Final Report

Project Name: Colorado *E. coli* Assessment and Management Project (Phase I)

Grant Contact: Colorado Stormwater Council (on Behalf of the Water Quality Forum's *E. coli* Work Group); Contact: Jill Piatt-Kemper, Chairperson; c/o City of Aurora, 15151 E. Alameda Parkway; Aurora CO 80012; email: Jpiatt@auroragov.org; tel.: (303) 739-7390.

Grant Category: Planning Grant (2007-2008)
Project Budget: $10,000

Report Summary: Phase I of the *E. coli* Assessment and Management Project funded under the Colorado Watershed Protection Fund is complete and has benefited from the investment of over 150 hours by stakeholders, including local governments, the Colorado Water Quality Control Division and EPA. The value of matching time is estimated at over $13,000, providing a 130% matching funds rate. Phase I of this project was completed by September 30, 2008. Table 1 briefly describes various work products. Work products generated to date are attached for more detail. Phase II of the project will build upon work completed under Phase 1.

Task	Description Work Product	Status
1	Annotated bibliography of existing *E. coli* resources by topic with hyperlinks to web resources (where available)	Bibliography completed and distributed to stakeholders (see attached). Due to rapidly changing state of the science, this bibliography may be updated during Phase II of the project.
2	Technical Memorandum; Evaluation of the EPA Report on the Experts Scientific Workshop on Critical Research Needs for the Development of New or Revised Recreational Water Quality Criteria – What does it mean to the Colorado stream segments listed as impaired for E. coli?	Detailed Powerpoint presentation summarizing key issues developed and presented at stakeholder meeting. Discussion anticipated to continue on this topic. Also posted to Water Quality Forum website (see attached).
3	Annotated Summary of 303(d) Listed Streams to Identify Common Characteristics, General Issues and Possible Common Approaches	Spreadsheet developed summarizing listed segments (attached); spreadsheet will evolve under Phase II of the project. Five meetings held to discuss issues and approaches to TMDLs (see agendas and/or meeting minutes attached). The majority of the work product under this task is based on meeting minutes where various approaches to the issues were discussed and documented. These meetings helped to lay the foundation for Phase II of the project.
4	Presentation of Findings at 2 Meetings	Presentation at Water Quality Forum in February 2008 (see attached), Water Quality Forum Retreat July 2008 and Colorado Association of Floodplain Managers Annual Conference September 2008 (abstract/Powerpoint attached).

Attachments:
Project Budget and Matching Hours Spreadsheets
Work Product for Various Tasks

Progress Report
Support for E. coli Work Group under Colorado Watershed Protection Fund Grant

Task	Description Work Product	Milestone	CWPF Funds	WWE Invoice #33359; Feb 29, 2008 (through January 31, 2008)	Description	WWE Invoice #33545 March 14, 2008 (through February 29, 2008)	Description	WWE Invoice #33691 (through March 31, 2008)	Description	WWE Invoice #34022 (through May 31, 2008)	Description	WWE Invoice #34170 (work completed through June 30, 2008)	Description
1	Annotated bibliography of existing *E. coli* resources by topic with hyperlinks to web resources (where available)	Interim Draft: March 2008 Final: September 2008	$3,000	$ 800.00	Began developing draft bibliography.	$ 550.00	N/A	$ 484.00	Continued developing draft bibliography.	$ 1,000.00	Continued Development of bibliography		
2	Technical Memorandum, Evaluation of the EPA Report on the Experts Scientific Workshop on Critical Research Needs for the Development of New or Revised Recreational Water Quality Criteria – What does it mean to	Interim Draft: February 2008 Final: September 2008	$3,500	$ 1,162.83	Began review of EPA report in preparation for February presentation.	$ 2,314.50	Developed summary of EPA report in Powerpoint, presented findings at February work group meeting. Work product posted on WQF website.		N/A				
3	Annotated Summary of 303(d) Listed Streams to Identify Common Characteristics, General Issues and Possible Common Approaches	Interim Draft: February 2008 Final: September 2008	$3,000	$ 300.00	Helped develop matrix of questions for 303(d) list of segments for distribution to the Work Group.		N/A	$ 242.00	Met with Becky Anthony, Water Quality Control Division to discuss Colorado TMDLs and how the Work Group could interact most meaningfully with the Division	$ 515.75	Support for May 8, 2008 stakeholder meeting regarding potential approaches to TMDLs in Colorado. Included general coordination, meeting minutes and follow-up.	$ 484.00	Support for June 26, 2008 meeting with EPA. Meeting minutes document key issues related to TMDL development in Colorado. Support included general coordination prior to meeting, meeting minutes and follow-up.
4	Presentation of Findings at 2 Meetings	Mar-08 Jun-08	$500	$ -	N/A	$ -	N/A	$ 121.00	Presented synopsis at March Water Quality Forum meeting.				
	Total		$10,000	$ 2,262.83		$ 2,864.50		$ 847.00		$ 1,515.75		$ 484.00	

*Due to interrelated nature of tasks, work completed may apply to several tasks. Budget allocated to tasks is approximate.

Progress Report
Support for E. coli Work Group under Colorado Watershed Protection Fund Grant

Task	Description Work Product	WWE Invoice #34351 (work completed through July 31, 2008)	Description	WWE Invoice #34537 (work completed through August 31, 2008)	Description	WWE Invoice #34811 (work completed through September 30, 2008)	Description	Total Invoiced*	Budget Remaining in Task	% Complete
1	Annotated bibliography of existing *E. coli* resources by topic with hyperlinks to web resources (where available)			$ 166.00	Wrap-up Phase I biblography.			$ 3,000.00	$ -	100%
2	Technical Memorandum, Evaluation of the EPA Report on the Experts Scientific Workshop on Critical Research Needs for the Development of New or Revised Recreational Water Quality Criteria – What does it mean to					$ 22.67	Close out task budget.	$ 3,500.00	$ -	100%
3	Annotated Summary of 303(d) Listed Streams to Identify Common Characteristics, General Issues and Possible Common Approaches	$ 1,331.00	Support for August 21, 2008 meeting with EPA. Research related to provisions for natural sources of bacteria for TMDL development.	$ 127.25	August 21, 2008 meeting.			$ 3,000.00	$ -	100%
4	Presentation of Findings at 2 Meetings			$ 295.17	Develop presentation for Colorado Association of Stormwater and Floodplain Managers Conference. (Majority of time/costs donated in September.)	$ 83.83	Presentation at Colorado Association of Stormwater and Floodplain Managers Conference. (Majority of time/costs donated.)	$ 500.00	$ -	100%
	Total	$ 1,331.00		$ 588.42		$ 106.50		**$ 10,000.00**	$ -	100%

*Due to interrelated nature of tasks, work com

Attendees: December 6, 2007	**Hours**	**Rate**	**Value**
Terry Baus	2	$ 85	$ 170
Joan Carlson	2	$ 85	$ 170
Jane Clary			$ -
Mary Fabisiak	2	$ 85	$ 170
Phil Hegeman	2	$ 85	$ 170
Ginny Johnson	2	$ 85	$ 170
Megan Monroe	2	$ 85	$ 170
Jon Novick	2	$ 85	$ 170
Dick Parachine	2	$ 85	$ 170
Jill Piatt Kemper	2	$ 85	$ 170
Jennifer Richards	2	$ 85	$ 170
Andrew Ross	2	$ 85	$ 170
Donna Scott	2	$ 85	$ 170
James McCarthy	2	$ 85	$ 170
Subtotal	26		$ 2,210
Attendees: February 7, 2008	**Hours**	**Rate**	**Value**
Terry Baus	2	$ 85	$ 170
John Burke	2	$ 85	$ 170
Megan Monroe	2	$ 85	$ 170
Dave Meyer	2	$ 85	$ 170
Jane Clary			$ -
Mary Fabisiak	2	$ 85	$ 170
Becky Dunavant	2	$ 85	$ 170
Mary Gardner	2	$ 85	$ 170
Becky anthony	2	$ 85	$ 170
Phil Hegeman	2	$ 85	$ 170
Alan Searcy	2	$ 85	$ 170
Jill Piatt Kemper	2	$ 85	$ 170
James McCarthy	2	$ 85	$ 170
Joan Carlson	2	$ 85	$ 170
Ken MacKenzie	2	$ 85	$ 170
Jon Novick	2	$ 85	$ 170
Jennifer Richards	2	$ 85	$ 170
Sharon Henderson Davis	2	$ 85	$ 170
Subtotal	34		$ 2,890

Attendees: May 8, 2008			
Becky Anthony	2	$ 85	$ 170
Terry Baus	2	$ 85	$ 170
Jane Clary			$ -
Richard Meyerhoff	2	$ 85	$ 170
Nathan Moore	2	$ 85	$ 170
Jon Novik	2	$ 85	$ 170
Joan Carlson	2	$ 85	$ 170
Jill Piatt Kemper	2	$ 85	$ 170
James McCarthy	2	$ 85	$ 170
Megan Monroe	2	$ 85	$ 170
Donna Scott	2	$ 85	$ 170
Subtotal	20		$ 1,700
Attendees: June 26, 2008			
Becky Anthony	2	$ 85	$ 170
Terry Baus	2	$ 85	$ 170
Jane Clary			$ -
Richard Meyerhoff	2	$ 85	$ 170
Nathan Moore	2	$ 85	$ 170
Jon Novik	2	$ 85	$ 170
Jill Piatt Kemper	2	$ 85	$ 170
James McCarthy	2	$ 85	$ 170
Megan Monroe	2	$ 85	$ 170
Joni Nuttle	2	$ 85	$ 170
Phil Hegeman	2	$ 85	$ 170
Becky Dunavant	2	$ 85	$ 170
Dan Scaife	2	$ 85	$ 170
Mary Fabisiak	2	$ 85	$ 170
John Burke	2	$ 85	$ 170
Sandra Spence	2	$ 85	$ 170
Dave Moon	2	$ 85	$ 170
Todd Harris	2	$ 85	$ 170
Jennifer Richards	2	$ 85	$ 170
Ginny Johnson	2	$ 85	$ 170
Subtotal	**38**		**$ 3,230**

Matching Funds to Date for E. coli Work Group

Attendees: August 21, 2008			
Becky Anthony	2	$ 85	$ 170
Bob Arastason	2	$ 85	$ 170
Terry Baus	2	$ 85	$ 170
Jane Clary	2		$ -
Mary Gardner	2	$ 85	$ 170
Jill Piatt Kemper	2	$ 85	$ 170
James McCarthy	2	$ 85	$ 170
Phil Hegeman	2	$ 85	$ 170
Becky Dunavant	2	$ 85	$ 170
Mary Fabisiak	2	$ 85	$ 170
Nancy Keller	2	$ 85	$ 170
Donna Scott	2	$ 85	$ 170
Ginny Johnson	2	$ 85	$ 170
Amy Woodis	2	$ 85	$ 170
Subtotal	**28**		**$ 2,210**

Other: CASFM Presentation (*Value of donated portion of time, excluding travel/conference costs*)			
Jane Clary	**8**	**$ 121**	**$ 968**

Total	**154**		**$ 13,208**

*Matching funds reflected above do not include the additional costs of meeting attendance such as gas, parking, value of conference room, etc. Additional matching time by Jim McCarthy related to periodic reporting to the Water Quality Forum is also not included. Travel, lodging and conference fees associated with presentations at Water Quality Forum Retreat and Colorado Association of Stormwater and Floodplain Managers are not included in the matching funds.

Bibliography of Bacteria References Related to Recreational Water Quality Criteria, Stormwater Management and Total Maximum Daily Loads

Compiled by Wright Water Engineers for
the Colorado Stormwater Council and the E. coli Work Group of the Water Quality Forum

Acknowledgements:
Substantial portions of this bibliography are based on references compiled by others. The following sources are recognized as key sources of information in this bibliography:

30% of the references were compiled by **Robert Pitt, P.E., Ph.D., University of Alabama**

30% of the references were compiled from **Sturdevant Rees, P. L., S. C. Long, R. Baker, D. H. Bordeau, R. Pei, and P. K. Barten. 2006. Development of Event-Based Pathogen Monitoring Strategies for Watersheds. Denver, CO: AwwaRF.**

20% of the references were compiled by the **U.S. Environmental Protection Agency** (**USEPA)** as part of the USEPA's Pathogen TMDL Guidance (EPA 2001)

15% of the references were compiled by participants in the **U.S. Environmental Protection Agency's Experts Scientific Workshop on Critical Research Needs for the Development of New or Revised Recreational Water Quality Criteria**

5% of the references were compiled by Others

It is noteworthy that references cited by the five groups of reference providers did not significantly overlap.

Purpose:
This bibliography was developed to provide a common base of references useful in developing approaches to E. Coli TMDLs in Colorado. Key words have been assigned to the references to facilitate sorting and searching by topic. Key words include the following:

Keyword Topic:
Agriculture
Criteria
Cryptosporidium
Enterococci
General
General Biology
Giardia
Illicit Discharge Detection/Elimination (IDDE)
Measurement
Methods (Analysis Methods)
Modeling
Natural sources
Pathogen Indicators
Source Identification
Source Water Protection
Standards
Stormwater
Treatment
Uncertainty
Use Attainability Analysis
Wildlife

Geographic Areas:
Australia
Canada
Coastal/Great Lakes/Beaches
Europe
New Zealand
U.S.
U.S. States {specific state names}

Key Bacteria/TMDL Websites

Source	Description	Hyperlink
Center for TMDL and Watershed Studies, Virginia Tech	TMDL Clearinghouse	http://www.tmdl.bse.vt.edu/site/knowledgebase/
International Stormwater BMP Database	Stormwater BMP Performance	http://www.bmpdatabase.org/BMPPerformance.htm
Robert Pitt, P.E., Ph.D., University of Alabama	Microorganisms in Urban Surface Waters (Module 7)	http://unix.eng.ua.edu/~rpitt/Class/ExperimentalDesignFieldSampling/MainEDFS.html
USEPA Water Quality Criteria-Microbial Pathogens	EPA website with information on Microbial Risk Assessment terms, Water Quality Standards and Implementation; Regulatory support documents; Drinking water health documents; and Proceedings	http://www.epa.gov/waterscience/criteria/humanhealth/microbial/
USEPA Expert Panel	Report of the Experts Scientific Workshop on Critical Research Needs for the Development of New or Revised Recreational Water Quality Criteria. EPA 823-R-07-006. June 2007.	http://www.epa.gov/waterscience/criteria/recreation/experts/index.html

Bibliography of Bacteria References
(periodic updates anticipated; last updated August 8, 2008)

Reference	Year	State or Country (if relevant)	Keywords	Colorado Geographic Location (if applicable)	Reference Reviewed/Cited By	Original Document Reference (if reference taken from another source)	Hyperlink
Adam, R. 1991. The biology of *Giardia* spp. *Microbiol. Rev.* 55(4): 706-732.	1991		General Microbiology		EPA Pathogen TMDL Guidance		
Adams, M.H. 1959. Bacteriophages. Interscience, New York.	1959		General Microbiology		EPA Pathogen TMDL Guidance		
Ahmed, F.E. (ed.) 1991. *Seafood safety.* Committee on Evaluation of the Safety of Fishery Products, Food and Nutrition Board, Institute of Medicine, National Academy Press, Washington, DC.	1991	Coastal/Great Lakes/Beaches	TMDL		EPA Pathogen TMDL Guidance		
Akerlinch, G. "The quality of stormwater flow." *Nord. Hyg. Tidskr.* (Denmark), 31,1. 1950.	1950	Denmark	Stormwater		Pitt	http://unix.eng.ua.edu/~rpitt/Class/ExperimentalDesignFieldSampling/MainEDFS.html	
Alaska Clean Water Alliance v. Clark . 1997. No. C96- 1762R, Washington D.C.	1997	Alaska	Standards		EPA Pathogen TMDL Guidance		
Alderisio, K.A., D. Wait, and M.D. Sobsey. 1996. Detection and characterization of male-specific RNA coliphages in a New York City reservoir to distinguish between human and non-human sources of contamination. In *Watershed Restoration Management: Physical, Chemical, and Biological Considerations* , pp. 133-142. New York City Water Supply Studies, American Water Resources Association, July.	1996	New York	Source Identification; Source Water Protection; Natural Sources		EPA Pathogen TMDL Guidance		
Alexander, L.M., A. Heaven, A. Tennant, and R. Morris. "Symptomatology of children in contact with sea water contaminated with sewage." *Journal of Epidemiology and Community Health* . Vol. 46, pp. 340-344. 1992.	1992	Coastal/Great Lakes/Beaches	Risk; Children		Pitt	http://unix.eng.ua.edu/~rpitt/Class/ExperimentalDesignFieldSampling/MainEDFS.html	
Altman, P.L., and D.S. Dittmer, editors. *Biology Data Book.* 2nd ed., V.II. Fed. of Amer. Soc. for Exp. Biology. 1973.	1973		General Biology		Pitt	http://unix.eng.ua.edu/~rpitt/Class/ExperimentalDesignFieldSampling/MainEDFS.html	
Ambrose, R.B., J.L. Martin, and J.F. Paul. 1992. *Estuaries and Waste Load Allocation Models* . Technical Guidance Manual for Performing Waste Load Allocations, Book III, Part 1. EPA 823-R-92-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC.	1992		TMDL; Models		EPA Pathogen TMDL Guidance		
American Public Health Association (APHA), American Water Works Association (AWWA), Water Environment Federation (WEF). 1995. *Standard Methods for the Examination of Water and Wastewater* , 19th Edition. Franson, A.H., A.D. Eaton, L.S. Clesceri and A.E. Greenbrg (eds.).	1995		Methods		EPA Pathogen TMDL Guidance		
American Public Health Association, Washington, DC. American Society of Agricultural Engineers (ASAE). 1998. *ASAE Standards,* 45th Edition. Standards, Engineering Practices, Data. Anderson, B.C. 1986. Effect of drying on the infectivity of *Cryptosporidia* -laden calf feces for 3 to 7 day old mice. *Amer. J. Vet. Res* . 47(10):2272-2273.	1998		Agriculture; Cryptospordium		EPA Pathogen TMDL Guidance		
American Water Works Association Research Foundation and U.S. Environmental Protection Agency, 2006. Development of Event-based Pathogen Monitoring Strategies for Watersheds.	2006		Monitoring; Stormwater; Source Water Protection; Natural Sources;		WWE		
Andelman, J., H. Bauwer, R. Charbeneau, R. Christman, J. Crook, A. Fan, D. Fort, W. Gardner, W. Jury, D. Miller, R. Pitt, G. Robeck, H. Vaux, Jr., J. Vecchioli, and M. Yates. *Ground Water Recharge Using Waters of Impaired Quality* . Committee on Ground Water Recharge. Water Science and Technology Board. National Research Council. National Academy Press. Washington, D.C. 1994.	1994		Risk; Fate and Transport; General Biology;		Pitt	http://unix.eng.ua.edu/~rpitt/Class/ExperimentalDesignFieldSampling/MainEDFS.html	
Anderson, SA; Turner, SJ; Lewis, GD. 1997. Enterococci in the New Zealand environment – Implications for water quality monitoring. *Water Science and Technology* 35(11-12): 325-331.	1997	New Zealand	Pathogen Indicators; Monitoring; Enterococci		EPA 2007 Experts Workshop Chapter 2	http://www.epa.gov/waterscience/criteria/recreation/experts/chapter02.pdf	
APHA, AWWA, WEF. 1998. *Standard Methods for the Examination of Water and Wastewater* , 20th edition. Washington, DC: American Public Health Association.	1998		Drinking Water; Monitoring		Awwarf		
Arango P.C., and S.C. Long. 1998. Alternative Bacterial Indicators of Sources of Microbial Inputs to Watersheds of Drinking Water Sources. In *Proceedings of the American Water Works Association Annual Conference and Exposition* , *Volume C* , June 21-15 (1998), Dallas, TX, pp. 679-687.	1998		Drinking Water; Monitoring		Awwarf		
Arango, C. 2000. Evaluation and Optimization of Detection Methods for *R. coprophilus* and Sorbitol-Fermenting *Bifidobacteria* as Source-Specific Indicator Organism for Drinking Water Sources. Doctoral dissertation, Department of Civil and Environmental Engineering, University of Massachusetts, Amherst, MA.	2000		Drinking Water; Monitoring		Awwarf		
Ashbolt, N.J., G.S. Grohmann, and C.S.W. Kueh. 1993. Significance of Specific Bacterial Pathogens in the Assessment of Polluted Receiving Waters of Sydney. *Water Science and Technology,* 27 (3-4): 449-452.	1993	Australia	Drinking Water; Monitoring		Awwarf		
Ashbolt, NJ; Bruno, M. 2003. Application and refinement of the WHO risk framework for recreational waters in Sydney, Australia. *Journal of Water and Health* 1(3): 125-131.	2003	Australia	Modeling; Criteria;		EPA 2007 Experts Workshop Chapter 6	http://www.epa.gov/waterscience/criteria/recreation/experts/chapter06.pdf	
Ashbolt, NJ; Reidy, C; Haas, CN. 1997. Microbial health risk at Sydney's coastal bathing beaches. Proceedings of the 17th Australian Water and Wastewater Association Meeting, pp.104-111. Melbourne, Australia.	1997	Australia	Pathogen Indicators;		EPA 2007 Experts Workshop Chapter 2	http://www.epa.gov/waterscience/criteria/recreation/experts/chapter02.pdf	

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Ashbolt, NJ; Roser, D. 2003. Interpretation and management implications of event and baseflow pathogen data. In: Pfeffer, MJ; Abs, DJV; Brooks, KN (eds.). Proceedings of the American Water Resources Association, New York, NY.	2003		Pathogen Indicators;		EPA 2007 Experts Workshop Chapter 2	http://www.epa.gov/waterscience/criteria/recreation/experts/chapter02.pdf	
Ashendorff, A, Principe, M.A., Seeley, A., LaDuca, J., Beckhardt, L., Faber Jr., Walter, Mantus, J. 1997. Watershed protection for New York City's supply. *Journal of AWWA* , 89 (3):75-88.	1997	New York	Drinking Water; Monitoring		Awwarf		
Atherholt, T.B., M.W. Lechevallier, and J.S. Rosen. 1998. Effect of Rainfall on *Giardia* and *Crypto* . *Journal of AWWA* , 90 (9): 66-80.	1998		Drinking Water; Monitoring		Awwarf		
Atherton F., C.P. Newman, and D.P. Casemore DP. 1995. An Outbreak of Waterborne Cryptosporidiosis Associated with a Public Water Supply in the UK. *Epidemiology and Infection* , 115 (1):123-31.	1995	U.K.	Drinking Water; Monitoring		Awwarf		
Auer, M.T. and S.L. Niehaus. 1992. Modeling fecal coliform bacteria—I. Field and laboratory determination of loss kinetics. *Water Resources* 27(4): 693-701.	1992		TMDL		EPA Pathogen TMDL Guidance		
Auer, M.T., and S.L. Niehaus. 1993. Modeling Fecal Coliform Bacteria I. Field and Laboratory Determination of Loss Kinetics. *Water Research,* 27 (4): 693-701.	1993		Drinking Water; Monitoring		Awwarf		
AVCO Economic Systems Corp. Storm Water Pollution From Urban Land Activity. USEPA Report No. 11034FKL07/70. NTIS No. PB 195 281. July 1970.	1970		Stormwater		Pitt	http://unix.eng.ua.edu/~rpitt/Class/ExperimentalDesignFieldSampling/MainEDFS.html	
AWWA. 1999a. *Waterborne Pathogens, AWWA Manual M48* . Denver, CO: American Water Works Association.	1999		Drinking Water; Monitoring		Awwarf		
AWWA. 1999b. *Water Quality and Treatment, 5th Edition* . Denver, CO: American Water Works Association, Denver.	1999		Drinking Water; Monitoring		Awwarf		
Badenoch, J. C., L.R. Bartlett, C. Benton, D.P. Casemore, R. Cawthorne, F. Earnshaw, K.J. Ives, J. Jeffery, H.V. Smith, M.S.B. Vaile, D.A. Warrell, and A.E. Wright. 1990. *Cryptosporidium* in water supplies. Report of the Group Experts. Copyright Controller of the HMSO, London, UK.	1990		TMDL		EPA Pathogen TMDL Guidance		
Badenoch, J.. 1990. *Cryptosporidium* – A Water-borne hazard. *Letters in Applied Microbiology,* 11(6):269-270.	1990		Drinking Water; Monitoring		Awwarf		
Bales, R.C, S.M. Li, K.M. Maguire, M.T. Yahya, C.P. Gerba, and R.W. Harvey. 1995. Virus and Bacteria Transport in a Sandy Aquifer, Cape Cod, MA. *Groundwater,* 33: 653-661.	1995	Massachusetts	Drinking Water; Monitoring		Awwarf		
Bannerman, R., K. Baun, M. Bohn, P.E. Hughes, and D.A. Graczyk. *Evaluation of Urban Nonpoint Source Pollution Management in Milwaukee County, Wisconsin, Vol. I.* Grant No. P005432-01-5, PB 84-114164. US Environmental Protection Agency, Water Planning Division, November 1983.	1983	Wisconsin	Stormwater		Pitt	http://unix.eng.ua.edu/~rpitt/Class/ExperimentalDesignFieldSampling/MainEDFS.html	
Bannerman, R.T., D.W. Owens, R.B. Dodds, and N.J. Hornewer. 1993. Sources of Pollutants in Wisconsin Stormwater. *Water Science and Technology,* 28 (3-5): 241-259.	1993	Wisconsin	Drinking Water; Monitoring		Awwarf		
Barbe, D.E., J.C. Francis, and M. Gunta. 1998. Seasonal Microbial Levels in Adjacent Watersheds. In *Proceedings of Water Resources Engineering* August 3-7: 1625-1630.	1998		Drinking Water; Monitoring		Awwarf		
Barnes, B; Gordon, DM. 2004. Coliform dynamics and the implications for source tracking. *Environmental Microbiology* 6(5): 501-519.	2004	U.S.	Pathogen Indicators		EPA 2007 Experts Workshop Chapter 2	http://www.epa.gov/waterscience/criteria/recreation/experts/chapter02.pdf	
Barten, P.K., T. Kyker-Snowman, P.J. Lyons, T. Mahlstedt, R. O'Connor, and B.A. Spencer. 1998. Managing a Watershed Protection Forest. *Journal of Forestry,* 96(8):10-15.	1998		Drinking Water; Monitoring		Awwarf		
Bartley, C. H., and L. W. Slanetz. "Types and sanitary significance of fecal streptococci isolated from feces, sewage, and water." *Am. J. Pub. Health* 50:1545-1552. Oct. 1960.	1960		Stormwater		Pitt	http://unix.eng.ua.edu/~rpitt/Class/ExperimentalDesignFieldSampling/MainEDFS.html	
Baudart, B., J. Grabulos, J.P. Barusseau, and P. Lebaron. 2000. *Salmonella spp* . and Fecal Coliform Loads in Coastal Waters from a Point vs. Nonpoint Source of Pollution. *Journal of Environmental Quality,* 29 (January-February): 241-250.	2000		Drinking Water; Monitoring		Awwarf		
Baudisova, D. 1997. Evaluation of *Escherichia coli* as the Main Indicator of Fecal Pollution. *Water Science and Technology,* 35 (11-12): 333-336.	1997		Drinking Water; Monitoring		EPA Pathogen TMDL Guidance		
Baxter-Potter, W.R., and M.W. Gilliland. 1988. Bacterial pollution in runoff from agricultural lands. *Journal of Environmental Quality* 17(1):27-34.	1988		TMDL		EPA Pathogen TMDL Guidance		
Beerens, H. 1991. Detection of Bifidobacteria by Using Propionic Acid as a Selective Agent. *Applied and Environmental Mictobiology,* 57: 2418-2419.	1991		Drinking Water; Monitoring		Awwarf		
Bellow, Barbara, 2003. *Managed Grazing in Riparian Areas* . National Center for Appropriate Technology, Appropriate Technology Transfer to Rural Areas (ATTRA) Livestock Systems Guide.	2003	U.S.	Agriculture		WWE		
Berg, G., editor. *Transmission of Viruses by the Water Route.* Interscience Publishers, NY. 1965.	1965		Stormwater		Pitt	http://unix.eng.ua.edu/~rpitt/Class/ExperimentalDesignFieldSampling/MainEDFS.html	
Berg, R. W., and A. W. Anderson. "Salmonellae and *Edwardsiella tarda* in gull feces: a source of contamination in fish procession plants." *Applied Microbiology*. 24, 3:501-503. Sept. 1972.	1972		Stormwater		Pitt	http://unix.eng.ua.edu/~rpitt/Class/ExperimentalDesignFieldSampling/MainEDFS.html	

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(periodic updates anticipated; last updated August 8, 2008)

