Geosyntec consultants

Water Quality Improvement Projects and BMPs to Achieve a Swimmable California

Webinar for the CA Water Quality Monitoring Council
January 24, 2018

Brandon Steets, PE
Geosyntec Consultants

Outline

1. Existing resources and guidance
   (Documenting the state of the practice)

2. Case studies

3. Takeaways and recommendations

Existing Resources and Guidance: BMP Database & Stormwater Magazine

- International Stormwater BMP Database for structural BMP performance data
- Stormwater Magazine Article (Sept 2016 issue) for general implementation planning guidance

INTERNATIONAL STORMWATER BMP DATABASE
www.bmpdatabase.org

International Stormwater Best Management Practices (BMP) Database

Pollutant Category Summary: Fecal Indicator Bacteria

Prepared by
Wright Water Engineers, Inc.
Geosyntec Consultants

Under Support From
Water Environment Research Foundation
Federal Highway Administration
Environment and Water Resources Institute of the American Society of Civil Engineers

December 2010

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WATER

Fecal Indicator Bacteria Reduction in Urban Runoff

« Previous Next »

Jane Clary, Brandon Steets, Jonathan Jones, Eric Strecker, and Marc Leisenring • September 20, 2016

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Editor's note: This article first appeared in the September 2012 issue of Stormwater.

Pathogens are the top cause of stream impairments nationally, with over 10,500 stream segments identified as impaired as of 2012—typically due to elevated concentrations of fecal indicator bacteria (FIB) in waterbodies. Although strict numeric effluent limits for stormwater discharges are not typically required yet in most communities, the implementation phase of total maximum daily loads (TMDLs) may result in National Pollutant Discharge Elimination System (NPDES) stormwater discharge permit requirements to reduce FIB, including numeric effluent limits. Such requirements have been typically based on

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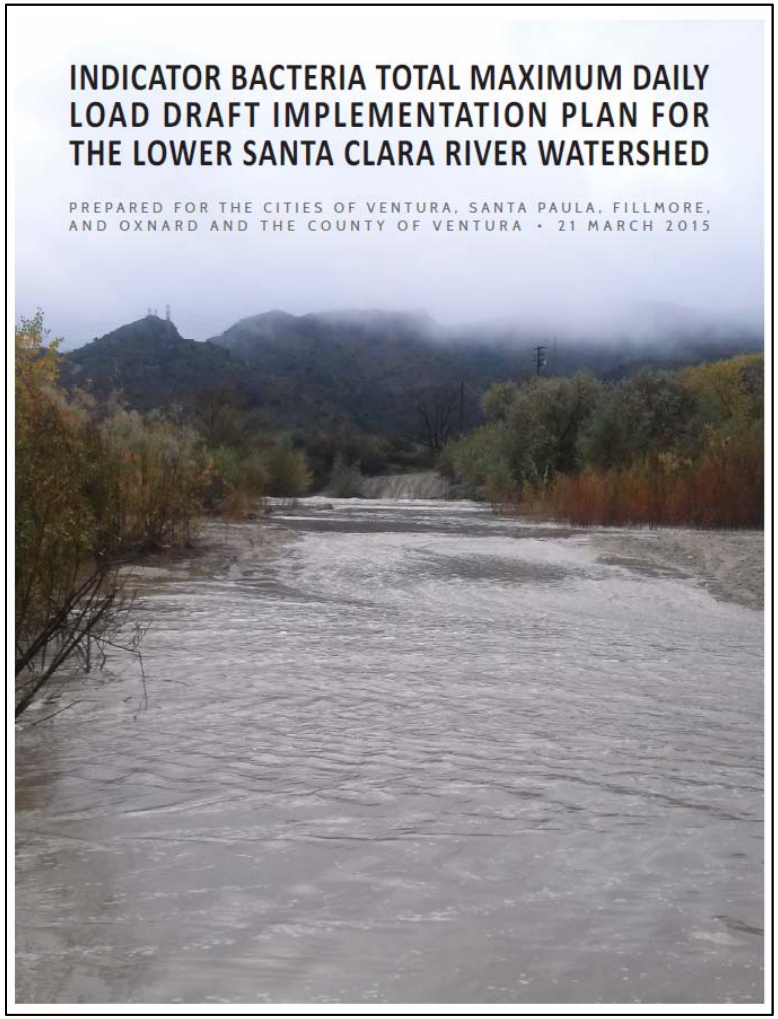
Existing Resources and Guidance: Watershed & Implementation Plans

- There is now an abundance of plans (WLA Attainment Plans, TMDL IPs, EWMPs/WMPs, CLRPs/WQIPs, etc.) outlining planned activities for meeting recreational WQS
- Each reflects region-specific implementation expectations and requirements

