RAINWATER HARVESTING

as a development-wide water supply

How can it work?

An investigation funded through the
INNOVATIVE WATER STRATEGIES
DIVISION of the
Texas Water Development Board

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http://www.rsihillcountrywater.org/rainwater-harvesting/

http://www.twdb.state.tx.us/innovativewater/rainwater/projects/txstate/index.asp

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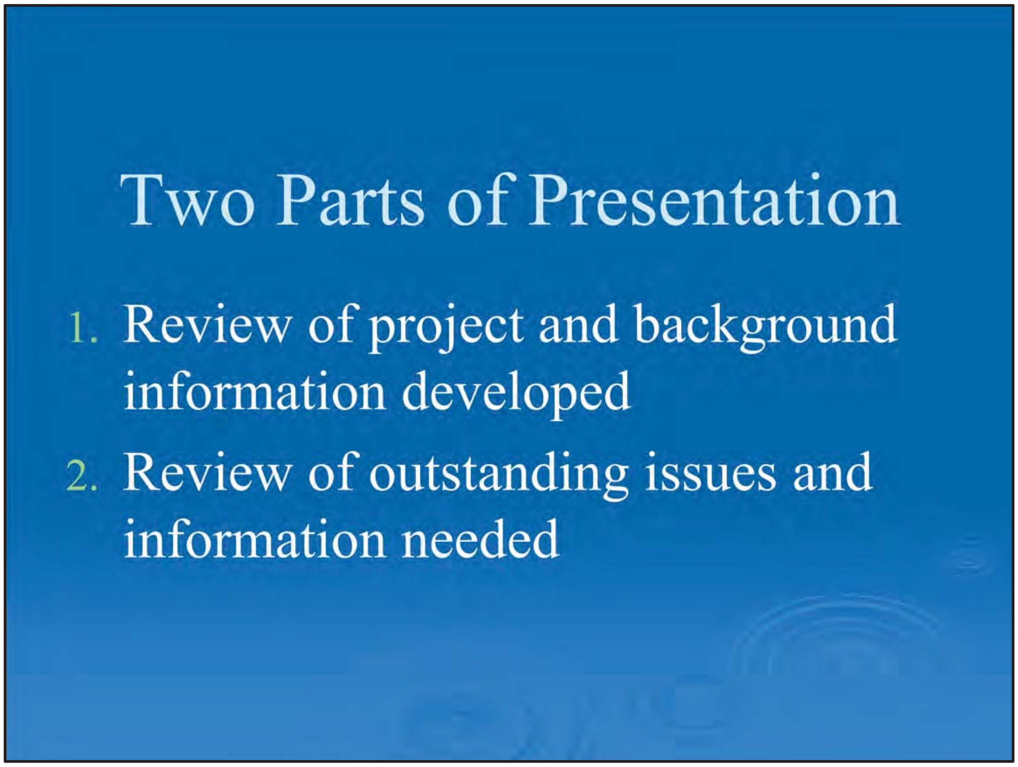
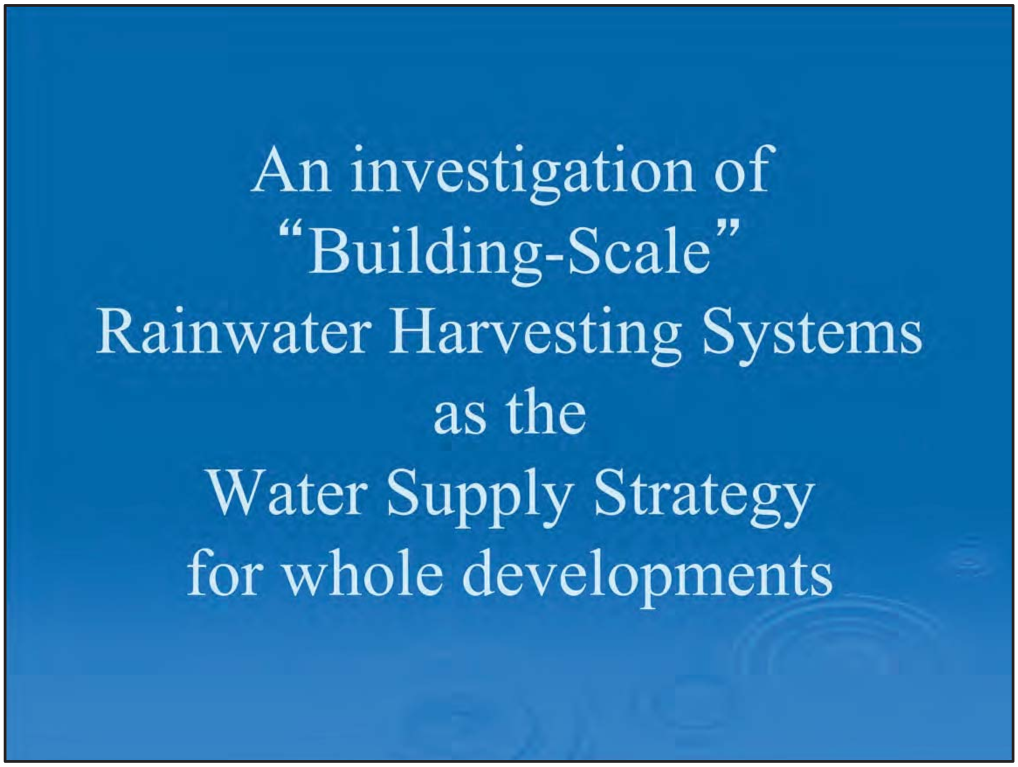


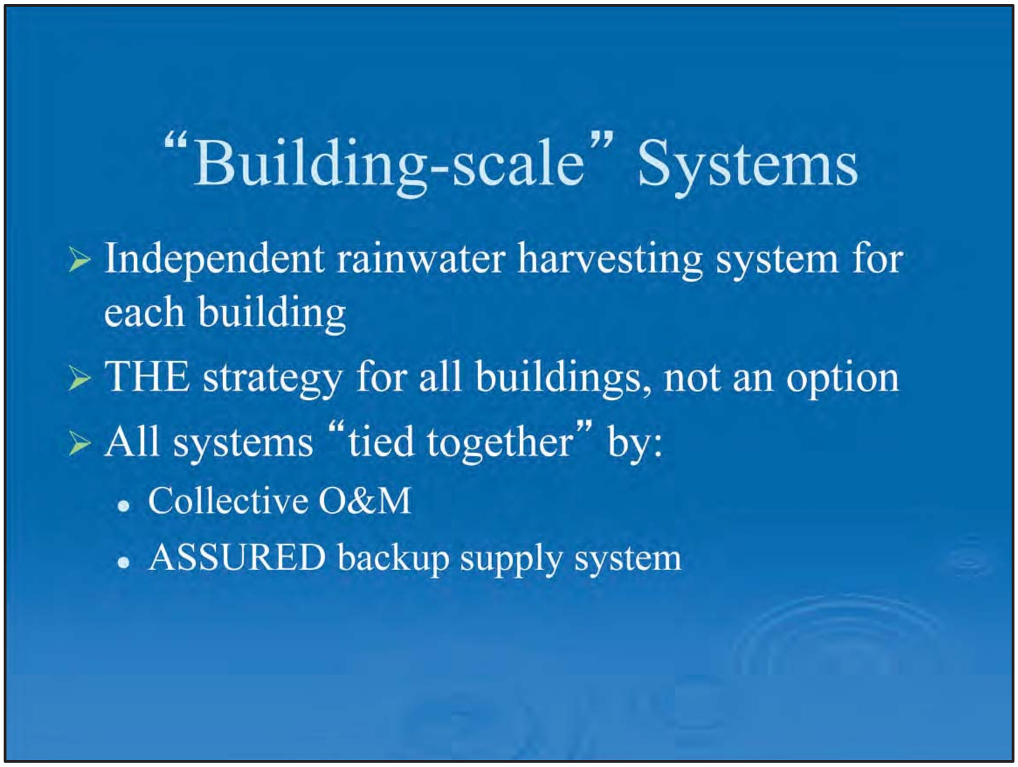
➢I'd like to add my welcome. And a thank you to everyone who has worked to make this possible and pull off this presentation. To Meredith Blount-Miller and Stacy Bray at RSI, and Karen Ford of White Hat Creative, who helped create the presentation. And to RSI staff for their support here today.

➢And special thanks to Christy and the Hill Country Alliance, whose advocacy on this issue was instrumental in making this whole project happen. And also for helping us out with the venue, and of course for sharing with us that great video.



First, an explanation of just what it is we're investigating.

- We're looking at BUILDING-SCALE rainwater harvesting systems that, collectively, would compose the water supply strategy for ALL the homes in a development, and any other buildings too.
- By "building-scale", we mean that each building has its own, self-contained rainwater catchment, storage, treatment, and distribution system.
- We're *not* looking at big collective systems serving a bunch of houses, that would most definitely kick the facilities over into being a "public water supply system".
- I wanted to get that out there, because that's been a point of confusion with some folks.



➢So, what we're considering is the thing most people think of when the term "rainwater harvesting" is used, each house with its own, completely independent system.

➢BUT, we're thinking of it as a consciously chosen strategy, the only strategy for the whole development, not each building owner doing it only if they want to.

➢This strategy might – probably should – include collective action to ensure this is a safe, ASSURED water supply for all the buildings in the development.

➢For example, all buildings may be "tied together", so to speak, by

•a collective arrangement for operation and maintenance of the treatment system, to assure the rainwater is safely potable when it enters the house;

OR

•a collective arrangement to assure every house can get a backup water supply if they need it in a drought;

OR BOTH

At some point we'll look at doing this in other areas of the state, but starting out our primary focus area is in and around the Hill Country, where aquifers are under stress, and it would be very expensive to extend waterlines from reservoirs or from aquifers outside the Hill Country.

So along the way, I'll note a couple tie-in's to some of the points in the video we just saw.

➢Now, I want to highlight that RWH is one of only a few options for water supply in developments out Hill Country.

➢Here's a list of those options:

- We could drill private wells on each lot.
- Or we could drill a community well and install a distribution system within the development.
- Now, these two options suffer a problem over a lot of the Hill Country.
- Many think we're overdrawing the aquifers, even at present levels of development.
- And as long as we stay stuck in a drought, that's expected to only get worse.
- A couple years ago, an article was published in the "Texas Observer" about the drawdown of Hill Country aquifers entitled "The End of the Hill Country", asserting that this would dry up springs and, well, in the author's opinion, "ruin" the Hill Country.
- And we saw some of that sentiment reflected in the video.
- So these folks question if we "should" try to support much more development on local groundwater.

➢Another option is a high-yield well or well field and a distribution system over a larger area.

- Most likely this would take the form of extending a line from an existing water supply system.
- But those don't cover a whole lot of the Hill Country.
- And of course, if these wells are IN the Hill Country, there'd be the same issue with sustainability.

➢And then there's large regional systems, piping water in from reservoirs or aquifers outside the area.

- Now of course, this isn't the sort of thing most developers could do all on their own.
- These would be built by people who are interested in selling water over a pretty large area.
- Well, y'all know what the Highland Lakes look like right now, and people are looking for solutions to keep

them from being emptied even more, to protect businesses that depend on the lakes.

•So maybe we don't have a lot of reservoir water to spare IN the Hill Country, that we can keep shipping out there.

•And if we import water from far, far away, that will be pretty darned expensive.

•So again the shakers and movers of that kind of project would want to sell a whole lot of water to pay for it.

•They'd want lots of development, the denser the better, to make water distribution cheaper.

•And like we saw in the video, a LOT of people question if we want a whole lot that sort of development in the Hill Country.

So all of these strategies have their issues.

And here is what we have left – The building-scale rainwater harvesting system

We might call them large-scale rainwater harvesting systems.

By the way, ALL of these are rainwater harvesting systems too.

•Rainwater gets collected off the land

•It gathers in reservoirs or aquifers

•And gets piped back to the house

So there's nothing the least bit "exotic" about using building-scale rainwater harvesting systems.

It's identical in concept to all these strategies.

It's just a much shorter water loop from where the rain falls to where the water gets used.

So using building-scale rainwater harvesting as the "conscious" water supply strategy for a whole development seems like an idea worth investigating.

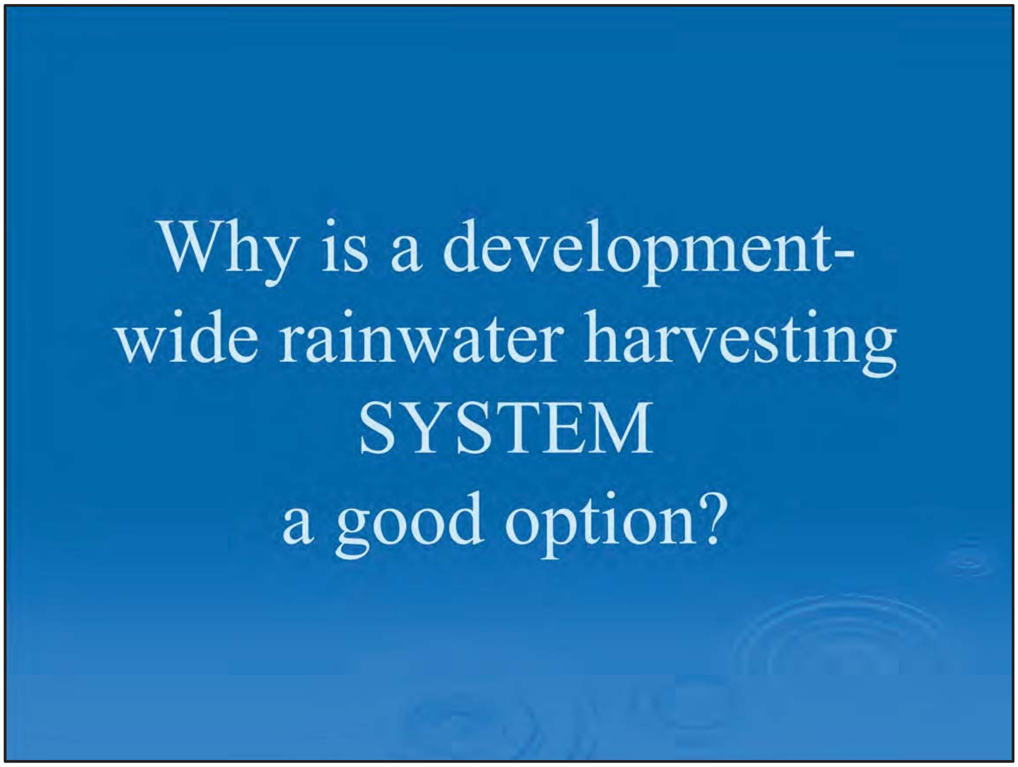
Somebody just needs to figure out how you can do that cost effectively VS these other options.

And how can we make this strategy practical for a broader population.

Doing things like organizing a backup water supply system.

And getting it straight how this system would be regulated and governed.

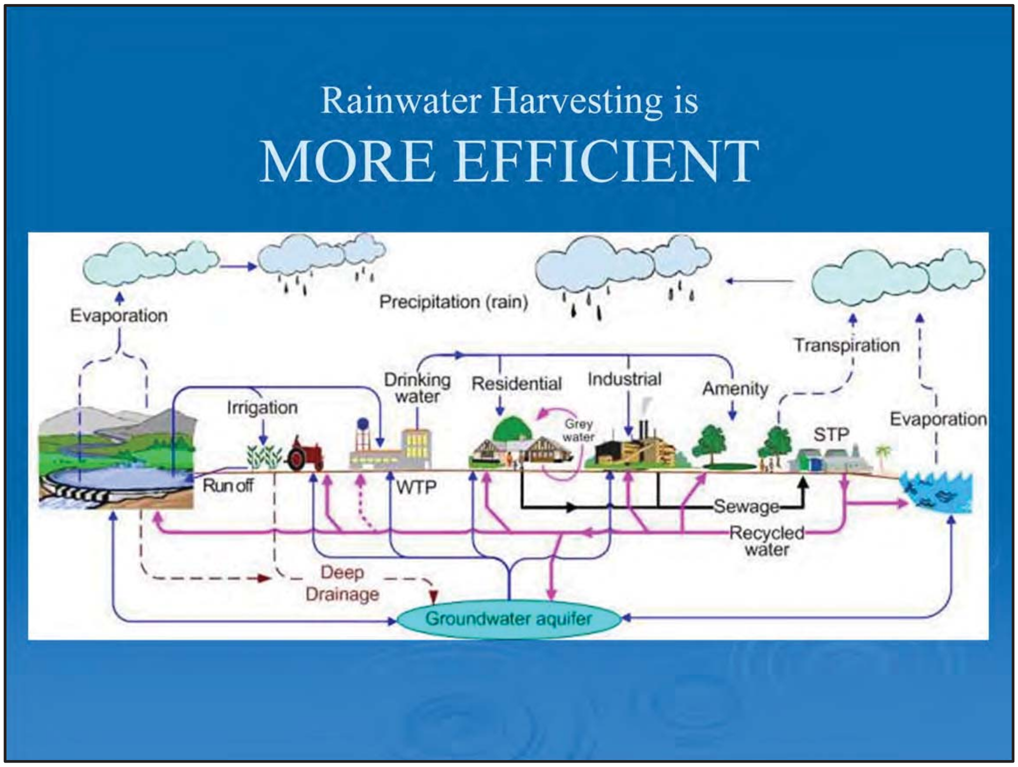
And THAT is what we're doing in this project.



➢Now, people can go do RWH on their own now if they want to.

➢So why would we want to push it as a development-wide water supply SYSTEM, and MANDATE that it be the exclusive strategy in that development?

➢As we see it, there’s a number of reasons.



➢Building-scale rainwater harvesting is an inherently MORE EFFICIENT water supply.

➢Close to 100% of the rain falling on the roof is captured and held for use.

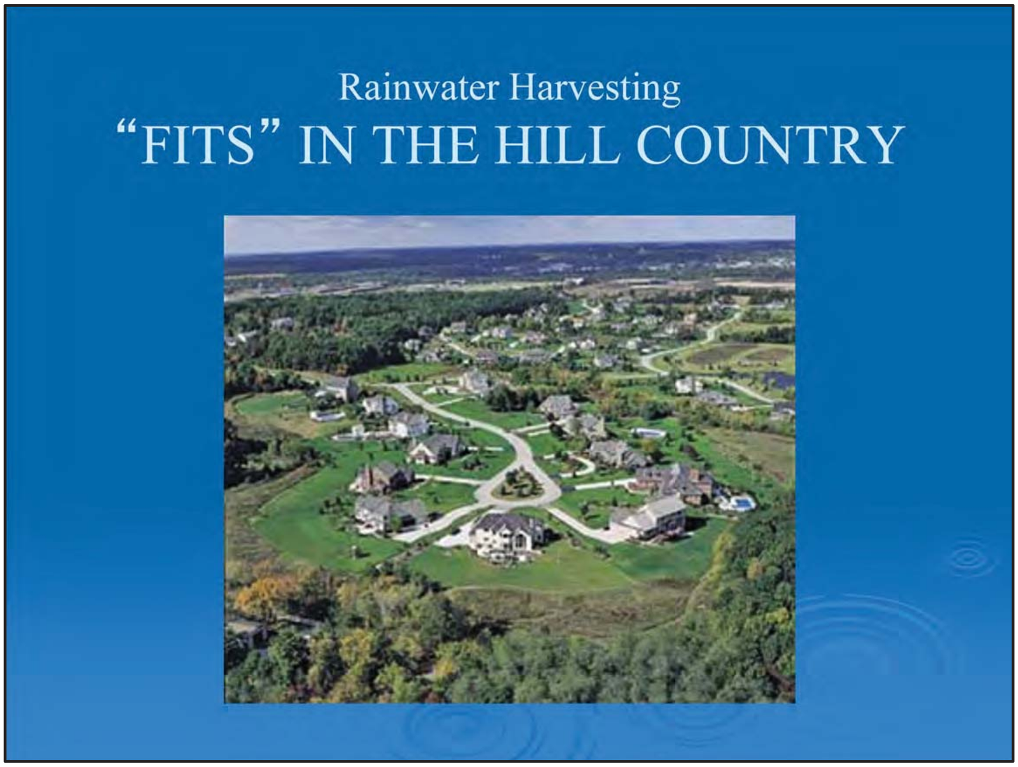
➢In all the large-scale rainwater harvesting systems, there's a lot of losses between the rain hitting the ground and the water flowing into the home or business.

➢For example, a BIG loss is evaporation from reservoirs.

➢Now some of these "losses" support ecosystem functions, so they're not all waste.

➢So one of our study activities will be to examine if capturing the rain before it hits the ground by a LOT of roofs would have an impact on those ecosystem functions.

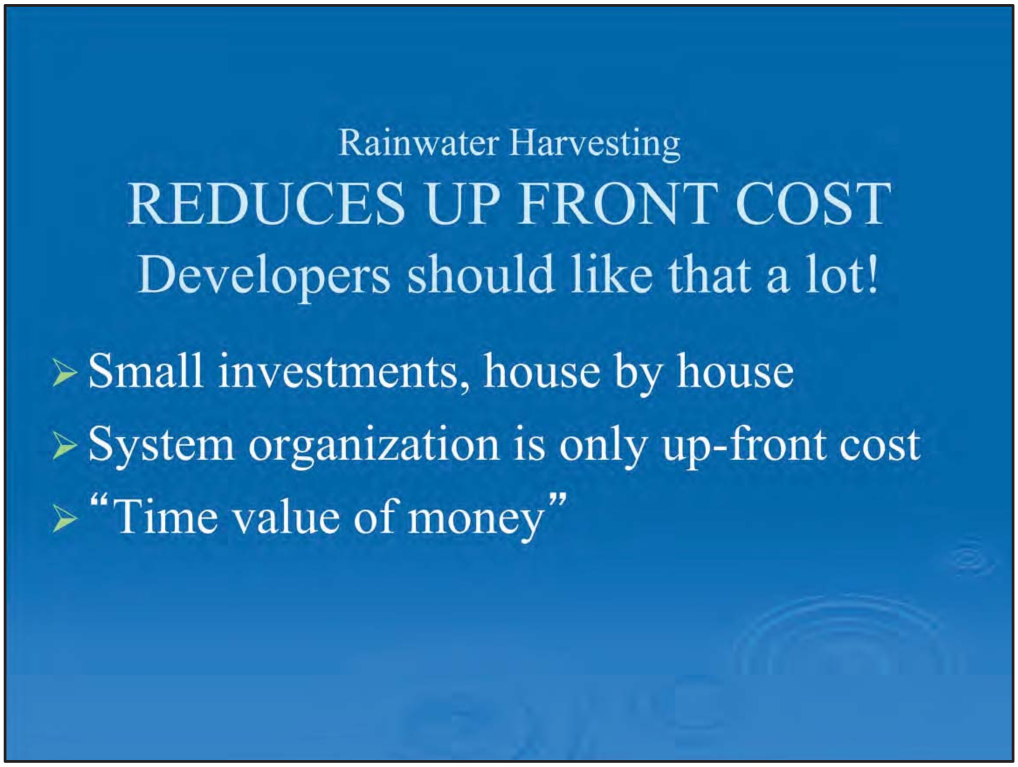
➢But in any case, the high capture efficiency or the building-scale system is pretty clear.



➢As I said, the main focus of our project is in and around the Hill Country.

➢We saw in the video that “conservation development” is a desirable development pattern there.

- Small clusters of homes, perhaps “villages” of homes, perhaps a village center as well, so the residents don’t have to drive some distance for even the most basic services.
- These clusters or villages would be spread around, with a lot of open space around them.
- As we saw in the video, this reduces the development footprint, and helps to preserve ecosystem integrity, relative to large lot developments that spread the same number of houses over a larger area.
- This building-scale rainwater harvesting strategy “fits” that pattern pretty well.
- It doesn’t create an impetus for larger, denser, closer-spaced development to make a conventional water system cheaper.



➢Rainwater harvesting also minimizes the costs for water supply that have to be paid up front of putting the first house on the ground.

•Although the initial cost per gallon may be higher, the building-scale rainwater harvesting facilities are relatively small incremental investments.

•And you incur them ONLY as needed to serve development *actually being installed*, one house at a time.

•Up front cost may be limited just to things like I noted earlier, setting up collective arrangements for system O&M and backup supply.

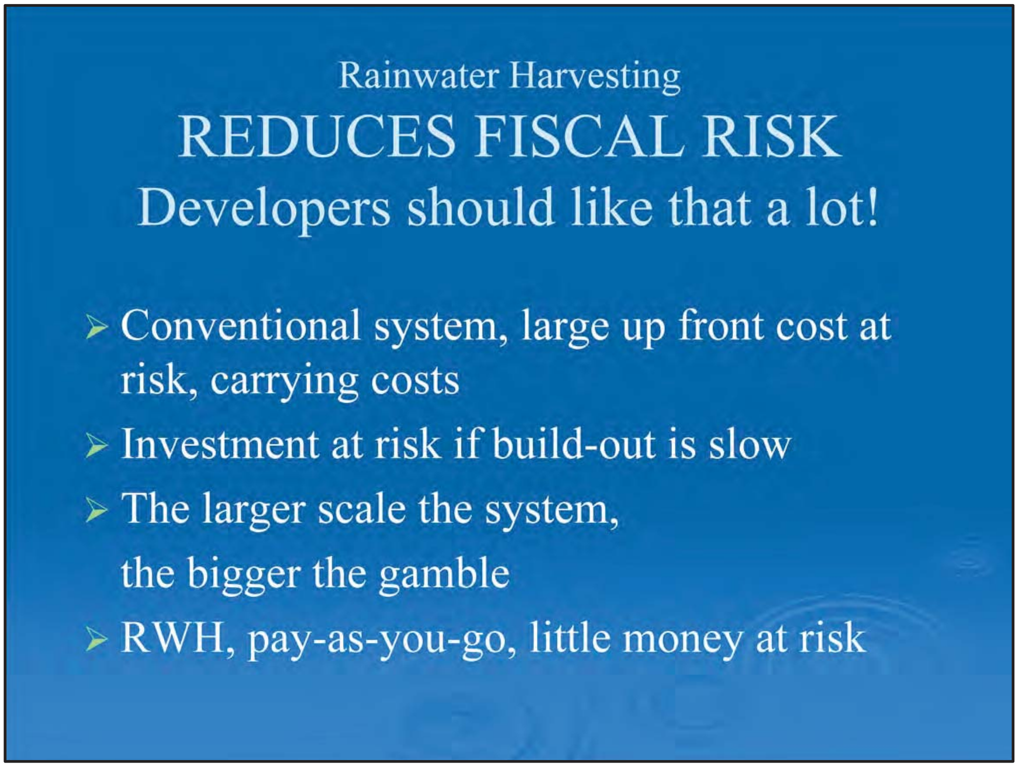
•And perhaps some demonstration of "water availability", in the platting process.

•For this option, probably less burdensome than what's required for any of the other options.

