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Celebrating 40 years of taking care of Missouri's natural resources.  
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## CapDet & Cost Analysis Spreadsheet

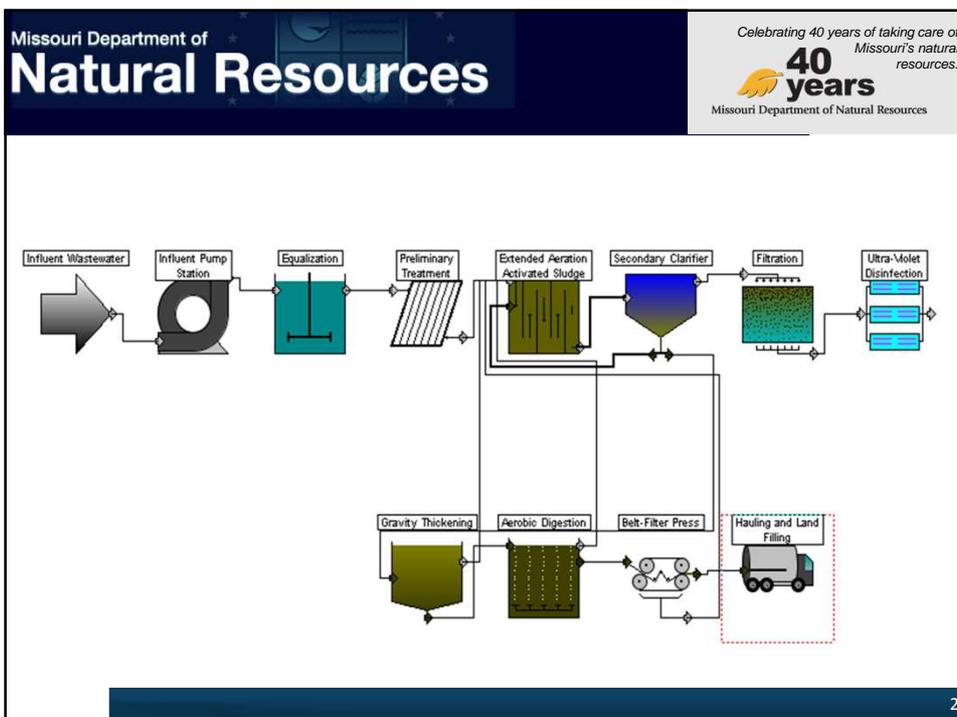
Cost Analysis Ad Hoc Meeting, December 2014

Leasue Meyers, EI  
Engineering Section



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## What is CapDet?

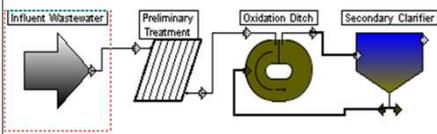
- CapdetWorks is a preliminary design and costing software program from Hydromantis (<http://www.hydromantis.com/CapdetWorks.html>)
- The design algorithms are based on the concepts of solids retention time and influent fractionation, and consistent with activated sludge models, including:
  - ASM1
  - Metcalf and Eddy (Wastewater Engineering: Treatment and Reuse, 4th Edition),
  - Theory, Design and Operation of Biological Nutrient Removal Activated Sludge by the Water Research Commission

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## CapDet Costing

- CapdetWorks uses a unit costing approach with an extensive costing database that accounts for the effects of inflation using cost indices.
- Costing Indices
  - Marshall & Swift Index
  - Engineering News Record Cost Index
  - Pipe Cost Index



The diagram illustrates a wastewater treatment process flow. It starts with 'Influent Wastewater' entering from the left. The flow then goes through 'Preliminary Treatment', which is represented by a rectangular tank with diagonal hatching. From there, the flow enters the 'Oxidation Ditch', shown as a circular tank with a central vertical shaft. Finally, the flow goes to the 'Secondary Clarifier', depicted as a trapezoidal tank with a blue gradient. Arrows indicate the direction of flow between these stages.

