Selecting and Designing a UV System

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Black & Veatch

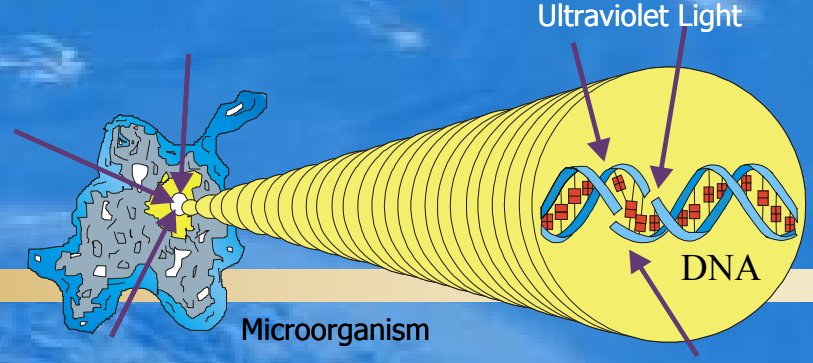
FAQ'S

- What does UV look like – in a plant – and where am I going to put it?
- What happens when the lights go out - power or UV lamps?
- How much does it cost?
- Some case histories may help answer these questions

Presentation Outline

- UV General Topics
- Roemer WFF
  - Design Issues
  - Evaluation
  - Current Status
- Vancouver, British Columbia
- Flagstaff, AZ

Why Ultraviolet?



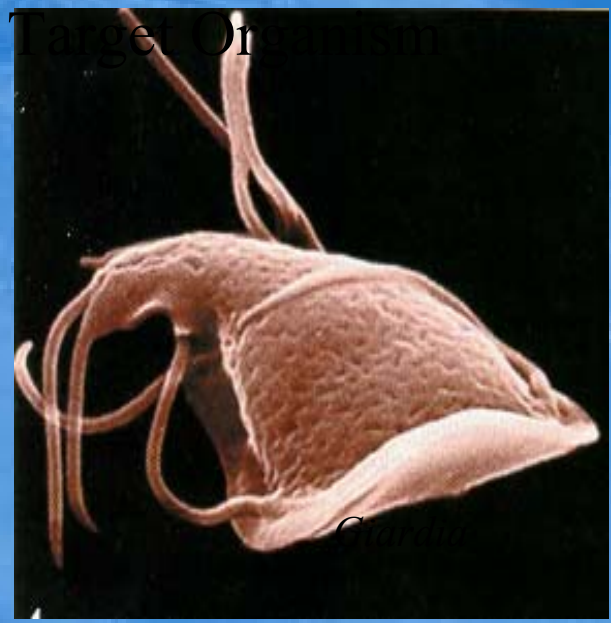
- Disinfection
  - Previously used for viruses
  - 1998: UV effective for *Cryptosporidium*
  - 2000: UV effective for *Giardia*
- Disinfection byproducts
  - Minimal known byproducts – low energy
  - May allow for reduced chlorine use
  - Produces nitrite but at low amounts
- Capital Cost
  - General rule-of-thumb: $0.05 to $0.10/gallon

What Systems Are Available?

- Medium pressure lamps
  - Calgon Carbon Corp.
  - Ondeo Degremont
  - Severn Trent Services
  - Trojan Technologies Inc.
- Low-pressure high-output lamps
  - Wedeco Ultraviolet Technologies

UV Dose

Transmittance
& Absorbance



Irradiance	x	Exposure Time	=	UV Dose
(mW/cm^2)	x	(seconds)	=	(mJ/cm^2)

UV Dose Requirements

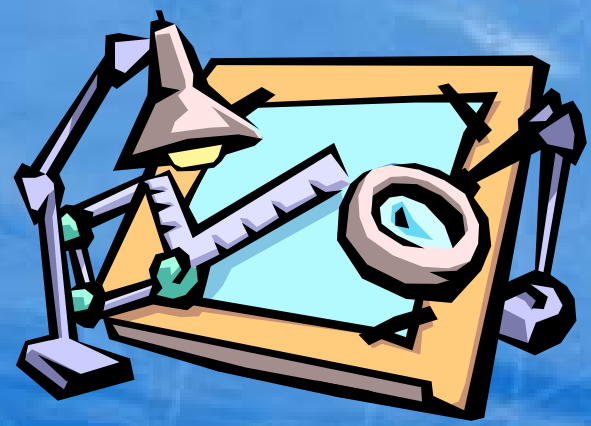
UV Dose Requirements Used During Validation Testing								
	Log Inactivation							
	0.5	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**
Cryptosporidium	1.6	2.5	3.9	5.8	8.5	12	-	-
Giardia	1.5	2.1	3.0	5.2	7.7	11	-	-
Virus	39	58	79	100	121	143	163	186

Source: Draft UV Disinfection Guidance Manual – US EPA

- UV doses (mJ/cm^2) based on scientific findings
- Need these doses to achieve given log inactivation
- Problem: reactors are not ideal; can not assure delivery of an exact dose

UV Design Issues

- Redundancy
- Regulatory issues
- Validation requirements
- Water quality
- Hydraulics - headloss
- Location/Space
- Number of reactors
- Operations
- Evaluation



West Valley Water – Rialto, CA

- Roemer Water Filtration Facility
  - Currently 9.6 mgd facility
  - 4 upflow contact clarifier/filters
  - Chlorine disinfection
- Blended Water Source
  - Lytle Creek – high quality
    - Limited to 6 mgd
  - California State Water Project (SWP) – higher organics

