

THE FITCHBURG-WAUBESA ARTESIAN SYSTEM

*Water & Land
Stewardship*

in the Northeast Corner of
Fitchburg

Water & Land Stewardship in Northeast Fitchburg

- Thank you for this opportunity to speak...
- ...on the *Northeast Neighborhood Plan* & its related *Storm Water Management Plan*, both produced by Ruckert/Mielke of Milwaukee.
- I am Cal DeWitt, of UW's Gaylord Nelson Institute.
- I am a member of the UW graduate faculties of
 - ◆ Land Resources,
 - ◆ Water Resources Management,
 - ◆ Limnology & Marine Science, &
 - ◆ Conservation Biology & Sustainable Development

My Three Major Topics

- 1. **Critique** of the Ruekert/Mielke Storm Water Plan for N.E. Fitchburg
- 2. **New Data** that show the critical need for a Groundwater Budget & Water Budget Policy
- 3. **Consequences** of N.E. Fitchburg Development for Water Budget, Water Balance, and Water Budget Integrity

Major Topic #1

Critique of the Ruekert/Mielke Storm Water Plan

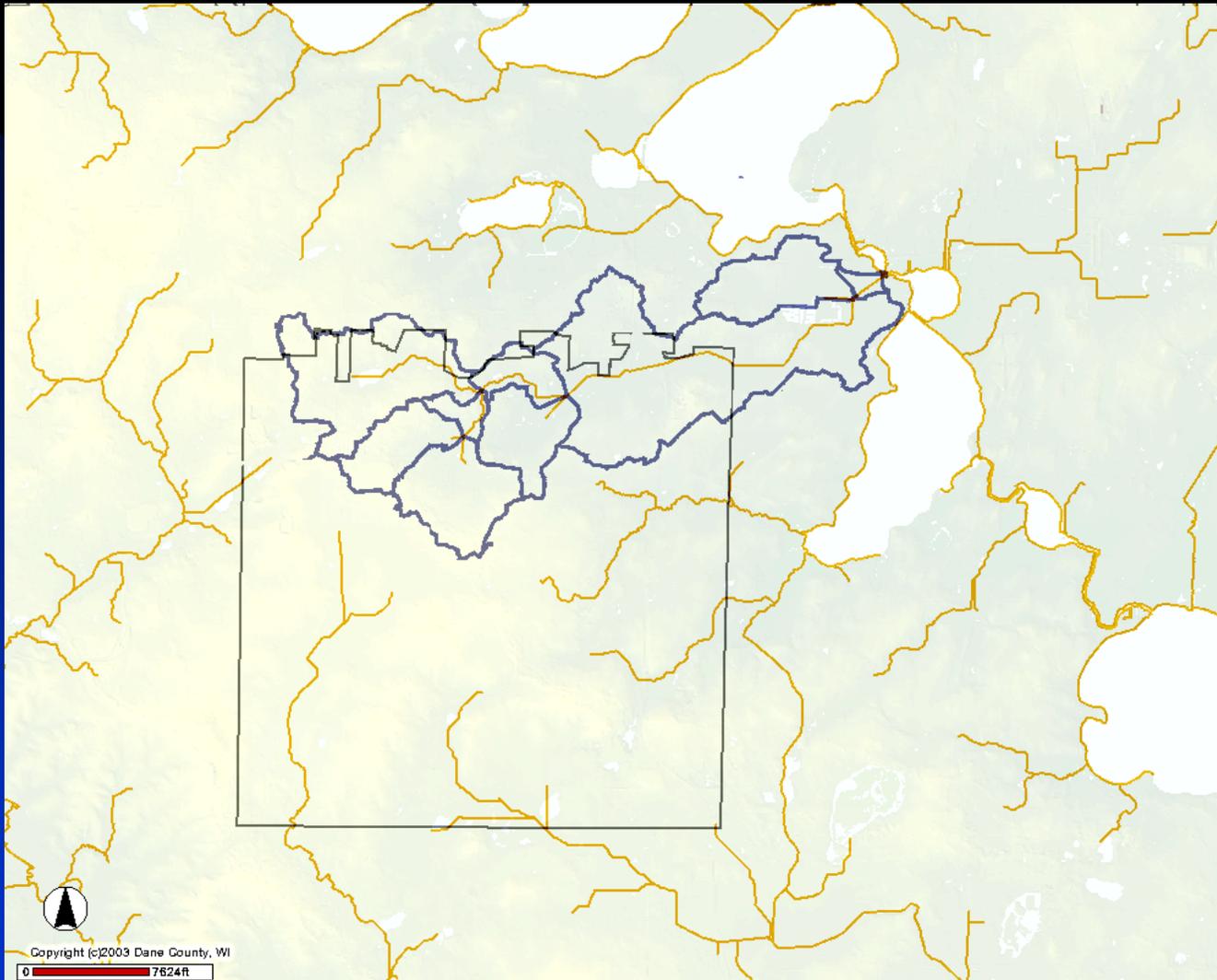
- 1. Failure to take the Watershed into account
- 2. The Storm Water Management Plan is not a Plan
- 3. Failure to Use Groundwater Modeling & Related Predictive Technology
- 4. Failure to recognize & analyze Phosphorus Loading
- 5. Failure to develop the Groundwater Budget as context for the site & system
- 6. Failure to address Eutrophication of Lake Waubesa

Eutrophication – ----- *Why must this be included?*

- This is the “Quality Bottom Line” of any storm water plan
- Failure to address Eutrophication means imposing expensive & extensive Future Remedial Projects on Fitchburg and citizens
 - ◆ *Four such projects have been done in past decades here at costs of tens of millions of dollars*

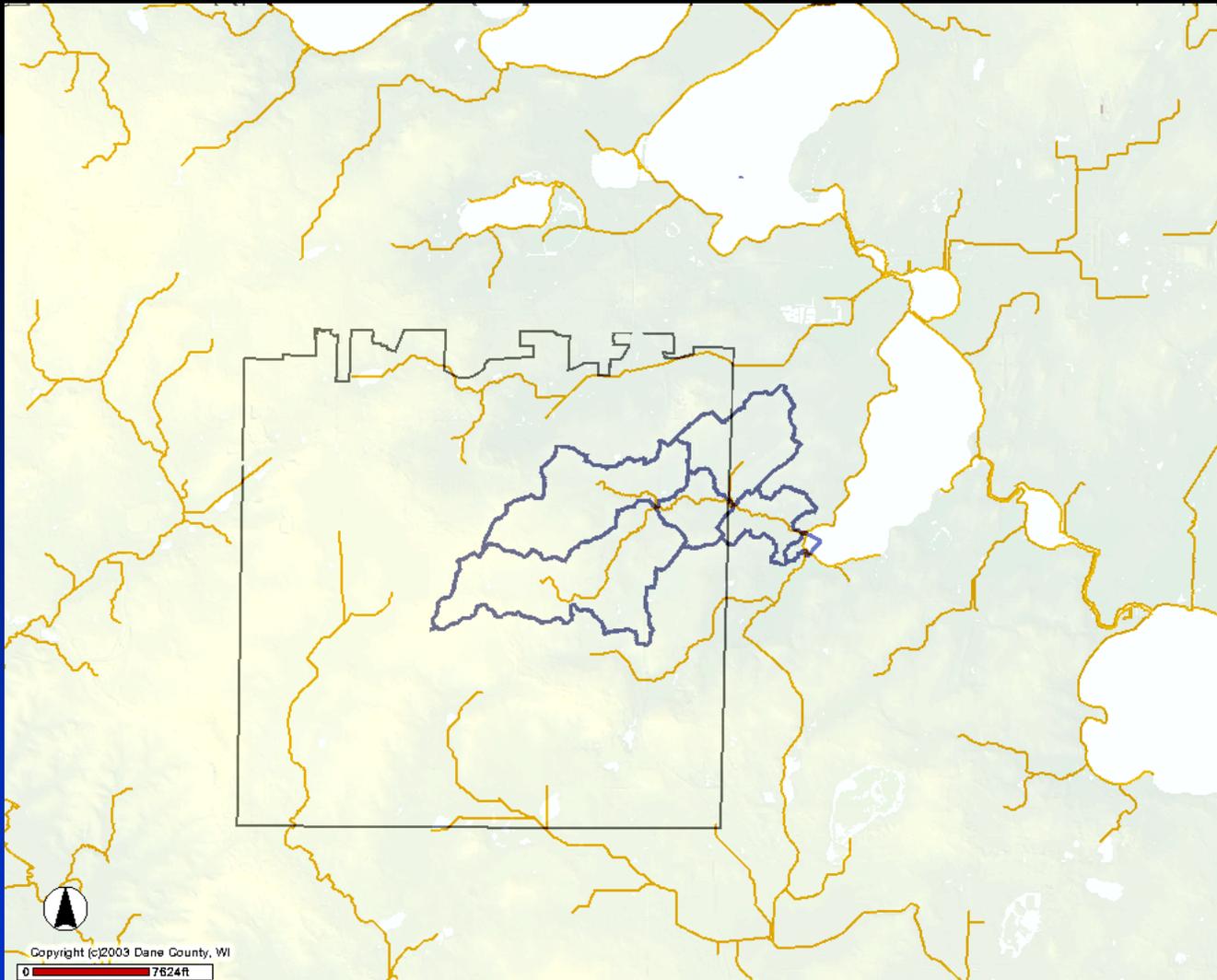
What are Our Watersheds?