Reference	Year	State or Country (if relevant)	Keywords	Colorado Geographic Location (if applicable)	Reference Reviewed/Cited By	Original Document Reference (if reference taken from another source)	Hyperlink
Bergstrom, J. Rockaway River Water Quality Study: Evaluating and Implementing TMDLs in an Urban Watershed.Presented at 8th Annual American Ecological Engineering Society Meeting: Biological Systems Engineering. Blacksburg, Virginia.	2008		TMDL; Urban Watershed		AEES		
Berka, C., H. Schreier, and K. Hall. 2001. Linking Water Quality With Agricultural Intensification in a Rural Watershed. *Water, Air, and Soil Pollution,* 127 (May): 389-401.	2001		Drinking Water; Monitoring		Awwarf		
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Waller, D.H. and Z. Novak. "Pollution loading to the Great Lakes from municipal sources in Ontario." *Journal WPCF*. March 1981.	1981	Canada	Pollution; Lake		Pitt	http://unix.eng.ua.edu/~rpitt/Class/ExperimentalDesignFieldSampling/MainEDFS.html	
Waller, D.H. and Z. Novak. *Municipal Pollutant Loads to the Great Lakes from Ontario Communities.* Canada/Ontario Agreement Research Report, Ottawa, Ontario (undated).	undated	Canada	Stormwater		Pitt	http://unix.eng.ua.edu/~rpitt/Class/ExperimentalDesignFieldSampling/MainEDFS.html	
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Weibel, S.R., R.J. Anderson, and R.L. Woodward. "Urban land runoff as a factor in stream pollution." *Journal WPCF.* 36:914-924. July 1964.	1964		Stream Pollution; Runoff		Pitt	http://unix.eng.ua.edu/~rpitt/Class/ExperimentalDesignFieldSampling/MainEDFS.html	
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Whitman, R. 2007. Project S.A.F.E. Website.	2007		Modeling; Criteria		EPA 2007 Experts Workshop Chapter 6	http://www.epa.gov/waterscience/criteria/recreation/experts/chapter06.pdf	http://www.glsc.usgs.gov/
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WHO. *Guide and Criteria for Recreational Quality of Beaches and Coastal Waters*. 28 October - 1 November 1974. Bilthoven. 1975.	1975	Coastal/Great Lakes/Beaches	Criteria		Pitt	http://unix.eng.ua.edu/~rpitt/Class/ExperimentalDesignFieldSampling/MainEDFS.html	
WHO. *Health Criteria and Epidemiological Studies Related to Coastal Water Pollution*. 1-4 March 1977. Athens. 1977	1977	Coastal/Great Lakes/Beaches	Criteria; Stormwater		Pitt	http://unix.eng.ua.edu/~rpitt/Class/ExperimentalDesignFieldSampling/MainEDFS.html	
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Woodruff, D.L. 1992. *Clostridium perfringens* as a Sewage Indicator in Coastal Sediments: Development and Comparison of an Alternative Method of Analysis. Master's thesis. Department of Environmental Science and Engineering, University of North Carolina, Chapel Hill, NC.	1992		Drinking Water; Monitoring		Awwarf		
WPCF. 1989. *Combined Sewer Overflow Pollution Abatement*. Manual of Practice No. FD-17. Task Force on CSO Pollution Abatement, Water Pollution Control Federation, Alexandria, VA.	1989		TMDL		EPA Pathogen TMDL Guidance		

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Wright, R.M., P.M. Nolan, D. Pincumbe, E. Hartman, O.J. Viator. 2001. *Blackstone River Initiative: Water Quality Analysis of the Blackstone River Under Wet and Dry Weather Conditions*. Boston, Massachusetts: EPA New England.	2001	New England	Drinking Water; Monitoring		Awwarf		
Wyer, D; Kay, D; Fleisher, JM. 1999. An experimental health-related classification for marine waters. *Water Research* 33(3): 715-722.	1999		Criteria Development;		EPA 2007 Experts Workshop Chapter 1	http://www.epa.gov/waterscience/criteria/recreation/experts/chapter01.pdf	
Wyer, M. D., G. O'Neill, D. Kay, et. al. "Non-outfall sources of faecal indicator organisms affecting compliance of coastal waters with directive 76/160/EEC." *Water Science and Technology*. 35: 11-12, 151-156. 1997.	1997		Fecal Coliform; Coastal Water Quality		Pitt	http://unix.eng.ua.edu/~rpitt/Class/ExperimentalDesignFieldSampling/MainEDFS.html	
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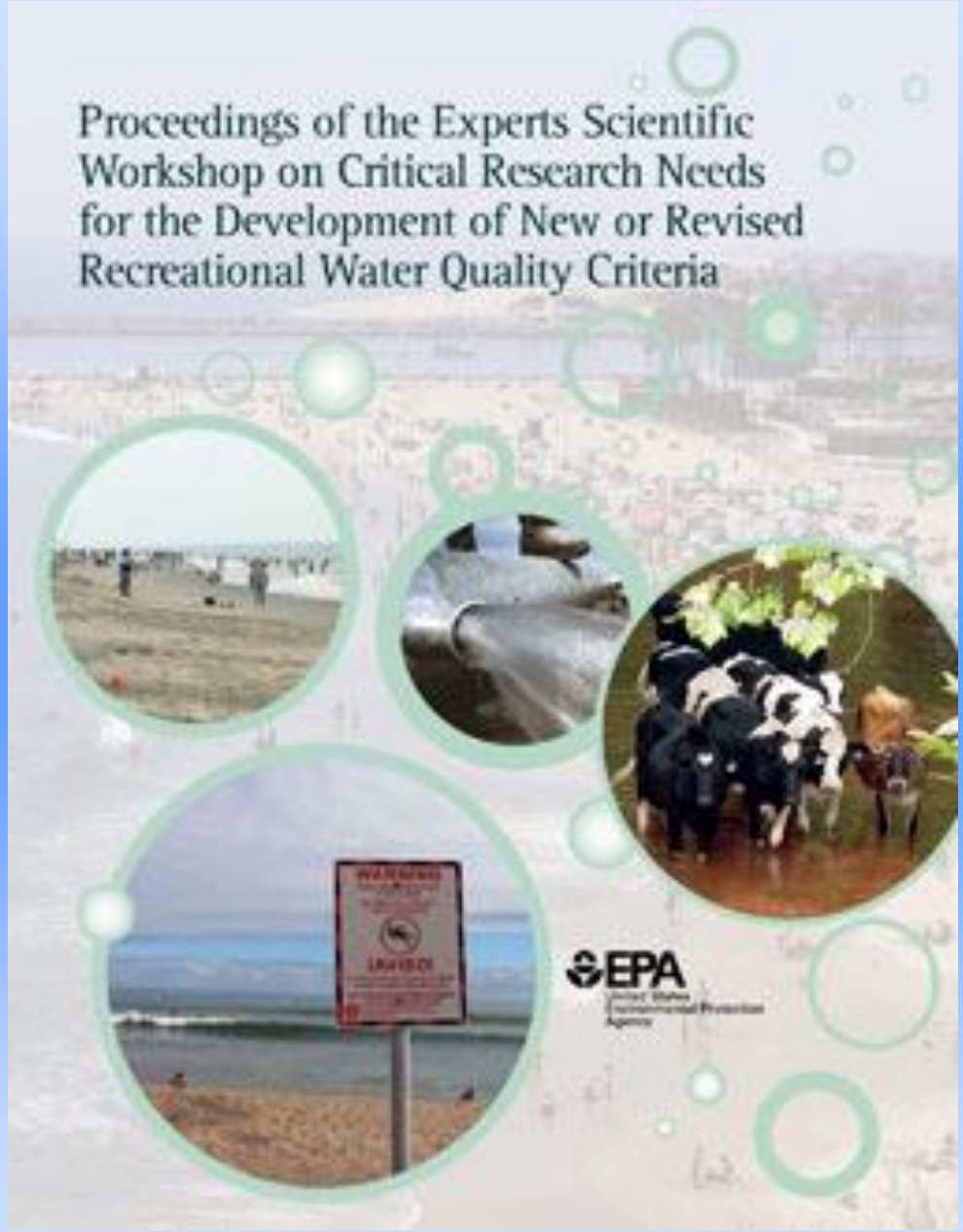
Zimmerman, T. "How to revive the Chesapeake Bay: Filter it with billions and billions of oysters." *U.S. News & World Report*. Pg. 63. December 29, 1997/January 5, 1998.	1998	Maryland, Virginia	Water Quality Management		Pitt	http://unix.eng.ua.edu/~rpitt/Class/ExperimentalDesignFieldSampling/MainEDFS.html	

Overview of "Pellston Style Workshop Bacteria Report"

What Does it Mean for CO TMDLs?

Presented by
Jane Clary
Wright Water Engineers, Inc.
at the E. coli Work Group
February 2008



Presentation Approach

- Overview
  - Who, what, when, where
  - Why changes needed
  - Major topics
- Key quotes/ comments for later reference (*not all slides will be discussed*)
- Discussion topics for future CO TMDLs

Obtain the full report: (http://www.epa.gov/waterscience/criteria/recreation/)

Background

- Who:
  - EPA invited 43 U.S. and international experts from academia, numerous states, public interest groups, USEPA and other federal agencies (“Pellston”-style workshop)
- When:
  - Meeting in March 2007, Report in June 2007
- Why:
  - To discuss the state of the science on recreational water quality research and implementation issues to support revised criteria by 2012.
  - The purpose was for EPA to obtain input from experts on the “critical path” research/needs in the near-term (2-3 yrs) for developing scientifically defensible new or revised recreational ambient water quality criteria.

Why Are New/ Revised Criteria Needed?
Selected Comments from Experts

- "Designed to protect swimmers from illnesses due to exposure to pathogens in recreational waters, the existing criteria are more than 20 years old." (EPA website)
- "1986 criteria provide defined criteria at a single risk level but do not provide for adjustment based on other sources of information such as sanitary investigations or source identification." p.166

Why (cont., p. 145)

- The 1986 criteria provide minimal implementation guidance.
- Due to most States' interpretation…, the criteria tend to be treated as requiring compliance at all times and in all waters. This interpretation has caused considerable problems in the assessment and TMDL arenas.
- Any new or revised criteria must include implementation guidance that allow for methods to address issues such as extreme flows and nonhuman sources of fecal contamination.

Why (cont. from p.166)

- The original basis for the 1986 criteria were freshwater and marine water epidemiological studies conducted at a limited number of sites with restricted geographic extent and waterbody type (lake beaches and marine beaches).
- "A concern exists that single value criteria may not be applicable to all waters across the United States—for instance, inland flowing waters…"
- In developing new criteria, epidemiological data or quantitative microbiological risk assessment (QMRA) for as wide a variety of fresh and marine waters as is possible should be used.

What's in the Report

Experts Assigned to Workgroups Corresponding to Chapters

1. Approaches to Criteria Development **
2. Pathogens, Pathogen Indicators, and Indicators of Fecal Contamination
3. Methods Development
4. Comparing Risk (to Humans) from Different Sources
5. Acceptable Risk
6. Modeling Applications for Criteria Development and Implementation
7. Implementation Realities**

**Read these chapters

Appendices

- A—Charge to the Expert Workgroup Members
- B—Participant List
- C—Translation of Epidemiology to Disease Burden by WHO and EU
- D—Summary of European Commission Directive
- E—Indicator Terminology *Good Reference*
- F—Summary of Measurements Currently Planned for the Doheny and Malibu Beach Epidemiology Study *We need to watch this*
- G—Development of Deterministic Models

Chapter 1
Approaches to Criteria Development

Standards Process

CWA Water Quality Standards are composed of 3 parts:

- Designated use (DU)
- Ambient water quality criteria (AWQC) to support the DU
- Antidegradation provisions to protect existing uses and high quality waters

Designated Use (§303(c))

- Use Attainability Analysis (UAA) required if fishable/swimmable uses not assigned
- Economic and social impacts may be considered

→ Criteria for protection of aquatic wildlife

↓

EPA **AWQC** for protection of human health

- Criteria based on DU
- Separate criteria for each pollutant (§304(a))
- EPA AWQC are guidance only

↓

In general, States and Tribes have four options (§303(c)):

- Adopt EPA §304(a) criteria
- Modify §304(a) criteria to reflect regional considerations
- Develop their own criteria (scientifically defensible)
- Adopt narrative criteria where numeric criteria cannot be determined

Also:

- EPA reviews changes to State or Tribal criteria for protection of the designated use and scientific defensibility
- State and Tribal criteria are not effective for CWA purposes until approved by EPA
- In the case of multiple DUs, criteria must support the most sensitive use
- State-adopted and EPA-approved State and Tribal WQS form the regulatory compliance numbers for CWA purposes

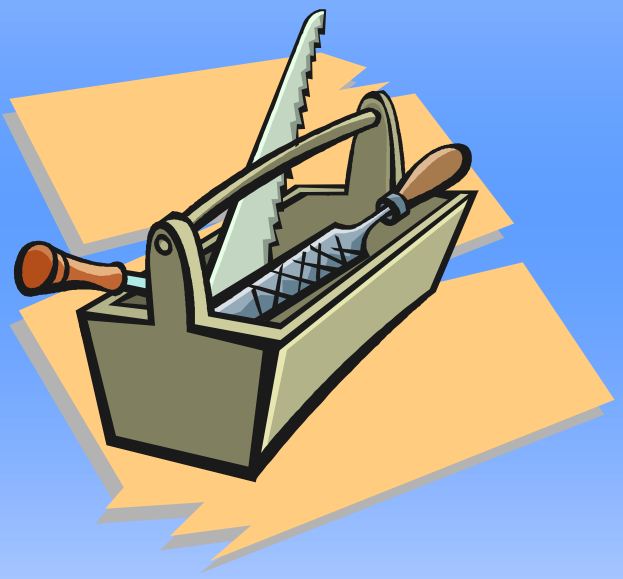
General Comments (from Executive Summary)

- Because of the diverse nature of watersheds throughout the United States, there was general agreement that criteria that have flexibility are desirable.
- A common statement:
  - A "one size fits all" criterion is inadequate for public health protection and the compliance applications under the CWA.
- Experts agreed:
  - EPA should develop implementation guidance, including monitoring protocols, concurrently with development of criteria and release them simultaneously.

This is good news!

EPA Suggests a Toolbox Approach

- Increased flexibility for better nation-wide application
- Equivalent risk levels must be achieved, regardless of selected tool
- Implementation issues exist related to how to relate different “tools”



Workshop Process

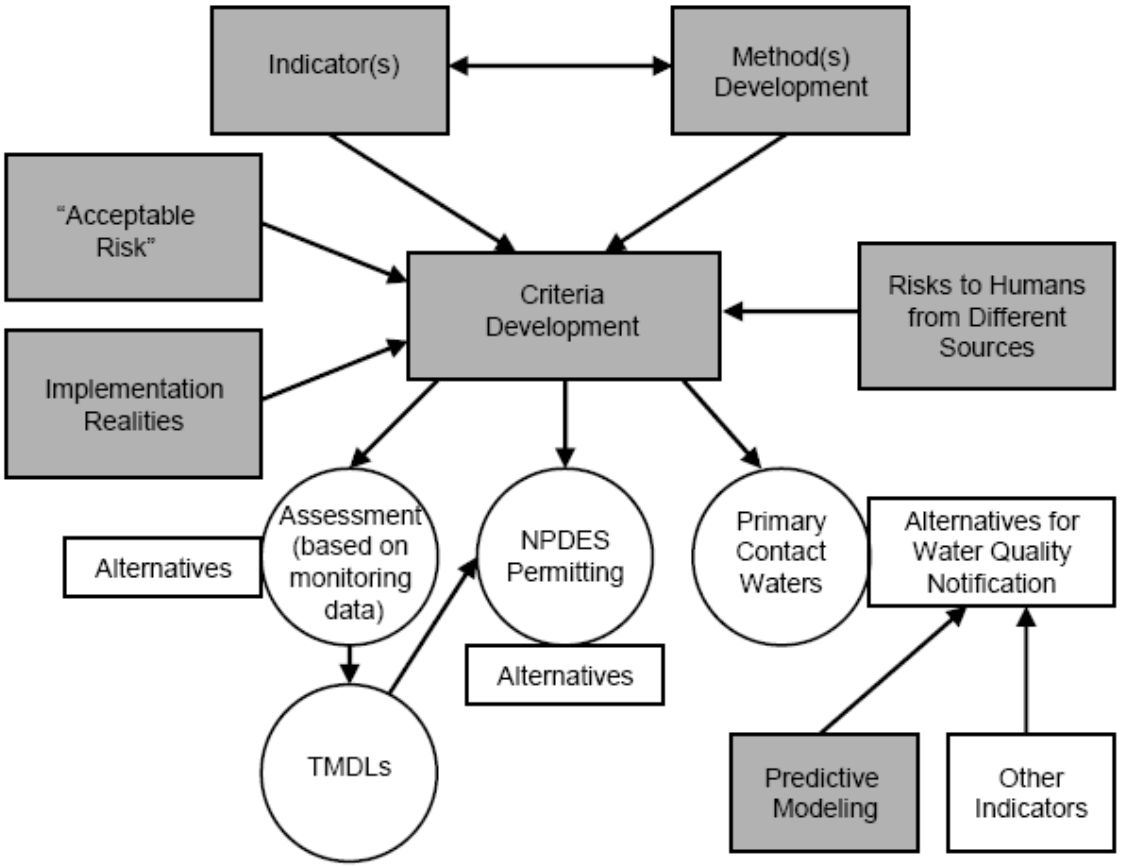


Figure 3. Flow Diagram of How the Workgroup Topics Contribute to the Development and Implementation of New or Revised Recreational Water Quality Criteria.

Benchmarks for Criteria Development (see p. 11)

1. Health-based.
2. Useful for and be compatible with all of the CWA criteria (e.g., BEACHES Act of 2000, assessment, notification, 303(d) listing, TMDLs, NPDES)
3. Scientifically defensible in a wide variety of geographical locations and water body types.
4. Sufficiently robust and flexible to provide adequate protection
5. Sufficiently robust and flexible to provide regulators the ability to protect susceptible (sensitive) subpopulations such as children and immunocompromised individuals. …protecting the health of children was paramount.
6. Linked with analytical methods that are reliable, robust, and reproducible
7. Protect primary contact recreation in various waters equally

Approaches Considered

- World Heath Organization (WHO)—2003
- European Union (EU)—2006 (in appendix)
- Modified EPA 1986 Criteria

WHO Approach (p. 14)

- “Recreational water quality and protection of public health are best described by a combination of sanitary inspection and microbial water quality assessments”
- “Banded" approach

Table 1. WHO Classification Matrix for Integrating Microbial Water Quality as Measured by Enterococci Density with Sanitary Inspection Category.

		Microbial Water Quality Assessment Category (95th percentile intestinal enterococci/100 ml)				
		A ≤40	**B** 41–200	**C** 201–500	**D** >500	**Exceptional circumstances**
Sanitary Inspection Category (susceptibility to faecal influence)	**Very low**	Very good	Very good	Follow up[1]	Follow up[1]	Action
	Low	Very good	Good	Fair	Follow up[1]	
	Moderate	Good[2]	Good	Fair	Poor	
	High	Good[2]	Fair[2]	Poor	Very poor	
	Very high	Follow up[2]	Fair[2]	Poor	Very poor	
	Exceptional circumstances	Action				

Notes:

[1] implies non-sewage sources of faecal indicators (e.g., livestock), and this should be verified (section 4.6.2).

[2] indicates possible discontinuous/sporadic contamination (often driven by events such as rainfall). This is most commonly associated with Combined Sewer Overflow (CSO) presence. These results should be investigated further and initial follow-up should include verification of sanitary inspection category and ensuring samples recorded include "event" periods. Confirm analytical results. Review possible analytical errors (see section 4.6.2).

[3] In certain circumstances, there may be a risk of transmission of pathogens associated with more severe health effects through recreational water use. The human health risk depends greatly upon specific (often local) circumstances. Public health authorities should be engaged in the identification and interpretation of such conditions (section 4.6.5).

[4] Exceptional circumstances (see section 4.6.5) relate to known periods of higher risk, such as during an outbreak with a pathogen that may be waterborne, sewer rupture in the recreational water catchment, etc. Under such circumstances, the classification matrix may not fairly represent risk/safety.

SOURCE: WHO, 2003.

EU 2006 Approach

- Generally adopted WHO 2003, with these changes:
  - Does not include the sanitary inspection category information for the purposes of recreational water classification. Instead, it uses only the microbial water quality assessment information to characterize the probability of exposure to human pathogens.
  - Used WHO criteria for marine waters and applied the same risk assessment framework to new epidemiological data to derive standards for fresh recreational waters
  - Allows sample discounting.
    - Under discounting, numeric excursions above the water quality standards that are predicted and/or measured do not count against the waterbody for compliance determination (i.e., such values are discounted from the data set prior to calculation of the 95th percentile, but only 15% of scheduled samples can be so discounted). Sample discounting is allowed when a predictive model, source reduction plan, and communication management system are in place to inform the public about short-term pollution events derived during predictable conditions (e.g., rainfall).

- See Appendix D for 2006 Bathing Directive

Table 2. Numerical Microbiological Water Quality Assessment Classification for Fresh (Inland) and Marine (Coastal and Transitional) Bathing Waters for the 24 EU Member States.

Inland (Fresh) Waters			
Indicator	Excellent	Good	Sufficient
(Intestinal) enterococci (cfu/100 mL)	200*	400*	360**
E. coli (cfu/100 mL)	500*	1,000*	900**
Coastal and Transitional (Marine) Waters			
Indicator	Excellent	Good	Sufficient
(Intestinal) enterococci (cfu/100 mL)	100*	200*	200**
E. coli (cfu/100 mL)	250*	500*	500**

Notes: * = Based on a 95th percentile evaluation; ** = Based on a 90th percentile evaluation to reduce the risk of statistical anomalies when using a small data set, which also allows lower limit values for enterococci and *E. coli* densities in inland waters to be classified as sufficient versus good microbiological water quality.

Source: Adapted from EP/CEU (2006).

Possible Provisions in an Alternative "Hybrid" Approach to EPA 1986 Criteria (p. 145)

- a provision to discount non-compliance with the single value criteria after investigation of the contributing watershed to confirm the absence of nonhuman sources and lower risk than implied by the criteria exceedance;
- criteria/use inapplicability during extreme high flow events; and
- a process to exclude natural sources of fecal indicator organisms (i.e., indicators specific to human sources are not present), according to the corresponding risk to human health.

Table 4a. Summary of Proposed Criteria Development Approaches: Strengths and Limitations

Criteria Approach	Science Supporting Approach	Strengths	Limitations
World Health Organization (WHO, 2003)	Fleisher et al., 1996 Kay et al., 1994, 2004 WHO, 1999 Wyer et al., 1999	• Flexible • Most comprehensive of available methods • Adopted by other countries • Incentives for beaches to upgrade • Allows more site appropriate protection of health	• Sanitary inspection component is qualitative; not quantitative • Greatest data needs • Would need to adapt potentially complex system to wide range of conditions in U.S. • Potential implementation issues
European Union (EP/CEU, 2006)	Fleisher et al., 1996 Kay et al., 1994, 2004 Wiedenmann et al., 2006 WHO, 1999, 2003	• Flexible • Relatively straightforward • Incentives for beaches to upgrade • Adopted by other EU Member States	• Discounting system has no direct precedent in the U.S. • Would need to devise robust and acceptable discounting scheme • Potential implementation issues
Current U.S. Criteria (US EPA, 1986)	US EPA, 1983, 1984	• Relatively straightforward • Currently in place in most states, new implementation issues less likely • Fewest data requirements	• Allows less flexibility • Single sample max (75^{th} percentile) has been criticized from implementation perspective • Credibility concerns in many parts of the U.S.

Table 4b. Summary of Three Proposed Criteria Development Approaches: Benchmarks

Criteria Approach	Criteria Attribute	Approach Compatible with Attribute
World Health Organization (WHO, 2003)	Health-based	Yes
	CWA §304(a) applications	Most challenging – unclear how different grades for beaches would be interpreted with respect to impaired waters; for example, TMDLs would need to be considered.
	Geographic variability	Not with current indicator, ongoing research could fill gaps
	Point vs. non-point	No, epidemiological data would be needed
	Multiple subpopulations	Could be, but in current configuration children not analyzed separately
	Uniform risk across waterbody types	Yes
	Linked to method that is validated	Yes currently, but will also depend on future indicators
European Union (EP/CEU, 2006)	Health-based	Yes, but differential risks from different sources of fecal contamination is not included, thus, this approach is less health-based than WHO approach
	CWA §304(a) applications	Yes, but challenging for same reasons as WHO approach
	Geographic variability	Not with current indicator, ongoing research could fill gaps
	Point vs. non-point	No
	Multiple subpopulations	Could be, but in current configuration children not analyzed separately
	Uniform risk across waterbody types	Yes
	Linked to method that is validated	Yes currently, but will also depend on future indicators
Current U.S. Criteria (US EPA, 1986)	Health-based	Yes, but concern about single sample standard, also concerns that differential risks from different sources of fecal contamination are not included
	CWA §304(a) applications	Yes
	Geographic variability	No
	Point vs. non-point	No
	Multiple subpopulations	No
	Uniform risk across waterbody types	No, fresh and marine recreational waters have different "acceptable risks"; this could be addressed in new or revised criteria
	Linked to method that is validated	Yes currently, but will also depend on future indicators

Misc. Comments

- Criteria for Secondary Contact (p. 28): "Workgroup members defined secondary contact as limited or incidental contact."
- "Is a single criterion available that is appropriate for the diverse range of geographic conditions (p. 29)?"
  - "No. Different regions of the country have different potentials for regrowth, persistence, indicator/pathogen die off rates (UV exposure), and indicator/illness rate relationships. The literature supports the conclusion that additional indicators will be necessary to accurately identify those recreational waters that are at risk across all geographic regions of the country."
- No approach identified as "the" preferred path, waiting on data.

Chapter 2
Pathogens, Pathogen Indicators, Indicators of Fecal Contamination

Overview

Complex discussion—read the chapter

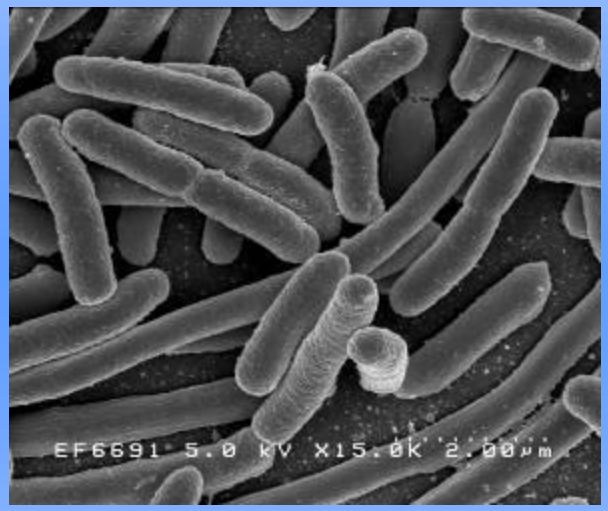
- Since 1986 AWQC, research has shown that this narrow health effects-based standard (i.e., epidemiological studies at beaches with point sources of human sewage) is limited in that it does not take into account differences in geographical conditions, ecology of microorganisms, and varying sources of fecal indicator bacteria.
- In this regard, the expected relationship between illness and indicator organism densities would be:
  - high if the source of contamination is human sewage,
  - moderate if the source was a mixture of human and animal feces, or
  - lower if the source is …replication of indicator bacteria in the environment, such as in soil, sediments, storm drains, or on plants or aquatic vegetative matter.

Monitoring Approach (p. 38)

- Tiered toolbox monitoring approach recommended:
  - ID point and non-point sources
  - Sanitary investigation
  - Select appropriate indicator
- Move from simplest and progress to more complex

E. coli as an Indicator

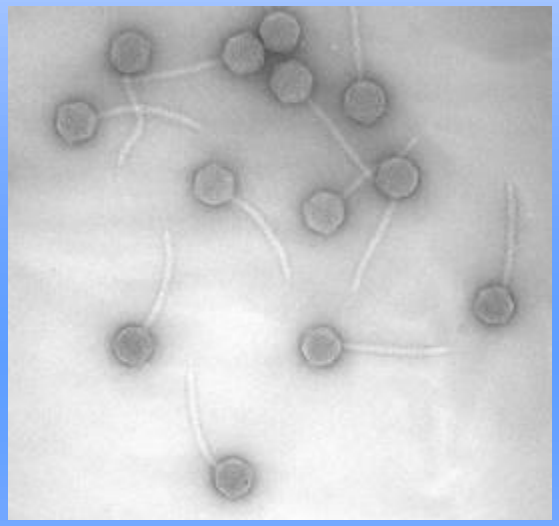
- "Of the traditional fecal indicators, only *E. coli* has been shown in epidemiological studies to consistently relate to health outcomes for freshwater recreational water users (Cabelli et al., 1982; Wade et al., 2003; Wiedenmann et al., 2006)."
- Sub-typing of different E. Coli strains not seen as helpful.



www.universityofcalifornia.edu/.../e_coli.jpg

Alternative Fecal Indicators

- **Bacteria**
  - ***Clostridium perfringens***
  - ***Bacteroides***
- Bacteriophages
  - ***Coliphages***
- EU Tracers
- Pathogens/Pathogen Indicators
  - Various problems (see p. 48)



whyfiles.org/coolimages/images/csi/0022a.jpg

Chemical Biomarkers

- Fecal sterols
  - (from cholesterol digestion; expensive/complex; possible supplement)
- Caffeine
  - (plant debris and dumping issues)
- Optical brighteners
  - But stills shows up in treated WWTP effluent
  - Reduce organic interference w/filter on flourometer

Indicators and Methods for Measuring Fecal Contamination

- Agreement that standards be based on fecal indicators. Reasons:
  - The level of occurrence and the types of pathogens in ambient waters vary greatly both temporally and spatially.
  - Some pathogens are only present in very small concentrations, yet may present a public health risk.
  - Methods to detect and quantify specific pathogens in ambient waters are not sufficiently developed at present to be practical for use in the near-term timeframe.
- Therefore, using suites of pathogens as the basis for new or revised criteria was not favored among workshop participants as a first "line of defense."
- However, pathogen monitoring may be useful as a subsequent tier for microbial water quality evaluation.
- For longer term research needs, further development of pathogen detection methods may result in a more important role.