Source Water Quality

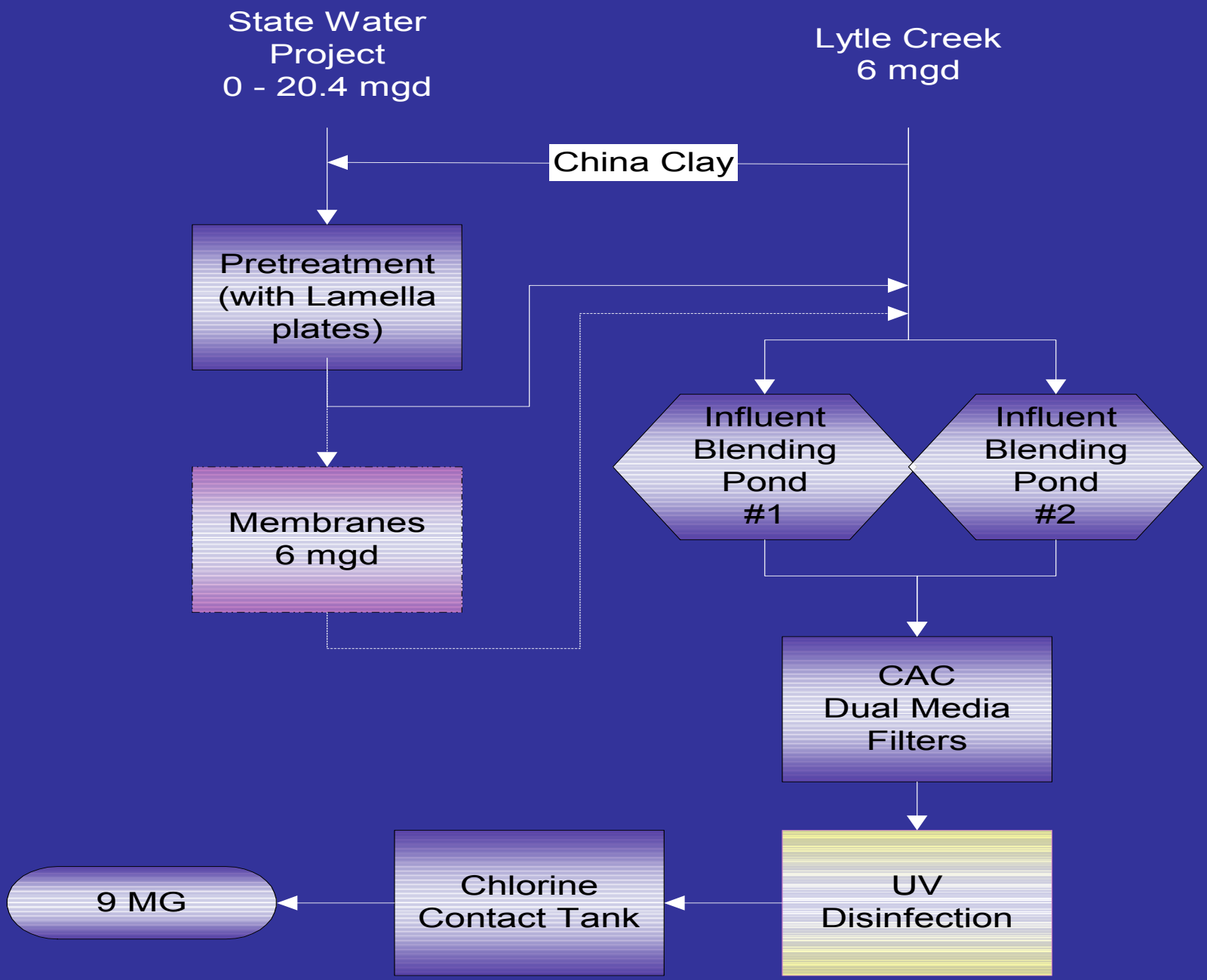
- TOC concentration of blended water is critical
  - Amount blended controlled to minimize DBP formation potential with use of free chlorine
- Blended water with TOC less than 2.0 mg/L
- Lytle Creek – china clay an issue

Constituent	Lytle Creek	State Water Project
Turbidity, NTU	0.3 – 20	1 – 4
TOC, mg/L	0.0 – 1.1	2.7 – 6.3
MPN/100 mL	Variable*	< 1,000
Temperature, °C	8 – 19.4	8 – 25
pH	7.6 – 8.6	7.9 – 8.3

* MPN values have exceeded 1,000 during summer periods due to recreational use of Lytle Creek

Treatment Objectives and Solutions

- Objectives
  - Minimize chlorine dose for *Giardia* CT compliance
    - Continue use of free chlorine
  - Increase capacity to 14.4 mgd
    - Increase SWP usage
  - Continue use of free chlorine
- Solutions
  - UV Disinfection
    - *Giardia* inactivation (dose of 40 mJ/cm^2)
  - Pretreatment
    - Reduce TOC levels of SWP by 35 percent

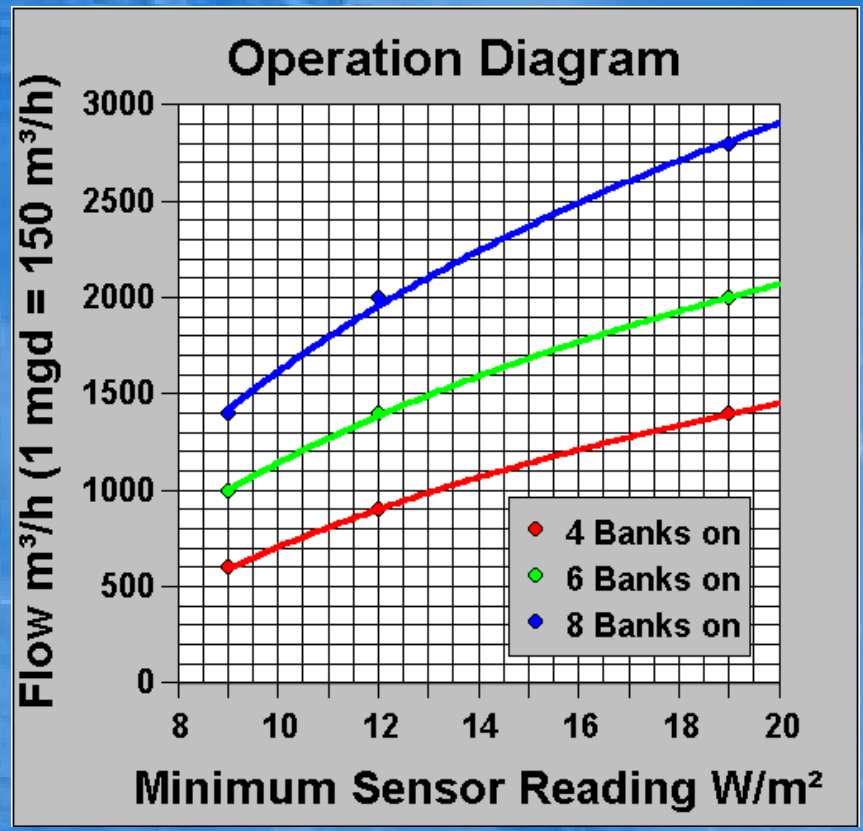

State Water Project
0 - 20.4 mgd
Lytle Creek
6 mgd
China Clay
Pretreatment (with Lamella plates)
Membranes
6 mgd
Influent Blending Pond #1
Influent Blending Pond #2
CAC Dual Media Filters
UV Disinfection
Chlorine Contact Tank
9 MG

Redundancy Requirements

- North Lake Tahoe Public Utility District
  - First UV system in California - unfiltered
  - NWRI/AwwaRF Guidelines
    - First edition
    - 2 reactors in series and in parallel
- Redundancy – NWRI standards
  - Second Edition
  - Reactors in parallel
  - Standby reactor

Regulatory Issues

- Worked with California DHS
  - Important for permitting UV reactor for *Giardia* credit
- DHS recommended:
  - Diversion point
  - Operational curves



Courtesy of Dr. Oluf Hoyer

What is Validation?

- UV Reactor is designed to achieve a given level of disinfection performance
  - under specific conditions
- Must verify claims made on performance
  - evaluate the reactor performance
- Specifically need to evaluate dose delivery and dose monitoring
  - monitoring provides the basis for assigning disinfection credit during operation
- UV is “special” – you cannot measure a residual to assess performance!