➢Delaying costs until the need for service is imminent works with the "time value of money".

•A dollar you have to spend today is worth more than the dollar you can put off paying till later.

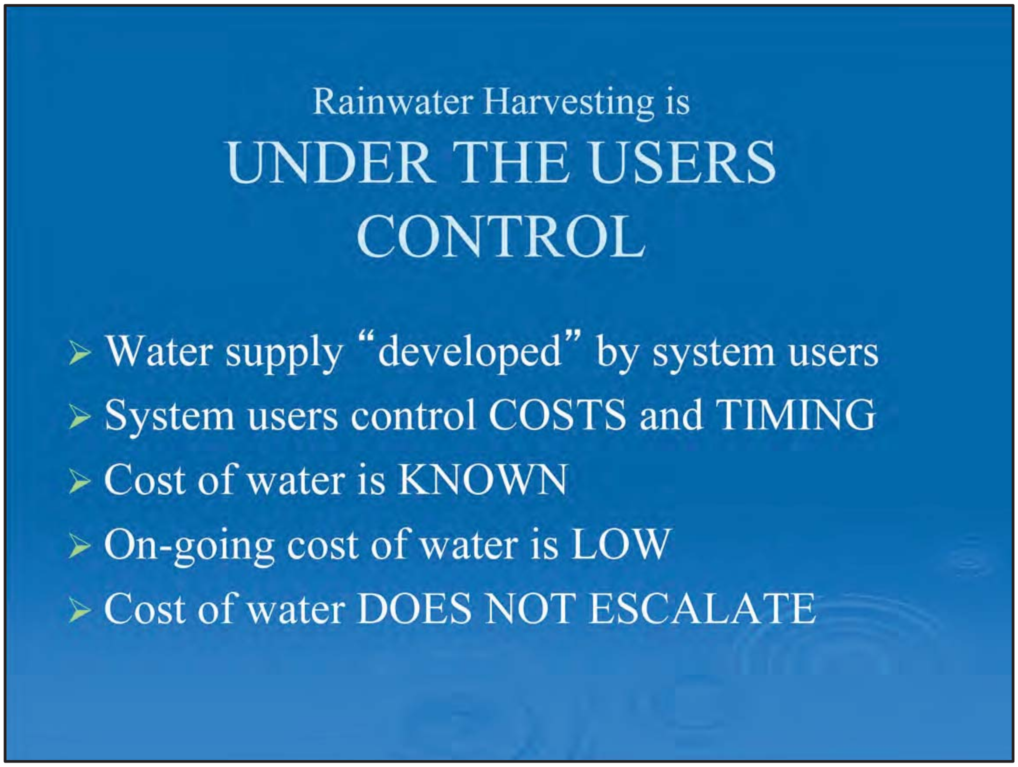
Since the up front costs are minimized, the short-term cost efficiency for the developer may be compelling.



➢Closely allied with previous point, low up front cost REDUCES FISCAL RISK for the developer.

- The large-scale infrastructure of a conventional water system is an "all-or-none" decision.
- It requires a very large investment well in advance of putting the first house on the ground.
- Since developments usually build out over many years, a lot of the capacity of those large-scale facilities wouldn't be fully utilized for many years.
- Someone would have to pay for the cost of these unused facilities in the meantime.
- And if economic conditions blunted or slowed buildout, the smaller than planned customer base would be stuck paying off the system, with higher water rates.
- The larger the system, the bigger the gamble.

➢With no costs incurred until the house it serves is built, building-scale rainwater harvesting wouldn't expose the developer or homeowners to any of that.

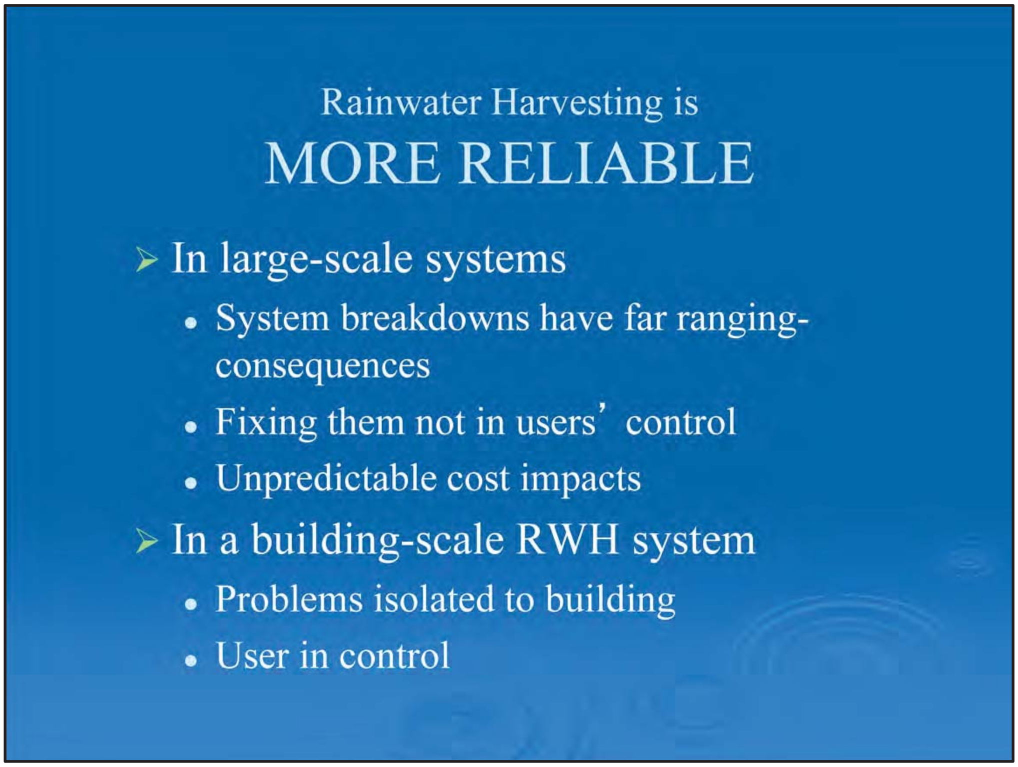


➢The cost and timing of getting large-scale water infrastructure installed and ready to provide service is typically out of the developer's control.

- •And CERTAINLY out of end user's control.
- •As would be the on-going cost of water obtained from that system.

➢With building-scale facilities, the water supply is "developed" by these users only as needed.

- •The cost and timing are ENTIRELY within the user's control.
- •The on-going cost of water would be KNOWN.
- •That cost would be LOW ***and*** would not be prone to escalation.



➢Also, from the standpoint of system operations and integrity, the rainwater harvesting strategy is MORE RELIABLE.

- In large-scale systems, things like treatment problems or line breaks could have broad ranging impacts, with unpredictable costs to the users.
- The end users would have no control over any of this.

➢In the building-scale system, any problems would be isolated to that building.

➢They could be directly addressed by the users, on a schedule that *they* would control.

➢Building-scale rainwater harvesting is also inherently MORE SUSTAINABLE.

- We reviewed previously how capture of the water supply for use in the building is inherently more efficient.
- And, in terms of resource management, the development would live, in large measure, on the water that falls on it.
- Needing to do this engenders a "conservation ethic", and that stimulates greater water use efficiency.
- Once you've got a large sunk cost in the ground for a piped water system, those efficiency strategies might not appear cost efficient, so they wouldn't be advanced.

➢And spurring on those efficiency enhancements would, of course, enhance water supply sustainability generally, over the whole region.

➢The rainwater you harvest off your roof is also BETTER WATER.

➢Rainwater is soft and fairly "pure" – it comes off a somewhat controlled surface.

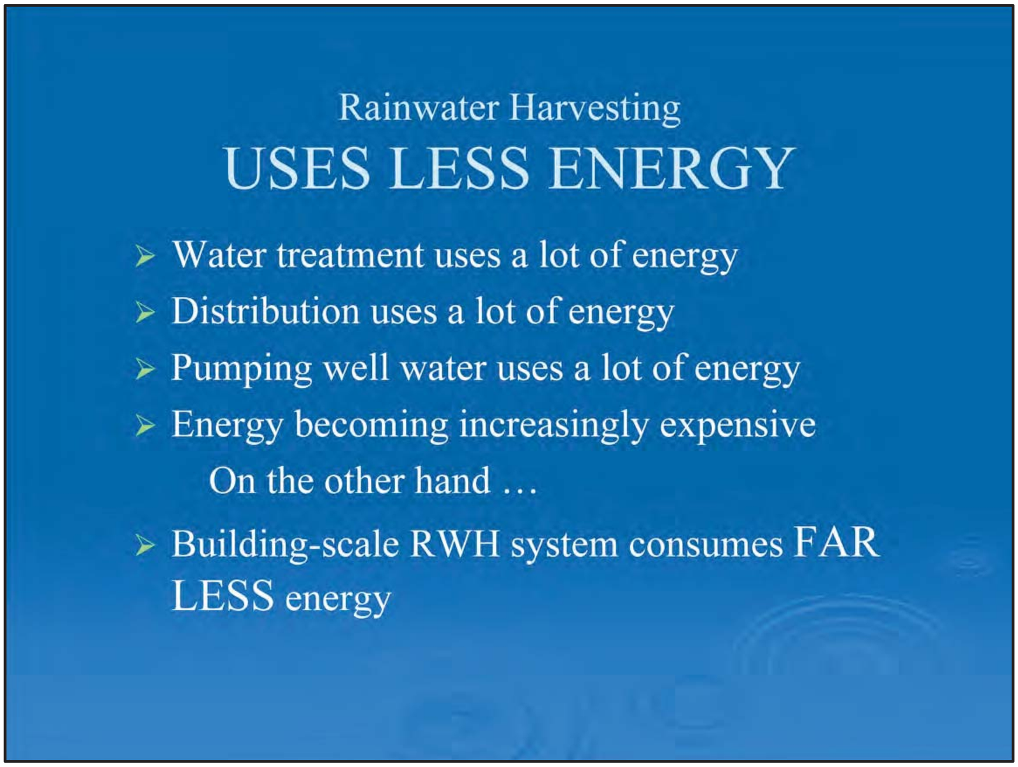
➢In large-scale rainwater harvesting systems, the ones that use aquifers and reservoirs as the "cistern", so to speak, there is no control of the collection area.

- So the water that gathers in this "cistern" is of random quality.
- It includes whatever pesticides, fertilizers, and other pollutants that wash off the land.
- And in many cases, there's discharges from wastewater plants in there too.
- So this water typically requires considerable treatment to get potable quality water.

➢Water from wells over much of the Hill Country is "hard", and that water may also need treatment.

➢And a large-scale delivery system requires the water to be heavily chlorinated.

➢So all this results in the water that's delivered to the users being somewhat degraded relative to the original quality of the rainwater.



➢And finally, the building-scale rainwater harvesting strategy would USE LESS ENERGY.

➢A large-scale treatment system and a far-flung distribution system consume a lot of energy.

➢For example, pumping water is the largest energy use among all the municipal operations by towns and cities.

➢Lifting water several hundred feet out of a well also consumes a lot of energy.

➢This is energy that's expected to become increasingly expensive.

➢On the other hand, a point-of-use treatment and pressurization system, with a very small lift out of a cistern, would consume far less energy.

➢And so the overall energy use – and operating cost – of this water supply strategy would be lower.

➢Well, that's an impressive list of reasons to consider the building-scale RWH strategy, no?

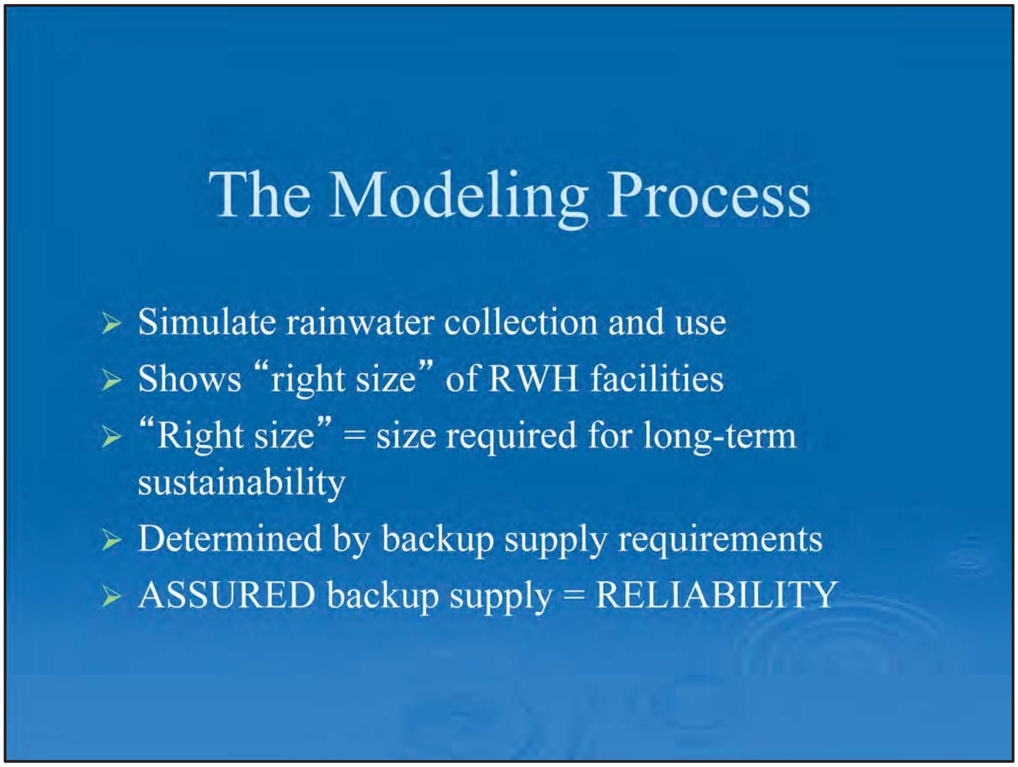
➢So again, the task before us, what we are aiming to do in this project, is to determine how this RWH strategy can be practically done, and how to make it as cost efficient as we can.

➢Here is a list of the activities we'll be doing to pursue those aims:

- •Yield-demand modeling. We do that to establish the sizes of roofs and cisterns required. This will be the prime determinant of rainwater harvesting system costs. I'll detail what that's all about here in a minute.
- •Backup supply options. Once we know from the modeling how much backup supply we'd need, then we can evaluate options for an ASSURED backup supply system, so this strategy would be just as drought-proof as any other strategy.
- •We've got regulatory issues to sort out with TCEQ, and we need to define what sort of governance the counties are going to require when the developer wants to plat a project using this strategy.
- •Building design issues. We need design strategies that'll most cost efficiently provide the collection area we'll need, and perhaps also incorporate the cistern into the building design, to make water storage more cost efficient.
- •We'll conduct a cost effectiveness analysis, comparing the global, life-cycle cost of this strategy to the others.
- •We'll examine the factors that impact on the marketability of this concept.
- •We'll consider sustainability, both water supply sustainability and the potential impacts on local hydrology.
- •And we'll create outreach and dissemination tools to make the findings of our investigations available for broad consumption.

➢I'll be reviewing all these activities here today except the outreach.

Yield-Demand Modeling



➢Yield-demand modeling is the first thing we need to address.

➢Because, in order to evaluate this strategy, we have to know what facilities we'd have to install to make it practically workable.

➢So, I'm going to run you through our modeling process, so you'll have an appreciation for what would be "practically workable"

- We run a rainwater harvesting model that simulates the collection of rainwater off the roof, and use of that water in and around that building.
- This shows us what would be the "right size" of the RWH facilities for that building.
- And then we can estimate the cost of the facilities we need to "right-size" this system.

➢By "right size", I mean – The long-term viability and sustainability of this strategy would be fairly well assured if that is the size of facilities we choose.

- Mainly, what we're looking for is, with a given system size and expected water usage profile, how much backup supply would be required, and how often would it be required?
- And once we know that, we can evaluate what arrangements we'd need to assure that amount of backup supply for every house in the development, so this water supply scheme would be every bit as reliable as any other strategy, even during the sort of drought we've just been through.

•*Then* we can evaluate the practicality of those arrangements for backup supply.

➢We're going to look at backup supply strategies later, but for the purpose of reviewing the modeling results, I'll just stipulate here that we expect the predominant method for backup supply would be tanker trucks.

➢We'll see that this method would have significant capacity issues, so we'd have to limit the backup supply needed by any one house in any one year to a pretty low level.

➢Now about the model we used:

•The sort of models commonly used, that just input the average rainfall in each month, won't give us that information – they can only offer a look at what the "average" conditions would be.

•But the weather is rarely "average", and it's important to understand how weather variations impact what's required.

•What we need is a model that covers a number of years, so we can see the impact in each year, through periods of higher and lower rainfall, as the water supply in storage goes up and down.

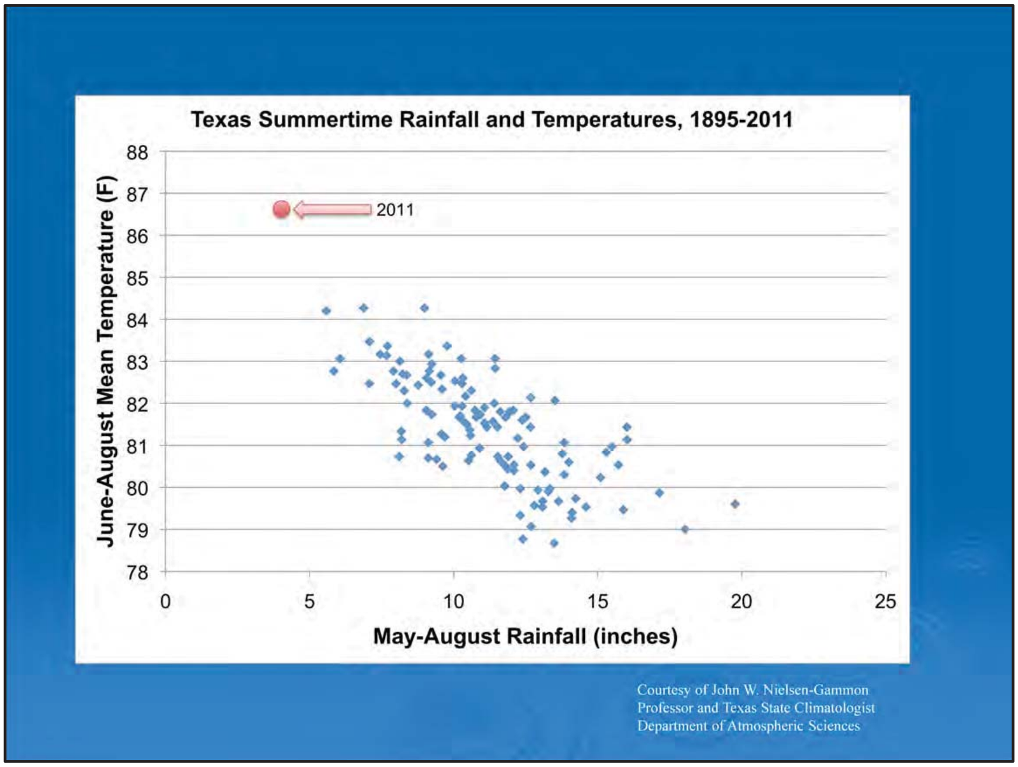
•So, we've used a model covering the last 25 years, 1987 thru 2011.

•It's a model I created a number of years ago, and have updated to cover these last few years.

•Which, as you all know, have turned out to be the critical period.

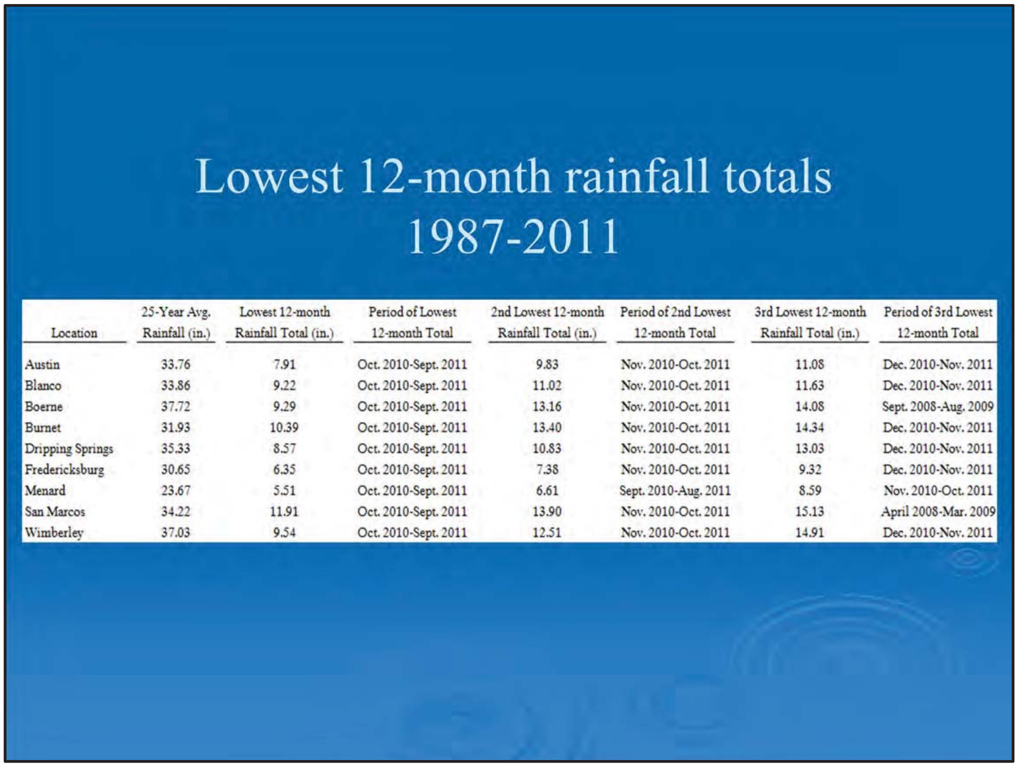
Rainwater Harvesting Model

- Average rainfall models inadequate
- Weather is not average
- Multi-year model
- Through wet and dry cycles
- Used 25-year model, 1987-2011
- Covers the “critical period”



➢Here's an indication of what I mean by "the critical period".

➢This slide, courtesy of state climatologist Dr. John Nielsen-Gammon, graphically shows that 2011 was an "outlier".



Lowest 12-month rainfall totals 1987-2011

Location	25-Year Avg. Rainfall (in.)	Lowest 12-month Rainfall Total (in.)	Period of Lowest 12-month Total	2nd Lowest 12-month Rainfall Total (in.)	Period of 2nd Lowest 12-month Total	3rd Lowest 12-month Rainfall Total (in.)	Period of 3rd Lowest 12-month Total
Austin	33.76	7.91	Oct. 2010-Sept. 2011	9.83	Nov. 2010-Oct. 2011	11.08	Dec. 2010-Nov. 2011
Blanco	33.86	9.22	Oct. 2010-Sept. 2011	11.02	Nov. 2010-Oct. 2011	11.63	Dec. 2010-Nov. 2011
Boerne	37.72	9.29	Oct. 2010-Sept. 2011	13.16	Nov. 2010-Oct. 2011	14.08	Sept. 2008-Aug. 2009
Burnet	31.93	10.39	Oct. 2010-Sept. 2011	13.40	Nov. 2010-Oct. 2011	14.34	Dec. 2010-Nov. 2011
Dripping Springs	35.33	8.57	Oct. 2010-Sept. 2011	10.83	Nov. 2010-Oct. 2011	13.03	Dec. 2010-Nov. 2011
Fredericksburg	30.65	6.35	Oct. 2010-Sept. 2011	7.38	Nov. 2010-Oct. 2011	9.32	Dec. 2010-Nov. 2011
Menard	23.67	5.51	Oct. 2010-Sept. 2011	6.61	Sept. 2010-Aug. 2011	8.59	Nov. 2010-Oct. 2011
San Marcos	34.22	11.91	Oct. 2010-Sept. 2011	13.90	Nov. 2010-Oct. 2011	15.13	April 2008-Mar. 2009
Wimberley	37.03	9.54	Oct. 2010-Sept. 2011	12.51	Nov. 2010-Oct. 2011	14.91	Dec. 2010-Nov. 2011

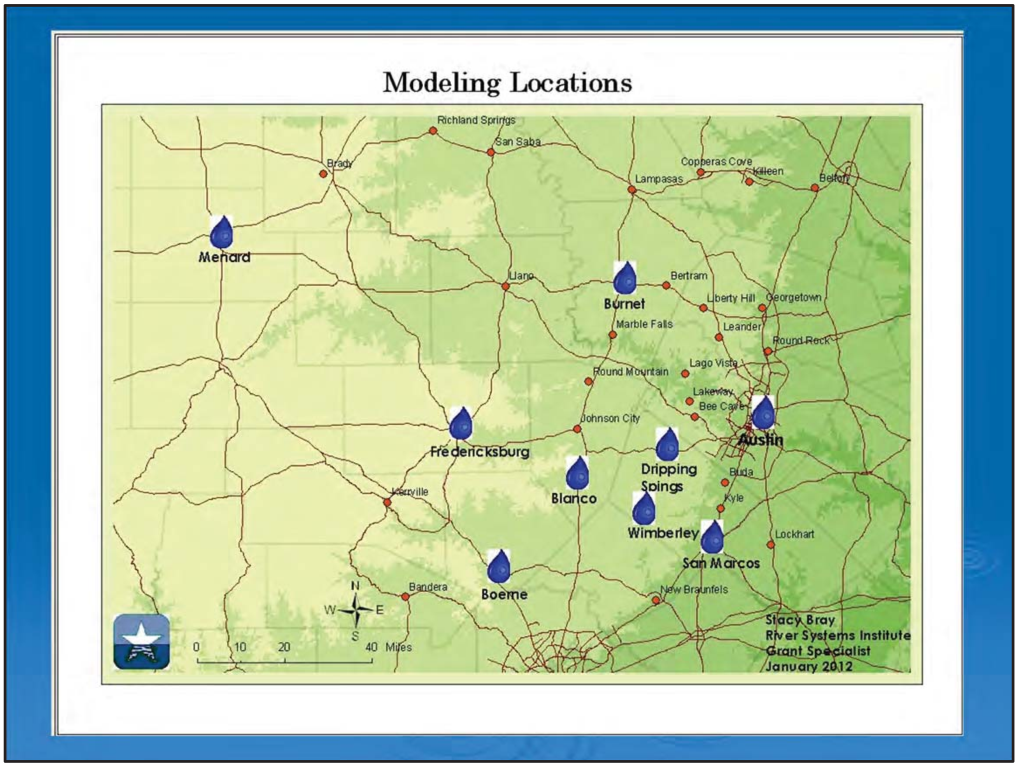
➢And this table highlights that in numerical terms.

