple arrows are sink holes confirmed sink holes. (The purple arrows and circles I have added)

REMOVED-DOCKETING DIV
2019 OCT 18 AM 11:32
PUCO

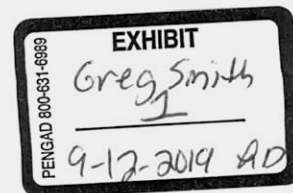


DUSTIN AUSTIN
EX. 2

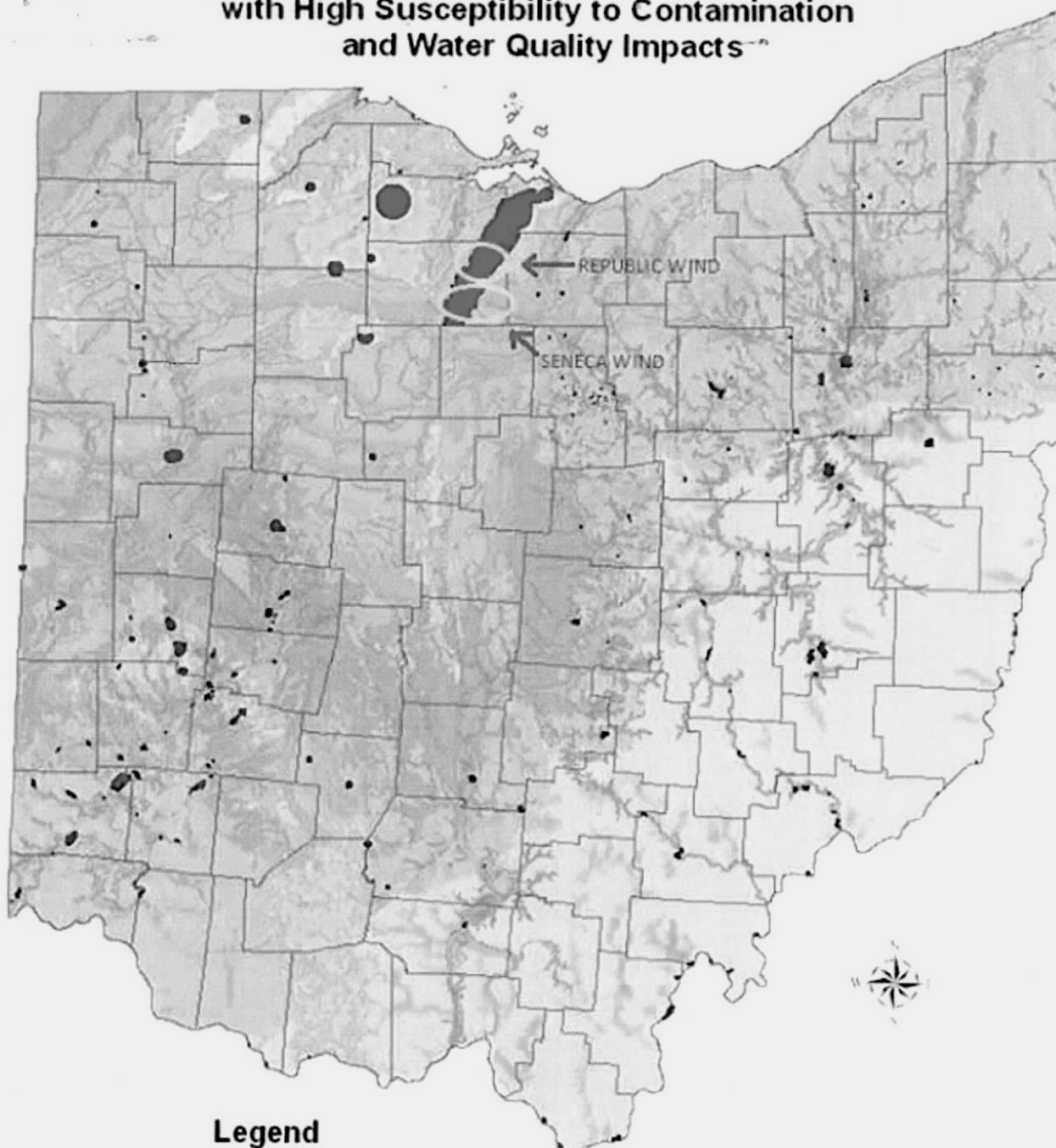


This map is from the staff report for Republic wind. There is a transmission line set to run through our family farm. You can compare the map from above to this, and see how many sink holes will be on BOTH sides of this transmission line. There are several other sink holes that will run along the sinkholes on neighboring farms! One of the sink holes being just feet away from one of the large sink holes.

Greg Smith EX. 1



**Community PWS using Ground Water
with High Susceptibility to Contamination
and Water Quality Impacts**



Legend

Glacial Geology

- Aluvial
- Beach Ridge
- Buried Valley
- Complex
- End Moraine
- Ground Moraine/Lacustrine
- Outwash/Kame
- Thin Upland
- Unglaciated Region

- Drinking Water Source Protection Areas for Community Public Water Systems using Ground Water with a High Susceptibility to Contamination and Water Quality Impacts
- Potential Karst Region
- County Boundaries

OhioEPA

REPUBLIC WIND LLC

The red points are field confirmed sinkholes, orange are suspected, yellow are suspect not visited, and blue are springs

The large plus signs are FAA Wind Turbine Coordinate Layout



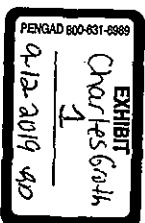
Charles Groth EX.1

Sheet1

Republic Wind OPSSB Public Comments Complete through 5/9/2019

Supporting Project

#	People	Name	Date Comment Filed	# Comments	Form Letter?	Residence	In Series Co.2	Huron/Sand Co.2	Notes
1	*Falsey Filed	No Name	06/25/18	1	Y		N	N	
1	Balt, James	Balt, James	05/21/19	1	Y	Newark, Ohio	N	N	
1	Baldasser, Barbara	Baldasser, Barbara	04/16/19	1	Y	2563 Columbia Rd, Westlake, OH	N	N	
1	Baldasser, Gary	Baldasser Farms Inc.	03/18/18	1	N	5393 Twp. Rd. 78, Green Springs, OH	Y		
1	Baldasser, Gary	Baldasser, Gary	02/13/18	1	Y				
1	Baldasser, Gary	Baldasser, Gary	02/13/18	1	Y	5120 N. Twp Rd. 78, Republic, OH	Y		
1	Barbour, Philip	Barbour, Philip	03/13/18	1	Y	5120 N. Twp Rd. 78, Republic, OH	Y		
1	Bartels, Joe	Bartels, Joe	08/11/18	1	Y	308 Magnolia Rd., Huron, OH 44839	N	N	
1	Bartels, Joe	Bartels, Joe	07/30/19	1	Y	Lima, OH	N	N	
1	Beckert, Jan	Beckert, Jan	04/08/19	1	Y	219 Westbranch, Medina, OH	N	N	
1	Beckman, John	Beckman, John	02/13/18	1	Y	no search results	Y		Same letter submitted to OPSSB twice on same date
1	Beaton, William	Beaton, William	02/13/2018 & 3/9/18	1	Y	3 Wm Beaton's in Seneca Co.	N		Same letter submitted to OPSSB twice on 2/13/18 & submitted again on 3/9/18 (assumed residence in Seneca County)
1	Berschoff, Richard	Berschoff, Richard	02/08/2018 & 2/25/19	1	Y	2725 Co. Rd. 80, Burgoon, OH	Y		Same letter submitted to OPSSB on two separate dates
1	Berschoff, Brad	Berschoff, Brad	02/13/18	1	Y	no search results	N		2 form letters submitted to OPSSB on the same day (one submitted twice on same date, so 3 submissions total on same date)
1	Berschoff, Steve	Berschoff, Steve	02/13/18	1	Y		N		Same letter submitted to OPSSB on two separate dates
1	Bischoff, Steve	Bischoff, Steve	03/09/2018 & 6/19/18	1	Y		N		
1	Bischoff, Brad	Bischoff, Brad	08/13/18	1	Y	1384 Section Line Rd 30, Bellevue, OH	N	N	
1	Bloom, Sharon	Bloom, Sharon	03/12/19	1	Y	1384 Section Line Rd 30, Bellevue, OH	N	N	
1	Bloom, Sharon	Bloom, Sharon	04/23/19	1	Y	1384 Section Line Rd 30, Bellevue, OH	N	N	
1	Burnol, Trevor	Burnol, Trevor	03/05/19	1	Y	15 St. Francis Ave., Tiffin, OH	Y		
1	Bower, Jason	Bower, Jason	04/08/19	1	Y	2300 River Rd, Willoughby Hills, OH	N	N	
1	Bowman, Ulrich	Bowman, Ulrich	03/12/19	1	Y	403 N. Main, Fostoria, OH	N	N	
1	Bradley, Heather	Bradley, Heather	03/25/18	1	Y	1340 Andrus St, Akron, OH	N	N	
1	Bretz, Gary	Bretz, Gary	02/27/19	1	Y	653 Reynolds Rd, Snifton, OH	N	N	
1	Bretz, Michael	Bretz, Michael	02/27/19	1	Y	6608 Twp Rd 131, McComb, OH	N	N	
1	Brooks, Bryant	Brooks, Bryant	03/07/19	1	Y	1870 Galatia Rd., North Baltimore, OH	N	N	
1	Brown, Beverly	Brown, Beverly	07/22/19	1	Y	329 Bowman St., Mansfield, OH	N	N	
1	Brown, Joe	Brown, Joe	05/16/19	1	Y	15055 E. Co. Rd. 24, Bellevue, OH	Y		
1	Burnan, Brendan	Burnan, Brendan	04/08/19	1	Y	2140 Milestone Dr, Findlay, OH	N	N	
1	Burnholder, Sharon	Burnholder, Sharon	01/23/18	1	Y	3824 Belmont Ave, Cleveland, OH	N	N	
1	Burnholder, Vernon	Burnholder, Vernon	08/18/18	1	Y	5630 Bismark Rd., Bellevue, OH	N	N	
1	Burnholder, Vernon	Burnholder, Vernon	09/11/18	1	Y	7564 E. Twp. Rd. 130, Republic, OH	Y		
1	Burns, Allison	Burns, Allison	07/03/19	1	Y	7564 E. Twp. Rd. 130, Republic, OH	Y		
1	Byers, MaryDeh	Byers, MaryDeh	07/23/19	1	Y	7894 E. Twp. Rd. 130, Republic, OH	Y		
1	Byers, MaryDeh	Byers, MaryDeh	08/21/19	1	Y	6895 Co. Rd. 6, New Regal, OH	Y		
1	Carles, Garrett	Carles, Garrett	02/06/19	1	Y	6180 E. Twp Rd 8, Republic, OH	Y		
1	Carothers, Sandy	Carothers, Sandy	08/20/19	1	Y	207 Poplar St., North Baltimore, OH	N	N	
1	Cathright, Carolyn	Cathright, Carolyn	03/09/18	1	Y	633 Vine St, Clyde, OH	N	N	
1	Caull, Heather	Caull, Heather	03/01/19	1	Y	137 Harvest Lane, Tiffin, OH	Y		
1	Chambers, Bruce	Chambers, Bruce	05/13/19	1	Y	1918 Huntington Dr., Findlay, OH	N	N	
1	Chaugra, Mario	Chaugra, Mario	01/28/18	1	Y	1730 Port Clinton Rd, Fremont, OH	N	N	
1	Chauvey, Greg	Chauvey, Greg	01/28/19	1	Y	14895 Co. Rd. 3, Carey, OH	N	N	
1	Cleveland, Erik	Cleveland, Erik	07/02/18	1	Y	8239 S. St. Rt. 53, McCutchenville, OH	Y		
1	Cleveland, Erik	Cleveland, Erik	08/13/18	1	Y	5081 E. Co. Rd. 44, Green Springs, OH	Y		
1	Cleveland, Erik	Cleveland, Erik	02/05/18	1	Y	5081 E. Co. Rd. 44, Green Springs, OH	Y		
1	Cleveland, Erik	Cleveland, Erik	02/05/18	1	Y	5081 E. Co. Rd. 44, Green Springs, OH	Y		
1	Combs, T-Ray	Combs, T-Ray	05/13/19	1	Y	47 Gary Ln, Tiffin, OH	N	N	
1	Connell, Matthew	Connell, Matthew	03/20/19	1	Y	10453 Spencer Lane, (Axxon ph #)	N	N	
1	Cope, Derek	Cope, Derek	04/23/19	1	Y	PO Box 602511, Cleveland, OH	N	N	
1	Crosby, Jeff	Crosby, Jeff	05/24/19	1	Y	Crosby, TX	N	N	
1	Crum, Paula	Crum, Paula	06/18/18	1	Y	5108 S. Co. Rd. 43, Tiffin, OH 44883	Y		*As a resident of the area* but from Crosby, TX
1	Crum, Paula	Crum, Paula	09/18/18	1	Y	5108 S. Co. Rd. 43, Tiffin, OH 44883	Y		
1	Daniels, Bill	Daniels, Bill	02/03/19	1	Y	102 N. Kline St., North Baltimore, OH	N	N	
1	Daniels, Rocco	Daniels, Rocco	07/29/19	1	Y	21 Memorial Dr, Berlin Heights, OH	N	N	



Same letter submitted twice on the same date with 2 different addresses (1st address is location of Whitpool plan in Findlay)

2 form letters submitted to OPSSB on the same day

As a resident of the area but from Crosby, TX

#	People	Name	Date	Comment Filed	#	Comments	Form Letter?	In Seneca Co.?	HumanSand. Co.?	Notes
1	1	Dannenberg, Larry	07/24/19		1	4175 N. US Highway 23, Fostoria, OH	Y	Y		
1	1	DeAngel, Arnold	01/23/18		1	2640 N. Twp. Rd. 165, Tiffin, OH	Y	Y		
1	1	Dewald, Betsy	07/29/19		1	792 Twp Rd 113, Tiffin, OH	Y	Y		
1	1	Dible, Tiffany	05/09/18		1	7446 N. Twp. Rd. 69, Kansas, OH	Y	Y		
1	1	Dickman, Roger	07/22/19		1	3872 Mead Rd, Monroeville, OH	N	N		
1	1	Dillon, Deborah	02/28/19		1	6040 Co. Rd. 113, Bellevue, OH	N	N		
1	1	Dillon, Bill	03/05/18		1	6554 Seal Rd, Bellevue, OH	N	Y		LTE shared with OPSB by Keith Meyers
1	1	Dinger, Gary	04/08/19		1	4889 W 147 th St, Cleveland, OH	N	N		
1	1	Dinger, David	04/05/19		1	7631 St. Rt. 4, Aurora, OH	N	N		
1	1	Dunfee, Gert	07/29/19		1	419 Indiana Ave, Sandusky, OH	N	N		
1	1	Eaton, Maynard	07/25/19		1	533 S Main St, Fostoria, OH	N	N		
1	1	Eaton, Gayle	08/23/19		1	3854 Park Overlook Dr, Beaver Creek, OH	N	N		
1	1	Estleman, Richard	07/22/19		1	987 Co. Rd. 260, Clyde, OH	N	Y		
1	1	Evans, Lynda	08/20/19		1	5911 Columbus Ave, Sandusky, OH	N	N		
1	1	Ferguson, Nadina	05/09/18		1	208 N. Union St., Fostoria, OH	N	N		
1	1	Fisher, Shane	04/26/19		1	1639 Amber Ave SW, Canton, OH	Y	N		
1	1	Forman, Jessica	08/23/19		1	7414 Twp Rd 163, Bloomville, OH	Y	N		
1	1	Foster, Annette	07/29/19		1	315 Parkway Dr., Bowling Green, OH	N	N		
1	1	Francis, Brian	01/09/19		1	Sandusky, OH	N	N		
1	1	Fritz, Deb	09/18/18		1	281 Section Line Rd. 305, Willard, OH	N	Y		for Laborers' Union Local 480
1	1	Fritz, Patrick	09/24/18		1	281 Section Line Rd. 305, Willard, OH	N	Y		
1	1	Gargner, Nicholas	06/08/18		1	no search results				Same letter submitted to OPSB twice on same date
1	1	Garcia, Theresa	02/13/18		1	11128 Braddock St, Canal Fulton, OH	N	N		
1	1	Gaug, Sam	03/14/18		1	3687 Wood Rd, (Madison Pk #)	N	N		
1	1	Gibb, Connor	04/08/19		1	1670 Swiss Rd, Fremont, OH	N	Y		
1	1	Gillenwater, Debra	05/21/19		1	565 W. Reagan Pkwy, Medina, OH	N	N		
1	1	Goeng, Edward	04/23/19		1	216 Poplar St., North Baltimore, OH	N	N		
1	1	Hagenberger, Joshua	02/19/19		1	6185 Greenfield Section Ln Rd, Willard, OH	Y	Y		
1	1	Hahler, Ben	09/18/18		1	6185 Greenfield Section Ln Rd, Willard, OH	N	Y		
1	1	Hahler, Ben	07/22/19		1	7844 W. Law Rd, Valley City, OH	N	N		
1	1	Hanes, Kyle	04/23/19		1	Tiffin, OH	N	N		
1	1	Heidelberg Univ. Greenhouse Club	04/17/18		1	975 Monroe St Apt 154, Bellevue, OH	N	Y		
1	1	Herral, Randy	06/21/19		1	2408 Dogtown, Monroeville, OH	N	Y		
1	1	Herman, Eric	09/18/18		1	461 W Lytle St, Fostoria, OH	N	N		
1	1	Hoffert, Holly	07/30/19		1	5146 Co Rd 12, Bloomville, OH	Y	N		
1	1	Hoffert, Tonia	07/29/19		1	128 Schonhardt St., Tiffin, OH	Y	Y		
1	1	Hoffman, Drew	03/14/19		1	3241 N. Co. Rd. 27, Bellevue, OH	Y	Y		
1	1	Holmes, Anthony	06/22/18		1	2743 S. St. Rt. 4, Aurora, OH	Y	Y		
1	1	Holmes, Jacob	06/22/18		1	2 Jennifer Holmes in Seneca Co.	Y	Y		
1	1	Holmes, Jenny	08/31/18		1	1795 Ellison-Trowbridge Rd, Elmore, OH	N	N		(assumed residence in Seneca County)
1	1	Holmes, Lawrence	02/13/18		1	1795 Ellison-Trowbridge Rd, Elmore, OH	N	N		Same letter submitted to OPSB twice on same date
1	1	Holmes, Lawrence	03/08/18		1	1795 Ellison-Trowbridge Rd, Elmore, OH	N	N		
1	1	Holmes, Timothy	07/01/19		1	2145 N. Co Rd. 27, Republic, OH	Y	Y		
1	1	Holmes, Timothy	06/29/18		1	2145 N. Co Rd. 27, Republic, OH	Y	Y		
1	1	Hopple, Suzanne	07/01/19		1	2569 N. Twp. Rd. 179, Republic, OH	N	N		
1	1	Howard, Kevin	06/19/18		1	152 Liberty St, Ridgeway, OH	N	Y		
1	1	Hoy, Sten	03/19/19		1	117 W Yeasting St, Gibsonburg, OH	N	N		
1	1	Hudacsek, Donna	07/24/19		1	1875 N. Twp. Rd. 179, Republic, OH	N	N		
1	1	Hudacsek, Jim	04/18/19		1	323 E. Maple St., North Baltimore, OH	N	N		
1	1	Hutchison, Jim	03/08/19		1	229 Meimore St., Tiffin, OH	Y	Y		
1	1	Huth, Charles	08/13/18		1	229 Meimore St., Tiffin, OH	Y	Y		
1	1	Huth, Charles	08/24/18		1	229 Meimore St., Tiffin, OH	Y	Y		
1	1	Huth, Charles	03/07/19		1	4213 Limerick Rd, Clyde, OH	N	Y		
1	1	Huth, Charles	07/30/19		1	5593 S. US 23, Alvada, OH	N	N		
1	1	James, Joshua	02/21/19		1	501 Adams Ave, Huron, OH	N	N		
1	1	Johnson, Logan	07/29/19		1		N	N		
1	1	Jones, John	07/29/19		1		N	N		

Sheet1

# People	Name	Date Comment Filed	# Comments	Form Letter?	Residence	In Seneca Co.?	Huron/Sand Co.?	Notes
1	Jones, Tyler	04/23/19	1	Y	333 Linden St, Ravenna, OH	N	N	
1	Jordan, Rich	03/01/19	1	Y	181 Dolet Rd., Middle Bass, OH	N	N	
1	JterVeen, Susan	07/22/19	1	Y	2065 Section Line Rd 30, Willard, OH	N	N	
1	Kagy, Ronald	06/24/19	1	Y	9425 E Twp Rd 58, Bloomville, OH	N	Y	
1	Kelley, Heather	02/15/19	1	Y	703 Vernon Ave, Delaware, OH	N	N	
1	Kemp, Katherine	04/18/2019 & 5/9/19	1	Y	2779 Section Line Rd, Bellevue, OH	N	Y	Same letter submitted to OPSB on two separate dates
1	Kiesel, Kathleen	09/18/18	1	Y	9964 E. Twp. Rd. 122, Republic, OH	Y		
1	Klapper, Glenn	07/03/19	1	Y	8649 Co Rd 23, Bellevue, OH	Y		
1	Klimesy, Joyce	07/02/18	1	Y	14748 Twp. Rd. 178, Bellevue, OH	Y		
1	Klimesy, Joyce	08/13/18	1	Y	14748 Twp. Rd. 178, Bellevue, OH	Y		
1	Klimesy, Joyce	09/24/18	1	Y	14748 Twp. Rd. 178, Bellevue, OH	Y		
1	Klimesy, Joyce	03/14/19	1	Y	14748 Twp. Rd. 178, Bellevue, OH	Y		
1	Klimesy, Joyce	06/24/19	1	Y	10769 E. St. Rt. 162, Republic, OH	Y		
1	Klimesy, Joyce	06/24/19	1	Y	10769 E. St. Rt. 162, Republic, OH	Y		
1	Klimesy, Joyce	03/06/19	1	N	103 Elm St., Bettsville, OH	Y		
1	Klimesy, Joyce	03/06/19	1	N	3571 W. 69 th St., Cleveland, OH	N		
1	Klimesy, Joyce	03/14/19	1	Y	98 Talmadge Rd., Kent, OH	N		
1	Klimesy, Joyce	03/06/19	1	Y	256 S Virginia Rd, Columbus, OH	N		
1	Klimesy, Joyce	07/29/19	1	Y	5295 St. Rt. 99, Monroeville, OH	N		
1	Klimesy, Joyce	02/13/18	1	Y	5295 St. Rt. 99, Monroeville, OH	N		
1	Klimesy, Joyce	03/09/18	1	Y	7066 Wyandot St., Harpers, OH	N		
1	Klimesy, Joyce	02/21/19	1	Y	4402 Cybourn Ave, Cleveland, OH	N		
1	Klimesy, Joyce	04/08/19	1	Y	2018 Co Rd 4, Rainpsun, OH	N		
1	Klimesy, Joyce	05/28/19	1	Y	address listed as "N/A"	N		
1	Klimesy, Joyce	03/22/19	1	Y	8759 W Twp Rd 172, Fostoria, OH	N		
1	Klimesy, Joyce	07/29/19	1	Y	5224 N. Twp. Rd. 179, Republic, OH	N		
1	Klimesy, Joyce	01/25/19	1	Y	1772 Co Rd 30, Tiffin, OH	Y		
1	Klimesy, Joyce	2/13/18 & 3/9/18	1	Y	1301 Festiva Ave, Findlay, OH	N		
1	Klimesy, Joyce	05/23/19	1	Y	3115 George Ave, Parma, OH	N		
1	Klimesy, Joyce	07/29/19	1	Y	249 N. Madison St, Republic, OH	Y		
1	Klimesy, Joyce	04/23/19	1	Y	2470 S. Co. Rd. 43, Republic, OH	Y		
1	Klimesy, Joyce	08/13/18	1	Y	4534 Co Rd 175, Clyde, OH	N		
1	Klimesy, Joyce	07/29/19	1	Y	4905 Burge Ave., Cleveland, OH	N		
1	Klimesy, Joyce	03/22/19	1	Y	11965 E. Twp. Rd. 8, Republic, OH	N		
1	Klimesy, Joyce	08/24/19	1	Y	4090 Clady Rd, Bloomville, OH	N		
1	Klimesy, Joyce	07/03/19	1	Y	4363 Rd. 15, Leipsic, OH	N		
1	Klimesy, Joyce	02/05/19	1	Y	415 Glenview Dr, Fostoria, OH	N		
1	Klimesy, Joyce	04/15/19	1	Y	5480 N. Twp. Rd. 78, Green Springs, OH	Y		Same letter submitted to OPSB twice on same date
1	Klimesy, Joyce	02/13/18	1	Y	5490 N. Twp. Rd. 78, Green Springs, OH	Y		Same letter submitted to OPSB on two separate dates
1	Klimesy, Joyce	03/09/2018 & 6/18/19	1	Y	904 Grand Pass, Sandusky, OH	N		
1	Klimesy, Joyce	05/09/19	1	Y	7227 Co. Hwy 2, McCutcheonville, OH	N		
1	Klimesy, Joyce	03/22/19	1	Y	581 E. Twp. Rd. 1194, Tiffin, OH	N		
1	Klimesy, Joyce	07/22/19	1	Y	581 E. Twp. Rd. 1194, Tiffin, OH	N		
1	Klimesy, Joyce	07/22/19	1	Y	1220 Tyler St, Sandusky, OH	N		
1	Klimesy, Joyce	05/21/19	1	Y	7853 E. Twp. Rd. 122, Republic, OH	Y		
1	Klimesy, Joyce	02/13/18	1	Y	1475 N. Twp Rd. 77, Republic, OH	Y		
1	Klimesy, Joyce	04/25/18	1	Y	1475 N. Twp Rd. 77, Republic, OH	Y		
1	Klimesy, Joyce	05/25/18	1	Y	1475 N. Twp Rd. 77, Republic, OH	Y		
1	Klimesy, Joyce	09/19/18	1	Y	1475 N. Twp Rd. 77, Republic, OH	Y		
1	Klimesy, Joyce	01/17/19	1	Y	1475 N. Twp Rd. 77, Republic, OH	Y		
1	Klimesy, Joyce	02/08/19	1	Y	1475 N. Twp Rd. 77, Republic, OH	Y		
1	Klimesy, Joyce	07/22/19	1	Y	1475 N. Twp Rd. 77, Republic, OH	Y		
1	Klimesy, Joyce	04/12/18	1	Y	7853 E. Twp. Rd. 122, Republic, OH	Y		
1	Klimesy, Joyce	05/29/18	1	Y	49 Minera St., Tiffin, OH 44883	Y		
1	Klimesy, Joyce	07/22/19	1	Y	49 Minera St., Tiffin, OH 44883	Y		
1	Klimesy, Joyce	08/12/18	1	Y	208 Spruce St., Sandusky, OH 44870	N		

2 form letters submitted to OPSB on the same day (one submitted twice on same date, so 3 submissions total on same date)

Union form letter, assumed not from Seneca County

from Defiance but letter says "I've lived in this area for 20 years"

Same letter submitted to OPSB twice on 2/13/18 & submitted again on 3/9/18

Seneca County is my home but address is in Crawford County

Same letter submitted to OPSB twice on same date

Same letter submitted to OPSB on two separate dates

Same letter submitted to OPSB twice on same date

# People	Name	Date Comment Filed	# Comments	Form Letter?	Residence	In Seneca Co.?	Huron/Sand Co.?	Notes
1	Miller, Kurtis	08/13/18	1	Y	13542 St. Rt. 162, Republic, OH	Y	Y	
1	Miller, Larry	04/18/19	1	Y	Gibsonburg, OH	N		
1	Miller, Melvin	07/22/19	1	Y	12418 Co. Rd. 6, Altica, OH	Y	Y	
1	Miller, Robert	09/24/18	1	Y	81 Brookhill Dr., Powell, OH	N	N	
1	Mills, Kyle	02/08/19	1	Y	212 N. Main St., Rawson, OH	N	N	
1	Milton, Thomas	04/23/19	1	Y	1289 Can'l Dr., Bedford, OH	N	N	
1	Mittoner, Mary Lou	07/02/18	1	Y	1157 E. Co. Rd. 24, Republic, OH	Y		
1	Moran, Stephen	04/24/19	1	Y	4538 W. 58 th St., Cleveland, OH	N	N	
1	Munnings, Scott	03/06/19	1	Y	6109 Eastview St., North Ridgeville, OH	N	N	
1	Murray, Brian	04/08/19	1	Y	27314 Maurer Dr., Olmstead Twp., OH	N	N	
1	Musko, Mary	04/12/18	1	Y	327 Cedar Point Rd., Sandusky, OH	N	N	
1	Nagy, Judy	07/25/19	1	Y	3005 Fox Rd., Sandusky, OH	N	N	
1	Nelis, Lois	05/18/19	1	Y	2820 Co Rd 181, Clyde, OH	N	Y	
1	Nelsen, Vickie	07/29/19	1	Y	523 N. Sandusky St., Tiffin, OH	Y		
1	Neumann, Tim	02/15/19	1	Y	411 Crystal Ave., Findlay, OH	N		
1	Nemkove, Doug	04/24/2018 & 8/19/18	1	Y	2139 S. Twp. Rd. 159, Tiffin, OH 44883	Y	N	Same letter submitted to OPSB on two separate dates
1	Neukovich, Matt	04/25/18	1	N	2139 S. Twp. Rd. 159, Tiffin, OH 44883	Y		
1	Novakovich, Matt	03/08/19	1	Y	11730 Christian Ave., Concord Twp., OH	N	N	
1	Oliver, James	03/13/18	1	Y	7500 E. Twp. Rd. 148, Republic, OH	Y		
1	Osborn, Robert	04/24/19	1	Y	141 Steele Ave., Painesville, OH	N	N	
1	Palmer, Mitchell	03/29/18	1	Y	2442 Jackson St., Lorain, OH	N	N	
1	Patterson, Brian	05/21/19	1	Y	18 Gary Ln., Tiffin, OH	Y		
1	Payne, Doubtas	05/21/19	1	Y	4431 Twp Rd 164, Green Springs, OH	Y		
1	Perry, Rodney	04/18/19	1	Y	85 Douglas St., Tiffin, OH	Y		
1	Pelkosek, Ed	03/08/19	1	Y	3268 W. 130 th , (Lakewood ph. #)	N	N	
1	Phillips, Robert	03/22/19	1	Y	5120 W 148 th , Brookpark, OH	N	N	
1	Pinion, Stanley, Emma	08/21/19	1	Y	2329 Co Rd 260, Clyde, OH	Y	Y	
1	Pound, Justin	03/14/18	1	Y	91 Radnor Ave. (Akron ph #)	N	N	
1	Rakes, Lori	07/22/19	1	Y	2976 Co. Rd. 181, Clyde, OH	Y	Y	
1	Rambreau, B.T.	03/06/19	1	Y	360 Fairwood, Berea, OH	N	N	
1	Raney, Wanda	05/09/19	1	Y	250 Howard St, Apt C, Bellevue, OH	N	Y	
1	Ramirez, Rick	04/01/19	1	Y	622 W 23 rd , Lorain, OH	N	Y	
1	Rannon, Francisco	07/29/19	1	Y	501 E. Center St., Bellevue, OH	N	Y	
1	Rathbun, Catherine	02/13/18	1	Y	1112 S. St. Rt. 19, Fremont, OH	N	Y	Same letter submitted to OPSB twice on same date
1	Reichoff, Logan	03/09/2018 & 6/19/18	1	Y	1112 S. St. Rt. 19, Fremont, OH	N	Y	Same letter submitted to OPSB twice on 2/13/18 & submitted again on 3/13/18
1	Ridenour, David	02/25/19	1	Y	13801 Leroy Ave., Cleveland, OH	N	N	
1	Riegel, Matt	05/13/19	1	Y	2707 Merimweather Rd., Sandusky, OH	N	N	
1	Riley, Browning	07/25/19	1	Y	10693 Twp Rd 178, Green Springs, OH	Y		
1	Rine, Jack	08/04/18	1	Y	34 McCollum St., Tiffin, OH	Y		
1	Rine, Robert	07/22/19	1	Y	10587 Co Rd 32, Green Springs, OH	Y		
1	Rine, Robert	02/13/18	1	Y	10442 E. Co. Rd. 34, Green Springs, OH	Y		Same letter submitted to OPSB twice on same date
1	Rine, Robert	06/12/4/19	1	Y	10442 E. Co. Rd. 34, Green Springs, OH	Y		
1	Robb, Joe	03/29/19	1	Y	13810 Old Pleasant Valley Rd, Middleburg Hts, OH	N	N	
1	Robinson, Ian	08/23/18	1	Y	Mead Rd., Bellevue (Monroeville)	Y		Mead Rd. addresses are Monroeville, but letter states Bellevue
2	Ronick, Dennis & Dawn	05/14/19	1	Y	1604 Bark Ln Dr, Fremont, OH	Y		
1	Ruffing, Don	02/13/18	1	Y	2 Don Ruffings in Seneca Co.	N		2 form letters submitted to OPSB on the same day (one submitted twice on same date, so 3 submissions total on same date)
1	Ruffing, Don	03/09/19	1	Y	2 Don Ruffings in Seneca Co.	N		
1	Sabbett, Matt	03/22/19	1	Y	706 E. 156 th , Cleveland, OH	N	N	
1	Saimmet, Deyk	01/23/19	1	Y	231 2 nd St., Sycamore, OH	N	N	
1	Saimmet, Roger	02/07/19	1	Y	5370 St. Rt. 199, Carey, OH	N	N	
1	Sandusky County Commissioners	12/20/17	1	N	Fremont, OH	N	N	
1	Schmopf, Dean	9/6/19 & 9/9/19	1	Y	3291 New Washington Rd, Bloomville, OH	N	N	Same letter submitted to OPSB on two separate dates
1	Schoemer, Stephen	02/13/18	1	Y	2533 Niver Rd., Willard, OH	N	Y	Same letter submitted to OPSB twice on same date
1	Schubach, Linda	07/22/19	1	Y	5621 N. Twp. Rd. 168, Green Springs, OH	Y		
1	Schubach, Thomas	02/13/2018, 3/9/18 & 7/5/18	1	Y	6785 N. Twp. Rd. 32, Clyde, OH	Y		Same letter submitted to OPSB twice on 2/13/18, submitted again on 3/9/18 & again on 7/5/18