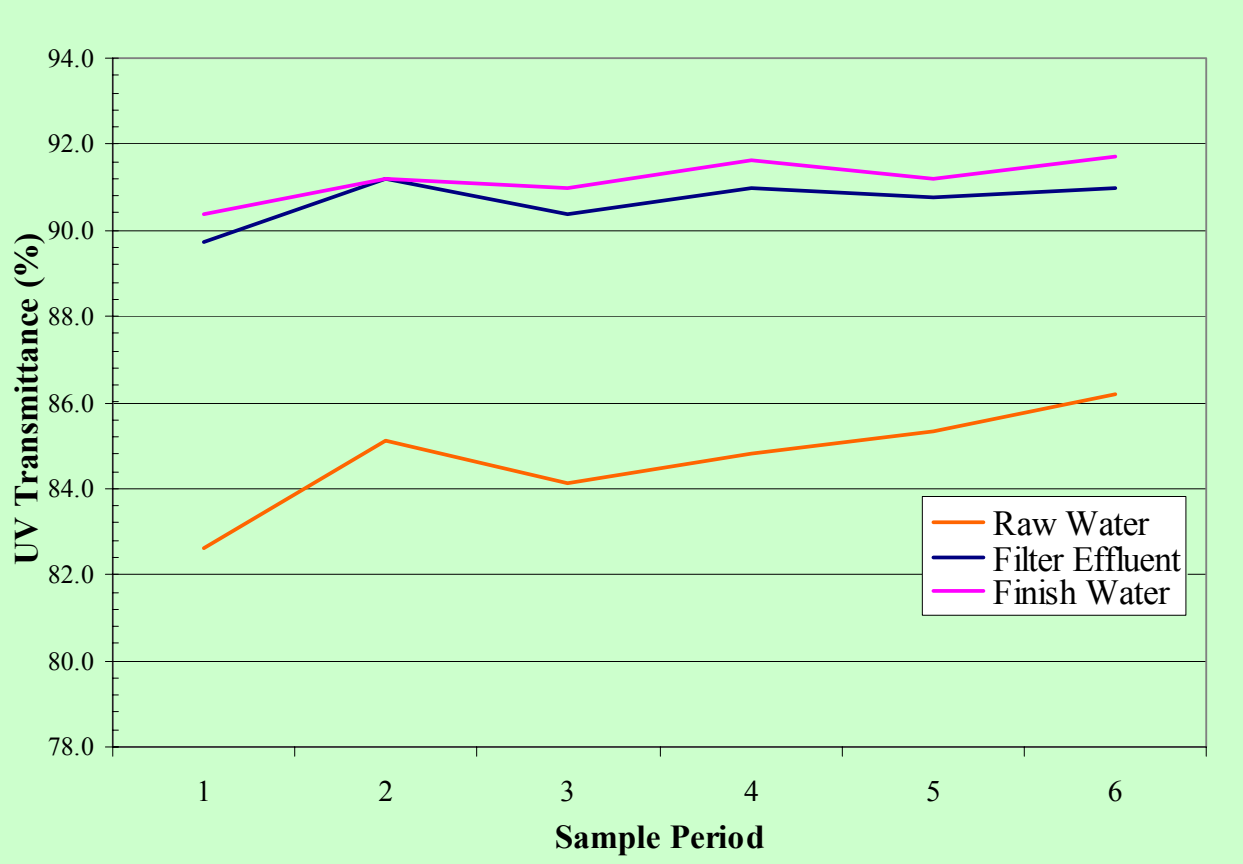
Why is Validation Necessary?

- Substantiate performance claims
- Some systems are proprietary (lamps, sensors, baffles)
- Predictive models have uncertainty associated with them
- UV intensity distribution complexities
  - Reflection/refraction/shadowing
- Hydraulics may not be as predicted
- Polychromatic UV systems present additional uncertainties (which wavelengths are most effective?)
- Obtain regulatory approval

Testing and Validation

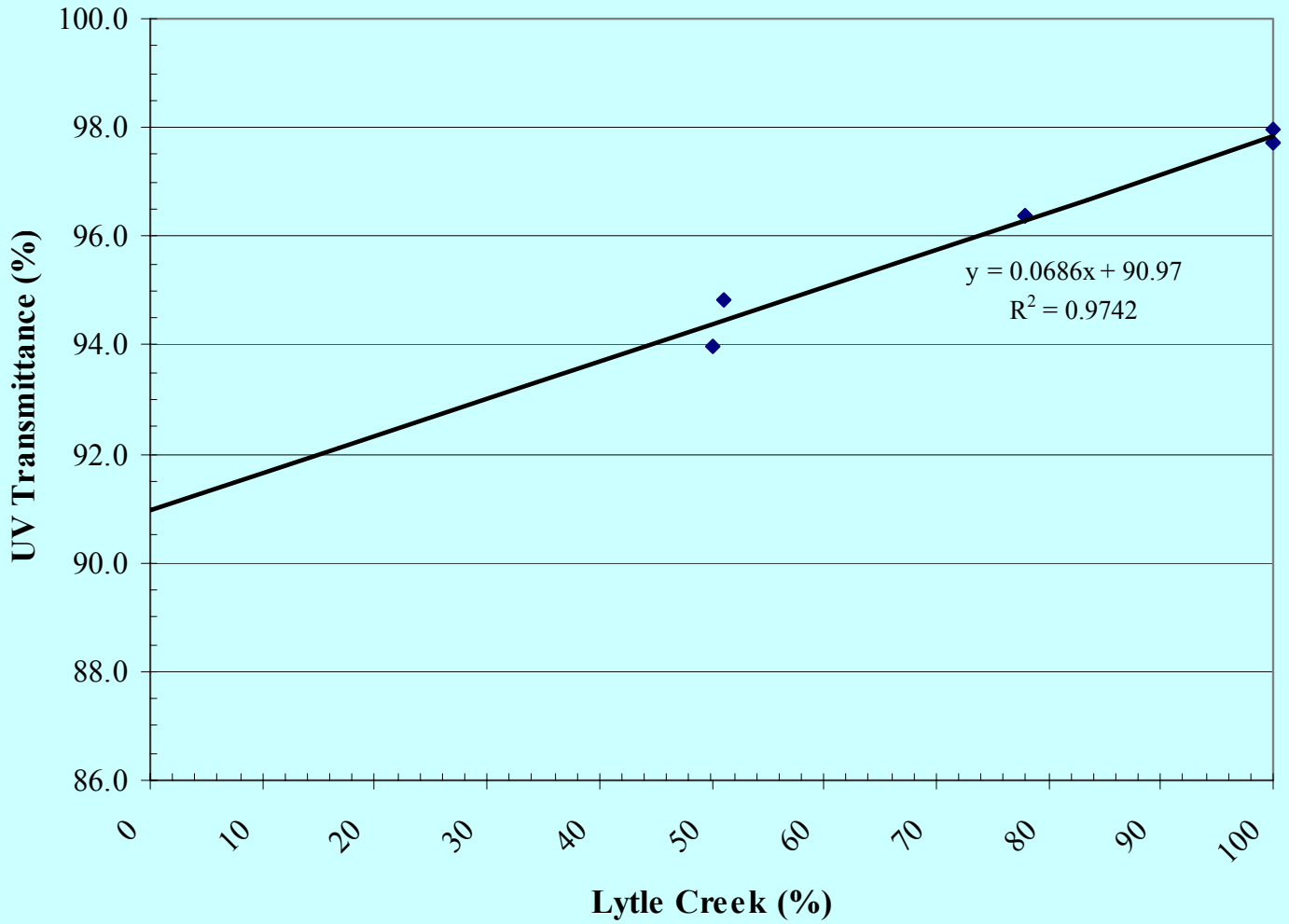
- Validation Testing
  - Prevalidated
  - Off-site validation
  - On-site validation
- Performance Testing
  - Determine if manufacturer meets guaranteed power and headloss
  - Penalty applies
- Verification Testing
  - Verify validation results