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## Equipment Costs

Find :   Match Case

Description	Cost	Cost Index	Value of Cost Index
1 ton of chlorine	\$950.00	ENR	7930.8
1 lb of methanol	\$0.50	ENR	7930.8
1 lb of carbon	\$5.00	ENR	7930.8
1000 cuft of natural gas	\$12.50	ENR	7930.8
1 gallon of fuel oil	\$2.22	ENR	7930.8
1 ft of fencing	\$19.25	MAS	1383.6
1 cuyd of gravel in place for drying beds	\$25.00	ENR	7930.8
1 cuyd of sand in place for drying beds	\$40.00	ENR	7930.8
1 cuft of installed plastic media for a trickling filter	\$4.70	MAS	1383.6
1 sqft of installed liner in a lagoon	\$2.20	MAS	1383.6
1 ft of perforated PVC pipe in place: 4-in diam.	\$11.00	ENR	7930.8
1 ft of perforated PVC pipe in place: 6-in diam.	\$16.00	ENR	7930.8
1 ft of perforated PVC pipe in place: 8-in diam.	\$22.00	ENR	7930.8
1 ft of 6-in diam., perforated polyvinyl chloride pipe	\$12.00	MAS	1383.6
1 ft of 24-in diam., reinforced concrete drainpipe for land treatment	\$27.50	MAS	1383.6
1 ft of 12-in diam., welded steel pipe	\$120.00	MAS	1383.6
8-in diam., cast iron pipe per foot	\$50.00	PIPE	738.8
6-in diam., cast iron tee	\$900.00	PIPE	738.8
6-in diam., cast iron bend	\$350.00	PIPE	738.8
8-in diam., cast iron plug valve	\$3,400.00	PIPE	738.8
12-in. diam., butterfly valve	\$2,000.00	MAS	1383.6
16-in pump	\$35,000.00	MAS	1383.6
100 gpm (at 40 ft) pump and driver unit	\$3,500.00	MAS	1383.6
3000-gpm pump and driver unit	\$18,000.00	MAS	1383.6
8-gpm at 70 ft of head sludge pump	\$5,500.00	MAS	1383.6
Variable frequency drive module for a 20-hp motor	\$4,300.00	MAS	1383.6
100-hp, 1200-rpm synchronous motor	\$7,175.00	MAS	1383.6
5-hp vertical turbine mixer	\$8,950.00	MAS	1383.6

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## CapDet Capabilities

- Design a wastewater treatment plant
- Designs based on many of the wastewater characteristics, not limited to flow
- Overall project costs
- Individual process unit
  - Operations & Maintenance Cost
  - Electrical Cost
  - Material cost

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## CapDet Scenarios



- CapDet is run on a few scenarios, it does not take into account every community's scenario and treatment technology.
- If a facility needs to upgrade, the engineer hired to complete the facility plan will evaluate options for the community on what they can afford & what site-specific conditions are.

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## Unit Processes in CapDet Works

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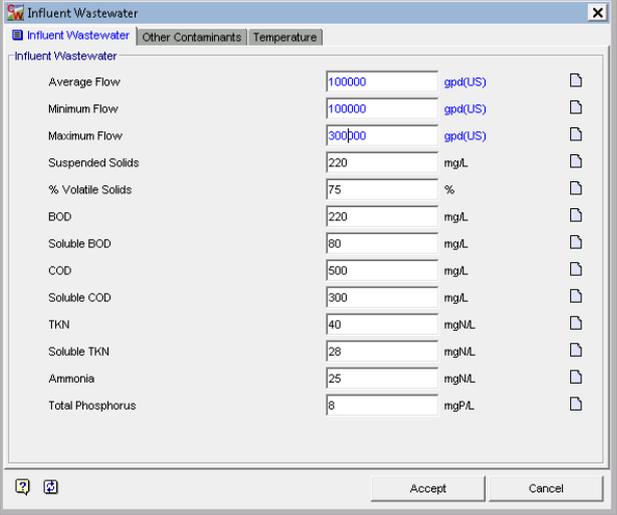
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## Influent Wastewater Characteristics



Parameter	Value	Unit
Average Flow	100000	gpd(US)
Minimum Flow	100000	gpd(US)
Maximum Flow	300000	gpd(US)
Suspended Solids	220	mg/L
% Volatile Solids	75	%
BOD	220	mg/L
Soluble BOD	80	mg/L
COD	500	mg/L
Soluble COD	300	mg/L
TKN	40	mg/NL
Soluble TKN	28	mg/NL
Ammonia	25	mg/NL
Total Phosphorus	8	mg/P/L