#People	Name	Date Comment Filed	#Comments	Form Letter?	Residence	In Seneca Co.?	Huron/Sand Co.?	Notes
1	Schubach, Wynn	05/29/18	1	Y	5921 N. Twp. Rd. 169, Green Springs, OH	Y		
1	Schubach, Wynn	08/18/18	1	Y	5921 N. Twp. Rd. 169, Green Springs, OH	Y		
1	Schubach, Wynn	08/13/18	1	Y	5921 N. Twp. Rd. 169, Green Springs, OH	Y		
1	Schubach, Wynn	08/18/18	1	Y	5921 N. Twp. Rd. 169, Green Springs, OH	Y		
1	Schubach, Wynn	09/24/18	1	Y	5921 N. Twp. Rd. 169, Green Springs, OH	Y		
1	Schubach, Wynn	07/22/19	1	Y	5921 N. Twp. Rd. 169, Green Springs, OH	Y		
1	Schumacher, Shaun	06/19/18	1	Y	16074 E. Twp. Rd. 104, Attica, OH	Y		
1	Scott, Isaac	03/14/19	1	Y	13801 Leroy Ave., Cleveland, OH	N		
1	Scott, William	07/29/19	1	Y	960 Quail Dr., Fremont, OH	N		
1	Sedlar, Jonathan	07/18/18	1	N	Ithaca, Michigan	N		Wind Turbine Service Technician
1	Seneca County Commissioners	12/20/17	1	N	Tiffin, OH	Y		Dated March 2016, but not filed until Dec. 2017 (later rescinded)
1	Seneca Regional Planning Comm.	12/20/17	1	N	Tiffin, OH	Y		Dated 2016, but not filed until Dec. 2017
1	Shelley, Alvin	07/02/18	1	N	4782 St. Rt. 347, Bellevue, OH	N		
1	Shook, Ronald	07/22/19	1	Y	4513 St. Rt. 4, Attica, OH	Y		Same letter submitted to OPSB twice on same date
1	Shumway, Michael	02/13/18	1	Y	14568 E. Co. Rd. 34, Bellevue, OH	Y		Dated April 2016, but not filed until Dec. 2017
1	Shumway, Michael	03/09/18	1	Y	14568 E. Co. Rd. 34, Bellevue, OH	Y		"Seneca County is my home" but address is in Crawford County
1	SIEDC	12/20/17	1	N	Tiffin, OH	Y		
1	Siesel, Carl	07/22/19	1	Y	5520 Scott Rd., New Washington, OH	N		
1	Simon, Joshua	03/07/19	1	Y	409 North Second St., North Baltimore, OH	N		
1	Sims, Greg	04/07/19	1	Y	481 E. 149 th , Cleveland, OH	N		
1	Smith, Barn	10/15/18	1	Y	5793 Egypt Rd., Willard, OH	N		
1	Smith, Dottie	07/29/19	1	Y	8841 Twp Rd 108, New Regel, OH	Y		
1	Smith, Doug	06/20/18	1	N	3 Doug Smiths in Seneca Co.	Y		(assumed residence in Seneca County)
1	Smith, Harold Jr.	07/17/18	1	Y	9718 E. Twp. Rd. 122, Republic, OH	Y		Age 68 years, form letter states parent of a school age student
1	Smith, Harold Jr.	08/13/18	1	Y	9718 E. Twp. Rd. 122, Republic, OH	Y		2 form letters submitted to OPSB on the same day
1	Smith, Harold Jr.	09/18/18	1	Y	9718 E. Twp. Rd. 122, Republic, OH	Y		
1	Smith, Harold Jr.	07/22/19	1	Y	9718 E. Twp. Rd. 122, Republic, OH	Y		
1	Smith, Karen	05/21/18	1	N	12199 E. Twp. Rd. 148, Republic, OH	Y		
1	Smith, Katherine	07/22/19	1	Y	12199 E. Twp. Rd. 148, Republic, OH	Y		
1	Smith, Ron	07/22/19	1	Y	12199 E. Twp. Rd. 148, Republic, OH	Y		
1	Snaveley, Steve	09/18/18	1	Y	1599 N. St. Rt. 19, Republic, OH	Y		
1	Snaveley, Steve	07/03/19	1	Y	1599 N. St. Rt. 19, Republic, OH	Y		
1	Snaveley, Steve	09/18/18	1	Y	1599 N. St. Rt. 19, Republic, OH	Y		
1	Snaveley, Sue	05/08/19	1	Y	1599 N. St. Rt. 19, Republic, OH	Y		
1	Southwick, Jessica	01/28/19	1	Y	313 E. Stevenson St., Gileadburg, OH	N		
1	Spaile, Gary	01/23/18	1	Y	600 Lime St., Fremont, OH	N		
1	Spillai, Charndle	02/13/18	1	Y	23220 Chagrin Blvd. Apt 246, Beachwood, OH	N		States she just purchased a home in Huron County
1	Stacy, Jacob	03/08/19	1	Y	8580 N. Co. Rd. 51, Old Fort, OH	N		Same letter submitted to OPSB twice on same date
1	Stacy, Jacob	03/08/19	1	Y	6347 Avon Lake Rd., Spencer, OH	N		
1	Steinmetz, Gerard	10/15/18	1	Y	15394 E. Twp. Rd. 122, Republic, OH	Y		
1	Steinmetz, Kelly	05/14/19	1	Y	1082 Millbrook Dr., Fremont, OH	N		
1	Steinmetz, Roger	02/13/2018 & 3/13/18	1	Y	4080 N. Twp. Rd. 81, Bellevue, OH	Y		Same letter submitted to OPSB twice on 2/13/18 & submitted again on 3/13/18
1	Steinmetz, Roger	06/18/18	1	Y	4080 N. Twp. Rd. 81, Bellevue, OH	Y		
1	Steinmetz, Roger	06/24/18	1	Y	4080 N. Twp. Rd. 81, Bellevue, OH	Y		
1	Steinmetz, Roger	07/03/19	1	Y	4080 N. Twp. Rd. 81, Bellevue, OH	Y		
1	Steinmetz, Susan	07/03/19	1	Y	4080 N. Twp. Rd. 81, Bellevue, OH	Y		
1	Sterner, Edward	05/13/19	1	Y	4670 Peru Center Rd., Monroeville, OH	Y		
1	Stockmeister, John	08/13/18	1	Y	8780 E. Twp. Rd. 44, Bloomville, OH	N		
1	Straubaugh, Dustin	02/05/19	1	Y	8358 Co. Hwy. 5, McCutcheonville, OH	N		
1	Stucky, Kendall	03/09/2018 & 6/19/18	1	Y	219 Mohawk St., Tiffin, OH	N		Same letter submitted to OPSB on two separate dates
1	Stucky, Mary	07/22/19	1	Y	219 Mohawk St., Tiffin, OH	Y		
1	Studer, Kenneth	07/22/19	1	Y	4148 Cleary Rd., Bloomville, OH	N		
1	Swardz, Karen	04/21/18	1	Y	158 W. Crestview Lane, Tiffin, OH	N		"Seneca County is my home" but address is in Crawford County
1	Swardz, Karen	09/18/18	1	Y	158 W. Crestview Lane, Tiffin, OH	Y		

# People	Name	Date Comment Filed	# Comments	Form Letter?	Residence	In Seneca Co.?	Huron/Sand. Co.?	Notes
1	Swidas, Joshua	03/20/19	1	Y	38153 Erie Rd Apt B17, Wiloughby, OH	N	N	
1	Tango, Anthony	04/16/19	1	Y	address: line left blank	N	N	assumed non-Seneca County resident
1	Tate, Kay	04/16/18	1	Y	2230 S. Co. Rd. 43, Republic, OH	N	N	
1	Tate, Kay	08/13/18	1	Y	2230 S. Co. Rd. 43, Republic, OH	Y	Y	
1	Tate, Kay	08/18/18	1	Y	2230 S. Co. Rd. 43, Republic, OH	Y	Y	
1	Tate, Kay	10/15/18	1	Y	2230 S. Co. Rd. 43, Republic, OH	Y	Y	
1	Taylor, Jacob	04/28/19	1	Y	918 W. 23 rd St, Lorain, OH	N	N	
1	Taylor, Jo	07/29/19	1	Y	Tiffin, OH	N	N	cannot confirm individual, assumed Seneca Co. resident
1	Taylor, Sarah	01/23/19	1	N	Cleveland Heights, OH	N	N	windustrious.org
1	Thiel, Javon	02/15/19	1	Y	335 Spring St, Upper Sandusky, OH	N	N	
1	Thompson, Julia	06/12/19	1	Y	150 St. Rt. 4, Ataca, OH	Y	Y	
1	Thompson, Sean	05/13/19	1	Y	150 St. Rt. 4, Ataca, OH	Y	Y	
1	Thompson, Sean	06/24/19	1	Y	150 St. Rt. 4, Ataca, OH	Y	Y	
1	Toler, Marquis	03/08/19	1	Y	2547 Manchester Rd, Akron, OH	N	N	
1	Tomaiko, Matt	04/01/19	1	Y	1903 Pilgrim St, Avon, OH	N	N	
1	Tomecko, Dan	07/03/19	1	Y	4050 Clady Rd, Bloomville, OH	N	N	
1	Turner, Karl	07/29/19	1	Y	132 Western Ave, Findlay, OH	N	N	
1	Walters, Kathryn	09/24/18	1	Y	6556 N. St. Rt. 18, Clyde, OH	Y	Y	
1	Walters, Kathryn	07/22/18	1	Y	6556 N. St. Rt. 18, Clyde, OH	Y	Y	
1	Walters, Roger	02/13/18	1	Y	6556 N. St. Rt. 18, Clyde, OH	Y	Y	
1	Walters, Roger	03/09/18	1	Y	6556 N. St. Rt. 18, Clyde, OH	Y	Y	
1	Walters, Roger	10/15/18	1	Y	6556 N. St. Rt. 18, Clyde, OH	Y	Y	
1	Walters, Roger	07/22/19	1	Y	6556 N. St. Rt. 18, Clyde, OH	Y	Y	
1	Weaver, Donald	02/25/19	1	Y	910 St Rt 67, Republic, OH	Y	Y	
1	Weber, William	02/25/19	1	Y	14029 Walkins Rd., Marysville, OH	N	N	cannot confirm individual, assumed Sandusky Co. resident
1	Weiss, Shawn	02/13/19	1	Y	128 Liberty St, Ridgeway, OH	N	N	
1	Williams, Eric	07/29/19	1	Y	Clyde, OH	N	N	
1	Williams, Frances	07/22/19	1	Y	24 Town & County Dr, Tiffin, OH	Y	Y	
1	Williams, Kevin	08/24/19	1	Y	8611 Twp Rd 32, Clyde, OH	Y	Y	
1	Williams, Kevin	08/23/19	1	Y	8611 Twp Rd 32, Clyde, OH	Y	Y	
1	Williams, Leandra	01/23/19	1	Y	1048 Fairwood Ave., Marion, OH	N	N	from Marion but letter says "I've lived in this area for 30 years"
1	Williams, Thomas	09/24/18	1	Y	4111 N. Co. Rd. 33, Tiffin, OH	Y	Y	
1	Williams, Thomas	07/22/19	1	Y	4111 N. Co. Rd. 33, Tiffin, OH	Y	Y	
1	Wilson, Stacy	02/13/18	1	Y	1397 W. Co. Rd. 11, Tiffin, OH	Y	Y	Same letter submitted to OPSB twice on same date
1	Wiltanen, Michael	04/23/19	1	Y	8610 Island Rd., Graton, OH	N	N	
1	Wlodarski, Barbara	03/23/19	1	Y	1615 Gudy Top Ln, Canfield, OH	N	N	
1	Wlodarski, Scott	08/22/19	1	Y	19687 Luckey Rd, Pemberville, OH	N	N	
1	Wood, Dan	07/30/18	1	Y	100 Liberty St, Milan, OH	N	N	
1	Wright, Nelson	08/18/18	1	Y	9870 E. Twp. Rd. 138, Republic, OH	N	N	
1	Wurm, Harold	07/22/19	1	Y	Willard, OH	N	N	
1	Yongling, Mary	06/16/18	1	Y	4583 Prairie Rd., Bellevue, OH	N	N	Lives in Huron Co.
1	Yongling, Tom	03/08/18	1	Y	6247 Young Rd., Bellevue, OH	N	N	Lives in Huron Co.
1	Zeller, Gabriel	11/20/17	1	N	142 Columbus Ave., Sandusky	N	N	
1	Zenisek, Shella	07/30/19	1	Y	607 Thompson St., Fremont, OH	N	N	
1	Ziebel, Donald	07/03/19	1	Y	8327 N. Twp. Rd. 82, Bellevue, OH	Y	Y	
1	Zieser, Egg Farm	07/03/19	1	Y	15401 E. Co. Rd. 34, Bellevue, OH	Y	Y	
257			321	299	47.0%	151	200	62.3%
TOTAL PEOPLE			TOTAL COMMENTS	TOTAL FORM LETTERS	% Comments from Seneca County	SENECA COUNTY TOTAL	SENECA & NEIGHBORING TOTAL	% Comments from Seneca & Neighboring Counties

53.1%
% of supporting comments that are form letters

# People	Name	Date Comment Filed	# Comments	Form Letter?	Residence	In Seneca Co.?	Huron/Sand. Co.?	Notes
Opposing Project								
# People	Name	Date Comment Filed	#Comments	Form Letter?		In Seneca Co.?	Huron/Sand. Co.?	Notes
1	no name	02/22/19	1	N	Residence Bellevue, OH	Y		
1	-, Tanya	04/22/19	1	N	no address listed	Y		
1	Adams, Donna	07/17/18	1	N	200 3 rd Ave., Tiffin, OH	Y		
1	Adelsperger, Larry	07/22/19	1	N	380 Memore St., Tiffin, OH	Y		
1	Alchholz, Chris	10/12/18	1	N	5739 E. Twp. Rd. 58, Bloomville, OH	Y		on behalf of ACFN, LLC (shared with OPSB by D. Hudok)
1	Alchholz, Chris	05/20/19	1	N	5739 E. Twp. Rd. 58, Bloomville, OH	Y		
1	Allison, Charles	06/19/18	1	Y	442 E. Twp Rd. 28, Tiffin, OH	Y		LTE shared with OPSB by Diane Hudok
1	Bailey, Nancy	12/20/18	1	N	3 Northwood Dr., Tiffin, OH	Y		
1	Baker, Cody	04/05/18	1	N	6208 S. Co. Rd. 43, Tiffin, OH	Y		
1	Beck, Krista	03/08/19	1	N	Gordon Twp. Erie County	N		
1	Beckman, Carrie	06/19/18	1	Y	2010 N. Co. Rd. 43, Republic, OH	Y		
1	Berg, Robert	05/13/19	1	Y	800 E. Twp. Rd. 58, Tiffin, OH	Y		LTE shared with OPSB by Diane Hudok
1	Bernard, Luke	09/09/19	1	N	11609 St. Rt. 162, Republic, OH	Y		
1	Bisser, Nathan	06/19/18	1	N	4291 S. St. Rt. 19, Bloomville, OH	Y		
1	Bohner, Myra	02/13/19	1	N	Van Wert, Ohio	N		
1	Bond, Barbara	12/20/18	1	N	221 E. Market St., Tiffin, OH	Y		
2	Bowers, Jason & Marsha	03/08/19	1	N	8797 E. Twp. Rd. 148, Republic, OH	Y		
1	Breiner, Justin	07/16/18	1	Y	10487 E. US 224, Africa, OH	Y		
1	Brodman, Heidi	06/20/18	1	N	1546 S. Co. Rd. 43, Tiffin, OH	Y		
1	Brooks, Paul	02/28/19	1	N	15 N. Douglas St., Bloomville, OH	Y		
1	Brooks, Anna	01/23/19	1	N	15 N. Douglas St., Bloomville, OH	N		grew up in & wants to return to Seneca Co (LTE shared with OPSB by Diane Hudok)
1	Burkholder, Carol	02/02/18	1	N	6641 E. Twp. Rd. 130, Republic, OH	Y		
1	Burkholder, Carol	11/14/18	1	N	6641 E. Twp. Rd. 130, Republic, OH	Y		
1	Busssey, John	06/20/18	1	Y	3871 N. Twp. Rd. 81, Bellevue, OH	Y		
1	Busssey, Stacey	06/20/18	1	Y	3871 N. Twp. Rd. 81, Bellevue, OH	Y		
1	Chambers, Thomas OD	01/15/19	1	N	1754 E. Co. Rd. 6, Tiffin, OH	Y		
1	Chambers, Thomas OD	01/25/19	1	N	1754 E. Co. Rd. 6, Tiffin, OH	Y		
1	Chambers, Thomas OD	07/22/19	1	N	1754 E. Co. Rd. 6, Tiffin, OH	Y		shared with OPSB by D. Hudok
1	Chappel, Rob	06/19/18	1	Y	8475 E. Co. Rd. 38, Republic, OH	Y		
1	Cholekewitsch, James	08/26/19	1	Y	8475 E. Co. Rd. 38, Republic, OH	Y		
1	Cholekewitsch, Julie	07/13/18	1	Y	4263 E. Co. Rd. 50, Tiffin, OH	Y		
1	Cholekewitsch, Julie	07/13/18	1	Y	4263 E. Co. Rd. 50, Tiffin, OH	Y		
1	Clapp, Ryan	09/06/19	1	N	8351 N. Co. Rd. 28, Bellevue, OH	Y		
1	Clark, Dave	07/11/18	1	N	3750 Twp. Rd. 44, Sycamore, OH	Y		
1	Clark, Diane	06/20/18	1	N	2308 E. Co. Rd. 36, Tiffin, OH	Y		
1	Clark, Ed	05/31/18	1	N	3671 S. St. Rt. 231, Tiffin, OH	Y		
1	Clark, Ed	06/27/18	1	N	3671 S. St. Rt. 231, Tiffin, OH	Y		
1	Clark, Ed	06/27/18	1	N	3671 S. St. Rt. 231, Tiffin, OH	Y		
1	Clark, Ed	06/27/18	1	N	3671 S. St. Rt. 231, Tiffin, OH	Y		
1	Clark, Ed	07/11/18	1	N	3671 S. St. Rt. 231, Tiffin, OH	Y		
1	Clark, Ed	07/27/18	1	N	3671 S. St. Rt. 231, Tiffin, OH	Y		
1	Clark, Ed	08/01/18	1	N	3671 S. St. Rt. 231, Tiffin, OH	Y		
1	Clark, Ed	11/14/18	1	N	3671 S. St. Rt. 231, Tiffin, OH	Y		
1	Clark, Ed	01/18/19	1	N	3671 S. St. Rt. 231, Tiffin, OH	Y		
1	Clark, Ed	03/06/19	1	N	6651 S. St. Rt. 231, Tiffin, OH	Y		
1	Colman, Linda	09/25/2018 & 11/14/18	1	N	8037 E. Twp. Rd. 3, Republic, OH	Y		Same letter submitted to OPSB on two separate dates
2	Cooley, Charles & Victoria	03/13/19	1	N	5616 E. Co. Rd. 58, Bloomville, OH	Y		
1	Cook, Jason	12/05/18	1	N	5221 E. Co. Rd. 58, Bloomville, OH	Y		
1	Cornett, Tim	05/17/18	1	N	3335 S. Twp. Rd. 17, Tiffin, OH	Y		on behalf of Custom Design (shared with OPSB by D. Hudok)
1	Cornell, Stephen	07/11/18	1	N	3335 S. Twp. Rd. 17, Tiffin, OH	Y		
1	Cornell, Stephen	07/22/19	1	N	15113 Co. Rd. 8, Africa, OH	Y		
1	Cullery, Frank	04/01/19	1	N	9507 Barrill Ln, Kensington, MD	N		Owns land in Seneca Twp., Seneca County
1	Curran, Michael	12/14/18	1	N		N		

#	People	Name	Date Comment Filed	# Comments	Form Letter?	Residence	In Seneca		Huron/Sand	Notes
							Co. 2	Co. 2		
1	Curran, Michael		12/17/18	1	N	9507 Barroll Ln, Kensington, MD no search results	N			LTE shared with OPSB by Diane Hudock
2	Daniel, Jack		09/24/18	1	N	16702 Twp. Rd. 178, Bellevue, OH	Y			
1	DePolo, Matt & Meinda		04/10/19	1	Y	10615 E. Twp. Rd. 8, Republic, OH	Y			
1	Dillingham, Jim		06/20/18	1	N	10615 E. Twp. Rd. 8, Republic, OH	Y			
1	Dillingham, Jim		10/18/18	1	N	2386 S. Twp. Rd. 191, Bloomville, OH	Y			
1	Distel, Jim		09/19/18	1	N	255 W. Co. Rd. 6, Tiffin, OH	Y			
1	Drape, Andrea		08/13/18	1	N	423 Circular St., Tiffin, OH	Y			
1	Dulgar, Jane		06/19/18	1	N	2589 E. Twp. Rd. 86, Tiffin, OH	Y			
1	Edbert, Jeff		05/21/18	1	N	261 E. Co. Rd. 16, Tiffin, OH	Y			
1	Everhart, Steven		02/19/19	1	N	251 E. Co. Rd. 16, Tiffin, OH	Y			
1	Everhart, Steven		02/26/19	1	N	251 E. Co. Rd. 16, Tiffin, OH	Y			
1	Everhart, Steven		07/22/19	1	N	1121 E. Co. Rd. 16, Tiffin, OH	Y			
1	Everhart, Steven		12/17/18	1	N	3888 N. St. Rt. 269, Bellevue, OH	Y			
1	Feasel, Jim		03/19/19	1	N	732 E. Co. Rd. 16, Tiffin, OH	Y			
1	Feasel, Jim		07/22/19	1	N	3888 N. St. Rt. 269, Bellevue, OH	Y			
1	Felton, James MD		06/19/18	1	Y	no search results	Y			
1	Ferguson, Bernadette		06/19/18	1	Y	6465 Co. Rd. 219, Bellevue, OH	N			
1	Frederick, Brittany		04/23/19	1	N	5286 Sherman-Monvich Rd, Millard, OH	N	Y		
2	Fritz, James & Pamela		04/30/19	1	N	70 Minerva St., Tiffin, OH	N			
1	Fritz, Joseph		11/06/18	1	N	Green Springs, OH	Y			(passed away in Dec. 2016)
1	Garber, Richard		06/05/18	1	N	1831 W. Main St., Bellevue, OH	N			
1	Gibson, Jodi		03/07/19	1	N	3854 N. Twp. Rd. 175, Republic, OH	Y			
1	Gore, Jeanne		08/13/18	1	Y	12485 E. Co. Rd. 12, Altica, OH	Y			
1	Goske, Daniel		08/13/18	1	N	1480 S. Twp. Rd. 79, Republic, OH	Y			
1	Goske, Jennifer		06/20/18	1	N	9232 E. Co. Rd. 32, Green Springs, OH	Y			
1	Graham, Dora		07/17/18	1	Y	9232 E. Co. Rd. 32, Green Springs, OH	Y			
1	Graham, Joann		07/17/18	1	N	3980 Twp. Rd. 81, Bellevue, OH	Y			
1	Green, Stacy		02/25/19	1	N	7245 S. Co. Rd. 43, Bloomville, OH	Y			
1	Green, Stacy		03/14/19	1	N	3360 E. Co. Rd. 44, Green Springs, OH	Y			
1	Gross, Janet		01/23/19	1	N	6085 E. St. Rt. 18, Republic, OH	Y			
1	Groth, Charles		06/19/18	1	Y	7784 E. Co. Rd. 6, Bloomville, OH	Y			
1	Hamilton, DeAnne		09/19/18	1	N	7784 E. Co. Rd. 6, Bloomville, OH	Y			
1	Handstone, Lisa		06/20/18	1	Y	2956 N. Co. Rd. 27, Bellevue, OH	Y			
1	Hanzel, Bruce		06/20/18	1	Y	14040 E. Twp. Rd. 178, Bellevue	Y			
1	Hanzel, Kathy		06/13/18	1	N	14040 E. Twp. Rd. 178, Bellevue	Y			
1	Hasselbach, Jeffrey		01/08/18	1	N	14040 E. Twp. Rd. 178, Bellevue	Y			
1	Hay, Deb		06/20/18	1	N	14040 E. Twp. Rd. 178, Bellevue	Y			
1	Hay, Deb		06/14/19	1	Y	14040 E. Twp. Rd. 178, Bellevue	Y			
1	Hay, Deb		02/08/18	1	Y	14040 E. Twp. Rd. 178, Bellevue	Y			
1	Hay, Derek		03/05/18	1	Y	459 E. Co. Rd. 16, Tiffin, OH	Y			
1	Hay, Duane		07/13/18	1	Y	4697 S. Twp. Rd. 151, Tiffin, OH	Y			
1	Hayward, Bruce		06/20/18	1	Y	4697 S. Twp. Rd. 151, Tiffin, OH	Y			
1	Hayward, Bruce		06/20/18	1	Y	4234 Autumnwood Dr., Tiffin, OH	Y			
1	Hetzel, Ken		06/20/18	1	N	207 E. Perry St., Tiffin, OH	Y			
2	Himebaugh, Neal & Sharon		12/31/18	1	Y	6378 S. Twp. Rd. 151, Tiffin, OH	Y			
1	Hiser, Keetha		02/05/19	1	N	6378 S. Twp. Rd. 151, Tiffin, OH	Y			
1	Hiser, Richard		06/19/18	1	N	6305 S. Twp. Rd. 151, Tiffin, OH	Y			
1	Hiser, Sandra		02/05/19	1	N	5900 N. Twp. Rd. 175, Republic, OH	Y			
1	Hiser, Sandra		08/12/19	1	N	5900 N. Twp. Rd. 175, Republic, OH	Y			
1	Hoepf, Crystal		09/04/19	1	N	4600 N. St. Rt. 19, Republic, OH	Y			
1	Hoepf, Crystal		06/22/18	1	Y	4600 N. St. Rt. 19, Republic, OH	Y			
1	Hoepf, Dawn		06/13/18	1	N	5900 N. Twp. Rd. 175, Republic, OH	Y			
1	Hoepf, Dawn		07/09/18	1	N	4600 N. St. Rt. 19, Republic, OH	Y			
1	Hoepf, Gary		06/20/2018 & 6/22/18	1	N	4600 N. St. Rt. 19, Republic, OH	Y			
1	Hoepf, Gary		08/22/19	1	N	4600 N. St. Rt. 19, Republic, OH	Y			
1	Hoepf, Gary		06/20/2018 & 6/22/18	1	N	1957 N. Co. Rd. 27, Republic, OH	Y			
1	Hoepf, Michelle		03/05/19	1	N	7240 S. Co. Rd. 43, Bloomville, OH	Y			
1	Hoffen, Jim				N					

#People	Name	Date Comment Filed	#Comments	Form Letter?	Residence	In Seneca Co.?	Huron/Sand Co.?	Notes
1	Hoffert, Jim	05/20/19	1	N	7240 S. Co. Rd. 43, Bloomville, OH	Y		
1	Holmer, Steve	10/09/18	1	N	no search results	Y		
1	Holmes, Glenn	12/05/18	1	N	237 N. Kilbourne St., Republic, OH	Y		
1	Holmes, Glenn	01/02/19	1	N	237 N. Kilbourne St., Republic, OH	Y		LTE shared with OPSB by Diane Hudok Vice President of Policy, American Bird Conservancy
1	Holmes, Glenn	03/13/19	1	N	1450 E Co. Rd. 38, Tiffin, OH	Y		
1	Hoyda, Jeffrey DDS	07/22/19	1	N	2470 S. Co. Rd. 43, Republic, OH	Y		shared with OPSB by D. Hudok
1	Hunter, Pamela	06/18/18	1	N	4570 S. Twp. Rd. 165, Tiffin, OH	Y		
1	Hurley, David	08/21/18	1	N	1835 S Co Rd 18, Tiffin, OH	Y		
1	Hurley, Nancy	07/22/19	1	N	3025 Co. Rd. 44, Green Springs, OH	Y		on behalf of Irving Equipment (shared with OPSB by D. Hudok)
1	Irving, Joe	12/12/17	1	N	3025 Co. Rd. 44, Green Springs, OH	Y		
1	Jess, Gregg	02/20/18	1	N	3025 Co. Rd. 44, Green Springs, OH	Y		
1	Jess, Gregg	02/22/18	1	N	9140 E. Twp. Rd. 122, Republic, OH	Y		
1	Jess, Gregg	01/11/19	1	N	7735 Twp Rd 81, Bellevue, OH	Y		LTE shared with OPSB by Diane Hudok
1	Jones, Paul	09/09/19	1	N	1751 N. St. Rt. 18, Republic, OH	Y		
2	Jordan, Don & Bonnie	02/09/18	1	N	Sycamore St. Tiffin, OH	Y		
1	Kalb, Deanna	07/22/19	1	N	Oak Harbor, Ohio			
1	Kaitow, Andrew	10/09/18	1	N	6010 Co. Rd. 113, Bellevue	N	Y	
1	Kaufman, Kimberly	02/20/18	1	N	6010 Co. Rd. 113, Bellevue	N	Y	on behalf of National Machinery (shared with OPSB by D. Hudok)
1	Kelbley, Ronald & Karen	08/20/18	1	N	6010 Co. Rd. 113, Bellevue	N	Y	Executive Director, Black Swamp Bird Observatory
2	Kelbley, Ronald & Karen	01/11/18	1	N	11 Venice Hills Ct., Attica, OH	Y		
1	Kelbley, Karen	02/13/19	1	Y	11 Venice Hills Ct., Attica, OH	Y		
1	Kelley, Doug	06/25/18	1	N	2554 S. Twp. Rd. 197, Attica, OH	Y		
1	Kelley, Mandy	02/21/19	1	N	378 Letlar St., Tiffin, OH	Y		on behalf of Tiffin Store-N-Lock (shared with OPSB by D. Hudok)
1	Kennard, Robert & Sandy	07/22/19	1	N	4295 N. Twp. Rd. 175, Republic, OH	Y		
1	Kerschner, Mike	08/30/18	1	N	not enough information to determine	Y		
1	Kessler, Michelle	11/28/18	1	N	8454 S Twp Rd 131, McCutchenville, OH	Y		on behalf of Beercro (shared with OPSB by D. Hudok)
2	Kimmel, (family)	07/22/19	1	N	333 Sycamore St., Tiffin, OH	Y		on behalf of Beercro (shared with OPSB by D. Hudok)
1	Klepper, Kris	07/22/19	1	N	9232 E. Co. Rd. 32, Green Springs, OH	Y		
1	Klepper, Mike	07/17/18	1	N	16464 E. Twp. Rd. 178, Bellevue, OH	Y		
1	Klotz, Chad	06/20/18	1	N	1099 E. Co. Rd. 50, Tiffin, OH	Y		
1	Kubitz, Len	04/09/18	1	N	60 E. Co. Rd. 6, Tiffin, OH	Y		
1	Kuhn, Randy	06/20/18	1	N	5251 E. Co. Rd. 16, Tiffin, OH	Y		
1	Kuhn, Randy	02/12/19	1	N	3622 E. Co. Rd. 113, Green Springs, OH	N	Y	
1	Lawson, Aaron	06/19/18	1	N	16418 E. Twp. Rd. 9, Attica, OH	Y		
1	Laese, Kurt	7/16/18	1	Y	16418 E. Twp. Rd. 9, Attica, OH	Y		
1	Leibengood, Nathan	07/16/18	1	N	16418 E. Twp. Rd. 9, Attica, OH	Y		
1	Limbird, Catherine	03/19/19	1	N	2461 S Co Rd 15, Tiffin, OH	Y		on behalf of Tiffin Transportation LLC (shared with OPSB by D. Hudok)
1	Limbird, Catherine	07/17/18	1	N	349 Hedges St., Tiffin, OH	Y		on behalf of Tiffin Transportation LLC (shared with OPSB by D. Hudok)
1	Limbird, James	07/22/19	1	N	1405 S Twp Rd 159, Tiffin, OH	Y		shared with OPSB by D. Hudok
1	Malberger, Kevin	07/22/19	1	N	16436 E. Twp. Rd. 44, Attica, OH	Y		
1	Malberger, Tom	07/22/19	1	N	no search results	Y		
1	McClung, Bob DMV	06/07/18	1	N	6755 S. St. Rt. 231, Tiffin, OH	Y		Same letter submitted to OPSB on two separate dates
1	McConnell, Erin	06/20/18	1	N	9599 E. Co. Rd. 38, Republic, OH	Y		
1	McConnell, Shane	08/20/2018 & 6/22/18	1	N	7520 E. St. Rt. 19, Republic, OH	Y		
1	Messersmith, Linda	02/12/19	1	N	14411 U.S. Rt. 224, Attica, OH	Y		
1	Miller, Beth	08/13/18	1	N	8884 S. St. Rt. 231, Tiffin, OH	Y		
1	Miller, Kelley	07/13/18	1	N	8884 S. St. Rt. 231, Tiffin, OH	Y		
1	Miller, L. Gail	06/19/18	1	Y	324 Ellis Ave, Bellevue, OH	Y		
1	Miller, Linda	07/13/18	1	N	7355 N. Twp. Rd. 81, Bellevue, OH	Y	Y	Same letter submitted to OPSB on two separate dates
1	Miller, Loren	04/16/19	1	N	10216 E. Co. Rd. 24, Republic, OH	Y		
2	Miseler, Peggy	09/09/19	1	N	10216 E. Co. Rd. 24, Republic, OH	Y		
1	Morsner, Charles & Linda	06/20/2018 & 8/13/18	1	N	10216 E. Co. Rd. 24, Republic, OH	Y		two separate non-form comments filed on same day
2	Morsner, Linda	02/28/18	1	Y				
1	Mulligan, Steve & Linda	02/23/18	1	N				
1	Mulligan, Linda	05/17/18	1	N				
1	Mulligan, Linda	05/17/18	1	N				