- The West Lake Waubesa Watershed that includes:
 - ◆ Nine Spring Creek Watershed
 - ◆ Swan Creek Watershed
 - ◆ Murphy Creek Watershed



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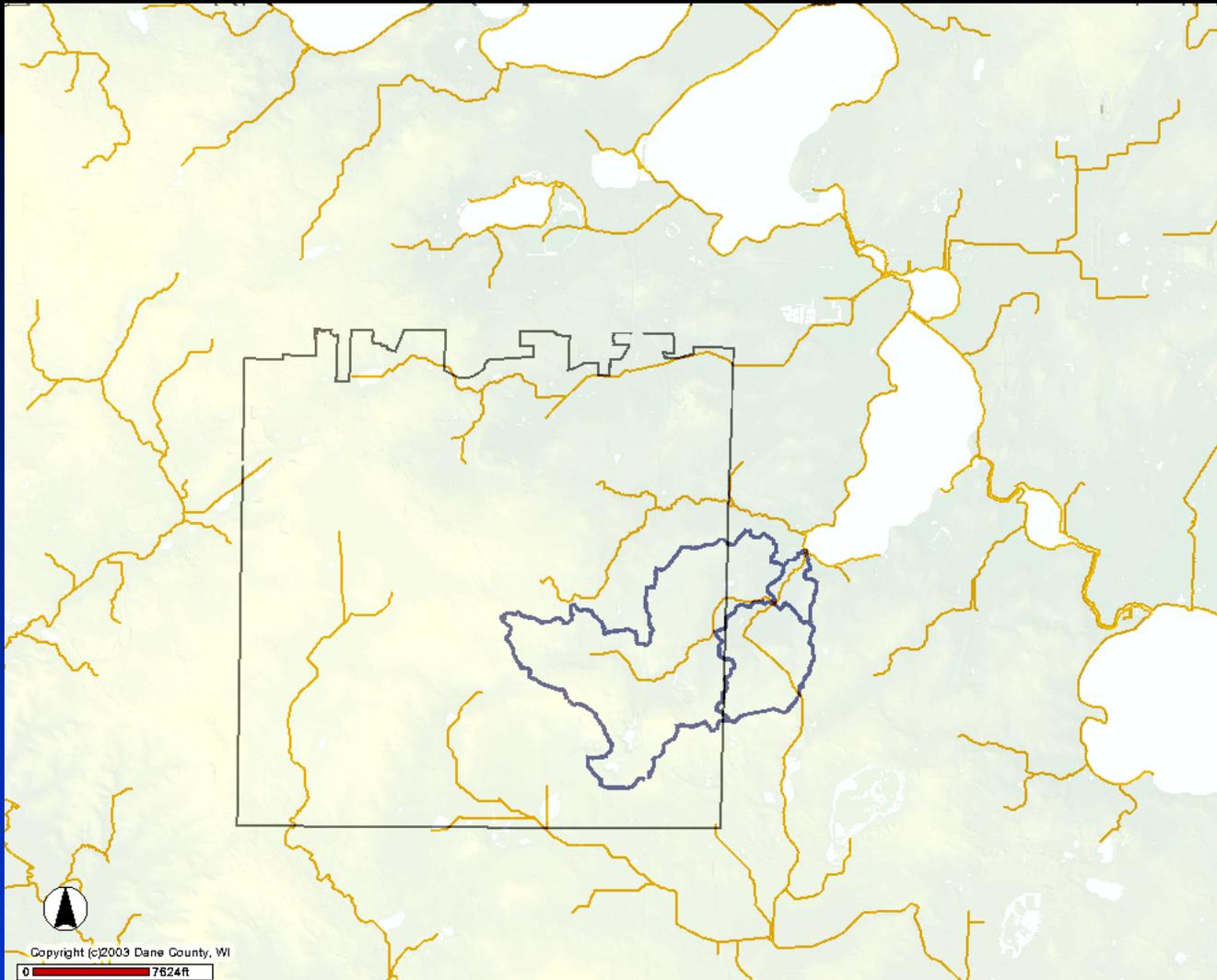
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Recommendation 1:

- The City of Fitchburg should conclude that these six deficiencies and failures of the two Ruekert/Mielke reports are wholly insufficient for providing a basis for extending urban services extension or permitting residential and business development in the northeast corner of Fitchburg

Major Topic #2

The Groundwater Budget

What do we believe so far?

At this point we believe that:

- ◆ Two aquifers lie below us, with an aquitard between.
- ◆ This aquitard limits vertical water flow, except in cracks.
- ◆ Both aquifers ultimately get their water from above.
- ◆ Municipal wells pump at 800-1000 feet from the lower aquifer.
- ◆ Rural wells pump at 50 to 200 feet from the upper aquifer.

The aquitard is sedimentary rock---Eau Claire shale formed layer by layer in bedded sediments that settled under an ancient sea.

We believe that this aquifer is about 100 feet thick.

The Groundwater Budget

New Data

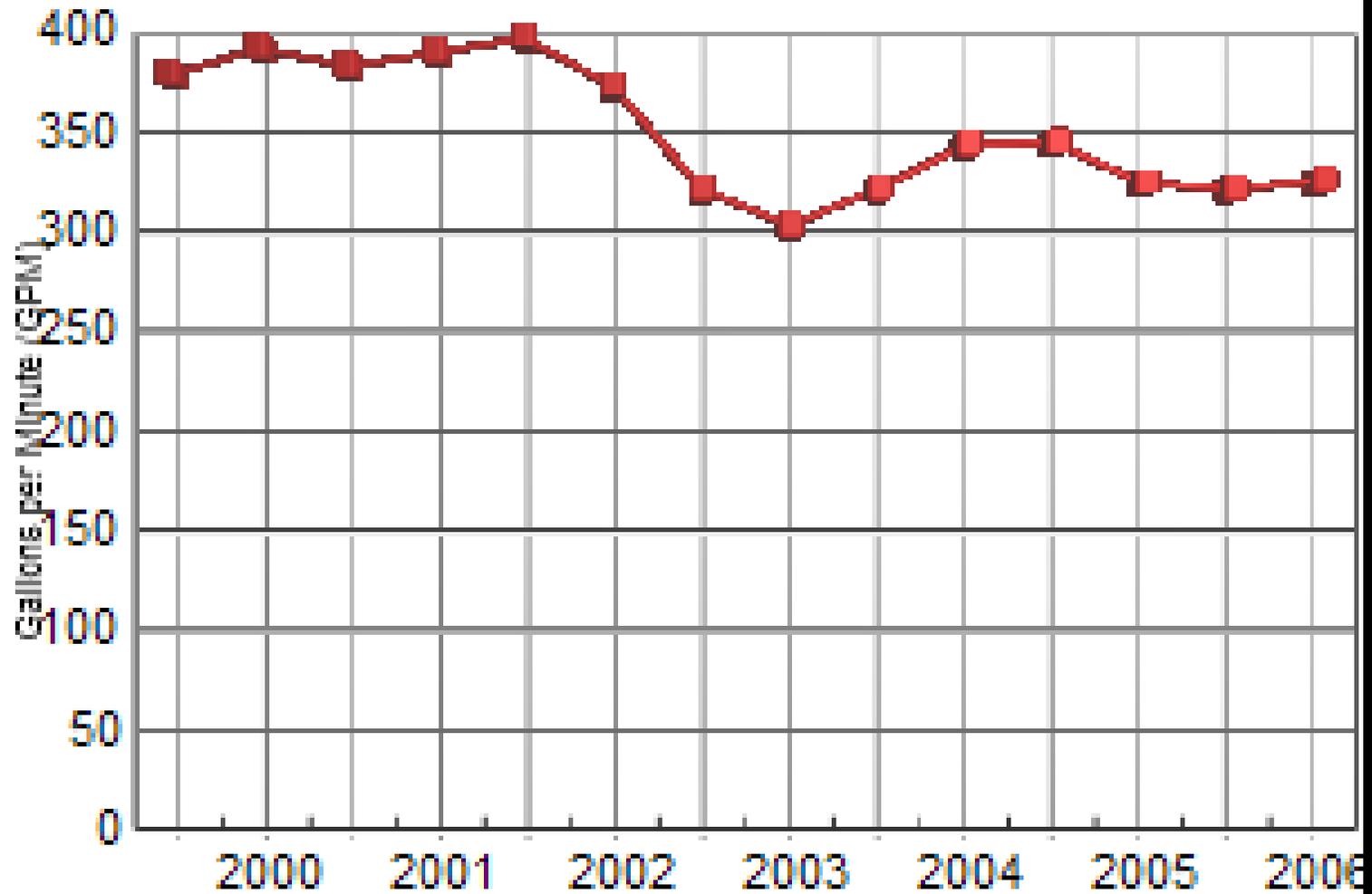
Are there any wells in the region that have shown sharp declines in flow?

If so, we can look into the reasons for these declines!

So, I looked across Fitchburg for wells with sharp declines in flow,

And this is what I found:

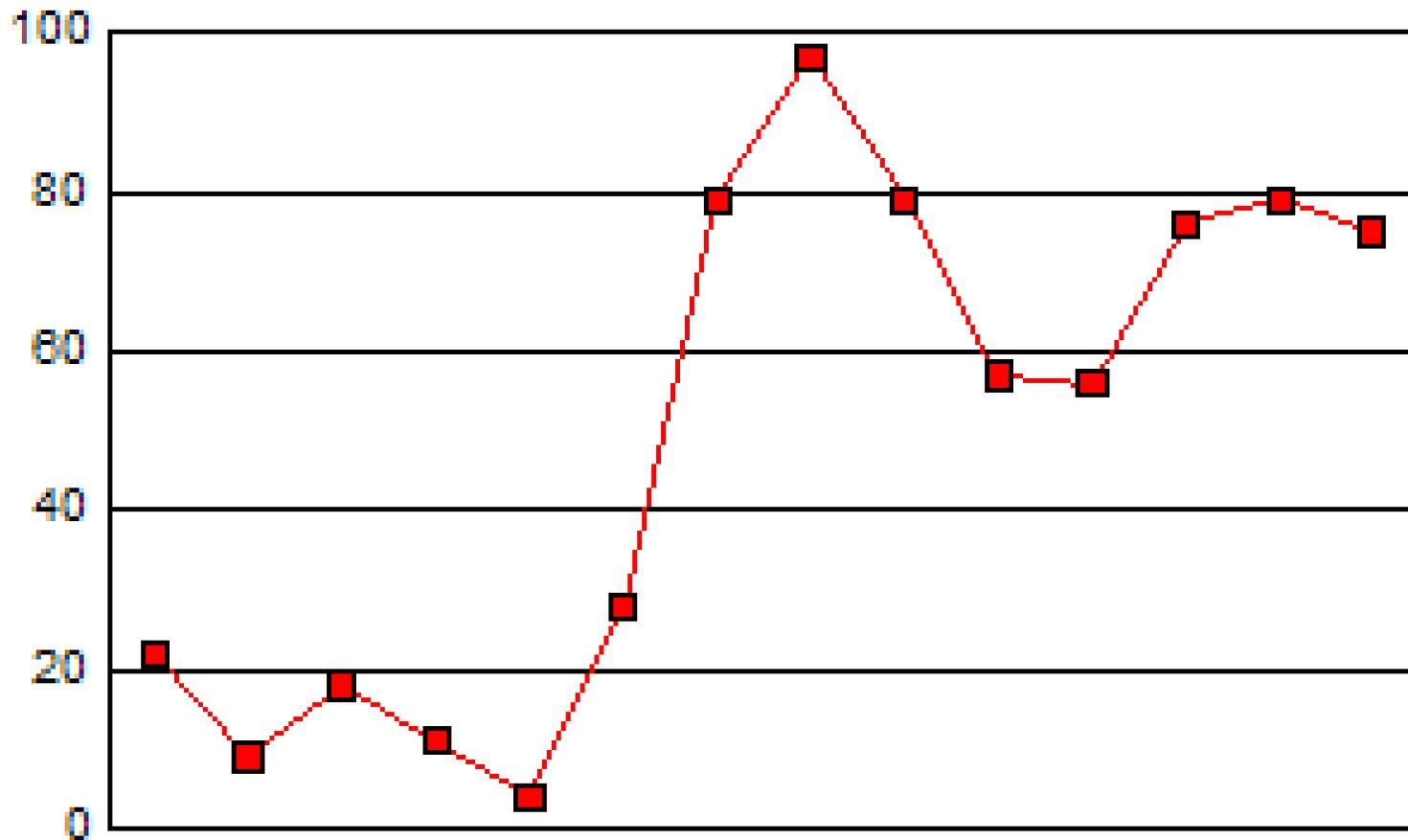
Artesian Flow - Well # 8 Nevin Fish Hatchery



This Graph can be “Turned Upside-Down”

- By subtracting the measured flow from 400 Gallons per Minute (400 GPM).
- This gives a new graph showing the number of GPM by which this flow misses 400 GPM.
- This is shown in the next graph.