- Average flow & minimum flow= permitted design flow
- Maximum flow= peak flow, estimated at 3:1 ratio

Characteristics of influent are of domestic/ municipal strength wastewater

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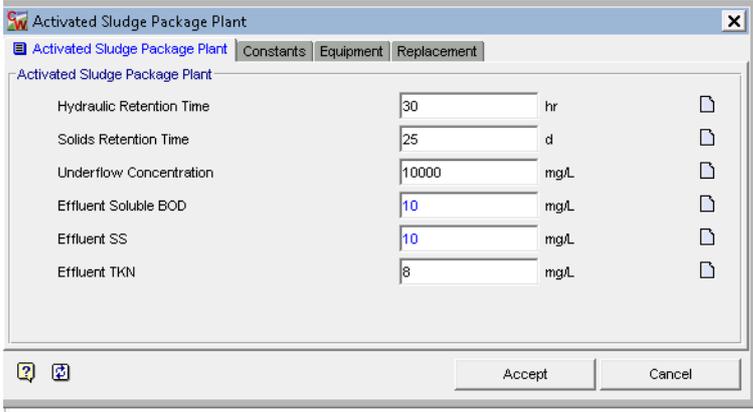
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## Activated Sludge Package Plant



Parameter	Value	Unit
Hydraulic Retention Time	30	hr
Solids Retention Time	25	d
Underflow Concentration	10000	mg/L
Effluent Soluble BOD	10	mg/L
Effluent SS	10	mg/L
Effluent TKN	8	mg/L

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## Secondary Clarifier

Secondary Clarifier

Design Basis: Peak Flow

Surface Overflow Rate: 500 gal(US)/(sqft-d)

Sidewater Depth: 12 ft

Specific Gravity: 1.03

Underflow Concentration: 1 %

Weir Overflow Rate - Maximum: 15000 gal(US)/(ft-d)

Effluent Suspended Solids: 10 mg/L

Type of Clarifier: Circular

Accept Cancel

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## CapDet Scenarios to Spreadsheet

- Losing Stream Effluent limits
- <5,000 gpd to 10 MGD
- 5 treatment technologies scenarios
  - Package plants (<5,000 gpd to 50,000 gpd)
  - Extended Aeration (<5,000 gpd to 10 MGD)
  - Oxidation Ditch (20,000 gpd to 10 MGD)
  - Sequencing Batch Reactor (20,000 gpd to 10 MGD)
  - Land Application (<5,000 gpd to 150,000 gpd)
- 2 disinfection technologies
  - Chlorine & UV

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### How is CapDet used?

- Capital Cost
- Operations & Maintenance Cost includes electrical & material
- In CapDet, we set
  - Pump replacement at 10 years
  - Structural replacement at 20 years (30 for land application)
  - Operator & Lab \$25 per hr
  - Administrative \$20 per hr

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### CapDet Operations & Maintenance

- The Annual O&M estimate includes
  - Operator, Administrative, & Lab costs
  - Electrical Cost (\$0.10/kWh)
  - Materials Cost, including any expected part replacement, ie: bulbs, pumps
  - Maintenance Costs
  - Chemical Costs

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## Unit Costs

Item	Value	Unit
Building Cost	90	\$/sqft
Excavation	8	\$/cuyd
Wall Concrete	500	\$/cuyd
Slab Concrete	350	\$/cuyd
Crane Rental	200	\$/hr
Canopy Roof	16	\$/sqft
Electricity	0.1	\$/MWh
Hand Rail	75	\$/ft
Land Costs	0.0	\$/acre

Land costs are zeroed out- for land application, the costs are calculated in the spreadsheet based on acreage

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## Unit Costs-Labor Rates

Item	Value	Unit
Construction Labor Rate	32	\$/hr
Operator Labor Rate	25	\$/hr
Administration Labor Rate	25	\$/hr
Laboratory Labor Rate	20	\$/hr

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## Unit Costs- financial

Field	Value	Unit
Interest Rate	5	%
Construction Period	3	years
Operating Life of Plant	20	years

For land application, the operating period of the plant is 30 years

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## Unit Costs-other

Field	Value	Unit
Engineering Design Fee	10	%
Miscellaneous	5	%
Administration/Legal	2	%
Inspection	2	%
Contingency	10	%
Technical	2	%
Profit and Overhead	0	%