# People	Name	Date Comment Filed	# Comments	Form Letter?	Residence	In Seneca Co.?	Huron/Sand Co.?	Notes
2	Mulligan, Linda	11/05/18	1	N	10216 E. Co. Rd. 24, Republic, OH	Y		
1	Myers, Lee & Valerie	07/26/18	1	N	1888 Co. Rd. 270, Clyde, OH	Y		
1	Neal, Francine	10/02/18	1	Y	778 E. Co. Rd. 50, Tiffin, OH	Y	Y	77 pages of detailed karst information
1	Neal, Jeffrey	10/02/18	1	N	7413 E. St. Rt. 18, Republic, OH	Y		
1	Neller, Craig	06/20/18	1	N	49 Oakbridge Pk, Tiffin, OH	Y		
2	Newman, Brad & Kris	07/22/19	1	Y	8137 S. St. Rt. 67, Sycamore, OH	Y		on behalf of Tiffin Aire Inc. (AT ad shared with OPSB by D. Hudock)
1	Nickles, Audrey	10/02/18	1	N	102 Broadway St., Republic, OH	Y		
2	Niederhoffer, Dennis & Linda	11/03/18	1	N	Bellevue, OH	Y		
1	Norman, Sally	04/18/19	1	N	8914 S. St. Rt. 100, Sycamore, OH	Y		
2	Oakleaf, Brad & Theresa	08/13/18	1	N	14581 Twp. Rd. 178, Bellevue, OH	Y		
1	Oney, Jennifer	08/13/18	1	N	14561 Twp. Rd. 178, Bellevue, OH	Y		
1	Oney, Kevin	02/22/19	1	N	1529 N. St. Rt. 19, Republic, OH	Y		
1	Owens, Ashley	06/20/2018 & 8/22/18	1	N	8539 E. Twp. Rd. 138, Republic, OH	Y		Same letter submitted to OPSB on two separate dates
1	Owens, Bob	02/13/19	1	N	1472 E. Co. Rd. 16, Tiffin, OH	Y		
1	Pardoe, Jennifer	08/21/18	1	N	4121 S Twp Rd22, Tiffin, OH	Y	Y	on behalf of Tiffin Transportation LLC (shared with OPSB by D. Hudock)
1	Paula, Tony	07/22/19	1	N	3336 Milloughby Rd., Willard, OH	Y		
1	Popa, Chris	02/21/19	1	Y	6438 S. Twp. Rd. 159, Tiffin, OH	Y		
1	Pope, Shanna	08/13/18	1	Y	310 W. Jefferson St, Republic, OH	Y		
1	Reesman, Theresa	06/20/18	1	N	6071 N. Co. Rd. 33, Tiffin, OH	Y		
1	Rennais, Garrison	07/16/18	1	N	7373 S. Twp. Rd. 17, Tiffin, OH 44883	Y		
2	Riedel, Tim & Christina	05/17/18	1	N	2625 St. Rt. 18 N, Republic, OH	Y		
1	Risner, Bob	02/12/19	1	N	5525 E. Twp. Rd. 106, Tiffin, OH	Y		
2	Routzahn, Mark & Diane	07/11/19	1	N	6305 S. Twp. Rd. 151, Tiffin, OH	Y		
1	Sampson, Jan	08/22/19	1	N	420 W Jamestown Ave, Tiffin, OH	Y		
1	Sampson, Jan	07/22/19	1	N	9730 E. Twp. Rd. 124, Republic, OH	Y		
1	SanGregory, Robert	06/18/18	1	Y	691 N. St. Rt. 18, Republic, OH	Y		
1	Schank, David	02/13/18	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Schlainger, Colin	06/20/18	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Schnee, Lori	02/13/19	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Schnee, Tom	02/21/18	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Schreiner, Sharon	03/25/19	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Schultz, Elaine	08/13/18	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Schultz, John	07/13/18	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Seaman, William	01/09/19	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Seliga, James	08/19/18	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Seneca County Commissioners	08/13/19	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Seneca County Commissioners	08/13/19	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Sheldcastle, Mark	10/06/18	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Shuff, Steve	07/22/19	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Silardi, Joe	01/23/19	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Silapine, Kathryn	02/06/19	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Smith, Adrienne	08/10/18	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Smith, Adrienne	08/13/18	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Smith, Greg	11/05/18	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Smith, Greg	12/17/18	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Smith, Greg	02/04/19	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Smith, Greg	02/05/19	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Smith, Jareen	06/20/18	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Smith, Jareen	01/29/19	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Smith, Madelyn	06/23/18	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Smith, Madelyn	01/29/19	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Smith, Mary	02/13/19	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Smith, Shelly	06/20/18	1	Y	4868 N. Tr 175, Republic, OH	Y		
1	Smith, Tom	06/13/18	1	Y	4868 N. Tr 175, Republic, OH	Y		
1	Sniffen, Dave	08/15/19	1	N	4868 N. Tr 175, Republic, OH	Y		
1	Sosalski, Rhoda	07/01/19	1	N	4868 N. Tr 175, Republic, OH	Y		

# People	Name	Date Comment Filed	# Comments	Form Letter?	Residence	In Seneca Co.?	Huron/Sand. Co.?	Notes
1	Starl, Lynndee	07/13/18	1	Y	2386 S. Twp. Rd. 181, Bloomville, OH	Y		
1	Stien, Kate	03/19/18	1	N	180 Lincoln Rd., Tiffin, OH	Y		
1	Steinmetz, James	03/18/19	1	N	10471 E. Co. Rd. 24, Republic, OH	Y		
2	Studen, Herman & Patricia	02/08/18	1	N	14271 E. Co. Rd. 34, Bellevue, OH	Y		
	Studen, Herman & Patricia	06/20/18	1	N	14271 E. Co. Rd. 34, Bellevue, OH	Y		
	Studer, Herman & Patricia	06/22/18	1	N	14271 E. Co. Rd. 34, Bellevue, OH	Y		
	Studer, Herman & Patricia	02/28/19	1	N	14271 E. Co. Rd. 34, Bellevue, OH	Y		
	Studer, Patricia	11/14/17	1	N	14271 E. Co. Rd. 34, Bellevue, OH	Y		
1	Taylor, Brittany	06/20/18	1	Y	10420 E. Twp. Rd. 122, Republic, OH	Y		
1	Taylor, Mark	06/20/18	1	N	510 S. Twp. Rd. 77, Republic, OH	Y		
1	Theis, Carol	11/21/18	1	N	442 S. Monroe St., Tiffin, OH	Y		
1	Trevino, Diane	10/25/18	1	N	227 Saint Francis Ave., Tiffin, OH	Y		
1	Turner, Susan Penny	10/25/18	1	N	Bellevue, OH	Y		
1	VanPeele, Beth	02/12/19	1	N	13740 Twp. Rd. 136, Bellevue, OH	Y		
1	Vogt, Christine	07/13/18	1	Y	13740 Twp. Rd. 136, Bellevue, OH	Y		
1	Vogt, Don	06/19/18	1	Y	13740 Twp. Rd. 136, Bellevue, OH	Y		
1	Voohtsees, Jason	06/19/18	1	N	124 N. Co. Rd. 43, Republic, OH	Y		
1	Voohtsees, Jason	08/13/18	1	Y	124 N. Co. Rd. 43, Republic, OH	Y		
1	Wagner, Jodelle	09/24/18	1	N	7433 S. Twp. Rd. 17, Tiffin, OH	Y		
1	Walton, Susan	06/07/18	1	N	640 E. Twp. Rd. 28, Tiffin, OH	Y		
2	Walton, Bob & Judy	12/20/18	1	N	640 E. Twp. Rd. 28, Tiffin, OH	Y		
1	Watson, Bob & Judy	06/05/18	1	N	11944 E. Twp. Rd. 122, Republic, OH	Y		
1	Watson, Mary K.	01/23/19	1	N	11944 E. Twp. Rd. 122, Republic, OH	Y		
1	Watson, Mary K.	07/18/18	1	Y	1370 E. Twp. Rd. 201, Tiffin, OH	Y		
1	Wensink, Gerry	04/05/19	1	N	Monroeville, OH	N	Y	
2	West, Anthony & Dian	06/05/18	1	N	3040 N. Twp. Rd. 155, Tiffin, OH	Y		
1	West, Travis	06/18/18	1	N	3040 N. Twp. Rd. 155, Tiffin, OH	Y		
1	Winegardner, Don	02/19/19	1	N	7470 E. St. Rd. 19, Republic, OH	Y		
1	Work, Michael	06/19/18	1	Y	3232 N. Twp. Rd. 155, Tiffin, OH	Y		
1	Wrean, Tim	01/02/19	1	N	Monroeville, OH	N	Y	
2	Wright, Nelson & Ann	03/05/18	1	Y	14750 E. Co. Rd. 34, Bellevue, OH	Y		
1	Wurm, Howard	11/05/18	1	N	Republic, OH	Y		
2	Wurm, Norman & Suele	06/27/18	1	N	11230 E. Co. Rd. 24, Republic, OH	Y		
1	Wurm, Norman	06/24/18	1	N	11230 E. Co. Rd. 24, Republic, OH	Y		
1	Zeman, Chris	06/25/18	1	N	6888 E. Twp. Rd. 138, Republic, OH	Y		
1	Ziebar, Jean	04/05/19	1	N	6888 E. Twp. Rd. 138, Republic, OH	Y		
1	Ziegler, Joyce	08/13/18	1	N	8327 N. Twp. Rd. 82, Bellevue, OH	Y		
2	Ziegler, Frederick & Kay	05/08/18	1	N	7551 S. Twp. Rd. 171, Bloomville, OH	Y		
	Ziegler, Frederick & Kay	02/18/19	1	N	7551 S. Twp. Rd. 171, Bloomville, OH	Y		
	Ziegler, Frederick & Kay	10/12/18	1	N	2091 S. Twp. Rd. 113, Tiffin, OH	Y		
	Ziegler, Frederick & Kay	01/23/19	1	N	2091 S. Twp. Rd. 113, Tiffin, OH	Y		
1	Zoeller, Fred	07/08/19	1	N	2091 S. Twp. Rd. 113, Tiffin, OH	Y		
	Zoeller, Fred	07/22/19	1	N	2300 S. St. Rd. 100, Tiffin, OH	Y		
229			267	60	89.1%	238	252	on behalf of Laminate Technologies (shared with OPSB by D. Hudock)
TOTAL PEOPLE			TOTAL COMMENTS	TOTAL FORM LETTERS	% Comments from Seneca County	SENECA COUNTY TOTAL	SENECA & NEIGHBORIN G TOTAL	% Comments from Seneca & Neighboring Counties

% of opposing comments that are form letters
22.5%

Neutral

# People	Name	Date Comment Filed	Form Letter?	Residence	In Seneca County?	Notes
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# People	Name	Date Comment Filed	# Comments	Form Letter?	Residence	In Seneca Co.?	Huron/Sand Co.?	Notes
1	No name Nehis, Lois Willard Schools Board of Education	08/13/19 11/30/17 03/08/19		N N N	not provided 2520 Co. Rd. 181, Clyde, OH 110 S. Myrtle Ave., Willard, OH	no no		various electrical industry documents States she supports wind energy, but implies she would move and hopes Apex would buy her house Rescind's stance taken on March 12, 2018

Notes

On 2/13/18 Apex filed 45 form letters in support, nearly every letter was filed twice with some filed 3x on the same date. Those 45 letters only had 21 signers.
On 3/6/18 Apex refilled 3 letters, each of which had already been filed in duplicate on 2/13/18 (thus these letters were filed 3x on two different dates)

Daniel White/4080 E. Twp. Rd. 58/Bloomville, OH 44818
Eden Twp.
Good evening, ladies and gentlemen and thank you for make the trip today.

OP38
Not in footprint
Is in viewshed

By now we are all very aware and informed on certain inalienable rights as ascribed in Article 1 of our Ohio Constitution.

I strongly believe the proposed Republic Wind project violates the constitutional rights of County residents, who reside in or near the project footprint, since in Ohio the local residents currently have little to no control of this process other than my offering, along with our fellow yellow brother's and sister's, testimony here tonight.

I object to the negative effects that 600+ ft. industrial wind turbines would have on: quality of life, public safety, negative impact on wildlife and the devaluation of property (both public and private). The fact that there are *documented cases of turbine blade failures where debris was thrown great distances that what our set back distances are, doesn't make any.....logical.....sense. I wonder how much further, with how much more velocity, greater point of impact and length of debris trail 600ft. wind turbines are capable of? Where is that study? If shorter than 400ft. turbines throw debris in excess of 1800ft., how much more dangerous are they at 600ft. tall? This is clearly a paramount public safety issue.

Additionally, with regard to our wildlife and spectacular local Seneca County parks and nature preserves, Ohio Department of Natural Resources and Seneca County Parks District have, based on field studies, requested a minimum 2.5 mile buffer radius to the nearest turbine in order to minimize the negative impact on migratory and year-round bird and animal flight and travel patterns, nesting and mating, insect and pollinator activity, etc (Anybody else not remember this part from their parent's "Bird's and the Bee's talk?") Funny right? Except it isn't!

Bowen Nature Preserve, located in Reed Township, is proposed to have ~~22~~ ^{21 (of approx. 47 in the total project)} turbines closer than the recommended 2.5 miles. Of these, 17 are 2 miles or closer, 13 are 1-1/3 mile or closer, 10 are less 1 mile, 6 are less than 1/2 mile and 4 are less than 1/3 of a mile. As overwhelmingly surrounded as this sounds, it might make sense to rename "The Alamo" Bowen

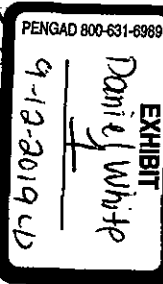
Two last thoughts to give your ears and minds a 7th inning stretch:

John Hancock, as president of the Continental Congress and 1st to sign the Declaration of Independence, signed large not because he was a braggadocious individual, but because England's King George III was reported to have such poor eyesight. John wanted to make sure George wouldn't need his glasses. We wear yellow to draw attention to a critical cause, to educate those who seek truth, to identify one to another, to knit together and build a patchwork quilt of community. And, well, you can't help but smile, radiate warmth and friendship and get at the task at hand in a yellow shirt.

Last thought:

The Native American people of the Iroquois had a way of making decisions that is a robust testament to the long view. When faced with a decision as a community they asked themselves "How will this course of action effect our people 7 generations from now?"

As a resident of Seneca County, I,...we....want to work towards what is good, right, true, noble and just. Often times at great cost in time, treasure and talent. I ask that you consider at least our next 30 years, our next generation and a half.



There is overwhelming opposition to this project in, both Seneca and Sandusky County, as attested by this evening's attendance of fellow yellow brothers and sisters.

I strongly...strongly...urge you to deny the construction certificate for this **specific** project, Republic Wind.

Thank you. God bless and have a safe drive home.

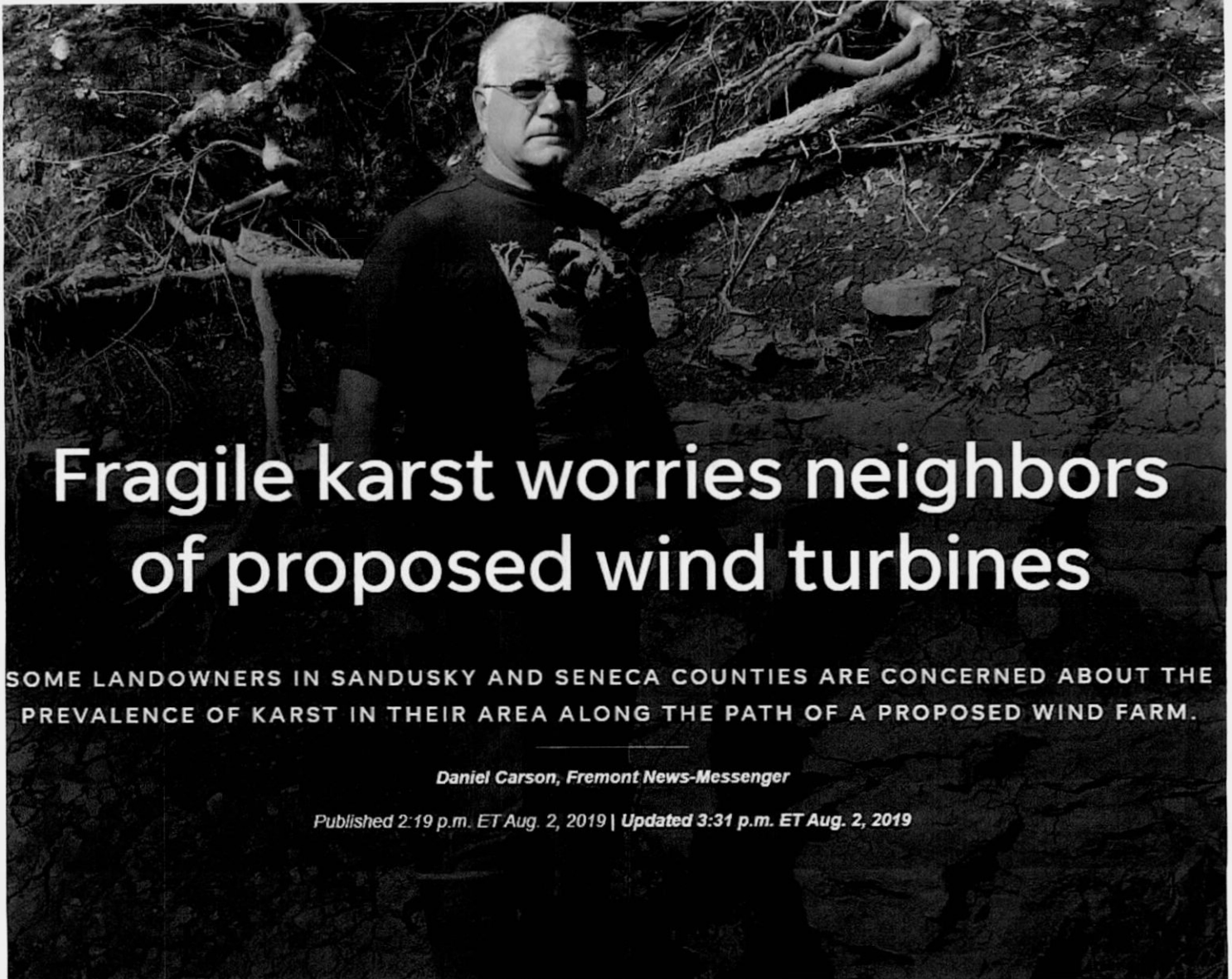
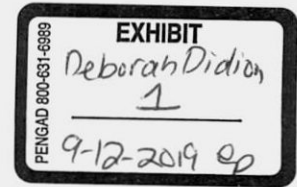
If challenged by legal counsel or Sitting Board:

*May, 2018...Ontario, Canada...debris thrown in excess of 1800' from a turbine only 382' high. How far can turbines 584-652' high throw? There are an average of 3800 blade failures **reported** per year globally, per *WindPower Engineering* magazine article.



Deborah Didion

EX. 1



Fragile karst worries neighbors of proposed wind turbines

SOME LANDOWNERS IN SANDUSKY AND SENECA COUNTIES ARE CONCERNED ABOUT THE PREVALENCE OF KARST IN THEIR AREA ALONG THE PATH OF A PROPOSED WIND FARM.

Daniel Carson, Fremont News-Messenger

Published 2:19 p.m. ET Aug. 2, 2019 | Updated 3:31 p.m. ET Aug. 2, 2019



AGI Environmental Awareness Series, 4

LIVING WITH KARST

A Fragile Foundation

George Veni

Harvey DuChene

Nicholas C. Crawford

Christopher G. Groves

George N. Huppert

Ernst H. Kastning

Rick Olson

Betty J. Wheeler

With a Foreword by
Philip E. LaMoreaux

American Geological Institute

in cooperation with

National Speleological Society
and

American Cave Conservation Association, Illinois Basin Consortium
National Park Service, U.S. Bureau of Land Management, USDA Forest Service
U.S. Fish and Wildlife Service, U.S. Geological Survey

YORK TOWNSHIP - To call Bellevue and its surrounding area Ohio's sinkhole capitol is not too much of stretch.

Sinkholes, disappearing streams, caves and springs are some of karst terrain's signature features, and these geologic hazards can be found throughout eastern Sandusky and Seneca counties.

So what will happen if these karst formations collide with proposed wind energy development in the region?

APEX Clean Energy says it will take great pains to build its proposed Republic Wind Farm around sensitive karst areas. The company's Republic plans include 47 turbines that could reach as high as 602 feet.

Sandusky County residents Deb and Casey Didion aren't convinced.

Every three or four years, water bubbles up from a Riddle Road karst area near the Didions' Bellevue home.

It forms a temporary lake on each side of elevated railroad tracks and floods the road.

Migratory birds find their way there and it's become a popular eBird hotspot on the Bellevue Birding Drive, a driving loop for birders that spans four counties.

Two of 47 proposed Republic Wind Farm industrial wind turbines are slated to go in a neighbor's corn field between the Didions' property and that karst area.

When earth is moved and concrete poured to build those turbine foundations, the Didions fear there will be catastrophic environmental impacts on well water systems, a massive redirection of the region's underground water flow and possible flooding if karst seams are fractured or filled.

"It's just fragile. You don't want to open them up. You don't want to plug them," Casey Didion said Monday, as he, his wife and Seneca Anti-Wind Union leader Deb Hay voiced their concerns about the turbines, karst and regional wind energy development in general.

Geotechnical process explained

The Republic Wind Farm project, as well as other proposed wind projects in Seneca, Sandusky, Erie and Huron counties, has generated fierce opposition from hundreds of landowners like the Didions.

APEX Clean Energy Spokesman Natasha Montague told the News-Messenger her company plans to start construction on the Republic project in 2020.

Ohio's Power and Siting Board still has not voted on whether to approve the Republic Wind field and there will likely be future public hearings locally and in Columbus this year on the project.

In an email, Montague laid out a series of steps she said the company takes to detect karst and avoid groundwater sources.

Apex is developing projects in areas of Oklahoma and Texas that have karst features, she noted.

Montague said Apex's geotechnical investigation process begins with preconstruction engineering, during which a third-party engineer conducts boring tests at turbine locations.

These tests help flag for the potential existence of karst.

If a turbine location is determined to be in a potential karst area, additional testing is conducted (such as electrical resistivity imaging or shear wave testing) to search for karst features.

Should the third-party engineer determine a location is unsuitable for turbine placement, a different turbine location will be activated, Montague said.

"Again, the geotechnical investigation begins long before preconstruction engineering. The groundwater hydrogeological and geotechnical report, which is included in our project application, is reviewed by the Ohio Power Siting Board prior to when we will begin borings," Montague said.

Montague said the typical and expected foundation of the turbine models under consideration in Apex's northern Ohio wind projects extend to a maximum depth of approximately 10 feet, which she described as not significant enough to impact groundwater.

She said turbines are intentionally sited away from wells and other water sources.

An OPSB staff report on the Republic project recommended that the agency's board authorize construction of the proposed wind farm, subject to 57 conditions.

The report noted that 27 of Apex's 47 proposed Republic turbines are situated in areas exhibiting karst features, according to the company.

Hay and the anti-wind union responded to the OPSB report and pointed out the 57 conditions identified by the state agency include: lack of appropriate siting for multiple turbines, interference with navigable airspace including air ambulance, interference with operations of the Seneca and Sandusky County airports, avoidance and mitigation of all existing microwave paths/licensed communication systems, multiple impacts to native wildlife, and concerns related to nighttime sound levels.

Her Seneca County home near Township Road 178 includes a karst area.

Hay showed the drop off in elevation as she stepped into vegetation that obscured her front yard sinkhole.

"If they change the flow of the water, I could have a lake in my front yard," Hay said.

Hay disputes Apex's assertions about turbine foundation construction and its impacts on groundwater.

She said wind companies will drive piles deep into the ground until they reach bedrock, disturbing multiple layers of black shale and limestone in the Bellevue karst region.

"And if they run into karst, they're just going to grout it. They're just going to fill it with rocks and stones," Hay said.



Deb Hay of the Seneca Anti-Wind Union is worried about construction of wind turbines over and around sensitive karst areas in Sandusky, Seneca and Erie counties.

(Photo: Daniel Carson/The News-Messenger)

Karst identified in Bellevue area

The Ohio Department of Natural Resources mapped nearly 1,000 karst areas in the Bellevue Quadrangle and parts of the Clyde and Castalia quadrangles in 2012 and 2013, with state geologist Douglas Aden producing a report on regional data he collected.

That includes the area near the Didions, who live on County Line Road.

The report's introduction includes the line, "different types of karst features may pose infrastructure complications, roads, utilities, houses and other facilities built in karst areas are at risk of subsidence, collapse and other damage."



Wind turbines in Findlay. APEX Clean Energy is planning to build up to 47 wind turbines in Sandusky and Seneca counties.

(Photo: File)

It's not hard to spot what Casey Didion called "karst tubes" in farm fields throughout the region, or trees and lower areas surrounded by vegetation that stick out like sore thumbs in fields otherwise filled with rows and rows of maturing corn stalks.

He pulled up to a friend's County Road 29 property in Seneca County and hiked back to show off a massive karst area.

"Some of these are as small as six to seven inches around and some of them get quite large, as some of these you can see," Didion said. "Seneca Caverns is a good example of one that goes down a long way."

Groundwater flows north through Bellevue's karst region.

Didion said the groundwater eventually makes its way to Lake Erie, going through the Blue Hole area in Castalia.



Riddle Road in Bellevue features an ODNR-identified karst area that has become an eBird hotspot for birders. A pair of Republic Wind Farm wind turbines have been proposed for the field south of the temporary lake formed in the karst area.

(Photo: Daniel Carson/The News-Messenger)

Previous flooding in Bellevue

Aden's 2013 ODNR report noted karst-related flooding that occurred in Bellevue in 2008.

ODNR's divisions of ground water and geological survey released an investigative report in 2009 that examined the unusual Bellevue flooding causes of the previous year.

On March 18, 2008, Bellevue-area groundwater levels rose to 40-year highs, with sinkholes acting as springs.

Kenn Rospert, a Bellevue resident who lives on Ohio 269, could have three proposed wind turbines from the Emerson Creek Wind project erected directly behind his property.

Rospert lives in Erie County. If he takes a walk across the street, he crosses over into Sandusky County.

Ohio 269 in front of Rospert's house remained closed for three months following the 2008 Bellevue floods.



This sinkhole in Seneca County is one of about 1,000 in the Bellevue karst region.

(Photo: Daniel Carson/The News-Messenger)

When there's an obstruction in the karst, the water just goes in all directions, Rospert said.

The ODNR investigative report recommended best management practices, such as sinkhole structures and grassed buffer strips and waterways, should be put in around sinkholes to minimize ground water contamination and to keep sinkholes open to prevent surface karst-related flooding.

Property owners like Rospert, the Didions and Hay rely on wells for water.

Jeannie Gore, a Bellevue business owner along U.S. 20, said well water contamination is one of her biggest fears with the proposed project.

"If wells get contaminated, we can't sell and move somewhere else. This is our home," Gore said.

In his backyard, Rospert's well also serves as an ODNR monitor site that records ground water levels.

Karst-generated pressure pushed Rospert's basement floor up during the 2008 flood

Rospert wonders what will happen to his well when wind companies start building turbine footers filled with 750 yards of concrete and 100 tons of steel.

"Once you start interrupting this water flow, residents are concerned they're going to lose their wells," Rospert said.

Montague said a stormwater permit is required by the National Pollutant Discharge Elimination System (NPDES) for the Republic Wind project.

She said this permit, administered by the Ohio Department of Natural Resources, ensures that proper stormwater controls are in place so construction can proceed in a way that protects a community's clean water and the surrounding environment.

Lori Riedy, owner of Russell's Flowers, Garden Center and Gifts on Ohio 269, operates her longtime family business a few blocks north of Rospert's home.

Her business depends on access to clean well water, as she has eight greenhouses of plants she waters on a regular basis.

When the 2008 flooding closed Ohio 269, Riedy was entering the busiest season of the year for her greenhouse.

"I've got greenhouses full of plants and nobody coming in to buy them," Riedy said.

Russell's Flowers closed for several days and Riedy helped sandbag other people's homes as she waited for floodwaters to recede in Bellevue.

ODNR's 2009 report noted that flooding due to upwelling ground water in the area in close proximity to Bellevue had happened only six times since 1800.

The last two occurrences prior to 2008 were in 1969 and 1937. All three of these occasions were in response to heavy precipitation events.

Riedy doesn't want wind turbine construction to result in plugged sinkholes and trigger a repeat of 2008's disaster.

"It's going to have an effect in our drainage and wells," she said.

Future of Republic Wind project

Apex will prepare a wind turbine assembly area by grading and removing vegetation within a maximum radius of 300 feet around each turbine location, according to the OPSB staff report.

The most likely type of turbine foundation would be a spread footing foundation. An alternative that could be used is a rock anchored pile-supported foundation, the company reported to the state agency.

The company projects the largest turbines in its Emerson Creek Wind project to produce pressure of approximately 1,050 pounds of pressure per square foot on surrounding earth and bedrock existing below the surface of turbine foundations.

In OPSB's staff report, the agency reported Apex's project area is comprised of

roughly 19,000 acres of leased private lands involving approximately 440 properties.

OPSB has not yet scheduled its next public hearing on the Republic project

Sandusky County commissioners voted July 25 to rescind the county's Alternative Energy Zone (AEZ), a move applauded by the anti-wind union and the Didions.

As the family waits to see how OPSB will rule on the Republic Wind project, Deb Didion said she and Casey have lived at their Sandusky County home for 33 years.

She understands why some area landowners signed leases with Apex, but didn't think the turbines were worth it to sign a similar lease.



These wind turbines are in Findlay. Apex Clean Energy is planning to build up to 47 wind turbines in Sandusky and Seneca counties.

(Photo: File)

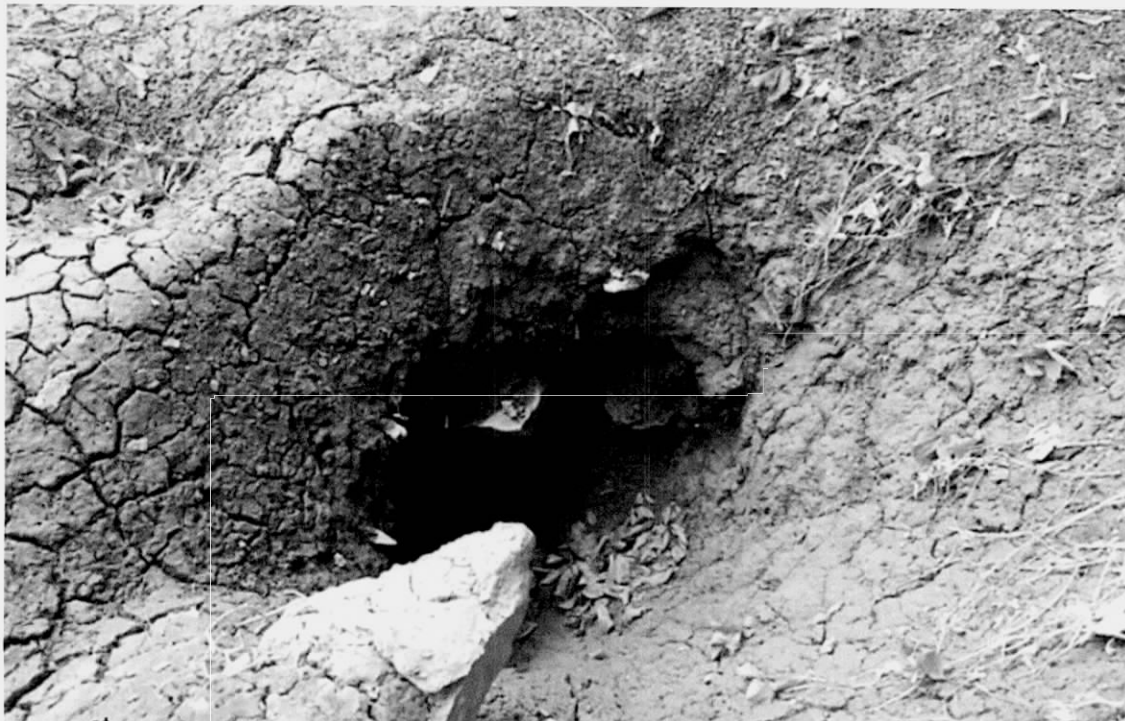
"You can gain all the money you want, but if it impacts your quality of life and lifestyle, it's not worth it," Didion said.