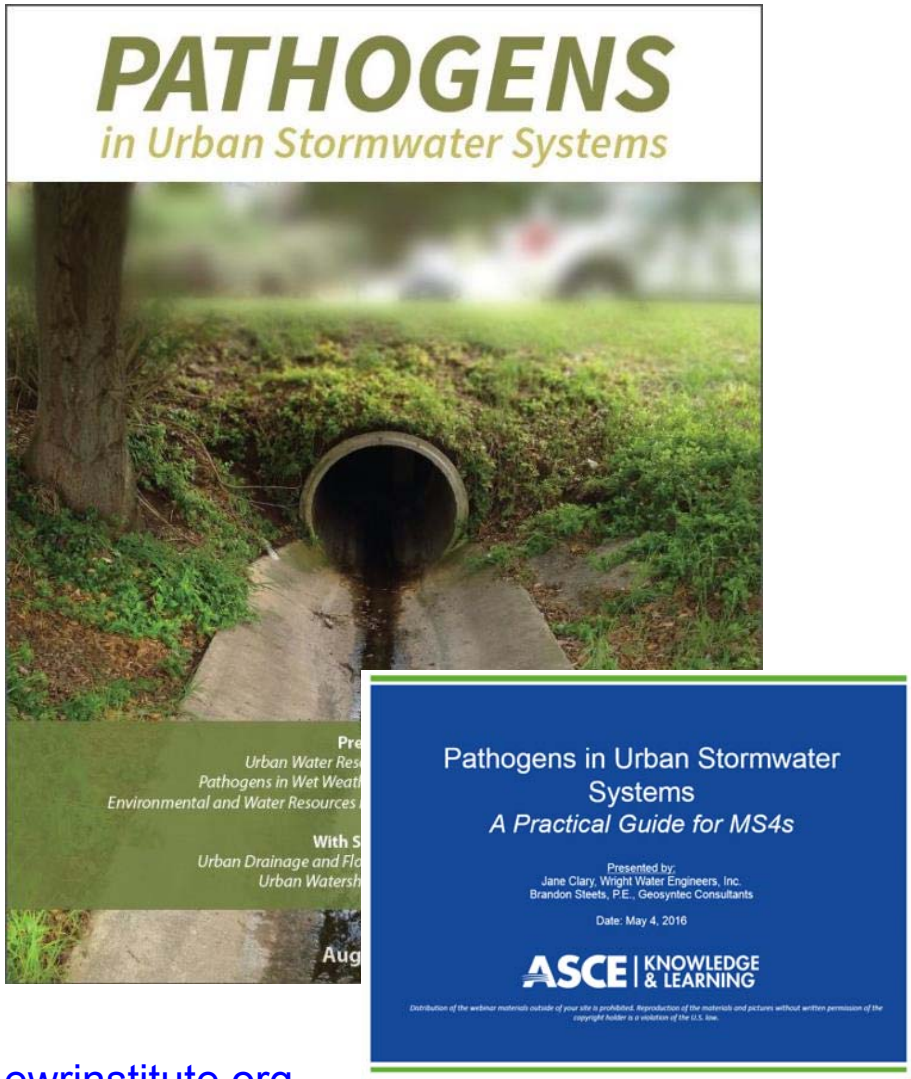
- Key question for your situation: how much regulatory flexibility do you have to limit controls to human waste sources?



Existing Resources and Guidance: 2014 ASCE Report and Webinars

CONTENT:

1. Introduction
2. Basic regulatory background
3. Sources of FIB in urban areas
4. Modeling fate and transport
5. Monitoring and **source tracking**
6. Statistical analysis
7. **Source controls**
8. **Structural controls**
9. **TMDL case studies**
10. Research needs
11. References (40 pages!)



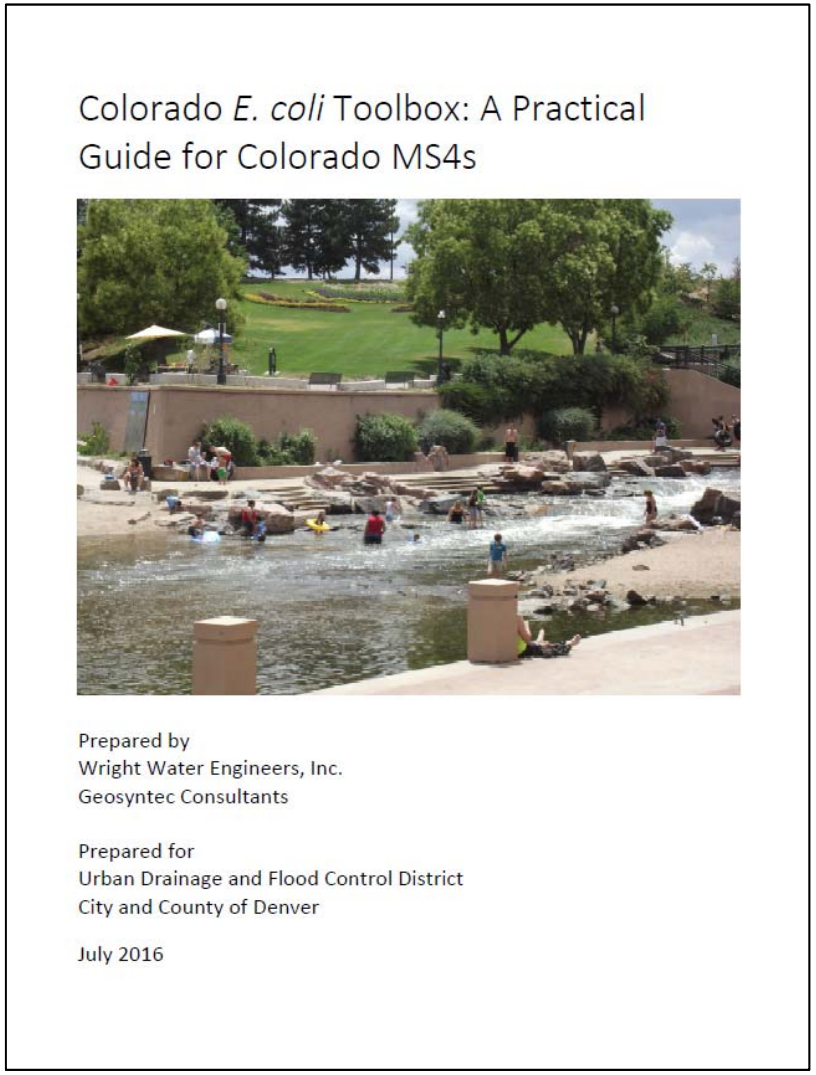
Report available for download at collaborate.ewrinstitute.org and webinar series available through mylearning.asce.org