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Description	Construction	Operational	Maintenance	Material	Chemical	Energy	Amortization
Primary Treatment	\$2,500	\$2,500	\$2,500	\$1,500	\$0	\$0	\$5,000
Oxidation Ditch	\$135,000	\$7,140	\$0	\$2,040	\$0	\$3,130	\$13,900
Secondary Clarifier	\$100,000	\$13,700	\$5,700	\$928	\$0	\$757	\$9,500
Other Costs	\$1,060,000	\$38,000	\$0	\$0	\$0	\$0	\$0

- Construction cost
- Annual O&M costs, including material, chemical and energy
- Did not use the amortization value

Influent/effluent out of each component

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## Scenarios Not Covered

- Influent pump stations
- Sludge handling
- Nutrient &/or Phosphorus removal

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## Spreadsheet

- Capital Cost-CapDet
- Operations & Maintenance-CapDet, includes electrical, material & chemical cost
- Calculated:
  - Present Worth,
  - Debt Retirement,
  - Number of Users, and
  - Monthly estimated Cost per User
- Linear interpolation for scenarios not simulated in CapDet

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## Cost breakdown

- Capital Cost- purchase price and installation costs (from CapDet Works)
- Annual Operations and Maintenance Cost- annual operational cost, maintenance cost, electricity, & chemicals, including standard replacement of components (i.e. bulbs & pumps) (from CapDet Works)
- Salvage Value- not calculated in the spreadsheet, but often is a salvage value

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## Cost breakdown

- Present Worth/Life Cycle Cost-sum of all recurring and one-time costs over the life span of a system, includes purchase price, installation cost, operating costs, and maintenance/replacement cost
  - Uses the Excel PV(rate, nper,pmt, fv, type) equation
- Debt retirement: the complete retirement of debt associated with the project's capital cost
- Cost per user: O&M costs and debt retirement per connection based on 5,000 gallons per month usage

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## Land Application

- CapDet estimates the amount of land required for application, along with the equipment required
- Scenarios ran for the 4 different regions in the state
  - North of Hwy 36: 120 days
  - Between Hwy 50 and Hwy 36: 90 days
  - Between Hwy 60 and Hwy 50: 75 days
  - South of Hwy 60: 60 days
- Land costs are from the 2013 Missouri Farm Land Values Survey

County	2013
Stoddard	\$5,964
Cropland value per acre	

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## Chillicothe

Community:	Chillicothe	<p style="color: red;">Dropdown tab to pick community</p> <p style="color: blue;">Autofill based on community</p>
County:	Livingston	
Location:	North Hwy 36	
Current Sewer User Rate (residential):	\$24.25	
Cost per Acre:	\$3,366	
Community Resource:	<a href="http://www.chillicothe.org/index.html">http://www.chillicothe.org/index.html</a>	
Community Environmental		
Commitments (ie: MS4, power plant, WTP):	power plant, water treatment plant, airport	
Interest Rate:	5%	
Equipment Life:	20 years	
Design Flow:	3 MGD	Design Flow entered
Number of Users (Default):	8108	<p style="color: blue;">Automatically calculates connections based on design flow</p>
Number of Users (Application):	3867	

Interest rate, equipment life, and number of users can be changed

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## Oxidation Ditch Scenarios

	0.02	0.03	0.04	0.05	10	3
Estimated Capital Cost of Oxidation Ditch	\$591,000	\$714,000	\$827,000	\$923,000	\$25,300,000	\$10,124,000
Annual Operating & Maintenance Costs	\$59,240	\$63,790	\$67,520	\$70,720	\$965,200	\$383,680
Annualization Factor	0.08024	0.08024	0.08024	0.08024	0.08024	0.0802
Annualized Capital Cost	\$47,423	\$57,293	\$66,361	\$74,064	\$2,030,137	\$812,376
Total Annual Cost of Project	\$106,663	\$121,083	\$133,881	\$144,784	\$2,995,337	\$1,196,056
Present Worth Factor	12.462	12.462	12.462	12.462	12.462	12.462
Total Present Worth of O & M Costs	\$738,261	\$794,964	\$841,448	\$881,328	\$12,028,525	\$4,781,501
Other Costs as Present Worth						
Salvage Value as Present Worth (subtracted)						
<b>Total Present Worth Costs</b>	\$1,329,261	\$1,508,964	\$1,668,448	\$1,804,328	\$37,328,525	\$14,905,501
Number of users:	54	81	108	135	27027	8108
Debt Retirement per year	\$47,423	\$57,293	\$66,361	\$74,064	\$2,030,137	\$812,376
Debt Retirement per user per month	\$73.11	\$58.88	\$51.15	\$45.67	\$6.26	\$8.35
O&M cost per user per month	\$40.58	\$29.13	\$23.12	\$19.38	\$1.32	\$1.75
User Cost per month per 5,000 gpd	\$113.69	\$88.01	\$74.28	\$65.05	\$7.58	\$10.10