- •As we see here, not only did the 2010-2011 drought the period cover the LOWEST 12-month rainfall,
- •In most cases it covered the SECOND and THIRD lowest too.
- •All of these 12-month totals were WAY below the 25-year average annual rainfall at these locations, anywhere from about 1/3 to *1/5* as much.
- •SO, not at all a surprise, we found from the modeling results that the drought period of 2010-2011 pretty much controls the “right-sizing” of rainwater harvesting systems, imposing somewhat larger backup supply requirements than any other period.
- •That “outlier” nature of this period would imply, statistically, we’re not likely to see a repeat of these conditions very often.
- •Now of course the potential impacts of climate change on this region are a “wild card” in this evaluation, but we should *expect* that if we “right-size” the rainwater harvesting systems for these conditions, they’ll be “right-sized” for *any* conditions we might encounter going forward.
- •And so we *can* be fairly well satisfied that this rainwater harvesting strategy WOULD be viable and sustainable over the long term.

➢Again, that is the primary purpose of the modeling.

Right-Size for Outlier

- 2010-2011 drought controls "right-sizing"
- Outlier ➔ Very infrequent
- Right-sized for any future conditions
- Reliable and sustainable



➢We conducted yield-demand modeling for nine locations in and around the Hill Country. The locations are shown on this map.

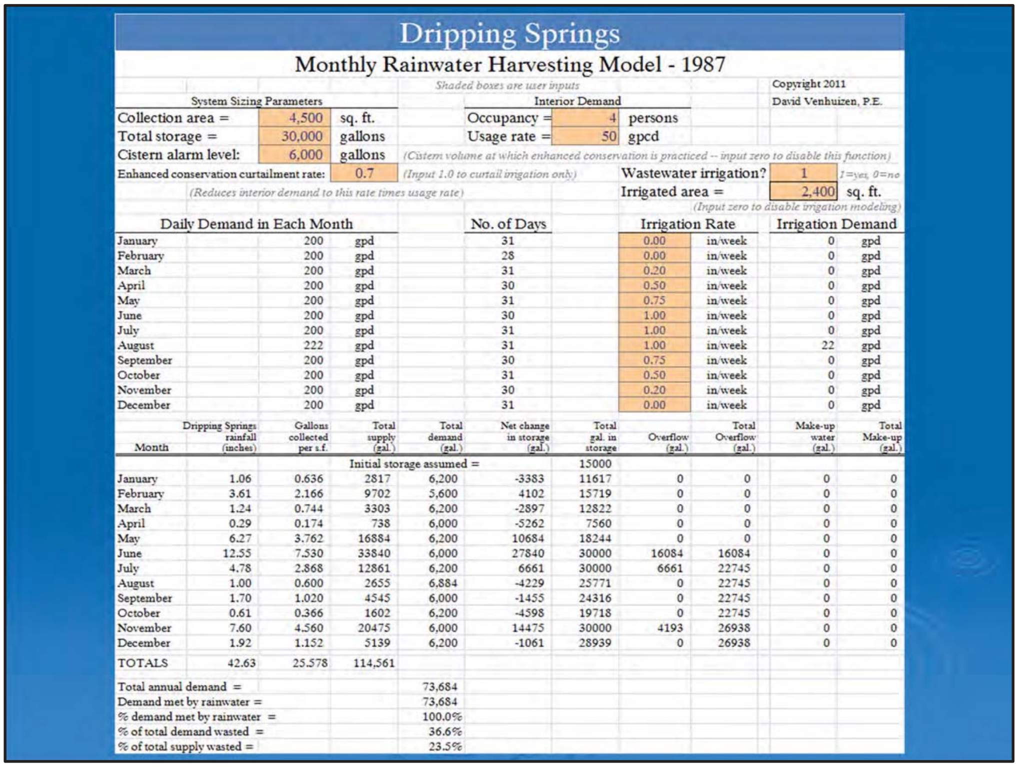
➢We've got Austin and San Marcos in the I-35 corridor.

➢Covering the areas of the Hill Country under the most development pressure, we've got

➢Burnet, Dripping Springs, Blanco, Boerne and Wimberley.

➢A little further out on the Edwards Plateau, getting a little drier on average, is Fredericksburg.

➢And then – I wanted to see how this strategy would fare much further out onto the Edwards Plateau, where average annual rainfall is significantly lower. I knew Billy Kniffen has been living on rainwater just fine in Menard, so I chose that as the modeling location for that purpose.



Dripping Springs

Monthly Rainwater Harvesting Model - 1987

Shaded boxes are user inputs

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David Venhuizen, P.E.

System Sizing Parameters			Interior Demand		
Collection area =	4,500	sq. ft.	Occupancy =	4	persons
Total storage =	30,000	gallons	Usage rate =	50	gpcd
Cistern alarm level:	6,000	gallons			

(Cistern volume at which enhanced conservation is practiced -- input zero to disable this function)

Enhanced conservation curtailment rate: 0.7 *(Input 1.0 to curtail irrigation only)*
(Reduces interior demand to this rate times usage rate)

Wastewater irrigation? 1 *1=yes, 0=no*
Irrigated area = 2,400 sq. ft.
(Input zero to disable irrigation modeling)

Month	Daily Demand in Each Month		No. of Days	Irrigation Rate		Irrigation Demand	
January	200	gpd	31	0.00	in/week	0	gpd
February	200	gpd	28	0.00	in/week	0	gpd
March	200	gpd	31	0.20	in/week	0	gpd
April	200	gpd	30	0.50	in/week	0	gpd
May	200	gpd	31	0.75	in/week	0	gpd
June	200	gpd	30	1.00	in/week	0	gpd
July	200	gpd	31	1.00	in/week	0	gpd
August	222	gpd	31	1.00	in/week	22	gpd
September	200	gpd	30	0.75	in/week	0	gpd
October	200	gpd	31	0.50	in/week	0	gpd
November	200	gpd	30	0.20	in/week	0	gpd
December	200	gpd	31	0.00	in/week	0	gpd

Month	Dripping Springs rainfall (inches)	Gallons collected per s.f.	Total supply (gal.)	Total demand (gal.)	Net change in storage (gal.)	Total gal. in storage	Overflow (gal.)	Total Overflow (gal.)	Make-up water (gal.)	Total Make-up (gal.)
		Initial storage assumed =				15000				
January	1.06	0.636	2817	6,200	-3383	11617	0	0	0	0
February	3.61	2.166	9702	5,600	4102	15719	0	0	0	0
March	1.24	0.744	3303	6,200	-2897	12822	0	0	0	0
April	0.29	0.174	738	6,000	-5262	7560	0	0	0	0
May	6.27	3.762	16884	6,200	10684	18244	0	0	0	0
June	12.55	7.530	33840	6,000	27840	30000	16084	16084	0	0
July	4.78	2.868	12861	6,200	6661	30000	6661	22745	0	0
August	1.00	0.600	2655	6,884	-4229	25771	0	22745	0	0
September	1.70	1.020	4545	6,000	-1455	24316	0	22745	0	0
October	0.61	0.366	1602	6,200	-4598	19718	0	22745	0	0
November	7.60	4.560	20475	6,000	14475	30000	4193	26938	0	0
December	1.92	1.152	5139	6,200	-1061	28939	0	26938	0	0
TOTALS	42.63	25.578	114,561							

Total annual demand =	73,684
Demand met by rainwater =	73,684
% demand met by rainwater =	100.0%
% of total demand wasted =	36.6%
% of total supply wasted =	23.5%

➢As I said, we ran the model for a 25-year period, 1987 thru 2011.

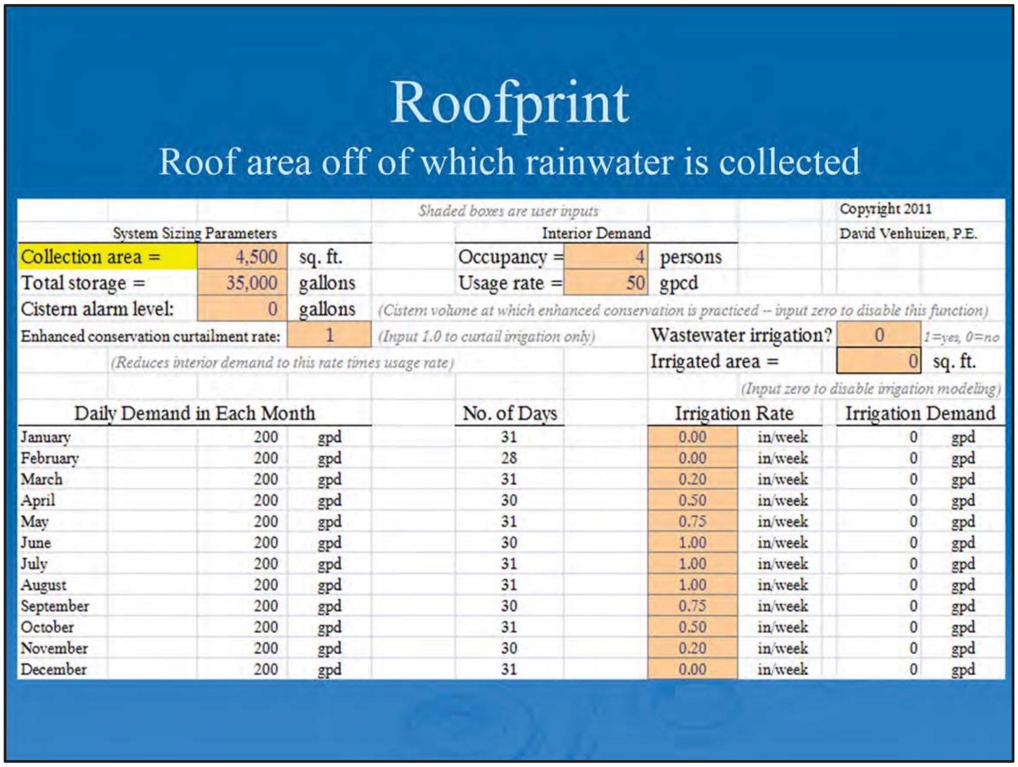
➢Here is the front page of the model, where we enter the inputs.

➢And it's also the model for the first year, 1987.

➢I'm guessing this looks like just a maze of numbers to most of you, but if we break it down, it's really not all that complex.

➢The shaded cells are the user inputs.

➢Let's look at those, one at a time.



Roofprint

Roof area off of which rainwater is collected

Shaded boxes are user inputs

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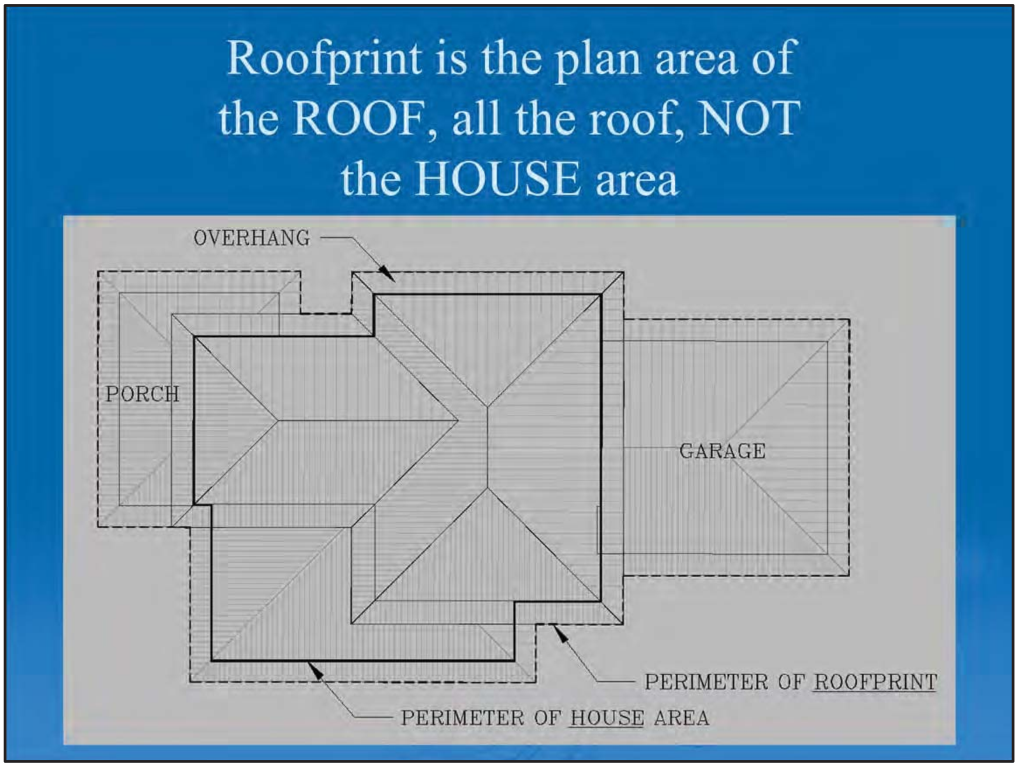
David Venhuizen, P.E.

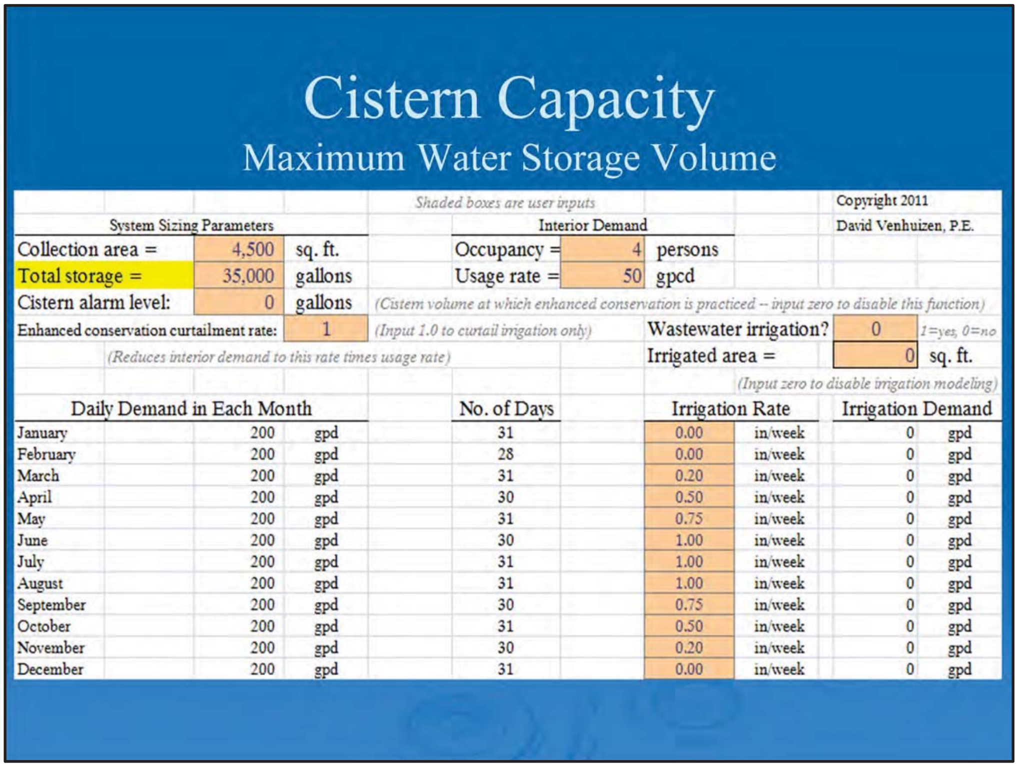
System Sizing Parameters			Interior Demand		
Collection area =	4,500	sq. ft.	Occupancy =	4	persons
Total storage =	35,000	gallons	Usage rate =	50	gpcd
Cistern alarm level:	0	gallons	*(Cistern volume at which enhanced conservation is practiced -- input zero to disable this function)*		
Enhanced conservation curtailment rate:	1	*(Input 1.0 to curtail irrigation only)*	Wastewater irrigation?	0	*1=yes, 0=no*
(Reduces interior demand to this rate times usage rate)			Irrigated area =	0	sq. ft.
			(Input zero to disable irrigation modeling)		

Daily Demand in Each Month			No. of Days	Irrigation Rate		Irrigation Demand	
January	200	gpd	31	0.00	in/week	0	gpd
February	200	gpd	28	0.00	in/week	0	gpd
March	200	gpd	31	0.20	in/week	0	gpd
April	200	gpd	30	0.50	in/week	0	gpd
May	200	gpd	31	0.75	in/week	0	gpd
June	200	gpd	30	1.00	in/week	0	gpd
July	200	gpd	31	1.00	in/week	0	gpd
August	200	gpd	31	1.00	in/week	0	gpd
September	200	gpd	30	0.75	in/week	0	gpd
October	200	gpd	31	0.50	in/week	0	gpd
November	200	gpd	30	0.20	in/week	0	gpd
December	200	gpd	31	0.00	in/week	0	gpd

- The first input is the area you're collecting rainwater from – or what we call "roofprint".
  - •Now, yes, 4500 sq. ft. IS typical of the roofprint area required, as we'll see when we look at some modeling results.
  - •So before you have a panic attack, and say this strategy will never work, because very few can afford that big of a house,
  - •This is NOT the area IN the house!



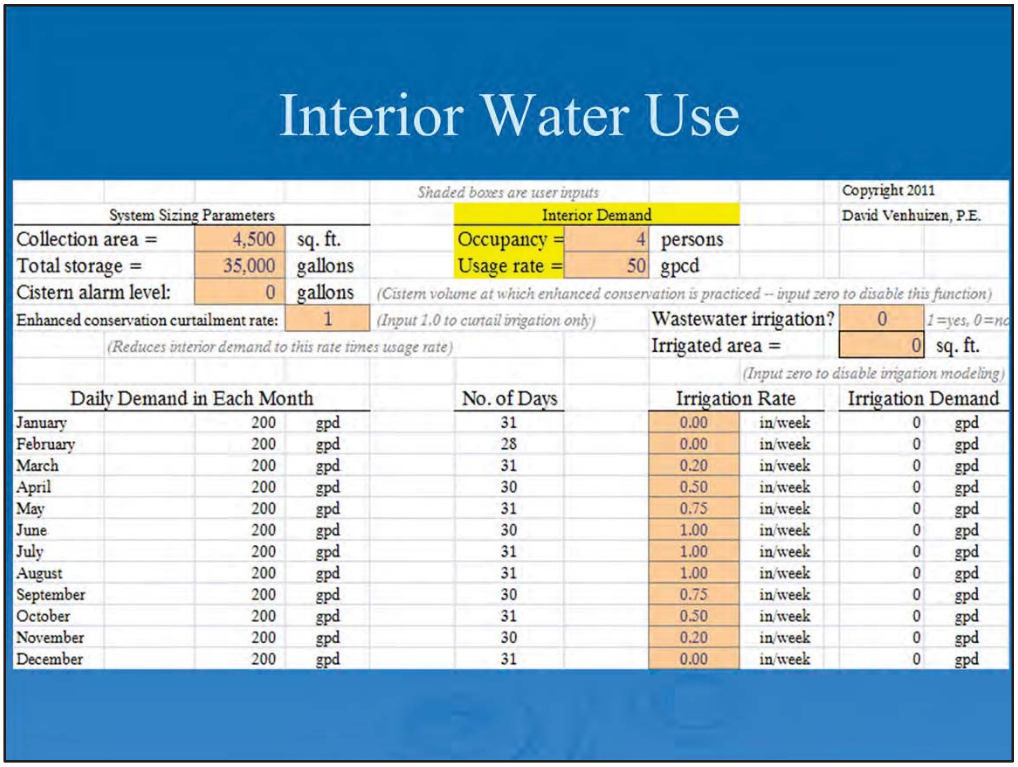
- Roofprint is the area within the perimeter of a plan view of the *whole* roof.
    - This includes overhangs and porches, so the area is bigger than the house.
    - It also includes the garage.
- So it's considerably bigger than the house floor area, at least for single-story houses.
    - But still we're generally going to need more roofprint than we'd have in most "standard" house designs.
    - One of the things we'll be looking at here later is how we can most cost efficiently increase the roofprint so we can capture all the water we need to.



System Sizing Parameters			Interior Demand		
Collection area =	4,500	sq. ft.	Occupancy =	4	persons
Total storage =	35,000	gallons	Usage rate =	50	gpcd
Cistern alarm level:	0	gallons	(Cistern volume at which enhanced conservation is practiced -- input zero to disable this function)		
Enhanced conservation curtailment rate:	1	(Input 1.0 to curtail irrigation only)	Wastewater irrigation?	0	1=yes, 0=no
(Reduces interior demand to this rate times usage rate)			Irrigated area =	0	sq. ft.
			(Input zero to disable irrigation modeling)		

Daily Demand in Each Month			No. of Days	Irrigation Rate		Irrigation Demand	
January	200	gpd	31	0.00	in/week	0	gpd
February	200	gpd	28	0.00	in/week	0	gpd
March	200	gpd	31	0.20	in/week	0	gpd
April	200	gpd	30	0.50	in/week	0	gpd
May	200	gpd	31	0.75	in/week	0	gpd
June	200	gpd	30	1.00	in/week	0	gpd
July	200	gpd	31	1.00	in/week	0	gpd
August	200	gpd	31	1.00	in/week	0	gpd
September	200	gpd	30	0.75	in/week	0	gpd
October	200	gpd	31	0.50	in/week	0	gpd
November	200	gpd	30	0.20	in/week	0	gpd
December	200	gpd	31	0.00	in/week	0	gpd

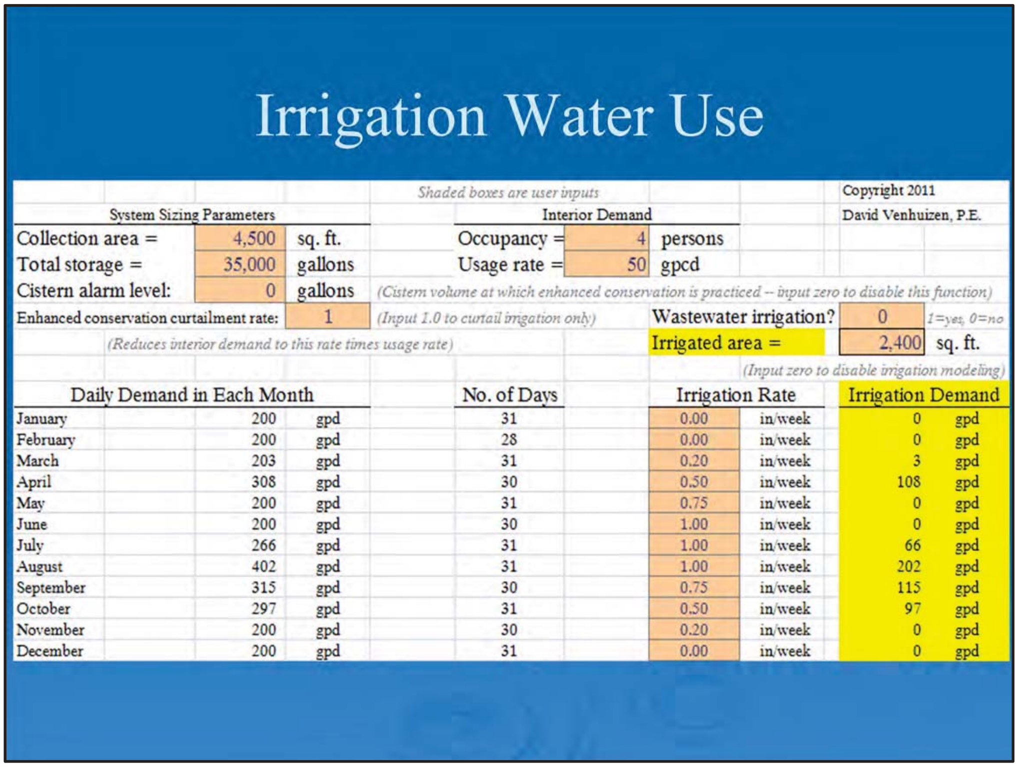
- The other input that defines the configuration of the rainwater system is the cistern capacity, the maximum volume of water storage that's provided.
- That's pretty straightforward, you just enter that in gallons, right here.



Daily Demand in Each Month			No. of Days	Irrigation Rate		Irrigation Demand	
January	200	gpd	31	0.00	in/week	0	gpd
February	200	gpd	28	0.00	in/week	0	gpd
March	200	gpd	31	0.20	in/week	0	gpd
April	200	gpd	30	0.50	in/week	0	gpd
May	200	gpd	31	0.75	in/week	0	gpd
June	200	gpd	30	1.00	in/week	0	gpd
July	200	gpd	31	1.00	in/week	0	gpd
August	200	gpd	31	1.00	in/week	0	gpd
September	200	gpd	30	0.75	in/week	0	gpd
October	200	gpd	31	0.50	in/week	0	gpd
November	200	gpd	30	0.20	in/week	0	gpd
December	200	gpd	31	0.00	in/week	0	gpd

➢Now lets's look over here, at interior water usage.

- We set the level of interior water use by entering the occupancy – the number of persons living in the house,
- and the average amount of daily water usage per person.
- I'll talk here in a bit about what we might expect to be the "right" interior water usage rate.