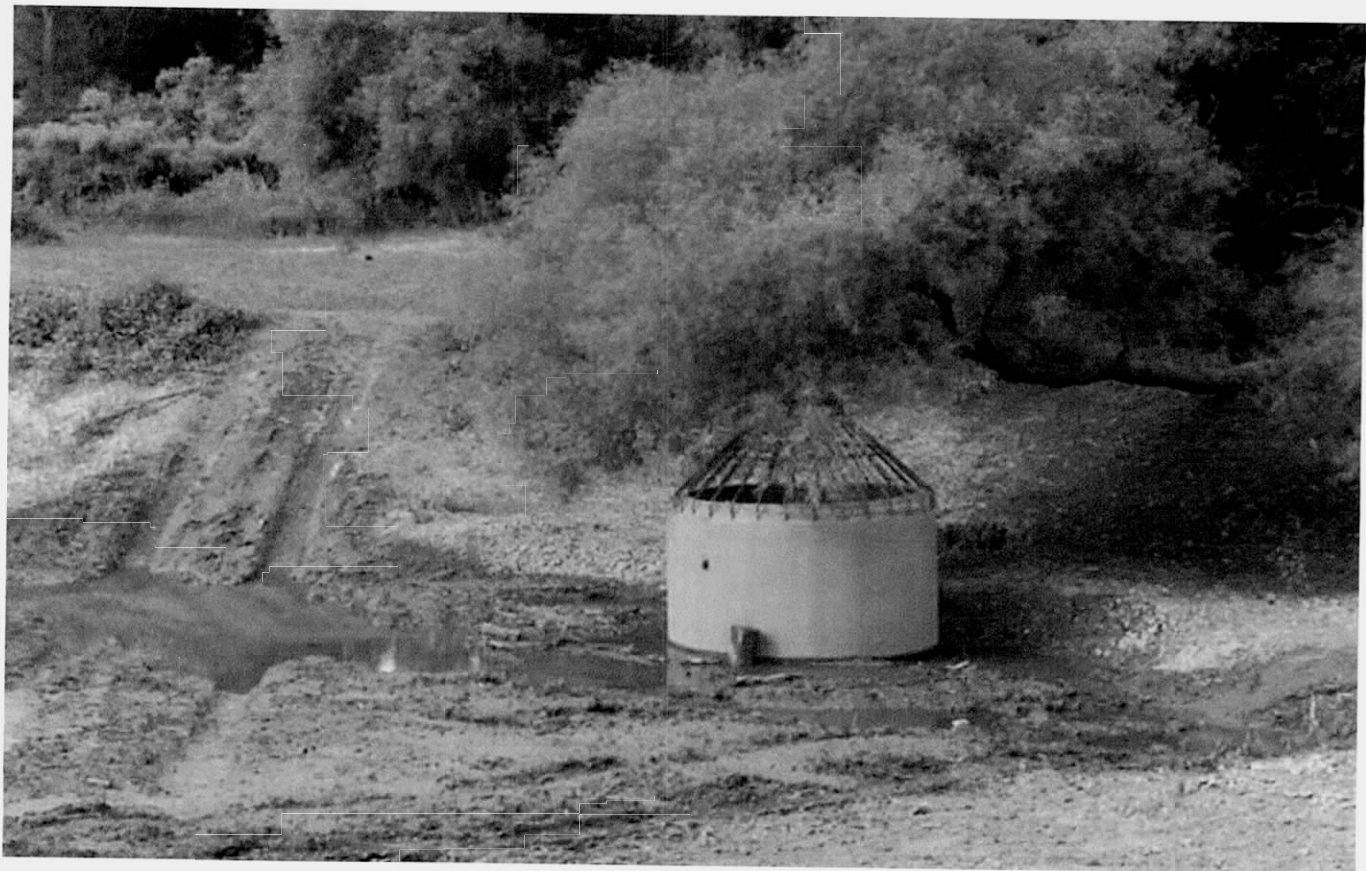
The proposed turbines prompted three of her nearby County Line Road neighbors to sell their homes and move away, Didion said.

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Deborah Didion

TESTIMONY

With respect to the Ohio Siting Board, I would like to start by reading your mission statement.

*"Our **mission** is to support sound energy policies that provide for the installation of energy capacity and transmission infrastructure for the benefit of the **Ohio** citizens, promoting the state's economic interests, and protecting the environment and land use."*

That is a strong powerful statement, "protecting the environment and land use". If you permit these wind turbines to be built over one of the most expansive karst in the state you will fall short of your mission statement.

There are many reasons to oppose the proposed wind turbines in Seneca, Sandusky, Erie, and Huron counties. I have not separated the counties because the karst that underlays those counties are one and the same.

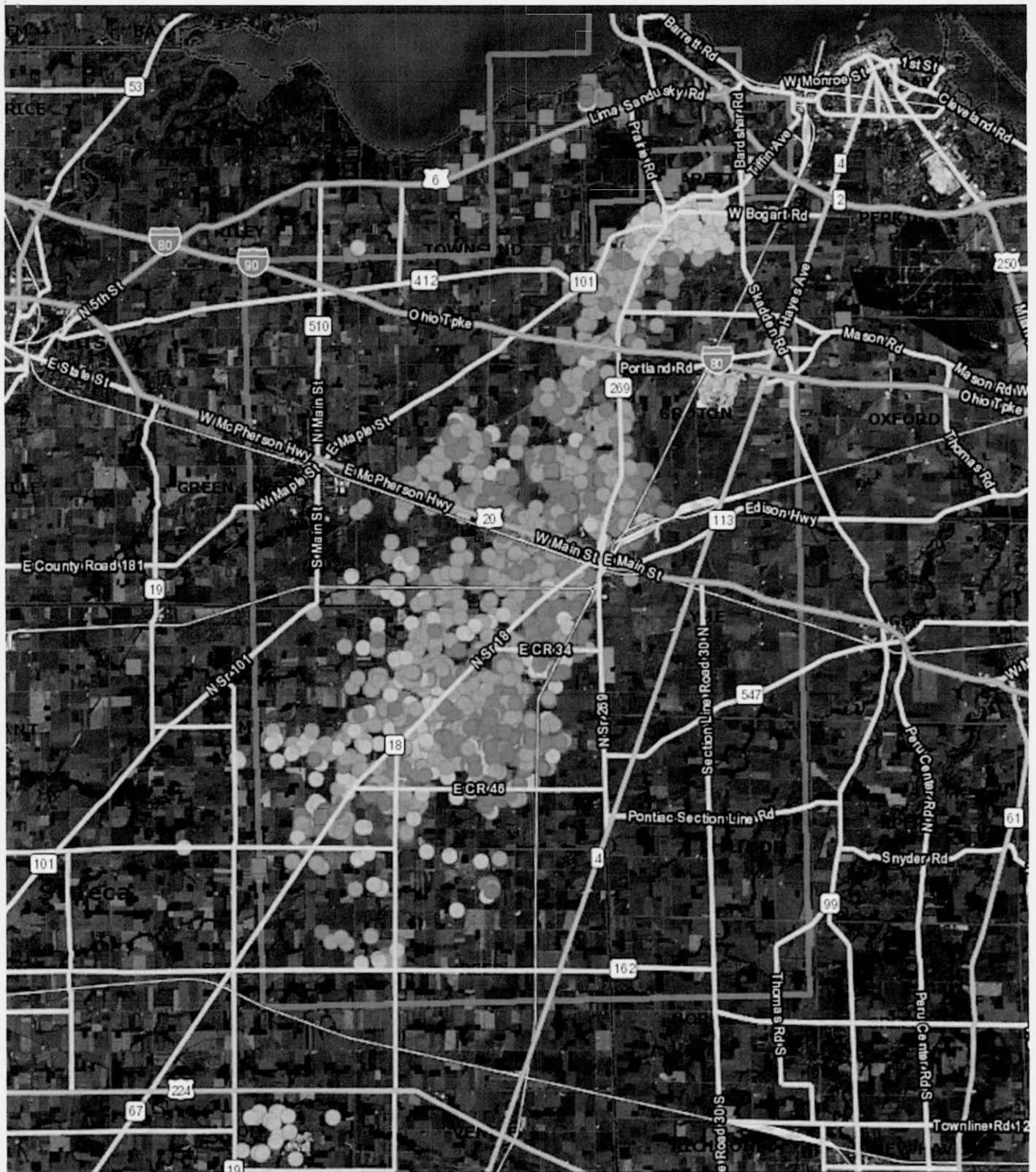
According to the American Geological Institute, "Karst areas are among the world's most diverse, fascinating, resource-rich, yet problematic terrains. They contain the largest springs and most productive groundwater supplies on Earth. .. many critical processes in karst occur underground, requiring monitoring of groundwater flow and exploration. They are also the landscapes most vulnerable to environmental impacts. Their groundwater is the most easily polluted.

Karst regions require special care to prevent contamination of vulnerable groundwater supplies and to avoid building in geologically hazardous areas. Living in karst environments may result in destabilization of the delicate equilibrium between surface and underground components of karst resulting in alteration of drainage patterns and increasing incidents of catastrophic sinkhole collapse, particularly in areas of unplanned urban growth. "

One of the best resources is our own Department of Natural Resources, which have studied the karst regions in Ohio and especially the four county area where the turbines are proposed to be built. The ODNR have multiple resources available to the public to learn about the karst area .If that were not enough, they have done a remarkable job putting an interactive karst map on their website that shows how extensive the karst area is.

There are hundreds if not thousands of articles explaining that building over a karst can be catastrophic. (I have brought two different resources for your viewing pleasure.) They explain the fragility of a karst system, how the aquifer system works within the karst system and the high risk of collapse and contamination to an ecosystem.

The aquifer that is within the karst area directly flows into Lake Erie. We already have seen the algae blooms that is what happens when farm chemicals, animal waste, and other pollutants make their way into a very delicate ecosystem.



Above is a screen shot of ODNR's interactive karst map. This screen shot includes Seneca, Sandusky, Erie, and Huron Counties. Underneath all those dots are either a field verified karst, suspected karst, and natural springs. This map is wonderful, as it shows the magnitude of the karst area that covers our four counties. Apex would like them to be divided by area but that is impossible because the four county area is one big karst! The next page shows one dot of the many dots above.

With the interactive program, from the ODNR, you can see that each dot has the potential to be massive. Each dot is interconnected in ways that you can't see from a dot on a map.

Interactive Karst Map from the ODNR



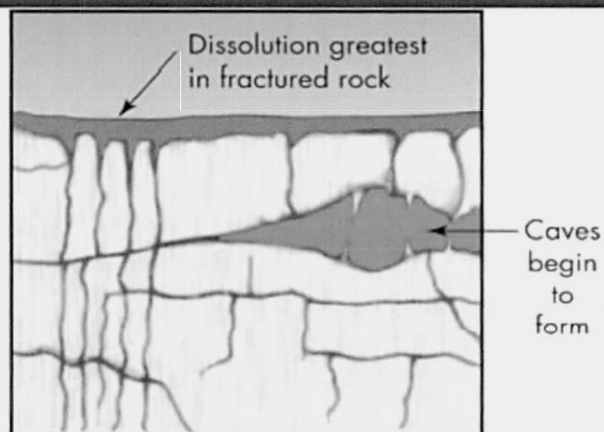
① Approximate location for 3 of the proposed wind turbines. ☆ Indicate private wells that draw off the karst above. The gray and brown areas are a screen shot of ODNR's interactive karst website. As you can see from this photo above the karst is extensive. Most of the karst is unseen from the surface. The aquifer system connects to other karst in the area.



This area is directly over the karst from the previous page. The surface water is a much smaller part of the actual karst. The blue dot also on the previous page reflects the location that these pictures were taken. The road closes yearly because of rain, this brings in some pretty amazing birds and has become an eBird hotspot for birders. Eagles have been spotted visiting the karst/aquifer area.

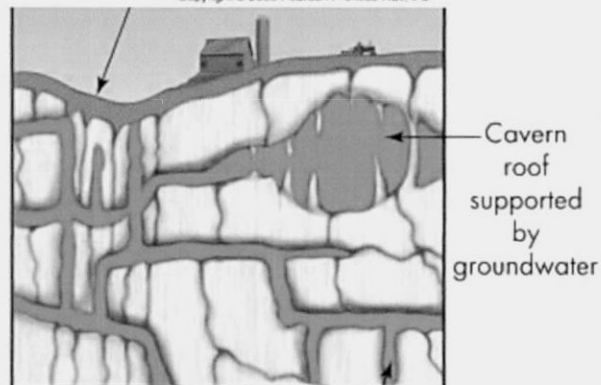
Sinkholes

- Groundwater dissolves soluble rock, creating fractures and caves.
- Dissolving continues to form larger caves and fractures.



(a)

Copyright © 2008 Pearson Prentice Hall, Inc.



(b)

Fractures enlarged by dissolution

Copyright © 2008 Pearson Prentice Hall, Inc.

You can visually see in the illustration above the fractures in the karst and how the underground aquifer system works. You can also visually see what makes our area so unstable.

The following are excerpts from the Fremont News Messenger article that was written by Daniel Carson and published Aug. 2, 2019. I have enclosed the article within this packet. Ms. Montague, APEX Clean Energy spokesperson, was interviewed via email and she stated that a "series of steps were laid out to detect karst and avoid groundwater sources." Had APEX checked with the ODNR they would have found extensive research regarding the karst region and how the ground water is affected when the karst is disturbed.

"APEX is developing projects in the Oklahoma and Texas that have karst features." Kenneth S. Johnson, William J. Bangsund, Neal A. Hines published an article regarding the risk in siting wind turbines in Blaine County, Oklahoma. "Catastrophic collapse of a wind turbine is clearly unacceptable, and minor settlement could also be a risk. Differential settlement by even 3 cm across a 15-m-wide turbine foundation could lead to the turbine tilting out of tolerance..."

I have done extensive research on the "developing projects", that is stated above, but have not found one turbine located over a karst in Oklahoma. There were some that were planned in 2017 but have never come to fruition. APEX is welcome to correct me if I am wrong.

"If a turbine location is determined to be in a potential karst area, additional testing is conducted,"

Our Ohio Department of Natural Resources has done an outstanding job of mapping Ohio's karst areas. I have enclosed in your packet a copy of the ODNR publication. As you can see by that publication, karst have been studied in Ohio since the 1980's. There is so much information on karst that I was able to gain multiple government sources stating that building over a karst can be catastrophic! Why would Apex choose one of the largest most vulnerable areas in Ohio to place 600 feet turbines on?

"The typical and expected foundation of the turbine models under consideration in northern Ohio wind projects extend to a maximum depth of approximately 10 feet, which she described as not significant enough to impact groundwater. Turbines are intentionally sited away from wells and other water sources."

Well Ms. Montague you do not understand how a karst and aquifer work. The soil filters the groundwater, it then filters through the karst into the aquifer system. ODNR states, "The many passageways formed in karst terrain allow for high connectivity between the land surface and the water table". The pilings that Apex will have to put in to stabilize the turbine can be up to 30 feet deep with multiple pilings on one turbine. Imagine the damage that will do to the karst system and aquifer system. You visually can see by the illustration provided what will happen if you start disturbing the karst and the aquifer system it supports. Also, existing turbines are 400 feet tall, ours will be 655 feet tall, you cannot compare foundations or make the claim the same type will work. That is physics, when something goes up the foundation must be larger.

Our own Department of Natural Resources has wonderful information for all of us. All academia versed in karst specifically mention how unstable the limestone is and how easily it is to destroy or contaminate an aquifer system. We have some of the best experts in the country, specifically the ODNR, versed in karst and aquifer systems and yet we are not listening to them. Sinking pilings into the ground will only fracture the karst even further and compromise the drinking water by letting groundwater go directly into the aquifer. You see how massive our karst is and it supplies fresh drinking water to thousands of residents within the four county area. How much will it cost to repair the damage that these turbines will do to the aquifer system? Once an ecosystem is destroyed you can not bring it back. This is a project that is so massive that it is beyond my comprehension, how this has even gotten this far in the process with the locations that they have proposed. This is much bigger than just putting up turbines this is our homes, our water sources, you can not put a monetary amount on that. We are talking the entire four county area is at critical risk. It's concerning to me that we are taking something that could be detrimental to our quality of life, water, and compromising its integrity. It's also concerning that we are talking about the money this project will bring. What will the cost be if hundreds if not thousands of wells are contaminated? What will the cost be if the 600+ turbines subside? I guarantee it will cost the state more money than these wind turbines will ever contribute to the great State of Ohio.

I respectfully ask that you deny the application of 17-2295-EL-BGN, Republic Wind Farm for the reasons stated above.

Deborah J. Didion

6040 County Road 113

Bellevue, Ohio 44811

Literature Cited

The following are websites that you can learn more about karst and aquifers and the impact they can have when disturbed.

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<https://www.usgs.gov/news/earthword-karst>

<https://karstwaters.org/educational-resources/water-quality/>

<https://www.americangeosciences.org/sites/default/files/karst.pdf>

<https://geosurvey.ohiodnr.gov/portals/geosurvey/PDFs/Karst/karstmap.pdf>

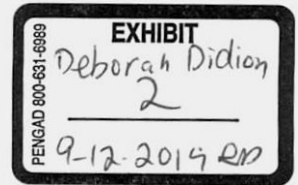
https://geosurvey.ohiodnr.gov/portals/geosurvey/PDFs/OpenFileReports/OFR_2013-1.pdf

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Deborah Didion EX. 2

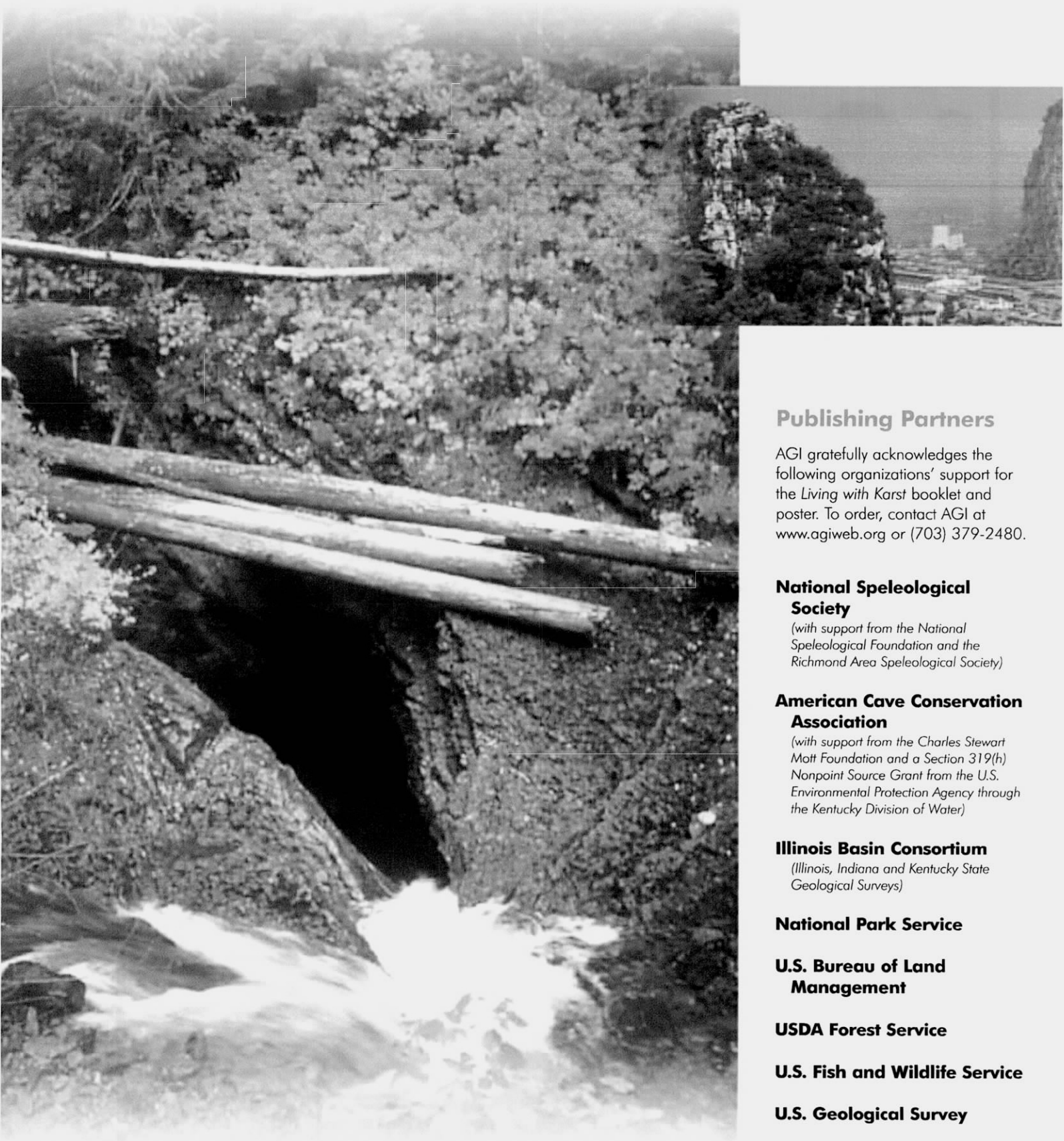


LIVING WITH KARST

A Fragile Foundation



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Illinois Basin Consortium

(Illinois, Indiana and Kentucky State Geological Surveys)

National Park Service

U.S. Bureau of Land Management

USDA Forest Service

U.S. Fish and Wildlife Service

U.S. Geological Survey

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Harvey R. DuChene, a petroleum geologist residing in Englewood, CO, has been studying caves throughout the world for over 35 years; he is particularly interested in sulfuric acid karst systems such as the Guadalupe Mountains of New Mexico and west Texas.

Nicholas Crawford, a professor in the Department of Geography and Geology and Director of the Center for Cave and Karst Studies at Western Kentucky University, has written over 200 articles and technical reports dealing with groundwater contamination of carbonate aquifers.

Christopher G. Groves is an associate professor and director of the Hoffman Environmental Research Institute at Western Kentucky University. His current work involves development of geochemical models to understand carbon cycling within karst landscape and aquifer systems. The Institute, hoffman.wku.edu, is working on a variety of cooperative karst-related research and educational programs.

Ernst H. Kastning is a professor of geology at Radford University in Radford, VA. As a hydrogeologist and geomorphologist, he has been actively studying karst processes and cavern development for over 30 years in geographically diverse settings with an emphasis on structural control of groundwater flow and landform development.

George Huppert is professor and chair of the Department of Geography and Earth Sciences at the University of Wisconsin at La Crosse. He has been active in researching karst management and conservation problems for over 30 years. He is also a life founding member and Vice President for Conservation of the American Cave Conservation Association.

Rickard A. Olson has served as the ecologist at Mammoth Cave National Park for the past seven years, and has conducted cave-related research on a variety of topics for the past 25 years. Most of his research efforts have been motivated by cave and karst conservation needs.

Betty Wheeler, a hydrogeologist in the Drinking Water Protection Section of the Minnesota Department of Health in St. Paul, has been studying karst groundwater processes for 17 years. She served as the book review editor for the *Journal of Cave and Karst Studies* for more than 10 years, and she is currently conducting susceptibility assessments of noncommunity public-water-supply wells throughout Minnesota.

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FOREWORD

Karst regions, areas underlain by limestone, dolomite, marble, gypsum, and salt, constitute about 25% of the land surface of the world. They are areas of abundant resources including water supplies, limestone quarries, minerals, oil, and natural gas. Many karst terrains make beautiful housing sites for urban development. Several major cities are underlain in part by karst, for example, St. Louis, MO; Nashville, TN; Birmingham, AL; Austin, TX; and others. However, since people have settled on karst areas, many problems have developed; for example, insufficient and easily contaminated water supplies, poor surface water drainage, and catastrophic collapse and subsidence features. By experience we have learned that each karst area is complex, and that special types of investigation are needed to help us better understand and live in them. In addition, urban development in these areas requires special sets of rules and regulations to minimize potential problems from present and future development.

The American Geological Institute produces the Environmental Awareness Series in cooperation with its Member Societies and others to provide a non-technical framework for a better understanding of environmental geoscience. This booklet was prepared under the sponsorship of the AGI Environmental Geoscience Advisory Committee (EGAC) with the support of the AGI Foundation. Publishing partners that have supported development of this booklet include: The American Cave Conservation Association, the Geological surveys in the states of Kentucky, Indiana, and Illinois (Illinois Basin Consortium), National Park Service, National Speleological Society, U.S. Bureau of Land Management, USDA Forest Service, U.S. Fish and Wildlife Service, and the U. S. Geological Survey.

Since its creation in 1993, the EGAC has assisted AGI by identifying projects and activities that will help the Institute achieve the following goals: increase public awareness and understanding of environmental issues and the controls of Earth systems on the environment; communicate societal needs for better management of Earth resources, protection from natural hazards, and assessment of risks associated with human impacts on the environment; promote appropriate science in public policy through improved communication within and beyond the geoscience community related to environmental policy issues and proposed legislation; increase dissemination of information related to environmental programs, research, and professional activities in the geoscience community.

This booklet describes ways to live safely, comfortably, and productively in karst areas, and illustrates that through use of improved science and technology, environmental concerns associated with karst can be better assessed and significantly resolved.

Philip E. LaMoreaux
*Chair, AGI Environmental
Geoscience Advisory Committee,
1993-*

P R E F A C E

Karst areas are among the world's most diverse, fascinating, resource-rich, yet problematic terrains. They contain the largest springs and most productive groundwater supplies on Earth. They provide unique subsurface habitat to rare animals, and their caves preserve fragile prehistoric material for millennia. They are also the landscapes most vulnerable to environmental impacts. Their groundwater is the most easily polluted. Water in their wells and springs can dramatically and rapidly fluctuate in response to surface events. Sinkholes located miles away from rivers can flood homes and businesses. Following storms, droughts, and changes in land use, new sinkholes can form suddenly, collapsing to swallow buildings, roads, and pastures.

The unique attributes of karst areas present challenges. In many cases, understanding the complex hydrologies of karst aquifers still requires specialists for accurate assessments. Unlike other terrains where most processes occur and can be observed at the surface, many critical processes in karst occur underground, requiring monitoring of groundwater flow and exploration and study of caves. Rather than being mere geologic curiosities, caves are now recognized as subsurface extensions of karst landscapes, serving vital roles in the evolution of the landscapes, and in defining the environmental resources and problems that exist in those areas.

This booklet unravels some of the complexities and provides easy to understand, sound practical guidance for living in karst areas. Major topics include

- Describing what karst is and how it "works."
- Identifying the resources and uses of karst areas from prehistoric to modern times.
- Outlining the problems that can occur in karst areas and their causes.
- Providing guidelines and solutions for preventing or helping overcome problems.
- Presenting sources of additional information for further research and assistance.

Karst areas offer important resources, with much of their wealth hidden underground. Careful use can produce many economic and scientific benefits. Sound management of karst areas requires the conscientious participation of citizens including homeowners, planners, government officials, developers, farmers, ranchers, and other land-use decision makers. It's up to you to manage your karst areas wisely. We hope this booklet helps.

We greatly appreciate the assistance we received from individuals and organizations in preparing this booklet. Several reviews helped craft the manuscript and ensure that the information was correct and up-to-date. Numerous photographs, in addition to those provided by the authors, were kindly donated for use. Our special thanks go to the organizations named on the inside cover who supported the publication and to the American Geological Institute for producing it.

George Veni and Harvey DuChene, editors
May, 2001

1 IT HELPS TO KNOW...



Sinkhole plain, typical of many well-developed karst landscapes.

For a landscape that makes up over a fifth of the United States, "karst" is a word that is foreign to most Americans. Major karst areas occur in 20 states and numerous smaller karst regions occur throughout the nation (Fig. 1). Karst describes landscapes characterized by caves, sinkholes, underground streams, and other features formed by the slow dissolving, rather than mechanical eroding, of bedrock. As populations have grown and expanded into karst areas, people have discovered the problems of living on those terrains, such as sinkhole collapse, sinkhole flooding, and easily polluted groundwater that rapidly moves contaminants to wells and springs. With the help of science and technology, residents and communities are developing solutions to the problems of living with karst.

What the Environmental Concerns Are

Karst regions require special care to prevent contamination of vulnerable groundwater supplies and to avoid building in geologically hazardous areas. Living in karst environments may result in

- Urban pollution of groundwater by sewage, runoff containing petrochemicals derived from paved areas, domestic and industrial chemicals, and trash;
 - Rural groundwater pollution from sewage, fertilizers, pesticides, herbicides, dead livestock, and trash;
 - Destabilization of the delicate equilibrium between surface and underground components of karst resulting in alteration of drainage patterns and increasing incidents of catastrophic sinkhole collapse, particularly in areas of unplanned urban growth;
 - Construction problems, particularly the clearing and stabilization of land for buildings and roads;
 - Challenges to water-supply development;
 - Challenges to mine dewatering and excavation.
- The financial impacts of these problems are substantial. As an example, the repair costs of five large dam sites in karst settings were in excess of \$140 million. According to the U.S. National Research Council report, *Mitigating Losses from Land Subsidence in the United States* (1991), six states have individually sustained at least \$10 million in damages resulting from sinkholes. As a result, awareness programs for catastrophic subsidence areas have been developed, as well as insurance programs applicable to sinkhole problems.

How Science and Technology Can Help

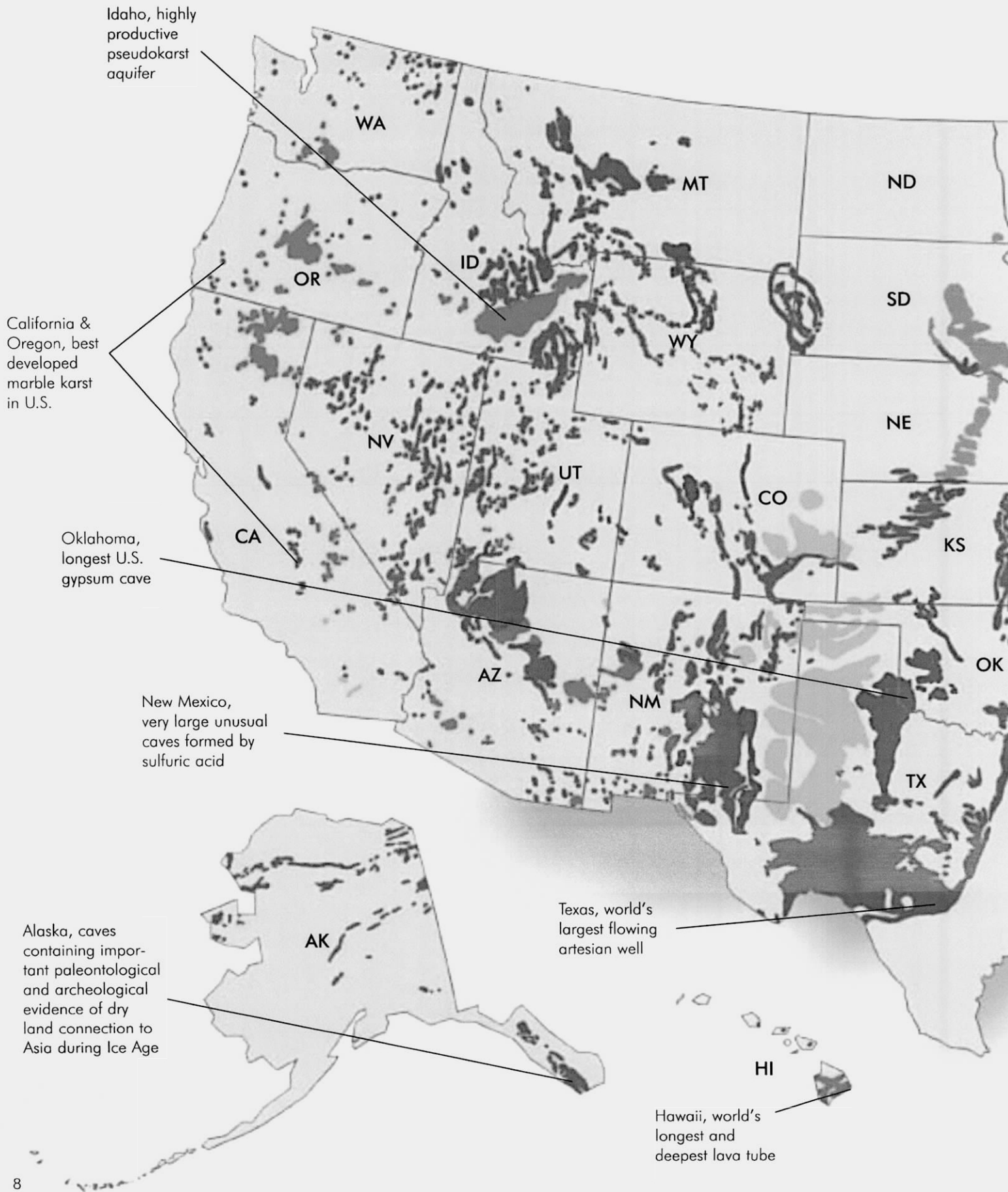
Complicated geologic processes increase the problems of living in karst regions. As our understanding of karst systems has improved, so has our ability to prevent many land-use problems and to remediate those that do occur. Science and technology can

- Provide information about karst aquifer systems so that residents can better protect groundwater supplies from pollution;
- Supply information on geological hazards such as areas with the potential for collapse due to shallow cave systems, thereby helping planners avoid building in unstable areas;
- Provide the means to map the subsurface hydrology and geology to identify areas where productive water wells may be located and to identify potential karst problems;
- Provide information for planners, developers, land management officials, and the general public about the special problems of living in karst environments; and
- Provide solutions for environmental problems when they do occur.