Chapter 3 Methods Development

Method Purposes

- Routine beach monitoring to
  - support public health warning notification systems;
  - support TMDL decisions;
- Rapid methods to track the progress of a sewage spill to improve the beach closure determinations;
- Compliance assessments conducted at NPDES outfalls
- Trend assessments over time

Methods Challenges (pp.59-60)

- Turn-around time for beach closure notification
  - cultural methods >24 hrs;
  - molecular methods faster, but may not be fast enough
- One-size-fits-all problem:
  - “There is growing recognition that [the indicator] may derive from many sources, including humans, domesticated animals, indigenous wildlife (including shore and migratory birds), and regrowth in sand, sediments, or on biofilms.”
  - “The health risk to humans varies depending on which of these sources is responsible for the measured [indicator].”
  - “The costly cleanup processes associated with the TMDL programs are not necessarily focused on the beaches that represent the greatest public health risk.
  - There are additional concerns that cleanup activities, and associated costs, are being targeted at beaches where [] concentrations that exceed standards result from natural sources and processes.”

Possible Adjustments to Address One-Size-Fits-All

1. Add additional indicators more closely related to human sources to replace or augment existing indicators in tiered fashion.
2. Adopt WHO-type framework for site-specific standards, but source ID tools needed

Rest of Chapter Focuses on

1. More rapid methods
   - Problems with counting dead bacteria
   - Practicality & cost
2. Methods more directly associated with human contamination
   - Difficulty relating to current system (“equivalency”)
   – New CA protocol: *Beta Testing of Rapid Methods for Measuring Beach Water Quality* (SCCWRP, 2007)
3. Source ID methods to characterize risk in developing site-specific standards.

Method Performance Criteria

- repeatability
- accuracy
- specificity
- sensitivity
- robustness
- range of applicability
- practicality

Microbial Source Tracking (p. 67)

- “Although there has been significant progress in the MST field over the past decade, variability among performance measurements and validation approaches in laboratory and field studies has led to a body of literature that is very difficult to interpret, both for scientists and for end users (Stewart et al., 2003; Stoeckel et al., 2004).”
- “Within the MST community…, library-independent methods are currently the priority, while chemical-based methods appear to be desirable for rapid screening and presence-absence tests (with perhaps quantification in the future).”
- “Library-based methods still have a role in MST, but only in those circumstances where detailed information is needed, such as many TMDL-based studies.”

Studies to Watch

- Doheny and Malibu Beach Epidemiology study (?2007-2009?)—looking at multiple methods and indicators combined with an epidemiology study

Chapter 4
Comparing Risk from Different Sources

Workgroup Perspective on Natural vs. Human Sources

- "It is widely believed that human feces poses a larger health risk than animal feces to swimmers and other primary contact recreational water users. This belief derives from the basic concept that virtually all enteric pathogens of humans are infectious to other humans, while relatively few of the enteric pathogens of animals are infectious to humans."

BUT…p. 77

- "…there remains a paucity of data on the risk of illness for swimmers at beaches exclusively (or primarily) impacted by feces from animals. The absence of such data makes it difficult to interpret the health significance of the frequent and persistent elevated fecal indicator levels in such waters that have been attributed to animals in many locations throughout the United States."
- "The bottom line is that there are few data to demonstrate whether animal feces pose a lower, greater, or equivalent health risk to bathers than human feces. If there is a difference, it would be helpful to know the magnitude of that difference in order for EPA to make appropriate public health recommendations."
- Targeted studies needed on this issue.

Workgroup Perspective on Relative Risks

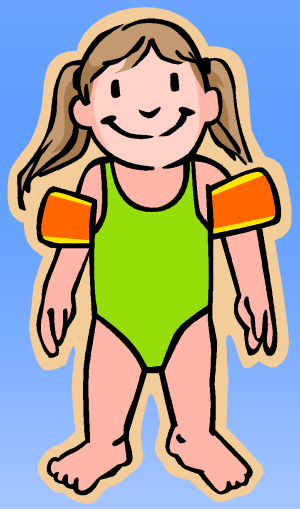


Table 5. Comparing Risks (to Humans) from Different Pathogen Sources.[a]

Source	Viruses	Protozoa	Bacteria	
Wildlife				
Aquatic birds	N	L	L-M	
Other (e.g., deer)	N	M	M	#2 priority
Agricultural animals				
Poultry	N	N	M-H	
Other (e.g., cattle, sheep)	N	M	M-H	#1 priority
Domestic animals				
Pets (e.g., dogs, cats)	N	L	L	
Fecal shedding by bathers				#3 priority
Adults	L	L	L	
Children	H	H	H	
Sewage				
No treatment (combined sewer overflows)	H	H	H	
No treatment (separate storm sewer overflows)	?*	?*	?*	
Secondary treatment**	H	H	M	
Plus chlorine**	H	H	L	
Plus UV	M-H (L with increased energy)		L	
Secondary environments* **	L	L	M	

[a] Does not have an explicit fate and transport component

* Risk largely depends on amount of human feces present

** Focus of most (U.S.) recreational water epidemiological studies

*** Sediment suspension and contact with beach sand

N = estimated no or negligible risk, L = estimated low risk, M = estimated medium risk, H = estimated high risk

Workgroup Comments (Table 5)

1. Current epidemiological literature suggests that the symptomatic profile of swimming associated illnesses indicates primarily viral illnesses.
2. Certain pathogens such as EHEC have a low probability of occurrence but are associated with severe health outcome.
3. Information available to the workgroup suggested that nonhuman fecal sources impacted freshwater sources more than marine water sources.
4. Combined sewer overflows (CSOs) were considered as untreated sewage.
5. Separate storm sewer overflows initially were put in the domestic animal row but subsequent discussion of recent studies suggested that they could have a human component in many communities.

Etiological Agents (p. 86)

- “Workgroup members felt it important to emphasize that there is a glaring lack of knowledge about the incidence with which specific pathogens cause swimmer-associated illnesses at both non-point source- and point source-impacted beaches.”

Fate and Transport (p.87)

- Direct deposition
- Indirect Deposition is more complicated…Very “wet” feces is more likely than “dry” feces to introduce pathogens into the aquatic environment. After defecation, the distance of the feces from surface water plays an important role as well.”
- Point Source
- Resuspension (1 paragraph)
- Ideally indicator will have same fate/transport as pathogen, but this is unlikely, so need to know how they relate.

Chapter 5
Acceptable Risk

Determining Risk Level and Subpopulations of Concern

- Agreement that children can have a higher risk of illness due to
  1. increased exposure from ingestion of higher volumes of water, and
  2. greater susceptibility due to immunological differences compared to healthy adults.
- Agreement that criteria not be established based on the susceptibility of immunocompromised individuals; rather, targeted risk communication and public health messages could be used to advise these individuals that they are at increased risk of illness and are advised not to swim.

"Acceptable Risk"

- Agreement to abandon term
- "The voluntary nature of recreational swimming needs to be clearly explained and put in context with other routinely and voluntarily accepted risks (e.g., driving to the beach, eating at local restaurants, smoking)." (p. 94)
- "It is not certain how accurate the current levels of protection are. "Magic" numbers like 8 or 19 cases of gastroenteritis in 1,000 swimmers can "take on a life of their own," increasing the risk of distraction from the basic objective—providing best effort to protect swimmers." (p. 99)
- "Most recreational water exposures are experienced by a minority of the population who are repeatedly (chronically) exposed." (p. 99)
- "More important than trying to enforce compliance with a fixed standard level of risk, is the need to work toward continual improvement in public health associated with recreational water use." (p. 100)

Areas of Discord

- “Although the phrase “tolerable risk” is now being used more frequently internationally, it was still not tolerated by all members of the workgroup.” p.100

Chapter 6
Modeling Applications for Criteria and Implementation

Overview (p. 107)

- Did not focus on models in TMDLs
- Model discussion focused on
  - Water quality notification/predictive models based on rainfall, etc.
  - Sanitary investigation models
- "There is limited understanding regarding the sources of microorganisms and their fate and transport in the aquatic environment, so the use of deterministic, process-based models criteria development and implementation is not practical for most U.S. water quality managers within the next five years (2012)."
- "Rather, **simple heuristic, statistical models that do not necessarily require an understanding of processes and mechanisms are more realistic for criteria development and implementation within the next 5 years."**

Timing/Notification Issues
Changes Indicator Concentrations

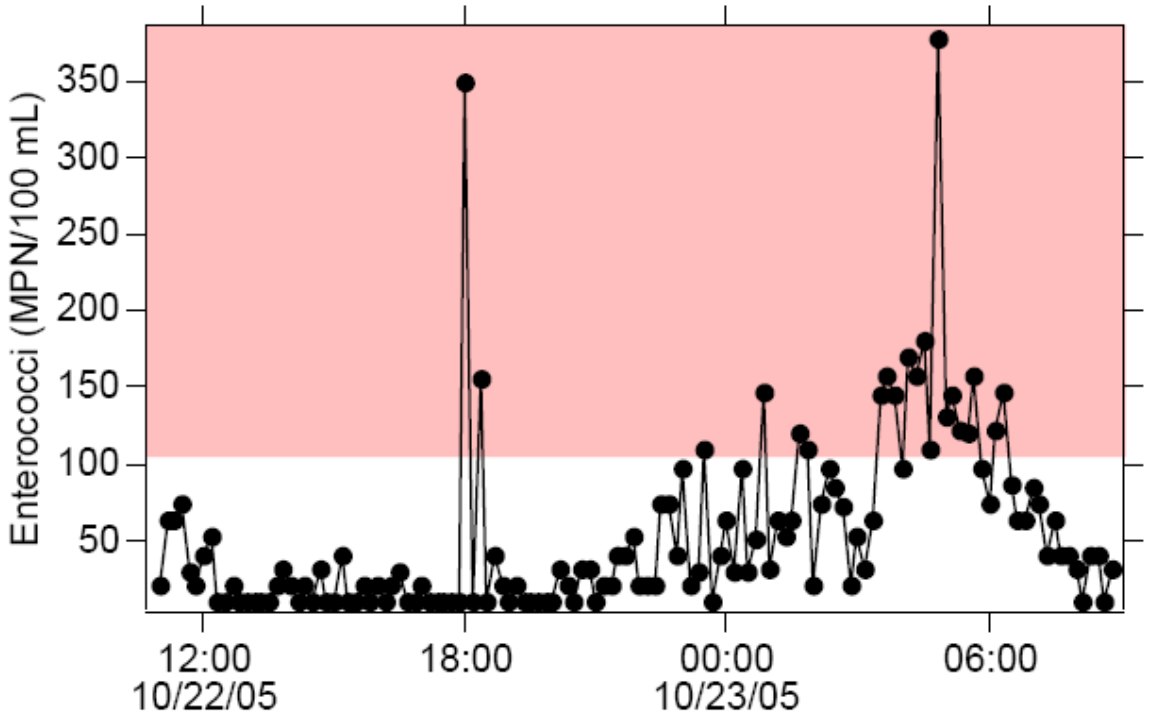


Figure 4a. Enterococci (MPN/100 mL) Sampled Every 10 Minutes at a Beach in California. (The reference background denotes the range of single sample exceedance.) SOURCE: A.B. Boehm, unpublished data (ENTEROLERT assay).

High Priority Model Research
Processes Affecting Fate and Transport

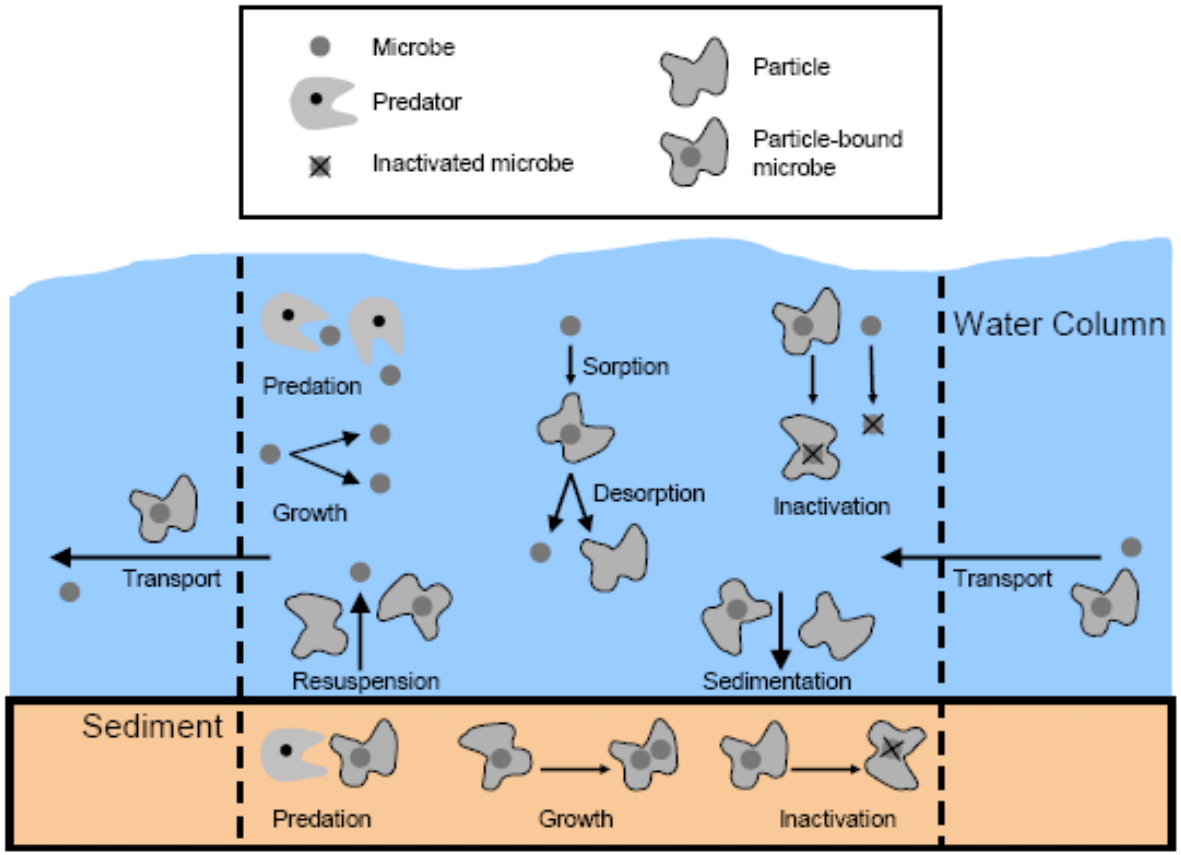


Figure 5. The Possible Fates of Microbes (Fecal Indicators and Pathogens) in Environmental Water and Sediment (the fate of nucleic acids may be different; this figure does not include those sources). SOURCE: Adapted from Olivieri et al. (2007).

Limits of Models

- “Sanitary investigation models that explore the relationship between land use, watershed attributes, and water quality are already in place and have been used in TMDL implementation (criteria implementation); however, they have not been specifically applied to criteria development. Creating a TMDL-like model for a waterbody prior to impairment may be viewed as proactive rather than reactive. Such models in use include deterministic models like Hydrological Simulation Program-Fortran (HSPF) and Storm Water Management Model (SWMM) for watershed loading, and CE-QUAL models for pathogen fate and transport (US EPA, 2002). **Feedback from some environmental engineers and consultants who apply these models to pathogen and fecal indicator transport suggests they provide highly uncertain predictions for pathogen and indicator concentrations and fluxes** (Ali Boehm, Stanford University, personal communication, 2007).” (p. 110)
- “…models developed from large data sets are generally considered better than models developed from smaller data sets.” (p. 113)

Notification Issues and Model Uses

- Spatial and temporal variability evident in indicator data sets and delay in obtaining monitoring results using conventional culture-based methods, rendered the single sample standard impractical for routine water quality notification purposes.
- Simple statistical models that do not necessarily require an understanding of processes and mechanisms have the potential to be incorporated into the new criteria, particularly for beach monitoring and water quality notification purposes.
- These models relate water quality to environmental factors like wind speed, prior rainfall, and tide level.

Additional Notes on Models

- See pp. 114-117 for discussion of advantages and disadvantages of models.
- Models used in TMDLs--Appendix G briefly describes:
  1. The L-THIA model (http://www.ecn.purdue.edu/run-off/lthianew/)
  2. SPARROW model (SPAtially Referenced Regression on Watershed attributes) (http://water.usgs.gov/nawqa/sparrow/index.html)
  3. LSPC is the Loading Simulation Program in C++, a watershed modeling system that includes streamlined Hydrologic Simulation Program Fortran (HSPF) algorithms
  4. HSPF, included in the BASINS3 watershed model system that is maintained by EPA (http://www.epa.gov/waterscience/BASINS/).

Chapter 7 Implementation Realities

(sprinkled through previous slides)

Summary of "Critical Path Research"

1. Human health impacts from different sources of fecal contamination
2. Measurement issues: climatic, geographic, and temporal variability
3. Determining risk level and subpopulations of concern
4. Indicators and methods for measuring fecal contamination

Summary

- Broad support to conduct research and include provisions that account for differences in climatic regions and geographic areas.
- Current state of the science calls for the criteria to be based on indicators of fecal contamination.
- Enterococci and *E. coli* are probably not appropriate indicators in all climatic regions (e.g., in tropical and subtropical climates) and geographic areas.

Summary Comments on Source Issues

- Broad support for criteria with provisions that account for differences in risks associated with
  - human versus nonhuman sources of fecal contamination, and
  - point versus non-point sources
- The absolute risk levels and the magnitude of differences between animal and human waste associated risks are not well characterized and may vary greatly geographically and temporally.
- Point sources and non-point sources of fecal contamination also differ in risk and those differences are not well characterized.

Conclusion

- EPA report addresses many of the concerns of Colorado communities faced with bacteria TMDLs.
- Critical path research needs have been well identified. EPA appears to have a good process with expert input.
- Colorado TMDLs have a timing issue due to revised EPA criteria in 2012.
- Some topics may warrant more detailed discussion by E. coli workgroup.

Discussion Time!

Possible Applications

- How can Colorado TMDLs be "paced," "~~phased~~," or "timed" to
  - 1) protect human health, BUT
  - 2) not waste resources on low-risk segments, given significant potential changes in 2012?

  (*How can we work together to move forward, but not go too far beyond EPA's current process?)*
- Can Colorado TMDLs reflect the WHO and EU tiered process, perhaps as part of the 303(d) listing methodology?

Factors to Consider for Colorado TMDLs Developed Prior to Revised Criteria in 2012

- Continue to stay away from "nonsensical mass loads" in TMDLs (see p. 139) (Seg. 14 TMDL did not use mass)
- Other factors:
  - "…alternative means of expressing loading reductions (e.g., "~~percent reduction~~," "load duration curve-based," "reference watershed" methods)"
  - "TMDL development … is further complicated [because] load reductions are typically strongly linked to hydrologic factors and intermittent sources such as stormwater runoff"
  - "establishing a static steady-state design condition, as is frequently done for other types of pollutant impairments, is not possible for bacteria due to the significant wet weather event-driven characteristics"

Type of Recreation/Risk

- Focus of workshop/standards really is on “swimmable” waters and beach closure notification; however, protection of children is identified as critical:
  - What does this mean for segments where swimming is not occurring, but water play is?
- If objective is to protect human health and human exposure is documented to be minimal, how can this be accommodated? What would documentation look like?

Other Possible Discussion Items

- Given precedent in other states and recognition of higher bacteria during wet weather, how should this be incorporated in Colorado TMDLs?
- Are there some basic steps that could be agreed on related to documenting:
  - Human sources of pathogens (sanitary surveys)
  - Actual likelihood of exposure
- Given acknowledgement of lower risks from non-human sources, can segments known not to have human sources (due to natural area conditions or sanitary surveys) be “lower” priority on 303(d) list?
- Is there opportunity for use of reference or baseline bacteria levels to help focus resources?

E. coli Workgroup Meeting Tentative Agenda

December 6, 2007, 1:00

1:00 – 2:30

Urban Drainage and Flood Control District

1.	Introductions	(5 min)
2.	Formally elect Chairperson or chair persons and coordinator	(10 min)
3.	Review Work Plan: focus on TMDL (permit requirements come later) Do we need to reevaluate the workgroups goal?	(30 min)
4.	Categorization of the 19 E. coli listed stream segments	(40 min)
5.	Next meeting for the Workgroup – January? **Bring your calendar**	(5 min)

At 500,000,000 fecal coliform / gram; it may be everywhere

Workgroup Goal: gain a better understanding of the issues with regulating *E. coli* and work to outline an approach for developing regulatory options for reaching and maintaining compliance.

E. coli Workgroup Meeting Agenda

1:30 – 3:00; February 7, 2008

Urban Drainage and Flood Control District

1. Introductions (5 min)

2. Status of Watershed Protection Fund grant (5 min)

3. Report on EPA's Scientific Workshop on Critical Research Needs for the Development of New or Revise: Jane Clary (45 min)

4. Update From the State: Becky Anthony (15 - 30 min)
   Some E. coli TMDLs, are about to start: discussion on how / what impacted parties would like to see.

   Discussion on use enterococci; is this a better indictor?

5. Next meeting for the Workgroup – March 6th or 13th or? **Bring your calendar** (5 min)

   Tentative Agenda: 1) review the survey of E. coli listed segments to determine what similarities we can identify that would be useful in developing TMDL templates covering like segments, 2) progress to date, 3) difficulties identified in developing and effective, achievable E. coli TMDL for segments with no obvious source

Seems everyone has a hunger for E. coli

Workgroup Goal: Working to eliminate a potential health hazard

E. coli Workgroup Meeting Minutes

1:00 – 3:00; May 8, 2008

Attendance: Jim McCarthy (City of Arvada), Nathan Moore and Becky Anthony (Water Quality Control Division), Terry Baus and Jon Novick (City and County of Denver), Richard Meyerhoff (CDM), Joan Carlson (U.S. Forest Service, Megan Monroe and Donna Scott (City and County of Boulder), Jill Piatt Kemper (City of Aurora), Jane Clary (WWE).

Location: Wright Water Engineers; 2490 W. 26th Ave., Suite 100A, Denver.

Discussion Items:

1. **Potential Framework for Bacteria TMDL Development Process in Colorado: Factors that Could be Included in a Decision-tree Approach--**Becky Anthony, Colorado Water Quality Control Division

   - Becky Anthony handed out a copy of the ASIWPCA March 24, 2008 Fact Sheet titled "Short Term Pathogen Criteria Actions: State Water Quality Standards" for general perspective on how the EPA 2012 revised ambient water quality criteria for bacteria affect States between now and the new criteria. (attached)

   - Becky Anthony and Nathan Moore provided a concept-draft handout for discussion regarding a potential approach/framework for E. coli TMDL development in Colorado. See attached handout for framework.

   - In general, the handout functions primarily to identify the types of information that are generally needed to begin a screening process for significant or insignificant pollutant sources and to identify which sources would be likely to be included in Load Allocations (LAs) or Wasteload Allocations (WLAs). The recommended process focuses first on collecting information from as many existing sources as possible, including use of GIS to develop a sense of land uses. As part of initial characterization of likely causes of exceedances, development of a Load Duration Curve was suggested to determine the types of flow conditions under which the exceedances are occurring and to develop an indication of whether these sources appear to be point or non-point source in nature. The intent of this curve is not for purposes of load allocations. Presence/absence of sources will include the seven sources included on the handout.

2. **Group Discussion and Questions**: The meeting was interactive, with many questions asked throughout Becky's presentation of the concept approach handout. Although time constraints did not enable a detailed discussion of all issues, the following list identifies general areas of discussion, indicating where general agreement was implied and where additional refinement is needed and/or where questions exist[1].

[1] Note: The notes in this section are impressions based on concerns or input verbalized at the meeting. In an effort to give the Division feedback on the draft framework, an effort has been made to identify items that "seemed reasonable" based on the discussion at the meeting. These general comments are not intended to "speak for" any individual participant, who may hold differing perspectives not verbalized at the meeting; instead, the intent is to document the general discussion and general feedback at the meeting.

- The big-picture framework seems reasonable, although details would need to be fleshed out in various areas.

- Generally, Becky is not inclined to use complex modeling and microbial source tracking approaches due to cost. The suggested approach focuses on using readily available information.

- Use of GIS to develop a general sense of land use and relative potential sources of pollutants in the watershed seems reasonable.

- The Load Duration Curve (LDC) concept generated a lot of discussion and is an area where additional discussion and or refinement could be warranted. Aspects of the discussion included:

    - Becky's intent with the LDC concept is to use it as a characterization tool to determine under what flow conditions the problems are occurring and to screen whether the problems appear to be point source or non-point source. Potential challenges noted with this approach during discussion include:

        - Complicating factors related to interpretation of flow conditions such as reservoir releases, diversions and irrigation return flows. In some cases, these issues vary throughout the length of a stream segment. For streams with straightforward hydrology, the LDC concept may be more reasonable to use; but there may be some issues on the more complicated hydrologic regimes (which are not uncommon in Colorado). Availability of good flow data may also pose a challenge in some cases.

        - Some discussion occurred related to separating wet versus dry weather conditions based on precipitation records. Other questions raised following the meeting included how long it takes for dry weather bacteria conditions to return following the descending limb of the hydrograph (i.e., even when flows return to normal, what is the lag time before bacteria concentrations return to normal?)

- Agriculture: some discussion occurred regarding whether the 10 percent threshold made sense. There was some confusion with how this related to the "urban agriculture" category. Also some discussion on Load Allocation (nonpoint source) versus Wasteload Allocation (point source). The general consensus was that permitted agricultural operations such as Confined Animal Feeding Operations (CAFOs) would be WLAs and other agriculture would be LAs. Becky mentioned Virginia Tech's Bacteria Source Load Calculator as a possible tool, but no one was familiar with how it worked or whether it could be a good tool to consider.

- A threshold of significance for agricultural contributions based on percent land use in the overall watershed seems to be reasonable at a screening level, but may require further discussion in determining whether a load allocation is appropriate. There could be significant watershed-specific variation.

- Sanitary-storm sewer screening for illicit connections was generally agreed to be reasonable. A few discussion items:
    - Some initial concern was expressed regarding the 5 gpm and 126/100 mL threshold due to the occurrence of high groundwater in many areas. Nathan pointed out that when storm outfall discharges are dominated by groundwater, E. coli is typically below 126/100 mL.
    - Some questions were noted about whether this screening was necessary in non-problem areas of the watershed; additional discussion is needed on this topic.
    - Percent contribution of storm outfalls to the stream would be estimated for the overall watershed; not on a single outfall basis. Although it makes sense to categorize this group at the watershed level, more discussion may be warranted on the details of this approach.
- Documentation of septic systems seemed reasonable. More discussion may be needed on the threshold of significance at the 1 house/40 acre level—this may be an overly stringent threshold. For example, the location of the septic system relative to the stream seems more relevant.
- The diffuse urban stormwater (wet weather) category needs more discussion and is generally acknowledged as a difficult issue, given that most urban runoff is well known to have elevated bacteria, regardless of land use (e.g., Pitt National Stormwater Quality Runoff Database, International Stormwater BMP Database, others). Wet weather contributions are difficult to monitor and difficult to control. Additional discussion of this issue is needed. The group generally agreed that wet weather runoff from a variety of land uses typically shows E. coli elevated above the stream standard. Load allocations applicable under wet weather conditions are a big concern. Some topics discussed included:
    - In general, it is better to conduct dry weather screening of stormwater outfalls and correct problems PRIOR to the TMDL to avoid the need for a WLA for this category. (Example: Littleton/Englewood did this on the South Platte.)
    - Risk based approaches used in other TMDLS where swimming is assumed to be negligible (and unsafe) during high flows; therefore, the risk of illness is negligible. Desire to kayak at high flows was discussed, but points were also made regarding the intent of the regulation regarding protection of subpopulations. This also resulted in discussion about streams that aren't used for swimming under dry weather conditions, but still have a primary contact standard.
- Identification of obvious point sources seemed reasonable.
- Wildlife: Some discussion occurred on this topic from a variety of perspectives;

- Urban wildlife may contribute to dry weather flows (thus, not appropriate for the diffuse wet weather category) for example in BMPs with permanent pools such as constructed wetlands.