Irrigation Water Use

Shaded boxes are user inputs
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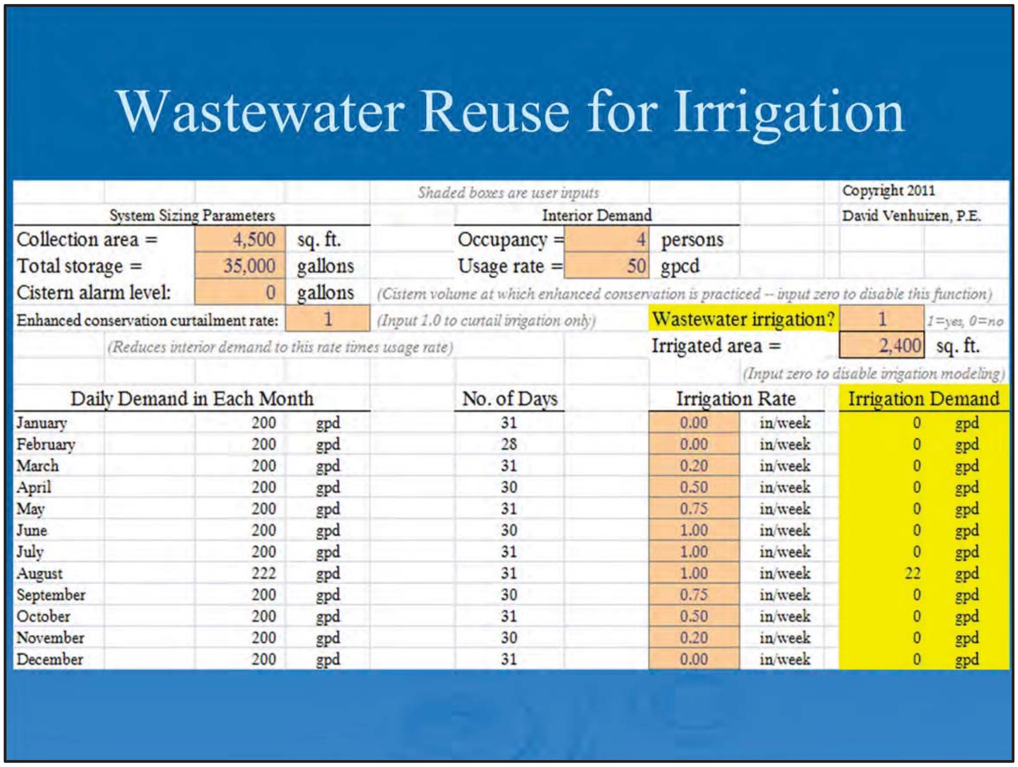
System Sizing Parameters
Collection area = 4,500 sq. ft.
Total storage = 35,000 gallons
Cistern alarm level: 0 gallons
Enhanced conservation curtailment rate: 1
(Reduces interior demand to this rate times usage rate)

Interior Demand
Occupancy = 4 persons
Usage rate = 50 gpcd
(Cistern volume at which enhanced conservation is practiced -- input zero to disable this function)
(Input 1.0 to curtail irrigation only)

Wastewater irrigation? 0 1=yes, 0=no
Irrigated area = 2,400 sq. ft.
(Input zero to disable irrigation modeling)

Daily Demand in Each Month			No. of Days	Irrigation Rate		Irrigation Demand	
January	200	gpd	31	0.00	in/week	0	gpd
February	200	gpd	28	0.00	in/week	0	gpd
March	203	gpd	31	0.20	in/week	3	gpd
April	308	gpd	30	0.50	in/week	108	gpd
May	200	gpd	31	0.75	in/week	0	gpd
June	200	gpd	30	1.00	in/week	0	gpd
July	266	gpd	31	1.00	in/week	66	gpd
August	402	gpd	31	1.00	in/week	202	gpd
September	315	gpd	30	0.75	in/week	115	gpd
October	297	gpd	31	0.50	in/week	97	gpd
November	200	gpd	30	0.20	in/week	0	gpd
December	200	gpd	31	0.00	in/week	0	gpd

- We can also include irrigation usage.
- That’s all too opaque to explain in detail here.
- Just two things to note.
- First, it’s presumed we’d be using drip irrigation, because, as rainwater harvesters we know we need to be efficient, and subsurface drip irrigation is about 90% efficient, as compared with maybe 50% for spray.
- And second, look at the irrigation demands listed here, because …

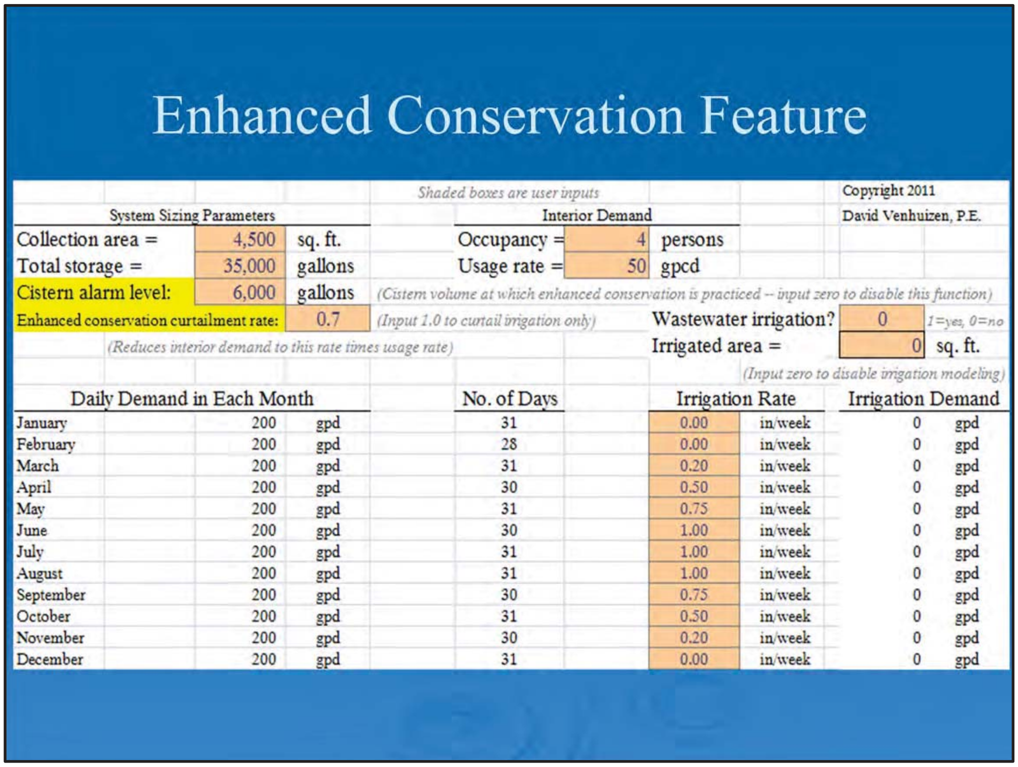


➢We can also look at the impact of reusing wastewater to defray irrigation demands.

- •And why wouldn't we do that? It costs a lot of money to add roofprint and to install a cistern.
- •After using that hard-won rainwater in the house and it comes out as wastewater, why just throw it away?
- •So we can model the impact of reusing it for irrigation if we enter "1" here.
- •And you can see here, those numbers under "Irrigation Demand" in the last slide mostly went to *zero.*
- •Now this is copied from the 1987 model, which was a very wet year, but you'd get significant reductions in every year, wet or dry.

➢So you see how really valuable wastewater reuse is for rainwater harvesters, IF they want to have an irrigated landscape.

➢We'll look at some numbers that illustrate that here in a bit.



Daily Demand in Each Month			No. of Days	Irrigation Rate		Irrigation Demand	
January	200	gpd	31	0.00	in/week	0	gpd
February	200	gpd	28	0.00	in/week	0	gpd
March	200	gpd	31	0.20	in/week	0	gpd
April	200	gpd	30	0.50	in/week	0	gpd
May	200	gpd	31	0.75	in/week	0	gpd
June	200	gpd	30	1.00	in/week	0	gpd
July	200	gpd	31	1.00	in/week	0	gpd
August	200	gpd	31	1.00	in/week	0	gpd
September	200	gpd	30	0.75	in/week	0	gpd
October	200	gpd	31	0.50	in/week	0	gpd
November	200	gpd	30	0.20	in/week	0	gpd
December	200	gpd	31	0.00	in/week	0	gpd

- The final feature of the model is an “enhanced conservation” factor.
- The idea here is that you merrily use water at the presumed “normal” rate, but when your cistern level gets low, down to this level here, you say, “Ohmygosh! I’d better start conserving!”
- So you curtail your use by this factor here, and continue to do that until you get enough rain that the water level in the cistern rises up above this point again.
- What we’re doing here is mimicking the behavior that’s encouraged by drought contingency plans of *all* the water providers in this region.
- In the case of a rainwater harvester, though, they have a real, very visible incentive for actually *adhering* to that behavior – the dwindling supply left in their cistern, and the prospect of having to get a pretty expensive backup supply.

Model Calculations

Month	Dripping Springs rainfall (inches)	Gallons collected per s.f.	Total supply (gal.)	Total demand (gal.)	Net change in storage (gal.)	Total gal. in storage	Overflow (gal.)	Make-up water (gal.)
			Storage at end of 2008 =			1672		
January	0.87	0.522	2304	6,200	-3896	1776	**0**	**4000**
February	1.06	0.636	2817	5,600	-2783	993	**0**	**2000**
March	3.14	1.884	8433	6,200	2233	3226	**0**	**0**
April	2.98	1.788	8001	6,000	2001	5227	**0**	**0**
May	1.02	0.612	2709	6,200	-3491	3736	**0**	**2000**
June	0.86	0.516	2277	6,000	-3723	2013	**0**	**2000**
July	2.10	1.260	5625	6,200	-575	3438	**0**	**2000**
August	1.04	0.624	2763	6,200	-3437	2001	**0**	**2000**
September	9.58	5.748	25821	6,000	19821	21822	**0**	**0**
October	6.35	3.810	17100	6,200	10900	32722	**0**	**0**
November	3.60	2.160	9675	6,000	3675	35000	**1397**	**0**
December	2.72	1.632	7299	6,200	1099	35000	**1099**	**0**

➢Okay, now that we've covered all the inputs, here's what the model does with them.

➢Again, way too opaque to run through in detail here.

➢The main thing to understand is that we get the amount of backup supply that would have been required in each month to keep the level in the cistern from going to zero, listed here.

➢And we get the amount of water that overflowed because the cistern filled up, listed here.

Dripping Springs

Monthly Rainwater Harvesting Model - 25-Year Summary

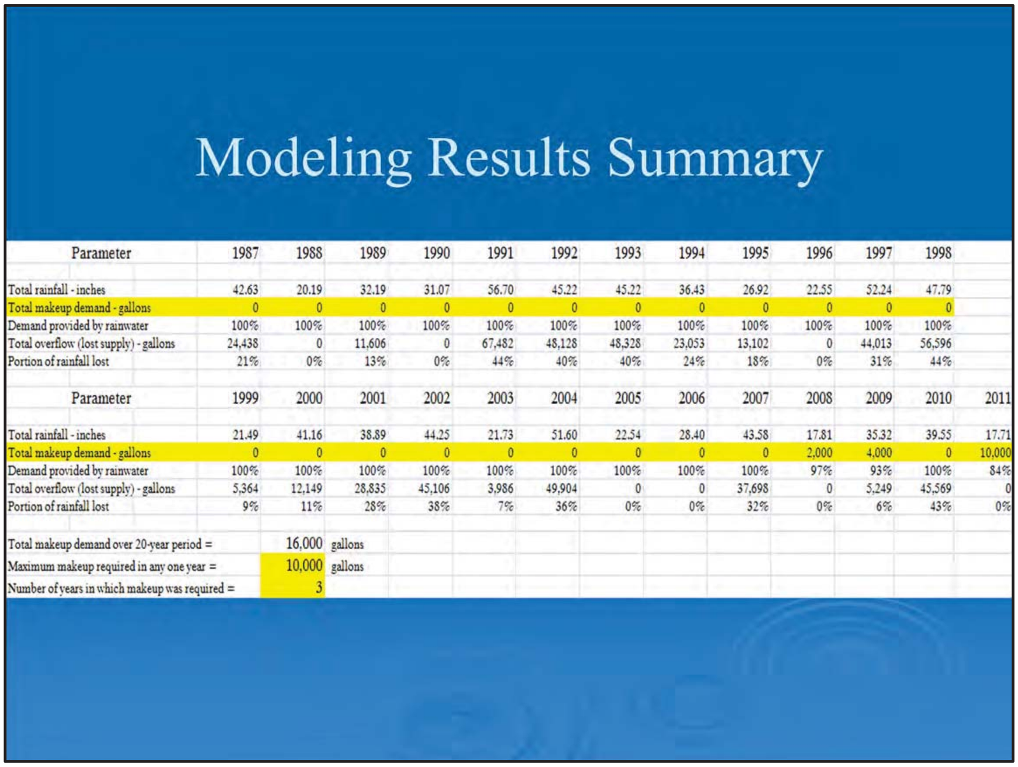
System Sizing Parameters			Interior Demand			Copyright 2011
Collection area =	4,500	sq. ft.	Occupancy =	4	persons	David Venhuizen, P.E.
Total storage =	30,000	gallons	Usage rate =	50	gpcd	
Cistern alarm level:	6,000	gallons				
Enhanced conservation curtailment rate:	0.7		Irrigated area =	2,400	sq. ft.	
			Wastewater irrigated?	1	(1=yes, 0=no)	

Interior Daily Demand in Each Month			No. of Days	Irrigation Rate	
January	200	gpd	31	0.00	in/week
February	200	gpd	28	0.00	in/week
March	200	gpd	31	0.20	in/week
April	200	gpd	30	0.50	in/week
May	200	gpd	31	0.75	in/week
June	200	gpd	30	1.00	in/week
July	200	gpd	31	1.00	in/week
August	200	gpd	31	1.00	in/week
September	200	gpd	30	0.75	in/week
October	200	gpd	31	0.50	in/week
November	200	gpd	30	0.20	in/week
December	200	gpd	31	0.00	in/week

Parameter	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	
Total rainfall - inches	42.63	20.19	32.19	31.07	56.70	45.22	45.22	36.43	26.92	22.55	52.24	47.79	
Total makeup demand - gallons	0	0	0	0	0	0	0	0	0	2,000	0	0	
Demand provided by rainwater	100%	100%	100%	100%	100%	100%	100%	100%	100%	97%	100%	100%	
Total overflow (lost supply) - gallons	26,938	0	11,606	0	67,482	48,128	48,328	23,053	13,102	0	47,873	56,596	
Portion of rainfall lost	24%	0%	13%	0%	44%	40%	40%	24%	18%	0%	34%	44%	
Parameter	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Total rainfall - inches	21.49	41.16	38.89	44.25	21.73	51.60	22.54	28.40	43.58	17.81	35.32	39.55	17.71
Total makeup demand - gallons	0	0	0	0	0	0	0	0	0	6,000	6,000	0	12,000
Demand provided by rainwater	100%	100%	100%	100%	100%	100%	100%	100%	100%	91%	90%	100%	80%
Total overflow (lost supply) - gallons	5,364	13,949	28,835	45,106	3,986	49,904	0	0	39,558	0	10,526	45,569	0
Portion of rainfall lost	9%	13%	28%	38%	7%	36%	0%	0%	34%	0%	11%	43%	0%

Total makeup demand over 20-year period =	26,000	gallons
Maximum makeup required in any one year =	12,000	gallons
Number of years in which makeup was required =	4	
Total overflow lost over 20-year period =	585,901	gallons
Maximum overflow lost in any one year =	67,482	gallons

- And then the totals of these for all the years are shown the summary page
- Here at the top is a review of the model inputs
- You can see that this model run included the "enhanced conservation" factor, that we're irrigating 2,400 sq. ft. and that we're practicing wastewater irrigation
- Below that is a summary for each year in the model



Modeling Results Summary

Parameter	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Total rainfall - inches	42.63	20.19	32.19	31.07	56.70	45.22	45.22	36.43	26.92	22.55	52.24	47.79
Total makeup demand - gallons	0	0	0	0	0	0	0	0	0	0	0	0
Demand provided by rainwater	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Total overflow (lost supply) - gallons	24,438	0	11,606	0	67,482	48,128	48,328	23,053	13,102	0	44,013	56,596
Portion of rainfall lost	21%	0%	13%	0%	44%	40%	40%	24%	18%	0%	31%	44%

Parameter	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total rainfall - inches	21.49	41.16	38.89	44.25	21.73	51.60	22.54	28.40	43.58	17.81	35.32	39.55	17.71
Total makeup demand - gallons	0	0	0	0	0	0	0	0	0	2,000	4,000	0	10,000
Demand provided by rainwater	100%	100%	100%	100%	100%	100%	100%	100%	100%	97%	93%	100%	84%
Total overflow (lost supply) - gallons	5,364	12,149	28,835	45,106	3,986	49,904	0	0	37,698	0	5,249	45,569	0
Portion of rainfall lost	9%	11%	28%	38%	7%	36%	0%	0%	32%	0%	6%	43%	0%

Total makeup demand over 20-year period =	16,000	gallons
Maximum makeup required in any one year =	10,000	gallons
Number of years in which makeup was required =	3	

➢Let’s zoom in on those summaries.

➢Again, we won’t wade through the details here.

➢The main thing is this line here – the backup supply required in each year.

➢And then down here in the summary:

•The largest amount of backup supply we needed in any one year.

•And the number of years that we needed *any* backup supply.

➢As I said before, these are the critical pieces of information we get from the model, so we can “right-size” our rainwater harvesting system to hold down the amount and frequency of backup supply.

➢Recall I said we expect the primary backup supply strategy would be tanker trucks.

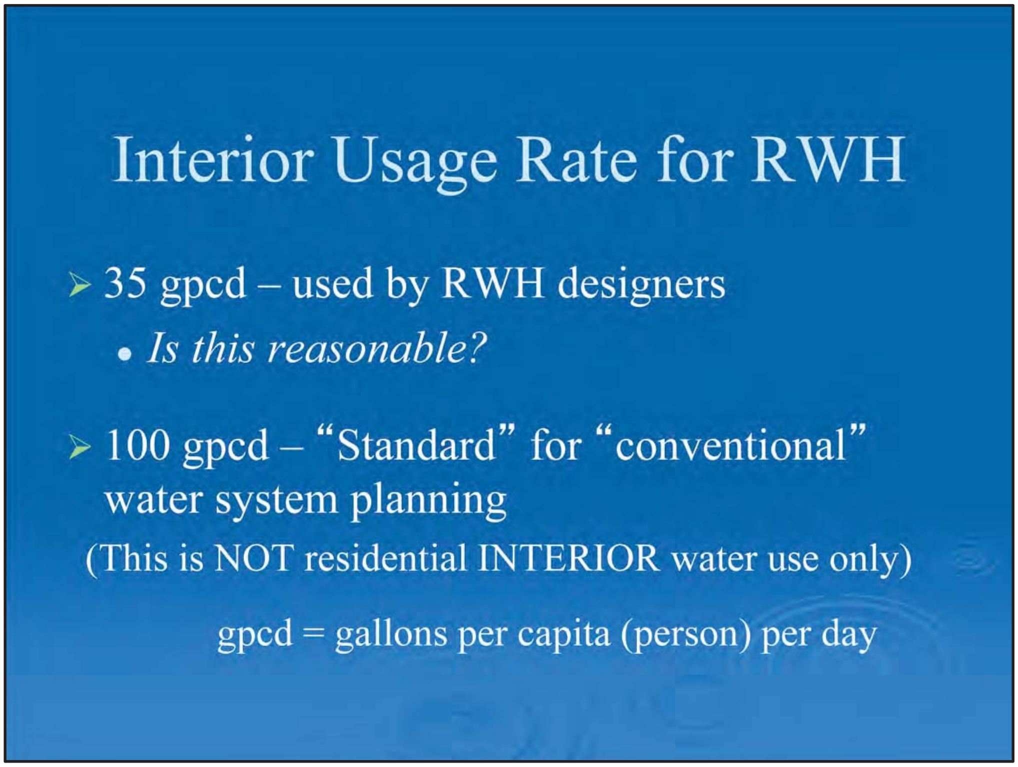
•So what we’re aiming for is a “tolerable” number of tanker truckloads in the worst year.

•We’ll talk about what “tolerable” means when we look at backup supply strategies.

➢We saw before what an “outlier” 2011 appears to be.

•And sure enough, you see in this instance how much backup supply is required in 2011, while the requirements in most other years is zero, and it’s pretty negligible even in the other recent drought period, in 2008-2009.

•So again our general presumption is, if the model shows the backup supply system is “manageable” in what up to now have been our “worst case” conditions, the rainwater system would be safely “right-sized” for any foreseeable future conditions.



➢Now let's take a look at that interior water usage rate.

➢What is the "right" level to use in this modeling process?

➢35 gallons per person per day is typically presumed by many rainwater practitioners.

•But the present population of rainwater harvesters are a *self-selected* population.

•So would this be a "reasonable" rate for a broader population, for the general homebuyer?

•Again, we're looking at this as a ***broadscale*** water supply strategy, that any developer might use.

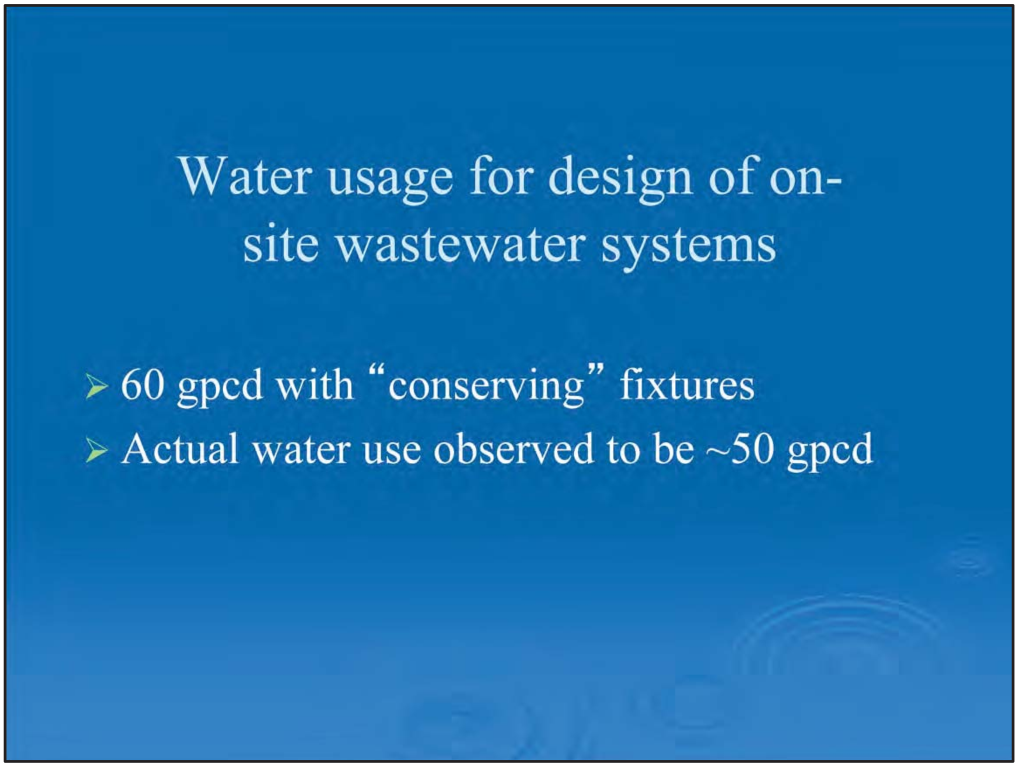
➢Let's look at some other estimates of water usage rate to get an idea of what might be "right" for that broader population.

•100 gpcd is the usage rate typically presumed for design of "normal" water supply systems.

•But the aim there is to assure no capacity limitations in the facilities.

➢In *rainwater harvesting systems*, our aim is to determine how LOW of a usage rate you could live with and not feel "deprived", that would be acceptable to that fairly broad population.

➢In any case, the number we're looking for is RESIDENTIAL INTERIOR water use, and that's not what that 100 gpcd number is.



➢One clue of what *interior* use might be is the water usage rate presumed for design of on-site wastewater systems, what most of you know by the colloquial term “septic systems”.

➢The standard rate stipulated in the Texas rules is 60 gallons per person per day.

➢That’s for so-called “conserving” water fixtures, but the fixtures that were called “conserving” when these rules were written are now all you can buy.

➢So 60 is the number that’s used for all new houses.

➢Many studies, however, show that the ACTUAL water usage rate in houses served by on-site wastewater systems is 50 gallons per person per day or less.

Household Water Usage Rates with Latest State-of-the-Art Fixtures
AWWA Study, circa 1990

Fixture/Use	Unit Demand	Usage Rate	Water Use (gpcd)
Toilets	1.5 gal/flush	4 flush/person/day	6.0
Showers	1.9 gal/min.	4.8 min/person/day	9.1
Washing machine	42 gal/load	0.3 load/person/day	12.6
Dishwasher	8.5 gal/load	0.17 load/person/day	1.4
Faucets	estimated	estimated	8.5
Baths	50 gal/bath	0.14 bath/person/day	7.0
		Total Water Use =	44.6

➢One clue of what *interior* use might be is the water usage rate presumed for design of on-site wastewater systems, what most of you know by the colloquial term “septic systems”.

➢The standard rate stipulated in the Texas rules is 60 gallons per person per day.

➢That’s for so-called “conserving” water fixtures, but the fixtures that were called “conserving” when these rules were written are now all you can buy.

➢So 60 is the number that’s used for all new houses.

➢Many studies, however, show that the ACTUAL water usage rate in houses served by on-site wastewater systems is 50 gallons per person per day or less.

➢This is actual usage data meticulously documented by Keenan Smith, an architect who is with us here today, whose family has been happily living on rainwater ever since he built his house out near Dripping Springs.

➢Here we see what their usage has been over the last 9 years, averaging just over 24 gallons per person per day, and the annual average never ran much over 28.

➢This usage is somewhat lower than most would expect you’d need to live “normally”, but Keenan doesn’t feel that he and his family have been “deprived” in any way.

➢Notably, Keenan led off relating his experience to me by saying that he considers his to be a pretty normal "Ozzie and Harriet" family.

➢His point being that he didn't feel like they were making anything like an extraordinary effort to conserve water. They just weren't being wasteful.

➢Now if you CAN use water at this rate, the rainwater harvesting strategy could be implemented more cost effectively, since you'd need a smaller roofprint and cistern.

➢This highlights the value of the users adopting a "conservation ethic".

➢I mean, do you really *need* a shower with 7 heads.

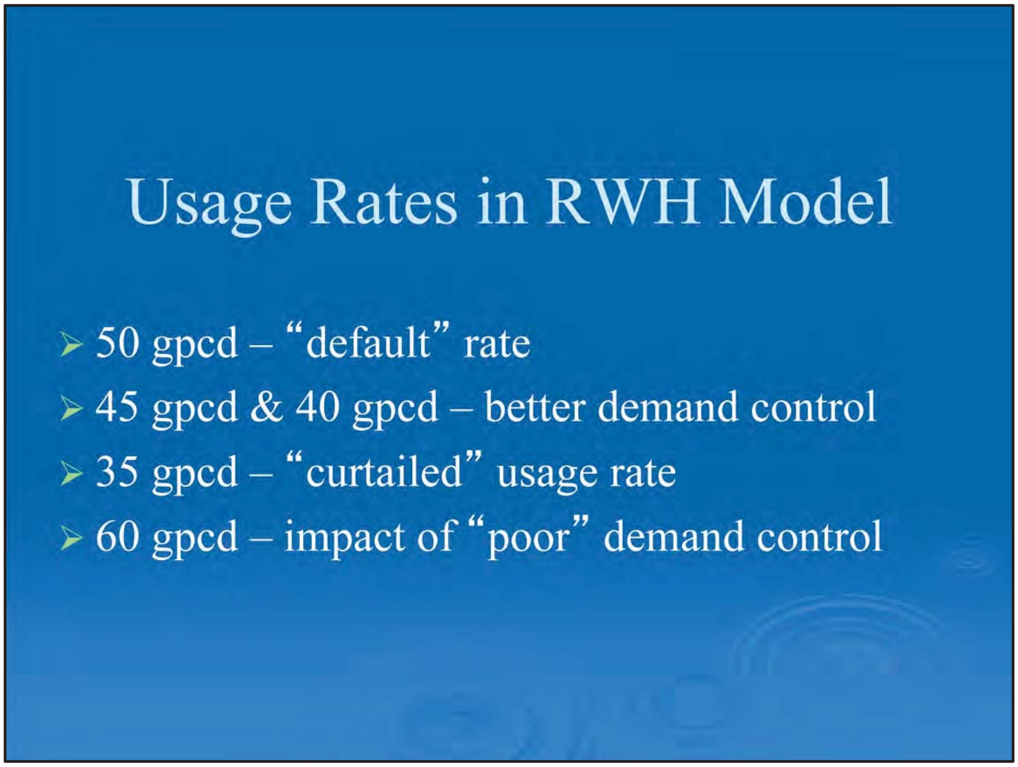
➢As Keenan's experience highlights, just don't be wasteful.