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## Dudley, Mechanical Treatment

Community		Mechanical Treatment				
Community:	Dudley	Package Plant	Extended Aeration	Oxidation Ditch	SBR	
County:	Stoddard	Capital Cost:	\$537,000	\$971,000	\$827,000	\$1,000,000
Location:	South Hwy 60	Annual O&M Costs:	\$59,512	\$99,300	\$67,520	\$59,512
Current Sewer User Rate (residential):	\$36.25	Annual Debt Retirement:	\$43,090	\$77,916	\$66,361	\$80,243
Cost per Acre:	\$5,964	Present Worth:	\$1,278,651	\$2,208,497	\$1,668,448	\$2,058,540
Community Resources:	<a href="http://www.booneco.com/Boone%20County%20Water%20and%20Sewer%20Department/2013%20Annual%20Report/2013%20Annual%20Report.pdf">http://www.booneco.com/Boone%20County%20Water%20and%20Sewer%20Department/2013%20Annual%20Report/2013%20Annual%20Report.pdf</a>	Debt retirement per user per month:	\$25.65	\$46.38	\$39.50	\$47.76
Community Environmental Commitments (ie: MS4, power plant, WTP):	0	O&M costs per user per month:	\$20.38	\$34.01	\$23.12	\$29.09
Interest Rate:	5%	User Cost per month:	\$46.03	\$80.39	\$62.62	\$76.85
Equipment Life:	20 years	Disinfection				
Design Flow:	0.04 MGD	Chlorine:		UV:		
Number of Users (Default):	108	Capital Cost:	\$803,000	\$132,000		
Number of Users (Application):	140	Annual O&M Costs:	\$60,070	\$4,089		
		Annual Debt Retirement:	\$64,435	\$10,592		
		Present Worth:	\$1,551,605	\$182,958		
		Debt retirement per user per month:	\$38.35	\$6.30		
		O&M costs per user per month:	\$20.57	\$1.40		
		User Cost per month:	\$58.93	\$7.71		

Mechanical Plant +UV Disinfection:		Package Plant	Extended Aeration	Oxidation Ditch	SBR
Capital Cost:		\$669,000	\$1,103,000	\$959,000.00	\$1,132,000.00
Annual O&M Costs:		\$63,601	103,889	\$71,609.00	\$69,601.00
Annual Debt Retirement:		\$53,682	\$88,508	\$76,933	\$90,835
Present Worth:		\$1,461,609	\$2,391,455	\$1,851,406.42	\$2,241,498.12
Debt retirement per user per month:		\$31.95	\$52.68	\$45.81	\$54.07
O&M costs per user per month:		\$21.78	\$35.41	\$24.52	\$30.49
User Cost per month:		\$53.73	\$88.09	\$70.33	\$84.56