- How should wildlife in large open space areas in urban areas be accounted for?

- Mass balance models in support of a TMDL were discussed in the context of whether density based (i.e., like the 126/100 mL used in South Platte) or load based allocations made sense. Several participants commented that the load based numbers don't seem meaningful. On the other hand, density-based TMDLs also have some shortcomings (e.g., 126/100 mL for wildlife doesn't seem practical).

- General discussion occurred regarding whether some of these threshold values should apply at the sub-basin or watershed level. This issue was raised in the context of the 10% agriculture threshold. It warrants more discussion.

- General discussion occurred regarding implementation of requirements into MS4 permits, implementation phase durations and how these mesh with the 5-year permit cycles. What happens when the BMPs have been implemented and the stream standard is still not attained?

Other General Questions/Discussion Items:

- How should the required "margin of safety" be developed for bacteria TMDLs? What are EPA's expectations? How do elevated background/natural concentrations affect the margin of safety and waste load allocations?

- What makes the most sense for the time component of bacteria TMDLs: Seasonal? Monthly? Annual? (No one thinks daily is appropriate.)

- What is the role of microbial source tracking in prioritizing mitigation activities? For example, if a stakeholder develops data showing that the only sources causing the exceedance are uncontrollable wildlife, how would this information be used by regulators for evaluating compliance?

- Is there opportunity for implementing a risk-based approach to mitigation and compliance? For example, using three key factors to prioritize implementation of activities to mitigate controllable bacteria sources: (a) exceedance magnitude/frequency; (b) source (e.g., human vs. wildlife); and (c) risk of human exposure (i.e., is anyone swimming?).

- What flexibility might be added into TMDLs implemented between now and EPA's new criteria targeted for 2012? For example, the EPA Experts Panel report seemed to consider some of the WHO/EU approaches that focus on removal of sanitary sources, placing less priority on natural contributions.

- Is EPA aware of any bacteria TMDL that has succeeded in attainment of stream standards?

- How will existing compliance schedules for E. coli TMDLs be affected if EPA significantly changes their criteria?

3. **Draft Bibliography of E. coli Resources**—Jane Clary provided a handout containing a draft bibliography in progress of references to be used as an informational resource related to E. coli TMDLs. She noted that it was interesting that the four major sources she used to develop the list had minimal overlap. The key sources included Bob Pitt's work in the stormwater field, the EPA Experts Workshop, EPA's TMDL guidance and other references compiled by WWE. A fifth source of information also being explored is the AwwaRF/EPA (2006) Pathogen Monitoring Guidance document. Jane requested the following input:

    - Additional references that participants have found to be useful/relevant.
    - Feedback on keywords to use for sorting.
    - Other general input.

4. **Next Meetings for the Workgroup**: The next meeting will include discussions with Dave Moon and Sandi Spence from Region VIII EPA regarding EPA's expectations for bacteria TMDLs, guidance on specific questions raised by the group and discussion related to documenting background concentrations of bacteria.

    - The target for that meeting is the week of June 16th. Becky will follow up with EPA to set a meeting date. If anyone is aware of standing meeting conflicts that week or the week following, please let Becky or Jim know ASAP so that we have a good turnout.
    - Jim recommended that we skip the month of July and reconvene in August to follow-up on issues raised during the May and June meetings.
    - Jim will provide an update on work group progress to the Water Quality Forum.

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ASIWPCA
Association of State and Interstate
Water Pollution Control Administrators

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Short Term Pathogen Criteria Actions: State Water Quality Standards Fact Sheet

March 24, 2008

The US Environmental Protection Agency (EPA) is on a timeline to have new pathogen criteria recommendations as well as criteria implementation recommendations developed by the end of 2012. The criteria recommendations are expected to cover all waters – those subject to the Beach Act, and those inland fresh waters not subject to the Beach Act. The new criteria recommendations may look substantially different than the current recommendations in found in *Ambient Water Quality Criteria for Bacteria - 1986*, as evidenced by EPA's post-1986 epidemiologic work focusing primarily on rapid DNA-based analytical methods. Although initial studies concentrated on using enterococci as the single bacterial indicator for both fresh and marine waters, EPA is still exploring other indicators and methods for future criteria recommendations.

While it is too early to project how the 2012 criteria recommendations will ultimately express pathogen criteria, States should be cognizant of the projected change and determine their best courses of action over the interim five year period.

The following suggestions are intended to help States make an informed decision in regard to any action on pathogen criteria:

I. Non-Beach Act/Non-Coastal Recreation Waters

A. States that have adopted the 1986 Bacteria Criteria - If States have adopted bacteria criteria based on the 1986 Guidance, no change in the criteria indicators or values are needed prior to the publishing of the projected 2012 Pathogen Criteria Recommendations. States may, however, wish to clarify data sufficiency and averaging period requirements in their standards to better assess attainment of the criteria. In this context, data sufficiency refers to the minimum number of samples required, and the timeframe in which those samples must be collected. The averaging period for the samples is still considered a duration component of the standard and would require EPA approval if changed. For instance, many States interpreted the 1986 Guidance to mandate a criterion based on a geometric mean of five samples collected over a 30-day period. That interpretation has created considerable hardship for those States in conjunction with 303d Assessments, since a majority of waters are not sampled with that degree of intensity.

EPA explained in the 2004 Beach Act Rule that the data sufficiency and averaging portions of the criteria need only reflect a state's understanding of the criteria – whether that be a geometric mean of 5 samples in 30 days, an annual geometric mean of all samples collected in a year, or a seasonal geometric mean of samples collected during a specified recreation season. The idea is to match the data sufficiency and averaging portions of States' criteria and assessment with their monitoring frequencies for ambient water quality samples.

The States and EPA are in agreement the bacteria standard is a general indicator of the *sanitary condition* of a waterbody. Therefore, the expression of the criterion can, and perhaps should be, expressed as a long term geometric mean without regard to the number of samples collected; for instance, a geometric mean of the total number of samples collected during the recreation season. At this point in the discussion EPA does not consider clarification of data sufficiency to be a *change* in a water quality standard requiring approval by EPA. Changing the averaging period is considered a change in the criterion duration, thus EPA would have approval authority over a change in averaging period. The Beach Act Rule explanatory text made clear it was not the intent of the 1986 Criteria Guidance to couple a criterion value with a specific number of samples averaged over a specific timeframe to form a bacteria standard. The intent was only to specify a geometric mean criterion value, while leaving the interpretation of the averaging period to the State. Although the Beach Act Rule did not specify an averaging period, EPA recommended that the averaging period be applied as a ''rolling'' or ''running'' average, but recognized it would still be appropriate for States to specify the averaging period whether that be a monthly, seasonal, or annual mean. Therefore, if a state chose to change its averaging period to seasonal, or annual mean, that change falls within EPA's range of recommended durations and approval should be straightforward.

In conjunction with a geometric mean criterion, EPA also encourages the use of a single sample maxima (SSM) criterion as is requisite for Beach Act States. Although an SSM is not mandatory for non-Beach Act State, those States may wish consider an SSM as a trigger mechanism for waterbody closures, or for aiding in assessment purposes.

B. States that have not adopted the 1986 Bacteria Criteria - If States have not adopted bacteria criteria based on the 1986 Guidance, decisions need to be made whether to maintain their existing criteria, or to adopt criteria based on the 1986 Guidance. EPA is aware that in many States criteria revisions can take several years to complete. Additionally, EPA is focusing its resources on the Critical Path Science Plan for pathogens and from that effort the development of improved pathogen criteria in the shortest possible timeframe.

Therefore, it is not anticipated EPA will promulgate the 1986 criteria for states still utilizing fecal coliform as an indicator due to EPA's current focus on developing an improved criterion, and the expectation that the improved criterion would be adopted shortly after the 2012 recommendations are published. However, if States are already moving down the path of adopting the 1986 criteria, they are encouraged to continue to pursue that adoption and to carefully evaluate the use of enterococci.

Although some of the most recent EPA epidemiologic studies have focused on enterococci as the sole indicator, the ASIWPCA membership still has concern about the exclusive use of enterococci, especially at levels specified in the 1986 Guidance. Many states have observed the ratios of enterococci to either fecal coliform or *E. coli* in flowing waters one to two orders of magnitude greater than the beach studies on which the 1986 Guidance criteria are based. In other words, flowing waters currently in attainment with either the fecal coliform or *E. coli* criteria may have a significantly higher probability of being non-compliant with the 1986 enterococci criteria, thus increasing the numbers of waters listed as impaired for bacteria. Therefore, it would be prudent for any state considering the adoption of enterococci as its indicator, to first complete studies comparing enterococci, fecal coliform, and *E. coli* densities from split samples. If the ratios of those densities are significantly different from the ratios on which the 1986 Guidance is based, use of the enterococci indicator may cause the listing of more waters as impaired for bacteria.

As discussed previously in regard to the *E. coli* and enterococci indicators, EPA does not consider clarification of data sufficiency to be a change in a water quality standard requiring approval by EPA for either indicator. EPA also does not consider data sufficiency changes to be a change in water quality standard for States with a fecal coliform indicator if they choose to retain that indicator and its currently specified criterion values in this interim period. Therefore, a State with a fecal coliform indicator could clarify any change in its data sufficiency requirements without necessitating EPA approval of the clarification. **EPA does, however, consider a change in averaging period a change in standard.** Since EPA does not consider a fecal coliform criterion as stringent as either the enterococci or *E. coli* criteria, approval of any change in the in a state's fecal coliform criterion – including averaging period – would most likely be disapproved by EPA.

II. Beach Act Coastal Recreation Waters - For coastal recreation waters, all Beach Act States have either adopted criteria as stringent as those delineated in the 1986 Guidance, or EPA has promulgated criteria for coastal recreation waters in those States. However, those States may still wish to explore modifications to the data sufficiency or averaging period portions of their criteria. As discussed above, States may find it advantageous to clarify the minimum sample requirements, or the averaging period requirements of their current standard to better match their assessment protocols.

Again, clarification of data sufficiency requirements are not considered *changes* in a standard requiring EPA approval. Changes in averaging period would require approval.

III. Summary – EPA is planning to develop new pathogen criteria and implementation recommendations by 2012. In the interim, States need to decide how to best address pathogen criteria in their water quality standards – make modifications, or maintain their current criteria. There are interim actions States could undertake that would potentially alleviate some assessment issues in their States. The following Table summarizes the options available to States based on the presence of coastal recreation waters in their State and their status in having adopted the 1986 Criteria:

	Criteria Options				
Water Type/Criteria Status	**Fecal Coliform Indicator**	***E. coli* and/or Enterococci Indicator**	**Modify Data Sufficiency Reqs.**	**Modify Averaging Period Reqs.**	**Single Sample Maxima**
Non-Beach Act Waters w/1986 Criteria	N/A	Mandatory	Optional	Optional	Optional
Non Beach Act Waters w/o 1986 Criteria	Applicable	Optional	Optional	N/A	Optional[a]
Beach Act Waters	N/A	Mandatory	Optional	Optional	Mandatory

[a] Only if *E.coli* or Enterococci are adopted as the indicator.

Terminology

Beach Act Coastal Recreation Waters - Great Lakes and marine coastal waters (including coastal estuaries) that states, territories, and tribes designate in their water quality standards for use for swimming, bathing, surfing, or similar water contact activities.

Non-Beach Act/Non-Coastal Recreation Waters - Inland waters; or waters upstream of the mouth of a river or stream having an unimpeded natural connection with the open sea and are not subject to the Beach Act.

Recommended Approach for Bacteria TMDL Development

1. Compile data from sources.
2. Calculate Load Duration Curves (LDCs) for affected segments.
3. Implement source survey for watershed
    * Identify Presence/Absence of source types
        (1) Agriculture
        (2) Sanitary to storm sewer system
        (3) Sanitary – Septic systems
        (4) Single known point source(s)
        (5) Diffuse urban stormwater flow (wet weather)
        (6) Wildlife – refers to natural, undisturbed areas
        (7) Urban farms (<10% agriculture)

If present → Significant/Non-significant

(1) Agriculture
    a. Identify agriculture land uses by type (animal, crop, etc.)
    b. Identify agricultural land uses with significant potential to contribute bacteria, including but not limited to, land used by farm animals and horses.
    c. Determine percent of watershed that is agricultural land with significant potential to contribute bacteria
        If > 10% → Assumed to be significant → Given a WLA (Unless there is information provided to prove otherwise)

(2) Sanitary to Storm Sewer System
    a. Dry weather flows exceeding 5 gpm and with E Coli densities exceeding 126 are assumed to be contributed to by sanitary sewer sources such as sanitary sewer seepage to storm sewer pipes and cross connections, unless additional information is available indicating otherwise. (discharges < 5 gpm or <126 is considered to be from other diffuse sources)
    b. Outfall loads are based on the stream standard (126) times the flow rate
    c. Percent contribution to stream flow is an aggregate of all outflows with values of > 126 and > 5 gpm flow as a percentage of stream load → WLA

(3) Septic systems present (based on # of households/sq. mile). Consider > 1 household on septic per 40 acres to be a potential significant source requiring additional evaluation → given a WLA allocation determined based on watershed specific information

(4) Single known source → considered on a case by case basis. Considered to be a point source → if significant → given a WLA

(5) Diffues Urban Wet Weather Sources
TBD

(6) Wildlife – occurs in non-urban areas = WLA (on a case by case basis)

(7) Urban agriculture – If > 10% of watershed area = WLA consistent with (1)

4. Develop GIS inventory of watershed (agriculture, septic, NPDES, etc.) in conjunction with #3.

5. Develop LDCs, GIS, and Mass Balance Models for TMDL.

E. coli Workgroup Meeting Minutes

1:00 – 3:00; June 26, 2008

Attendance: Jim McCarthy (City of Arvada), Becky Anthony, Joni Nuttle and Phil Hegeman (Water Quality Control Division), Terry Baus and Jon Novick (City and County of Denver), Becky Dunavant (CDM), Dan Scaife (U.S. Forest Service, Megan Monroe (City and County of Boulder), Jill Piatt Kemper (City of Aurora), Jane Clary (WWE), Mary Fabisiak and John Burke (City of Westminster), Sandra Spence and Dave Moon (USEPA), Todd Harris (Metro District), Jennifer Richards (CH2MHill), Ginny Johnson (Colorado Springs).

Location: Colorado Department of Public Health and Environment

Meeting Focus: Open discussion and brainstorming with Dave Moon and Sandie Spence of EPA Region VIII regarding *E. coli* TMDLs and recreational water quality standards.

Discussion Items:

1. Dave Moon noted that EPA's 2004 *Implementation Guidance for Ambient Water Quality Criteria for Bacteria* remains the appropriate reference for looking at bacteria standards issues. (This guidance relates to the *Ambient Water Quality Criteria for Bacteria-1986*) He noted that the 2012 date for revised standards is a "target" and that everyone should be aware that it will be quite a while before revised standards would work their way into the Colorado Basic Standards, which would then filter into the specific basins like the South Platte. Regardless of the issues raised by the EPA Experts Panel, the currently approved standards are applicable criteria.

2. Becky Anthony asked some questions about how to incorporate margin of safety into bacteria TMDLs. Various aspects of this issue were discussed in terms of looking at the 95% confidence interval associated with risk curves in combination with the geometric mean plus some measure of variability. (*This issue has some complexities that are difficult to fully characterize in the context of a brief meeting*.)

3. Both EPA and CDPHE desire that the standards that are in place should be attainable (i.e., the standards should be meaningful). Site specific or ambient based standards based on well-done studies that are logical and defensible are a possibility. However, the criterion of < 8 swimmer illnesses per 1,000 swimmers can't be increased. Even though risk assessment data for freshwater settings are limited, there isn't anything better to use at this time. Dave noted that there is not a good risk assessment available for *E. coli* concentrations above roughly 200/100 mL—this is a constraining factor. There was some discussion about the swimming pool regulation value of 235/100 mL—it was noted that this is a daily maximum set at the 75% value, not a geometric mean.

4. The two basic approaches to looking at standards include: 1) risk-based and 2) attainability. Colorado basic standards include provision for site specific standards for "natural or irreversible human induced conditions." This is a more difficult standard to prove in urban areas. Some discussion about the California Park elk issue included the fact that this is a remote area, making it different than urban settings affected by wildlife. With regard to the attainability issue, key factors include whether the standard is physically attainable, as well as financially attainable.

5. The water quality standards drive the TMDL—TMDLs have to fit into the boundaries created by the standard. Other states have some wildlife off-ramp type language that the group might want to look at; however, EPA headquarters' position on these off-ramps is currently somewhat unclear.

6. Phil noted that due to the human health component, segments listed as impaired for bacteria are ranked as high priority on the 303(d) List. The Division's inclination would be to focus first on streams that have meaningful data sets in terms of identifying sources of impairment. The Division cannot postpone looking at bacteria issues due to uncertainty surrounding future standards.

7. Off ramps for bacteria TMDLs that were brainstormed included:

    a. Connecting the designated use with the standard—for example, if bacteria are elevated during high flows and no one is swimming during that time, then this could be taken into consideration in TMDLs. Complicating factors that were discussed included kayaking during high flows, and conversely, how this concept would be applied where the recreational use is limited to wading.

    b. Seasonal standards that connect the designated use to the water quality during the season of use. (But the group noted that this doesn't help in the case of bacteria, where the higher concentrations are typically in the summer during season of recreational use.)

    c. "Natural conditions" off ramps that are provided for in the Basic Standards. Phil discussed 31.7(1)(b):

> "A numeric standard may be assigned by the Commission either to apply on a statewide basis or to specific state surface waters. A numeric standard will be assigned by the Commission when it is presented with evidence that a particular numeric level for a parameter is the suitable limit for protecting the classified use. A numeric standard consists of a numeric level and may include a description as to how that numeric level is to be measured. Numeric standards will include appropriate averaging periods and appropriate frequencies of allowed excursions. A numeric standard may be exceeded due to temporary natural conditions such as unusual precipitation patterns, spring runoff or drought. Such uncontrollable conditions are not cause for changing the numeric standard."

    Some open discussion on varying perspectives on the "temporary natural conditions" provision followed. A concern with this type of narrative statement is how it is applied on a case-by-case basis, which can create problems for the state agencies.

    d. Listing methodology—although the standards themselves are not flexible, the listing methodology for the 303(d) list may have some opportunities for more flexibility. The group concluded that this should be further explored.

    e. Phil noted that the Commission had been expecting groups to come back with suggested off-ramp language for wildlife in 2005(?), but no one did so.

8. Becky Anthony discussed an example from California from the TMDL conference that had some creative assessment approaches based on seasonality.

9. Required sampling frequencies for *E. coli* were discussed. Phil noted that in terms of assessing compliance, the 30-day geometric mean relates to setting discharge permits, but the timeframe/sampling frequency is not required for assessing attainment of stream standards—the available data for the past five years are simply used.

10. Sandie Spence discussed aspects of approaches used in other states.

    a. Bacteria source tracking is a tool that can be considered in the TMDL process; however, this does not take the place of logical, deductive reasoning. In many cases, the BST data are not robust enough to draw the types of conclusions that are desired. So, this is "a" tool, but not necessarily "the" tool.

    b. Some TMDLs have used modeling approaches, particularly in agricultural areas where variables such as head of cattle are entered. The Dakota's have some bacteria TMDLs.

    c. A phased TMDL approach can be good. The example discussed included 1) ruling out/correcting illicit connections; 2) implementing pet waste ordinances and 3) re-assessing whether the standard is attainable once all key sources have been corrected. Neither Colorado nor EPA are mandating which BMPs should be implemented.

11. Sandie asked a question about Becky's draft TMDL guidance regarding WLAs vs. LAs. It was decided that agricultural sources (including urban farms) and wildlife sources would be given a load allocation as opposed to a waste load allocation. These sources are considered to be non-point sources as opposed to point sources.

12. Resegmentation issues related to recreational uses were discussed. For example, in cases where streams transition from open space/public property to private property, resegmenting could be appropriate in terms of recreational classification; however, this creates administrative headaches for the Division in assessing attainment of stream standards. An idea was suggested regarding a narrative qualifier to the standards that would cause them to apply in areas of public access; however, this still creates some challenges for the Division. A "point of compliance" concept was discussed in this context. (*There was no clear resolution to open discussion on this topic*.)

Action Items:

1. The group concurred that it is important to participate in the 303(d) Listing Criteria work group process being headed up by Aimee Konowal (303-692-3530, aimee.konowal@state.co.us). Although the recreational standards themselves can't really be changed, the method of assessment does have some latitude—this is a critical opportunity for input affecting bacteria TMDLs.

2. Jim McCarthy will report on the Work Group activities at the Water Quality Forum in July.

3. The next work group meeting will be held in late August, date to be determined.

Notes prepared by Jane Clary, WWE.
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E. coli Workgroup Meeting Minutes

9:00 – 11:00; August 21, 2008

Attendance: Jim McCarthy (City of Arvada), Becky Anthony and Phil Hegeman (Water Quality Control Division), Becky Dunavant (CDM), Jill Piatt Kemper (City of Aurora), Jane Clary (WWE), Mary Fabisiak (City of Westminster), Ginny Johnson (Colorado Springs), Donna Scott (City of Boulder), Amy Woodis (MWRD), Bob Arastason (City of Aurora), Nancy Keller (City of Pueblo), Mary Gardner (Littleton/Englewood WWTP).

Location: Colorado Department of Public Health and Environment

Meeting Focus: Refine Framework for Bacteria TMDL Development Process in Colorado, discuss "wildlife off ramps"

Discussion Items:

1. Refine Framework for Bacteria TMDL Development Process in Colorado:

   What data are needed?
   Assessment based on last five years, but 10 would be nice because of changes in hydrologic conditions. Even with many stream segments having only seasonal uses, a monthly geometric mean is used to determine compliance; if there are multiple sites on the segments, all data for the month is used in calculating the geometric mean; however, outliers at individual sites will likely be flagged. Could look at seasonal data to help identify a source, but wouldn't help much in assessing attainment.

   How will insufficient data impact the TMDL?
   While the data set to list many of the stream segments was not extensive, the data needed to remove a segment will be significant (the Catch-22 of the TMDL world).

   What to do if dry weather screening shows no sources?
   This situation would probably result in there not being a WLA TMDL for wet weather flows.

   What could a "Wildlife off-ramp" look like?
   See attached August 21, 2008 draft summary from Jane Clary

3. Draft Bibliography of E. coli Resources. A final draft is targeted to be available for the October meeting.

4. Next meeting for the Workgroup: October_?_

   Tentative Agenda:

   1) Survey of E. coli stream segments: what GIS Layers should be included - land use, geology, stormwater permittees, WWTFs; anything else? USDA GIS clearinghouse is a good website to review for this information.
   2) Load duration curve discussion
   3) Possibly more on Wildlife off-ramps?

   Future agenda items: delisting methodology.

Representative Precedents for Natural Conditions/Wildlife Off-ramps for Bacteria in State Water Quality Standards

Per discussions at the June *E. coli* Work Group meeting, TMDLs must be completed in accordance with currently applicable State Water Quality Standards. If the *E. coli* Work Group participants wanted to propose changes to current Colorado Basic Standards to better reflect naturally occurring bacteria conditions, the hearing schedule is as follows:

> Basic Standards
> October 2008: Issues Scoping
> November 2008: Issues Formulation
> June 2010: Rulemaking Hearing
>
> (South Platte Issues Formulation November 2008)

Examples of provisions for naturally occurring conditions in State Water Quality Standards for several states are provided below; many examples from other states also exist.

Colorado

Current "natural conditions" off ramps that are provided for in the Basic Standards 31.7(1)(b): (*identified by Phil Hegeman at last meeting*)

> "A numeric standard may be assigned by the Commission either to apply on a statewide basis or to specific state surface waters. A numeric standard will be assigned by the Commission when it is presented with evidence that a particular numeric level for a parameter is the suitable limit for protecting the classified use. A numeric standard consists of a numeric level and may include a description as to how that numeric level is to be measured. Numeric standards will include appropriate averaging periods and appropriate frequencies of allowed excursions. A numeric standard may be exceeded due to temporary natural conditions such as unusual precipitation patterns, spring runoff or drought. Such uncontrollable conditions are not cause for changing the numeric standard."

The other mechanism in Colorado for taking into account naturally occurring conditions is related to the ambient based standards alternative. This has the effect of natural sources being addressed on a segment-by-segment basis, whereas wildlife/natural sources "offramps" addresses the issue at the 303(d) listing level (determination of standards attainment).

> 31.7 PROCESS FOR ASSIGNING STANDARDS AND GRANTING, EXTENDING, OR REMOVING TEMPORARY MODIFICATIONS
>
> (1)(b)(ii) Ambient Quality-Based Standards
>
> For state surface waters where evidence has been presented that the natural or irreversible man-induced ambient water quality levels are higher than specific numeric levels contained in tables I, II, and III, but are determined adequate to protect classified

uses, the Commission may adopt site-specific chronic standards equal to the 85th percentile of the available representative data…

North Dakota

CHAPTER 33-16-02.1 STANDARDS OF QUALITY FOR WATERS OF THE STATE

Section 33-16-02.1-09. Surface water classifications, mixing zones, and numeric standards

Fecal Coliform[2]: Not to exceed 200 organisms per 100 ml as a geometric mean of representative samples collected during any 30-day consecutive period, nor shall more than 10 percent of samples collected during any 30-day consecutive period individually exceed 400 organisms per 100 ml. For assessment purposes, the 30-day consecutive period shall follow the calendar month. This standard shall apply only during the recreation season May 1 to September 30.

E. coli[2]: Not to exceed 126 organisms per 100 ml as a geometric mean of representative samples collected during any 30-day consecutive period, nor shall more than 10 percent of samples collected during any 30-day consecutive period individually exceed 409 organisms per 100 ml. For assessment purposes, the 30-day consecutive period shall follow the calendar month. This standard shall apply only during the recreation season May 1 to September 30.

[2]Where the fecal coliform or *E. coli* criteria, or both, are exceeded and there are natural sources, the criteria may be considered attained, provided there is reasonable basis for concluding that the indicator bacteria density attributable to anthropogenic sources is consistent with the level of water quality required by the criteria. This may be the situation, for example, in headwater streams that are minimally affected by anthropogenic activities.

(Source: http://www.legis.nd.gov/information/acdata/pdf/33-16-02.1.pdf)

Utah

R317. Environmental Quality, Water Quality, R317-2. Standards of Quality for Waters of the State, R317-2-14. Numeric Criteria.

Footnote to TABLE 2.14.1 NUMERIC CRITERIA FOR DOMESTIC, RECREATION, AND AGRICULTURAL USES

(7) Where the criteria are exceeded and there is a reasonable basis for concluding that the indicator bacteria are primarily from natural sources (wildlife), e.g., in National Wildlife Refuges and State Waterfowl Management Areas, the criteria may be considered attained. Exceedences of bacteriological numeric criteria from nonhuman nonpoint sources will generally be addressed through appropriate Federal, State, and local nonpoint source programs.

(Source: http://www.rules.utah.gov/publicat/bulletin/2005/20050501/27593.htm)

Proposed Changes:

> (7) Where the criteria are exceeded and there is a reasonable basis for concluding that the indicator bacteria *E. coli* are primarily from ~~natural sources (~~wildlife~~)~~, e.g., in National Wildlife Refuges and State Waterfowl Management Areas, the criteria may be considered attained, provided the density attributable to ~~human~~ non-wildlife sources is less than the ~~geometric mean criterion~~ criteria. Exceedences of ~~bacteriological numeric criteria~~ *E. coli* from nonhuman nonpoint sources will generally be addressed through appropriate Federal, State, and local nonpoint source programs.

(Source: http://www.waterquality.utah.gov/WQS/20080715_E_coli_Wording.pdf)

Montana

and
ENVIRONMENTAL QUALITY CHAPTER 30, WATER QUALITY Subchapter 6 Surface Water Quality Standards and Procedures (http://www.deq.state.mt.us/dir/Legal/Chapters/CH30-06.pdf)

> "Naturally occurring" means conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil and water conservation practices have been applied. Conditions resulting from the reasonable operation of dams in existence as of July 1, 1971, are natural.
>
> (k) In accordance with 75-5-306(1), MCA, it is not necessary that wastes be treated to a purer condition than the natural condition of the receiving water as long as the minimum treatment requirements, adopted pursuant to 75-5-305, MCA, are met.

Reference to Montana Code:

> 75-5-306. Purer than natural unnecessary -- dams.
>
> (1) It is not necessary that wastes be treated to a purer condition than the natural condition of the receiving stream as long as the minimum treatment requirements established under this chapter are met.
>
> (2) "Natural" refers to conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil, and water conservation practices have been applied. Conditions resulting from the reasonable operation of dams at July 1, 1971, are natural.