Rainwater Harvesting System Water Use History
4-Person Household, 2 Adults, 2 Children

Year	Total Water Use (gallons)	Average Daily Water Use (gpd)	Average Daily Water Use per Person (gpcd)
2003	32,457	88.9	22.2
2004	34,361	93.9	23.5
2005	33,840	92.7	23.2
2006	32,007	87.7	21.9
2007	35,529	97.3	24.3
2008	34,482	94.2	23.6
2009	38,544	105.6	26.4
2010	41,118	112.7	28.2
2011	36,174	99.1	24.8
9-year avg.	35,390	96.9	24.2

- This is actual usage data meticulously documented by Keenan Smith, an architect who is with us here today, whose family has been happily living on rainwater ever since he built his house out near Dripping Springs.
- Here we see what their usage has been over the last 9 years, averaging just over 24 gallons per person per day, and the annual average never ran much over 28.
- This usage is somewhat lower than most would expect you'd need to live "normally", but Keenan doesn't feel that he and his family have been "deprived" in any way.
- Notably, Keenan led off relating his experience to me by saying that he considers his to be a pretty normal "Ozzie and Harriet" family.
- His point being that he didn't feel like they were making anything like an extraordinary effort to conserve water. They just weren't being wasteful.

- Now if you CAN use water at this rate, the rainwater harvesting strategy could be implemented more cost effectively, since you'd need a smaller roofprint and cistern.
- This highlights the value of the users adopting a "conservation ethic".
- I mean, do you really *need* a shower with 7 heads.
- As Keenan's experience highlights, just don't be wasteful.



➢This indicates that perhaps a usage rate of 35 gallons per person per day *could* be fairly routinely maintained by a lot of the population.

➢But again we’re looking at RWH as a *broadscale* strategy.

➢So we didn’t go *that* conservative in our modeling.

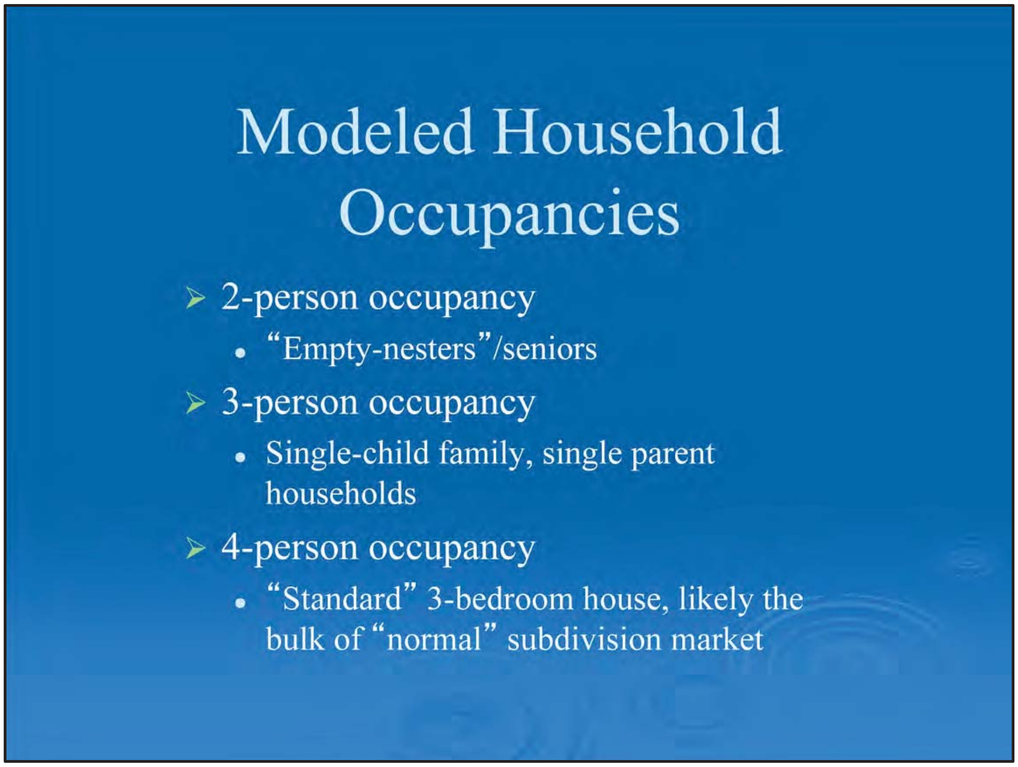
➢We used 50 gallons per person per day as our “default” rate, since it appears that a fairly broad population could readily live at that rate without a hint of “deprivation”.

➢We also evaluated 45 and 40 gallons per person per day, to show the value of better demand control.

➢And then we looked at 35 gallons per person day when the “enhanced conservation” factor kicks in.

➢For those model runs, we set the “normal” usage rate at 50, and the curtailment rate at 0.7, so that the curtailed rate was 35.

➢Then we also modeled 60 gallons per person per day to show the impact of not so good demand control.



➢Now let's look at the range of house occupancies that we modeled.

➢We started at the low end with a 2-person occupancy.

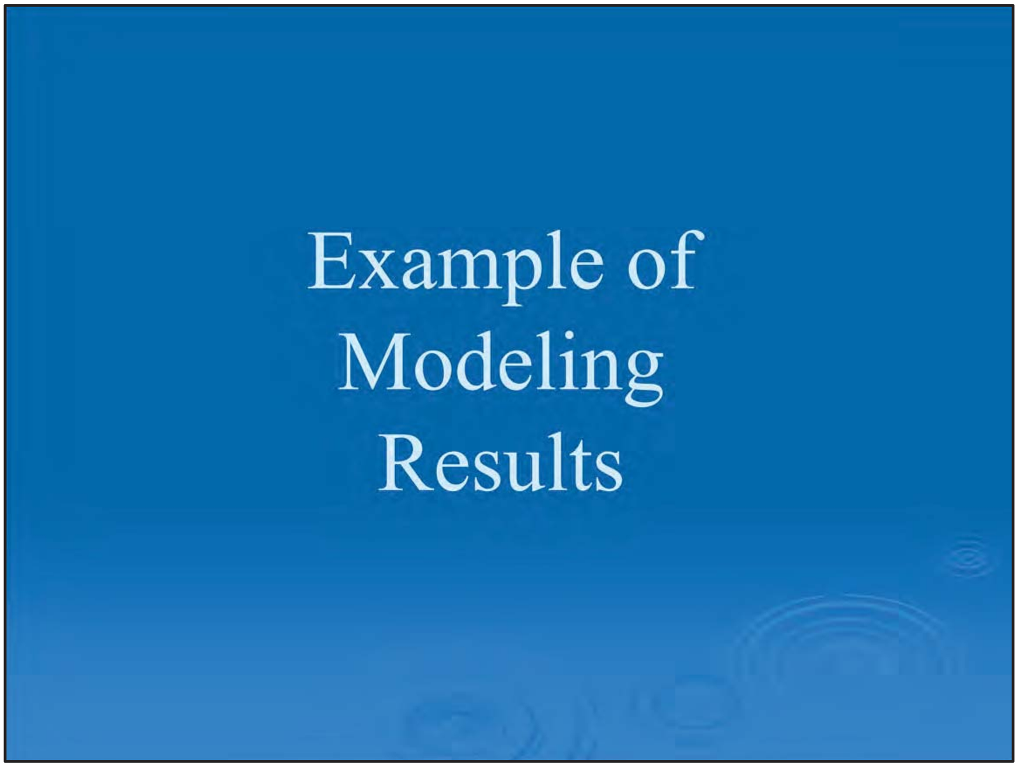
- A good deal of the market around the Hill Country is aimed a seniors.
- Sun City up by Georgetown is an example of that.
- We know of one development near Dripping Springs, aimed at this market, that *is* planning to use rainwater harvesting.

➢Then we looked at a 3-person occupancy.

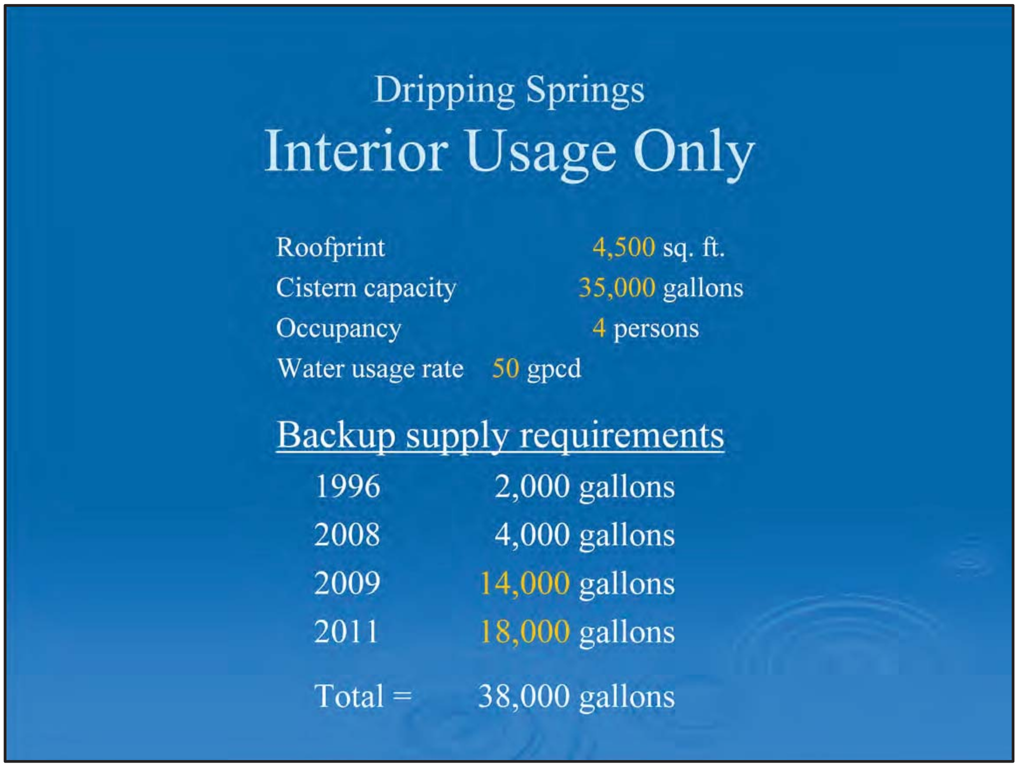
- This might be that same market, but living with an aging parent or other loved one.
- It would also cover a single-child household, or a single-parent household with two children.
- These are not at all uncommon demographics these days.

➢But probably the "standard" for most "mainstream" subdivisions is 4 persons, the standard occupancy of a 3-bedroom house that's presumed in the on-site wastewater code.

- Demographics show that the development-wide average household size in most Hill Country developments is below 4 persons, but of course the water supply system really has to be sized for the "standard" occupancy, at least.
- Some houses would have higher occupancies, and that would have to be examined in each case, but we've presumed that using RWH facility sizes required for a 4-person occupancy would cover the bulk of the market.
- Note too that a 5-person occupancy using water at a rate of 40 gallons would be the same total usage as 4 persons using at 50 gallons.
- Some water uses don't scale directly with occupancy, uses like laundry, dishwashing and cleaning, so a lower usage rate could be more readily maintained at higher occupancy.



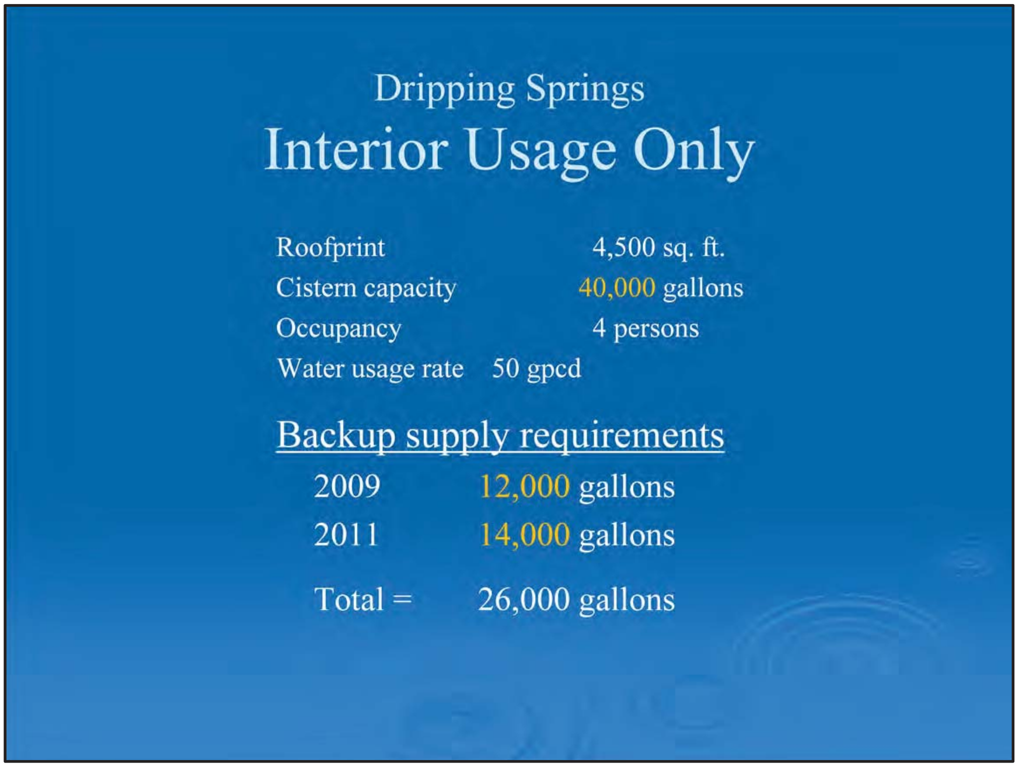
- Now we're going to look at some modeling results for just one site, to give you a glimpse of how it all shakes out.



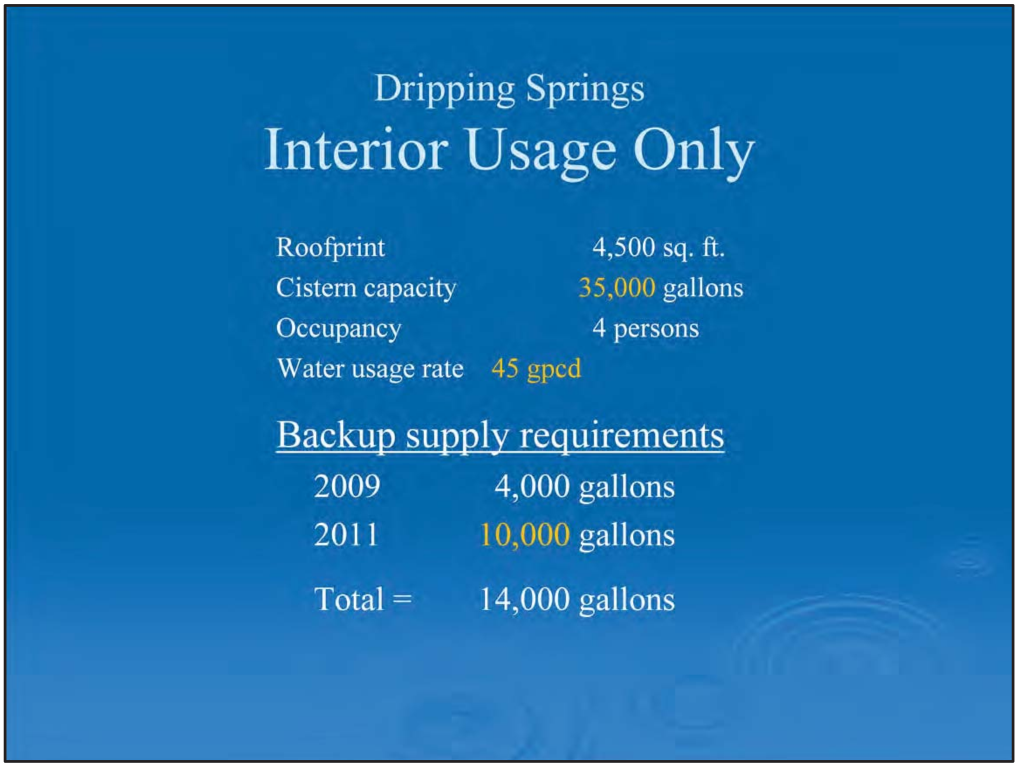
➢We're using Dripping Springs for our example.

➢Here we see the backup supply that would have been required if we had 4500 sq. ft. of roofprint, a 35,000-gallon cistern, and a 4-person occupancy using water at 50 gallons per day.

➢Again, I'll go over the capacity issues for a tanker truck backup supply system later, but please just accept for now my evaluation that the amounts required in 2009 and, especially, in 2011 are a bit higher than we'd like to see in the critical years.



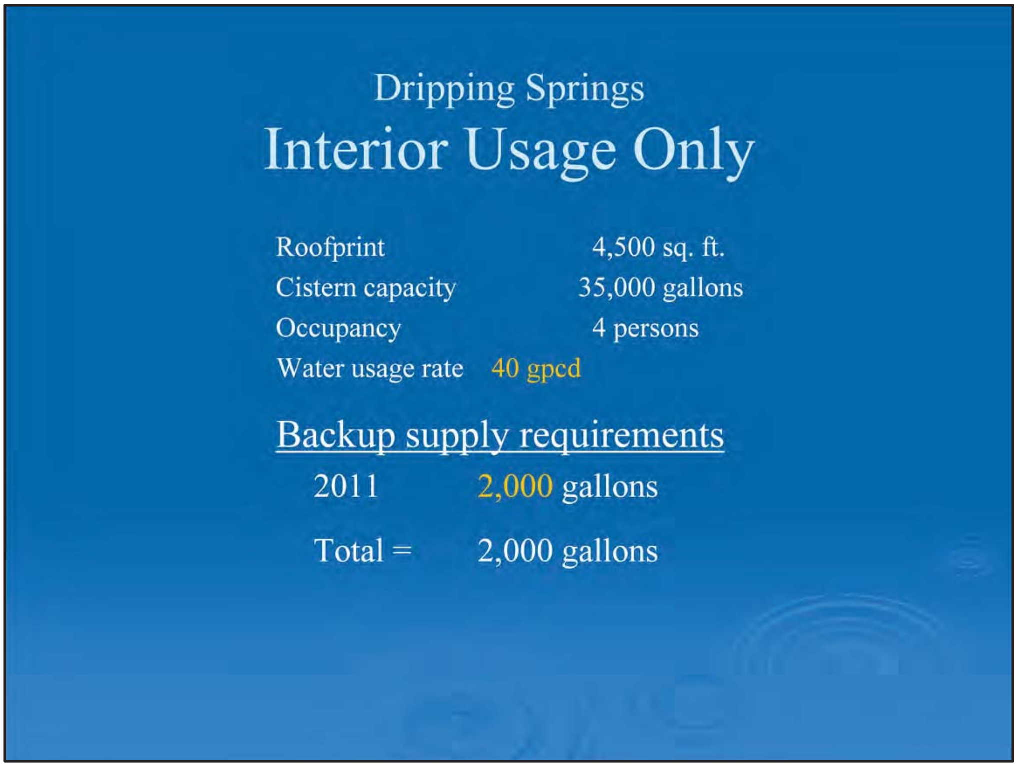
- So let's see what it's like if we try a larger cistern.
- Here's the results if we increase it to 40,000 gallons.
- Down some in the critical years, but not a whole lot.



➢So let's look at lowering our water usage rate, putting that "conservation ethic" into practice, and maintaining better demand control.

➢Here's the situation, back to a 35,000-gallon cistern, with a usage rate of 45 gallons.

➢Quite tolerable in 2009 now, but still perhaps higher than we'd like in 2011.



➢How about doing even better demand control, reducing the usage rate to 40?

➢Now we've got backup supply down to a negligible level.

➢So again, practicing good demand control – practicing that "conservation ethic" – particularly in the critical drought periods, can allow you to get by on a smaller system while needing very little backup supply.

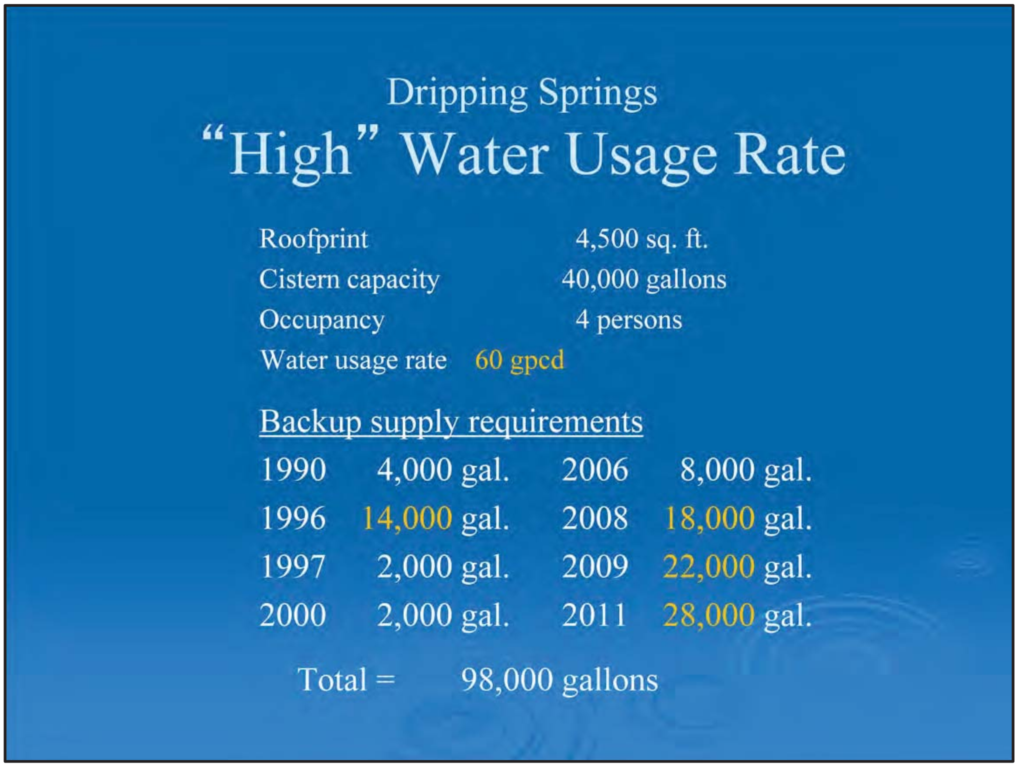
➢Okay, now let's look at the situation if we employed the "enhanced conservation curtailment" that I described earlier.

➢Still a little higher than we'd like in 2011.

➢The bottom line we gather from these results is we could call this system "right-sized" if the users would practice sufficient demand control in critical drought periods.

➢But if they want to go on using 50 gallons a day routinely, no matter what, they'd have to have a larger roofprint, or cistern, or both.

➢Or strain the backup supply system.

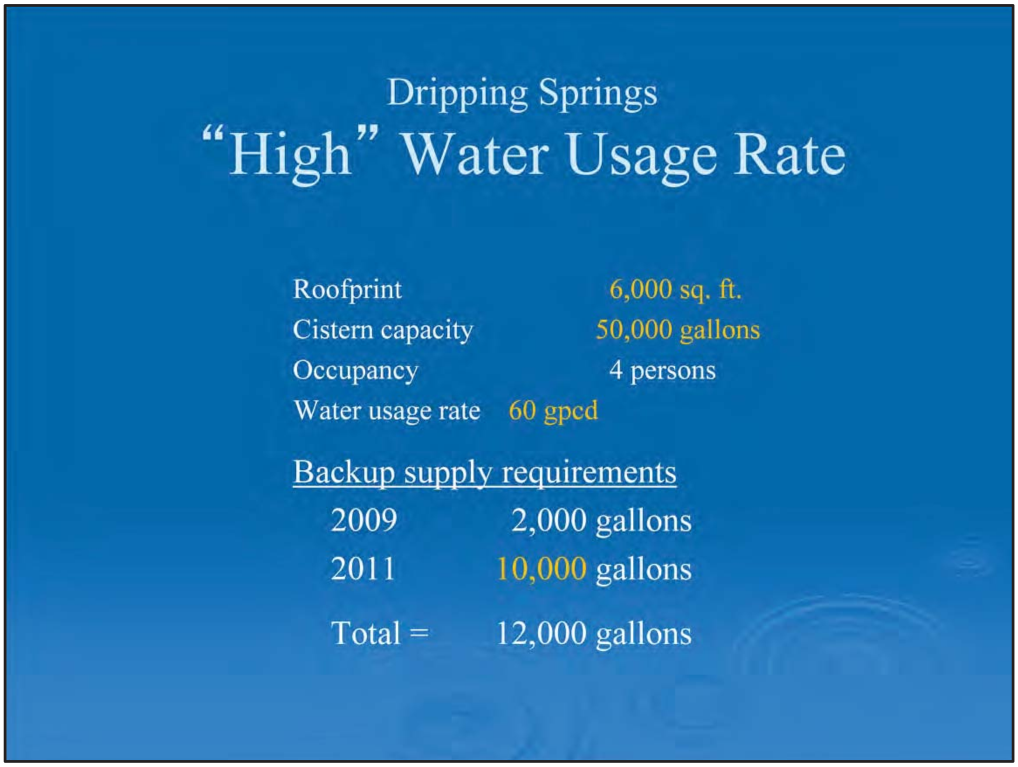


➢Now let's look at the situation if the users just HAVE to use water at a higher rate.

➢If they just can't live without seven shower heads in the shower stall, or any of the other behavior that's pretty much at odds with a "conservation ethic".