Water Quality - UVT



- Minimal UVT data
- Worst case would be 100% SWP water
- Selected 89% UVT for design

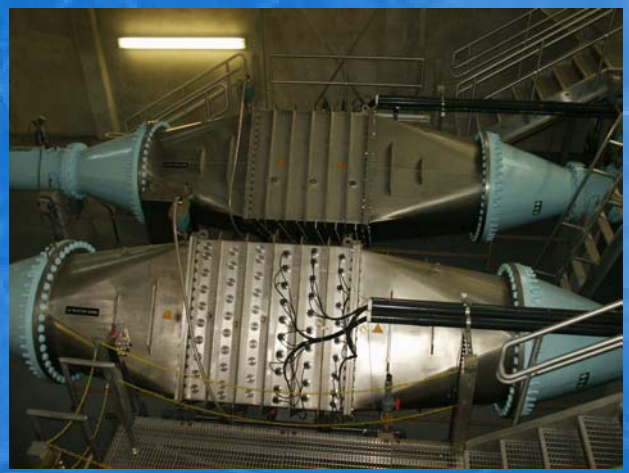
Combined Filter Effluent UVT – Roemer WFF



Hydraulic Limits and Location

- Maintain gravity feed to clearwell
  - Avoid pumps
- Evaluation showed head available
- Allowed 12 inches of loss for reactor

Space Requirements



- MP reactors
  - Require less space
  - Filter effluent application
- LPHO reactors
  - Largest space requirement
  - Length, width, access
- Roemer WFF
  - Space adjacent to clearwell
  - Layout for LPHO

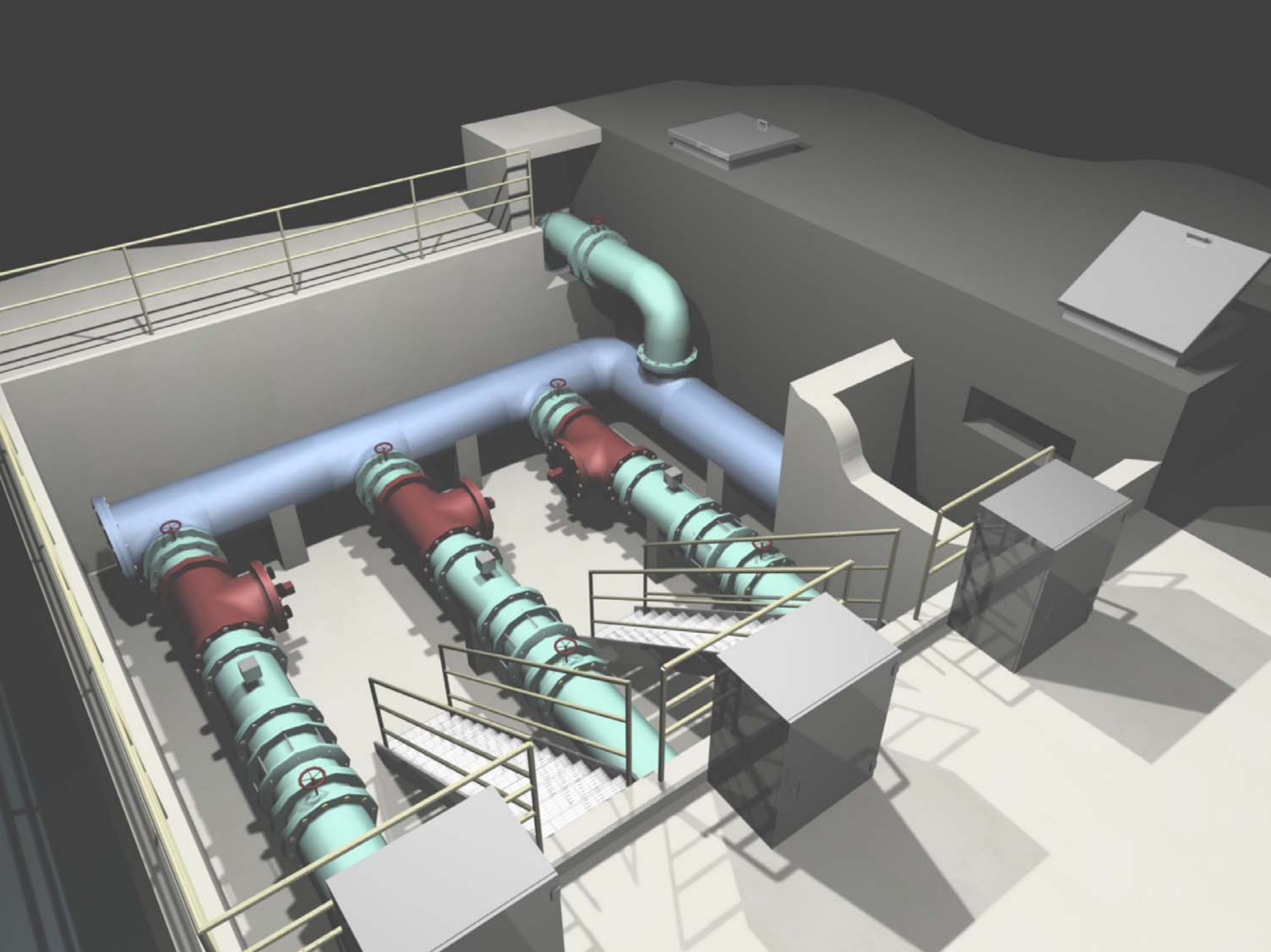
Operations – Monitoring

- Plant staff on-site for 8-hours/day
  - Fully automated system
- Monitor for operations and shutdown
  - Transmittance
  - Intensity
  - Flow (positive flow split)
  - Temperature (shut down on high temperature)
  - Reactor alarms
  - Verify validated conditions

Addressing Off-Specification Conditions

- Options
  - Shut down
  - Divert (diversion needed for on-site testing)
  - Operate through (increase chlorine)
  - Rely on monthly volumes

Start with Easiest Option First!