Nevin Artesian Well #8 Reduction of Flow from 400 GPM



Here are three photos of
the *Nevin Trout Hatchery*

at 3911 Fish Hatchery Road
in Fitchburg

- Entrance Sign
- The Nevin Trout Hatchery Main Building and Office
- Artesian Well # 8, located at the southeastern corner of the building just behind this Office
 - ◆ The plastic tube shown is putting out water under its own Artesian pressure.



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My Search through many tables of well data found:

- Pumpage from Municipal Well #10 corresponded with the reduction in flow from Artesian Well #8.
- Well #10 is a High Capacity Well located at 2689 Granite Circle near Lacy Road a short distance east of the City Hall.



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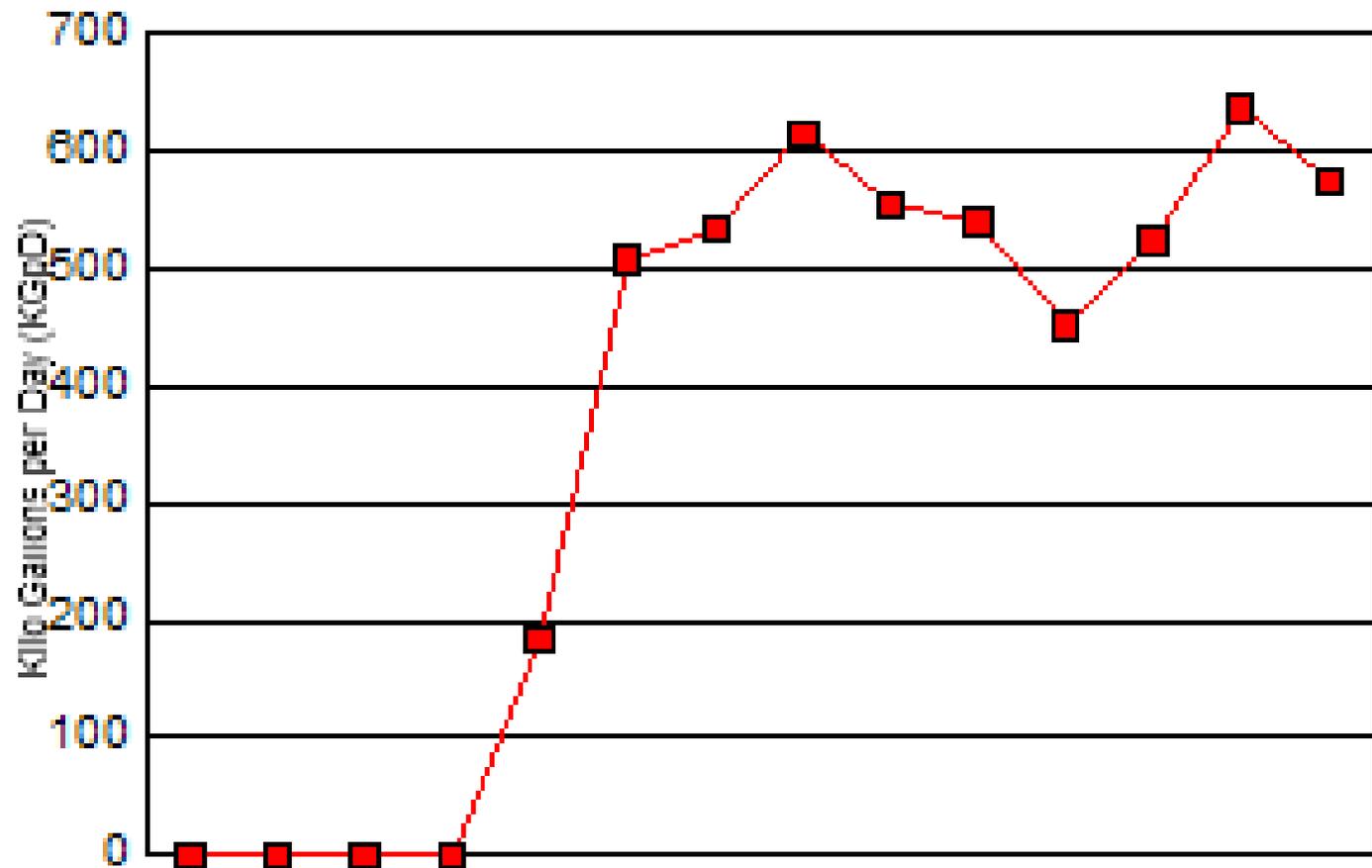
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Here is the Pumpage of Municipal Well #10

- The data shown here are averages of 6 months of flow.
- The period chosen for this average was December through May, and June through November.
- These periods were chosen because inspection showed that these two 6-month periods were closest to being equal to each other.

Municipal Well # 10

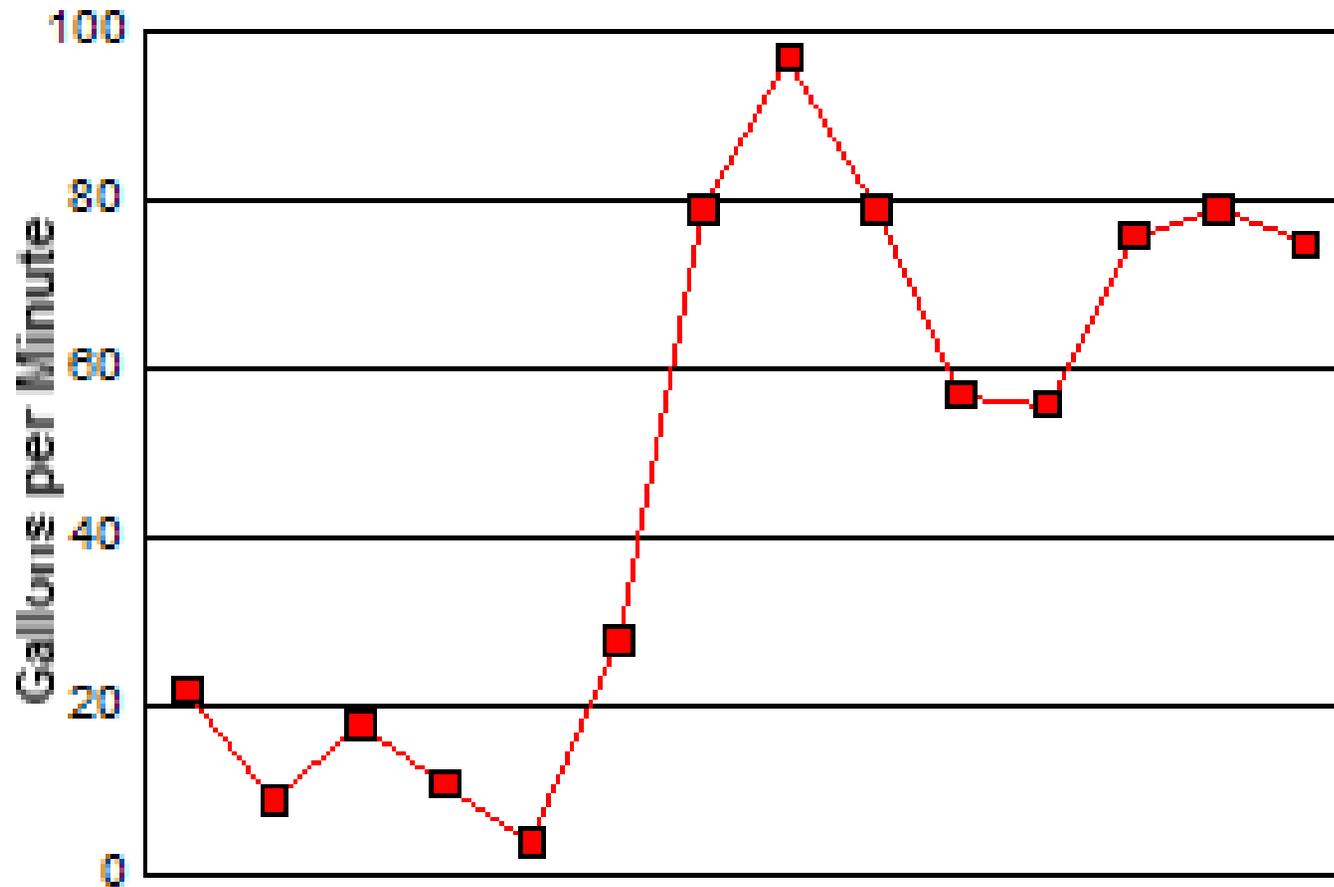
Fitchburg (also # MK 457)



Here are the data from Artesian Well #8 again

- But now these data are shifted by 12 months.
- This brings them into better accord with the data from the Municipal Well,
- And also suggests that there is a time lag between pumpage from Well #10 and flow from Well #8.