KARST



Karst is
landforms
and
landscapes
formed
primarily
through the
dissolving
of rock.



U.S. Karst Map

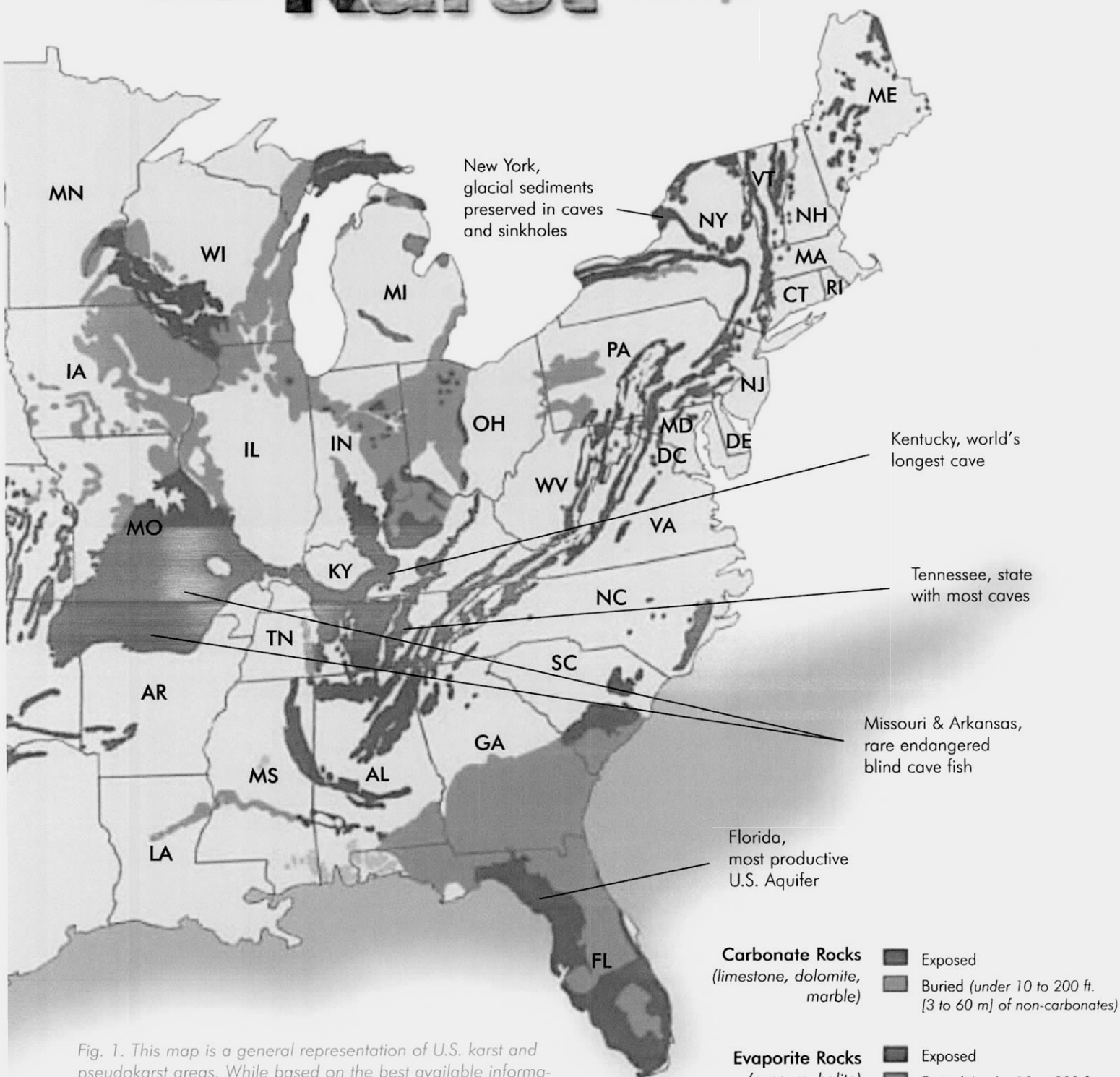


Fig. 1. This map is a general representation of U.S. karst and pseudokarst areas. While based on the best available information, the scale does not allow detailed and precise representation of the areas. Local geologic maps and field examination should be used where exact information is needed. Karst features and hydrology vary from place to place. Some areas are highly cavernous, and others are not. Although most karst is exposed at the land surface, some is buried under layers of sediment and rock, and still affects surface activities.

2 WHAT IS KARST?

*Tourist
trails
through
large
karst
pinnacles
in Lunan
Stone
Forest,
China.*

L andforms produced primarily through the dissolving of rock, such as limestone, dolomite, marble, gypsum, and salt, are collectively known as karst. Features of karst landscapes include sinkholes, caves, large springs, dry valleys and sinking streams. These landscapes are characterized by efficient flow of groundwater through conduits that become larger as the bedrock dissolves. In karst areas, water commonly drains rapidly into the subsurface at zones of recharge and then through a network of fractures, partings, and caves, emerges at the surface in zones of discharge at springs, seeps, and wells.

The appearance of karst varies from place to place, with different features having greater or lesser prominence according to local hydrogeologic factors. Even ancient or "paleokarst" that is buried under other rocks and sediments and is not exposed at the surface can have an effect on surface land use. Several false or "pseudokarst" areas also occur, especially in the western United States (Fig. 1). These regions contain karst-like features which have developed in poorly soluble rocks. Although formed by different processes, pseudokarst areas are often similar to karst areas in how they are used and affected by human activities.

How Karst Forms

Karst forms as water dissolves soluble bedrock. Although water alone can dissolve salt and gypsum, limestone, dolomite, and marble are less soluble and require acidic water. Carbonic acid is a mild, naturally

occurring acid that is very common in groundwater. This acid is created when water falling through the atmosphere takes on a small amount of carbon dioxide. As the slightly acidic rainwater passes through soil, the water absorbs additional carbon dioxide and becomes more acidic. Acidic water readily dissolves calcite, the principal mineral in limestone and marble, and an important mineral in dolomite.

Acidic groundwater moving through fractures and other spaces within the rock gradually alters small openings creating large passages and networks of interconnected conduits. Solution sinkholes form by dissolving the bedrock at the surface downward as surface water is captured and diverted underground (Fig. 2). Most flow and enlargement take place at or just below the water table, the level below which the ground is saturated with water. The circulation of water and bedrock dissolution are greatest there because fractures are connected and most open, whereas underground spaces tend to become

Fig. 2. This solution sinkhole holds water above the water table. Although most sinkholes drain rapidly, some like this one, have natural plugs and may hold water for many years.



progressively narrower and smaller with depth. Where these openings are dissolved large enough to allow human entry, they are called "caves."

Fig. 3. (Right) Horizontal cave passages form below the water table, and they usually have a smooth, rounded to elliptical shape. The water table has since dropped below this Mexican cave, and recent floods washed in the boulders.



Most caves form at or just below the water table, and consequently cave passages are generally horizontal. In cross section, these cave passages are elliptical tubes usually developed in soluble beds of rock (Fig. 3). In contrast, passages formed above the water table are canyon-like corridors that have been formed by dissolution and physical erosion as water cut down through the rock. Cross sections of cave passages formed above the water table are narrow and tall, and pits are common (Fig. 4).

Caves above the water table are tributaries to caves below the water table. Over time, small channels and conduits merge to form large cave passages in the downstream direction. In a mature cave system, an underground branching, tree-like drainage network develops that resembles surface stream systems (Fig. 5). The flow of water is concentrated in large conduits and typically emerges at a few springs with high rates of discharge. At this stage, the karst groundwater system

Fig. 5. (Below) Flow patterns for underground water in karst commonly have a branching shape. Small branches, which begin by capturing surface water from sinkholes and fractures, gain in size and water volume as they flow downstream, merge, and eventually discharge at springs.



Fig. 4. (Above) Vertical cave passages, like this one, typically form above the water table, usually along fractures, and they efficiently channel water that enters caves down to the aquifers below.



Fig. 6. (Left) This split-level cave in Mexico formed by water first flowing through the dry upper passage, which was abandoned as the water table dropped and groundwater cut a new route through the lower passage to reach the current water table.

Fig. 8. (Right) The sharp edges along the walls and the tell-tale angular rocks on the floor are evidence that this passage formed by the collapse of a deeper passage.



Fig. 7. (Right) A "speleothem" is a mineral deposit formed in caves by precipitation from mineral-rich water. Common examples are stalactites hanging from the ceiling, stalagmites growing up from the floor, and columns where the two join. Natural Bridge Caverns is a show cave in Texas.



is a coherent part of the hydrologic cycle. Water passes downward from the surface, through this efficient system of natural "pipes" and emerges elsewhere at the surface as seeps and springs.

Because springs usually discharge into valleys that are continually deepened by surface streams, water tables gradually fall and springs migrate to lower elevations. Consequently, newer cave passages form at lower elevations, while previously formed upper-level passages and rooms are drained (Fig. 6). These caves are relatively dry except for dripping water and an occasional stream making its way from the surface to the water table. Water dripping or flowing into passages may deposit calcite speleothems, such as stalactites, stalagmites, and columns (Fig. 7). Ceilings of rooms and passages collapse when passages become too wide to support the bedrock overlying them (Fig. 8). The danger of collapse increases when water is drained from the cave and its buoyant force is not present to help support ceilings. Some collapse sinkholes develop where collapse of the cave roof reaches the surface of the Earth (Fig. 9). More commonly, they develop when soil collapses after deeper soils wash into underlying caves.

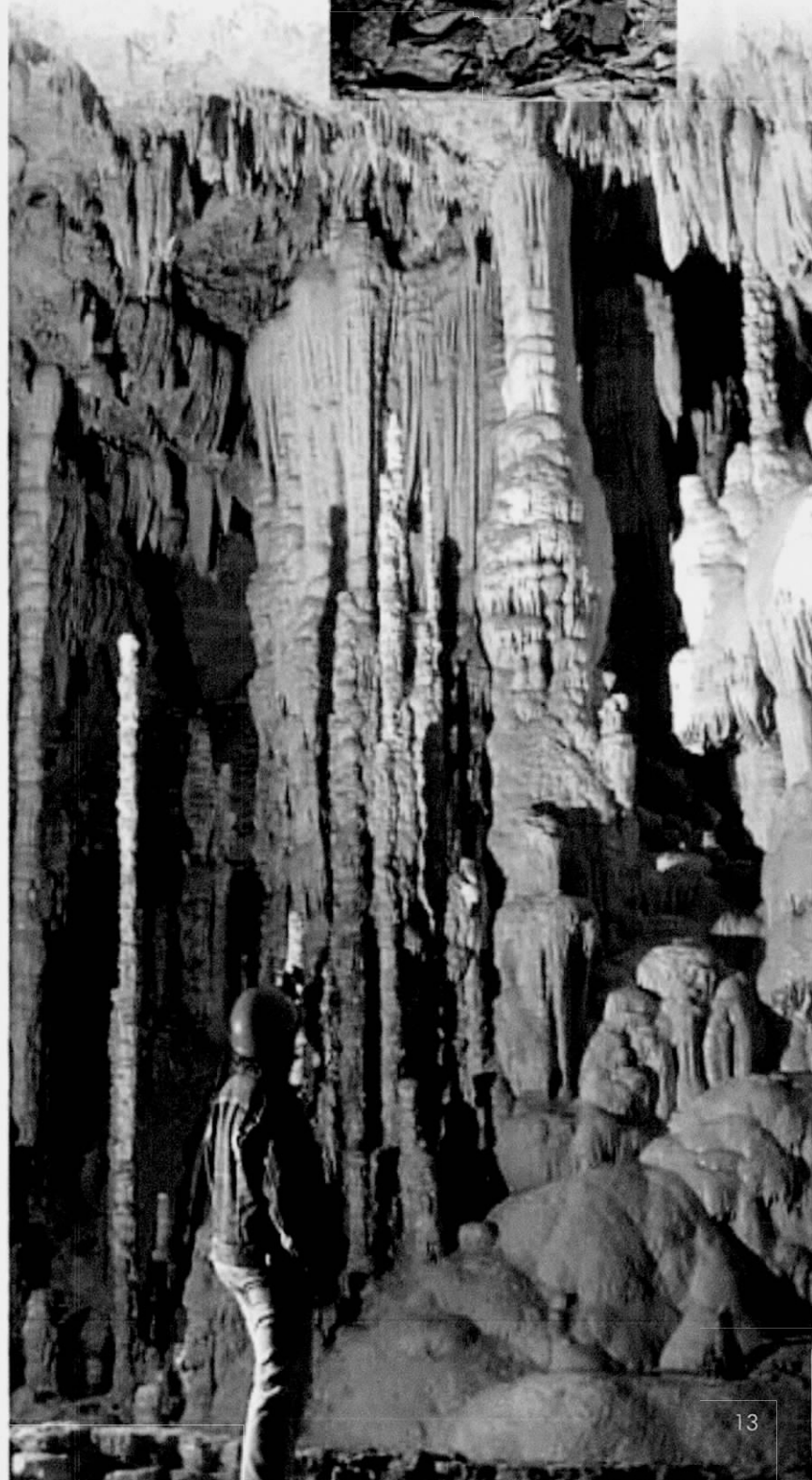


Fig. 9. (Below) On rare occasions, a collapsing cave room or passage may extend high enough that a collapse sinkhole forms in bedrock on the surface.



Fig. 10.
When it rains,
this New
York swallet
"swallows"
all of the
water that
flows down
the creek
bed.

Unlike other landscapes, groundwater recharge into karst aquifers carries substantial amounts of dissolved and suspended earth materials underground. First, the water contains ions that are produced naturally as the rock is dissolved. Second, water conveys particles that range in size from submicroscopic clay particles to boulders. Great volumes of sediment are transported underground in karst areas, sometimes resulting in openings becoming clogged. The mechanical and chemical removal of material in karst occurs throughout the zone between the land surface and the bedrock. Unlike other terrains, where weathering forms a soil that may thickly



Fig. 11. The fractures
and pits in this limestone
have become larger as
the surrounding rock
dissolved by solution.

blanket the bedrock and retard erosion, in karst, the continual removal of material into the subsurface allows high, sustained rates of erosion. Many karst areas, especially in the western United States where soil production is slow, are covered with only thin or patchy soils.

Hydrologic Characteristics

Karst features may or may not be easily recognizable on the surface, but areas where the surface bedrock is limestone or gypsum have a high probability of karst development. Karst areas commonly lack surface water and have numerous stream beds that are dry except during periods of high runoff. These regions have internal drainage; streams flow into the closed depressions called sinkholes where there is no surface outlet. A typical sinkhole is bowl shaped, with one or more low spots along its bottom. In some cases a swallow hole, or swallet, may be present at the bottom of the sinkhole where surface water flows underground into fractures or caves (Fig. 10). Water may also enter a karst aquifer along streams that flow over karst areas and disappear from the surface. A stream of this type is known as a sinking stream and in some cases it may lose water along a substantial part of its length. In the subsurface, the storage and flow of groundwater is controlled by the porosity and permeability of the rock.

Porosity and Permeability

All rock contains pore spaces. Porosity is the percentage of the bulk volume of a rock that is occupied by pores (Fig. 11).

For example, a porosity of 20% means that bedrock is 80% solid material (rock) and 20% open spaces (pores or fractures). Voids in the bedrock are the openings where groundwater can be stored. Where voids are connected, they also provide the paths for groundwater flow.

Permeability is a measure of how well groundwater flows or migrates through an aquifer. A rock may be porous, but unless those pores are connected, permeability will be low. Generally speaking, the permeability of rocks in well-developed karst areas is very high when networks of fractures have been enlarged and connected by solution (Fig. 12).

In most limestones, the primary porosity and permeability, or hydrologic characteristics created as the rock formed, are generally low. However in karst areas, large cavernous porosities and high permeability are common. These hydrologic characteristics, including fractures and openings enlarged by solution, are almost always secondary or tertiary features that were created or enhanced after the rock was formed.

The Hydrologic Cycle

The source of groundwater for all aquifers is precipitation. When rain falls, plants and soil absorb some of the rain water, some of it drains into streams, some evaporates, and the remainder moves downward into aquifers recharging them (Fig. 13). Groundwater moves through the hydrologic cycle as part of a dynamic flow system from recharge areas to discharge areas that flow into streams, lakes, wetlands, or the oceans. Streams that flow during periods of little rainfall are fed by groundwater.

Fig. 12. The bedrock surface in karst terrains is often highly fissured and permeable. In areas lacking soil, this surface can be directly viewed and is called karst pavement (Fig. 52).

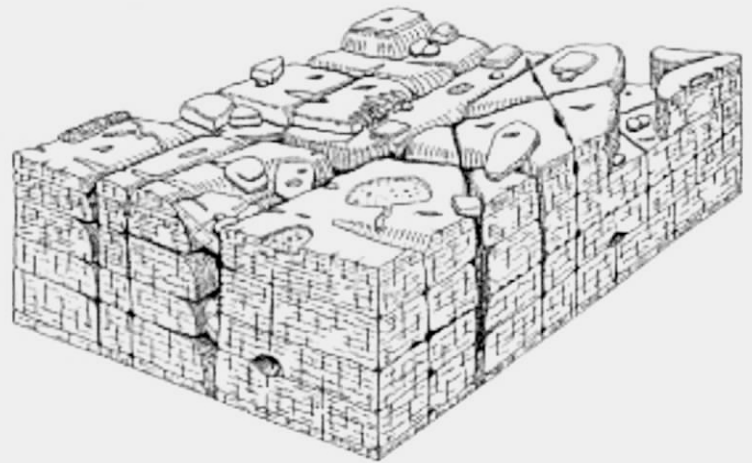
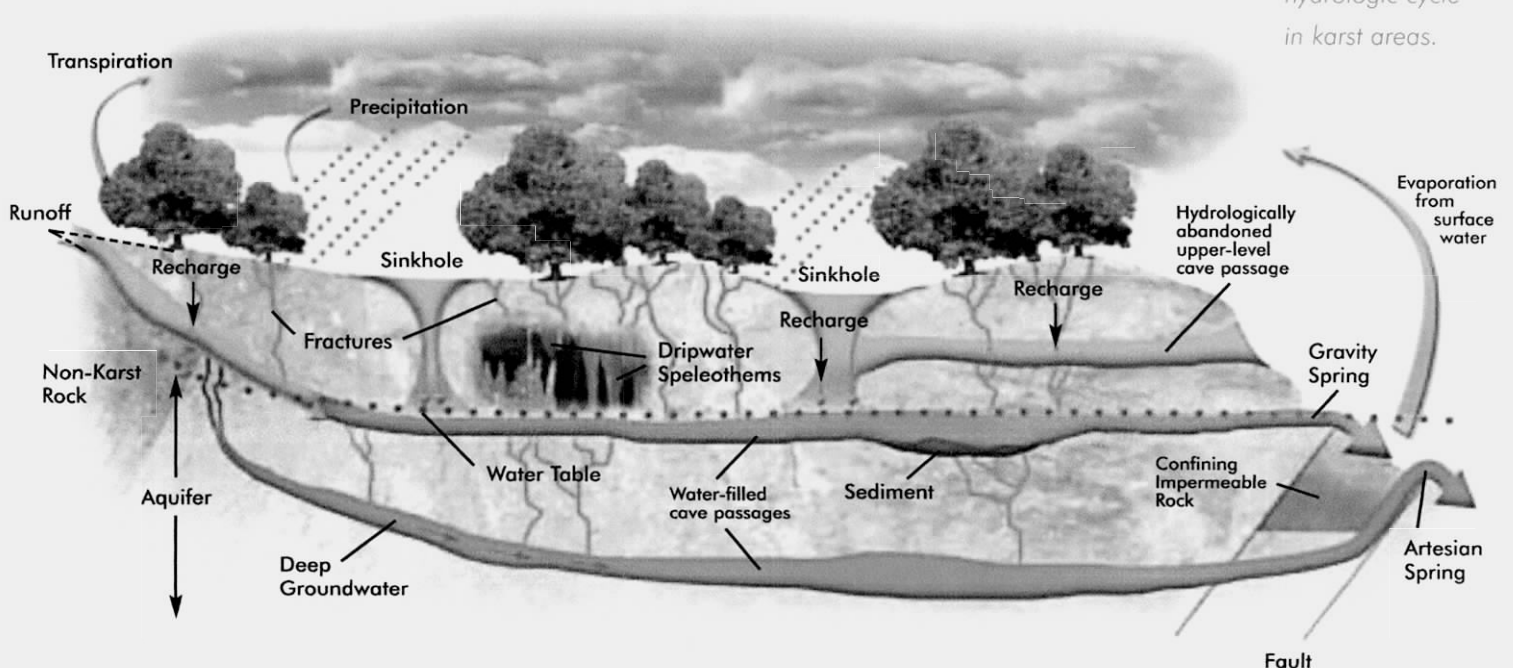


Fig. 13. The hydrologic cycle in karst areas.



The Karst Aquifer

An aquifer is a zone within the ground that serves as a reservoir of water and that can transmit the water to springs or wells. Karst aquifers are unique because the water exists and flows within fractures or other openings that have been enlarged by natural dissolution processes. However, water flow in karst aquifers is commonly localized within conduits, with little or no flow in the adjacent rock. This situation means that successful wells must intersect one or more voids where the water is flowing. In a karst region, drilling for water may be a hit-or-miss endeavor; in contrast to drilling in porous media aquifers where flow conditions are more uniform and the probability of finding adequate water is higher.

Vadose and Phreatic Zones

The area between the surface of the land and the water table, which is called the vadose zone, contains air within the pore spaces or fractures. In the vadose zone, groundwater migrates downward from the surface to the phreatic zone, in which pore spaces are filled with water. The boundary between the vadose and phreatic zones is the water table (Fig. 14). The vertical position of the water table fluctuates in response to storms or seasonal changes in weather, being lower during dry times and higher during wetter periods. In non-karst aquifers, the vadose and phreatic zones are called the unsaturated and saturated zones. The use of those terms in regard to karst aquifers is not recommended, because chemical saturation of the water with dissolved minerals is a critical factor in aquifer flow and development.

Karst aquifers may contain perched water, which is groundwater that is temporarily pooled or flowing in the vadose zone.

Although perched water generally occurs in relatively small volumes, it can provide water to wells and springs.

Groundwater Recharge and Discharge

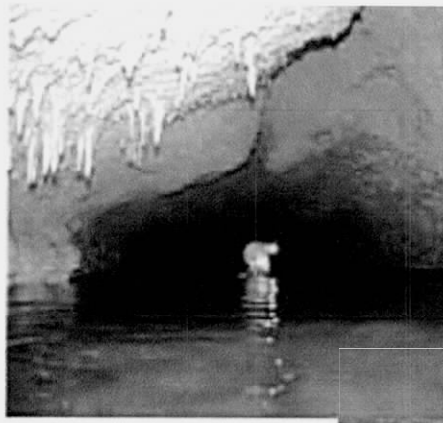
The process of adding water to an aquifer is known as recharge. Where surface water enters an aquifer at specific spots, such as sinkholes and swallets, discrete recharge occurs. When water infiltrates into underlying bedrock through small fractures or granular material over a wide area, the recharge process is referred to as diffuse recharge. Where water comes to the surface at specific springs (Fig. 15) or wells, it is known as discrete discharge, but where water flows out of the ground over a larger area, such as a series of small springs or seeps, the discharge is diffuse. While recharge and discharge vary in magnitude in all aquifers, they vary the most in karst aquifers by allowing the greatest rates of water flow. Large springs tend to be most commonly reported. Thus, those states with the greatest number of recorded springs, including more than 3,000 each in Alabama, Kentucky, Missouri, Tennessee, Texas, Virginia, and West Virginia, also have significantly large karst areas.

Once sufficient permeability is established through the bedrock, water circulates freely from places of recharge to areas of discharge. In karst areas where the water table is near the surface, such as Florida's Suwannee River basin, declines in the water table can change springs into recharge sites, and rises in the water table can convert sinkholes into springs. Features that sometimes discharge water and other times recharge water are known as estavelles.

In areas where groundwater in karst flows through open conduits, the aquifers

Once sufficient permeability is established through the bedrock, water circulates freely from places of recharge to areas of discharge.

Fig. 14. The surface of this cave stream marks the water table of this karst aquifer. The area above the water table is called the "vadose zone" and the area below, where all voids are filled with water, is the "phreatic zone."



respond very quickly to surface events such as storms and stream flooding. This response is typically many times greater and faster than would occur in non-karst aquifers. Therefore, interactions between surface and groundwater processes are greatly enhanced in karst.

It is important to know that even in the absence of surface streams, a karst region is a zone of drainage into the aquifer; the entire area can be a recharge zone. Surface water over the whole area, not just within sinkholes, carries sediment and pollutants into the subsurface. Removal of vegetation from surrounding areas through farming, forestry, or urbanization may significantly change drainage conditions leading to alteration of the aquifer by clogging of openings, ponding, and flooding, as well as contamination of groundwater resources. As the world's population grows and continues expanding onto karst areas, people are discovering the problems of living on karst. Potential problems and environmental concerns include sinkhole flooding, sinkhole collapse, and easily polluted groundwater supplies, where contaminants move rapidly to wells and springs. The following chapters discuss assets of karst as well as some of the challenging aspects of living in karst areas.



Fig. 15. Some springs rise from streambeds while others pour out of bedrock. Blanchard Springs Caverns, Arkansas.

3 WHY KARST AREAS ARE IMPORTANT

Karst areas are rich in water and mineral resources and they provide unique habitats and spectacular scenery.

Karst areas are among the most varied of Earth's landscapes with a wide array of surface and subsurface terrains and resources. Some of their features are unique to karst, and others tend to be most abundant in karst regions. The following sections describe the most frequently used or encountered karst resources.

Water Resources

Without a doubt, water is the most commonly used resource in karst areas. Although the lack of surface water is commonly characteristic of karst areas, they also contain some of the largest water-producing wells and springs in the world. Until the development of well-drilling technologies, communities generally were located along the margins of karst areas, downstream from large springs that provided water for drinking, agriculture, and other uses.

Historical accounts describe the vital role of karst groundwater for communities as far back as pre-Biblical times in Europe and the Middle East. Assyrian King Salmanassar III recognized the importance of karst springs as early as 852 B.C., as recorded in the description of his study of the cave spring at the head of the Tigris River. For centuries throughout the world, water has been channeled from springs toward towns and fields, or collected from caves and sinkholes in vessels (Fig. 16) or by hand or wind-powered pumps. These methods are still used in parts of the world where drilling technology is not affordable or practical.

Water-well drilling has allowed more people to move into karst areas. However, water yield from karst aquifers can range from zero to abundant, depending on the number of fractures and voids penetrated by a well



Fig. 16. Until recently, many Maya of Mexico and Central America would walk long distances each day to a nearby cave, then climb down inside to retrieve water, as shown in this 1844 drawing by Frederick Catherwood.

bore and the amount of water they carry. The world's largest flowing artesian well intersected a cave passage in Texas' Edwards Aquifer estimated to be 8 ft (2.4 m) high, and tapped water under such pressure that it shot a 3-ft (1 m) diameter, 30 ft (9 m) high fountain into the air and flowed at a rate of 35,000 gallons/minute (2.2 cubic meters/second) (Fig. 17).

The cavernous nature of karst aquifers allows considerable volumes of water to be stored underground. This is especially valuable in arid climates where evaporation is high. In some parts of the world, cave streams are large enough to economically merit damming to store water for direct usage, mechanical water-wheel power, hydroelectric power, and to limit downstream flooding. The Floridan Aquifer in Florida yields over 250 million gallons/day (947,500 m³/day) to wells, and Figeih Spring, in Syria, which is the 3rd largest spring in the world, on average discharges 63,200 gallons/minute (4.0 m³/sec) and supplies the entire city of Damascus with water.



Fig. 17. Before it was capped, the record-setting "Catfish Farm Well" shot water 30 ft (9 m) into the air from the Edward Aquifer in Texas.

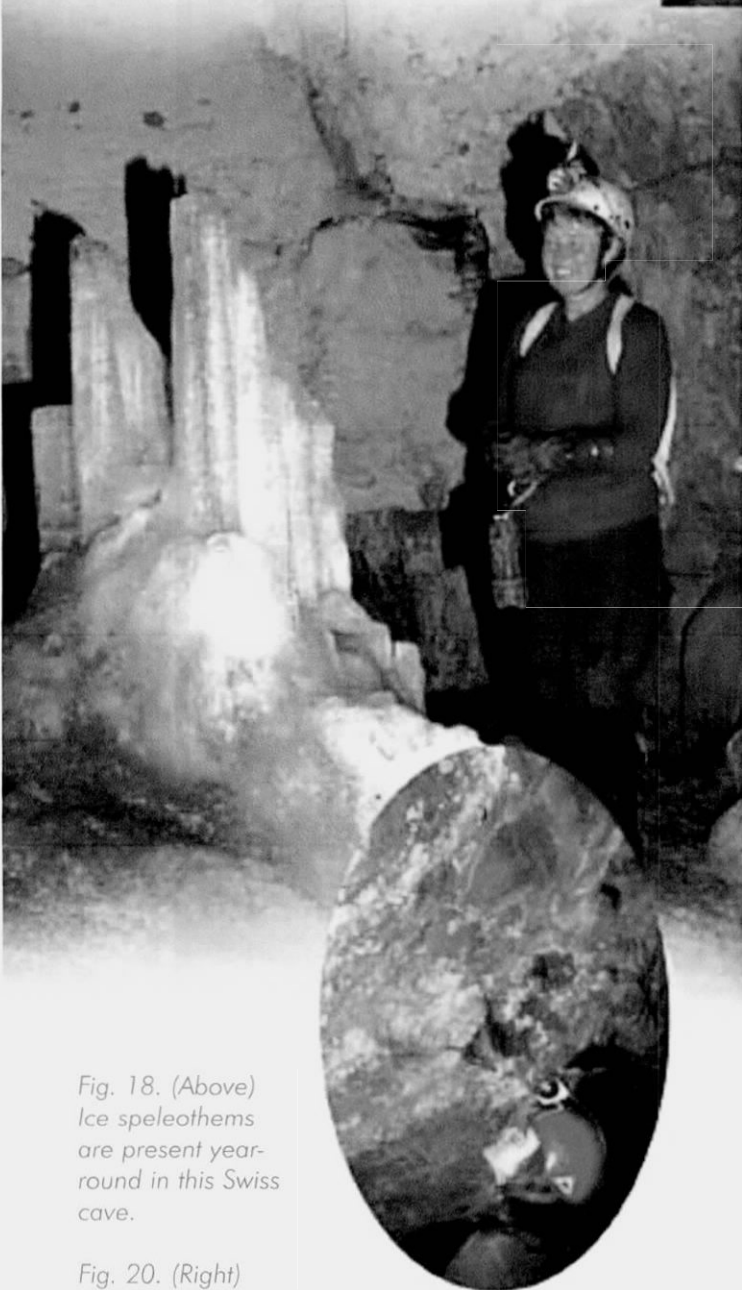


Fig. 18. (Above) Ice speleothems are present year-round in this Swiss cave.

Fig. 20. (Right) Cinnabar and other hydrothermally deposited minerals in a cave intersected by a mine.

Earth History

Karst plays an important role in increasing our understanding of the history of past climates and environments on Earth. Sediments and speleothem or mineral deposits in caves are among the richest sources of paleoclimate information, providing detailed records of fluctuations in regional temperature,



Fig. 19. Vats used in the 1800s to leach saltpeter for gunpowder. Mammoth Cave, Mammoth Cave National Park, KY.

atmospheric gases, rainfall, ice ages, sea-level changes, and plants and animals that once inhabited the areas during the past several hundred thousand years.