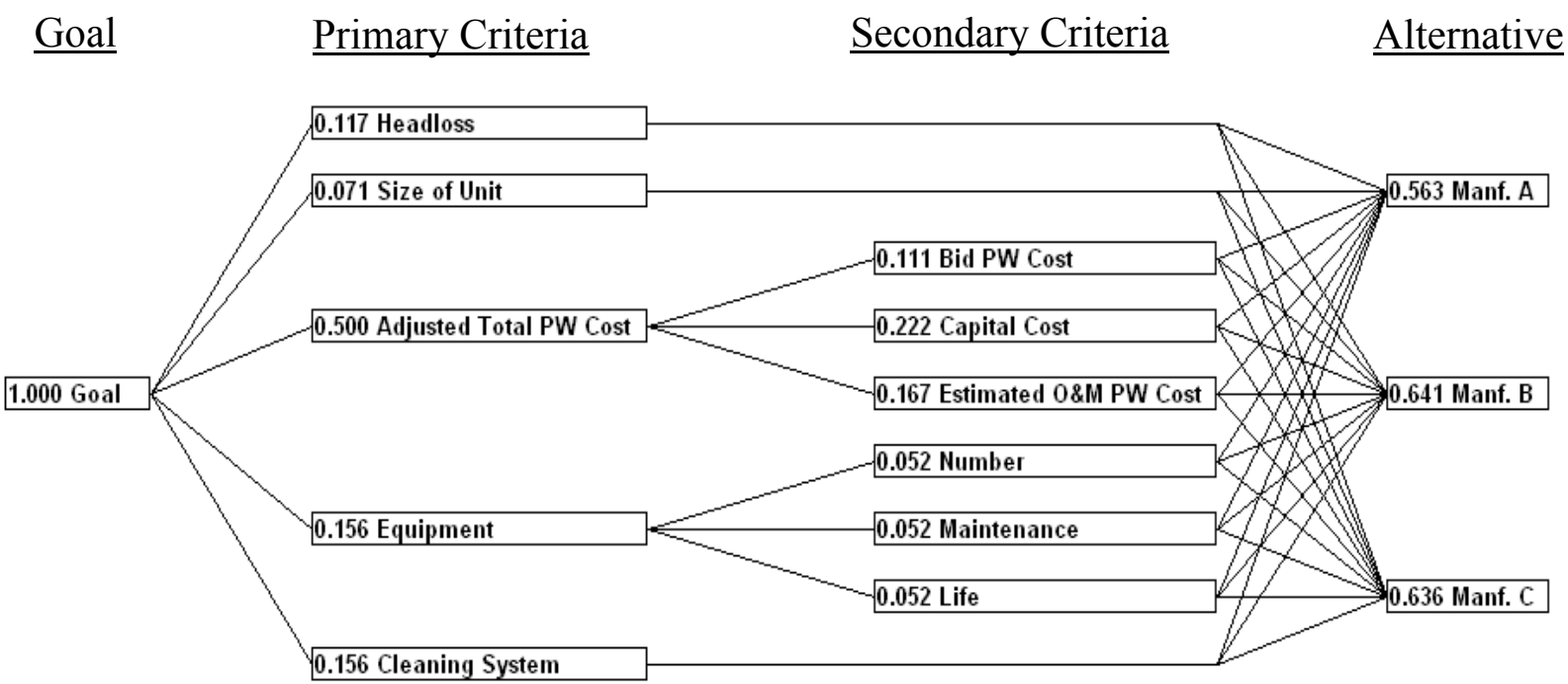
Project Timeline

- Design to 90 percent
- Procure UV equipment
  - Prequalification
  - Bid
  - Site visits
  - Bid evaluation
- Conclude design
- Bid construction

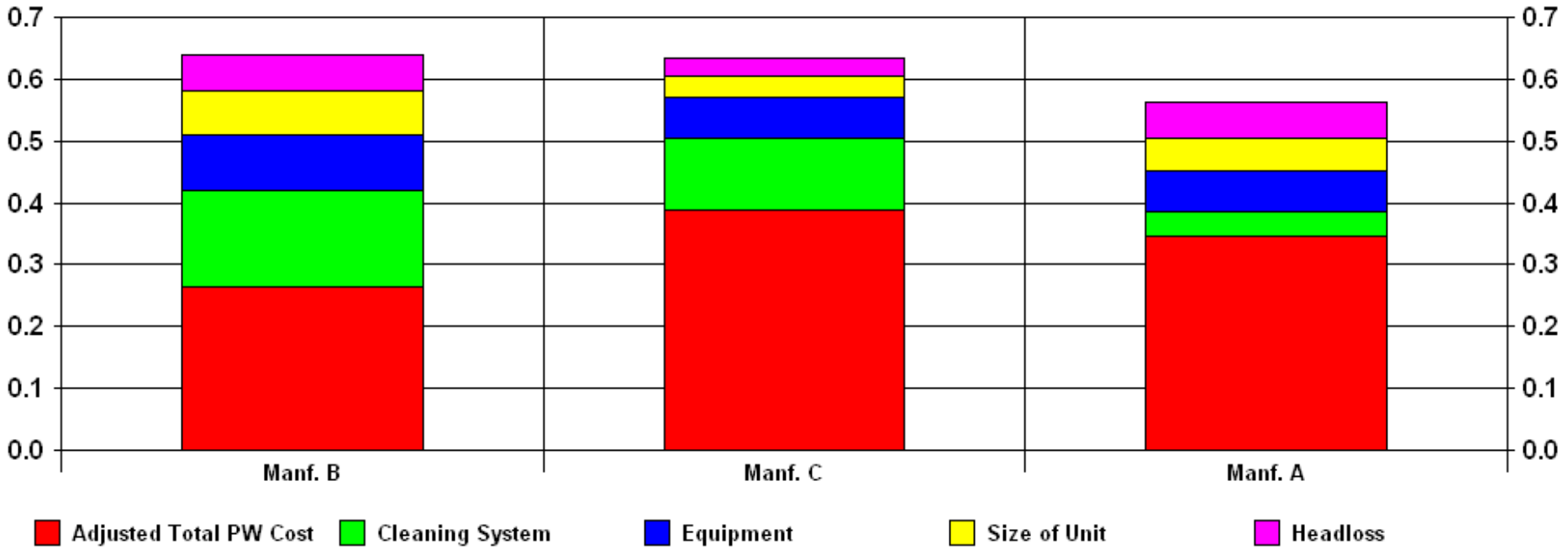
Manufacturer Evaluation

- Cost
  - Bid present worth
  - Capital cost
  - Total present worth
- Headloss
- Size of unit
- Cleaning system
- Equipment
  - Number
  - Life
  - Maintenance