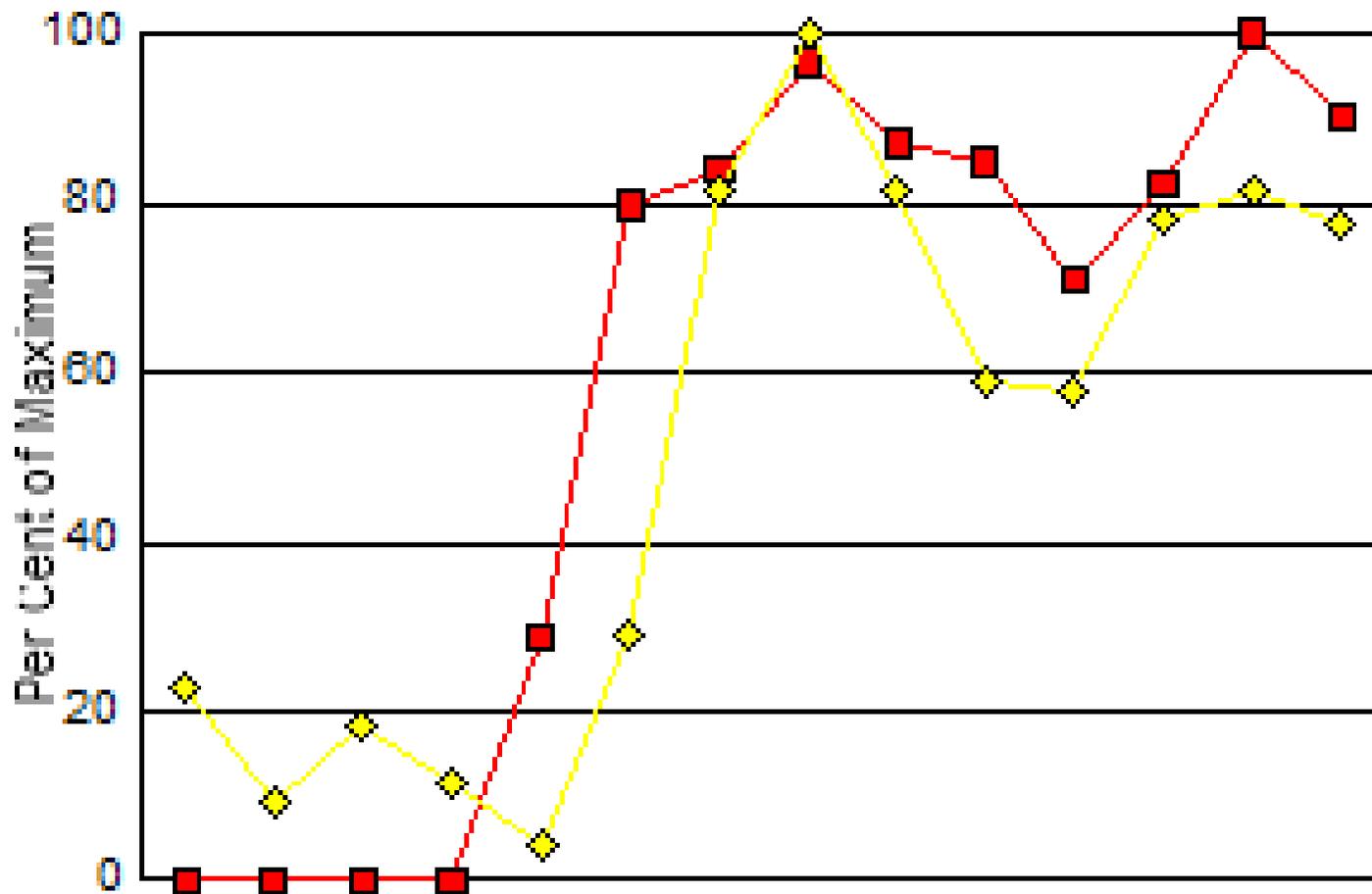
Flow Reduction - Nevin Well # 8 *Phase Shifted 12 Months*



When these curves for both wells are overlaid they begin to match up

- Here the flows of both wells are shown in per cent of their approximate maximum flows.
- This makes the two curves more comparable.
- The maximum selected for Well #8 is 385 GPM and 455.25 GPM for Well #10.

Wells # 10 & #8 Compared



What This Means

- There is a connection between Municipal Well #10 and Nevin Artesian Well #8
- Since the Nevin Artesian Well is 180 feet deep, there is a connection between the upper and lower aquifers
- The lag of the effect of Well # 10 on Nevin # 8 is about 12 months; the distance is about 1 mile
- This means that the flow rate between these two wells is approximately 5280 feet per 365 days or approximately 14.5 feet (4.4 meters) per day.

This is Quite Different from what we expected

- What we had believed about aquifers and aquitards will have to be revised.
- Water is flowing thousands of times faster than we had supposed.
- Water apparently is moving between aquifers.

What this Means for Policy is:

There is a Vital Need for a
Groundwater Budget
coupled with
Watershed Budgets

A Groundwater and Watershed System
without a Budget is like a City
without a Financial Budget...

A Double Bottom-Line

- A Quality Bottom Line – maintaining good water and preventing Eutrophication
- A Quantity Bottom Line – that
 - ◆ keeps the Groundwater Budget in Balance, and
 - ◆ Assures that we do not “live beyond our means”

Recommendation 2:

- The City of Fitchburg recommends to Dane County and CARPC:
- (1) that they place high priority on developing a policy to develop and apply a Groundwater Budget for the region, and
- (2) that they work with Fitchburg on procedures for monitoring and evaluating diminished well and spring flows in the City and Region.

Consequences of Developing the N.E. Corner of Fitchburg on Water Budget Integrity

- There are two objectives for a Water Budget:
 - ◆ (1) Balancing water quantities, and
 - ◆ (2) Maintaining and improving water quality.

- There are two interlinked components in a Water Budget:
 - ◆ (1) A Groundwater Budget, and a coupled
 - ◆ (2) Watershed Water Budget

There are Three Additional Aspects to a Water Budget:

- These are:
 - ◆ (1) Inventory and Evaluation of Ecosystem Services, as provided in the Landscape
 - ◆ (2) Collective Wisdom, as published on the Landscape
 - ◆ (3) The practice of Reciprocal Service by People with Long-Range Interests in Sustainability

1. Ecosystem Services

- Ecosystem Services are Services provided by natural ecosystems, for example:
 - ★ Moderation of Flood Flows and Drought Flows by Wetlands.
 - ★ Production of Oxygen and Consumption of Carbon Dioxide by Photosynthesis in Green Plants.

Look at the Clear-Water Area in the next slide...

- Along the edge of Waubesa Wetlands, and
- At the mouths of three streams:
 - ◆ Murphy Creek (south)
 - ◆ Deep Spring Creek (middle)
 - ◆ Swan Creek (north)



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Cleansing and Flushing of Lake Waubesa

- The slide we have just seen shows one of these ecosystem services.
- It is the flow of groundwater from springs, fens, and spring mounds from the Fitchburg-Waubesa Artesian Basin.
- It is this flow coupled with groundwater and surface water flows from Nine Springs, Swan, and Murphy Creek---also part of the Fitchburg-Waubesa Artesian Basin.
- This combined flow pushes clear water north to the Yahara River outlet at McFarland.
- Without this flow the southern “boot” of Lake Waubesa would be stagnant and would eutrophy.

The next slide shows Swan Creek

during the August 2007 Flooding

- The location here is Swan Creek Bridge on Lalor Road
- While Swan Creek was muddy during this flood event,
 - ◆ Murphy Creek remained clear
 - ◆ Badfish Creek remained clear
- Swan Creek's "ecosystem service" clearly is being compromised by upstream run-off over barren soil.



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Waubesa Wetlands in Flood

- During the August 2007 flooding, Waubesa Wetlands looked as shown in the next slide.
- Water flow in its creeks increased dramatically, but did not leave its banks.
- Water in its creeks remained crystal clear and sparkling.



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Deep Spring...

- This spring, even when sometime overwashed with Waubesa floodwaters, continues pouring out crystal clear, cold water.
- It joins with other large springs on Deep Spring Creek and brings its continual cleansing action for the “boot” of Lake Waubesa.
- And its Purple Bacteria often can be seen from the air, as it is here in Spring 2007 from 1000 feet altitude.



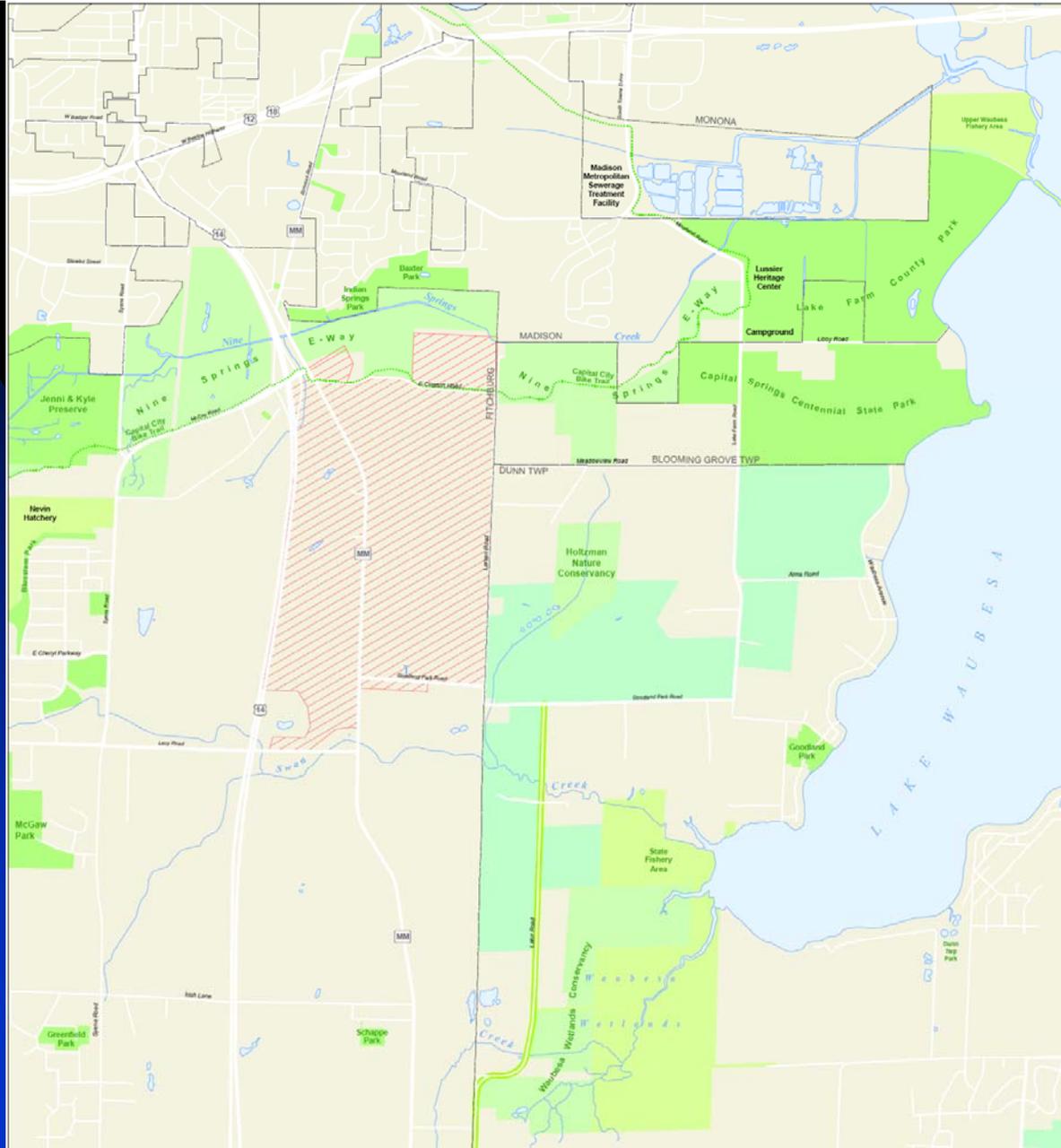
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2. Collective Wisdom published in the Landscape