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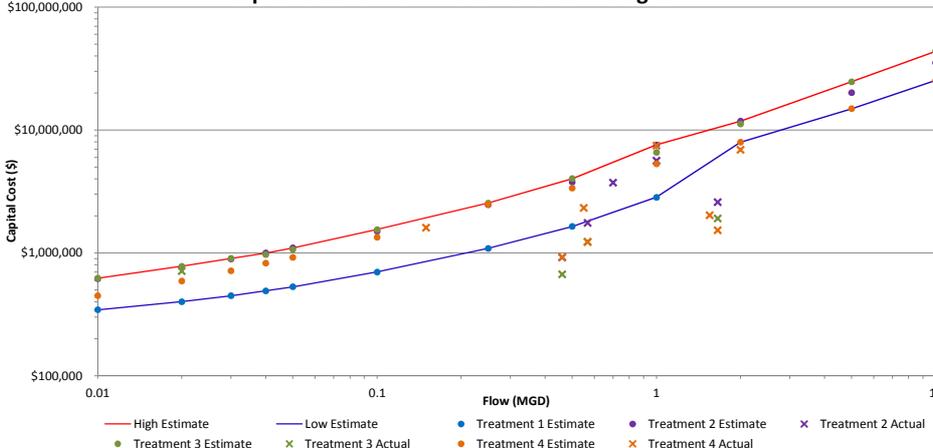
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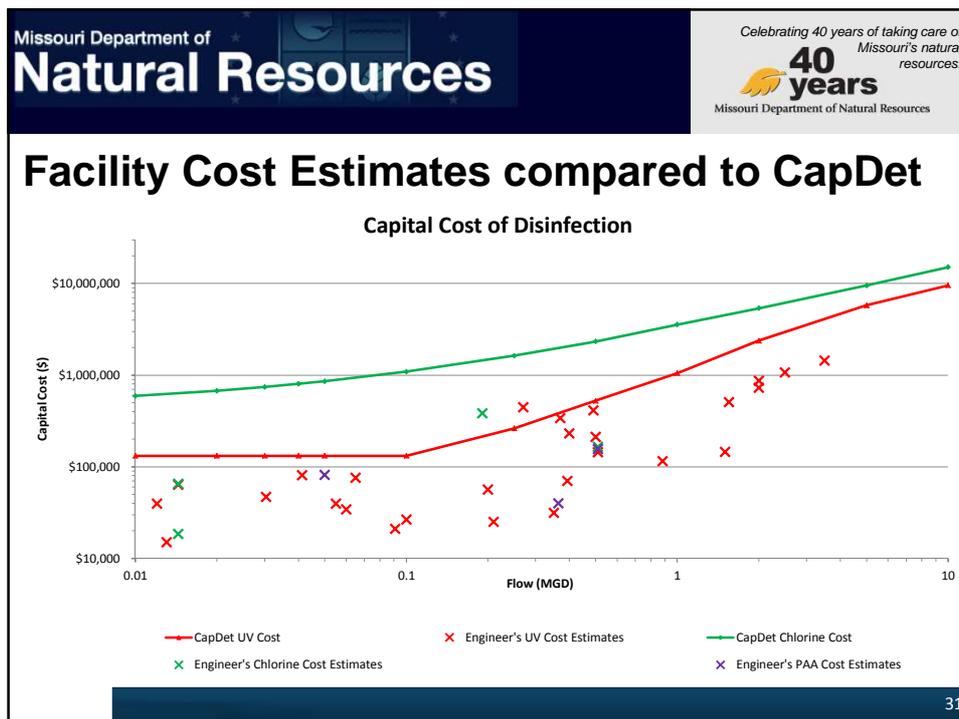
## Facility Cost Estimates compared to CapDet

### Capital Cost vs. Flow Treatment Technologies



The graph illustrates the relationship between flow rate and capital cost for different treatment technologies. The red line (High Estimate) shows a steeper increase in cost as flow increases compared to the blue line (Low Estimate). Actual data points (crosses) for Treatment 2 and Treatment 4 are generally higher than their respective estimates (circles).

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## Limitations to CapDet

- Proprietary technologies (LEMNA, SAGR, etc...)
- Estimate based on national indices, not site-specific
- CapDet is not designed for smaller facilities
- Comparison of the same process units & scope of project
- Piping & pumps- it provides cost estimate and general info, but does not account for site- specifics
- Does not reflect site-specific conditions: the facility plan developed after a facility decides it needs to upgrade will account for the site-specific costs.

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## Improvements to Cost Analysis Estimates

- More actual costs to continue tracking & evaluating
  - If you have costs that you would like to provide, please provide.
- Number of connections/users to reflect:
  - Communities with multiple treatment facilities
  - Communities that are losing population
- Inflow & Infiltration
- Pretreatment

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- CapDet 3.0 released November 2014
  - Updates include
    - MBR unit process
    - MBBR unit process
    - IFAS unit process
    - Cost information

Introducing ...

**CAPDET**  
Works **3.0**

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## Questions

**Leasue Meyers**  
**leasue.meyers@dnr.mo.gov**  
**(573) 751-7906**



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