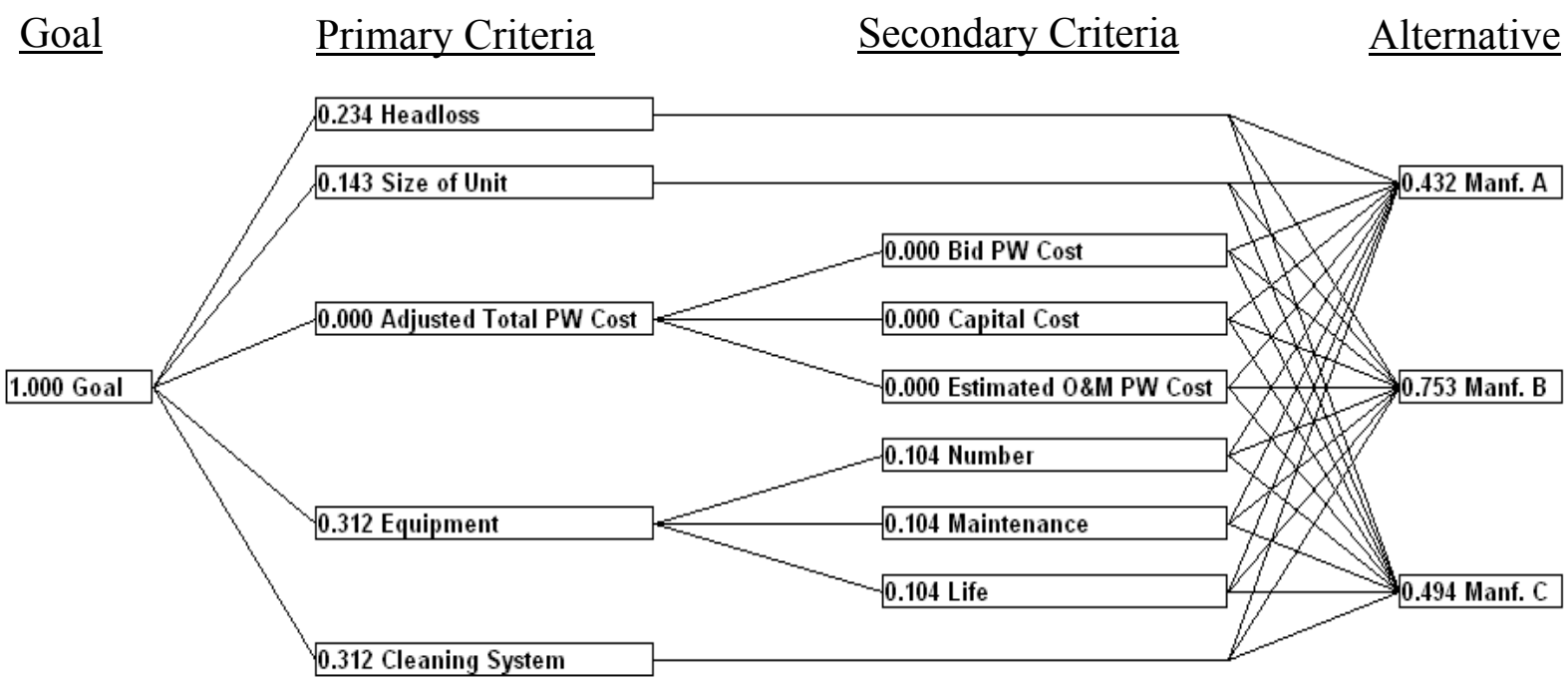
Decision Analysis Hierarchy



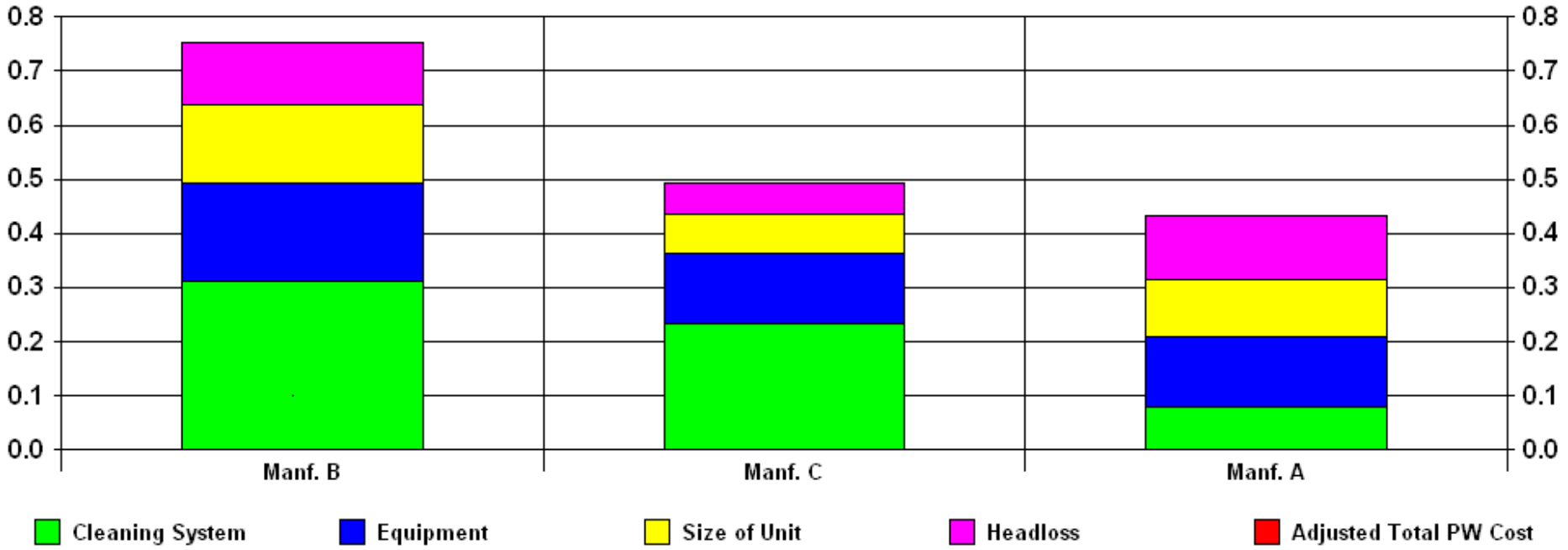
Contributions By Category