(Source: http://data.opi.state.mt.us/bills/mca/75/5/75-5-306.htm)

Wyoming

WATER QUALITY RULES AND REGULATIONS, Chapter 1 WYOMING SURFACE WATER QUALITY STANDARDS

Section 27. *E. coli* Bacteria.

(a) Primary Contact Recreation. In all waters designated for primary contact recreation, during the summer recreation season (May 1 through September 30), concentrations of *E. coli* bacteria shall not exceed a geometric mean of 126 organisms per 100 milliliters based on a minimum of not less than 5 samples obtained during separate 24 hour periods for any 30-day period. All waters in Table A of the Wyoming Surface Water Classification List are designated for primary contact recreation unless identified as a secondary contact water by a"(s)" notation. Waters not specifically listed in Table A of the Wyoming Surface Water Classification List shall be designated as secondary contact waters. During the period October 1 through April 30, all waters are protected for secondary contact recreation only.

[other text for Secondary contact omitted]

Single-sample maximum values may be used to post recreational use advisories in public recreation areas and to derive single-sample maximum effluent limitations on point source discharges. An exceedence of the single-sample maxima shall not be cause for listing a water body on the State 303(d) list or development of a TMDL or watershed plan. The appropriate recreational use category (i through iv above) shall be determined by the administrator as needed, on a case by case basis. In making such a determination, the administrator may consider such site-specific circumstances as type and frequency of use, time of year, public access, proximity to populated areas, and local interests.

(d) Variances. Temporary and/or permanent variances to the *E. coli* values provided in (a) through (c) above may be granted in instances where the primary source of bacterial contamination is found to be natural in origin (wildlife), unavoidable (off-channel stock watering pits), or otherwise in the public interest.

(Source: http://deq.state.wy.us/wqd/WQDrules/Chapter_01.pdf)

Also see:
http://deq.state.wy.us/wqd/watershed/surfacestandards/Downloads/Triennial/Draft_Implementation_Policies.pdf

Prepared by: Jane Clary Z:\Project Files\07\071-141\071-141.000\Engineering\Natural Conditions Off-rampsjkc.doc

Survey of 303(d) Listed Streams for E. coli/Fecal Coliform (Matrix Status as of 10/27/08--additional updates planned during 2008/2009)

	Segment	303(d) listed segments for E. coli/Fecal Coliform	Person providing information/basis of knowledge /contact information	Land Use Characteristics (Uniform, Diverse, or Distinctive Segments)	Dominant type(s) urban, ag, open space/natural) (basis of information)	Has source characterization been completed? If so, what types and what are expected sources of bacteria.	If formal source characterization has not been conducted, what are the "perceived" sources?	Have any trends been identified?	Have wet and dry weather conditions been monitored separately?	If sources have been identified, what are expected control measures (BMPs)? What BMPs are already in place?	Are WWTPs on the stream consistently meeting E. coli / fecal coliform std?	Observed recreational activity	Provide other thoughts/comments, or attach documents with more information
1	COARFO01	Fountain Creek and tributaries above Monument Creek	Lisa Ross: lross@springs.gov.com (tel. 719-385-5064) Ginny Johnson, Colorado Springs Utilities (tel: 719-668-4375)	Distinctive Segments	Upper 1/2 rural; lower 1/2 urban	In progress. Contract with USGS.		preliminary data only at this point	only within City of C/S limits	so far we've identified broken sanitary sewer lines outside of the City of C/S and they have been repaired.	yes	wading possible	
2	COARFO02a	Fountain Creek, Monument Creek to Hwy 47		Distinctive Segments	Upper 1/2 urban; lower 1/2 agriculture/rangeland	Not yet.	Cross connections, occasional line breaks, wildlife, cows, regrowth of existing E. coli in sediments.		only within City of C/S limits		yes	wading possible	
3	COARMA04a	Wildhorse Creek											
4	COARMA13	Cucharas River, source to Walsenburg PWS diversion											
5	COSPBD01	Mainstem of Big Dry Creek, including all tributaries, lakes, reservoirs and wetlands, from the source to the confluence with the South Platte River	Jane Clary, Watershed Coordinator, clary@wrightwater.com; 303-480-1700	Distinctive Segments	Upper 2/3 residential/open space mixture; lower 1/3 agriculture	In progress. Dry weather sampling being conducted. Monthly instream monitoring program. Wildlife survey in urban open space as Eagle Scout project. Wildlife, domestic pets, agriculture and possibly septic systems may be sources.	See previous answer. Perception is that most sources will be non-point in nature and difficult to control.	No distinct upstream to downstream trend. Higher E. coli in the summer months.	No--ambient based program. Some events may follow storm events.	Best opportunities for control would be to identify and eliminate illicit discharges, if any. Provide pet waste bags and disposal containers in open space. Possibly explore opportunities for voluntary partnerships with agricultural users.	Yes	Wading may be a possibility in certain portions of open space but has not been observed during sampling or other survey activities. Dangerous culverts and drop structures make the stream inappropriate for boating in most segments. Access is restricted by steep banks, thick vegetation and private property in many areas. UAA regarding Recreation classification was completed, resulting in Rec 1b classification.	**Examples would be data spreadsheets, plots, interpretive memos, studies, etc. that would enable us to know "what we know" about E. coli in Colorado.
6	COSPBO02	Boulder Creek, Indian Peaks Wilderness to South Boulder Creek (below 13th Street in Boulder)	Donna Scott: ScottD@bouldercolorado.gov (tel: 303-413-7364)	(13th Street to confluence w/ SBC) Uniform	Urban	In progress. Analysis included: monthly instream monitoring, and outfalls and segment monitoring bimonthly to weekly for E. coli, flow, quantitative fluorescence, bacteroides, temperature. No confirmed human sources	natural sources, some illegal connections/ dumping from outfalls- not likely sewage	Certain outfalls high in e. coli and other constituents	dry only	Sediment and/or nutrient control, storm sewer maintenance		Tubing, wading, fishing, kayaking in summer months	
7	COSPBO07b	Coal Creek, HWY 36 to Boulder Creek	Donna Scott										
8	COSPBO08	All tributaries to South Boulder Creek, including all lakes, reservoirs, and wetlands from South Boulder Road to the confluence with Boulder Creek and all tributaries to Coal Creek from Highway 93 to the confluence with Boulder Creek (Rock Creek)	Donna Scott										
9	COSPBO10	Boulder Creek, Coal Creek to St. Vrain Creek	Donna Scott										
10	COSPBT09	Little Thompson River, Culver Ditch to Big Thompson River											
11	COSPCL15	Clear Creek, Youngfield St. to S. Platte River											
12	COSPCL18a	Ralston Creek and tributaries below Arvada Reservoir (Ralston Creek)	James McCarthy: jim-m@arvada.org, 720.898.7765	Uniform	Uniform: residential	In progress. Dry weather sampling being conducted, with no dry weather outfalls showing above 126			No sampling program is only for dry weather screening	Data shows no exceedances for dry weather so source identification is not appropriate	NA	Wading is a possibility in certain portions along open space; retrieval of Frisbees along a Frisbee golf course is the only human contact observed. Lack of flow and culverts make the stream inappropriate for boating, kayaking, or swimming. There is private property in many areas. Previous UAA regarding Recreation classification have been completed.	
13	COSPCP12	Cache la Poudre River, Box Elder Creek to S. Platte River				Several entities discharge into the segment, including South Fort Collins Sanitation District (a separate district from the City of Ft. Collins), Kodak, Windsor, and the City of Greeley.							
14	COSPLS02b	Tributaries to S Platte River, Beaver Creek, Bijou Creek and Kiowa Creek (Beaver Creek)											
15	COSPSV06	Tributaries to the St Vrain River (Dry Creek)											
16	COSPUS14	S. Platte River, Bowles Ave. to Burlington Ditch	Jon Novick: jon.novick@ci.denver.co.us 720-865-5468) Terry Baus: tery.baus@ci.denver.co.us 720-446-3603	Urban - light and heavy industry and commercial along river with residential neighborhoods in upper portions of storm sewer drainage basins. Parks scattered through out the basins.	Urban - City and County of Denver zoning data.	No. Characterization for human vs. non-human sources is planned starting in the spring of 2008.	Cross connections between sanitary and storm sewers, wildlife including geese and raccoons, pet waste, regrowth of existing E. coli in sediments.	Downstream increases in instream levels of E. coli are well established. Instream E. coli levels also increase with increasing instream temperatures, are higher during and after storm events, and also appear to be related to intensity of solar radiation.	Yes	Enhanced infrastructure maintenance activities.	Yes	Wading, swimming, and boating observed at the Confluence with Cherry Creek. Fishing observed upsteam of the Confluence.	TMDL complete and approved by EPA. TMDL implementation plan being developed. Will be incorporated into CCOD's MS4 permit.
17	COSPUS15	S. Platte River, Burlington Ditch to Big Dry Creek (Clear Creek to Fulton Canal diversion and Burlington canal headgate to MWRD.)	Sharon Henderson Davis: sdavis@mwrd.dst.co.us 303.286.3360										

Survey of 303(d) Listed Streams for E. coli/Fecal Coliform (Matrix Status as of 10/27/08--additional updates planned during 2008/2009)

	Segment	303(d) listed segments for E. coli/Fecal Coliform	Person providing information/basis of knowledge /contact information	Land Use Characteristics (Uniform, Diverse, or Distinctive Segments)	Dominant type(s) urban, ag, open space/natural) (basis of information)	Has source characterization been completed? If so, what types and what are expected sources of bacteria.	If formal source characterization has not been conducted, what are the "perceived" sources?	Have any trends been identified?	Have wet and dry weather conditions been monitored separately?	If sources have been identified, what are expected control measures (BMPs)? What BMPs are already in place?	Are WWTPs on the stream consistently meeting E. coli / fecal coliform std?	Observed recreational activity	Provide other thoughts/comments, or attach documents with more information
18	COSPUS16a	Sand Creek	Mary Dawson: Mdawson@auroragov.org 303-739-7372	Uniform w/n Aurora	Urban w/n Aurora	In progress. Dry weather sampling being conducted	Perception is that most sources will be non-point in nature and difficult to control.	No.	No, sampling program is only for dry weather screening	Too early to tell.	Yes.	Wading is a possibility in certain portions along open space.	Attached is data from WQCD.
19	COUCYA20	Tributaries to the Yampa River above Elkhead Creek within National Forest (First Creek below Second Creek, Elkhead Creek below First Creek)	Joan Carlson: jycarlson@fs.fed.us (tel: 303-275-5097)	Uniform	Open space/natural -- rangeland and wildlife habitat	Seasonal sampling indicates wildlife (elk) contribution in early summer before cows come on, combination cows and wildlife (beaver present in segment as well) during summer grazing season. Very low potential for human sources.		High variability in duplicate samples (i.e. two samples taken at the same place at the same time).	Not purposely -- some scheduled sampling days it was raining and some it was not.	Allotment Management Plan for NFS lands was rewritten in 2006 to include additional BMPs for riparian area restoration. Grazing on State Land section in watershed is currently unregulated.	N/A	Draft UAA was completed. Very little existing primary contact recreation is known to occur. Potential is limited by access -- 20 miles from nearest town, main access road closed to motor vehicles Dec 1 to July 1, access to listed segments on NFS lands requires a 2+ mile hike across State Land Section, permission is required to access State Land, stream is in open area with little shade, willows and steep banks limit access to water. Most recreational use in California Park is by hunters. No developed recreation facilities in the area.	Based on Draft UAA, we intend to propose a change to Recreation Use Class N for the listed segment in the June 2008 triennial review rulemaking hearing for the Upper Colorado River Basin with the E coli numeric criteria of 630 cts/ml. Data shows Class N standard is met, even with wildlife contribution.

Some estimate that 50 stream segments in Colorado could be impacted by the current standard.

Update on E. coli Work Group Progress

Jim McCarthy
City of Arvada
and
Jane Clary
Wright Water Engineers, Inc.
March 17, 2008

Colorado Watershed Protection Fund Grant Tasks

1. Annotated bibliography of existing *E. coli* resources by topic with hyperlinks to web resources
2. Evaluation of the EPA Report on the *Experts Scientific Workshop on Critical Research Needs for the Development of New or Revised Recreational Water Quality Criteria*
3. Annotated Summary of 303(d) Listed Streams to Identify Common Characteristics, General Issues and Possible Common Approaches
4. Presentation of Findings

1. Bibliography

- In progress
- Representative Topics
  - Stormwater BMP Performance
  - TMDLs—Varying approaches around the country
  - Monitoring/Analysis
  - Evolving water quality criteria
  - Source controls
  - Natural sources—land use
  - Modeling issues
  - Grazing/agriculture

TMDL Survey Major Findings

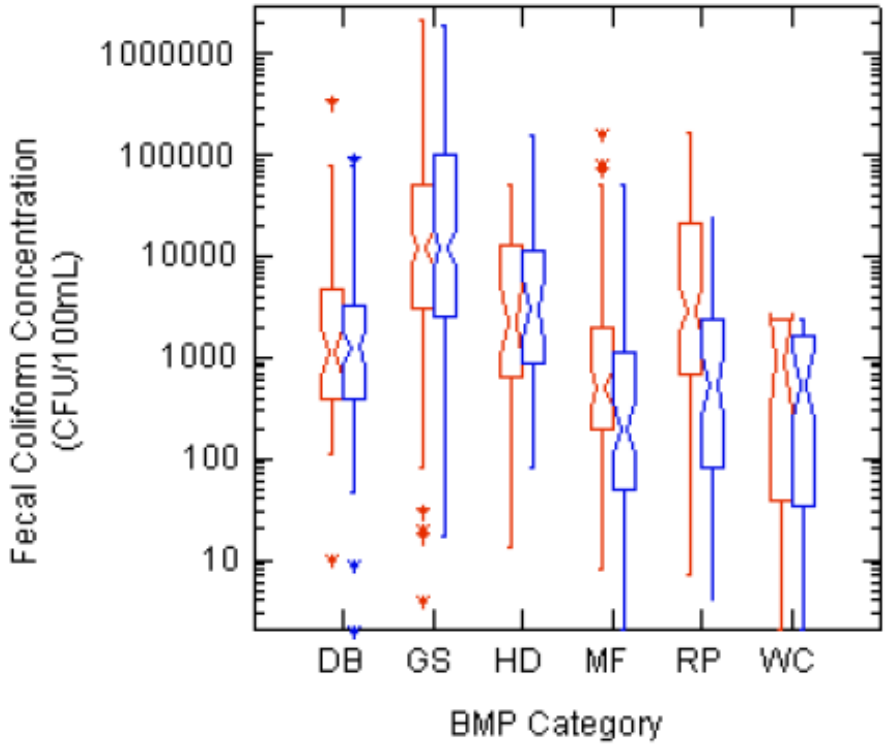
- Many bacteria TMDLs, but no one-size-fits all approach
- Some target reductions in geographic areas, but most target specific sources (e.g. dogs, septic, illicit connections)
- Computer models have been used successfully, incorrectly and avoided…Similar findings for Microbial Source Tracking
- Tendency to go with a number, even if not based on adequate data
- Did not identify any TMDL that has met all goals, although many have moved toward goals
- GIS is a key tool

TMDL Survey Major Findings (cont.)

- Some focus on watersheds, others on stream segments
- Social/community issues factor into TMDLs—important to keep parties at the table
- Load reductions commonly specified (not just numeric target)
- Stormwater and non-point sources typically targeted, WWTPs typically not the source
- Monitoring typically specified
- Adaptive management is a must
- Adequate and consistent funding is critical to measurable success

Stormwater BMP Performance Implications for MS4 Permits

Figure 1. Notched Box and Whisker Plots Summarizing Paired Fecal Coliform BMP Monitoring Results (Source: International Stormwater BMP Database 2007)

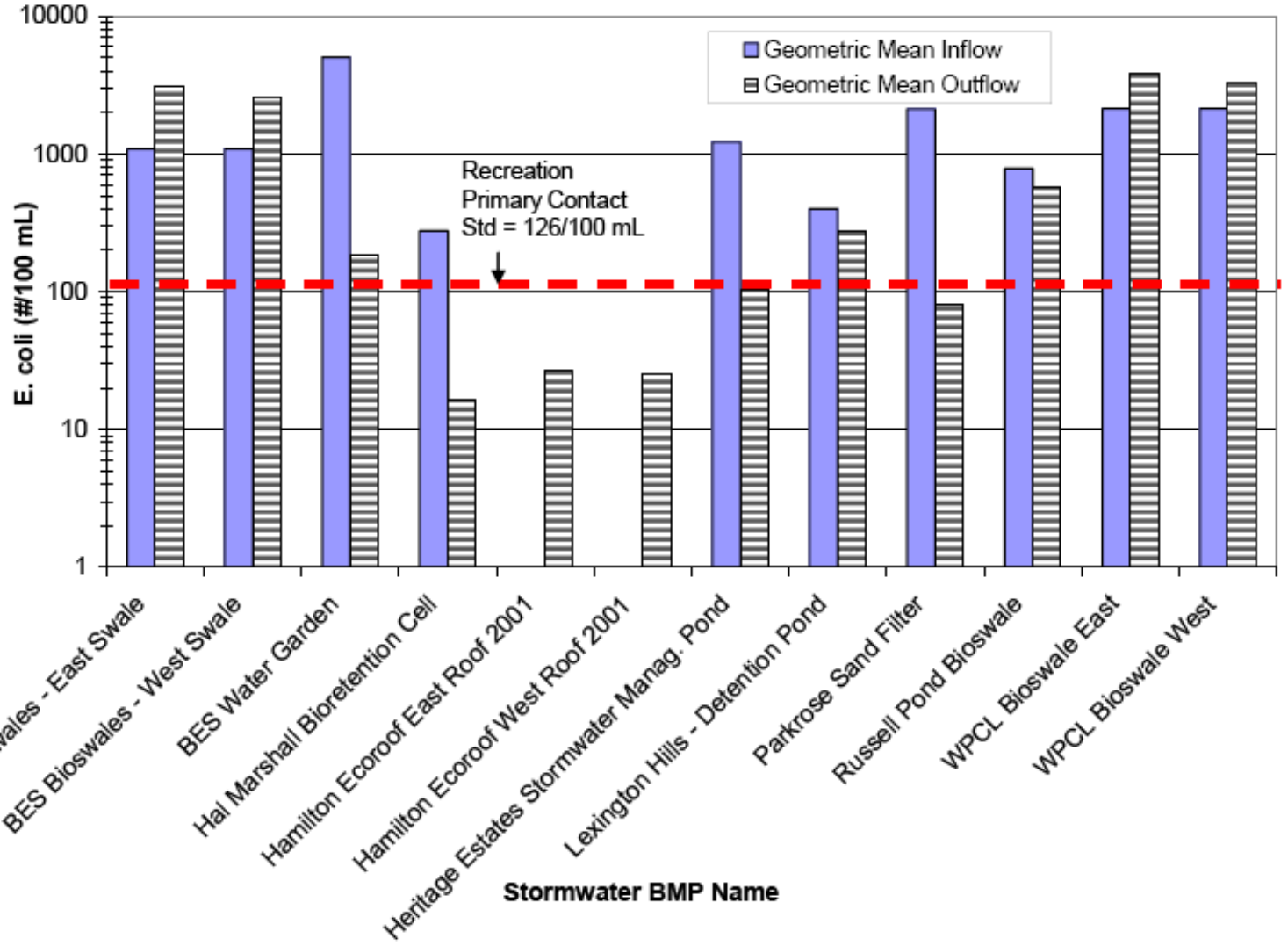


Key:

Inflow (Red)
Outflow (Blue)

DB= Detention Basin
GS= Grass Swales
HD=Manufactured Devices
MF= Media Filters
RP= Retention Ponds
WC=Wetland Channels

Figure 2. Comparison of Geometric Mean E. coli Data for Stormwater BMPs in International Stormwater BMP Database



Task 2. Overview of "Pellston Style Workshop Bacteria Report"

What Does it Mean for CO TMDLs?

Presented by
Jane Clary
Wright Water Engineers, Inc.
at the E. coli Work Group
February 2008

Background

- Who:
  - EPA invited 43 U.S. and international experts from academia, numerous states, public interest groups, USEPA and other federal agencies (“Pellston”-style workshop)
- When:
  - Meeting in March 2007, Report in June 2007
- Why:
  - To discuss the state of the science on recreational water quality research and implementation issues to support revised criteria by 2012.
  - The purpose was for EPA to obtain input from experts on the “critical path” research/needs in the near-term (2-3 yrs) for developing scientifically defensible new or revised recreational ambient water quality criteria.

Why Are New/ Revised Criteria Needed?

Selected Comments from Experts

- “Designed to protect swimmers from illnesses due to exposure to pathogens in recreational waters, the existing criteria are more than 20 years old.” (EPA website)
- “1986 criteria provide defined criteria at a single risk level but do not provide for adjustment based on other sources of information such as sanitary investigations or source identification.” p.166

Why (cont., p. 145)

- The 1986 criteria provide minimal implementation guidance.
- Due to most States' interpretation…, the criteria tend to be treated as requiring compliance at all times and in all waters. This interpretation has caused considerable problems in the assessment and TMDL arenas.
- Any new or revised criteria must include implementation guidance that allow for methods to address issues such as extreme flows and nonhuman sources of fecal contamination.

Why (cont. from p.166)

- The original basis for the 1986 criteria were freshwater and marine water epidemiological studies conducted at a limited number of sites with restricted geographic extent and waterbody type (lake beaches and marine beaches).
- "A concern exists that single value criteria may not be applicable to all waters across the United States—for instance, inland flowing waters…"
- In developing new criteria, epidemiological data or quantitative microbiological risk assessment (QMRA) for as wide a variety of fresh and marine waters as is possible should be used.

Workshop Process

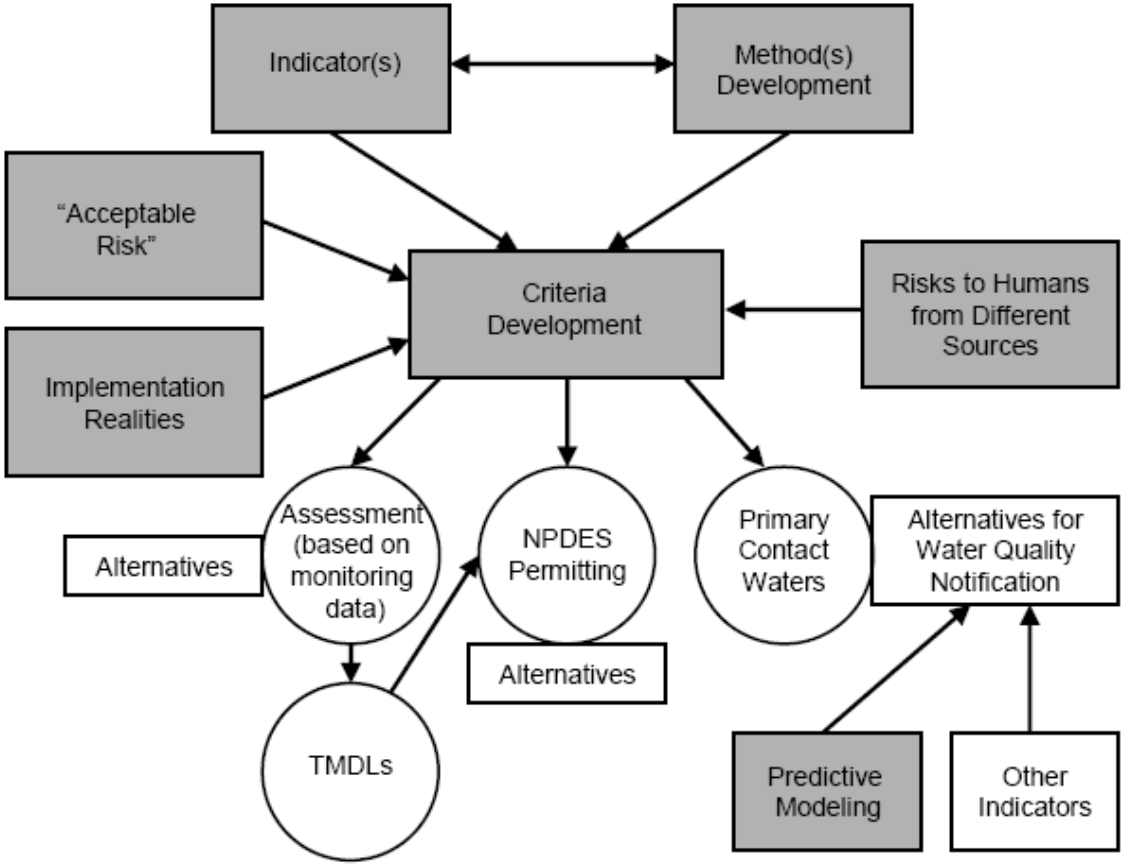


Figure 3. Flow Diagram of How the Workgroup Topics Contribute to the Development and Implementation of New or Revised Recreational Water Quality Criteria.

EPA Suggests a Toolbox Approach

- Increased flexibility for better nation-wide application
- Equivalent risk levels must be achieved, regardless of selected tool
- Implementation issues exist related to how to relate different “tools”

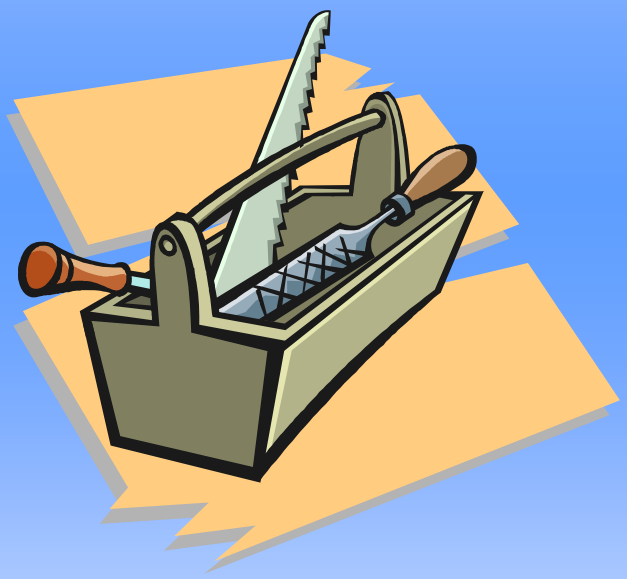


Table 1. WHO Classification Matrix for Integrating Microbial Water Quality as Measured by Enterococci Density with Sanitary Inspection Category.

		Microbial Water Quality Assessment Category (95th percentile intestinal enterococci/100 ml)				
		A ≤40	**B** 41–200	**C** 201–500	**D** >500	**Exceptional circumstances**
Sanitary Inspection Category (susceptibility to faecal influence)	**Very low**	Very good	Very good	Follow up[1]	Follow up[1]	Action
	Low	Very good	Good	Fair	Follow up[1]	
	Moderate	Good[2]	Good	Fair	Poor	
	High	Good[2]	Fair[2]	Poor	Very poor	
	Very high	Follow up[2]	Fair[2]	Poor	Very poor	
	Exceptional circumstances	Action				

Notes:

[1] implies non-sewage sources of faecal indicators (e.g., livestock), and this should be verified (section 4.6.2).

[2] indicates possible discontinuous/sporadic contamination (often driven by events such as rainfall). This is most commonly associated with Combined Sewer Overflow (CSO) presence. These results should be investigated further and initial follow-up should include verification of sanitary inspection category and ensuring samples recorded include "event" periods. Confirm analytical results. Review possible analytical errors (see section 4.6.2).

[3] In certain circumstances, there may be a risk of transmission of pathogens associated with more severe health effects through recreational water use. The human health risk depends greatly upon specific (often local) circumstances. Public health authorities should be engaged in the identification and interpretation of such conditions (section 4.6.5).

[4] Exceptional circumstances (see section 4.6.5) relate to known periods of higher risk, such as during an outbreak with a pathogen that may be waterborne, sewer rupture in the recreational water catchment, etc. Under such circumstances, the classification matrix may not fairly represent risk/safety.

SOURCE: WHO, 2003.

Table 2. Numerical Microbiological Water Quality Assessment Classification for Fresh (Inland) and Marine (Coastal and Transitional) Bathing Waters for the 24 EU Member States.

Inland (Fresh) Waters			
Indicator	Excellent	Good	Sufficient
(Intestinal) enterococci (cfu/100 mL)	200*	400*	360**
E. coli (cfu/100 mL)	500*	1,000*	900**
Coastal and Transitional (Marine) Waters			
Indicator	Excellent	Good	Sufficient
(Intestinal) enterococci (cfu/100 mL)	100*	200*	200**
E. coli (cfu/100 mL)	250*	500*	500**

Notes: * = Based on a 95th percentile evaluation; ** = Based on a 90th percentile evaluation to reduce the risk of statistical anomalies when using a small data set, which also allows lower limit values for enterococci and *E. coli* densities in inland waters to be classified as sufficient versus good microbiological water quality.