Mineral Resources

Prehistoric peoples found shelter and mineral resources in caves. It is well-documented that they mined caves for flint (also known as chert) to make stone tools and for sulfate minerals and clays for medicines and paint pigment. In Europe, a soft speleothem known as moonmilk was used as a poultice, an antacid, to induce mother's milk, and to remedy other medical woes. Prior to refrigeration, cold caves were mined for ice (Fig. 18), and in the early 1800s, the beer brewing industry of St. Louis, Missouri, was based on the availability of caves as places of cold storage.

In the United States during the Revolutionary War, War of 1812, and Civil War, over 250 caves were mined for saltpeter, which was used in the production of gunpowder (Fig. 19). Like saltpeter, phosphate-rich bat guano deposits used to enrich agricultural soils are mined in caves. Bat guano was the most highly rated fertilizer of the 19th and early 20th centuries until it was supplanted by cheaper and more easily obtained chemical fertilizers.

The most common mineral resource extracted from karst areas is the quarried rock itself. Limestone, dolomite, marble, gypsum, travertine, and salt are all mined in large quantities throughout the world. Quarry operators prefer mining non-cavernous rock, but in many areas this is not available and many caves are lost. Unfortunately, sometimes the

exotic mineral deposits called speleothems are also mined from caves, despite such collecting being an illegal activity in many states. The removal of speleothems results in the loss of thousands of years of information on Earth's history and the vandalism of beautiful natural landscapes.

Karst areas, including ancient or paleokarst, may contain large reserves of lead, zinc, aluminum, oil, natural gas, and other valuable commodities. Paleokarst is karst terrain that has been buried beneath younger sediments. Significant economic ore deposits accumulate in the large voids in paleokarst rocks, especially where mineral-bearing thermal or sulfide-rich solutions have modified the bedrock. In some areas, lead and zinc deposits are common, forming large economically valuable mineral deposits like those in Arkansas and Missouri (Fig. 20). Many oil and gas fields throughout the world tap highly porous and permeable paleokarst reservoirs where tremendous volumes of petroleum are naturally stored. Abundant deposits of aluminum occur in laterite soils composed of the insoluble residue derived from limestone that has been dissolved in humid climates.

Ecology

Many species of bats, including those that form some of the world's largest colonies, roost in caves (Fig. 21). Nectar feeding bats are important pollinators, and a number of economically and ecologically important plants might not survive without them. Insectivorous bats make up the largest known colonies of mammals in the world. Populations from some of these colonies may

eat nearly a million pounds (454,000 kg) of insects per night, including moths, mosquitoes, beetles, and related agricultural pests. Fruit-eating bats eat ripe fruit on the branch, scatter the seeds, and thereby contribute to the propagation of trees. In Pacific islands, the regeneration of at least 40% of tree species are known to depend on bats, and in western Africa, bats carry 90-98% of the seeds that initiate reforestation of cleared lands.

Because caves lack sunlight, they create highly specialized ecosystems that have evolved for survival in low-energy and lightless environments. Troglobites are animals that are adapted to living their entire lives underground. They have no eyes, often lack pigment, and have elongated legs and antennae. Some have specialized organs that detect smell and movement to help them navigate in a totally dark environment and find food. Fish, salamanders, spiders, beetles, crabs, and many other animals have evolved such species (Fig. 22). Since cave habitats are

Fig. 21. Mexican free-tailed bats flying out from Bracken Cave, Texas, at night to feed. Each spring, about 20 million pregnant bats migrate to this maternity colony from Mexico. On average, each gives birth to one pup and by the fall the population swells to 40 million — the largest bat population and greatest known concentration of mammals in the world. During a typical night, they will eat roughly 1,000,000 pounds (454,000 kg) of insects, including many agricultural pests.

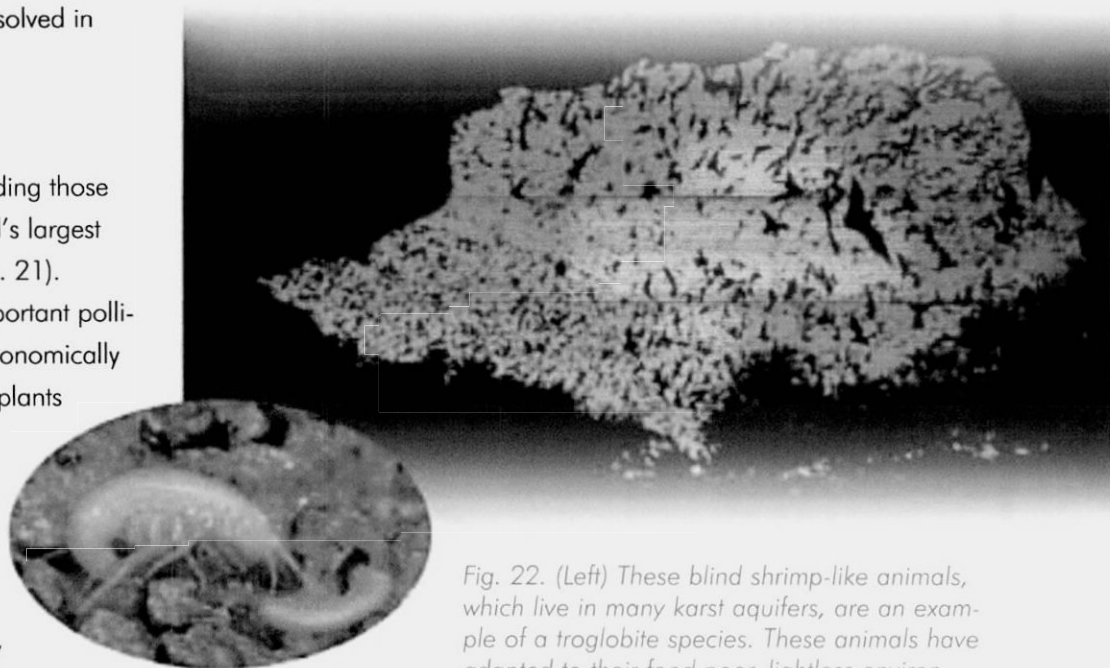


Fig. 22. (Left) These blind shrimp-like animals, which live in many karst aquifers, are an example of a troglobite species. These animals have adapted to their food-poor, lightless environment by loss of sight and lack of pigmentation.

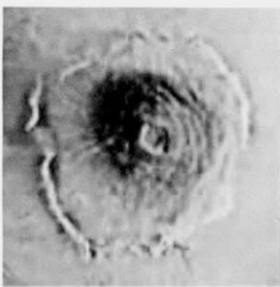


Fig. 23. (Left) The study of microbes in biologically extreme cave environments is teaching scientists how and where to search for life on Mars and other planets.

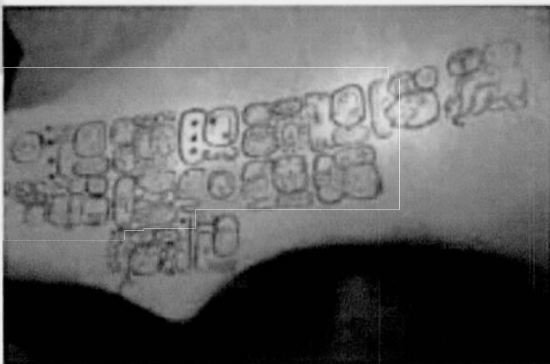


Fig. 24. (Right) Thirteen hundred year old Mayan hieroglyphic paintings preserved in a Guatemalan cave.

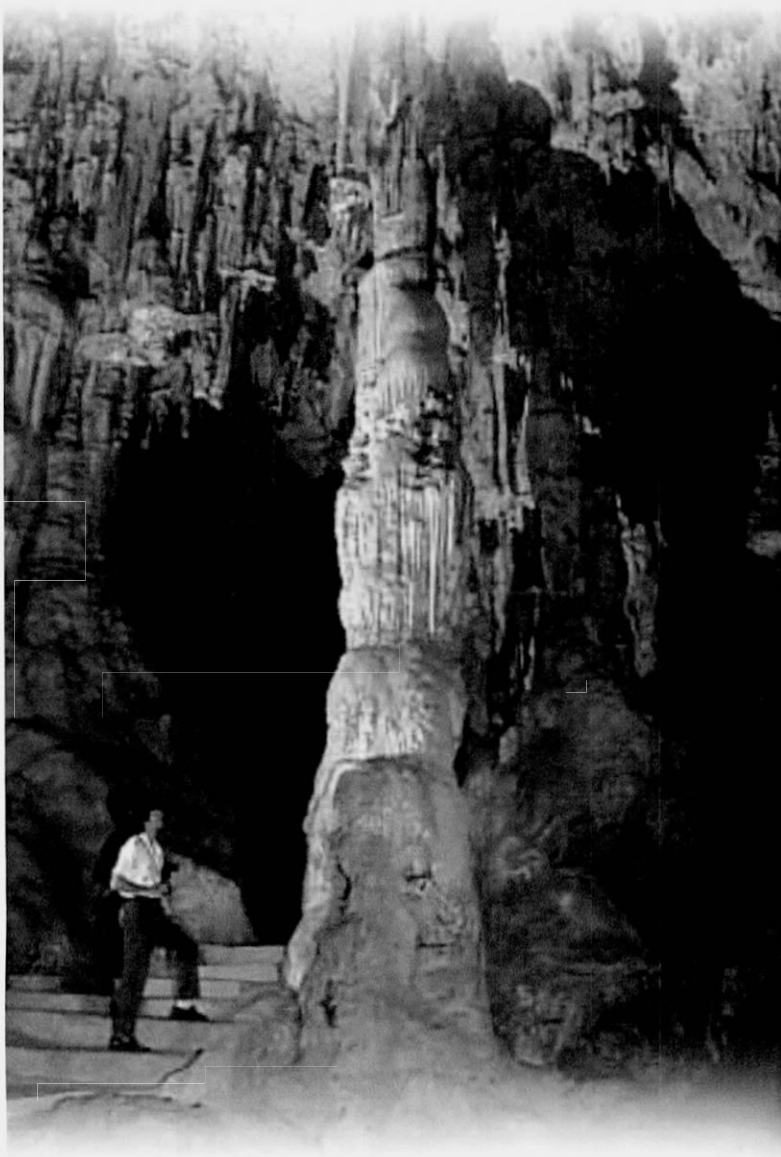


Fig. 25. A tourist enjoying the splendors of Bailong Dong (White Dragon Cave), a show cave in China.

far less complex than those on the surface, biologists study these animals for insights into evolution and ecosystem development. An extreme example of an isolated karst ecosystem is in Movile Cave, Romania. Geologic evidence indicates that the cave was blocked-off from the surface for an estimated 5 million years until a hand-dug well accidentally created an entrance in 1986. This cave has a distinct ecosystem based on sulfur bacteria that are the base of a food chain that supports 33 invertebrate species known only from that site.

Microbial organisms in caves have only recently been studied, but they are important contributors to biological and geological processes in karst environments. Microbes accelerate dissolution by increasing the rate of limestone erosion in some circumstances. In other cases, they may contribute to the deposition of speleothems. Changes in the number and types of certain bacteria are indicators that have been used to trace groundwater flow paths and to identify pollution sources. Several cave microbes are promising candidates for cancer medicines, and others may be useful for bioremediation of toxic wastes spilled into the environment. Certain sulfur-based microorganisms are being studied as possible analogs for life in outer space (Fig. 23).

Archaeology and Culture

From early times in human development, caves have served, first as shelters, and later, as resource reservoirs and religious sites. Many of the world's greatest archaeological sites have been found in caves, where fragile materials that would easily be destroyed in other settings have been preserved. Caves

were reliable sources of water when other sources went dry, and minerals and clays were mined for both practical and ceremonial use. Generations of habitation resulted in deep accumulations of bones, ash, food scraps, burials, wastes, and other materials. The archaeological importance of caves stems not only from the volume of cultural material, but also from the degree of preservation. Fragile and ephemeral items such as footprints, woven items of clothing and delicate paintings are examples of these rare artifacts (Fig. 24).

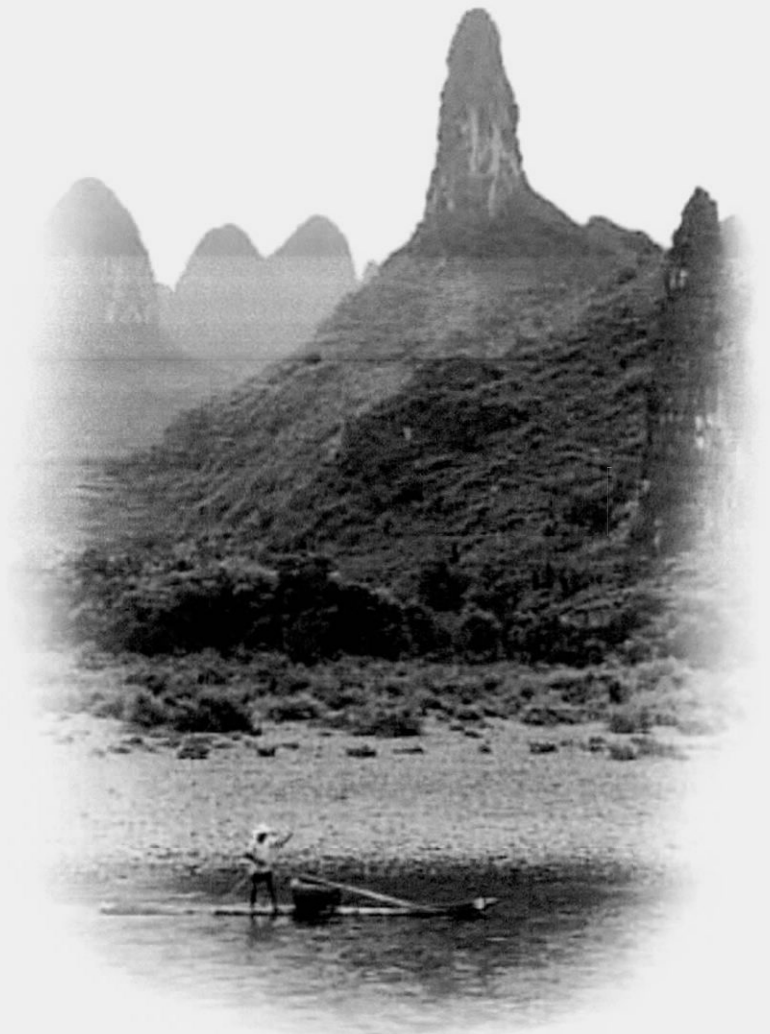
Recreation

Karst areas provide three main types of recreational settings: show or commercial caves, wild caves, and scenic areas. For many people, their only exposure to the karst environment occurs when they visit show caves. There, they can view delicate and grand mineral displays, vaulted chambers, hidden rivers, and other underground wonders (Fig. 25). Some of the world's most outstanding caves are open to the public in the United States. Mammoth Cave, Kentucky, is the world's longest cave with over 355 miles (572 km) mapped. Carlsbad Caverns, New Mexico, which like Mammoth Cave, is a U.S. national park, contains some of the world's largest rooms and passages. Caverns of Sonora, a privately owned cave in Texas, is internationally recognized as one of the world's most beautiful show caves.

"Wild" caves remain in their natural state, and they are located throughout the country on public and private land. For most people, a visit to a wild cave is a one-time adventure, but for thousands of "cavers" worldwide, it is a regular pastime. Caving is a sport that contributes to science, because many cavers create detailed maps as they explore and note features that may be of scientific importance.

The above-ground portions of karst areas form some of the most unusual landscapes in the world, epitomized by the impressive Tower Karst region of southeast China (Fig. 26). Other exceptionally scenic karst regions occur in, but are not limited to, Brazil, Croatia, Cuba, France, Malaysia, Slovenia, Thailand, the United States, and Vietnam. Recreational activities in scenic karst areas include car touring, boating, hiking, fishing, camping, swimming, backpacking, nature watching, photography, and, of course, exploring wild and show caves.

Fig. 26. The spectacular tower karst along the Li River in China.



ENVIRONMENTAL & ENGINEERING CONCERNS



Sinkhole collapse in Winter Park, Florida.

When karst landscapes are sites of urban development, their particular structural and hydrological characteristics must be understood. The occurrence of cavities in the rock and the soil requires special engineering considerations to provide stable foundations for the construction of roads and buildings. Because groundwater moves very rapidly in karst regions, pollutants can be spread long distances in a short period of time. Adequate supplies of drinking water may be difficult to locate and are at risk of contamination. Sinkhole collapse, drainage problems, and groundwater contamination are engineering and environmental concerns associated with development on karst terrains.

Sinkhole Collapse

Although collapse of cave passages within solid limestone bedrock is part of the normal process of landscape development in karst areas, it is a very rare event over human time scales. Most observed collapses occur in soils and sediments overlying the bedrock. In some karst areas, such sinkhole collapses reach spectacular proportions and cause considerable damage. For example, many catastrophic sinkhole collapses, such as the one on the opposite page have occurred within the relatively young, soil-covered karst of north-central Florida. This sinkhole developed in Winter Park, Florida, in 1981. Within a few days it had grown to over 330 ft (100 m) long by 300 ft (90 m) wide, swallowing cars, buildings, trees, a road, and part of a swimming pool.

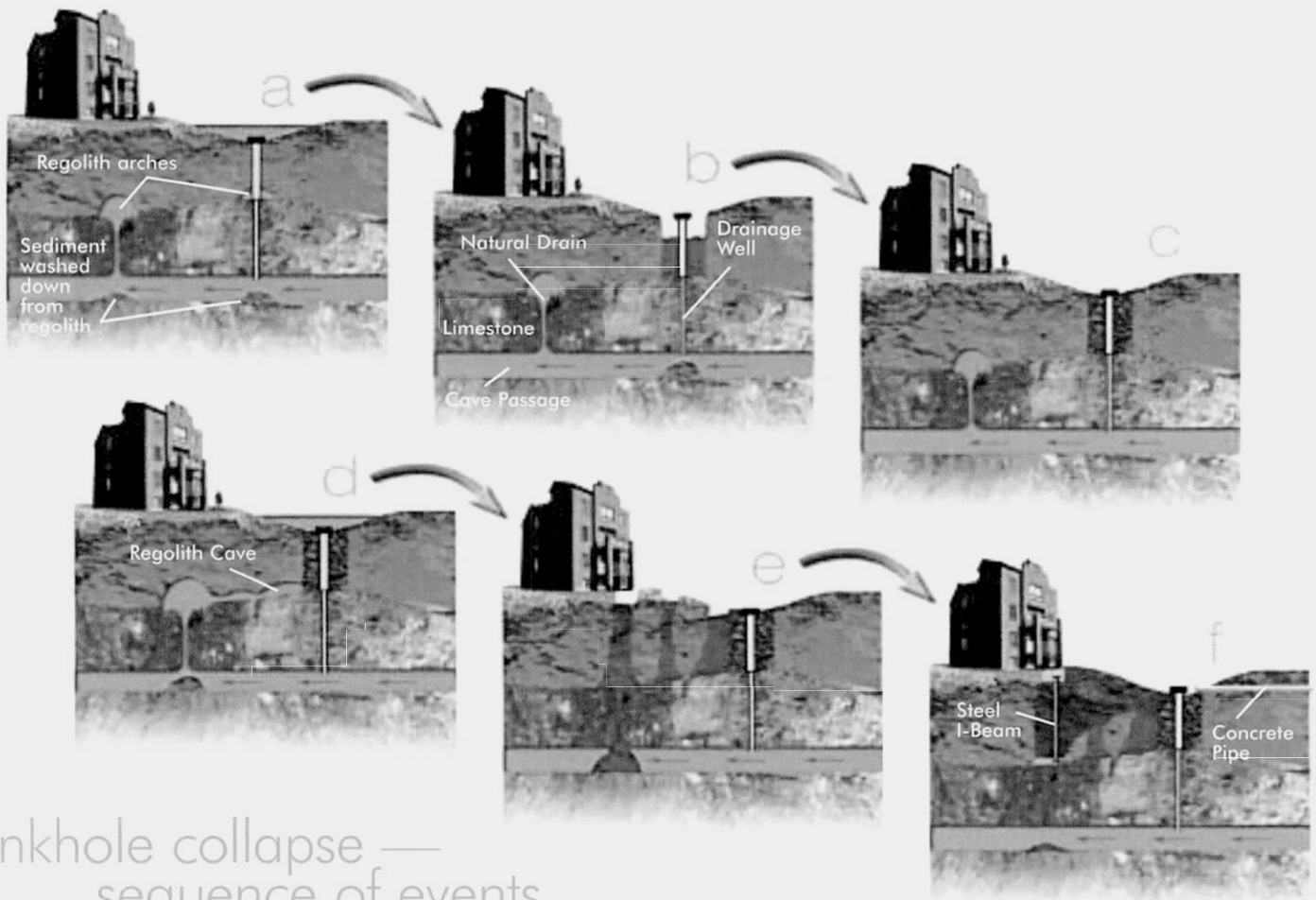
Probably the most catastrophic sinkhole event in recorded history occurred in December 1962, in West Driefontein, South Africa. Twenty-nine lives were lost by the sudden disappearance of a building into a huge collapse that measured over 180 ft (55 m)

across. This event, along with an additional 10 fatalities and a great deal of property damage from sinkhole collapse during the 1960s and 1970s, caused the government of South Africa to establish an intensive research program addressing the problems and mechanisms of sinkhole collapse. Collapses in the "dolomite land" areas of the country result from water entering the ground from failed water and sewer systems, poorly designed drainage, and ground vibrations. In one study in suburban Pretoria, it was determined that 96% of nearly 400 sinkholes were induced by human activities. Rapid lowering of the area's water table by dewatering deep gold mines caused a loss of buoyant support and resulted in especially large collapses.

Sinkhole collapses occur naturally; they also may be induced by human activities (Fig. 27). Natural sinkholes and induced sinkholes can generally be separated on the basis of physical characteristics, frequency and density of occurrence, and environmental setting. Induced sinkholes generally develop much faster than natural sinkholes, although all collapse sinkholes require some dissolution of the underlying bedrock.

Fig. 27. Catastrophic sinkhole collapses have occurred in karst areas around the world and have proven costly in both dollars and lives.





Sinkhole collapse — sequence of events

Fig. 28. (Above) (a) In the layer of unconsolidated rock material, or regolith, arches form at a drainage well below a retention basin and at a natural drain under a building. (b) During a flood, collapse occurs at the drainage well. (c) The collapse is excavated to bedrock and filled with rocks (large at the bottom and smaller toward the top) to allow drainage into the well yet block sediment flow. In this example, that remediation is not adequate. (d) Water and sediment begin to flow to the natural drain, enlarging that regolith arch and forming a horizontal regolith cave. (e) Surface collapse occurs in three places due to collapse of the regolith arch over the natural drain and collapse of the regolith cave. (f) The collapses are excavated to bedrock under the building and a concrete slab poured over the natural drain in the bedrock. Steel I-beams are installed to support a new steel reinforced building foundation. The excavation is then filled with compacted soil, the retention basin is graded over, and a concrete pipe laid to direct storm-water runoff to a stream, storm sewer, or another retention basin.



Fig. 30. Sinkhole collapse commonly results where the casings of drainage wells are not properly sealed to the bedrock.

Urbanization increases the risk of induced sinkhole collapse. The risk of collapse may increase because of 1) land-use changes, stream bed diversions, and impoundments that locally increase the downward movement of water into bedrock openings beneath the soil, and 2) greater frequency and magnitude of water-table fluctuations caused by urban groundwater withdrawal and injection.

Induced sinkhole collapses typically form by the collapse of the regolith, a general term for the layer of unconsolidated material near the surface of the land, including soil, sediment, and loose rocks (Fig. 28). Collapses are especially catastrophic when the soils and sediments are at least 20-30 ft (6-9 m) thick. These collapses result from soil washing into an underlying cave system, leaving voids in the unconsolidated material above the bedrock. In some cases, collapses occur as slow subsidence of the land surface over periods of weeks to years, rather than sudden collapses that occur over periods of minutes to days.

In areas where the water table is normally above the soil-bedrock contact, soil collapses occur when the water table drops below the soil zone, either during droughts or due to high pumping rates (Fig. 29). These collapses are caused by loss of buoyant support above the voids, or by upward propagation as saturated soil falls or washes downward. Eventually, the surface subsides gradually or abruptly collapses. Soil collapses also occur in situations where the water table is below the soil-bedrock contact. Construction and land-use changes that concentrate surface runoff in drains and impoundments will locally increase the downward movement of water. The rapidly moving water causes soil to be washed into holes in the bedrock, leaving voids behind.

Increasing the load on these voids by construction or by accumulation of impounded water can initiate collapse. Collapses can also be caused by water leaking from drainage wells, pipelines, septic tanks, and drainage ditches (Fig. 30).

Although many sinkholes collapse with little or no advance warning, other collapses can be recognized by features at the land surface that indicate their development. Some of the more common features include

- Circular and linear cracks in soil, asphalt, and concrete paving and floors;
- Depressions in soil or pavement that commonly result in the ponding of water;
- Slumping, sagging, or tilting of trees, roads, rails, fences, pipes, poles, sign boards, and other vertical or horizontal structures;
- Downward movement of small-diameter vertical structures such as poles or posts;
- Fractures in foundations and walls, often accompanied by jammed doors and windows;
- Small conical holes that appear in the ground over a relatively short period of time;
- Sudden muddying of water in a well that has been producing clear water; or
- Sudden draining of a pond or creek.



Fig. 29. Water well drilling near this Florida home triggered a sinkhole collapse beneath both the drill rig and the house.

Drainage Problems

Most of the rain that falls in a karst area drains into the ground rather than flowing to a surface stream. Sinkholes may provide drains where water enters the underground flow system (Fig. 31). Cave entrances may also serve as drains. In many cases, the drains may be buried under the soil. In undisturbed karst areas, the capacity of a sinkhole drain is more or less in balance with the long-term climate and it can drain the water produced by most storms. Water backs up only during large storms when input exceeds outflow (Fig. 32).

Problems occur when the landscape is altered by urban development. Erosion is a common side effect of construction, transporting soil to the lowest part of the sinkhole where it clogs the drain. Thereafter, smaller, more frequent storms are capable of flooding the sinkhole. Impermeable ground covers such as roads, parking lots, and buildings increase the rate at which water collects and flows on the surface, flooding homes and businesses in the sinkhole (Fig. 33). Some flood-prone areas are miles from the nearest surface stream or flood-plain,

and property owners may not realize that they are at risk until a flood occurs.

Storm-water drainage systems can be constructed to direct runoff away from urban centers. Where sinkholes are common, the shape of the landscape complicates construction of these systems. Storm-water sewers are expensive to build where soils are thin and simple gravity drainage isn't possible without extensive trenching and/or zig-zagging the sewers around sinkholes.

One moderately effective solution is the installation of storm-water drainage wells, sometimes called "drywells." The U.S. Environmental Protection Agency classifies these drainage wells as Class V, group 5 injection wells. They are constructed in sinkhole bottoms, ditches, and storm-water retention structures where water collects after heavy rains. Drainage wells may be constructed by drilling, or by placing a pipe into a hole made by a backhoe. At some locations, the effectiveness of a drainage well can be enhanced by modifications to cave entrances, sinkhole drains, and sinkhole collapses (Fig. 34). A drainage well will function as intended if it intersects at least one unclogged crevice of sufficient size to direct storm-water into the subsurface.

Unfortunately, water directed into drainage wells is similar to water flowing directly into caves and most sinkholes, because it bypasses natural filtration and goes directly into the aquifer (Fig. 35). Runoff water should be sent to drainage wells only after incorporating Best Management

Practices (page 37) to reduce the introduction of refuse and contaminants into groundwater (Fig. 36). In some commercial and industrial areas, storm-water runoff may be diverted into

Fig. 31.
A sinkhole
plain, typical
of many well
developed
karst land-
scapes.





Fig. 33. (Left)
A shopping center
parking lot built in a
Kentucky sinkhole
floods parked cars.

Fig. 35. (Below) Unfiltered
storm-water runoff from
an urban area floods into
a normally dry cave
entrance.



Fig. 36. (Below) This sinkhole has been
modified to drain storm-water runoff. Two
drainage wells have been drilled into the
floor of the sinkhole. Rocks and hemispher-
ical metal grates provide some filtration of
sediments and organic debris.



Fig. 34.
(Left) This cave
entrance has been
modified to accept
drainage and prevent
clogging from debris
to minimize flooding
of an urban Kentucky
neighborhood.

Fig. 32.
(Below)
A rural roadway
covered by
sinkhole
floodwaters.





Fig. 37. (Above) A large sinkhole collapse around a poorly installed drainage well.

Fig. 38. (Below) During normal flow in a shallow karst aquifer, (a), water is captured from sinkholes and fractures and moves downstream. A collapse in the cave passage restricts the flow, but not significantly. When flooding occurs, (b), the collapse acts like a leaky dam, allowing the normal flow to pass but holding back most water, raising the water table to flood Sinkholes 2 and 3. Sinkhole 1 is above the water table, but holds water due to a constriction that prevents rapid flow down into the cave stream. When a drainage well is placed in Sinkhole 1 to breach the constriction and relieve sinkhole flooding, (c), more water reaches the flooding cave system so the water table and flood levels in Sinkholes 2 and 3 rise even higher. At such times, buildings that would normally be above flood levels might get flooded. The same result occurs when Sinkhole 1 does not have a constriction, but receives more water as impervious material from urbanization covers the surrounding area.

Drainage well-induced sinkhole flooding

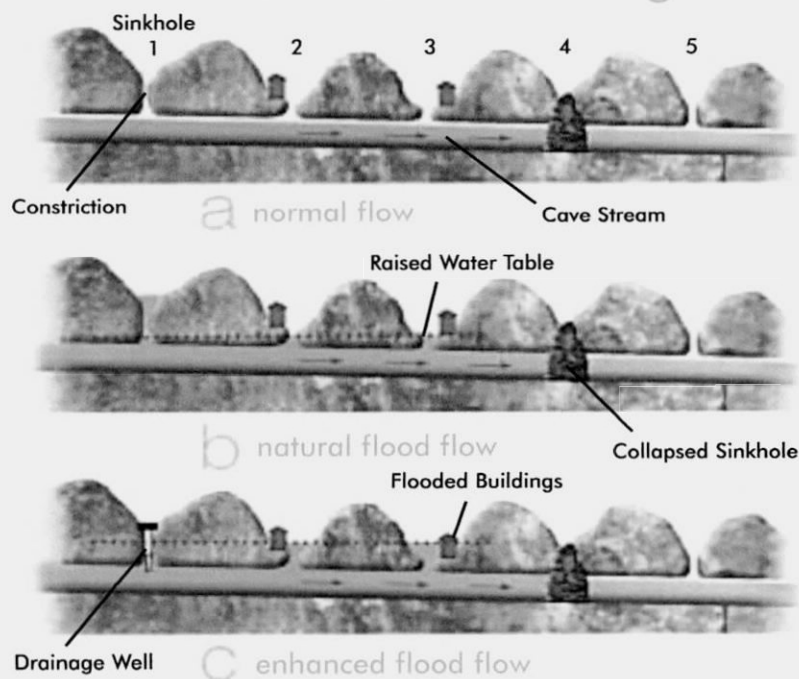


Fig. 39. Sewage, fuels, and other chemicals leave a black stain on the floor of this Kentucky cave stream.



sanitary sewers, or pretreated on site before being disposed into drainage wells. Even if good quality recharge can be maintained, the increased flooding could harm rare or endangered ecosystems within the aquifer.

Induced sinkhole collapse is a potentially severe problem associated with poor drainage well installation (Fig. 37). The casings of many old wells only extend through the soil and rest on uneven bedrock surfaces. This situation allows water to flow out from the gaps between the casings and bedrock to saturate the surrounding soil each time the well fills with water. When the water level drops below the gap, saturated soil flows into the well, leaving a void in the soil that expands upward to the surface. Extending and sealing the casings of wells into the bedrock can alleviate this problem.

Drainage wells, while meant to relieve sinkhole flooding, can cause other sinkholes to flood. Sinkholes can flood from the bottom, as water rises upward through the drain. When the capacity of the underground drainage system is exceeded, it causes any excess water in the ground to flow up into a sinkhole. This type of flooding is sometimes made worse by urban development in the headwaters of a karst drainage system and the injection of storm water into drainage wells (Fig. 38).

Groundwater Contamination

Urban and Industrial

Contamination is common in karst aquifers beneath urban areas with high population densities. Pollutants include septic tank effluent, runoff that contains metals, oil and grease, solid trash and wastes, and accidental or intentional dumping of chemical wastes by industrial facilities and homeowners. Karst aquifers in the United States have been

Fig. 41. Runoff into this sinkhole is polluted by livestock manure.



contaminated by toxic metals, polychlorinated biphenols (PCBs), radioactive chemicals, organic solvents, and many other pollutants (Fig. 39). Although these contaminants are common in any developed area, it is the ease with which they can enter karst aquifers and the rapid rates at which they can be spread that makes karst groundwater especially vulnerable.