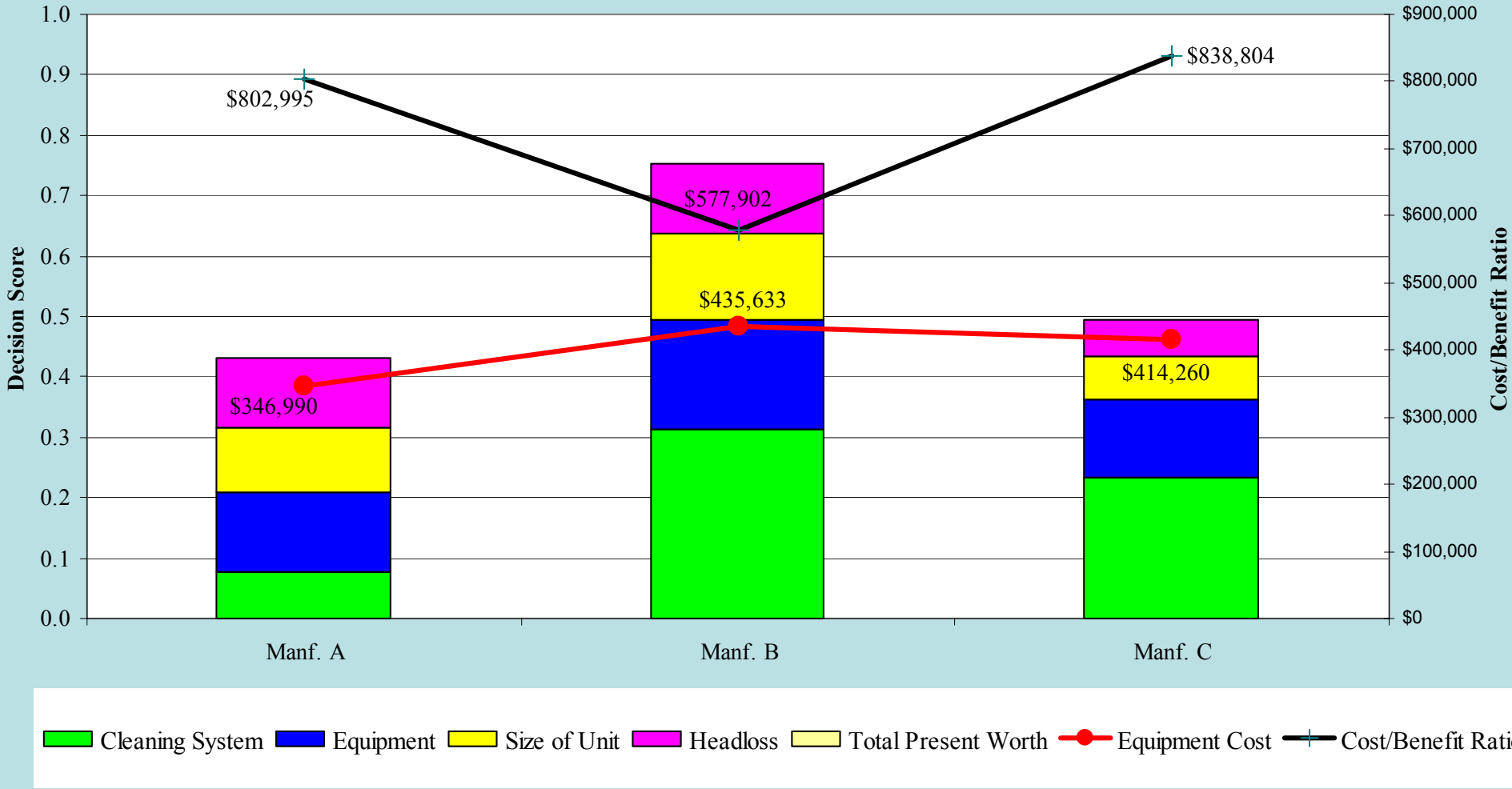
Decision Hierarchy Without Costs



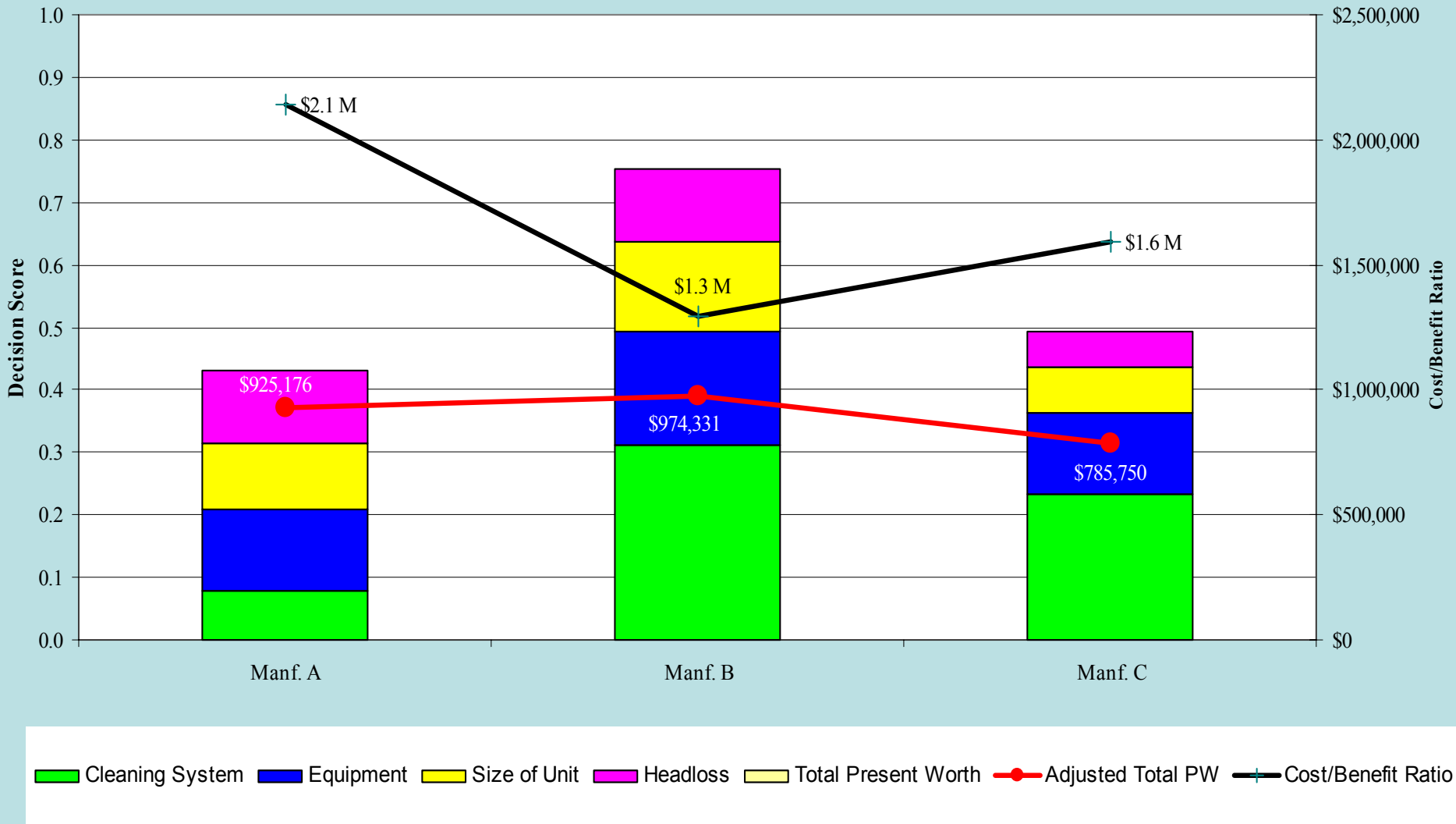
Contributions by Category – Without Cost