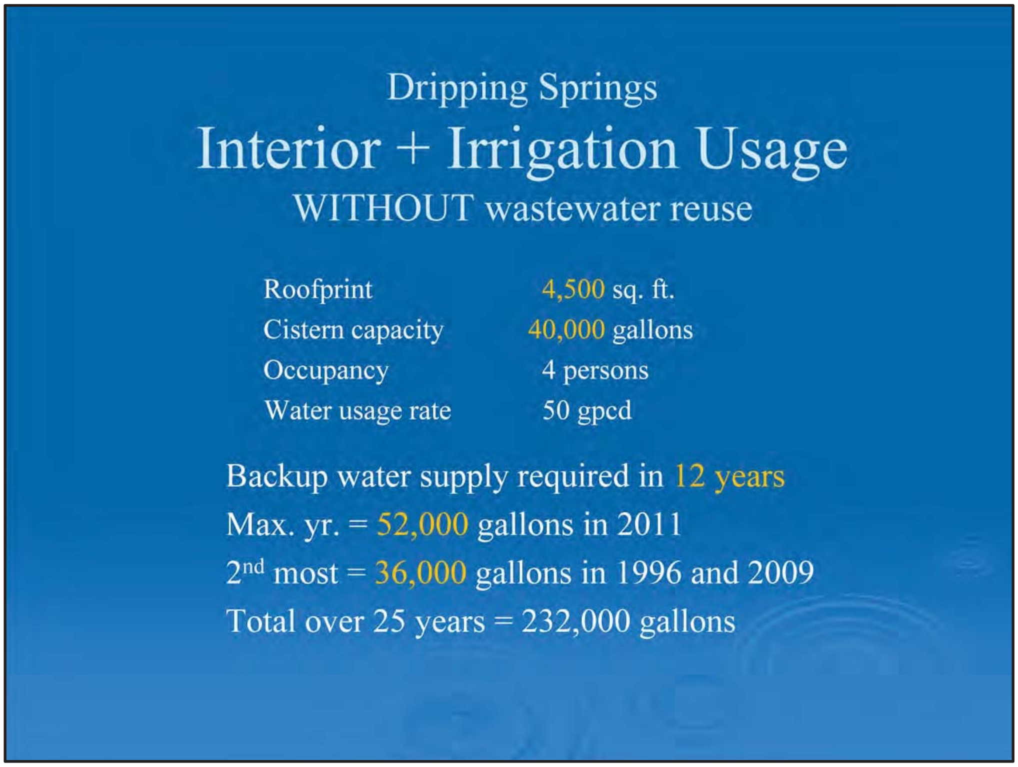
➢If they used 60 gallons a day, with the system having 4,500 sq. ft. of roofprint and a 40,000-gallon cistern that we looked at a bit ago, these would have been the consequences.

➢VERY high makeup requirements in the critical years, and some would have been required in many more years.



➢So, with water usage at this rate, to hold backup supply to a "tolerable" level, they'd have to upsize the system.

- Even with 1,500 sq. ft. more roofprint and 10,000 gallons more cistern capacity, the backup supply requirements might still be a bit high in the critical year.
- They'd have to practice better demand control during the most critical drought periods, but they'd be fine most of the time.
- The larger system would increase the cost a bunch, though, so that's their price for this rather poor demand control.

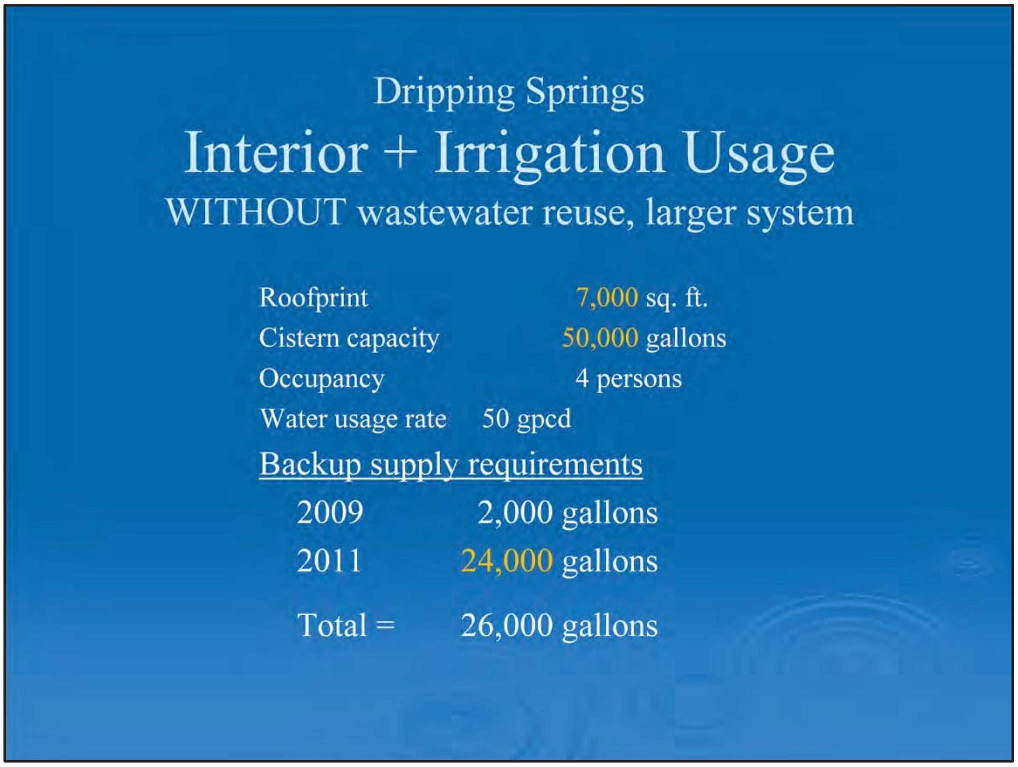


➢Now let's look at what happens if we try to also provide irrigation water.

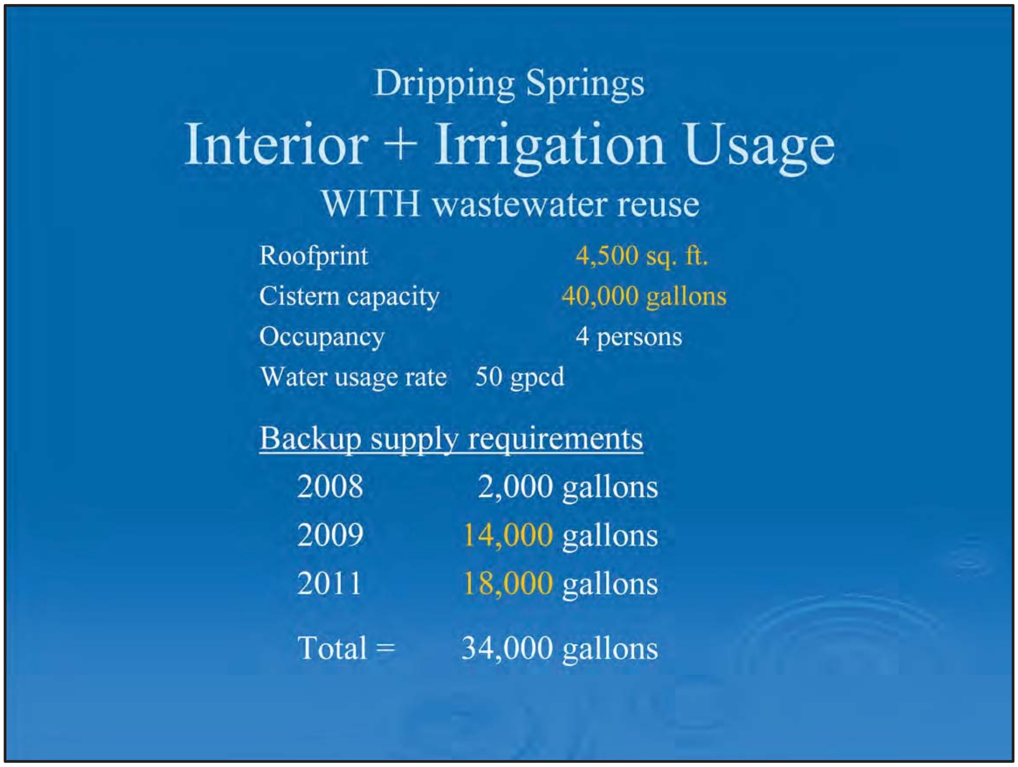
➢Here it is, WITHOUT practicing wastewater reuse.

- This is for a case with 4500 sq. ft. of roofprint and a 40,000-gallon cistern, like that case we looked at previously.
- In that case, you might recall, covering just the interior usage, we would have needed 12,000 and 14,000 gallons backup supply in the critical years of 2009 and 2011.
- But with irrigation added – WOW! Look at those backup supply requirements!

➢To get backup supply down to a "tolerable" level with this irrigation use, we'd have to have a bigger system.



- Something like this.
- But even upsizing the system by 2500 sq. ft. of roofprint and 10,000 gallons of cistern capacity, they'd still need to significantly curtail their irrigation in a year like 2011.



➢But what if we reuse the wastewater to defray irrigation?

- •As we saw when reviewing model inputs, we'd drastically reduce the amount of irrigation water drawn directly from the cistern, without running it through the house first.
- •With reuse, you see we're back down pretty close to what the backup requirements would have been to provide just interior usage alone.
- •So you'd have to ask, why pay for that larger roofprint and cistern?
- •You've got to have a wastewater system anyway, why not pay a little more for that, to get a drip irrigation field, and reuse all that water instead of just throwing it away?

➢Again, this shows that, if a rainwater harvester wants to maintain an improved landscape to beautify the lot, wastewater reuse would be VERY valuable, allowing them to do that without having to upsize their system at all.

➢Now you may be asking, can you really do this in an on-site wastewater system?

➢Absolutely!

➢Don't want to get too deep into the weeds on this, but …

- For over 20 years, I've been designing on-site systems that provide high quality treatment in a re-circulating gravel filter, and disperse the effluent in a subsurface drip irrigation field.
- I always tell the client, we're standing the problem on it's head.
- Instead of looking for some convenient place on the lot to GET RID of this water, we ask, where is the best place to USE it, where is the highest value landscaping that we want to drought-proof?

➢What we see here are drip fields that are part of that type of system.

➢Again I've been designing that system for over 20 years, it's a well established system, accepted by all the local jurisdictions, they're out there working, fairly trouble-free, requiring very little attention.

➢We CAN do this!

➢Indeed, we SHOULD do this.

➢High quality pretreatment and drip irrigation is what *should* be done all over the Hill Country.

➢That type of system is *very* environmentally friendly, pretty much blunting any pollution from wastewater management.

➢Keeping the water below ground eliminates hazards of contact with effluent.

➢And *because* it’s underground, you can have the drip field right up around the house, where the high value landscaping you want to irrigate would certainly be.

➢But more to the point for our present discussion, drip irrigation is by far the most efficient way to irrigate, so you get much more irrigation benefit from the same amount of water, again extending that hard-won rainwater supply as far as possible.

➢And by the way, when the soil is wet and you don’t need irrigation, the drip field acts like a drainfield, the water percolates “away”, just like in any “septic system” drainfield.

➢Only this water carries very little pollution along with it to “away”.

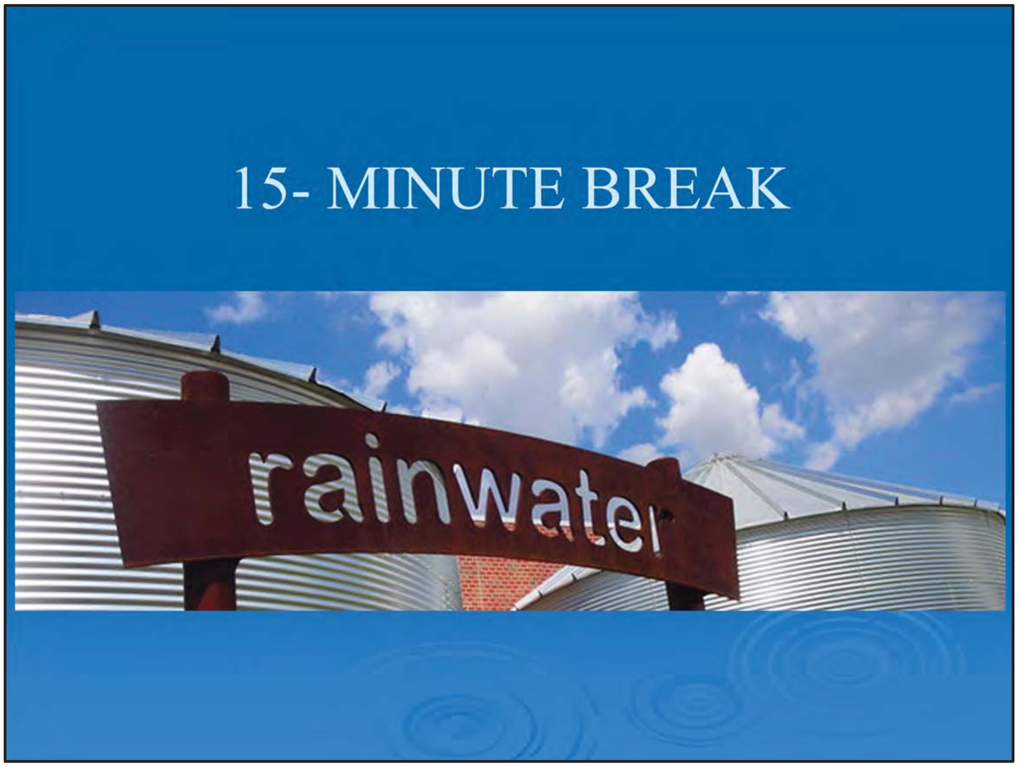
➢So the bottom line here, if we want this rainwater harvesting strategy to support irrigated landscapes, we’re well advised to revisit wastewater management policies, and perhaps *require* drip irrigation reuse on those properties.

➢This is the end of the information presentation part of the forum

➢Questions or comments, please

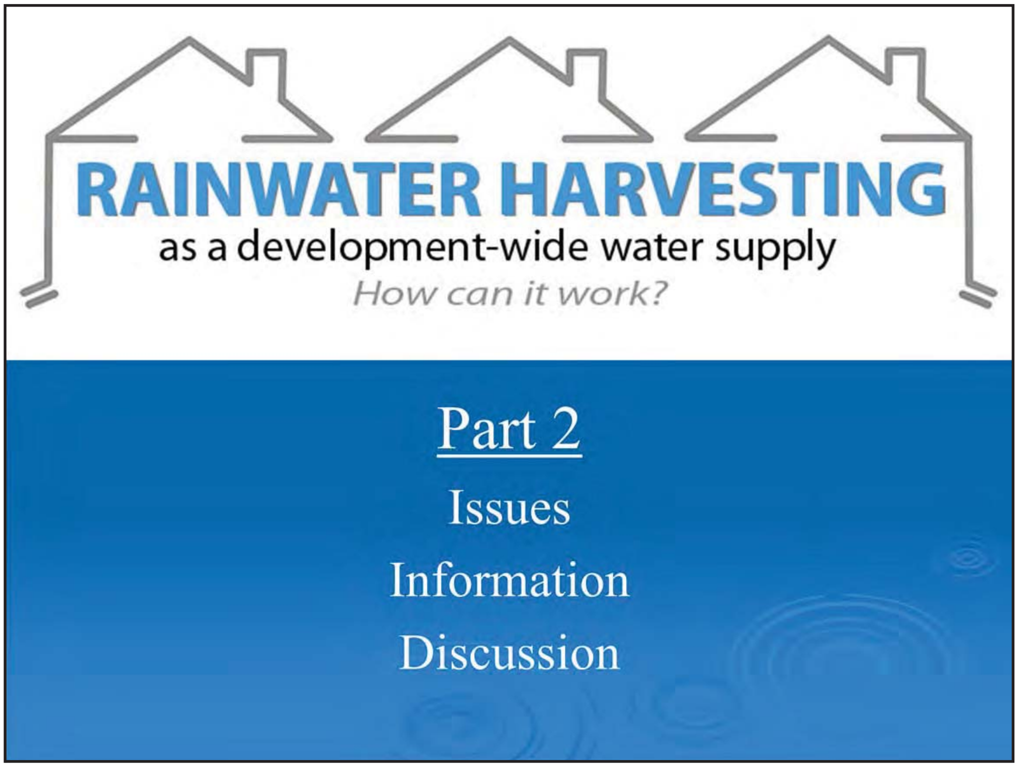
Questions and Discussion

Audience Involvement!



➢We're going to take a 15-minute BREAK

➢And then we'll get on to the part where we lay out the information we need help with to evaluate building-scale rainwater harvesting as the development-wide water supply strategy



- On to the information gathering part of our forum.
- We're going to cover the issues we need to evaluate to determine if this rainwater harvesting strategy can be practical and cost effective.
- And we request that any of you who are able to, and are interested, to help us out by providing various bits of information to help us piece this all together.
- You have in your packet forms that list the information items I'll be pointing out, that we need some help with.

➢Here on my oh-so-eloquently titled slide are the general areas we'll cover here:

- Options for the backup supply system.
- Regulation of this type of system by TCEQ, county-level governance through the platting process, and what role the Groundwater Conservation Districts might have.
- Building design issues. We'll look at how to most cost effectively provide that large roofprint, and if there's a way to makes cisterns more cost efficient by integrating them into the house construction.
- We'll look next at the cost effectiveness analysis of our rainwater harvesting strategy vs. other water supply options.
- And then I'll briefly touch on marketability and sustainability.

➢As we discuss each of the items, please mark on your forms if you can offer some assistance on that item.

➢Also please fill in your contact information, of course, so we can get in touch.

➢Please leave them on the table where you signed in when you leave.

➢We really, really appreciate any assistance you can offer.

- Okay, our first topic is how we’d get backup supply to the houses.
- We’ve identified some options, but we’d like to hear if you can think of any others.

➢Here's what we came up with:

- Drill a well on the development and feed water from it to the cisterns at each house through a "minimal" distribution system.
- Drill a well on the development and distribute the water with a tanker truck.
- Connect to a public water system and install a conventional distribution system in the development.
- AND
- Tanker trucks that get water from a public water supply system that would sell to water haulers.

➢ Let's go through these options, and at the end I'll throw it open to questions, comments, and any other suggestions.

➢The first option is a community well on the project, and what I term a "minimal" distribution system. We'll look at what "minimal" might mean in minute.

➢But no matter how "minimal" it is, the distribution system would cost money.

- So I'm guessing the developer wouldn't be too excited about this option unless the houses were pretty close together.
- But in the Hill Country, many oppose dense development, and that's somewhat enforced by requirements for large lot sizes.
- And that would space out the houses, and drive up the cost of a distribution system.
- Remember though, from the video, that "conservation developments" are a desirable development pattern in the Hill Country – the houses clustered close together, with contiguous open space around the clusters.
- So the overall density would remain low, but the houses would be close together.
- In that sort of development, maybe this option might be deemed "affordable".

➢Now the first question about using groundwater for backup – is it available?

- In a legal sense that is.
- Of course you wouldn't even *consider* this strategy if there *literally* wasn't any good water under your land.

- •So, what level of availability would you have to demonstrate when you plat the project?
- •Remember, as long as the rainwater systems were "right-sized", groundwater use would be pretty low, and much of the time it wouldn't be used at all.
- •But if the people can get water through the pipe anytime they want it, what controls would you have to put in place to be sure they're not using "too much" groundwater.

➢So, there's some institutional issues to work through here.

➢Now, what is the "right size" for that "minimal" distribution system?

- •When you need backup supply, the system could be run 24/7 if that's what's needed.
- •So the flow rate could be pretty low.
- •We can figure out what that 24/7 rate would have to be for any number of houses fed from one well, and then increase that to – what? What would the decision-makers decide is "right"?

➢I'll take a guess that we're talking about 2-inch lines, so how "minimal" of a cost are we talking about?

➢We need help with cost estimates for those waterlines.

- •And also for the well, storage tank, pressurization unit.
- •We need to know what operations and maintenance there'd be if this system only flows every so often.
- •And what would that O&M cost?
- •So any engineers who can help us with those costs, we need you.
- •Please mark on your forms the cost items you can help us with.

➢We also need to figure out the regulatory status of this system.

➢Would a "minimal" system even be allowable?

- •The TCEQ regulations for waterlines all presume the distribution is the one and only full time source of water, so they require things like minimum capacity requirements, that simply wouldn't apply in this case.
- •So what would TCEQ require here?

➢We also have some questions on whether this would even meet the definition of a "public water supply system", which is currently being addressed.

➢I'll just pose the question: Is there a basis for any TCEQ regulation?

➢If so, what would be the interconnect requirements?

➢We're hoping that TCEQ can give us some guidance here.

➢The second option is to drill a community well on the development, and provide the backup supply with a tanker truck.

- Because the well is right on the development, you could run many trips per day.
- So it wouldn't suffer the capacity problems that we'll see for the other tanker truck option here in a minute.

➢Here again, we have the same questions about water availability as the last option.

➢Also again, what would be the cost of the well and storage tank?

➢Any special maintenance protocol if the well only runs every few years?

➢What does a tanker truck cost?

➢Could this development lease one only when they needed it?

➢What are the operations and maintenance costs of the tanker truck?

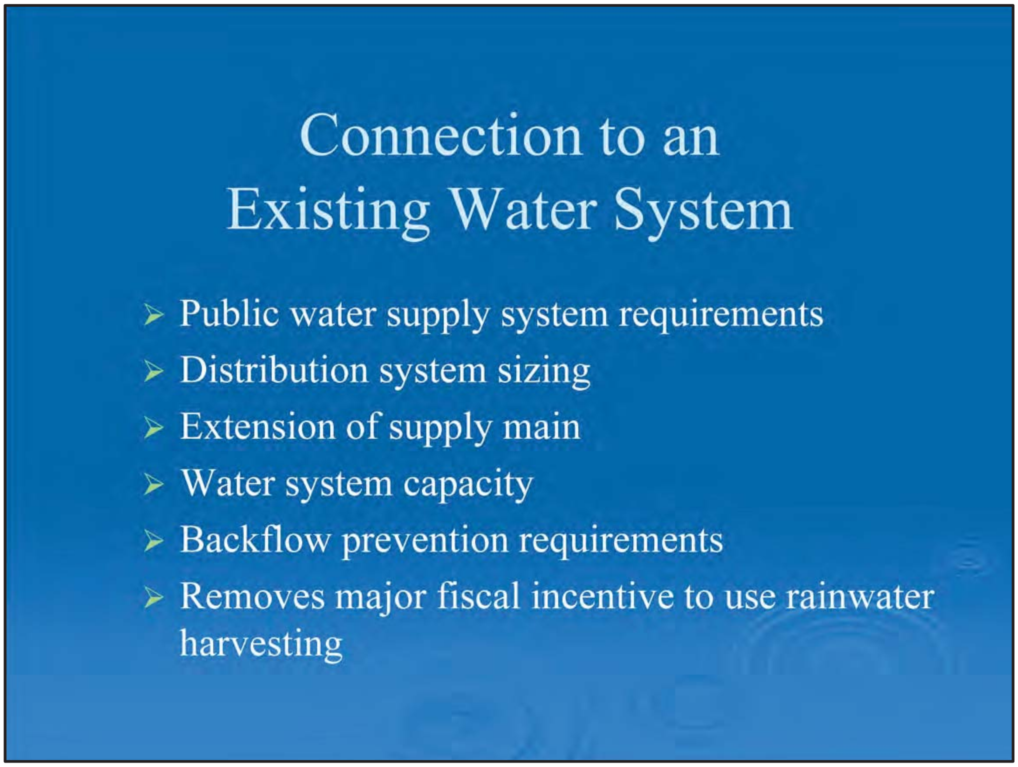
➢What uses could be made of the tanker truck when it's *not* used for backup supply in this development?

➢Remember, we expect it to be needed only for a few months every few years.

➢Again, please mark your forms if you can help us with any of these questions and costs.

➢Also, here again, what is the regulatory status of the well?

➢And of the trucking operation?



➢The third option is to connect to a public water supply system and install a distribution system in the development.

- Now this would most definitely meet the definition of a "public water supply system".
- So would it have to be full sized, like if it was the only water supply, or could it be smaller?

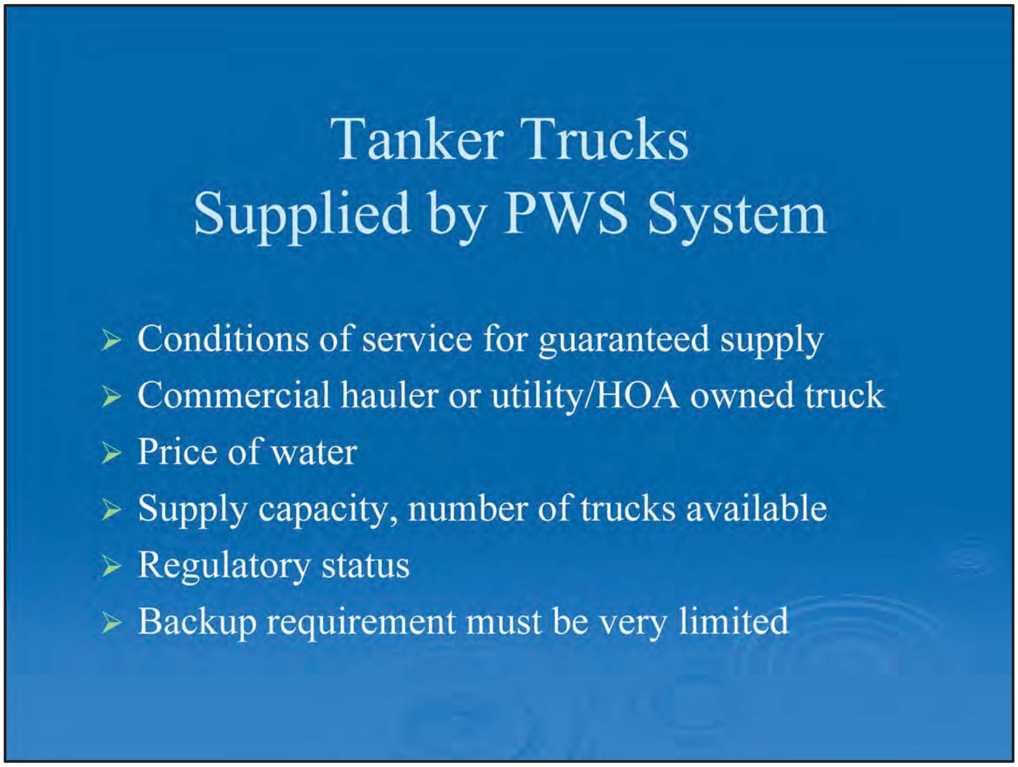
➢You'd probably also need to extend a water main to get water to the development, because if it was already right there, would the developer even consider the RWH strategy?

➢Of course, the water system would have to be able to increase their pumpage to cover this supply.

- Again that raises questions about how much water this development would draw, and how that could be controlled once the connection is made.
- And the interconnect requirements need to be defined.
- Legislation passed in the last session has TCEQ already working on that part of the regulatory puzzle.

➢But perhaps the biggest question about this backup supply strategy is again, why would the developer consider it?

- If he has to install the water main and waterlines up front of being able to sell any houses, this removes a major incentive for considering the RWH strategy to begin with.



➢So we come to the same method that most current rainwater harvesters use for backup supply.

➢Tanker trucks that get water from a public water supply system and deliver it to each home.

- As I said earlier, this is the method we expect most developments would choose, because the developer doesn't have to install anything, and it – maybe – has no regulatory issues.
- I say maybe, because we're talking here about a water supply SYSTEM. If that's declared when the development is platted, we guess there will be some arrangement to ASSURE backup supply when it's needed.
- So how formalized does it need to be?
- What's it going to cost to set it up?