Accidental spills and intentional dumping of waste rapidly contaminate karst aquifers because chemicals travel easily through the soil and limestone bedrock. Spills along roads and railroads, leaking oil and gas wells, pipelines, and especially underground storage tanks have harmed many karst aquifers (Fig. 40). Gasoline has been the cause of some notable contamination problems in Hick's Cave, Kentucky, and Howard's Waterfall Cave in Georgia, where one person lost his life when the flame from a carbide miner's lamp ignited gasoline fumes. In the mid-1980s, the U.S. Environmental Protection Agency declared a "Health Advisory" for Bowling Green, Kentucky, when gasoline fumes from leaking underground storage tanks collected in the Lost River Cave System beneath the town. With time, the fumes rose into homes and schools where they posed serious health and safety problems. Eventually the source of the leak was cut off, and the underground river was able to flush the explosive material from the system.

In karst areas, landfills present special challenges. Throughout the world, landfills leak into karst aquifers and cause severe contamination problems with greater frequency,

speed, and severity than in non-karst aquifers, even with modern pollution prevention methods. Part of the problem is the ease with which contaminants move through karst. Another important problem is how soils can wash into underlying voids below landfills, causing collapses that can breach liners meant to hold landfill waste in place.

Rural and Agricultural

In rural and agricultural areas, karst aquifers are subject to environmental degradation from a variety of sources including chemical fertilizers, pesticides, and herbicides, along with their breakdown products. Levels of these contaminants are high following seasonal application periods, and increase during storms. Elevated concentrations of pathogens can also be flushed through soils into aquifers beneath animal pastures and feedlots (Fig. 41). Bacterial concentrations within karst aquifers in these areas can increase thousands of times as a result of such flushing. Well and spring waters in karst are commonly contaminated, yet in rural areas there may not be an alternative water supply. Municipal water treatment and distribution facilities



Fig. 40. A railroad runs through a sinkhole plain. Leaks and spills along transportation and pipeline corridors have introduced significant contaminants into karst aquifers.

Fig. 42. Soils eroded from a housing development run unfiltered into a karst aquifer.

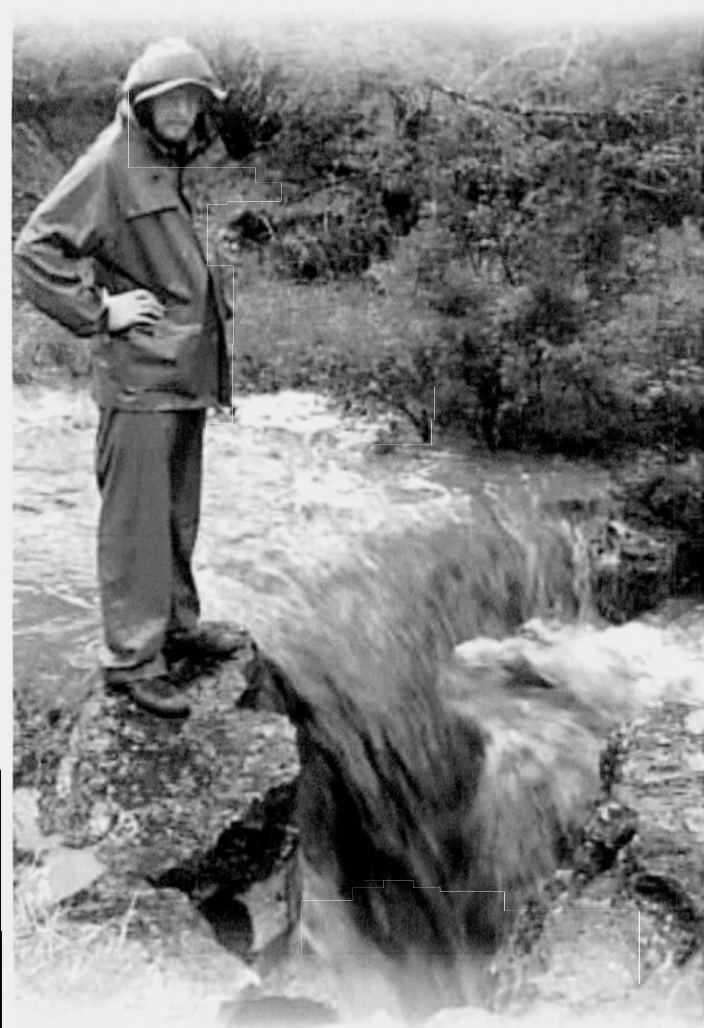
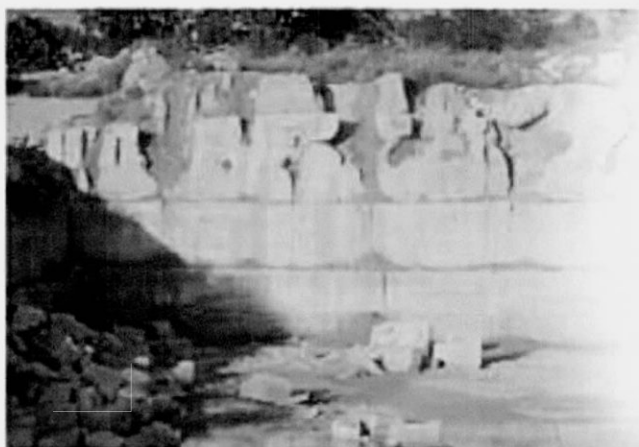


Fig. 43. Mining in and near karst aquifers poses threats of contamination from sediments and toxic metals, and destroys caves and any resources they contain.



are not available in sparsely populated karst landscapes, especially in developing areas of the world.

Another problem in karst regions is the transport of sediment into the aquifer by flowing water, making soil and other sediment washed from rural and urban land use and mining operations a significant contaminant (Fig. 42-43). Sediments can also impact the flow of groundwater by filling in conduits and modifying underground drainage. Programs to minimize soil loss are critically important for many karst areas. The impact of herbicides associated with no-till farming practices on groundwater quality should also be carefully evaluated.

A common practice in many rural landscapes is the dumping of household refuse, construction materials, and dead livestock into sinkholes. Karst aquifers have been found to contain automobile tires, car parts (Fig. 44), and in one underground river in Kentucky, a park bench and refrigerator. The amount of contamination that enters an aquifer is related to the volume and types of materials that are dumped into the sinkholes. Common harmful

products include bacteria from dead animals; used motor oil and antifreeze; and "empty" herbicide, solvent, and paint containers (Fig. 45). These substances readily enter the aquifer and rapidly travel to nearby water wells and springs. Few people would throw a dead cow into a sinkhole if they realized that the water flowing over the carcass might be coming out of their kitchen faucet a few days later.

Sewage Disposal

Ideally, a rigorously maintained sewage treatment system is best for communities located on karst, including suburban and rural subdivisions. This solution is not always financially or practically possible, especially when dealing with isolated rural home or farm sites where individual septic systems are the norm. Properly designed, constructed, and, most importantly, maintained small septic systems can and have been successfully installed on karst. However, this is commonly not the case. Most karst areas have thin, rocky soils that are inadequate to reduce bacteria levels effectively. Older systems may leak from years of use without repair, or be overloaded from initially poor design or later changes to the household. Owners of failing systems often state that they have had minimal or no problems even though they have provided no maintenance! These systems can contribute significant pollutants to the groundwater. The U.S. Environmental Protection Agency has noted that the failure of septic systems is a major source of karst groundwater pollution.

Residential sewage disposal systems generally consist of a septic tank designed and constructed to hold raw sewage, separate solids from liquids, digest organic matter through anaerobic bacterial action, and allow clarified effluent to discharge to a buried soil absorption system. After effluent leaves the septic tank, it flows through a series of buried perforated pipes and is discharged into the soil. Here, pathogens are removed by microbial plant and animal life, filtration, chemical decomposition, and bonding within the soil. Septic tank effluent must be fully purified before it passes to the water table and becomes drinkable water. In non-karst areas, effluent continues to be processed after it



Fig. 44.
This Texas cave was used as a rural dump and is filled with car parts and other trash.

leaves the soil as it slowly flows through the small pores and fine cracks of the aquifer. The slow movement of the effluent provides time for pathogenic bacteria and other microbial organisms to die.

Fecal coliform bacteria are organisms that live in the intestines of humans and warm-blooded animals. They have a limited life span after leaving the body so that even one colony of these bacteria indicates that water has recently been in contact with human or animal waste. Bacteria levels in wells, cave streams, and springs in karst areas may increase by thousands of times during storms. These high levels are caused when runoff from fields and septic-tank leach fields rapidly percolates through thin soils and into the bedrock. In areas where soils are too thin to effectively reduce bacteria levels, associated shallow karst aquifers should be considered unsuitable water sources. Shallow aquifers can contaminate deeper aquifers by leakage along natural fractures and conduits and through poorly designed or maintained wells. Municipal water treatment facilities should be developed in urban, residential, business, and industrial areas. Significant advances in sewage and septic system technology have recently been made and should be examined for their potential use.



Fig. 45.
Household trash fills the sinkhole leading into a cave in West Virginia.



History-Making Days
in the

Pike Spring Basin

Fig. 46.
(Right)
Endangered
Kentucky
Cave
Shrimp.

The landscape near Mammoth Cave National Park in central Kentucky is characterized by sinkholes, underground drainage via a karst aquifer, and intimately connected ecosystems above and below ground. A portion of the park lies within the Pike Spring Groundwater Basin, with groundwater and cave passages freely crossing the park boundary. Aquatic cave life in this basin includes blind fish, crayfish, and the largest known population of the Kentucky Cave Shrimp, which is on the federal Endangered Species List (Fig. 46). Mammoth Cave, with more than 355 mi (572 km) of charted passages, supports diverse ecosystems and is connected with and ultimately drained by the Green River (facing page).

Over the past two centuries in this rural area, residents have dumped refuse into sinkholes on their properties. Until recently, trash pickup and sanitary landfills were unavailable, and sinkholes were seen as convenient dump sites. This misplaced waste has washed into the underlying caves over time, and trash has been reported by survey teams near the park under Hamilton Valley in the Salts Cave section of Mammoth Cave.

In an effort to mitigate the environmental hazards of trash-filled sinkholes, a volunteer cooperative project called *Don't Mess With Mammoth Days* was organized in the mid-1990s. The Cave Research Foundation, Mammoth Cave National Park, and Hart County Solid Waste have been the primary organizers, with crucial assistance from the National Speleological Society, and the American Cave Conservation Association.

On the first field day, which was held in March 1996, more than 30 volunteers removed tangles of wire, sheet metal, broken glass, appliances, and automobile parts that had been discarded in sinkholes (Fig. 47). Seven truckloads of rubbish and recyclable metal were removed, and remedial work was performed on gullies to stop erosion. Subsequently, participation in *Don't Mess With Mammoth Days* events has varied from 25 to 45 volunteers, with similar impressive outcomes. To date, approximately 150 tons of

rubbish, and 30 tons of recyclable metals have been recovered from dumps within the Pike Spring Basin. Although much of this waste is non-toxic, many agricultural chemical containers with residual product have been recovered as well. Ecologically, sinkholes funnel food into caves, and when they are clogged with trash, the organic matter needed by wildlife such as the Kentucky Cave Shrimp cannot get into the caves.

How long will it take to clean up Pike Spring Basin? Nobody knows. We need to learn how many dumps exist, and how many landowners within the basin would welcome the clean-up effort. Changing the way people dispose of solid waste will take time, because proper disposal of trash also costs money. Dumping trash into sinkholes may not cost money today, but the costs in terms of groundwater pollution, loss of ecosystems, and risks to public health are far greater. Cooperative efforts like *Don't Mess With Mammoth Days* provide a much-needed service, help clean up the environment, and educate by example. In the long term, education is the best tool for cleaning up and maintaining karst environments.

Fig. 47. Volunteers hauling trash out of a large sinkhole that had been used as a garbage dump for many years.

5 GUIDELINES FOR LIVING WITH KARST



Karst watershed protection is of special concern to residents of San Antonio, Texas.

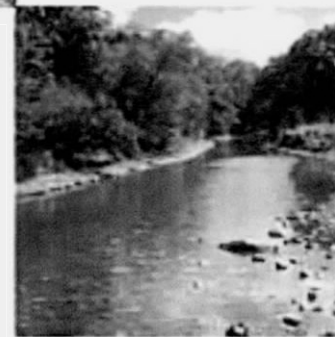
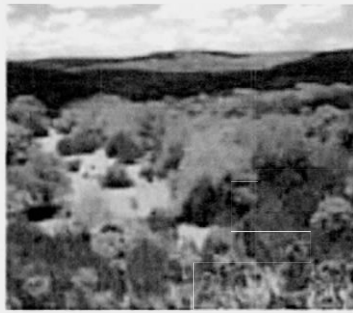


Fig. 48.
As San Antonio, Texas, grows, it is purchasing and preserving undeveloped sensitive karst areas to protect its groundwater supply.

The proper management of a groundwater basin is more important on karst than any other terrain. Management planning must consider all of the natural resources found within the basin, as well as interactions with adjacent areas. In this way, the quality of land, water, and subterranean environments and resources will be maintained.

The following guidelines provide a template for avoiding and solving problems encountered by people who live in karst environments.

Best Management Practices

The goal of Best Management Practices (BMPs) is to conserve natural resources, including prevention of soil erosion and minimizing the amount of contaminants that reach the groundwater system. BMPs cover a wide range of topics such as irrigation water recovery, land reclamation, nutrient management, and the sealing of abandoned wells. Many BMPs are mandated by federal, state, county and other regulatory agencies, but not all are specific to karst and thus may not adequately address karst issues. In some karst areas, best management will require exceeding the mandated BMPs with more effective actions.

Urban, Industrial, and Road Development

Industrial and urban developments commonly produce a greater variety and toxicity of contaminants than do rural areas. Communities located along the margins of karst areas should limit development in karst and encourage development in other directions. Some cities near karst regions have gone as

far as purchasing aquifer areas for permanent protection.

In May 2000, the citizens of San Antonio, Texas, voted for a 1/8 cent sales tax increase to raise \$65 million over four years for the purchase of critical portions of the Edwards Aquifer as well as other important watershed and biological areas (Fig. 48). Where communities are located within extensive karst areas and prohibition of development in karst is not feasible, regulations may be needed to satisfactorily protect karst resources, particularly as related to the location of landfills, underground storage tanks, oil and gas wells and pipelines, and facilities that manufacture and/or store hazardous materials.

Protection of stream watersheds is vital to protecting biological and water quality. Studies examining the relationship of stream water quality to impervious cover, such as roads, buildings, and parking lots, show increased degradation when impervious cover exceeds 15% of the watershed area. Since the extent of impervious cover is a measure of urban impact that can be correlated to pollutant-load levels in urban runoff, aquifer water-quality ordinances in Austin and San Antonio, Texas, require that the percentage of impervious cover be kept low in growing urban areas. Other land-management measures that can help protect watersheds include

- Identifying and studying highly vulnerable karst features, such as caves, sinkholes,



Fig. 49. A road being built over and sealing a cave runs the risk of collapse and problems with water quality and quantity.



Fig. 50. Possible contaminants at higher elevations cannot directly reach the well because of the casing, but the well draws water from a cave stream that is exceptionally vulnerable to contamination.

and fractures enlarged by solution, prior to development. Construction may then be planned to avoid the features and preserve natural drainage into them (Fig. 49). These areas could be developed into educational neighborhood parks that increase the value of adjoining land and of the overall developments. It is important to remember that protection of these features alone will not protect karst aquifers.

- Leaving low traffic roads without curbs so that contaminants in the runoff will be diluted over broad areas and filtered through vegetated areas and soils.
- Channeling curbed runoff from major roads into storm-water sedimentation and filtration basins with hazardous materials traps. Vegetated wetland basins are the most effective at removing contaminants from the water. For such basins to be effective, they must be properly maintained and the filter material changed regularly. Runoff that may enter caves or sinkholes should either be diverted or treated through filtration systems. In 1993, the Indiana Department of Transportation established landmark guidelines for the planning, design, construction, and maintenance of roads in karst areas.
- Minimizing the use of pesticides, fertilizers, and de-icing salts on roads and urban landscapes on karst. Plants native to the area and tolerant to local pests, diseases, and climatic conditions can be grown to reduce the need for chemical support and treatment.
- Monitoring the groundwater quality of springs and wells to determine the effectiveness of the groundwater protection measures enacted. Wells are important to a monitoring plan, but not nearly as important as nearby springs that drain the area. Contaminants in karst aquifers can easily

flow past and be missed by monitoring wells, giving a false sense of security. Springs, however, capture essentially all flow (and contaminants) within their drainage basins. Sampling during high flows after storms is a good time to determine if significant levels of contaminants are present in the aquifer.

Water Supplies

Wells

As a general rule, wells should be placed where there is little or no surface drainage toward the well site. They should be located away from, and at a higher elevation than, any nearby source of contamination. Wells should be constructed to prevent contaminated water from the surface or upper level aquifers from leaking into the drinking-water aquifer. Where necessary, casing should be installed through any contaminated zone and into the productive aquifer to protect the drinking water supply from contamination. The spacing between the casing in a well and the wall of the borehole should be cemented to prevent leakage and downward migration of contaminated water (Fig. 50).

Wells should be tested for coliform bacteria and nitrates at least once a year, more often in areas of thin soil cover, and especially following storms when bacteria are most likely to be washed into the aquifer. County extension agents, community and county health agencies, water well contractors or private laboratories can provide information and assistance for well testing.

When a well is no longer used it should be disconnected from existing water systems, kept clean and, if possible, its casing should be removed. The well bore should be sealed with clean rock and a sand-cement grout to produce a continuous plug from the bottom

of the well to the surface. When all abandonment procedures are complete, the well should be permanently capped. These actions are designed to prevent surface water from migrating down the well bore and polluting the aquifer.

Water well requirements vary from state to state, so it is necessary to check with the regulatory agency in your area for minimum setback distances for wellhead protection and other regulations. As an example, Minnesota requires that

- Wells must be located at least 75 ft (23 m) from cesspools, leaching pits, and dry wells, and 100 ft (30 m) or more from below-ground manure storage areas (i.e., manure lagoons), and large petroleum tanks which are protected with a containment dike, etc. They must be a minimum 150 ft (46 m) from a chemical preparation or storage area, large unprotected petroleum tanks, wastewater treatment pond or wastewater treatment plant, and they must be at least 50 ft (15 m) from septic tanks, subsurface sewage disposal fields, graves, livestock yards and buildings, and manure storage piles.
- Wells with casings less than 50 ft (15 m) deep and penetrating less than 10 ft (3 m) of clay or shale must be at least 150 ft (46 m) from cesspools, leaching pits, and dry wells, and at least 100 ft (30 m) from a subsurface sewage disposal field or manure storage pile.

Regulators and well owners must understand that although such guidelines are helpful, commonly, they are not written for karst areas. General guidelines cannot assure protection from contamination given how easily pollutants can flow long distances through



Fig. 51. Water flowed abundantly and forcefully from the first wells drilled into Texas' Edwards Aquifer in 1897. Now, with large water withdrawals from the aquifer, water discharge is restricted.

karst aquifers. Where greater assurance against pollution is needed, a detailed, site-specific hydrogeologic study, possibly to include a dye tracing test, pumping test, and test drilling may be necessary.

Groundwater Mining

While water quality issues receive most attention in the management of karst aquifers, water quantity can pose equally significant problems in arid and semi-arid climates. The large and open conduits that make karst aquifers so prone to contamination also allow massive volumes of water to be pumped out by wells (Fig. 51). If average water withdrawal exceeds the average recharge of the aquifer, the groundwater is being mined, meaning it

is removed without being fully replenished. Long-term continuation of such practices is not sustainable. Springs will run dry, as will wells. Some wells can be deepened, with increased energy costs of raising water greater distances to the surface. Taken to the extreme, the aquifer would no longer yield useful quantities of water and would be abandoned.

Several methods can be used to prevent groundwater mining

- Develop a groundwater budget for the aquifer to determine its sustainable yield.
- Monitor major spring flows as rough estimates of balanced water use; extended periods of low or no flow may indicate overuse of the aquifer.
- Apply water conservation and water reuse measures.
- Consider enhancing recharge into the aquifer through dams and diversion of uncontaminated surface water into sink-holes; enhanced recharge will tend to quickly flow out of the aquifer and should only be considered for karst aquifers with high storage and relatively low velocities.
- Develop limits for the amount of water that can be withdrawn from the aquifer. Set the limits so that the water used, whether discharged from wells or springs, does not exceed average aquifer recharge. To meet these limits may require limiting community growth within the aquifer's region. Florida has developed legislation and regulations that require strict adherence to defining the impact of groundwater withdrawals on surface water, shallow aquifers, and the Floridan Aquifer. The regulations require the development of a "regional impact statement" and an application for a "consumptive use permit" based upon detailed surface water and groundwater studies.

Septic and Sewage Systems

Standard septic systems should not be placed near sinkholes, caves, springs, fractured bedrock, crevices, bedding planes, or areas of thin soil cover. There should be a minimum of 3 ft (0.9 m) of aerated soil (i.e., soils that show no mottling) below the bottom of drain field trenches. Less than that amount could result in pathogens reaching the groundwater system (Fig. 52). Soils underlying these septic systems should have percolation rates between 1 and 60 minutes/inch (0.4 to 24 minutes/cm). If the minimum parameters cannot be met, a mound system is the next preference. Other possible systems would include a designed active wetland or other experimental system with frequent groundwater monitoring results to check water treatment efficacy.

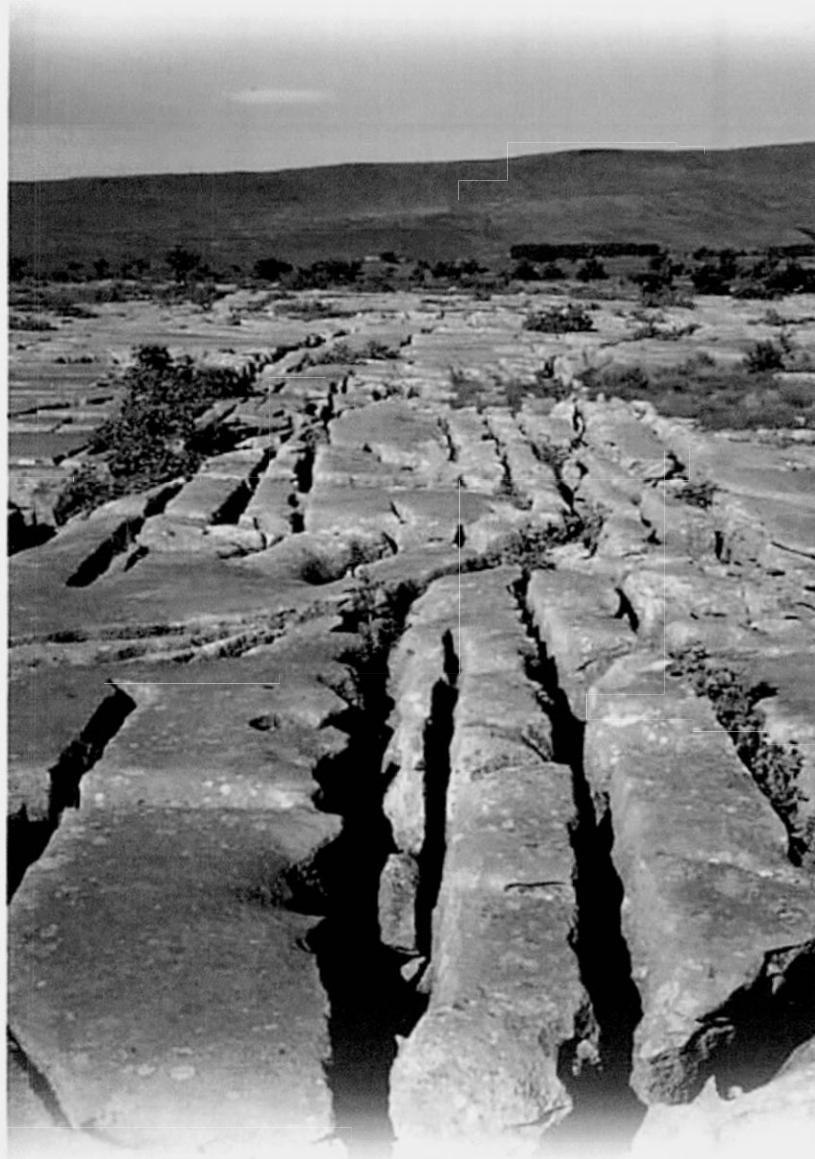
Continued maintenance is critical to the proper performance of a septic system. Maintenance is probably the most ignored BMP of operating a home septic system. Unfortunately, if the drainage does not back-up into the house it is assumed that the system is operating properly. The holding tank needs to be pumped at regular intervals (depending on the size of the tank and the number of people served) or sewage will clog the system, and untreated waste may discharge into the karst. This can happen without noticeable effects in the house. If the septic tank has not been pumped for several years and the system appears to be operating properly, suspect a leak from the tank into the karst aquifer.

Good septic-system operating practices include

- Having the system inspected regularly and pumped annually if possible, but at least every three years.

(continued on page 44)

Fig. 52. Establishing non-polluting septic systems is difficult in karst due to thin or absent soils, such as this karst pavement in Great Britain, or soils underlain by such highly dissolved limestone that promote soil collapses and rapid movement of contaminants into aquifers.



Hidden River Cave

Back from the Brink



Fig. 53. (Left)
Hidden River
Cave today, in
the town of
Horse Cave,
Kentucky.



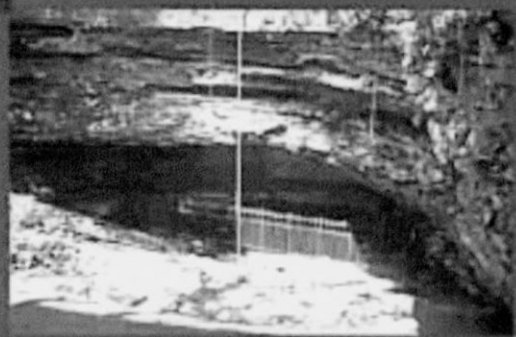
(Above) Historic
Water Works at
Hidden River
Cave — the cave
provided the town
with drinking
water from around
1900-1930. By
the 1930s the
water had
become too con-
taminated for use.

The largest spring in Kentucky is fed by water flowing through Hidden River Cave, and the best-known entrance to the cave is located in the city of Horse Cave (Fig. 53). Beginning in 1887 the cave served as an important water supply and attraction for the city. Tours and boat rides were offered in the cave for 27 years. However, in 1931 an oil refinery began dumping its wastes into a sinkhole that drained into the cave stream. About the same time, residential sewage began to be disposed directly into the ground. By the early 1930s, the cave was abandoned as a water supply and in 1943 the cave was closed to the public due to the stench that rose from its waters out of the entrance and up to the city streets.

Eventually, water from a spring 20 miles (32 km) away was tapped for the community, and a sewage treatment plant was built in 1964. Unfortunately, the treatment plant increased pollution of the aquifer, by gathering all of the city's wastes, providing only a low level of treatment, and discharging the treated wastes into a sinkhole. Toxic heavy metals escaped treatment at the plant, and increased agricultural and urban runoff bypassed the plant and flowed directly into the cave.

In 1989, a new regional waste-water plant was built that treated the effluent to a higher standard and discharged the treated water into the Green River and away from the karst. As a result, the aquifer is slowly recovering; rare species thought lost have begun to repopulate the cave from refuges in small, unpolluted areas. Hidden River Cave is again open to the public, and it now houses the American Cave and Karst Center and Museum. Hidden River Cave is a model that shows both how severe sewage and general groundwater contamination problems can become in karst terrains, and the methods to solve those problems.

(Below)
Karst Exhibit at
American Cave
Museum.



Historic entrance of Hidden River Cave taken around 1940 before the cave became heavily polluted.



(Left) Trickling Filter at old Horse Cave Sewage Treatment Plant. The poorly treated effluent was discharged into caves and sinkholes upstream from the city of Horse Cave.

- Avoid putting excess water through the system;
- Repairing or replacing malfunctioning systems quickly;
- Never pumping out of an inspection riser. (Report any contractor who pumps from an inspection port to the state licensing or health board);
- Putting only sewage into the system. Do not put hazardous material in the system and never put any chemical down your drain that you would not drink (e.g., paints, thinners, solvents, oils, etc.);
- Protecting the land over the septic tank and leach field. Do not build over it. Do not allow any vehicles, including garden tractors, snowmobiles, all-terrain vehicles, etc., to drive across it. Plant lawn or native grasses and other ground covers to reduce soil erosion;
- Avoiding septic tank additives. Additives can destroy the biomat, which is formed by bacteria that naturally treat and purify the wastewater; and
- Using a reputable, licensed, and bonded septic-system contractor. If your state does not license such contractors, compare the education and apprenticeship credentials among different contractors, and request

information from a county extension agent or a community or county health agency, on county- and state-level septic pumping standards. At a minimum, choose a contractor who is bonded.

Sewage systems can be effective at minimizing impacts to karst aquifers if they are properly built and maintained. If not, their large flows of effluent can easily pollute major sections of aquifers. Sewer lines should be inspected regularly. In areas where sinkhole collapse is common, annual inspections and/or closely-spaced flow meters are needed to detect loss of effluent; double-walled pipelines with leak detectors in the outer pipe may be warranted in some cases. Wherever possible, sewage treatment facilities should be located off karst areas. If the treated wastewater cannot be released away from the karst, it should be treated to as near drinking-water quality standards as possible before release, especially if the aquifer is used as a potable water supply.

Sinkhole Flooding and Collapse

An effective way of dealing with sinkhole flooding in the hard-rock karst areas of the mid-continental U.S. is by building storm water retention basins. These are constructed depressions where runoff from streets, parking lots and other impermeable areas is stored until it can slowly drain through the soil.

Retention basins alleviate local flooding problems and provide a means of filtering storm water through the soil, thus protecting the karst system from silt, trash, and some pollutants. Basins designed and maintained to filter sediments and pollutants are known as sedimentation and filtration basins.

Fig. 54.
Some sinkhole ponds in Bowling Green, Kentucky, are used in innovative ways to capture and treat urban runoff for non-potable uses.



Bowling Green, Kentucky, a city of over 50,000 residents, is built almost entirely on a sinkhole plain (Fig. 54). Building codes there require flood easements below a line 12 inches (30 cm) above the standing water level produced by a 100-year storm of 3 hours duration where there is effectively no drainage through a sinkhole. The area below this line has been defined as a "sinkhole flood plain." Storm-water retention basins are required to accommodate drainage produced by changes in land-use accompanying development. Although the city has been successful in reducing flood losses, the numerous storm water retention basins have taken valuable urban land out of production and are expensive for developers to build and maintain. Land uses that affect the hydrologic system, such as filling of sinkholes with debris, are illegal in some areas.

Sinkhole Collapse

The most important tool in preventing and repairing sinkhole collapse is site-specific knowledge of the karst system, as well as an understanding of how karst processes affect engineered structures through time (Fig. 55). Sinkhole collapse is difficult to predict even in well-studied karst regions. Dangerous areas such as the floors of large karst valleys may be easily recognized, but buried sinkholes and fracture trends are harder to detect. When combined with large withdrawal of groundwater and a dropping water table, these areas have the greatest potential for collapse. The seemingly random nature of collapse events dictates that a special knowledge of karst is needed to guide urban and suburban development in these areas.

A variety of approaches can help avoid sinkhole collapse problems associated with urban development of karst areas.

- Karst areas should be mapped thoroughly to help identify buried sinkholes and fracture trends. Geophysical methods, aerial photography, and digitally enhanced multi-spectral scanning can identify hidden soil drainage patterns, stressed vegetation, and moisture anomalies in soils over sinkholes.
- Sinkhole collapses are commonly "repaired" by dumping any available material into the hole. This technique usually diverts water to other locations and promotes collapse. Mitigate by excavating collapses to the bedrock drain, then refilling the dug hole with material graded upward from coarse rocks to finer sediments to allow natural flow through the bedrock drain without the loss of sediments that cause collapse. If a storm-water drainage well is needed, its casing should extend into and be tightly sealed along the bedrock.
- In large sinkholes, use bridges, pilings, pads of rock, concrete, special textiles, paved ditches, curbs, grouting, flumes, overflow channels, or a combination of methods to provide support for roads and other structures.
- Large buildings should not be built above domes in caves. In areas where caves have collapsed in the past, a test-drilling program is needed prior to construction to avoid building on unstable bedrock.
- In less severe cases and in rural areas, place fences around sinkholes to keep animals out and discourage dumping. Construct berms to divert polluted runoff, and establish natural vegetation buffer zones to help filter pollutants and sediment.

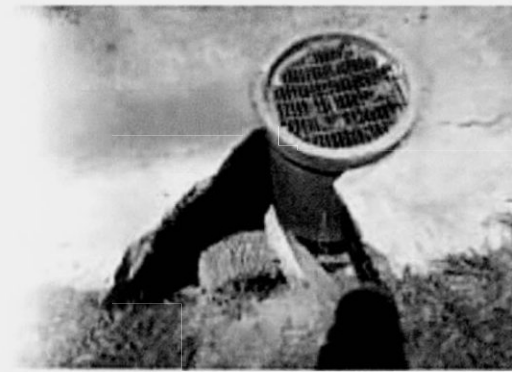


Fig. 55.
A small sinkhole collapse has formed around a poorly installed drainage well.