- This is the Wisdom that is published in the Land and Life of Citizens and Governments in the Landscape
- Some of this Wisdom is shown on the following slide where Sensitive Areas have been protected by Various Conservation Easements



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Examples of this **Collective Wisdom** *on the Landscape*

- Fourth Street Marsh Restoration between Wick's Farm and Lake Waubesa
- Restoration of Esox Marsh at the Bible Camp on Lake Waubesa
- Public Land Purchase for Wetland Creation and Groundwater Injection System to correct Siltation of Lake Kegonsa, Colladay Point
- Heritage Park Land Purchase for Run-Off Interception on Lake Waubesa's south shore

3. Reciprocal Service

- This is the return of services by citizens and government back to the ecosystems that serve us.
- This is a “service with”--- a “con-” (meaning “with”) service.
- This is Reciprocal Service, Con-Service, Con-Servation.
- It means never simply taking, but also giving back to the systems that serve us at similar or greater levels.

Examples of our Con-Service:
Eutrophication Remediation
in the
Fitchburg-Waubesa Artesian System

- Eutrophication of Lakes Waubesa and Kegonsa by treated sewage diversion via aqueduct from MMSD to Badfish Creek & the Rock River
- Construction of two in-lake Sanitary Sewers to eliminate septic leakage from converted cottages
- Defeat of the Libby Landfill on the western shore of Lake Waubesa, preventing leachate production
- Restoration of Fourth Street Marsh to intercept and process non-point agricultural run-off

And Finally a “Stewardship Bottom Line”

- Helping all of us to live within our financial means
- Preserving and providing the opportunity for each of us to be stewards of water, land, and life

A Triple Bottom-Line

- A Quality Bottom Line –
(preventing Eutrophication)
- A Quantity Bottom Line –
(Groundwater Budget Balance)
- A Stewardship Bottom Line –
(Reciprocal Service Con-Service)

This Ends my Presentation on September 4, 2007

- In the Question and Answer Period following I was asked for more information.
- I was also inspired by the Plan Commission's interest to continue this research.
- The next section was produced in response between September 4 and September 17, 2007.

The *Fitchburg-Waubesa* Artesian System

- The Fitchburg-Waubesa Artesian Basin is defined here as the system of aquifers and aquitards centered in the northeast quadrant of Fitchburg whose structure and relationships affect and control groundwater recharge, discharge, and piezometric pressures and flows.
- Discharge includes artesian wells, springs, fens, peat mounds, and seeps. It also includes pumpage by wells.
- Recharge is principally by rainfall, with some septic field return.

Recommendation 3:

- That Fitchburg City Staff
 - ◆ 1. Consider the emerging understanding about the Fitchburg-Waubesa Artesian Basin, and summarize it.
 - ◆ 2. Consider the implications of any development for the Fitchburg-Waubesa Artesian Basin.
 - ◆ 3. Work with the DNR and the Town of Dunn to “un-ditch” Swan Creek east of Lalor Road & restore functionality.
 - ◆ 4. Determine the sources of Swan Creek sediment, as seen at Lalor Road, toward restoring water quality.
 - ◆ 5. Apply these considerations and work to re-evaluate the wisdom of any further development within this Basin.
 - ◆ 6. Work with the Fish Hatchery on the reduced flows and diminished oxygen levels in Artesian Well #8.



The

Fitchburg-Waubesa *Artesian Basin*

Further Investigations

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Gaylord Nelson Institute

University of Wisconsin-Madison

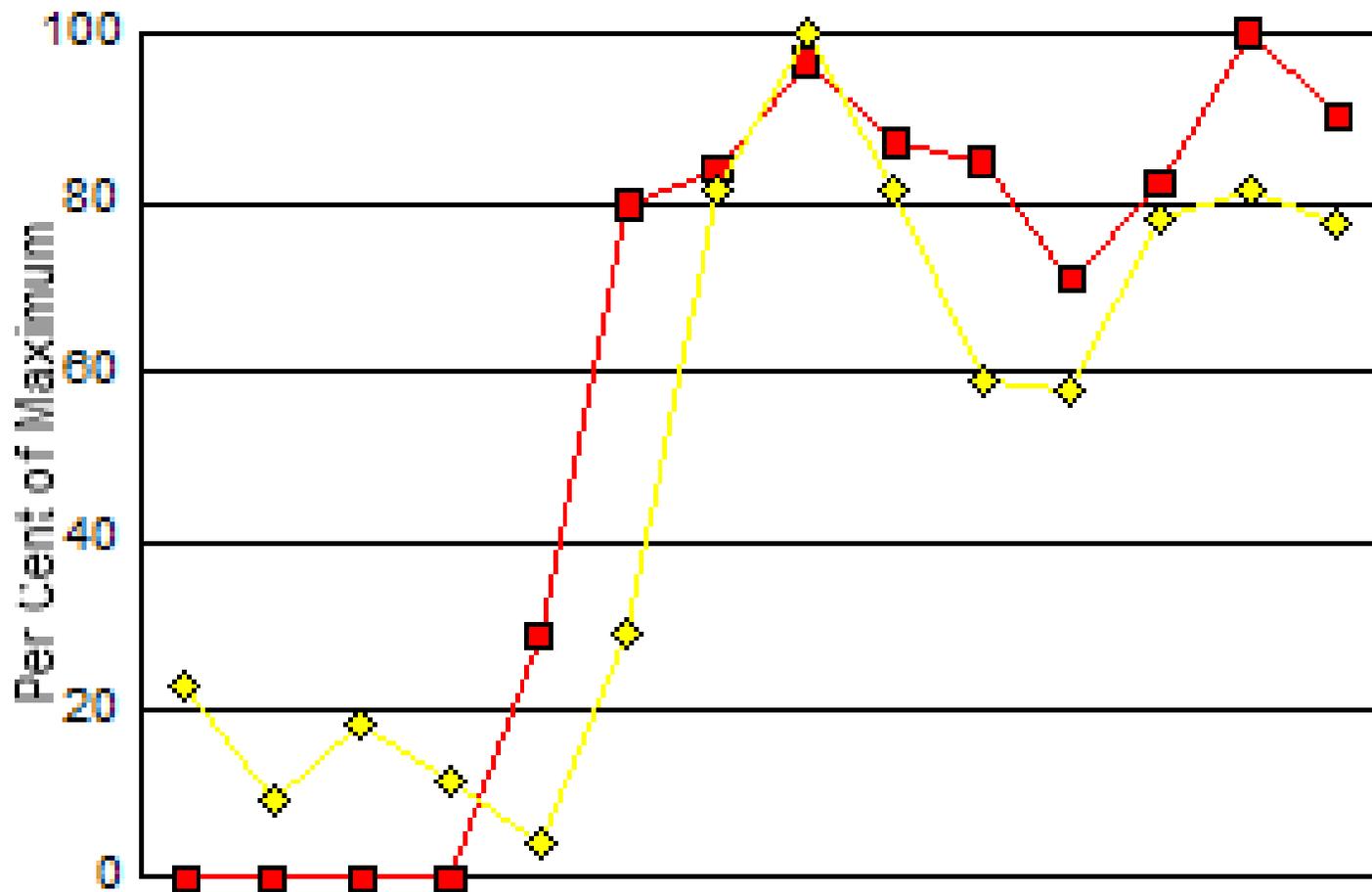
Research Beyond the Presentation of September 4, 2007

- The Presentation to the Fitchburg Plan Commission on September 4, 2007 is presented above.
- Following a Question and Answer Period on this Presentation I continued this Research for the purpose of continuing to develop our mutual understanding.