➢Now, could the homeowners get a contract with a water hauler that would guarantee delivery?

➢If so, what would that guarantee cost?

➢What would it make sense for the homeowners to buy their own truck?

➢Who would operate it? Under what conditions? What would that cost?

➢Where are the water sources that will sell to water haulers?

➢How long would the haul be to this development? How many trips could a truck make in a day?

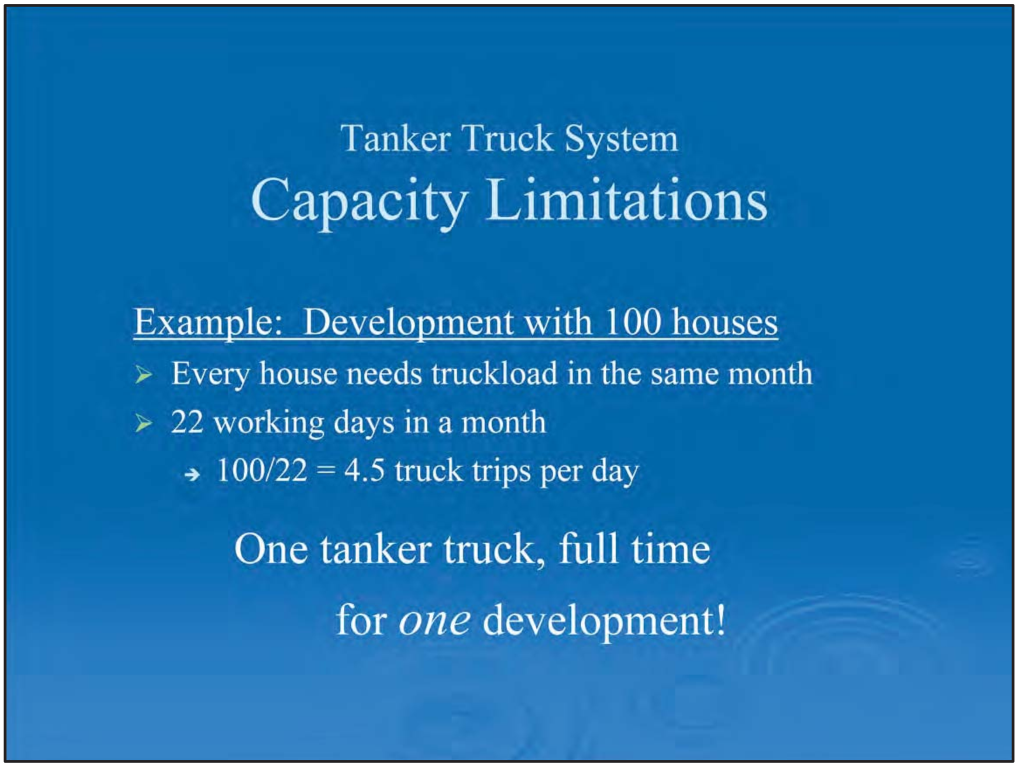
➢How big the tanker truck fleet operating in around where this development is?

➢How fast could that fleet be expanded?

➢What would be the regulatory status if this operation was formalized, rather than operating on a call-up-at-need basis like it is now?

➢Again, we're looking forward to getting' in to this with TCEQ.

➢Finally, I expect this strategy would absolutely REQUIRE you to hold backup supply to pretty low levels.



➢Here's why.

➢Presume we have a development with 100 houses.

➢And assume every house needed a truckload of water in a month.

➢Remember, that's what the modeling shows we'd need in the critical periods.

➢So that would require 100 truck trips in that month.

➢Assuming there are 22 working days in a month, that would be 4.5 truck trips a day.

➢Unless travel time is very long, 4 to 5 truck trips a day should be feasible.

➢At that rate, you'd have to have a truck you can pretty much *dedicate* to this ONE development whenever we got into a critical drought period.

➢So if we had a lot of developments on rainwater, we'd need a lot of trucks.

➢And would these trucks be stranded assets, sitting idle for perhaps years, then needed for a short time, then idle again?

➢Or would there be other uses for these trucks when they aren't needed for backup supply?

➢Now, maybe we could increase the capacity we get out of each truck.

➢The modeling results show that, with our "right-sized" systems, the "capacity crunch" only occurs every few years, and would only last a few months.

➢So perhaps we could expand the service hours, and get more trips per day from each truck.

➢Anyway, this shows how critical it is to "right-size" all the rainwater systems.

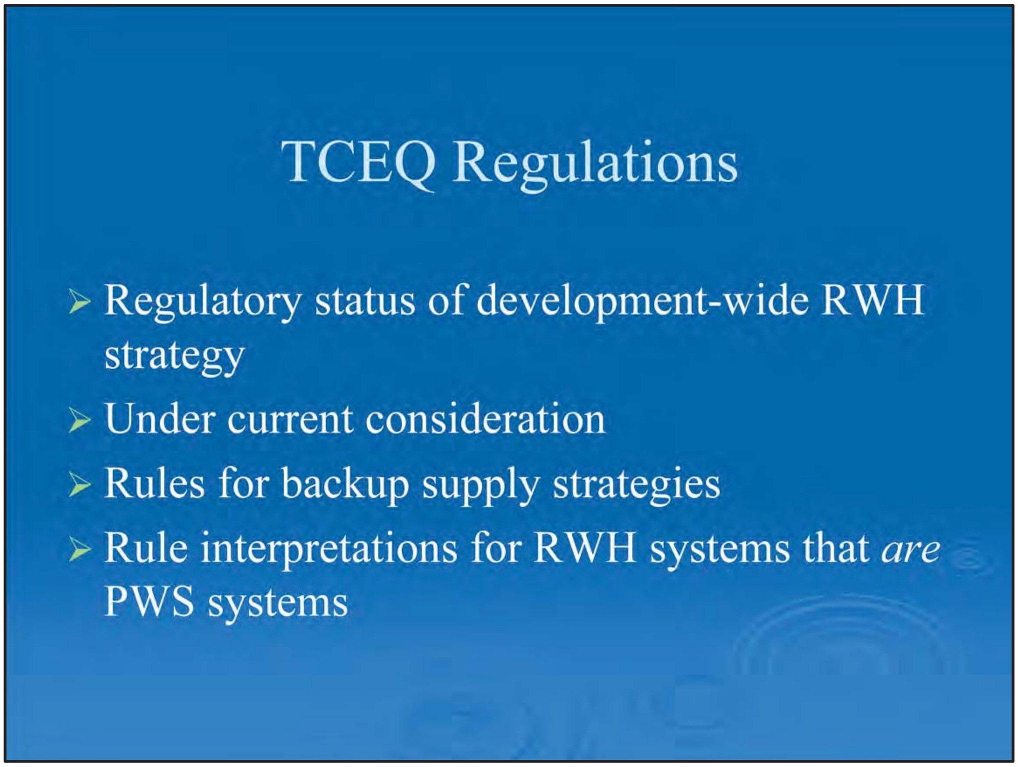
➢Of course, if we size the rainwater systems for 50 gallons per person per day, but use water like Keenan and his family did, the whole problem would become rather insignificant.

➢And with that, any questions or comments on that subject, or does anyone have any options to suggest that we haven't considered yet?

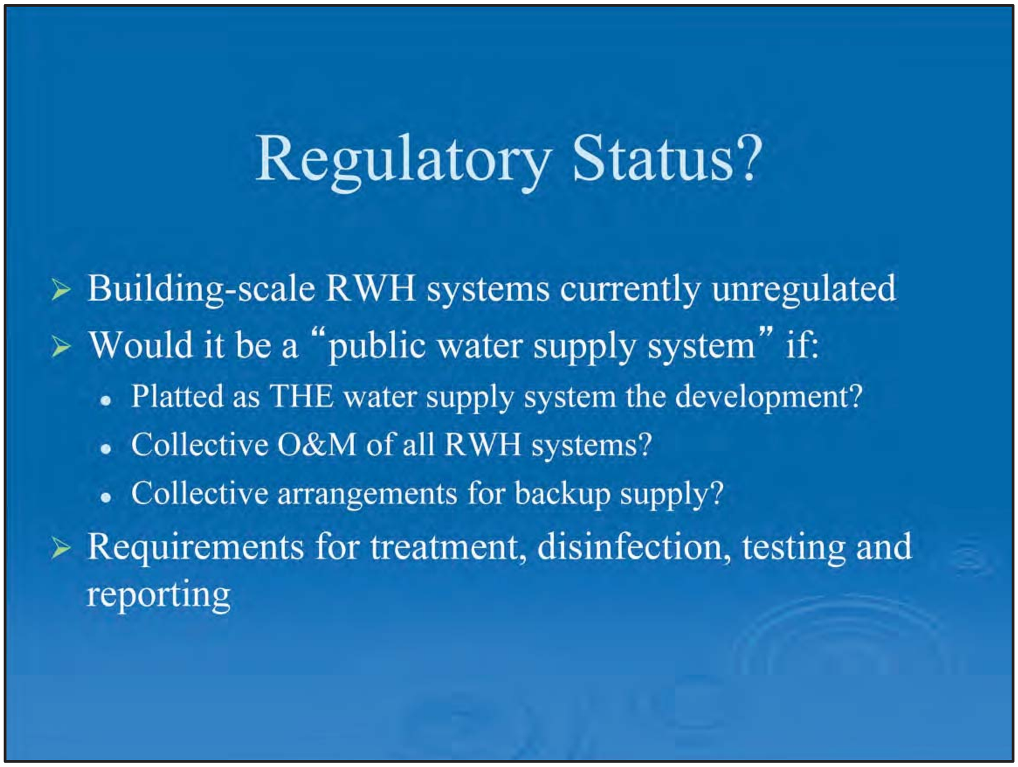
Questions & Discussion on Backup Supply Systems

➢I raised some questions about the regulatory status of the backup supply strategies.

➢This leads us to regulation and governance of the RWH strategy.



- Turning first to TCEQ regulation, here's some issues to be resolved:
  - There's questions about the regulatory status of the RWH systems under our development-wide strategy?
  - Are there any rules under consideration that might change that status?
  - I already noted questions about how rules apply to the backup supply systems.
  - And there are questions about interpretation of rules for RWH systems that ARE "public water supply system".



➢Here's the questions we've asked TCEQ about the regulatory status of the building-scale RWH systems.

➢Right now, all of these systems are being done by one user at a time, totally on their own with *no* regulations.

➢It's pretty much a caveat emptor situation.

➢They're on a similar basis as a private well.

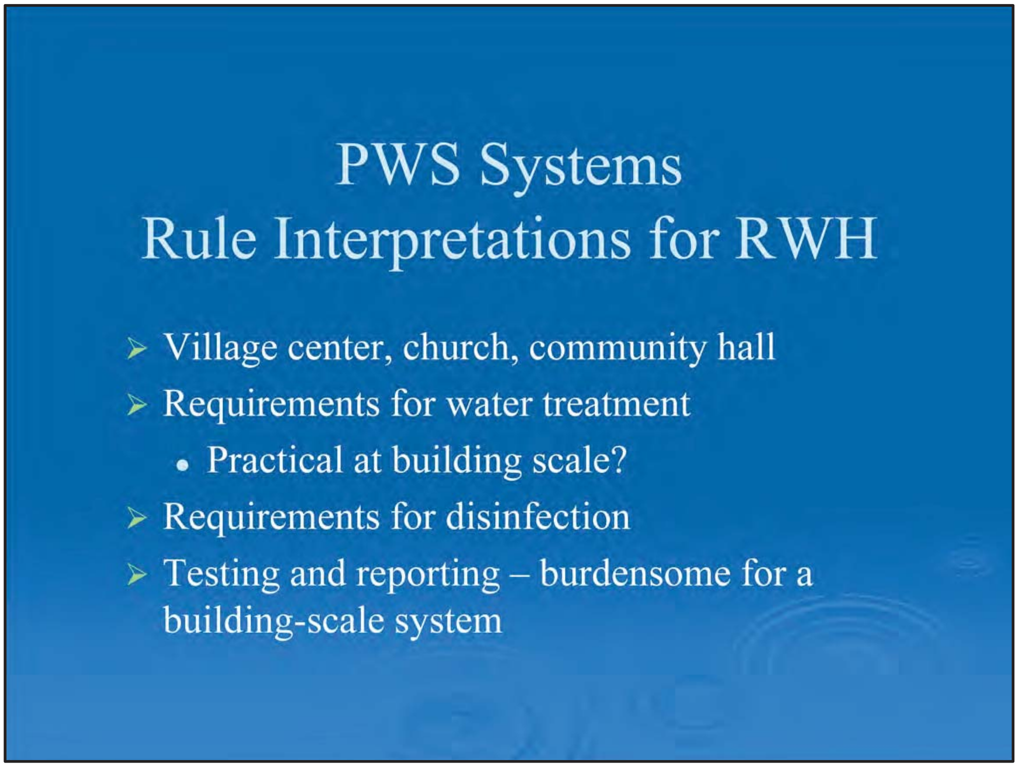
➢So, if a collection of these rainwater harvesting systems are understood to be THE development-wide water supply SYSTEM, would that change TCEQ's view of what regulations apply?

- Would just declaring that in the platting process trigger a change in status?
- Would it change if collective arrangements were made for operations and maintenance of all the rainwater systems in the development?
- If collective arrangements were made to secure an assured backup supply?

➢Would any of this cause them to be classified as a "public water supply system"?

➢If so, what would be required:

- For water treatment?
- For disinfection?
- For water testing?



➢Then we have the case of RWH systems that *are* unequivocally "public water supply systems".

➢Examples are a village center, or churches, or community centers.

➢We need to know what the options are for water treatment.

- •TCEQ classifies roof-harvested rainwater as "surface water".
- •And so it appears they expect it to be treated in a full-blown "surface water" treatment plant.
- •That would be clearly out of the question for a building-scale system.
- •You couldn't afford to build it or to operate it at that scale.

➢TCEQ has also indicated they see chlorination as the *only* option for disinfection.

- •You could do that at the building-scale, but many would question why you would intentionally poison a perfectly good water supply like that.

➢Most rainwater harvesters use a cartridge filtration system and UV disinfection unit.

➢Would those be allowed?

➢Discussions with EPA indicate it's their view the federal regulations DO allow them.

➢And finally, what would the testing and reporting requirements be for these systems?

➢Would they be affordable at the building-scale?

➢Clearly, we need to resolve these matters.

➢We'll continue to pursue these issues with TCEQ.

➢Anyone who wants to be proactive in helping us to address all this, please note that on your information forms.

➢Okay, moving on to questions and issues about county-level governance.

➢I have to wonder, if you ask the commissioners court to "bless" rainwater harvesting as your development-wide water system, that is, approve a plat that says that, what would they require?

➢It's one thing if an individual goes out and decides on their own to do rainwater harvesting instead of drilling a well.

➢Everyone is saying, okay, we don't need to do anything about that, we can let them take care of themselves.

➢As I said, it's like a private well.

➢But, if it's formally declared that rainwater systems at every house in the development collectively constitute the water supply SYSTEM for that development, what then?

➢The buyers in the development might need to assured this SYSTEM would provide a safe and secure water supply for the life of the project.

➢Just like they do for other water supply options.

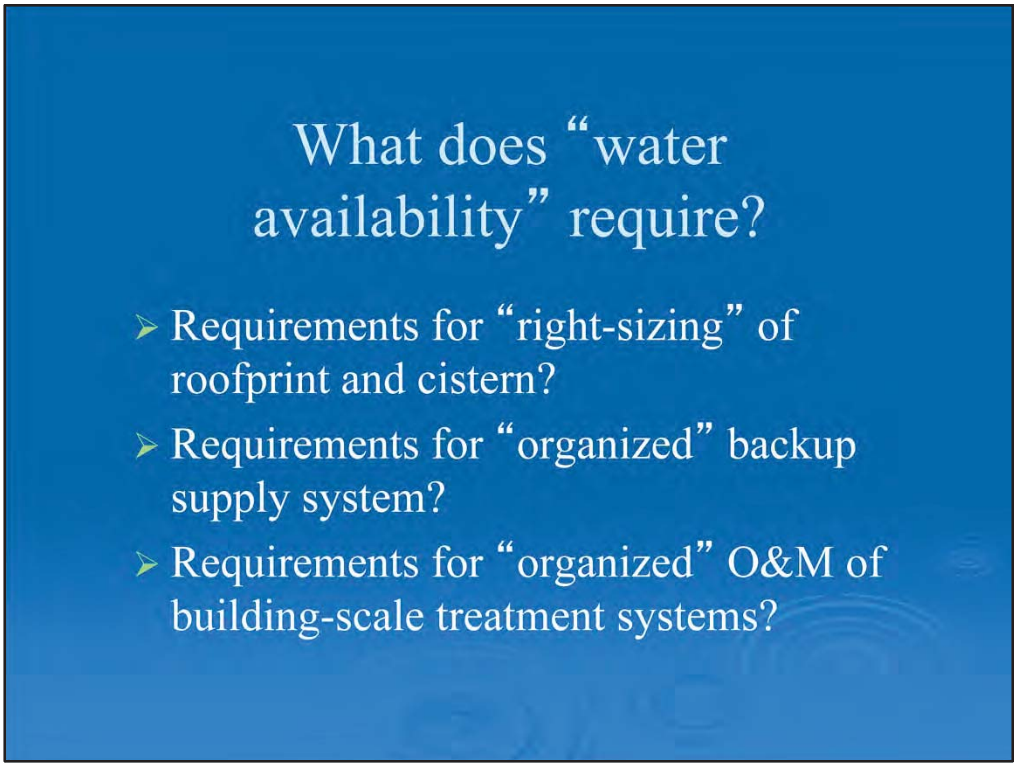
➢What this gets down to is what it takes to demonstrate "water availability" for this strategy.

➢And what about water treatment?

➢Should there be uniform standards for treatment units, or should this continue to be a caveat emptor thing?

➢Should there be some arrangement to assure professional oversight?

➢And should there be some standards for backup supply, to assure it's available when needed?



➢About "water availability", many of the county platting rules require the developer to demonstrate that there is an "adequate" potable water supply being made available to the lot buyers.

➢Well, in the case of these rainwater systems, what will determine "water availability" is the "right-sizing" of the cistern and roofprint, along with a backup supply system that can deal with what "right-sizing" imposes on it.

- So, would the commissioners court make rules that define what "right-size" is.
- Or would it require the developer to present standards for what the "right size" is?
- And how they'd assure all the builders conformed to those standards?

➢Would they require arrangements for backup supply to be defined and formalized, or would they consider it okay to let every homeowner take care of this on their own?

➢And as for assuring the water supply is potable, would they require the developer to define how the treatment units would be maintained.

➢I've communicated with representatives of a few county governments about all this.

➢To sum it up, it appears that little of this has really been thought through, because there aren't any developers coming to them and asking for plat approval with this water supply strategy.

➢So we have the classic chicken-or-egg problem here.

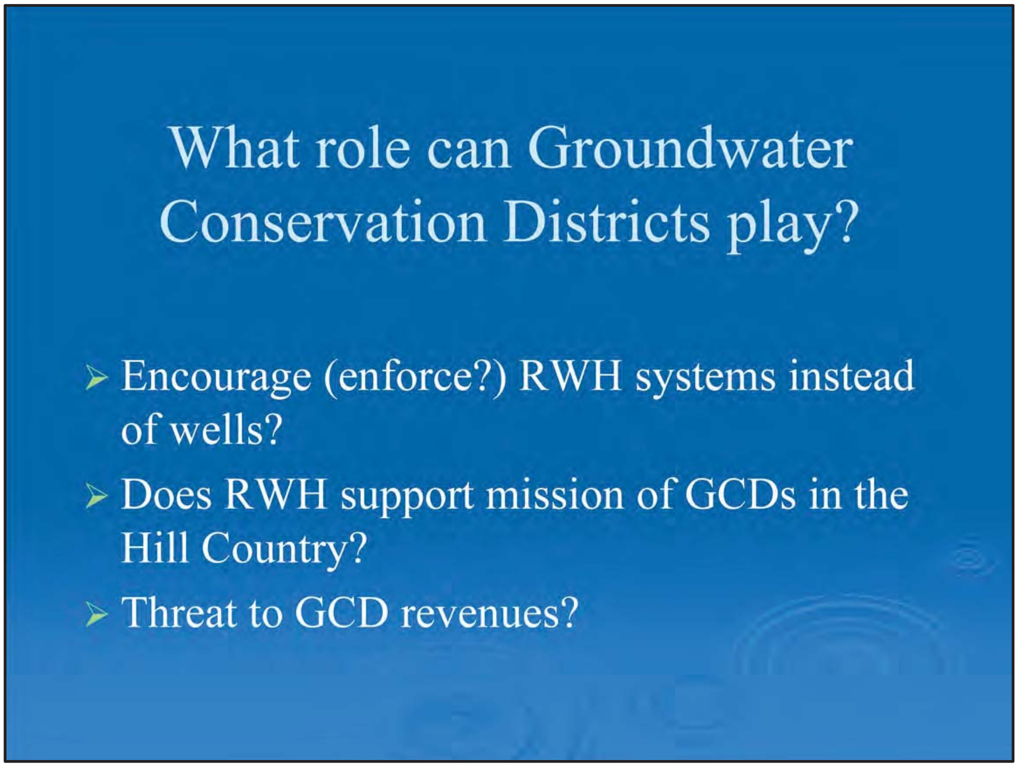
➢We really can't expect a developer to commit to this strategy unless they knew the answers to all these questions.

➢We'll continue to communicate with the county governments and learn how they view all this.

➢We're asking all county government employees to take these questions to commissioners in your county and see what clarity we can arrive at.

➢We'd be happy to come discuss this with them at their convenience.

➢Anyone who wants to be proactive in helping us with this, please note that on your information forms.



- Moving on to the Groundwater Conservation Districts.
- Do the GCDs have a role to play in the RWH strategy?
- Could they encourage developers to do that instead of drilling wells?
- Would this support and augment their groundwater mission?
- Again, in many areas of the Hill Country, aquifers are under stress, and the RWH strategy could circumvent further stress by future development.
- But then, since some of these districts are funded by well or pumpage fees, this strategy might also be seen as threatening their revenue stream.
- We're going to be discussing these matters with some of the GCDs in our Hill Country focus area.
- If you're with a GCD, or have an interest in their operations, please mark on your information form if you can help with this.
- Questions, comments, suggestions on regulation and governance

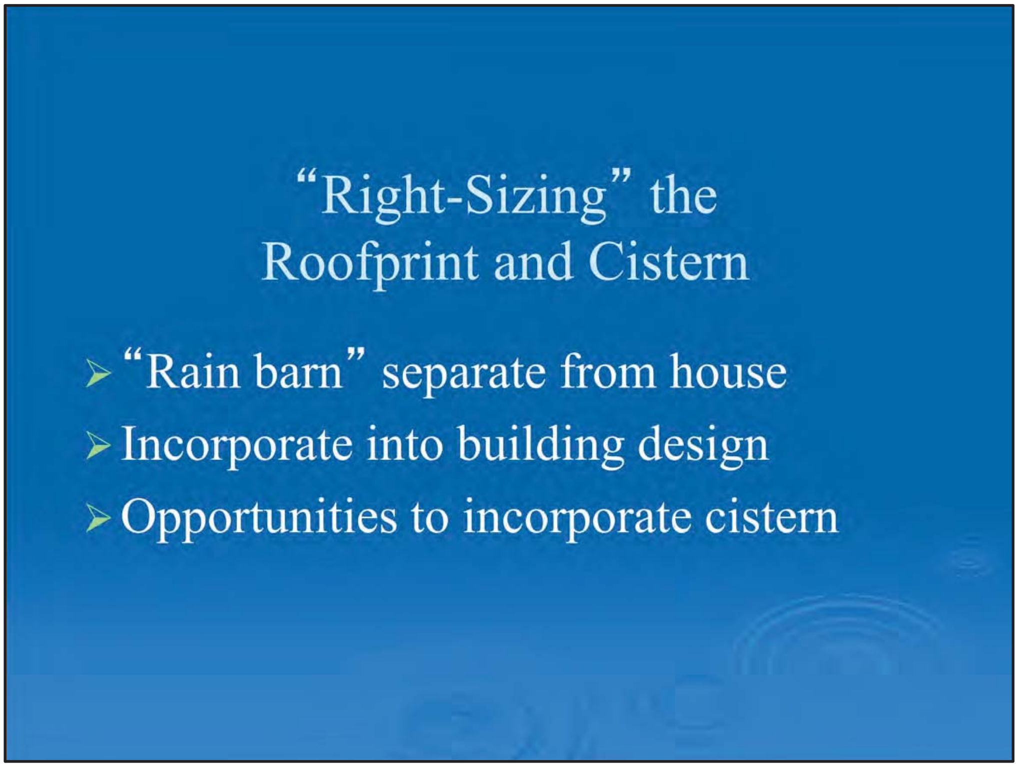
Questions & Discussion on Regulation and Governance

- Now we’re going to shift gears and talk about building design issues.
- The modeling results tell us the “right sized” roofprint is larger than we’d have in most 3 or 4 bedroom houses.
- So we need to see how we can most cost efficiently provide those “right-sized” roofprints.

"RIGHT-SIZED" RWH FACILITIES AT EACH MODELING LOCATION

Modeling Location	2-Person Occupancy Roofprint (sq. ft.)	2-Person Occupancy Cistern Size (gallons)	4-Person Occupancy Roofprint (sq. ft.)	4-Person Occupancy Cistern Size (gallons)
Austin	2,500	15,000	4,500	35,000
Blanco	2,500	15,000	4,500	35,000
Boerne	2,500	15,000	4,500	35,000
Burnet	2,500	15,000	4,500	30,000
Dripping Springs	2,500	15,000	4,500	35,000
Fredericksburg	3,000	20,000	5,000	40,000
Menard	3,000	20,000	5,500	40,000
San Marcos	2,500	15,000	4,500	30,000
Wimberley	2,500	15,000	4,500	30,000

- Here's what the modeling indicates are the minimum sizes we'd need.
- Looks like 2500 sq. ft. for a 2-person occupancy for the most part, running to 3,000 sq. ft. when we get further out onto the Edwards Plateau.
- This is probably going to be okay with a 2-person occupancy.
    - In a project being planned for the seniors market near Dripping Springs, the developers are looking at house designs that *would* provide around 3,000 sq. ft.
    - An architect I've discussed this with also thought that 2500 sq. ft. might be just right for this sort of housing.
- Now looking at the roofprint for a 4-person occupancy, looks like 4500 sq. ft., going up to 5,000 or 5500 further out onto the Edwards Plateau.
- That will require us to figure out how to add some "extra" roofprint.
- And it looks like we'd need 30, 35 thousand gallons of cistern with that 4500 sq. ft. of roofprint.