Source: Adapted from EP/CEU (2006).

Timing/Notification Issues
Changes in Indicator Concentrations

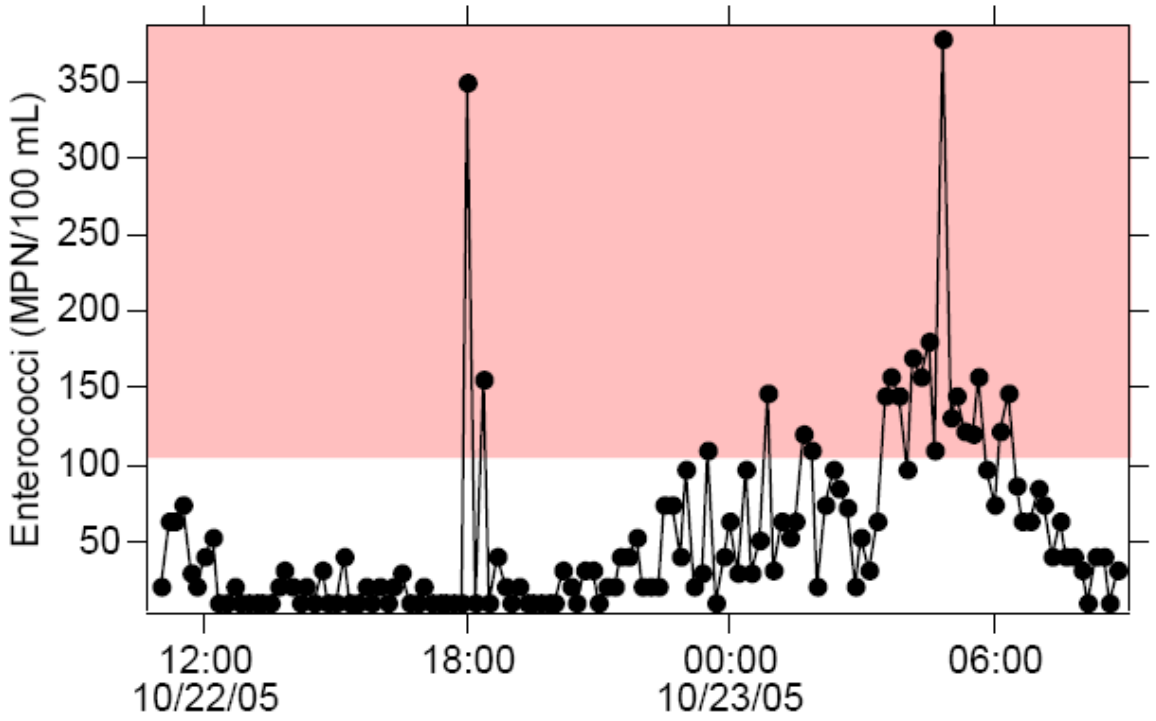


Figure 4a. Enterococci (MPN/100 mL) Sampled Every 10 Minutes at a Beach in California. (The reference background denotes the range of single sample exceedance.) SOURCE: A.B. Boehm, unpublished data (ENTEROLERT assay).

High Priority Model Research
Processes Affecting Fate and Transport

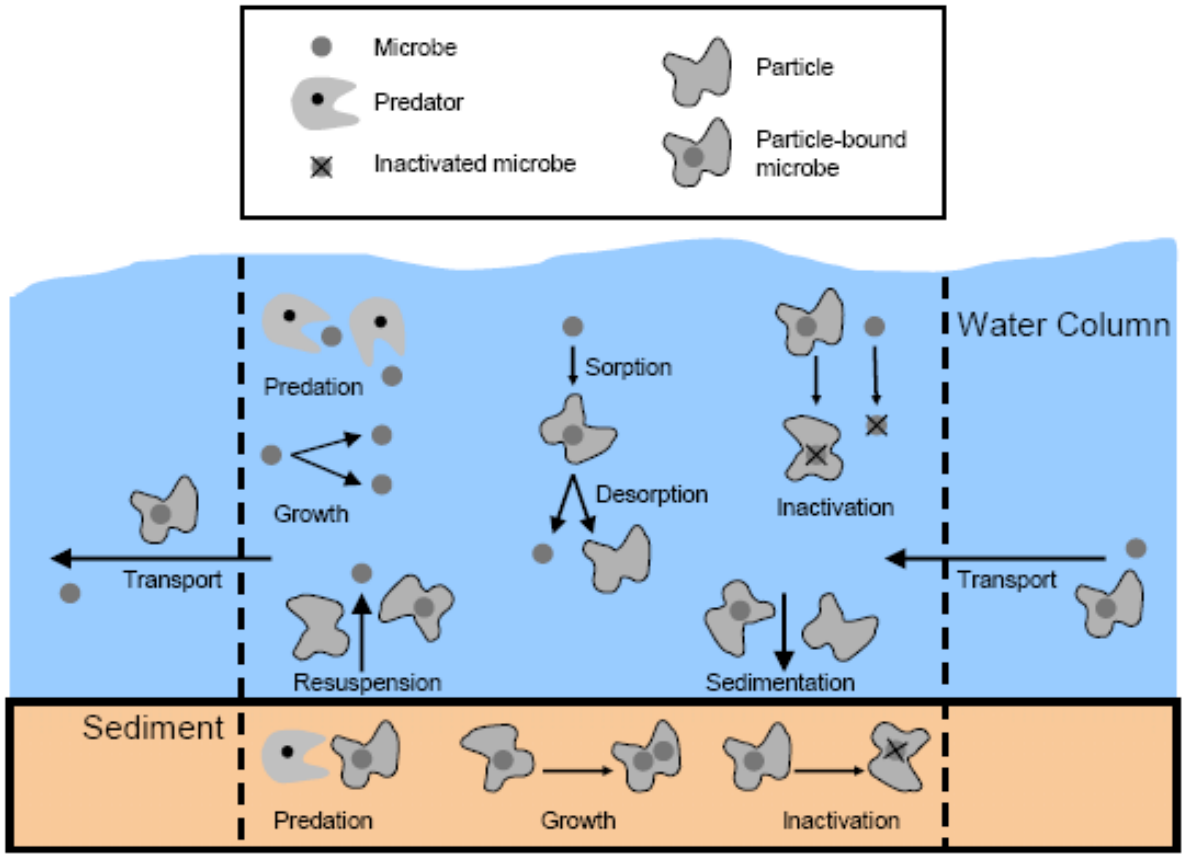


Figure 5. The Possible Fates of Microbes (Fecal Indicators and Pathogens) in Environmental Water and Sediment (the fate of nucleic acids may be different; this figure does not include those sources). SOURCE: Adapted from Olivieri et al. (2007).

Summary of "Critical Path Research"

1. Human health impacts from different sources of fecal contamination
2. Measurement issues: climatic, geographic, and temporal variability
3. Determining risk level and subpopulations of concern
4. Indicators and methods for measuring fecal contamination

Conclusions from Review of EPA Experts Report

- EPA report addresses many of the concerns of Colorado communities faced with bacteria TMDLs.
- Critical path research needs have been well identified. EPA appears to have a good process with expert input.
- Colorado TMDLs have a timing issue due to revised EPA criteria in 2012.
- Some topics may warrant more detailed discussion by E. coli workgroup.

Task 3. Colorado's 303(d) List—What are the common factors?

- 22 segments with widely varying characteristics
  - Urban
  - Agriculture
  - Transitional urban-agriculture
  - National Forest
- Varying degrees of recreational use
  - Swimming/kayaking
  - Incidental ingestion potential, but no swimming
- Varying degrees of knowledge on sources
  - Human sources
  - Natural sources
- What should TMDLs look like given these differences and the evolving state of the science and possibly changing water quality standards?

Questions?

Jim McCarthy
City of Arvada
720-898-7765

Jane Clary
Wright Water Engineers
303-480-1700

Getting Real with Bacteria, Stormwater BMPs, and TMDLs

By Jane Clary[1] and Jonathan Jones[2], P.E., D.WRE

Many communities throughout the United States are faced with Total Maximum Daily Loads (TMDLs) for bacteria, typically for either *E. coli* or fecal coliform. For local governments responsible for National Pollutant Discharge Elimination System (NPDES) Municipal Separate Stormwater (MS4) permits, this issue can be particularly challenging and many questions arise with regard to whether stormwater best management practices (BMPs) can reduce bacteria in stormwater runoff. In Colorado, 22 stream segments are listed on the State 303(d) list for *E. coli*, with 16 additional segments included on the State's Monitoring and Evaluation list. Many valid questions exist regarding how attainable current stream standards are and what measures are truly meaningful in reducing bacteria in streams and in development of meaningful TMDLs.

This paper will provide national, state and local perspective on these issues based on a variety of research including:

1) Analysis completed based on the Best Management Practice (BMP) performance data contained in the International Stormwater BMP Database,

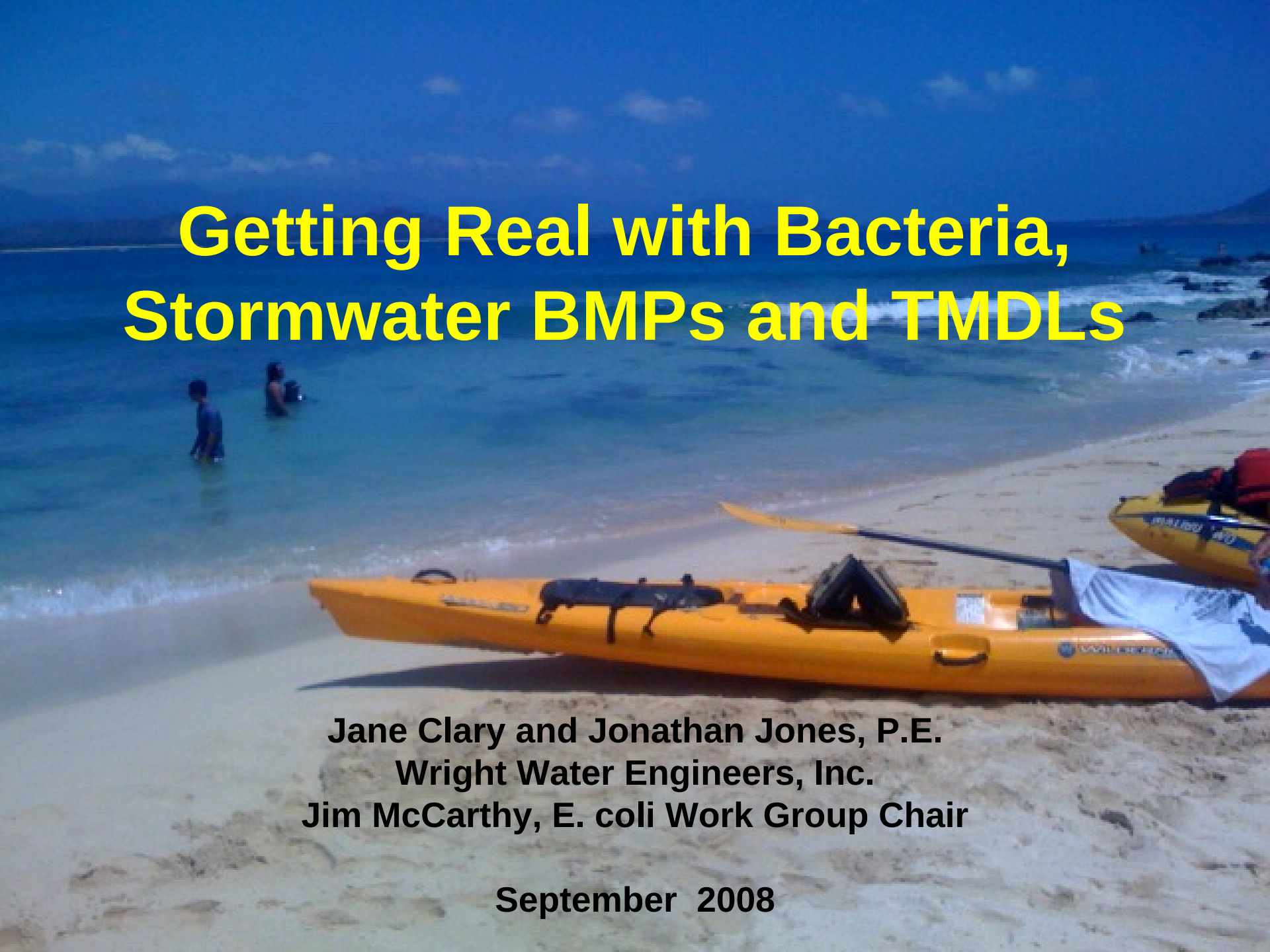
2) Efforts to date under the *E. coli* Work Group, including a synopsis of key findings from the U.S. Environmental Protection Agency's expert panel report on revision of recreational water quality criteria by 2012, and

3) Examples of real-world bacteria-related issues from diverse local watersheds.

Findings from analysis of these sources of information will be used to provide some recommendations regarding the types of efforts that are expected to provide meaningful results in terms of bacteria reduction in stormwater and receiving waters. Implications for development of TMDLs with the potential to provide real improvement of water quality will also be identified.

[1]Senior Water Resources Scientist, Wright Water Engineers, Inc.; 2490 W. 26th Ave., Suite 100A; Denver, CO 80211; clary@wrightwater.com.
[2] Chief Executive Officer, Wright Water Engineers, Inc.; 2490 W. 26th Ave., Suite 100A; Denver, CO 80211; jonjones@wrighwater.com.

Getting Real with Bacteria, Stormwater BMPs and TMDLs

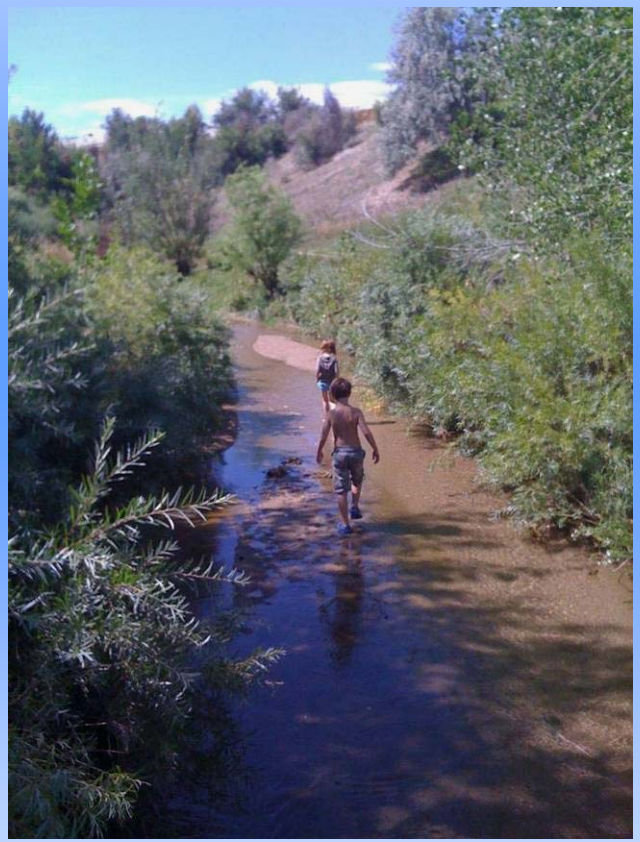


Jane Clary and Jonathan Jones, P.E.
Wright Water Engineers, Inc.
Jim McCarthy, E. coli Work Group Chair

September 2008

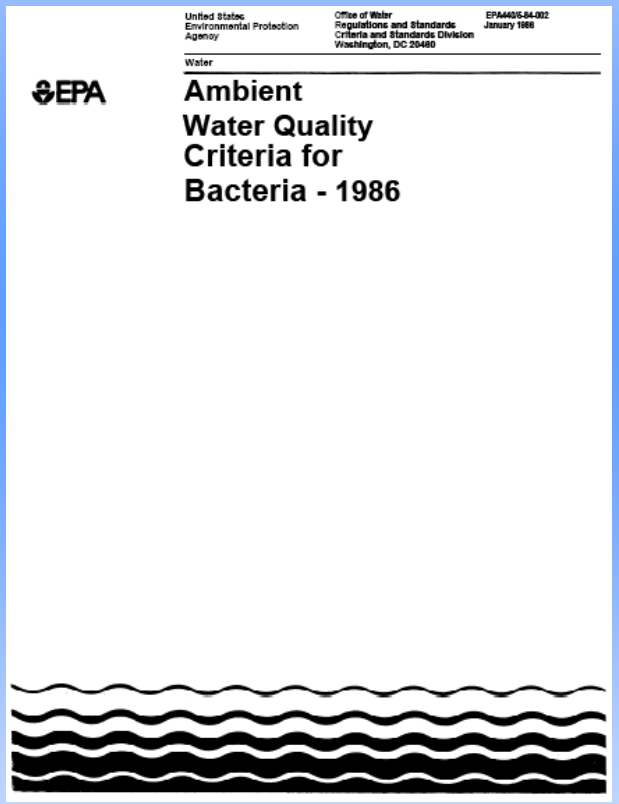
Overview

- Basic introduction to the E. coli issue
  - EPA and Colorado standards
  - 303(d) listings and TMDLs
- Efforts of the E. coli Work Group--approaches to attaining standards in CO
- Local case study: Big Dry Creek
- MS4s and BMPs: what will really work?



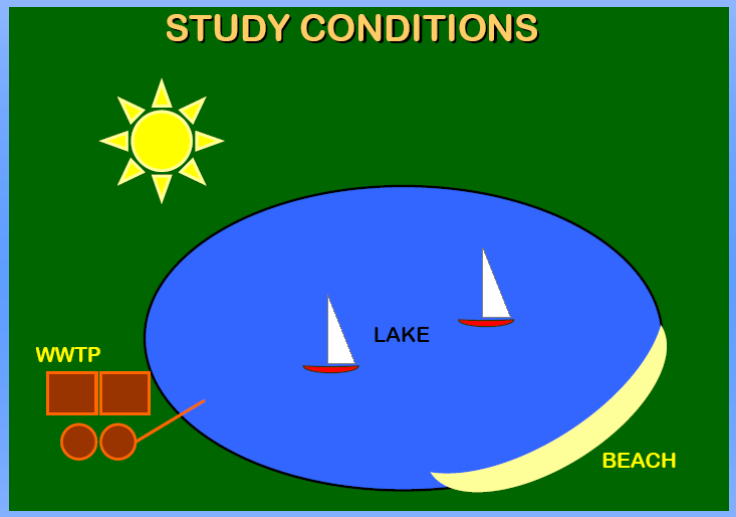
Ambient Water Quality for Recreational Use (EPA 1986)

- Section 304(a)(1) of the Clean water Act requires the EPA to publish criteria for water quality
- Bacteria criteria released 1976, updated in 1986, scheduled for update 2012
- EPA Water Quality Criteria lead to State Water Quality Standards



EPA 1986 Criteria

- 1972 studies to update US Public Health Service studies from1940s/1950s
- Marine studies (Cabelli) at beaches:
  - New York City, Boston and Lake Pontchartrain.
- Freshwater studies (Dufour) at beaches:
  - Lake Erie, PA and Keystone Lake, Tulsa
  - Contamination from effluents discharged from single point-sources.
- "Does swimming in sewage-contaminated water carry a health risk for bathers; and, if so, to what type of illness?"



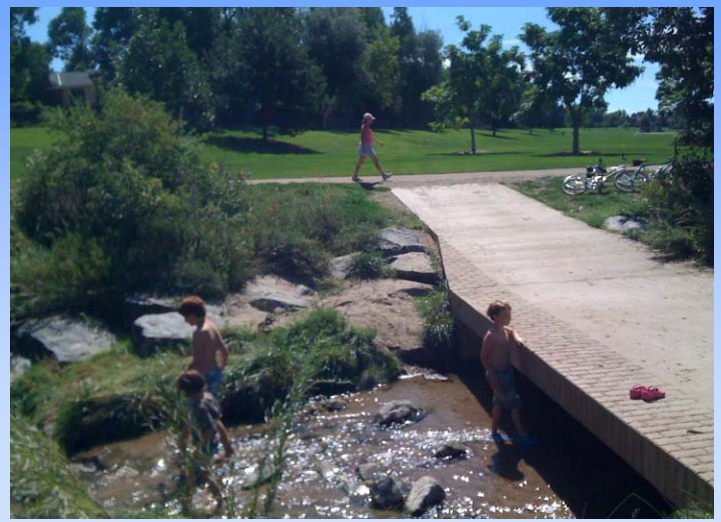
Graphic Source: Michael Bloom, PBS&J, Houston, TX

Current Colorado E. Coli Numeric Standards (attainment based on Geometric Mean)

CLASS E (Existing Primary Contact) and **CLASS U** (Undetermined Use)	**CLASS P** (Potential Primary Contact Use)	**CLASS N** (Not Primary Contact Use) (5 x Class E)
126/100 mL	205/100 mL	630/100 mL

What is Considered Primary Contact Recreation?

- “Recreational activities where the ingestion of small quantities of water is likely to occur. Such activities include but are not limited to swimming, rafting, kayaking, tubing, windsurfing, water-skiing, and frequent water play by children.”



What are the implications?

- Over 10,000 impaired streams nationally due to bacteria (#1 listing)
- More bacteria TMDLs than any other contaminant
- Over 20 stream segments listed for E. coli on Colorado 303(d) list
  - "High priority" ranking for TMDLs
  - Urbanized areas where contact likely will probably be first (South Platte Basin)
  - Stormwater permit holders need to understand the issues

Tasks Under Watershed Protection Fund Grant to Colorado Stormwater Council/E. coli Work Group

1. Annotated bibliography of existing *E. coli* resources (>600 references)
2. Evaluation of the EPA Report on the *Experts Scientific Workshop on Critical Research Needs for the Development of New or Revised Recreational Water Quality Criteria*
3. Annotated Summary of 303(d) Listed Streams to Identify Common Characteristics, General Issues and Possible Common Approaches
4. Sharing Findings and continuing discussions

Task 2. Overview of "Pellston Style Workshop Bacteria Report"

- 43 experts March 2007
- Critical path research needs

Why (cont., p. 145)

- “1986 criteria provide defined criteria at a single risk level but do not provide for adjustment based on other sources of information such as sanitary investigations or source identification.” p.166
- Due to most States’ interpretation…, the criteria tend to be treated as requiring compliance at all times and in all waters. This interpretation has caused considerable problems in the assessment and TMDL arenas.
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- The original basis for the 1986 criteria were freshwater and marine water epidemiological studies conducted at a limited number of sites with restricted geographic extent and waterbody type (lake beaches and marine beaches).
- "A concern exists that single value criteria may not be applicable to all waters across the United States—for instance, inland flowing waters…"
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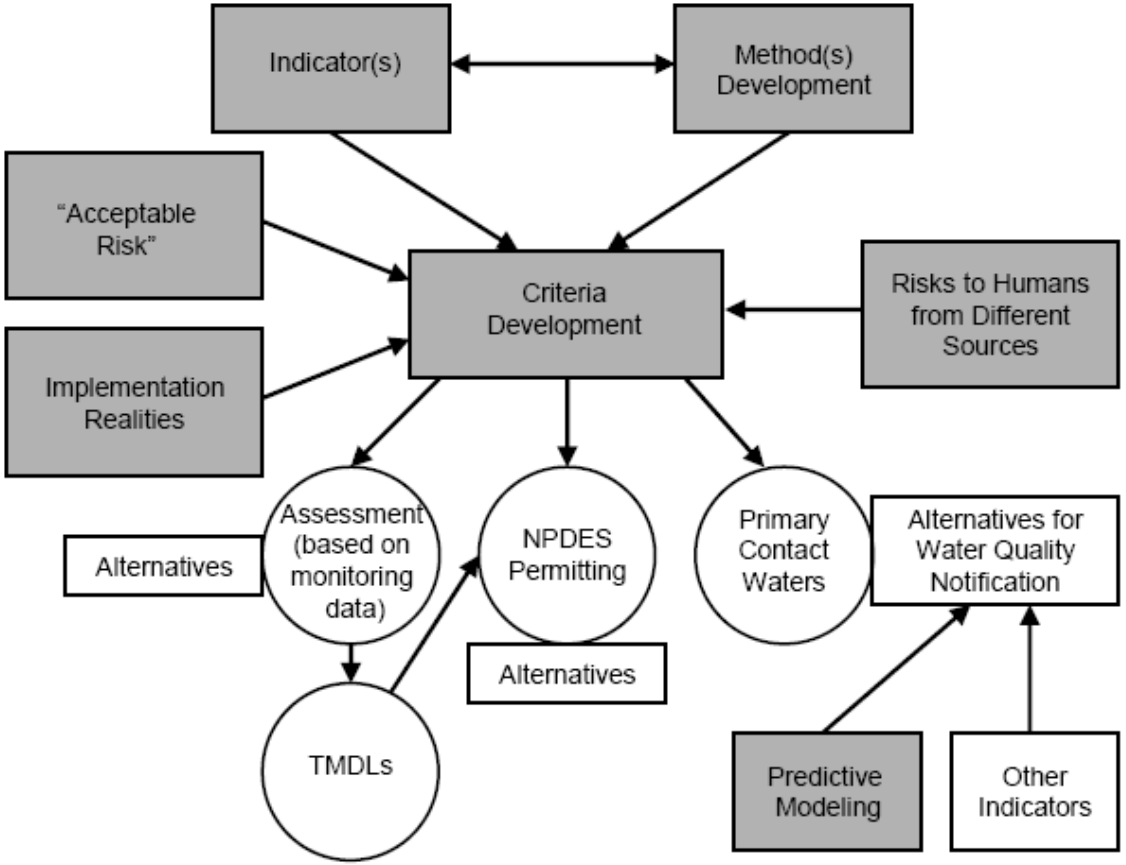
Workshop Process



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		Microbial Water Quality Assessment Category (95th percentile intestinal enterococci/100 ml)				
		A ≤40	**B** 41–200	**C** 201–500	**D** >500	**Exceptional circumstances**
Sanitary Inspection Category (susceptibility to faecal influence)	**Very low**	Very good	Very good	Follow up[1]	Follow up[1]	Action
	Low	Very good	Good	Fair	Follow up[1]	
	Moderate	Good[2]	Good	Fair	Poor	
	High	Good[2]	Fair[2]	Poor	Very poor	
	Very high	Follow up[2]	Fair[2]	Poor	Very poor	
	Exceptional circumstances	Action				

Notes:

[1] implies non-sewage sources of faecal indicators (e.g., livestock), and this should be verified (section 4.6.2).

[2] indicates possible discontinuous/sporadic contamination (often driven by events such as rainfall). This is most commonly associated with Combined Sewer Overflow (CSO) presence. These results should be investigated further and initial follow-up should include verification of sanitary inspection category and ensuring samples recorded include "event" periods. Confirm analytical results. Review possible analytical errors (see section 4.6.2).

[3] In certain circumstances, there may be a risk of transmission of pathogens associated with more severe health effects through recreational water use. The human health risk depends greatly upon specific (often local) circumstances. Public health authorities should be engaged in the identification and interpretation of such conditions (section 4.6.5).

[4] Exceptional circumstances (see section 4.6.5) relate to known periods of higher risk, such as during an outbreak with a pathogen that may be waterborne, sewer rupture in the recreational water catchment, etc. Under such circumstances, the classification matrix may not fairly represent risk/safety.

SOURCE: WHO, 2003.