In the September 4 Presentation

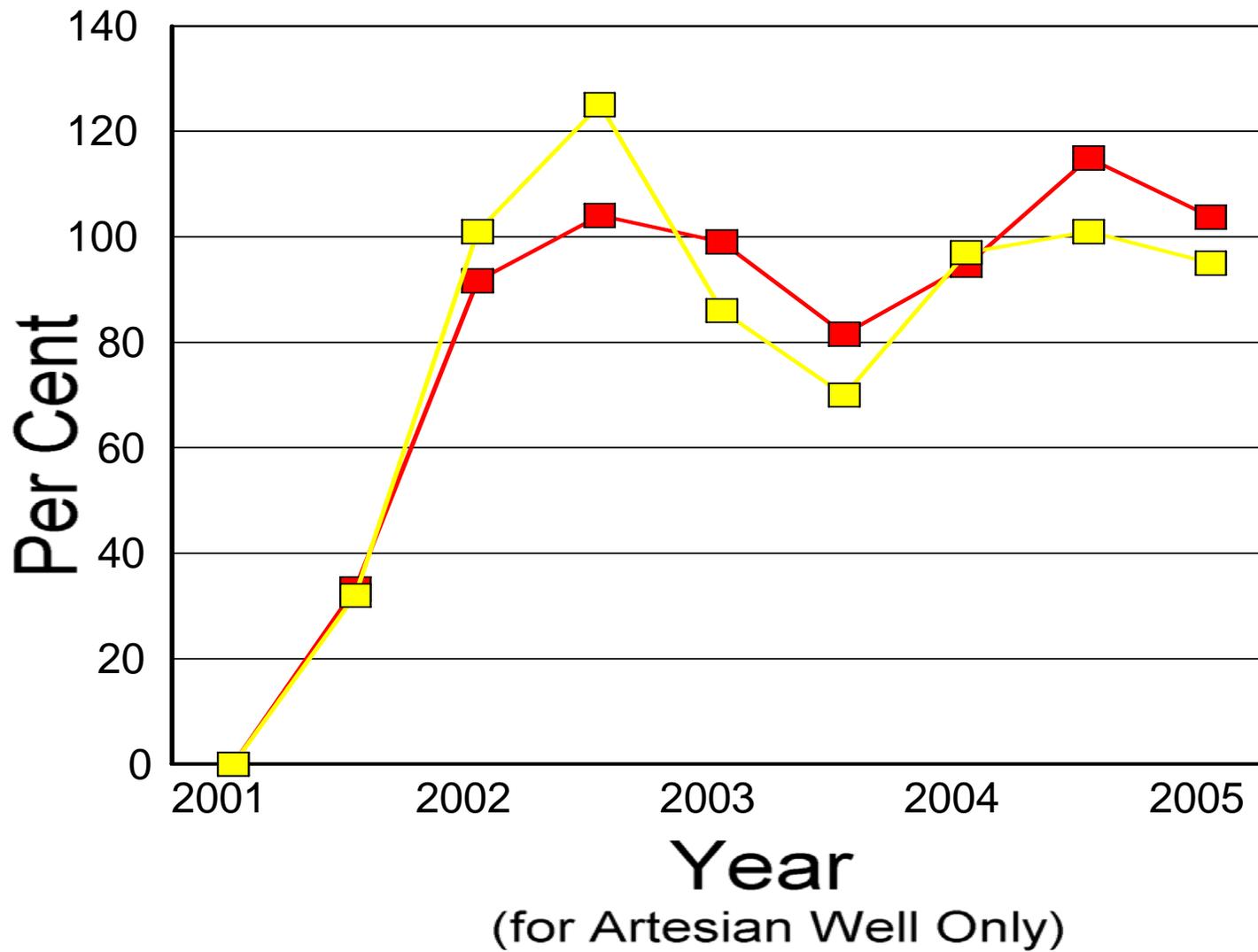
- I presented the following slide.
- It shows the pumpage of Fitchburg Municipal Well #10 compared with reduction in Flow of the Nevin Trout Hatchery Artesian Well #8.
- It was plotted with a lag of 12 months for the Artesian Well.
- Here is that plot repeated:

Wells # 10 & #8 Compared



Progressively Shortened Lag Times

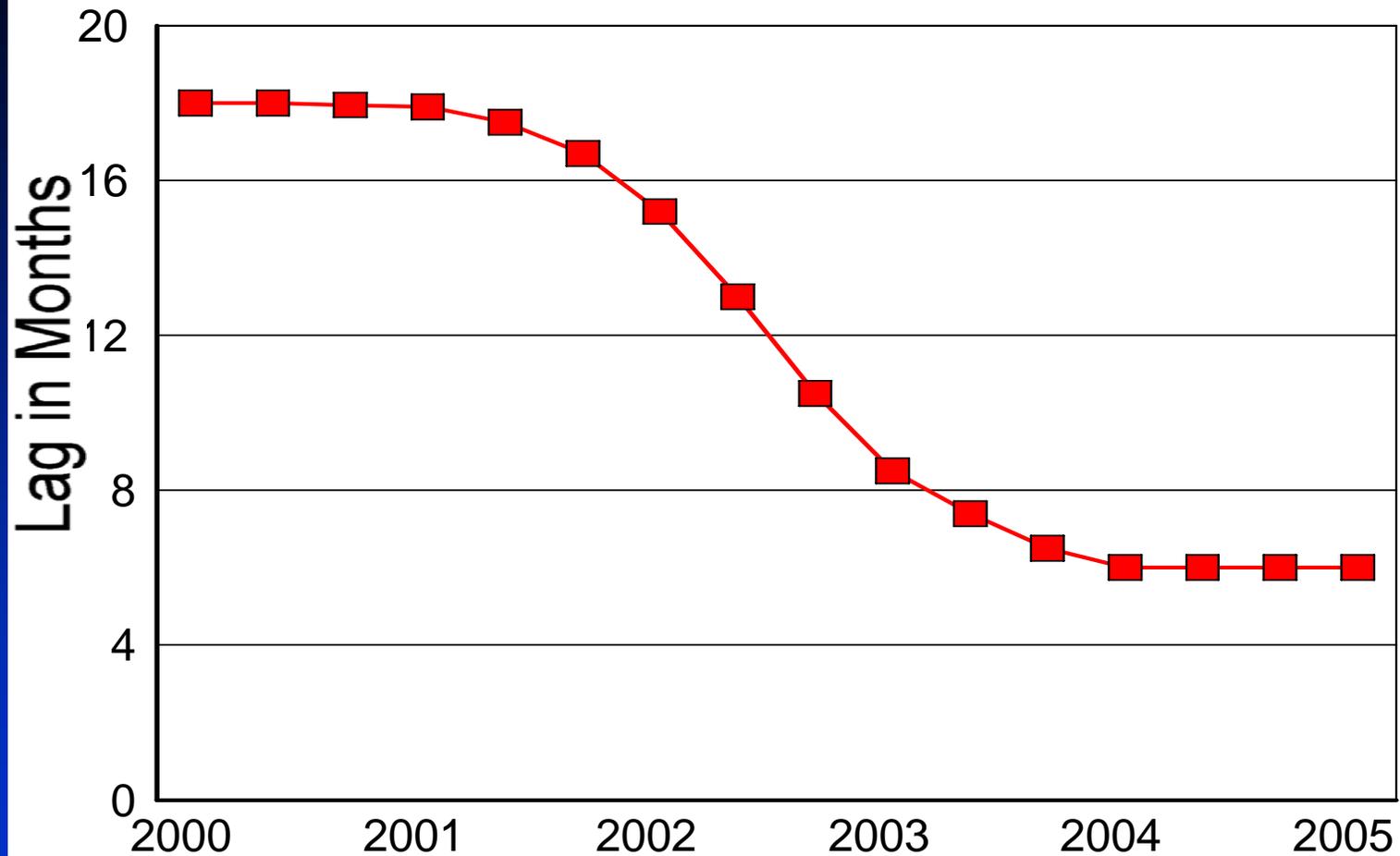
- The graph we have just seen applies a 12-month lag between pumpage by Well #10 and flow reduction in Artesian Well # 8.
- When the lag time is initially set at 18 months, and then progressively shortened to 12 months and then to 6 months, the following is seen.



...bringing the “Peaks and Troughs” to correspond with each other

- Note how this brings the “peaks and troughs into correspondence.
- This indicates that there very likely is such a progressive reduction in the lag between “cause and effect.”
- This can be illustrated conceptually with the following graph.

Progressive Reduction in Lag from 18 months to 6 months



...and here is how this
can be represented in
Table Form

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Time Lags between Effect of Well #10 on Well #8

Impact Yr for W#8	Corr. Yr for W#10	Lag in Months
2001		...
	2000	...
2002		...
	2001	18
2003		18
	2002	12
2004	2003	6
	2004	6
2005		6
	2005	6
2006		6
	2006	6

...so how does the Pumpage Well relate to the Artesian Well geographically?

- I used the G.I.S. system of Dane County to put the building footprints of Well #8 and Well #10.
- And then I measured the distance between them.
- Here is the map:



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Measurement of Distance

- Using the G.I.S. measuring tool provided, I measured the distance between these wells 10 times.
- For five of these ten times my result was 5505 feet, and that is my best estimate of the distance between them.

...and so what is the rate?

- For the following lags, this rate is:
 - ◆ 18 months: 10 feet per day
 - ◆ 12 months: 15 feet per day
 - ◆ 6 months: 30 feet per day
- The lag now appears to be continuing at 6 months
- Once the flow was established, therefore, the flow is 30 feet per day.

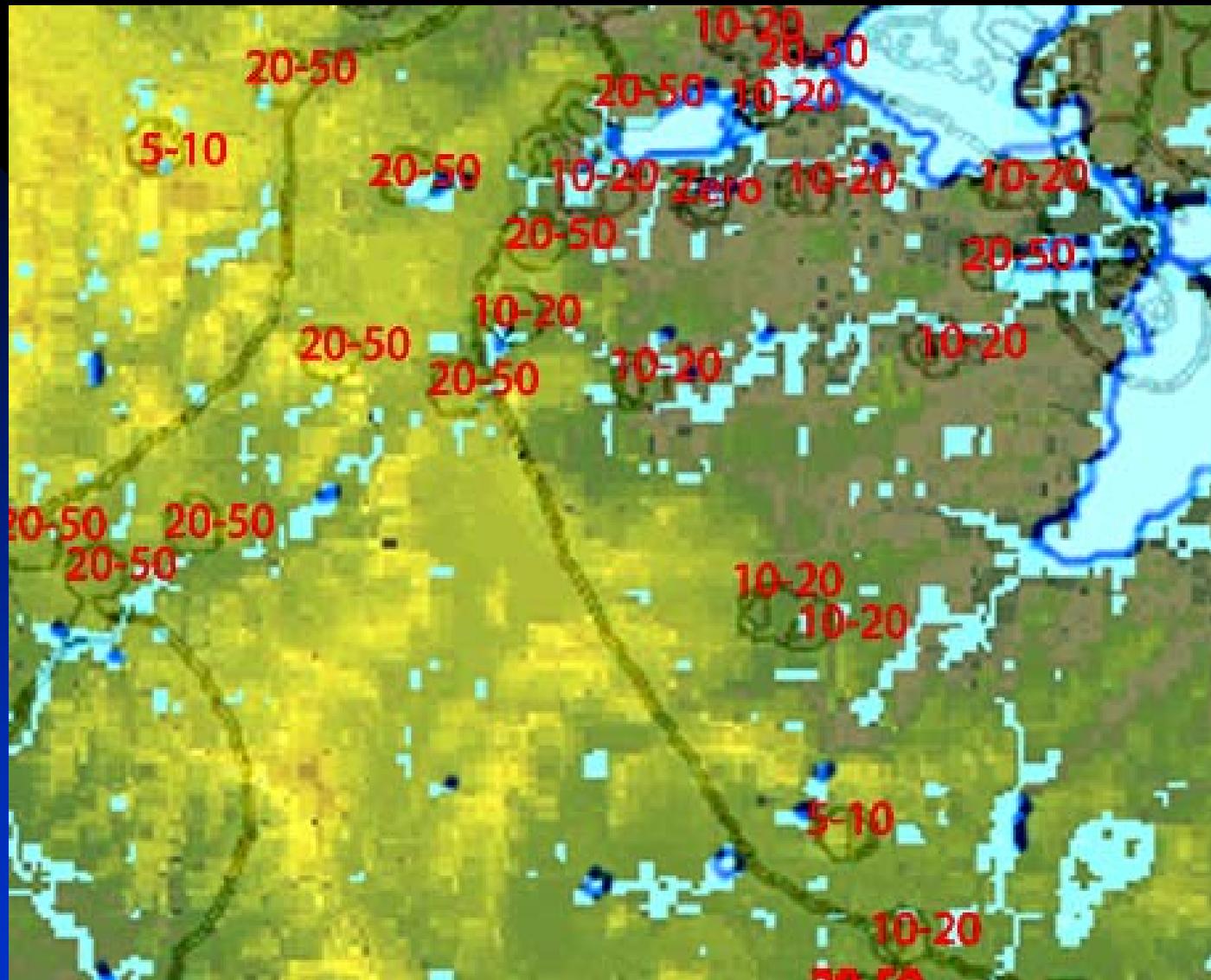
...and what is the explanation?