Cost Benefit Analysis: Equipment Cost



Cost Benefit Analysis: Total Present Worth



Manufacturer Selected

- Trojan Technologies
  - Validated reactor
    - UVT – 89 percent
    - Dose – 40 mJ/cm^2
    - Capacity – 7.2 mgd
  - Reactor type – 6L24
  - UVT Monitor
  - Collimated Beam
- Equipment Cost
  - Engineer's estimate - $400,000
  - Actual - $435,633

Current Status of Roemer WFF

- Regulatory review – COMPLETED
- Prequalification – COMPLETED
- Design/bid – COMPLETED
- Currently under construction
- On-site testing: January 2005

Roemer WFF Final Thoughts

- Awarded UV system to Trojan
  - Site visits as part of selection
  - Evaluation using cost and other factors in cost/benefit analysis
- UV cost approximately $1,800,000
  - $0.12 per gallons
  - Diversion basin, redundancy, full cost of building modification
- Why UV?
  - *Giardia* inactivation with reduced chlorine
  - Meet future regulations

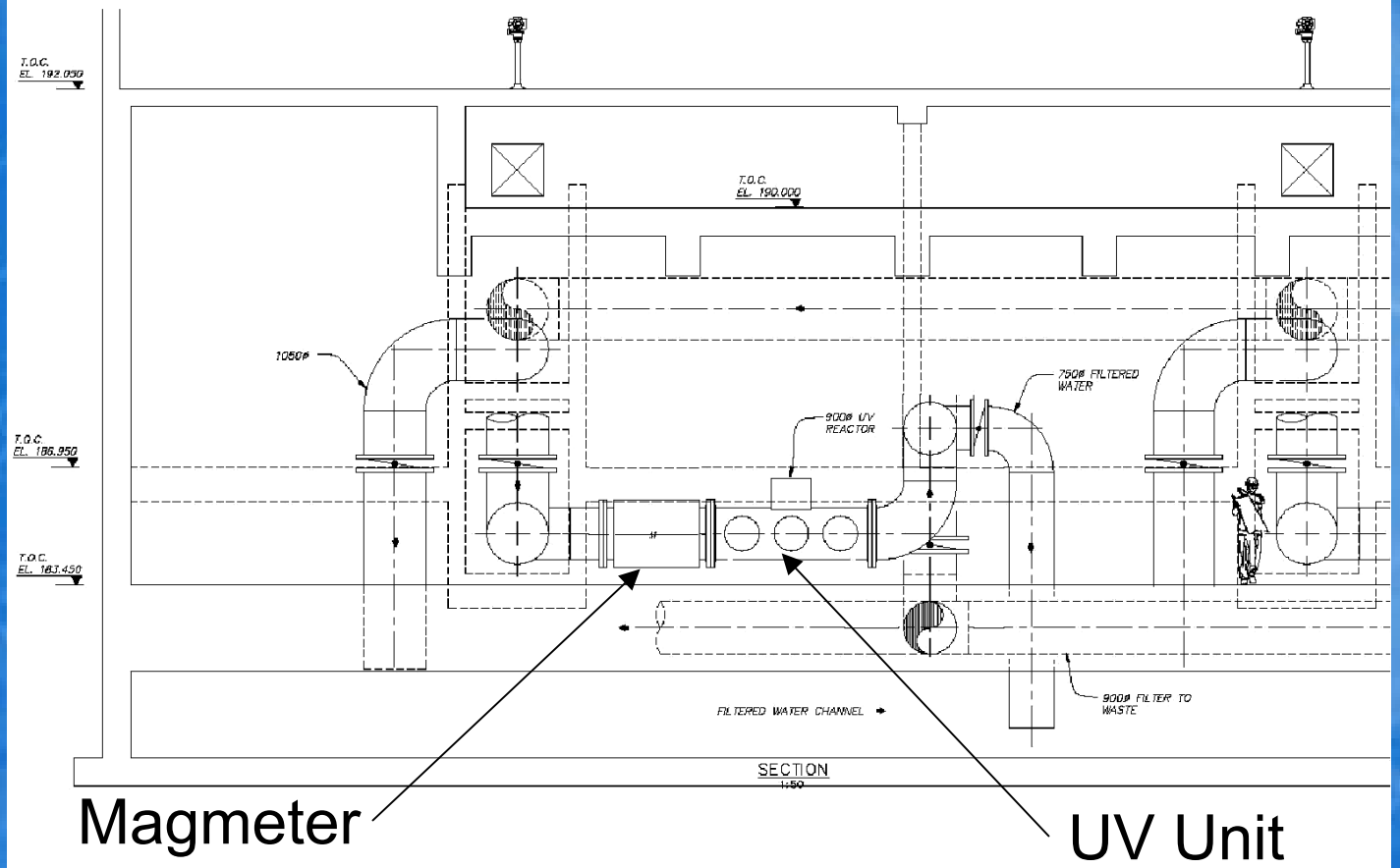
480 MGD VANCOUVER PROJECT

- New Direct Filtration WTP
- Reservoir supplies
- Twenty-four 22 mgd UV units, one at each filter effluent
- Two extra filters; can shut down the filter(s) when the lights go out – no UPS at this time
- Medium pressure UV units – for reduced size

480 MGD VANCOUVER PROJECT

- UV put in filter pipe gallery to reduce cost
  - Eliminated need for new “UV” gallery/building
  - Used filter rate controller / flowmeter for UV flow monitoring and control
- Project is under design
- Cost approx. $14M or $0.03 per gallon
- Why UV? - multiple barrier (not required to meet current regulations)

480 MGD VANCOUVER PROJECT



8 MGD FLAGSTAFF PROJECT

- Upgrade, new filters & UV in exist. WTP
- Source water - reservoir
- Single 8 mgd medium pressure UV unit by Severn Trent, Aquionics
- UV after filtration, separate from filter gallery
- New pumping units provided after filtration to pump through UV and also for better utilization of existing clearwell

8 MGD FLAGSTAFF PROJECT

Summary

- UV can be located in a filter pipe gallery or in a separate enclosed area after filtration
- If available head is very limited or needs to be improved, pumping is an option
- When power or lamps go out, design solutions are available to provide continuous disinfection if deemed necessary

Summary

- Some utilities have elected to install UV early to increase multiple barriers without regulatory requirements
- Reg. guidelines are now available, & UV provides an additional barrier effective against cysts and a means to reduce chlorine requirements and DBP formation

Summary

- Approx. capital cost of case histories $30,000, $38,000, & $120,000 per mgd
- Wide range reflects degree of redundancy, installation challenges, and size of plant
- O&M cost $5 to $30 per mg
- Patent cost $15 per mg

International Ultraviolet Association

- http://www.iuva.org
- Can request a one week trial membership

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