Workgroup Perspective on Relative Risks

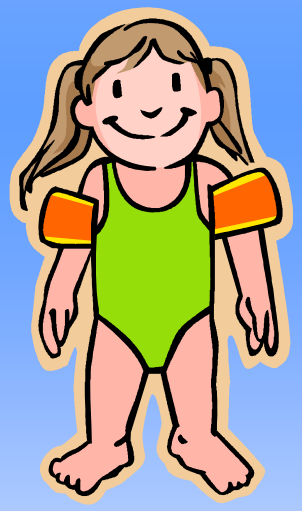


Table 5. Comparing Risks (to Humans) from Different Pathogen Sources.[a]

Source	Viruses	Protozoa	Bacteria	
Wildlife				
Aquatic birds	N	L	L-M	
Other (e.g., deer)	N	M	M	#2 priority
Agricultural animals				
Poultry	N	N	M-H	
Other (e.g., cattle, sheep)	N	M	M-H	#1 priority
Domestic animals				
Pets (e.g., dogs, cats)	N	L	L	
Fecal shedding by bathers				#3 priority
Adults	L	L	L	
Children	H	H	H	
Sewage				
No treatment (combined sewer overflows)	H	H	H	
No treatment (separate storm sewer overflows)	?*	?*	?*	
Secondary treatment**	H	H	M	
Plus chlorine**	H	H	L	
Plus UV	M-H (L with increased energy)		L	
Secondary environments* **	L	L	M	

[a] Does not have an explicit fate and transport component

* Risk largely depends on amount of human feces present

** Focus of most (U.S.) recreational water epidemiological studies

*** Sediment suspension and contact with beach sand

N = estimated no or negligible risk, L = estimated low risk, M = estimated medium risk, H = estimated high risk

Timing/Notification Issues
Changes in Indicator Concentrations

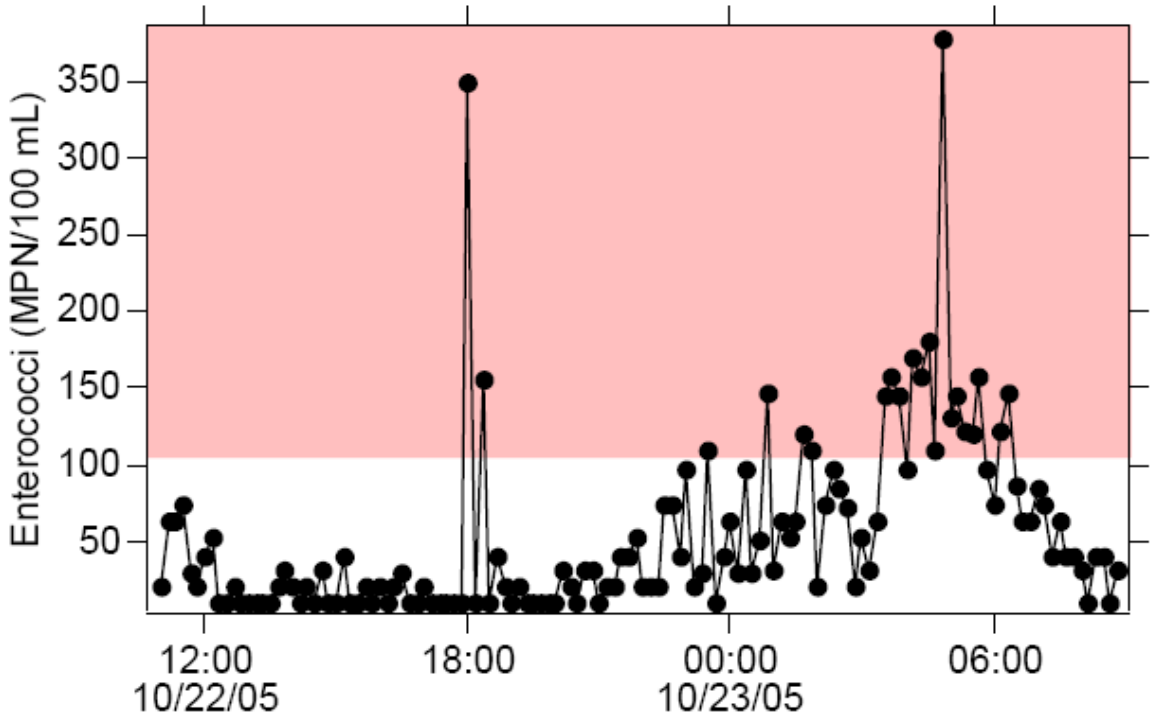


Figure 4a. Enterococci (MPN/100 mL) Sampled Every 10 Minutes at a Beach in California. (The reference background denotes the range of single sample exceedance.) SOURCE: A.B. Boehm, unpublished data (ENTEROLERT assay).

High Priority Model Research
Processes Affecting Fate and Transport

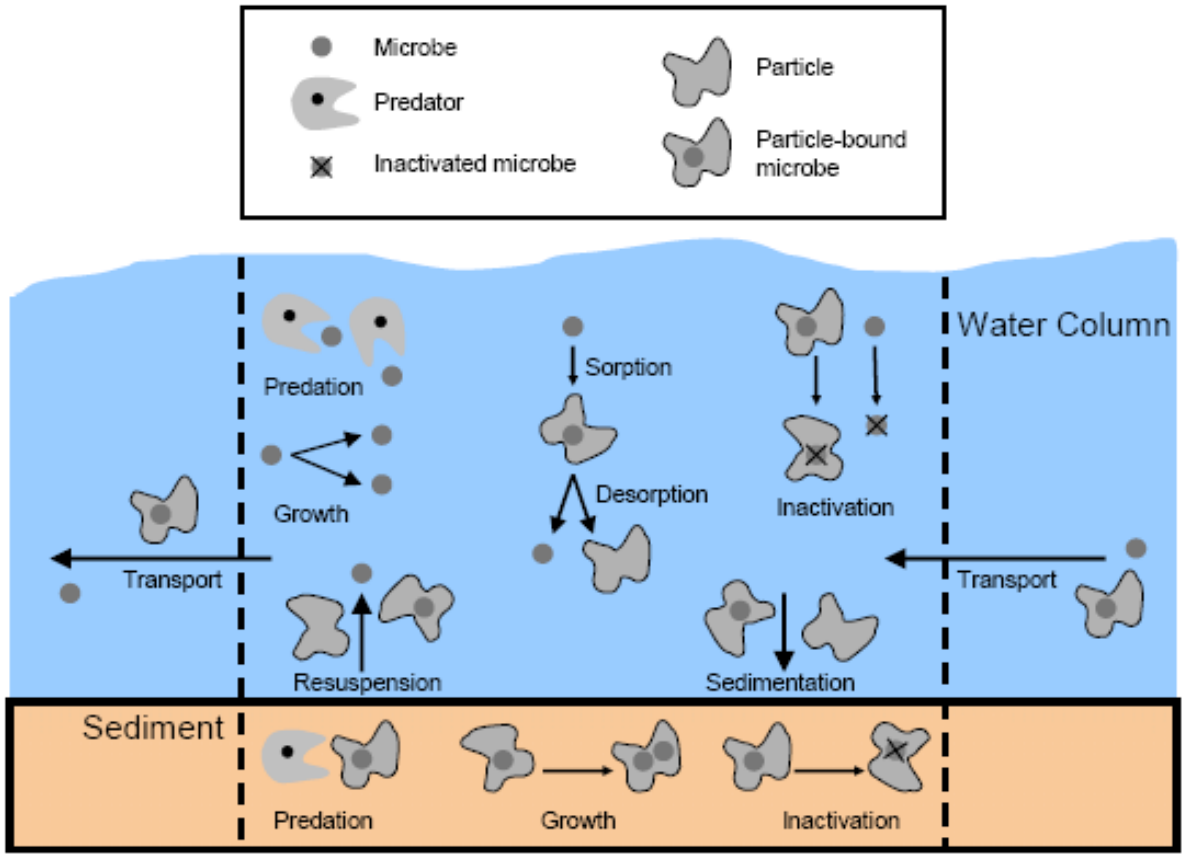
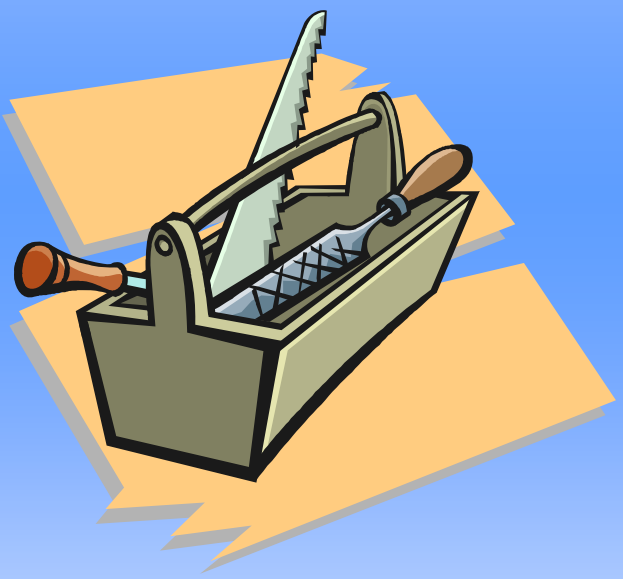


Figure 5. The Possible Fates of Microbes (Fecal Indicators and Pathogens) in Environmental Water and Sediment (the fate of nucleic acids may be different; this figure does not include those sources). SOURCE: Adapted from Olivieri et al. (2007).

EPA Suggests a Toolbox Approach

- Increased flexibility for better nation-wide application
- Equivalent risk levels must be achieved, regardless of selected tool
- Implementation issues exist related to how to relate different “tools”



Summary of "Critical Path Research"

1. Human health impacts from different sources of fecal contamination
2. Measurement issues: climatic, geographic, and temporal variability
3. Determining risk level and subpopulations of concern
4. Indicators and methods for measuring fecal contamination

Task 3. Colorado's 303(d) List—What are the common factors?

- 22 segments with widely varying characteristics
  - Urban
  - Agriculture
  - Transitional urban-agriculture
  - National Forest
- Varying degrees of recreational use
  - Swimming/kayaking
  - Incidental ingestion potential, but no swimming
- Varying degrees of knowledge on sources
  - Human sources
  - Natural sources
- What should TMDLs look like given these differences and the evolving state of the science and possibly changing water quality standards?

E. coli Work Group Discussions: What is the current reality?

- Reality is:
  - If changes are made to EPA standards, it will be at least 2012; then not into CO Basic Standards Until at least 2015
  - Bacteria TMDLs must move forward within current framework
  - WQCD has a draft screening/step-wise process being discussed with E. coli Work Group
  - Currently, the primary options for listed streams:
    - TMDL
    - Change Use Classification or Resegment (based on UAA)
    - Ambient Based Standard (if natural or irreversible conditions prevent attainment of the standard)
    - Wildlife off-ramp in Basic Standards?

Three Colorado Case Studies: No one size-fits-all solution

- South Platte River Segment 14
  - First Colorado bacteria TMDL
  - Primary contact recreation “destinations” exist
  - Elevated E. coli in dry weather discharges first priority
  - MS4 permit primary implementation tool
  - All sources assigned 126/100 mL
- Elkhead/Yampa River
  - Standard not attained
  - Change of use to “Not Primary Contact” for remote area with large elk herd, some cattle grazing
- Big Dry Creek
  - Had a temporary modification until 12/07
  - Mixture of land use and access
  - Not a primary contact recreation destination
  - Dry weather discharges do not appear to be problem
  - Some agricultural contribution, but not used for frequent water play by children
  - Wildlife expected to be a key source

Big Dry Creek Case Study

- 110 square miles
- 42 mile length
- Rocky Flats to Fort Lupton

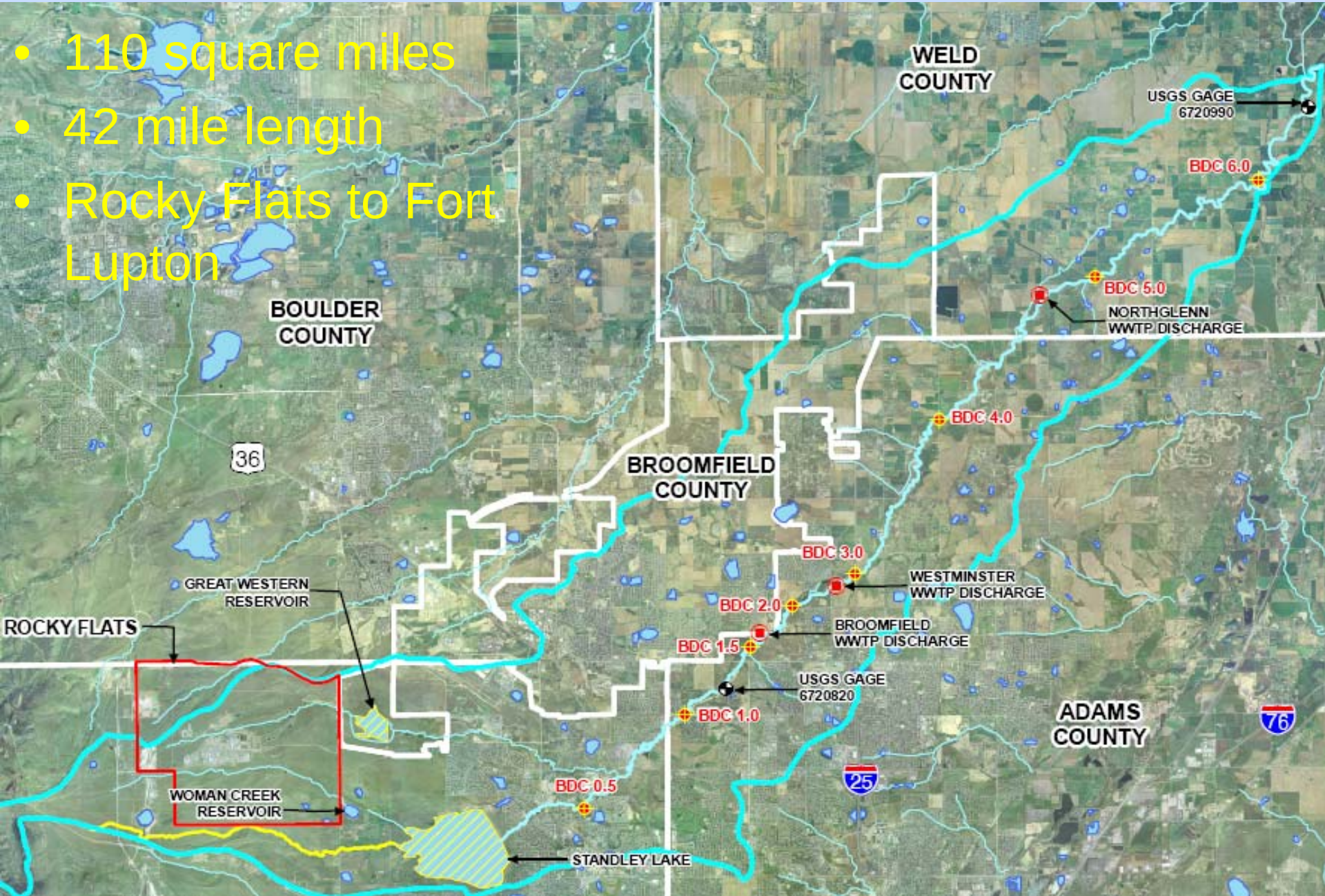
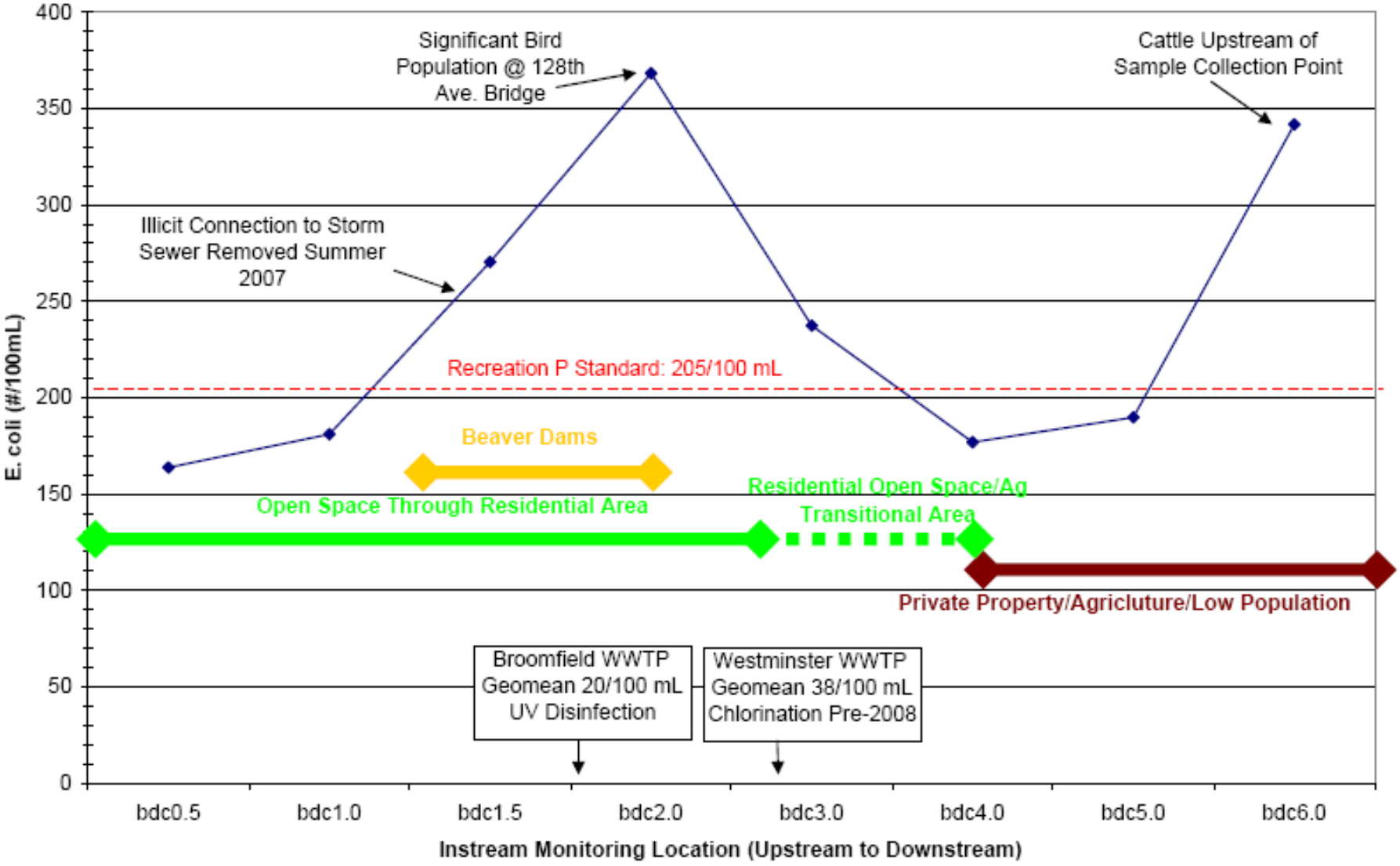
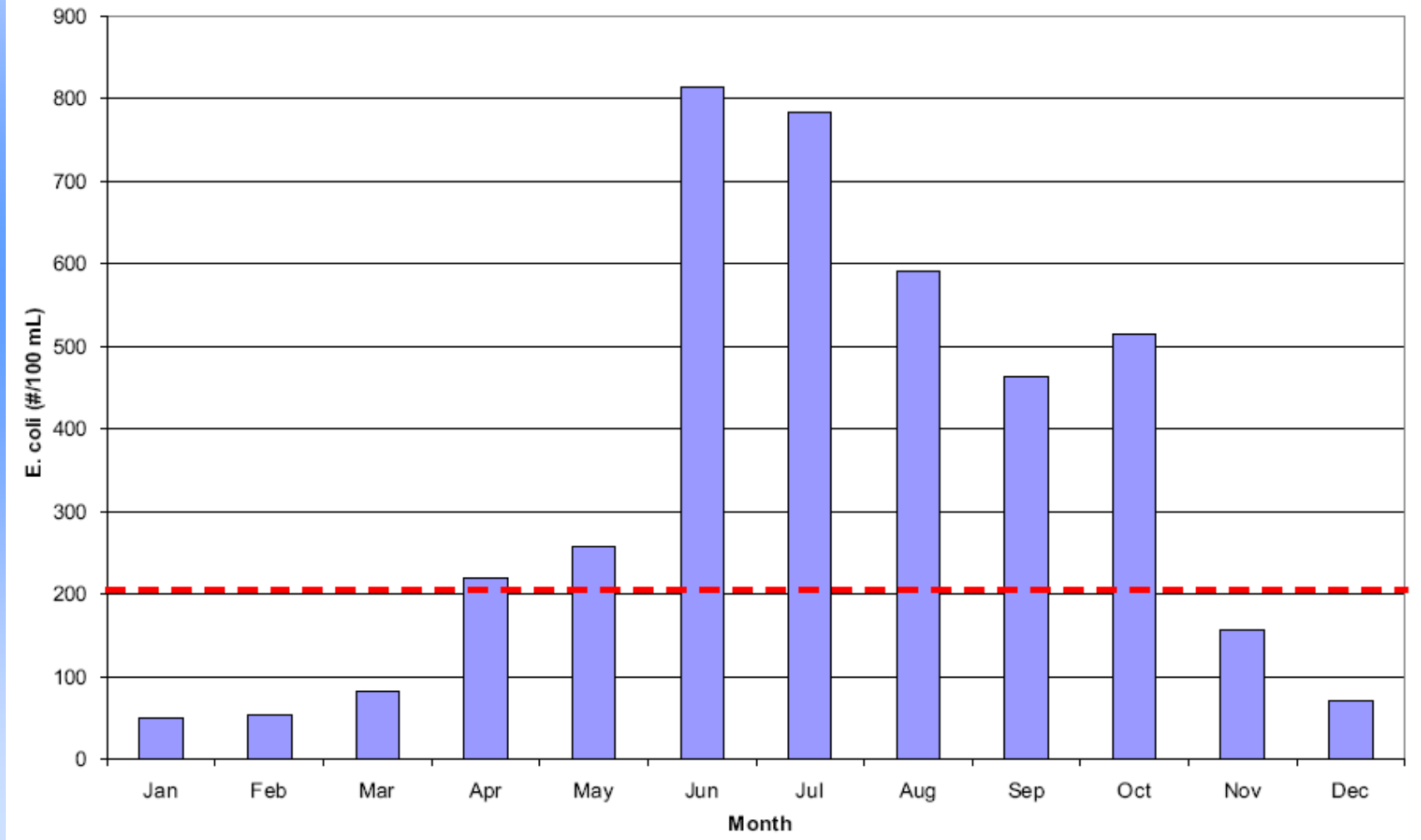


Figure 2. Land Use and Potential Source Descriptions
Geometric Mean E. coli Based on Monthly E. coli Data 2003-2007



Big Dry Creek E. Coli 2003-2007 Seasonal Trend

Figure 7. Monthly Geometric Mean *E. coli* at Big Dry Creek Instream Locations (2003-2007)



Part I Dry Weather Screening

FIGURE 1a

PROJECT NO. 971-179.094

BIG DRY CREEK

E. COLI

DRY WEATHER SAMPLE LOCATIONS

LEGEND

- Instream Sample Points
- Dry Weather Sample Locations (Broomfield)
- Dry Weather Sample Locations (Westminster)
- Beaver dams
- Broomfield Storm Outfall*
- Westminster Storm Outfall*

1 INCH EQUALS 700 FEET

0 350 700 1,400 FEET

WRIGHT WATER ENGINEERS, INC.
2490 W 26TH AVE 100A
DENVER, CO. 80211
(303) 480-1700

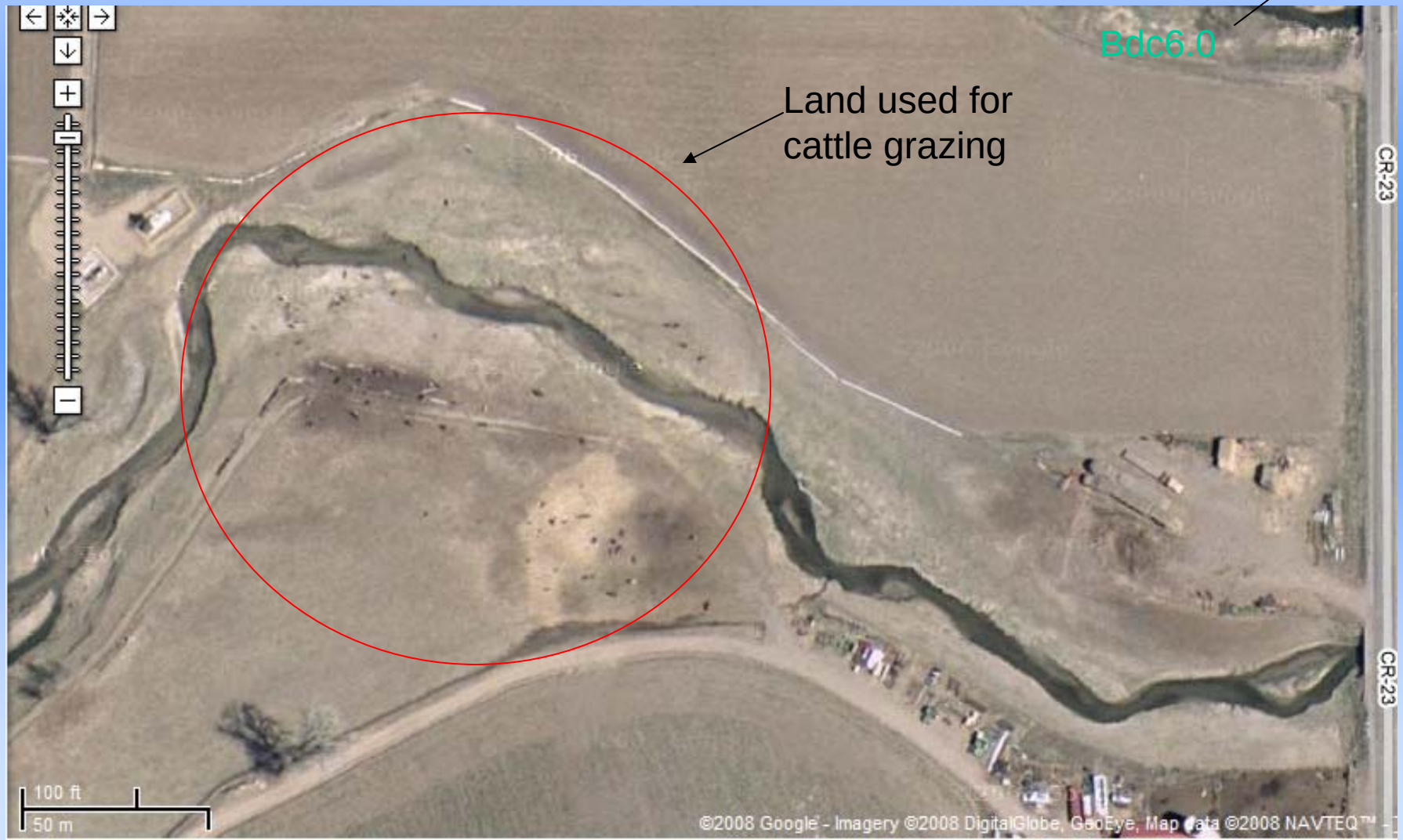

DO NOT ENTER
HEAD
Smokin
on pot
Hydro

One Illicit Discharge Identified and Corrected

Other Sources

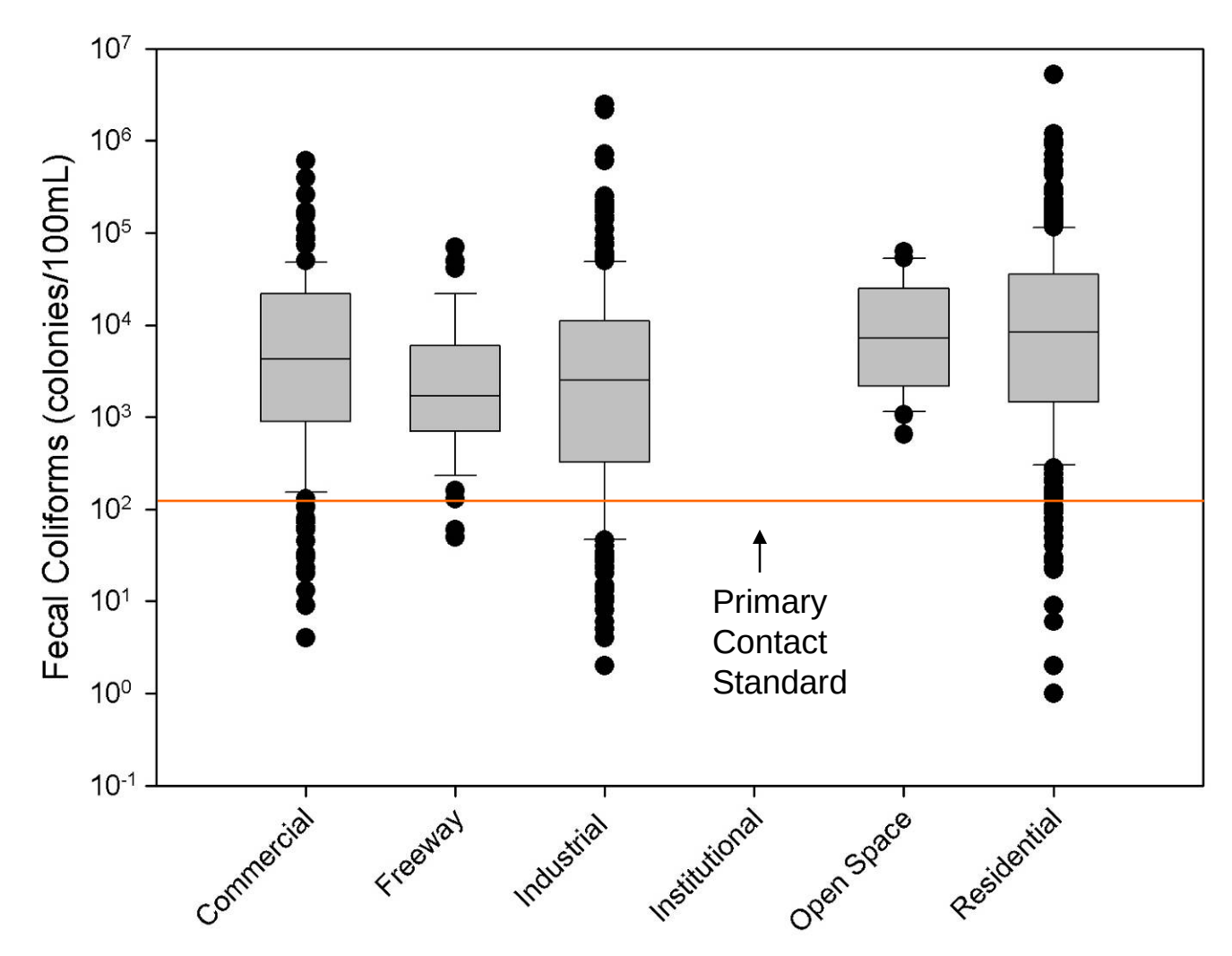
Part 2. Aerial Photo Review
Agricultural/Private Property

Agricultural Land Use Immediately Upstream of bdc6.0



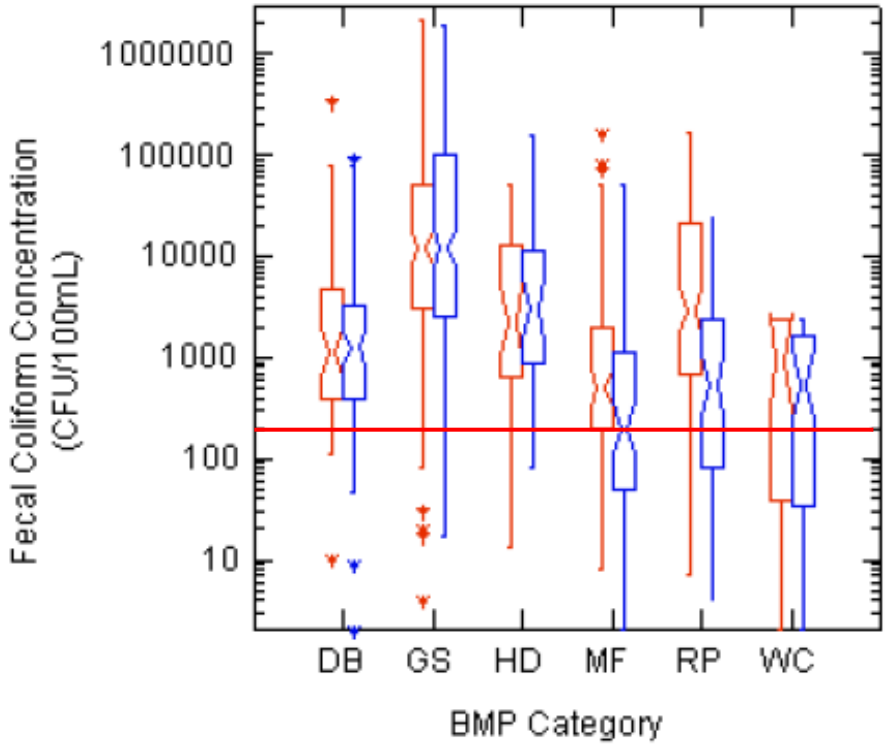
Reducing Bacteria Loads: What can realistically be expected?