- There is a transit route between the Pumpage Well and the Artesian Well.
- This route is progressively cleared as water flows through it, most likely by:
 - ◆ Dissolution (dissolving of material)
 - ◆ Transport and clearance of fine particles

So Where is that Eau Claire Shale?

And How Thick is It?

- Hydrogeologist, Ken Bradbury, has examined rock cores from the region.
- I have put his figures on thickness of the Eau Claire Shale on the following map, in feet.
- It is shown in ranges:
 - ◆ Zero (south of Lake Wingra)
 - ◆ 5-10 feet
 - ◆ 10-20 feet
 - ◆ 20-50 feet



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Hydrogeologists Ken Bradbury, John A. Cherry and others:

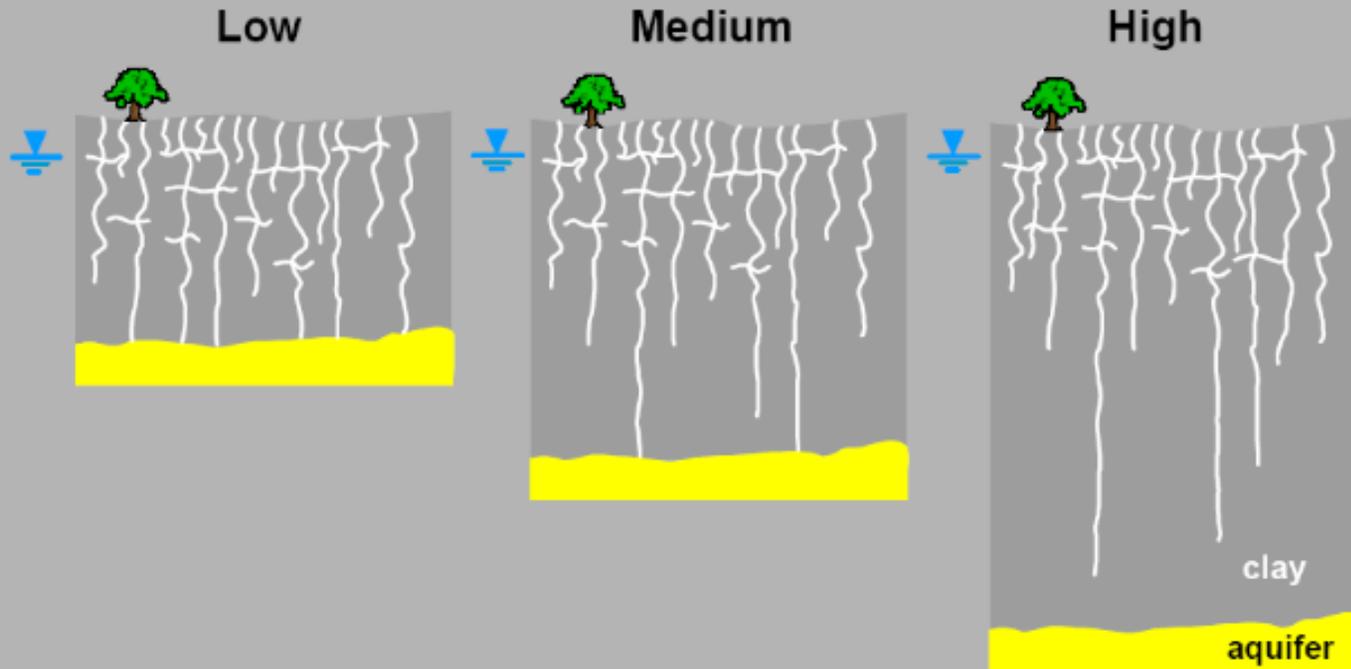
- Have produced a careful study on the “Integrity of Aquitards.”
- They find that the truly functional part of an aquitard usually is a small part of its total thickness.
- This means that the thinner the aquitard, the less likely it is to block vertical flow of water.
- When they are as thick as 100 feet, they likely are serving as true aquitards.
- When they are as thin as only 10-20 feet, however, they likely are not performing as aquitards.

...in other words:

- The integrity of an aquitard gets less and less as it gets thinner and thinner.
- Aquitards therefore can be envisioned as having integrity, according to thickness, of
 - ◆ Low
 - ◆ Medium, and
 - ◆ High

(As shown on the next slide.)

DIFFERENT INTEGRITY DUE TO DIFFERENT THICKNESS

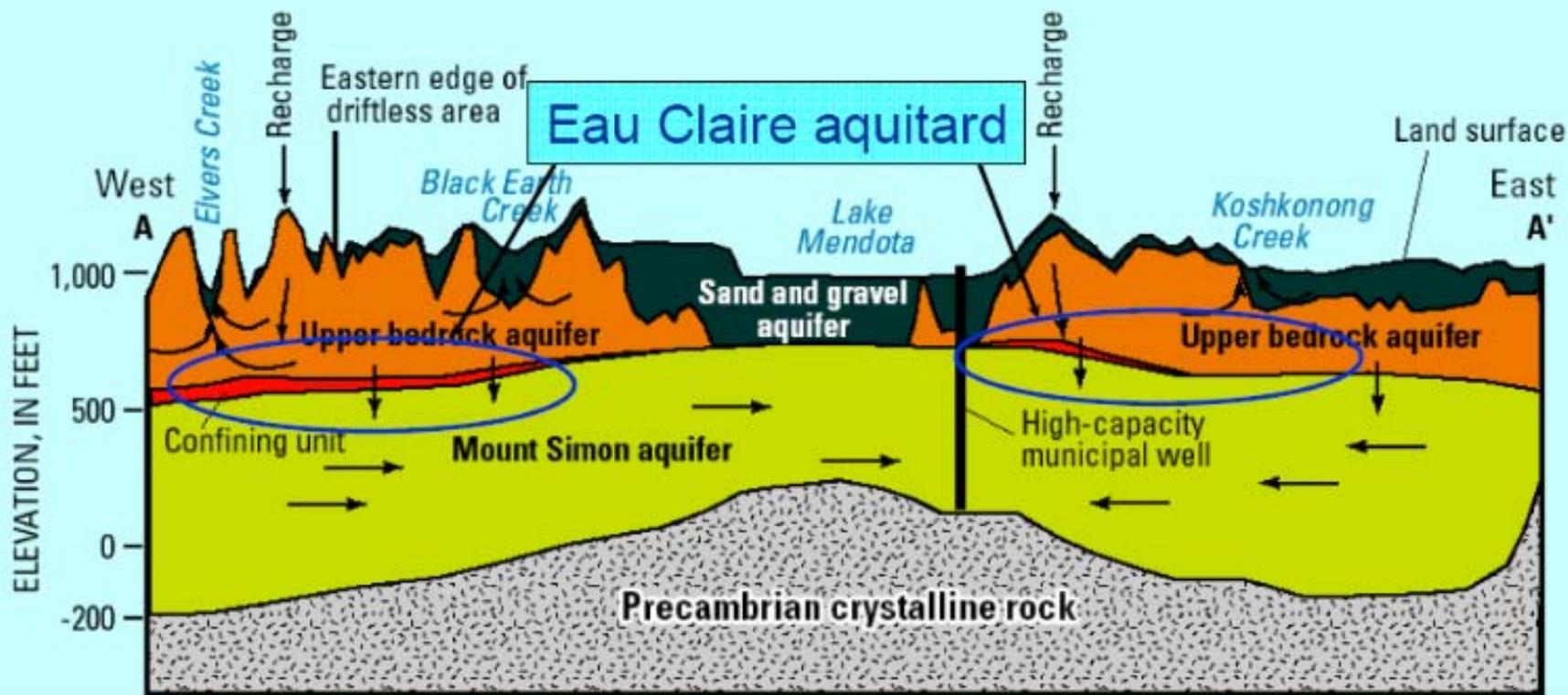


From: Bradbury, K., J. Cherry, B. Parker, T. Eaton, D. Hart, M. Gotkowitz, and M. Borchardt, 2003. Measures of aquitard integrity. Geological Society of America.

...and the way this works out for Dane County is:

- The Eau Claire Shale gets thinner and thinner as it gets closer to the Yahara Chain of lakes.
- Until it disappears altogether.

(This is shown in the next slide.)



From: Bradbury, K., J. Cherry, B. Parker, T. Eaton, D. Hart, M. Gotkowitz, and M. Borchardt, 2003.

Measures of aquitard integrity. Geological Society of America.

...SO

- The Mount Simon Aquifer (below)
is joined with
- The Upper Bedrock Aquifer (above)
and these are joined with
- The Sand and Gravel Aquifer (uppermost)
and so
- The Three Aquifers then work as a Single Aquifer
- Then there is no separation...

Knowledge of Aquitards

- According to Hydrogeologists, Ken Bradbury, John A. Cherry, B.L. Eaton, D.J. Hart, M. Gotkowitz, and M.A. Borchart,
 - ◆ The traditional hydrogeologic and engineering literature has vastly oversimplified aquitards.
 - ◆ Often, aquitards can be thinner, and adjacent aquifers thicker, than previously understood.
 - ◆ The bulk hydraulic properties of aquitards are generally very poorly known.