Fig. 56. Animal wastes are stored on a concrete pad until they can be applied onto fields when plants will most readily take up nutrients, breakdown bacteria, and reduce the contaminants washed down into the aquifer. This process also saves farmers money on commercial fertilizers.

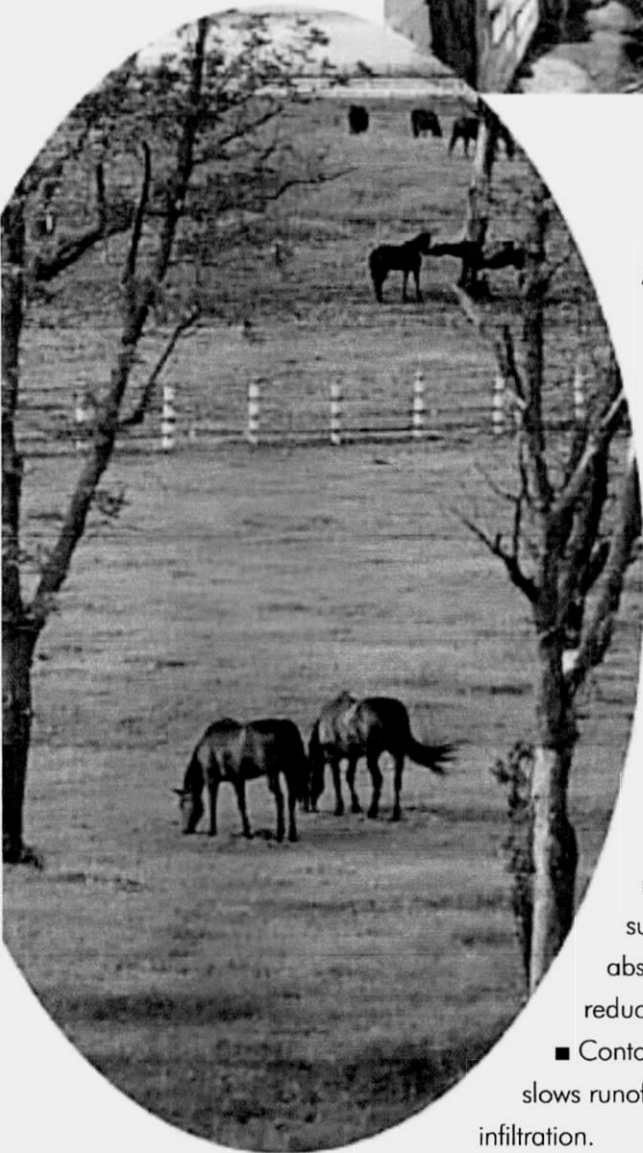


Fig. 57. Livestock can be well-maintained in karst pastures by following best management practices.

Agriculture

An important objective in managing agricultural lands in karst regions is to keep polluted surface water out of the groundwater system.

Some methods to help achieve this goal are

- "No till" cultivation, where plant residue is kept on the surface of the soil to absorb water and reduce erosion.
- Contour tillage, which slows runoff and increases soil infiltration.
- Reseeding cleared areas as quickly as possible to reduce erosion.
- Using fertilizers wisely and only in necessary amounts.
- Minimizing the use of pesticides, and using less toxic and biodegradable types.
- Not dumping waste material into sinkholes.
- Creating a long-term plan for living on karst by conducting a whole-farm and /or household evaluation of all land uses, including application or disposal of nutrients,

pesticides, and hazardous materials as well as maintenance of the groundwater system.

Livestock Production

An important part of the Best Management Practices concept is recognition of the social and economic needs of the landowners and farmers whose land use practices directly impact the health of the aquifer. In karst regions, a general goal of livestock management is to keep runoff and livestock away from waterways, sinkholes, springs, crevices, and caves. On demonstration farms in the Midwestern United States, specially constructed cattle feedlots have been built where solid cattle waste is stored on a concrete stack pad (Fig. 56), with liquid waste channeled into a lined lagoon. The solid and liquid wastes are applied to fields during active phases of the growing cycle so that the plant uptake of the nutrients in these substances is maximized.

Some guidelines for keeping effluent from pastures and feedlots out of karst aquifers are

- Maintaining a herd size within the carrying capacity of the soil and water resources.
- Resting heavily grazed fields (Fig. 57).
- Using movable paddock-style pasturing when possible.
- Surrounding waterways, caves, springs, crevices, and sinkholes with strips of vegetation and fences.
- Frequently moving salt licks and watering tanks to reduce soil compaction and mini-

mize the concentration of waste products.

- Constructing sealed manure-holding tanks that are well maintained and regularly inspected.
- Cleaning abandoned manure storage sites and basins, and applying residual manure and stained soils to cropland.
- Using downspouts, gutters, berms, and storm water culverts to divert runoff away from farm buildings, feedlots and manure storage areas.

Timber Harvesting

Some methods of timber harvesting remove much of the vegetation from an area and can cause significant soil erosion unless mitigating steps are taken. In karst areas, soils and plant debris can be washed into sinkholes and caves resulting in pollution of groundwater (Fig. 58). Some suggestions for a timber harvest plan in karst areas are

- Locating roads, skid trails, and work areas away from places where storm water enters the groundwater system.
- Maintaining an unharvested buffer zone around streams, springs, sinkholes, and caves (Fig. 59).
- Using bridges or culverts where roads and skid trails cross streams to minimize erosion and turbidity.
- Stabilizing cut areas quickly to prevent erosion. Slopes should be seeded and protected.
- Leaving some waste wood on the land to help stabilize it further, and to return nutrients to the soil as the waste decays.
- Not dumping waste cuttings into sinkholes or cave entrances because the debris reduces water quality, hinders drainage, and damages the habitat of cave species.
- Using selective harvesting rather than clear-cutting techniques when feasible.

timber



Fig. 58. Timber harvest debris clogs this Canadian sinkhole, resulting in flooding and less water to replenish the aquifer.

Fig. 59. This Canadian sinkhole is in a forested area, but with an appropriate buffer area to allow unrestricted clean water to enter the aquifer.





Laws and Regulations

Because karst areas are extremely vulnerable to environmental impacts, laws and regulations that are effective in other terrains may not be as effective in karst settings. Human development and exploitation of karst aquifers can trigger catastrophic events and result in numerous legal actions that go beyond property boundaries. Few laws provide direct, significant levels of protection for karst and caves, yet substantial indirect protection may exist depending on local rules and jurisdictions. With increased awareness of the ways cave protection also protects groundwater and other resources, many existing statutes are likely to be strengthened. The following section gives examples of laws and regulations that can apply to development and use of karst areas. For a more thorough consideration of laws that may be of some benefit in the protection of karst, the reader should refer to the 1997 article in *Environmental Geology* by LaMoreaux and others (facing page).

Caves and Karst The Federal Cave Resources Protection Act of 1988 directed the secretaries of the interior and agriculture to inventory and list significant caves on federal lands, and provides a basis for protecting caves. Public Law 101-578, enacted in 1990, directed the Secretary of the Interior to work through the National Park Service to establish and administer a cave research program and to prepare a proposal for Congress that examined the feasibility of a centralized national cave research institute. The Lechuguilla Cave Protection Act, passed in 1993, recognized the international significance of the scientific and environmental values of the cave. In 1998, Congress passed the National Cave and Karst Research Institute Act that mandated the National Park Service to establish and operate the institute.

Puerto Rico, the Cherokee Nation, and 22 U.S. states have cave protection statutes in effect. Typically, they focus on protecting speleothems and placing gates on caves. Some include prohibitions against dumping trash or hazardous materials into caves, and protection for cave fauna and archaeological and historic materials. A number of states have laws protecting paleontological, archaeological and historic sites, and some of these include specific mention of caves. Even without the mention of caves as such in these laws they are likely protected by being significant sites. In addition, caves may be protected as critical habitat under the provisions of some state endangered species acts. Unfortunately, in many states violation of these laws are considered misdemeanors or low-level felonies and the penalties are often slight. State cave-protection laws commonly apply on state land only, and damage can be done in a privately owned cave if the landowner gives permission. More information on state cave and karst protection laws can be found in Huppert's 1995 article on the topic (facing page).

Aquifers The Safe Drinking Water Act (SDWA), the Resource Conservation and Recovery Act (RCRA), and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) aim to protect non-karst and karst aquifers. SDWA sets drinking water standards that are used to protect groundwater, to include provisions for sole-source aquifers and wellhead protection. RCRA gives the U.S. Environmental Protection Agency authority to set up programs to prevent hazardous

wastes from leaching into groundwater from landfills, surface impoundments, and underground tanks. CERCLA is often called the "Superfund" because it set up a fund to support federal and state responses to hazardous waste problems.

Water quality Probably the most influential regulations that protect karst, albeit indirectly in most cases, are the many federal, state, and local laws established to protect surface and groundwater quality. Caves and karst features are seldom addressed in most water rules. However, in order to adequately protect their highly vulnerable karst areas and features, municipalities, counties, and water management agencies can pass local ordinances that provide higher levels of protection than broad-sweeping state and federal regulations. For example, New Castle County, Delaware, has passed subdivision, zoning, and building codes dealing with water-resources protection in that karst area, including amending the building code to require special procedures in "subsidence areas."

Wildlife Some caves and karst springs provide habitat for species that are listed as endangered or threatened by the U.S. Fish and Wildlife Service or equivalent state agencies (Fig. 60). Regulations to protect caves and karst areas in order to preserve their species commonly include measures that protect water quality, and sometimes require standards more stringent than those in some water laws. For example, Texas has no state pumping limits for groundwater. However, sustainable pumping of Texas' Edwards Aquifer is required by federal statute to preserve adequate flows for endangered species living in the springs, which in turn protects local communities from overpumping and depleting their primary water supply.

Antiquities The Federal Archaeological Resources Protection Act can be of significant use in the conservation of caves on federal land. Most states also have regulations protecting historic and prehistoric materials. Cave specific rules are rare, but caves are included within the usual scope of these laws.

Insurance While insurance policies don't fall under the category of laws and regulations, they can be legally and financially useful or required. In Florida, insurance is available to cover personal and property damages as a result of a catastrophic sinkhole collapse. In the sinkhole plain of central Kentucky, federal flood insurance has been made available to people living in sinkholes that flood from rises in underground streams.

References

- Huppert, George N. 1995. "Legal Protection for Caves." *Environmental Geology*, Vol. 26, No. 2, pp. 121-123.
- LaMoreaux, P. E., W. J. Powell and H. E. LeGrand. 1997. "Environmental and Legal Aspects of Karst Areas." *Environmental Geology*, Vol. 29, No. 1/2, pp. 23-36.



Fig. 60. Protection of Rhadine beetles and other endangered species living in caves and karst aquifers has provided protection for those resources where laws to provide for human needs have sometimes been inadequate.

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Fig. 60. Protection of Rhadine beetles and other endangered species living in caves and karst aquifers has provided protection for those resources where laws to provide for human needs have sometimes been inadequate.

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References

- Huppert, George N. 1995. "Legal Protection for Caves." *Environmental Geology*, Vol. 26, No. 2, pp. 121-123.
- LaMoreaux, P. E., W. J. Powell and H. E. LeGrand. 1997. "Environmental and Legal Aspects of Karst Areas." *Environmental Geology*, Vol. 29, No. 1/2, pp. 23-36.

6 LOOKING TO THE FUTURE

Karst regions, like this one in Norway, provide water resources, environmental challenges, habitats, and recreation.

This booklet has provided an overview of karst areas, what they are, and how we can benefit from their resources while minimizing our impact on them. Karst terrains are so complex that it has been impossible to cover all of their aspects and issues in a booklet of this size. However, we have aimed to provide you with a good starting point for understanding and appreciating karst, as well as some directions toward sound management. As understanding of karst areas has grown, we are thrilled to see increasing interest in these regions. We hope that this booklet and the enclosed poster will greatly increase the numbers of people who understand the meaning of the word “karst” and how it affects their daily lives.

Where to Find Help

This section covers organizations that are likely to have useful information about karst and karst hydrogeology. In addition, some university departments of geology, geography, civil engineering, biology, and agricultural science offer courses related to karst issues, and may have karst experts. Local soil conservation agents are another possible source of information and assistance in some karst areas. Karst hydrogeology is a highly specialized field. Unless you are dealing with a karst-specific organization, remember that karst experts, while growing in number, are still relatively few across the country.

Land-use planners in karst areas commonly find themselves without skilled individuals for carrying out the fieldwork needed to resolve a problem or situation. The following organizations may be able to provide information and assistance about caves and karst. Nearly every state in the

United States has a cave or speleological association and several state and regional cave conservancies also exist, including in Indiana, Texas, Virginia, and the southeastern United States.

American Cave Conservation Association

www.cavern.org

The American Cave Conservation Association (ACCA) is a national organization dedicated to the conservation and management of caves and karst resources. ACCA operates the American Cave and Karst Center and Museum in Horse Cave, Kentucky. It sponsors cave management workshops and symposia, provides curricula and training programs for teachers and students, operates public-education programs, designs and constructs cave gates, and provides technical assistance and public information on cave management issues.

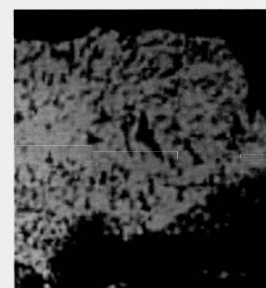
American Cave Conservation Association
American Cave and Karst Center
P.O. Box 409
Horse Cave, Kentucky 42749
Tel: (270) 786-1466
e-mail: acca@caveland.net

Bat Conservation International

www.batcon.org

If a development plan involves bats, Bat Conservation International should be contacted for information. It is headquartered in Austin, Texas, and works closely with the public and local to international levels of government to promote understanding, research, and conservation of bats.

Bat Conservation International
P.O. Box 162603
Austin, Texas 78716
Tel: (512) 327-9721



Bureau of Land Management

www.blm.gov/nhp/

The Bureau of Land Management (BLM), an agency within the U.S. Department of the Interior, administers 264 million acres of America's public lands — about one-eighth of the land in the United States — and about 300 million additional acres of subsurface mineral resources. Most of the lands the BLM manages are located in the western United States, including Alaska, and are dominated by extensive grasslands, forests, high mountains, arctic tundra, and deserts. The BLM manages a wide variety of resources and uses, including energy and minerals; timber; forage; wild horse and burro populations; fish and wildlife habitat; wilderness areas; archaeological, paleontological, and historical sites; and other natural heritage values.

Bureau of Land Management
Office of Public Affairs
1849 C Street, N.W., Room 406-LS
Washington, D.C. 20240
Tel: (202) 452-5125

Center for Cave and Karst Studies

caveandkarst.wku.edu/

The Center for Cave and Karst Studies is located on the campus of Western Kentucky University in Bowling Green, which sits virtually in the center of a large karst landscape that extends from southern Indiana, through central Kentucky and Tennessee, and into northern Alabama. The Center, founded by Dr. Nicholas Crawford, is the only university program in the United States dedicated to karst studies. Its focus is on karst environmental management issues and it offers research assistantships for students, consultations and research for the public, and summer courses at Mammoth Cave National Park on topics such as, karst geology, hydrogeology, geomorphology, ecology, and archaeology.

Center for Cave and Karst Studies
Department of Geography and Geology
Western Kentucky University
Bowling Green, Kentucky 42101-3576
Tel: (502) 745-4555

IAH Karst Commission

www.iah.org/

The IAH Karst Commission activities are in full agreement with the principal aims of the International Association of Hydrogeologists to advance hydrogeological science by international cooperation between hydrogeologists and specialists in other disciplines with an interest in this field. Thus, the Karst Commission tries by focusing on karst groundwater to initiate, encourage and promote relevant studies; to cooperate with other relevant organizations; to promote or organize meetings or joint meetings with other appropriate organizations; to publish the proceedings of its special studies and scientific meetings; and to promote a better understanding of karst hydrogeological principles.

Heinz Hötzl, Chairman
Department of Applied Geology
University of Karlsruhe
76128 Karlsruhe, Germany
Tel: +49 721 608 8096
e-mail: Heinz.hoetzl@bio-geo.uni-karlsruhe.de

David Drew, Vice-chairman
Department of Geography
Trinity College Dublin
Dublin 2, Ireland
Tel: 353 1 608 1888
e-mail: ddrew@mail.tcd.ie

Karst Waters Institute

www.uakron.edu/geology/karstwaters

The Karst Waters Institute is a group of leading researchers in the fields of karst geology, biology, and engineering. Although headquartered in West Virginia, its members are distributed throughout the United States. The Institute



hosts international symposia on karst and has published several reports.

Karst Waters Institute
P.O. Box 490
Charles Town, West Virginia 25414
Tel: (304) 725-1211/ (202) 885-2180
e-mail: karst@american.edu

National Park Service

www.aqd.nps.gov/

Caves and karst features occur in about 77 units of the National Park System (NPS). The number of caves ranges from as few as 10 to 15 caves per unit — as in the Chesapeake & Ohio Canal National Historic Park — to more than 400 caves per unit — as in the Grand Canyon National Park. At this time, there are over 3600 known caves in the National Park System.

National Park System units may solicit the assistance of the Geologic Resources Division with the management and preservation of caves and karst. Recent management included the placement of gates on caves in Mammoth Cave National Park, Kentucky; assessments of cave resources at Petroglyphs National Monument, New Mexico; inventories of the culturally sensitive and important caves of Hawaii Volcanoes National Park; the generation of recommendations for the protection, development, and interpretation of Cathedral Caverns State Park, Alabama; and the development of cave management and protection in China, Mexico, and the Ukraine, including the Crimean peninsula.

Ron Kerbo, Cave Specialist
NPS Geologic Resources
Division
P. O. Box 25287
Denver, CO 80225-0287
e-mail: ron_kerbo@nps.gov

National Speleological Society

www.caves.org

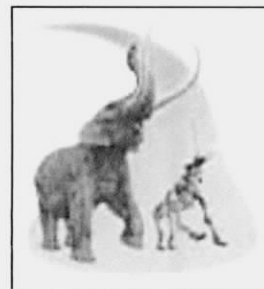
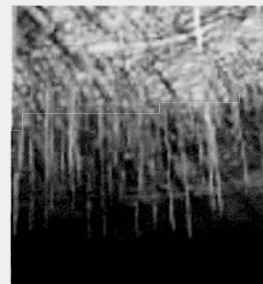
The National Speleological Society (NSS), a member organization of the American Geological Institute, is an 11,000-member group dedicated to exploration, research, and conservation of caves and karst. The NSS has a history of helping to resolve problems uniquely associated with karst. An extensive library and bookstore are available at the NSS headquarters in Huntsville, Alabama. About 180 NSS chapters, called "grottos" are located throughout the country. Some of the Society's internal and affiliated organizations are specifically geared toward assisting with the management of caves and karst areas, and NSS has published some major books on cave and karst science.

National Speleological Society
2813 Cave Avenue
Huntsville, Alabama 35810-4431
Tel: (256) 852-1300
e-mail: nss@caves.org

USDA Forest Service

www.fs.fed.us/

The Forest Service recreation, geology, and watershed programs have key roles in cave and karst management, helping the agency administer 192 million acres to effectively achieve its mission of "Caring for the Land and Serving People." The Forest Service recognizes that caves are a sensitive resource and must be protected. Caves can be locations of sensitive wildlife or cultural resources. In order to protect this valuable resource, the Forest Service does not release information about the locations of specific caves under Forest Service management. In 1996, the oldest human skeletal remains (9,300 years old) in Alaska and Canada were discovered in a Prince of Wales Island (POW) cave, in



the Tongass National Forest. This cave, which is one of 500 inventoried caves on POW and its outlying westerly islands, is the focus of a significant international multidisciplinary effort to study the Ice Age and post-Ice Age environment and earliest occupation of northern Prince of Wales Island. In addition to the human skeleton discovery at the cave, black bear bones dating back to over 41,000 years were excavated at the cave.

USDA Forest Service (Headquarters)
P.O. Box 96090 (RHWR)
201 14th Street, S.W.
Washington, D.C. 20090-6090

U.S. Fish and Wildlife Service

www.fws.gov

The U.S. Fish and Wildlife Service's major responsibilities are for migratory birds, endangered species, certain marine fish and mammals, and freshwater fish. The Service helps citizens learn about fish, wildlife, plants, and their habitats. Its National Conservation Training Center in West Virginia is the Nation's premier site for fish and wildlife conservation education, where people from government, industry, and non-profit groups all come for the latest in professional conservation training. The Service provides an array of electronic Web sites, where their most popular publications and hundreds of wildlife photographic images are posted and may be downloaded. The U.S. Fish and Wildlife Service has offices in every state and many territories. You can find contact information for each office and, in some cases, find office numbers and individuals listed in online phone directories. For the Refuges Visitor Guide, please call (800) 344-9453.

U.S. Fish and Wildlife Service (Headquarters)
1849 C Street N.W.
Washington, D.C. 20240

U.S. Geological Survey

www.usgs.gov

The U.S. Geological Survey (USGS) collects and disseminates information about the Earth and its resources. USGS groundwater programs encompass regional studies of groundwater systems, multidisciplinary studies of critical groundwater issues, access to groundwater data, and research and methods development.

The Learning Web, on the USGS web site, is dedicated to K-12 education, exploration, and life-long learning. Information and activities there help visitors learn how biology, geology, hydrology, and geography can help them understand our changing world. A USGS publication of particular interest to students and teachers is Open-file Report 97-536-A, *Karst Topography*, Paper model by Tau Rho Alpha, John P. Galloway, and John C. Tinsley III.

U.S. Geological Survey (Headquarters)
12201 Sunrise Valley Drive
Reston, Virginia 20192
Tel: 1 (888) ASK-USGS
e-mail: ask@usgs.gov



American Geological Institute

www.agiweb.org

The American Geological Institute is a nonprofit federation of 37 geoscientific and professional associations that represent more than 120,000 geologists, geophysicists, and other earth scientists. Founded in 1948, AGI provides information services to geoscientists, serves as a voice of shared interests in our profession, plays a major role in strengthening geoscience education, and strives to increase public awareness of the vital role the geosciences play in mankind's use of resources and interaction with the environment.



State Geological Surveys

Karst occurs in almost every U.S. state. Alabama, Florida, Kentucky, Illinois, Indiana, Missouri, Tennessee, Texas, Virginia, and West Virginia are just a few of the states containing large karst areas. In states having lesser amounts, karst may still be a significant resource. South Dakota, for example, has little karst, but its karst resources include Wind Cave National Park and Jewel Cave National Monument. Some state geological surveys, including the members of the Illinois Basin Consortium (Kentucky, Indiana, and Illinois), have karst specialists on staff. To learn more about the natural resources — including karst — and natural history of your state, contact its geological survey.

Geological Survey of Alabama

Tuscaloosa, AL
(205) 349-2852
www.gsa.state.al.us

Alaska State Geological Survey

Fairbanks, AK
(907) 451-5001
www.dggs.dnr.state.ak.us/

Arizona Geological Survey

Tucson, AZ
(520) 770-3500
www.azgs.state.az.us

Arkansas Geological Commission

Little Rock, AR
(501) 296-1877
www.state.ar.us/agc/agc.htm

Division of Mines & Geology

Sacramento, CA
(916) 323-5336
www.consrv.ca.gov/dmg

Colorado Geological Survey

Denver, CO
(303) 866-2611
www.dnr.state.co.us/geosurvey

Geological and Natural History Survey of Connecticut

Hartford, CT
(860) 424-3540
dep.state.ct.us/cgnhs/index.htm

Delaware Geological Survey

Newark, DE
(302) 831-2833
www.udel.edu/dgs/dgs.html

Florida Geological Survey

Tallahassee, FL
(904) 488-4191
www.dep.state.fl.us/geo/

Georgia Geologic Survey

Atlanta, GA
(404) 656-3214
www.dnr.state.ga.us/dnr/enviro/aboutepd_files/branches_files/gsb.htm

Hawaii Geological Survey

Honolulu, HI
(808) 587-0230
kumu.icsd.hawaii.gov/dlnr/Welcome.html

Idaho Geological Survey

Moscow, ID
(208) 885-7991
www.idahogeology.org/

Illinois State Geological Survey

Champaign, IL
(217) 333-5111
www.inhs.uiuc.edu/isgsroot/isgshome/isgshome.html

Indiana Geological Survey

Bloomington, IN
(812) 855-5067
www.indiana.edu/~igs

State Geological Surveys

Iowa Department of Natural Resources
Iowa City, IA
(319) 335-1575
www.state.ia.us/government/dnr/index.html

Kansas Geological Survey
Lawrence, KS
(785) 864-3965
www.kgs.ukans.edu

Kentucky Geological Survey
Lexington, KY
(859) 257-5500
www.uky.edu/KGS

Louisiana Geological Survey
Baton Rouge, LA
(225) 388-5320
www.lgs.lsu.edu

Maine Geological Survey
Augusta, ME
(207) 287-2801
www.state.me.us/doc/nrimc/mgs/mgs.htm

Maryland Geological Survey
Baltimore, MD
(410) 554-5500
www.mgs.md.gov/

**Massachusetts Executive Office of
Environmental Affairs**
Boston, MA
(617) 727-5830 (Ext. 305)
www.state.ma.us/envir/eoea.htm

**Michigan Department of Environmental
Quality**
Lansing, MI
(517) 334-6923
www.deq.state.mi.us/gsd/

Minnesota Geological Survey
St. Paul, MN
(612) 627-4780
www.geo.umn.edu/mgs/index.html

Mississippi Office of Geology
Jackson, MS
(601) 961-5500
www.deq.state.ms.us/newweb/homepages.nsf

**Missouri Department of Natural
Resources**
Rolla, MO
(573) 368-2160
www.dnr.state.mo.us/dgls/homedgls.htm

Montana Bureau of Mines & Geology
Butte, MT
(406) 496-4180
mbmgsun.mtech.edu

Nebraska Geological Survey
Lincoln, NE
(402) 472-3471
csd.unl.edu/csd.html

Nevada Bureau of Mines and Geology
Reno, NV
(775) 784-6691
www.nbmgs.unr.edu/

**New Hampshire Department of
Environmental Services**
Concord, NH
(603) 271-3503
www.des.state.nh.us

New Jersey Geological Survey
Trenton, NJ
(609) 292-1185
www.state.nj.us/dep/njgs

**New Mexico Bureau of Mines & Mineral
Resources**
Socorro, NM
(505) 835-5420
www.geoinfo.nmt.edu/

New York State Geological Survey
Albany, NY
(518) 474-5816
www.nysm.nysed.gov/geology.html

State Geological Surveys

North Carolina Geological Survey

Raleigh, NC
(919) 733-2423

www.geology.enr.state.nc.us

North Dakota Geological Survey

Bismarck, ND
(701) 328-8000

www.state.nd.us/ndgs

Ohio Department of Natural Resources

Columbus, OH
(614) 265-6988

www.dnr.state.oh.us/odnr/geo_survey/

Oklahoma Geological Survey

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GLOSSARY

anaerobic bacteria Bacteria that can live in the absence of free oxygen.

aquifer A body of rocks or sediments, such as cavernous limestone and unconsolidated sand, which stores, conducts, and yields water in significant quantities.

berm A relatively narrow, horizontal shelf, ledge, or bench designed and constructed to deflect water.

best management practices (BMPs) State and/or Federal land-use regulations designed to conserve natural resources and minimize the amount of contaminants that reach the groundwater system

bioremediation The use of biological agents to clean up chemical pollutants.

calcite Calcium carbonate, CaCO_3 , the principal mineral in limestone.

carbonic acid A mild, naturally occurring acid, H_2CO_3 , that dissolves limestone, dolomite, and marble to form karst landscapes.

casing Pipe inserted and cemented into a borehole to prevent collapse and to prevent contaminated water from leaking into or out of a well.

cave A natural underground open space, generally with a connection to the surface and large enough for a person to enter. Caves in karst areas are dissolved out of soluble rock, such as limestone, dolomite, marble, gypsum, or halite.

chert A hard mineral composed mainly of microscopic silica crystals. It commonly occurs in limestone and is also called flint.

dendritic drainage A drainage pattern in which the streams branch in a tree-like pattern.

dissolution In karst, the process of dissolving rock to make landforms.

dolomite A carbonate sedimentary rock composed chiefly of the mineral dolomite, $\text{CaMg}(\text{CO}_3)_2$.

drainage well A type of well used to drain excess surface water, where the aquifer is permeable enough and the water table far enough below the land surface, to remove water at a satisfactory rate.

dry well A storm-water drainage well.

ecosystem A community of organisms and the environment in which they live including the non-living factors that exist in and affect the community.

effluent A liquid discharged as waste, such as contaminated water from a sewage works or a factory; water discharged from a storm sewer or from land after irrigation.

fecal coliform bacteria Organisms that live in the intestines of humans and other warm-blooded animals.

graded fill Material used to fill and stabilize a collapsed sinkhole. The material grades from coarse at the bottom to fine at the top of the stabilized area.

groundwater (a) That part of the subsurface water that is in the phreatic (saturated) zone, including underground streams. (b) Loosely, all subsurface water including water in both the vadose (unsaturated) and phreatic zones.

grout A cement or bentonite slurry of high water content, fluid enough to be poured or injected into spaces and thereby fill or seal them.

guano Accumulations of dung in caves, generally from bats.

gypsum A widely distributed mineral composed of calcium sulfate and water, $\text{Ca}(\text{SO}_4) \cdot 2\text{H}_2\text{O}$.

hydrologic cycle The circulation of water from the atmosphere as precipitation onto the land, where it flows over and through the land to the sea, and its eventual return to the atmosphere by way of evaporation from the sea and land surfaces and by transpiration from plants.

karst A type of topography that is formed on limestone, gypsum, and other soluble rocks, primarily by dissolution. Karst landscapes are characterized by sinkholes, caves, and underground drainage.

karst aquifer A body of rock in a karst area that contains sufficient saturated permeable material to conduct groundwater and to yield significant quantities of water to springs and wells.

limestone A sedimentary rock consisting chiefly of calcium carbonate, CaCO_3 , primarily in the form of the mineral calcite.

marble A metamorphic rock consisting predominantly of recrystallized calcite or dolomite.

mitigation The process minimizing or eliminating the effects of a problem.

paleoclimate The climate of a given period of time in the geologic past.

paleokarst Ancient karst features that have subsequently been buried under sediments.

pathogen Any microorganism or virus that can cause disease.

permeability The property or capacity of a rock, sediment, or soil to transmit fluid.

phreatic zone The subsurface zone below the water table in which all spaces are filled with water. Also known as the saturated zone.

pit A vertical cavity extending down into the bedrock; usually a site for recharge, but sometimes associated with collapse.

porosity The percentage of a rock that is occupied by pores, whether isolated or connected.

potable water Water that is safe and palatable for human use.

pseudokarst A landscape that has features similar to those found in karst landscapes, but which are formed in relatively non-soluble rocks by non-karst processes.

regolith A general term for the layer of unconsolidated fragmented rock and soil that nearly everywhere forms the surface of the land and overlies the bedrock.

retention basin Constructed depressions where runoff from streets, parking lots, and other impermeable areas is stored until it can slowly drain through soil into the bedrock.

saltpeter Naturally occurring sodium nitrate or potassium nitrate. Found in floor sediments of some caves, and formerly used in the manufacture of gunpowder.

sinkhole A funnel-shaped depression in a karst area, commonly with a circular or oval pattern. Sinkhole drainage is subterranean and sinkhole size is usually measured in meters or tens of meters. Common sinkhole types include those formed by dissolution, where the land is dissolved downward into the funnel shape, and by collapse where the land falls into an underlying cave.

sinkhole plain A plain on which most of the local relief is due to sinkholes and nearly all drainage is subterranean.

sinking stream A surface stream that loses water to the underground in a karst region.

speleothem Any secondary mineral deposit that is formed in a cave. Common forms include narrow cone-shaped stalactites that hang from ceilings, usually broader cone-shaped stalagmites that build up from the floors, and columns where stalactites and stalagmites have joined.

swallet The opening through which a sinking stream loses its water to the subsurface.

swallow hole A closed depression or cave into which all or part of a stream disappears underground.

terrain A tract or region of the earth's surface considered as a physical feature.

troglobite An organism that must live its entire life underground.

vadose zone The subsurface zone between the surface of the land and the water table. Also known as the unsaturated zone

water table The subsurface boundary between the vadose (unsaturated) and phreatic (saturated) zones.

C R E D I T S

Front Cover — (Above ground, left to right) Karst towers, Li River and Guilin, China (G. Veni); Sinkhole plain, Bosnia (© J. Wykoff); Clean water flowing into an aquifer (G. Huppert); Sinkhole collapse, Winter Park, Florida (Files of the Florida Sinkhole Research Institute courtesy of B. Beck, original photographer unknown); Limestone pinnacles, Black Stone Forest, China (G. Veni); St. Louis, Missouri (Corbis Images).

(Below ground, left to right) Chandelier Ballroom in Lechuguilla Cave, New Mexico (© D. Bunnell); Prehistoric bowl in Chiquibul Cave, Belize (G. Veni); Stream passage in Nutt Cave, West Virginia (© C. Clark); Blind cave isopod, Mammoth Cave (© C. Clark); Gypsum crystal (© C. Clark).

Inside Front Cover/ Title Page — Canadian sinkhole in forested area (G. Huppert); Karst towers, Guilin, China (G. Veni); Cave stream, Texas (K. Menking)

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