- So what would be the best, the most cost efficient way to do that?
- Well, there's always the option of putting up what's been called a "rain barn", a free-standing roof, perhaps a pole-barn, that's constructed specifically to create the roofprint.
- But a "rain barn" creates extra cost that doesn't give us much benefit, besides just the roofprint.
- I suggest a better idea would be to integrate that extra roofprint into the house design.
- And perhaps the cistern too, instead of free-standing tanks apart from the house.

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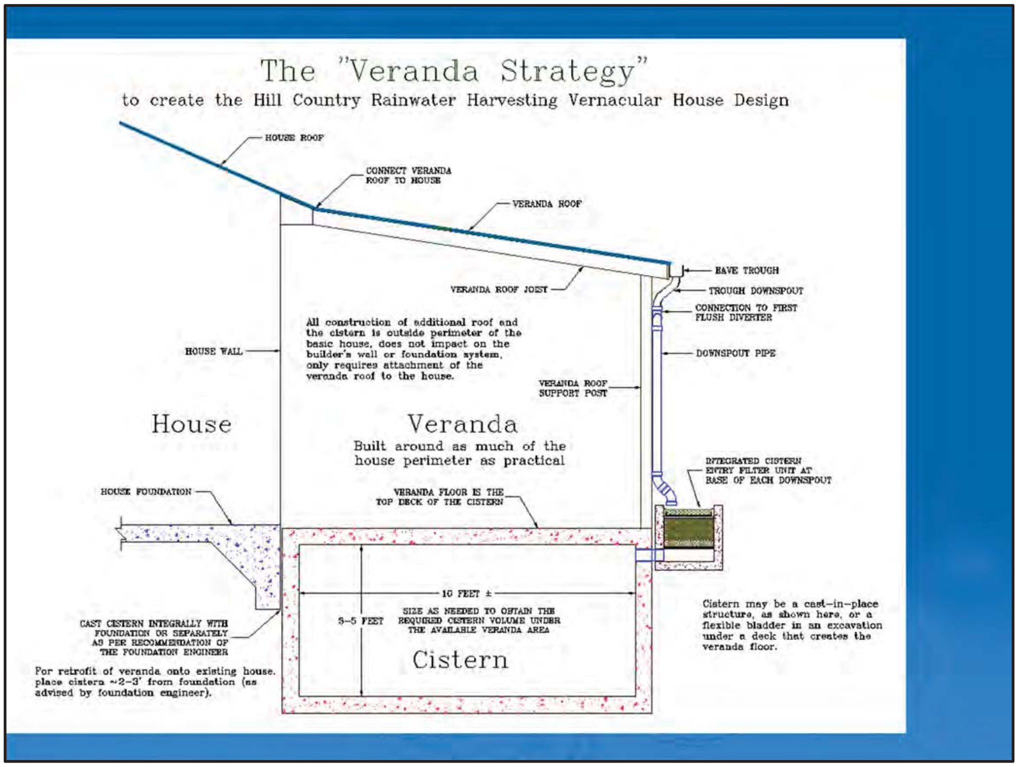

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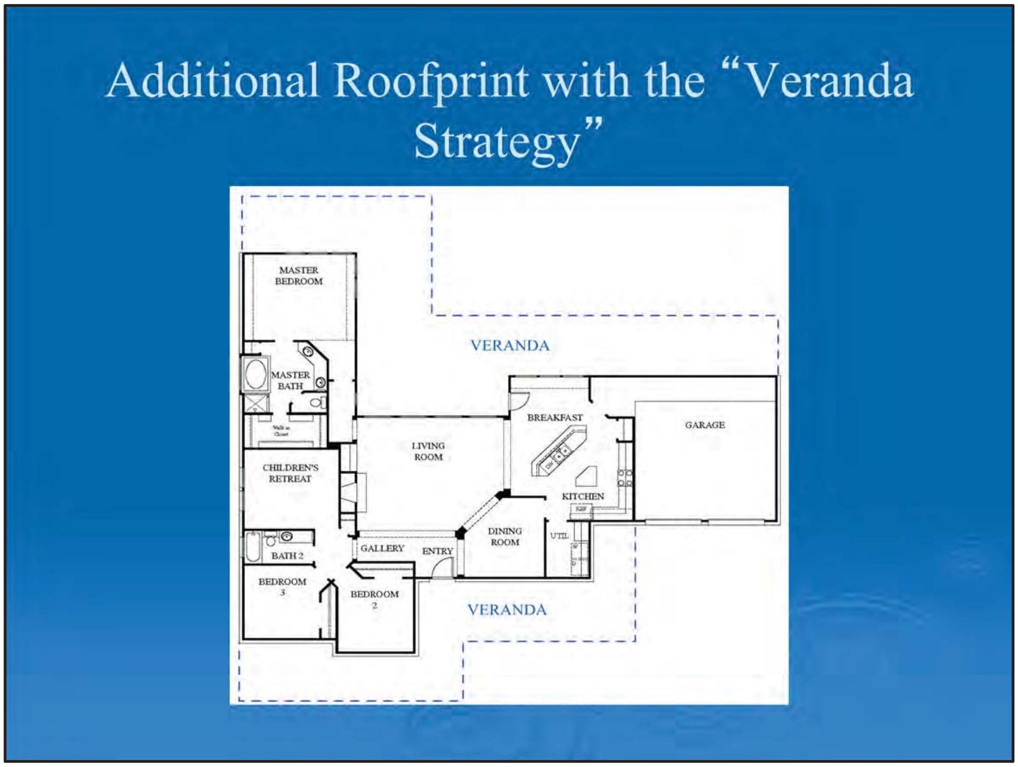


➢Okay, so how realistic is to get 4500 sq. ft. of roofprint with typically-sized 3 or 4 bedroom home?

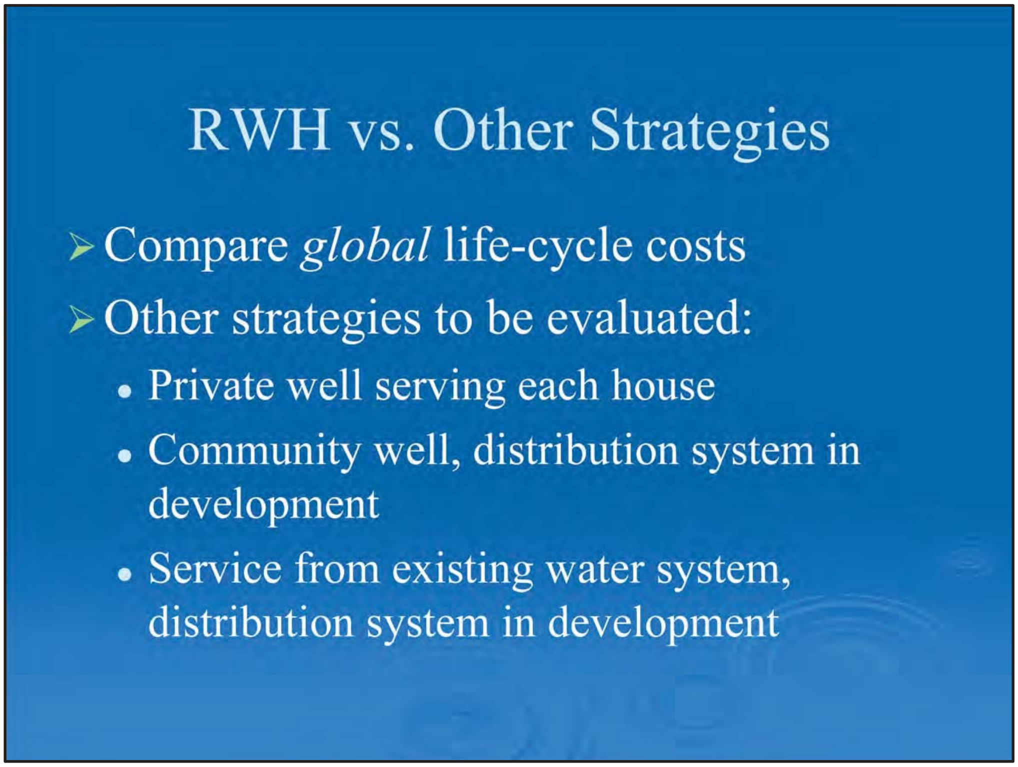
➢I've reviewed standard plans of a few homebuilders who've been active in the Hill Country, and sketched on veranda areas where it seemed they might fit, like we see here.

➢And I've concluded that we *could* get the roofprint we need.

- So we need to think that, if we were to design the house from the very beginning around this idea, we could get our required roofprint, in better designs, more cost efficiently.
- We could come up with a "Hill Country rainwater harvesting vernacular" house design concept.
- I've spoken to a few architects about this, and they've agreed this could be a business opportunity.
- I've also spoken to some folks about creating a design competition for architecture students.
- Or perhaps a design studio project.
- We'll continue to pursue these ideas.
- If you have an interest in helping us with building design issues, please mark that on your information form.

Questions & Discussion
on
Building Design Issues

Our next topic is determining if this rainwater harvesting strategy is cost effective relative to the other water supply options.



➢We need to consider costs on a global basis, capturing all the costs, and we need to look at life-cycle costs, not just the capital costs, so we can see what would be the better investment for society.

➢Here are the other water supply options we're going to evaluate:

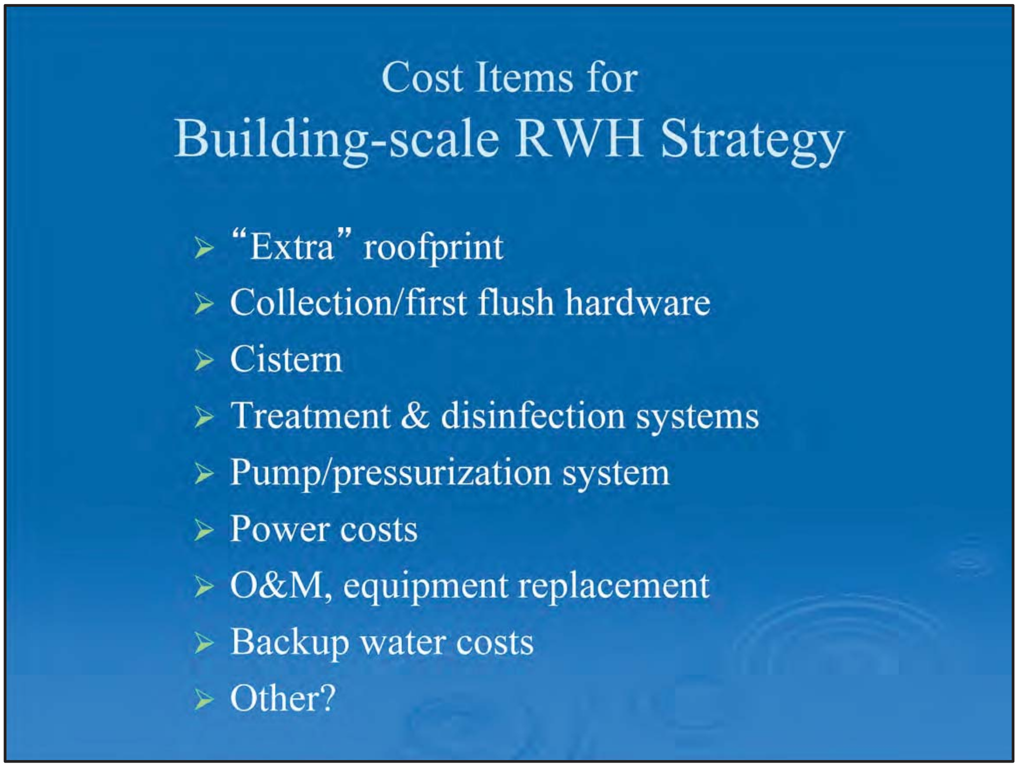
- A private well on each lot.
- A community well and distribution system in the development.
- And, getting service from an existing public water supply system and installing a distribution system in the development.

➢As we go through the cost factors for each of the water supply options, please mark on your information form any of those costs that you can help us with.

➢But also, obviously we'd get the most meaningful cost comparison if we could evaluate these options in context, in a real situation.

➢So, any developers out there who can offer up a project that we could hang these costs on, we'd LOVE to hear from you. Please mark that on your information form, or just talk to us after we break up.

➢Or if you know any developers, or about any developments, that might be a candidate for this, please let us know.



➢So, with that, here’s my list of the cost factors we need for the rainwater harvesting strategy:

➢READ OFF ITEMS

➢Can anyone suggest anything I’ve missed?

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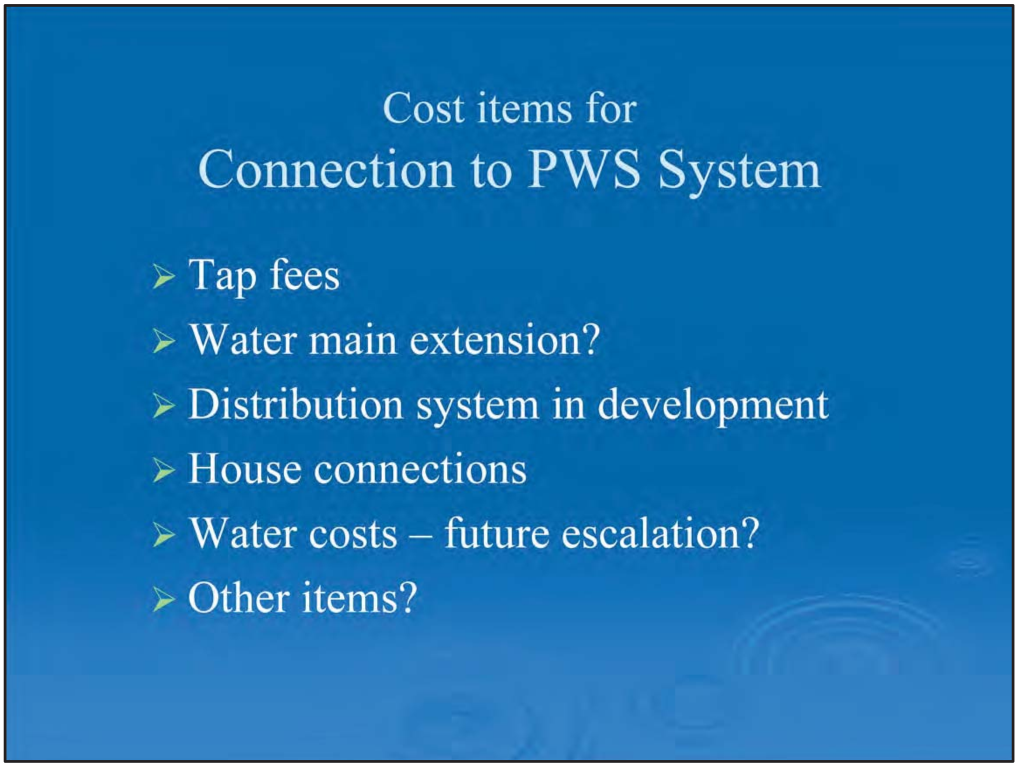
➢READ OFF ITEMS

➢Can anyone suggest anything I’ve missed?

➢Next, here's the cost items for a community well on the development and waterlines to each of the houses:

➢READ OFF ITEMS

➢Have I missed anything on this one?



➢And finally, the cost items for tapping into an existing public water supply system

➢READ OFF ITEMS

➢Missing anything?

➢Okay, thanks for helping us review the cost items.

➢Again, if you can help us obtain estimates for any of these items, please mark that on you information form.

- Moving on now to marketability.
- As we see it, that’s going to hinge on all the stuff we’ve just discussed.

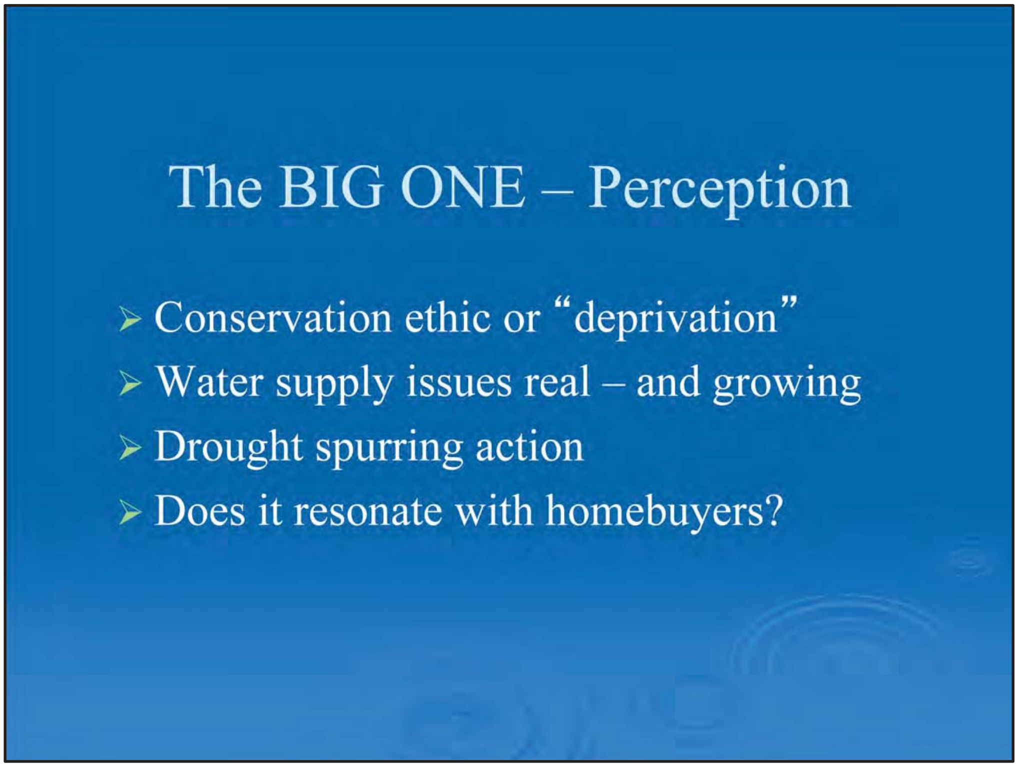
➢The backup supply system. You're probably going to ASSURE a backup supply, if you want this concept to be marketable to a broad population. That's probably going to be a issue for the lenders too.

➢As we've just gone through, you're going to need house designs that are "friendly" to rainwater harvesting, so they're attractive and you get value from that extra roofprint.

➢And the developers, the builders, the finance people, and the buyers are going want regulatory clarity.

➢Of course, the rainwater harvesting option has to be cost effective. We've discussed how the developer would avoid up front costs, so it seems like a good deal for him, but we also have to look at it from the viewpoint of the builder, and ultimately, the homebuyer.

➢And then, the financers are going to have to be on board – ready, willing and able to lend for homes using rainwater systems for water supply.



➢But also, there's the BIG ONE – "perception". I pointed out the value of a "conservation ethic", but to some it might look like "deprivation" if you can't be totally unconscious about your water use habits.

- •Now this concept IS going to be hard to sell to a segment of the population.
- •Question is, just how large a segment.
- •The water supply problems facing this region are real and growing.
- •People around here have been hit with the conservation message a lot recently, because of the droughts.
- •We've got the stark visual of the lakes.
- •So will the "conservation ethic" resonate with a big enough slice of the market that this perception thing won't be too big of a barrier, won't keep developers from going for the rainwater harvesting strategy?

➢And then of course, there's the "what else" category. I'm sure there's issues that we haven't listed.

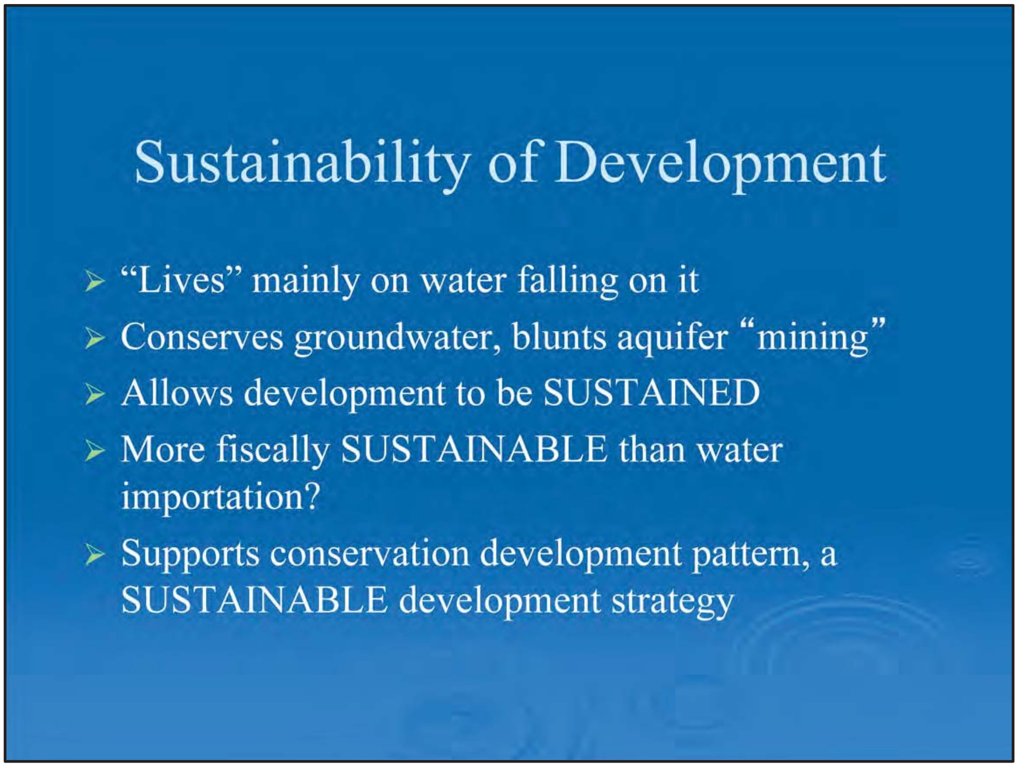
➢One we know of is fire insurance, an issue that I didn't know where to put, and that we don't currently have a handle on.

➢So we're going to be seeking out developers and builders to get their perspectives on all this.

➢So if you are one, or if you know of one who might work with us, please note that on your information form.

➢Or any sustainable development advocates, if you see rainwater harvesting as a step in that direction, and you got ideas on how to market sustainability, we'd like to hear from you too.

- The final item we'll discuss *is* sustainability.
- As we see it, sustainability has two major aspects.



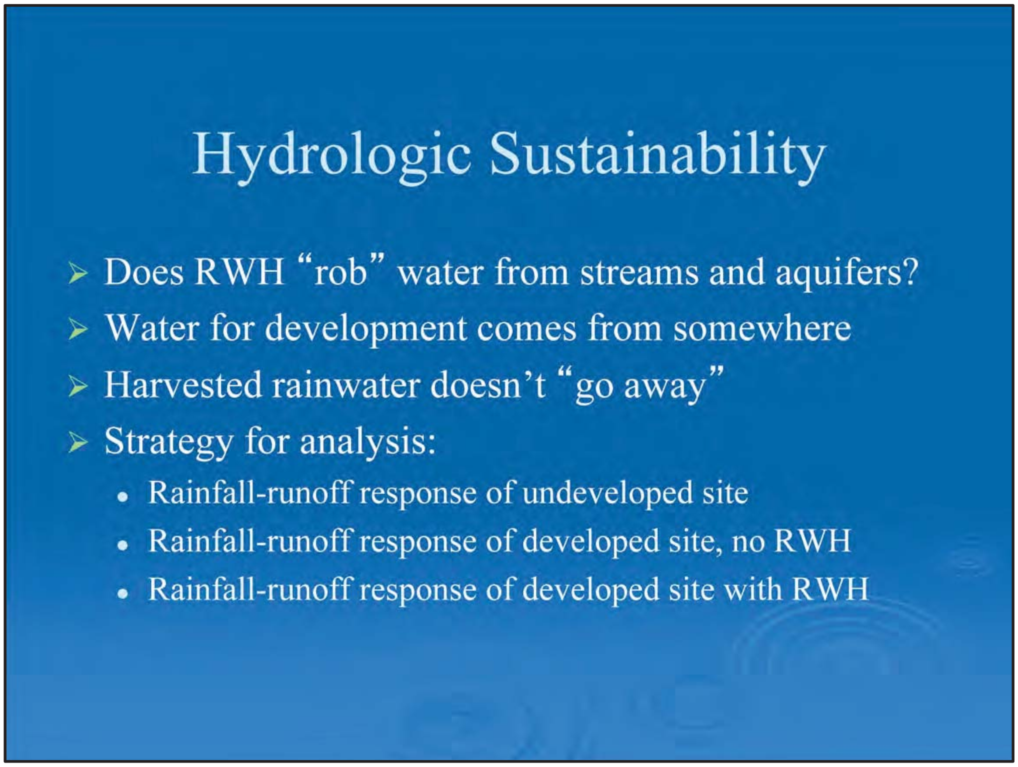
➢One is all about sustainability of development.

- First, because of limited water supplies.
- As I reviewed back at the beginning of the presentation, under the rainwater harvesting strategy, development lives mainly on water falling on the development.
- This can conserve groundwater and blunt the "mining" of aquifers.
- And that can allow development to be SUSTAINED despite lack of available groundwater.

➢So if we don't have the water in the Hill Country to support the development, would rainwater harvesting be more fiscally sustainable than long-distance water importation schemes.

➢As we also reviewed earlier, this rainwater harvesting strategy fits with and supports the conservation development pattern favored for the Hill Country.

- And as we saw in the video, many consider that to be more sustainable in terms of "preserving" the Hill Country character.



➢The other dimension to sustainability is the impact on the local hydrology.

➢I just noted that the development lives on the water falling on it.

➢By capturing that water, instead of it running off, are we "robbing" water from streams and aquifers?

➢Would we be making the Hill Country ecology less sustainable?

➢Is this question silly? Or is it serious?

➢Why might it be silly?

➢Water for development will come from somewhere.

➢And this captured water doesn't just "go away".

➢Very little is actually consumed by the residents of the development.

➢Most of it eventually does go back into the environment and re-enters the hydrologic cycle.

➢Capturing and using that water in the house doesn't necessarily alter in any significant way the movement of water through the watershed.

➢So, would this rainwater harvesting strategy represent a “significant” alteration, or not?

➢Here’s how we intend to analyze this issue:

- We’ll model the rainfall-runoff response of an undeveloped site.
- Then we’ll model it in a developed state
- First without the roof runoff being captured and sequestered on the site.
- Then with rainwater harvesting.
- Comparing these, we can see the immediate impact on the local hydrology.

➢If anyone with expertise in this area would like to offer us the benefit of their knowledge, we’d greatly appreciate the input. If you can help, please state that in the “other” category on your information forms.

With that, let's take questions, comments or suggestions about any of the topics we've covered today.

Thank you to the

Texas Water Development Board

for funding this investigation of
Building-scale RWH Systems as a Development-wide Water Supply Strategy

Thank you also to Hill Country Alliance for sponsoring our forum today.