National Stormwater Quality Database (Pitt, Maestre, Morchecco 2004)



Stormwater BMP Performance Implications for MS4 Permits

Figure 1. Notched Box and Whisker Plots Summarizing Paired Fecal Coliform BMP Monitoring Results (Source: International Stormwater BMP Database 2007)



Key:

Inflow (Red)
Outflow (Blue)

DB= Detention Basin
GS= Grass Swales
HD=Manufactured Devices
MF= Media Filters
RP= Retention Ponds
WC=Wetland Channels

Figure 2. Comparison of Geometric Mean E. coli Data for Stormwater BMPs in International Stormwater BMP Database

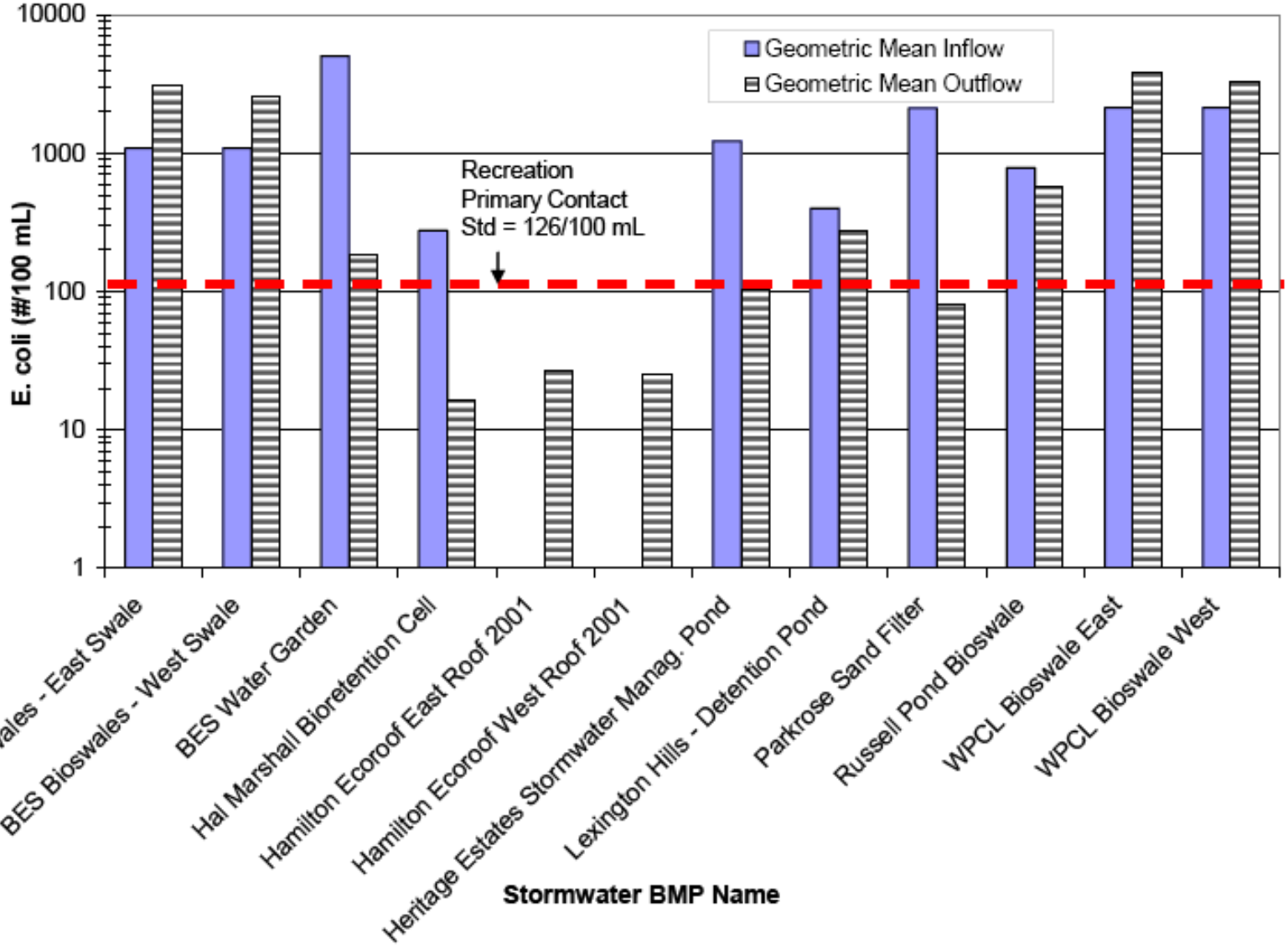


Figure 4. Detention Basin Fecal Coliform Data (10 Studies)

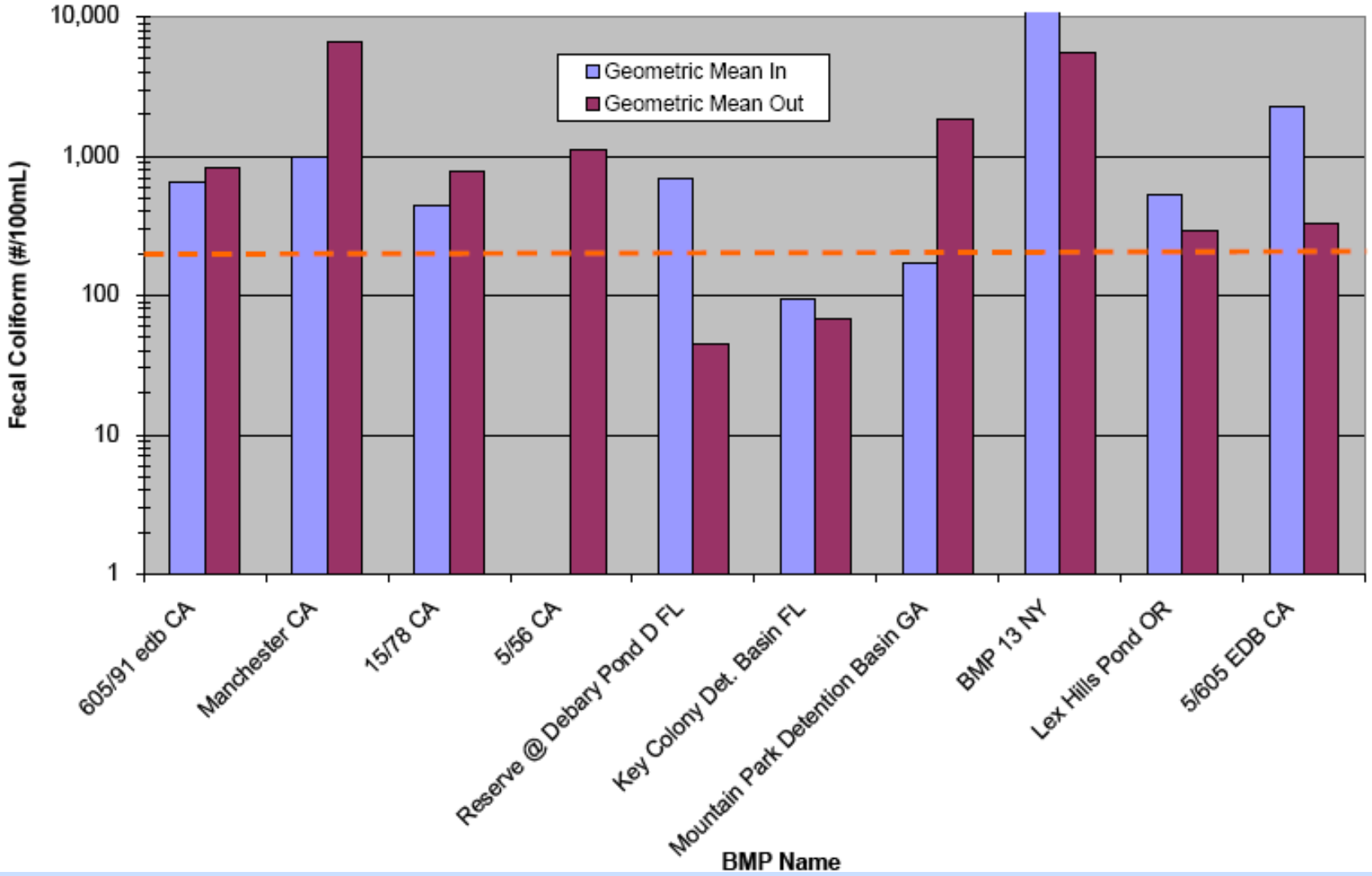
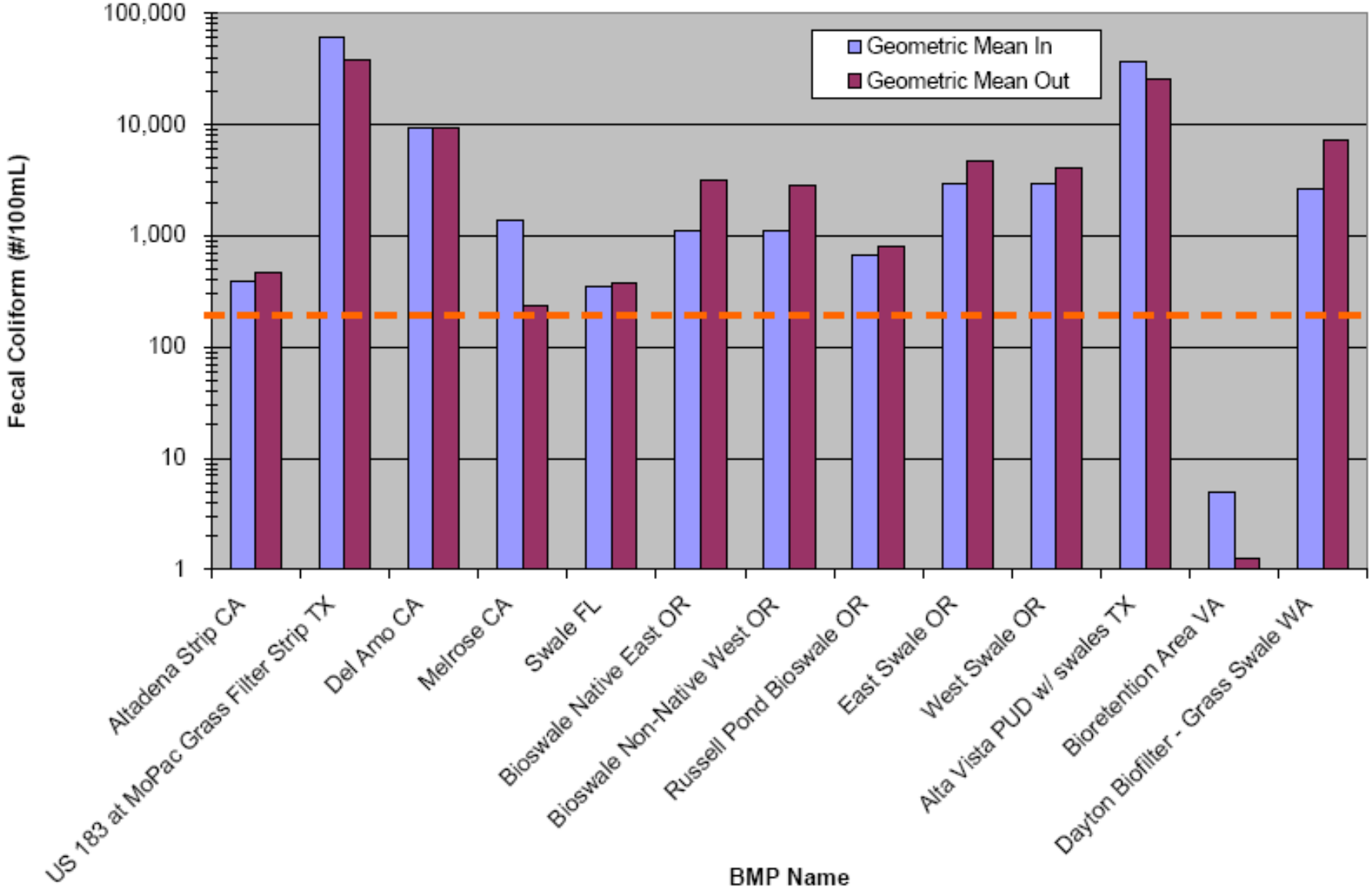
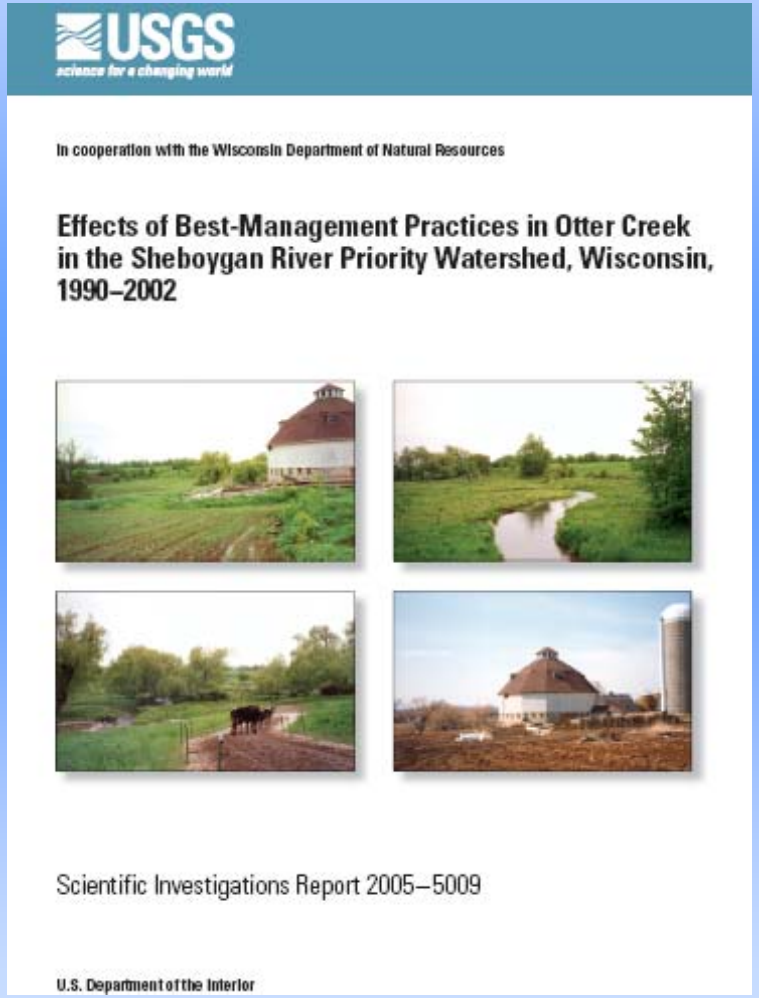


Figure 5. Bioswale (Grass Strips/Swales) Fecal Coliform Data (13 Studies)



Agricultural BMPs

- BMPs: streambank protection and fencing, stream crossings, grade stabilization, buffer strips, various barnyard-runoff controls, nutrient management, and a low degree of upland BMPs.
- "…fecal coliform concentrations in base-flow samples increased over the study period.
- However, reductions for other pollutants did occur.


USGS
science for a changing world

In cooperation with the Wisconsin Department of Natural Resources

Effects of Best-Management Practices in Otter Creek in the Sheboygan River Priority Watershed, Wisconsin, 1990–2002

Scientific Investigations Report 2005–5009

U.S. Department of the Interior

USGS Results

Response variable	Number of samples for pre-/post-BMP periods	Median concentration (mg/L)		
		Pre-BMP	Post-BMP	Significance level
		Combined seasons		
Total suspended solids	40/40	9.0	5.2	**0.02/decrease**
Total phosphorus	40/41	0.07	0.074	0.052
Dissolved ammonia nitrogen	40/41	0.0325	0.022	0.06
Biochemical oxygen demand	39/37	2.0	1.1	**0.0001/decrease**
Fecal coliform	34/37	550	2,000	**0.0002/increase**
		Nonvegetative season		
Total suspended solids	21/11	9.0	7.0	0.11
Total phosphorus	21/11	0.07	0.061	0.088
Dissolved ammonia nitrogen	21/11	0.053	0.03	0.066
Biochemical oxygen demand	20/11	2.2	1.3	**0.001/decrease**
Fecal coliform	18/11	490	810	0.13
		Vegetative season		
Total suspended solids	19/29	9.0	5.0	0.29
Total phosphorus	19/30	0.06	0.082	**0.004/increase**
Dissolved ammonia nitrogen	19/30	0.018	0.021	0.36
Biochemical oxygen demand	19/26	1.8	1.1	**0.029/decrease**
Fecal coliform	16/26	675	2,250	**0.0013/increase**

"The cause of this sharp increase has not been determined."

What can be realistically controlled?

- WWTP discharges
- Illicit discharges/ connections to MS4
- Domestic pets
  - Pet waste ordinances
  - Disposal cans
  - Enforcement
- Agriculture (*in some cases*)

Conclusions

- Meeting existing EPA criteria and Colorado criteria is extremely difficult.
- There is not a one-size-fits-all solution.
- Ongoing research is needed, particularly with regard to natural sources and risks to humans.
- “Real” sources of bacteria from human sewage should be corrected.
- Pet ordinances should be enforced and waste receptacles provided in public areas.
- Realistic solutions need to be developed that recognize natural sources in a variety of settings.
- Engagement of the regulated community is important in developing realistic solutions.

Questions?

Jane Clary
Wright Water Engineers
clary@wrightwater.com
303-480-1700

Progress Report

Project Name: Colorado *E. coli* Assessment and Management Project

Grant Contact: Colorado Stormwater Council (on Behalf of the Water Quality Forum's *E. coli* Work Group); Contact: Jill Piatt-Kemper, Chairperson; c/o City of Aurora, 15151 E. Alameda Parkway; Aurora CO 80012; email: Jpiatt@auroragov.org; tel.: (303) 739-7390.

Grant Category: Planning Grant (2007-2008)

Project Budget: $10,000

Progress Report: The *E. coli* Assessment and Management Project funded under the Colorado Watershed Protection Fund is approximately 80% complete and has benefited from the investment of approximately 100 hours by stakeholders, including local governments, the Colorado Water Quality Control Division and EPA. The funded portion of this project is on-track for completed by September 30, 2008. Table 1 briefly describes the status of various work products. Work products generated to date are attached for more detail.

Task	Description Work Product	Status
1	Annotated bibliography of existing *E. coli* resources by topic with hyperlinks to web resources (where available)	Draft bibliography completed and distributed to stakeholders (see attached)
2	Technical Memorandum; Evaluation of the EPA Report on the Experts Scientific Workshop on Critical Research Needs for the Development of New or Revised Recreational Water Quality Criteria – What does it mean to the Colorado stream segments listed as impaired for E. coli?	Detailed Powerpoint presentation summarizing key issues developed and presented at stakeholder meeting. Discussion anticipated to continue on this topic. Also posted to Water Quality Forum website (see attached).
3	Annotated Summary of 303(d) Listed Streams to Identify Common Characteristics, General Issues and Possible Common Approaches	Draft spreadsheet developed summarizing listed segments (attached). Four meetings held to discuss issues and approaches to TMDLs (see agendas and/or meeting minutes attached).
4	Presentation of Findings at 2 Meetings	Presentation at Water Quality Forum in February 2008 (see attached), Water Quality Forum Retreat July 2008 and planned for Colorado Association of Floodplain Managers Annual Conference September 2008 (abstract attached).

Attachments:
Project Budget and Matching Hours Spreadsheets
Work Product to Date for Various Tasks

Progress Summary Prepared by Jane Clary, Wright Water Engineers, August 1, 2008

Progress Report
Support for E. coli Work Group under Colorado Watershed Protection Fund Grant

Task	Description Work Product	Milestone	CWPF Funds	WWE Invoice #33359; Feb 29, 2008 (through January 31, 2008)	Description	WWE Invoice #33545 March 14, 2008 (through February 29, 2008)	Description	WWE Invoice #33691 (through March 31, 2008)	Description	WWE Invoice #34022 (through May 31, 2008)	Description	WWE Invoice #34170 (work completed through June 30, 2008)	Description	Total Invoiced	Budget Remaining in Task	% Complete
1	Annotated bibliography of existing *E. coli* resources by topic with hyperlinks to web resources (where available)	Interim Draft: March 2008 Final: September 2008	$3,000	$ 800.00	Began developing draft bibliography.	$ 550.00	N/A	$ 484.00	Continued developing draft bibliography.	$ 1,000.00	Continued Development of bibliography			$ 2,834.00	$ 166.00	94%
2	Technical Memorandum, Evaluation of the EPA Report on the Experts Scientific Workshop on Critical Research Needs for the Development of New or Revised Recreational Water Quality Criteria - What does it	Interim Draft: February 2008 Final: September 2008	$3,500	$ 1,162.83	Began review of EPA report in preparation for February presentation.	$ 2,314.50	Developed summary of EPA report in Powerpoint, presented findings at February work group meeting. Work product posted on WQF website		N/A					$ 3,477.33	$ 22.67	99%
3	Annotated Summary of 303(d) Listed Streams to Identify Common Characteristics, General Issues and Possible Common Approaches	Interim Draft: February 2008 Final: September 2008	$3,000	$ 300.00	Helped develop matrix of questions for 303(d) list of segments for distribution to the Work Group.		N/A	$ 242.00	Met with Becky Anthony, Water Quality Control Division to discuss Colorado TMDLs and how the Work Group could interact most meaningfully with the Division	$ 515.75	Support for May 8, 2008 stakeholder meeting regarding potential approaches to TMDLs in Colorado. Included general coordination, meeting minutes and follow-up.	$ 484.00	Support for June 26, 2008 meeting with EPA. Meeting minutes document key issues related to TMDL development in Colorado. Support included general coordination prior to meeting, meeting minutes and	$ 1,541.75	$ 1,458.25	51%
4	Presentation of Findings at 2 Meetings	Mar-08 Jun-08	$500	$ -	N/A	$ -	N/A	$ 121.00	Presented synopsis at March Water Quality Forum meeting.					$ 121.00	$ 379.00	94%
	Total		$10,000	$ 2,262.83		$ 2,864.50		$ 847.00		$ 1,515.75		$ 484.00		$ 7,974.08	$ 2,025.92	80%

Attendees: December 6, 2007	**Hours**	**Rate**	**Value**
Terry Baus	2	$ 85	$ 170
Joan Carlson	2	$ 85	$ 170
Jane Clary	2		$ -
Mary Fabisiak	2	$ 85	$ 170
Phil Hegeman	2	$ 85	$ 170
Ginny Johnson	2	$ 85	$ 170
Megan Monroe	2	$ 85	$ 170
Jon Novick	2	$ 85	$ 170
Dick Parachine	2	$ 85	$ 170
Jill Piatt Kemper	2	$ 85	$ 170
Jennifer Richards	2	$ 85	$ 170
Andrew Ross	2	$ 85	$ 170
Donna Scott	2	$ 85	$ 170
James McCarthy	2	$ 85	$ 170
Subtotal			$ 2,210
Attendees: February 7, 2008	**Hours**	**Rate**	**Value**
Terry Baus	2	$ 85	$ 170
John Burke	2	$ 85	$ 170
Megan Monroe	2	$ 85	$ 170
Dave Meyer	2	$ 85	$ 170
Jane Clary	2		$ -
Mary Fabisiak	2	$ 85	$ 170
Becky Dunavant	2	$ 85	$ 170
Mary Gardner	2	$ 85	$ 170
Becky anthony	2	$ 85	$ 170
Phil Hegeman	2	$ 85	$ 170
Alan Searcy	2	$ 85	$ 170
Jill Piatt Kemper	2	$ 85	$ 170
James McCarthy	2	$ 85	$ 170
Joan Carlson	2	$ 85	$ 170
Ken MacKenzie	2	$ 85	$ 170
Jon Novick	2	$ 85	$ 170
Jennifer Richards	2	$ 85	$ 170
Sharon Henderson Davis	2	$ 85	$ 170
Subtotal			$ 2,890

Matching Funds to Date for E. coli Work Group

Attendees: May 8, 2008			
Becky Anthony	2	$ 85	$ 170
Terry Baus	2	$ 85	$ 170
Jane Clary	2		$ -
Richard Meyerhoff	2	$ 85	$ 170
Nathan Moore	2	$ 85	$ 170
Jon Novik	2	$ 85	$ 170
Joan Carlson	2	$ 85	$ 170
Jill Piatt Kemper	2	$ 85	$ 170
James McCarthy	2	$ 85	$ 170
Megan Monroe	2	$ 85	$ 170
Donna Scott	2	$ 85	$ 170
Subtotal			$ 1,700
Attendees: June 26, 2008			
Becky Anthony	2	$ 85	$ 170
Terry Baus	2	$ 85	$ 170
Jane Clary	2		$ -
Richard Meyerhoff	2	$ 85	$ 170
Nathan Moore	2	$ 85	$ 170
Jon Novik	2	$ 85	$ 170
Jill Piatt Kemper	2	$ 85	$ 170
James McCarthy	2	$ 85	$ 170
Megan Monroe	2	$ 85	$ 170
Joni Nuttle	2	$ 85	$ 170
Phil Hegeman	2	$ 85	$ 170
Becky Dunavant	2	$ 85	$ 170
Dan Scaife	2	$ 85	$ 170
Mary Fabisiak	2	$ 85	$ 170
John Burke	2	$ 85	$ 170
Sandra Spence	2	$ 85	$ 170
Dave Moon	2	$ 85	$ 170
Todd Harris	2	$ 85	$ 170
Jennifer Richards	2	$ 85	$ 170
Ginny Johnson	2	$ 85	$ 170
Subtotal			**$ 3,230**
Match To Date	**98**		**$ 7,820**

*Matching funds reflected above do not include the additional costs of meeting attendance such as gas, parking, value of conference room, etc. Additional matching time by Jim McCarthy related to periodic reporting to the Water Quality Forum is also not included.