(Bradbury, et al. 2003. Integrity of Aquitards, GSA)

What does this finding mean for us all?

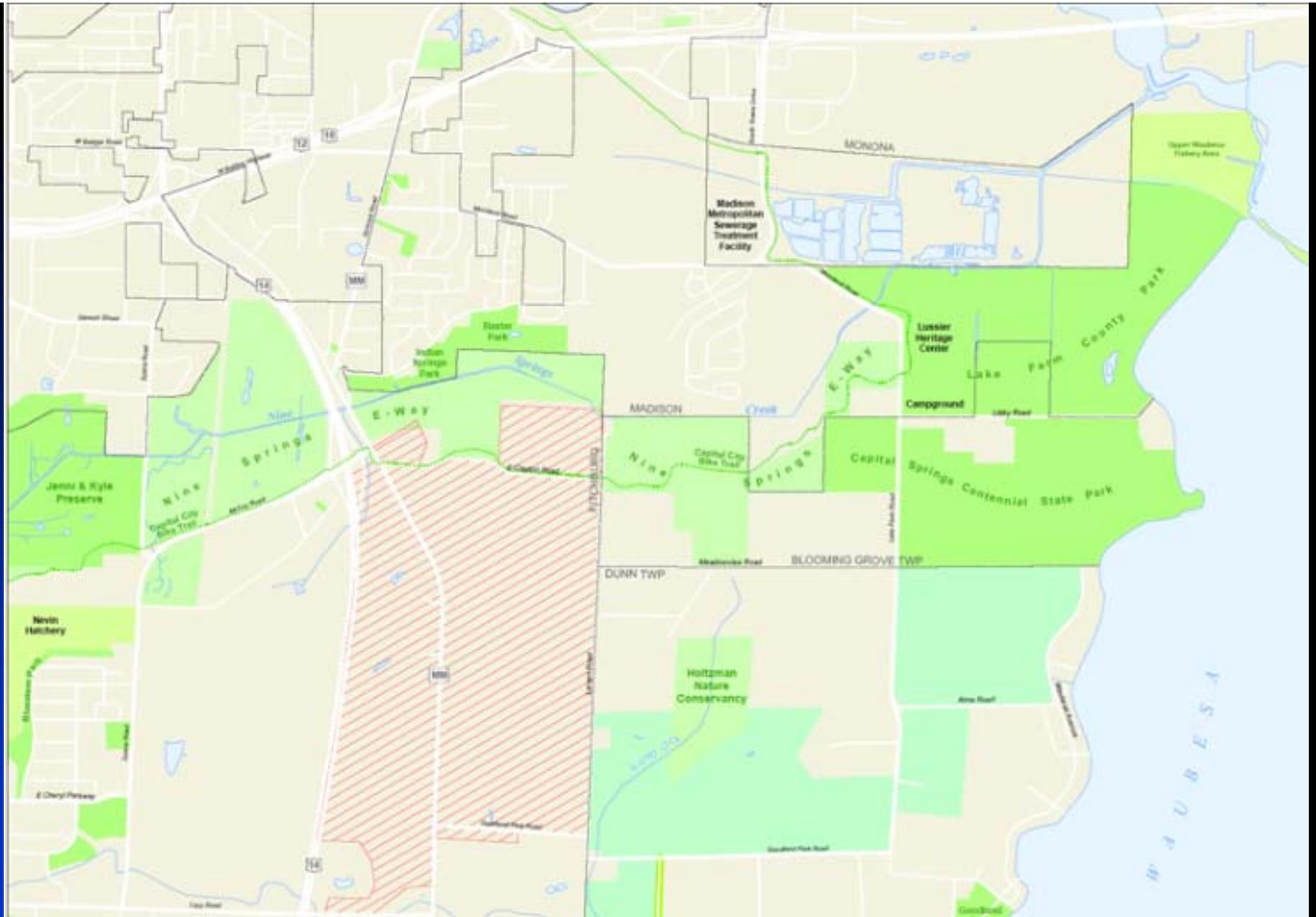
- The need to gain understanding (and apply wisdom).
- The need to understand that the northeast corner of Fitchburg needs to be treated rather like how Rhode Island treats Block Island.
- The need to assure taking no more water from this sensitive corner than what we put back.

What is the Local Context of this Finding?

- It is the Northeast Corner of Fitchburg:
 - ◆ With Nevin Fish Hatchery and its Artesian Wells & springs to the West
 - ◆ With the Nine Springs spring flowage on the North
 - ◆ With the Holtzman wetland conservancy & Capital Springs Centennial Park on the East

THERE ARE SPRINGS ALL AROUND...

(Shown on the following slide)



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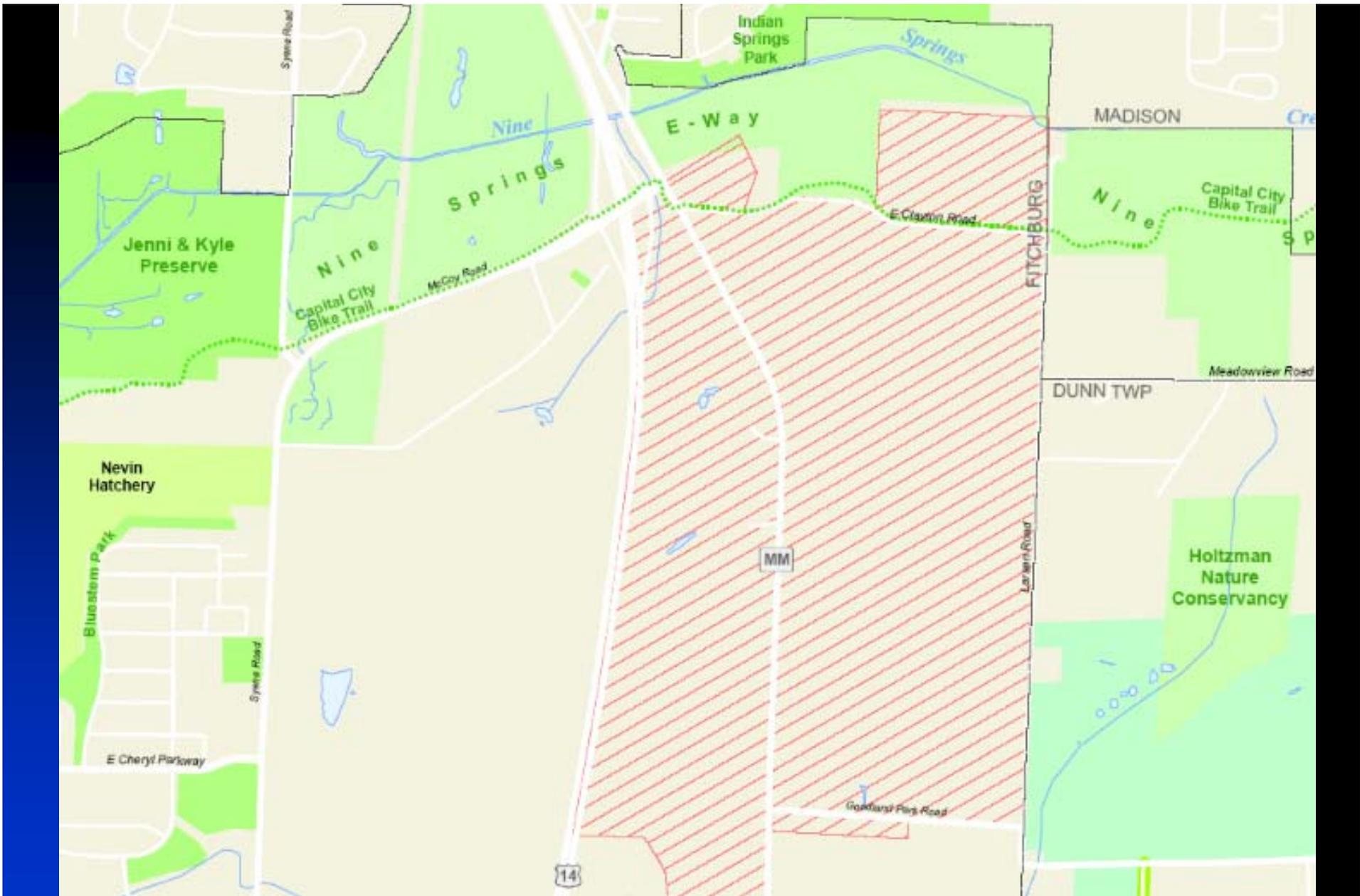
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...and closer up it looks like this:

First a Map....

and then...

a Repeat of an Aerial Photo
showing it from above



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...and interestingly,
this context already
appears to have been
understood & respected.

- This is illustrated in Fitchburg's most recently published General Land Use Plan (1995)

(See next slide)

While these new discoveries:

- Make problematic any substantial urban development of the northeast corner of Fitchburg, and
- Bring the focus of urban development to areas with High Integrity Aquitards

They also bring some things into the light.

...and one of these things is
new appreciation for
On-Site Wastewater Systems

- **The Onsite Wastewater Resource Center**
(University of Rhode Island) concludes,
 - ◆ Onsite Wastewater Treatment allows water to be recycled to replenish groundwater supplies.
 - in contrast with
 - ◆ Municipal wastewater treatment that discharges further downstream or out of the water entirely.

...and this Onsite Water Resources Center

- Reports on Rhode Island' program on Block Island where there simply must be a “sustained yield” approach to freshwater supplies, and also
- Reports on Chepachet Village

...as a Recycling Leader:

- The City of Fitchburg can incorporate water recycling into its program.
- Block Island (RI) and Chepachet Village, Rhode Island (rhymes with “hatchet”) could be studied.
- A Combination of Conventional and Advanced Treatment Systems could be used.

What's next?

- More work and thought on the nature and workings of of the Fitchburg-Waubesa Artesian Basin.
- Recognition another aquiclude that to this point has eluded us, and yet is importantly involved in the springs, fens, wetlands, and streams of the Fitchburg-Waubesa Artesian Basin.
- Greater integration of fragmented scientific disciplines with policy and increased movement toward policy-relevant science.

...I hope I will be able to
interest others...

- ...in their visiting an Artesian Mound with me, in the Fitchburg-Waubesa Artesian Basin in the near future.
- ...in exploring with me the workings of water at the interface of groundwater and the land surface.
- This is the “Invitation to Wonder...”

I offer to you.