Existing Resources and Guidance: 2016 Colorado Report

CONTENT:

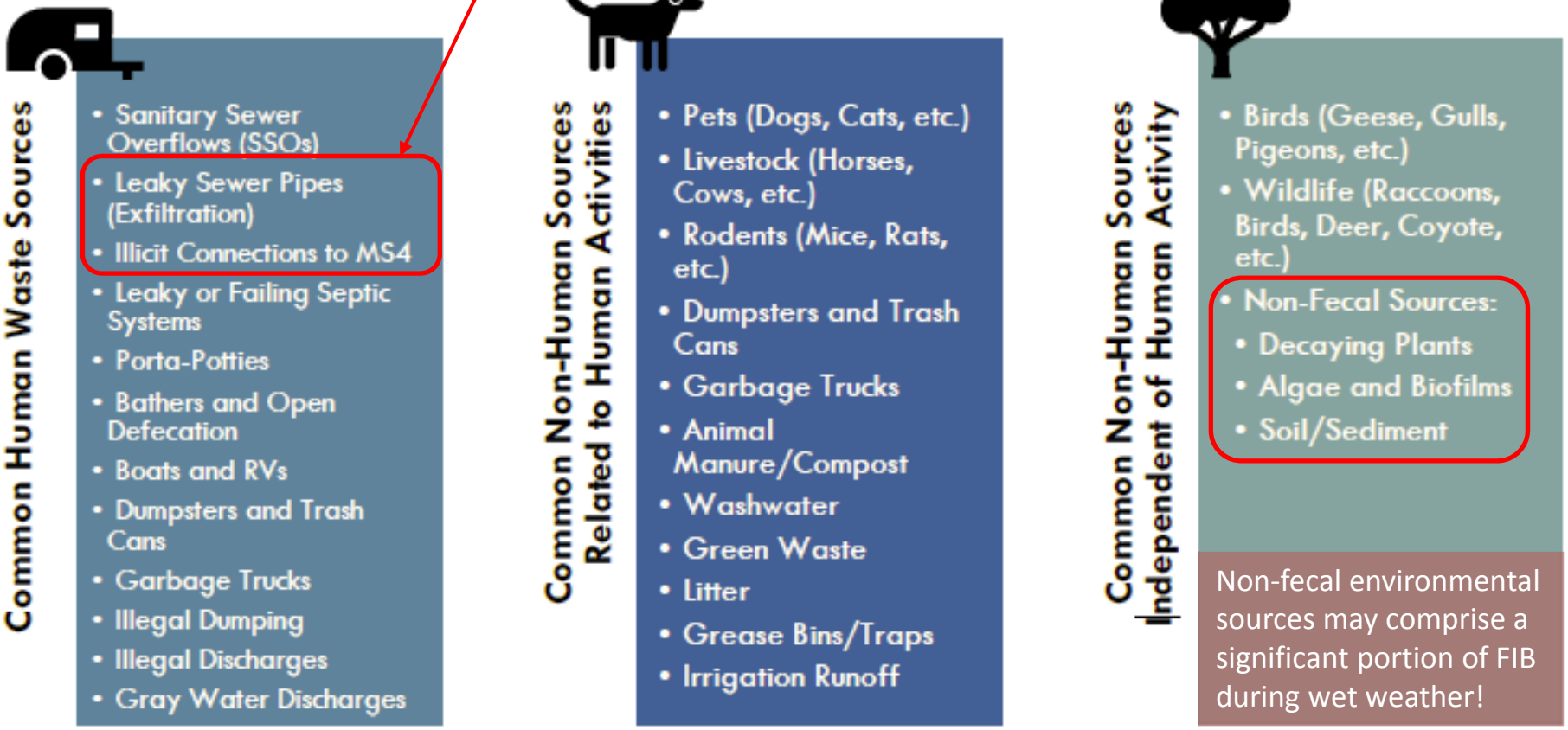
1. Introduction
2. **Source Tracking**
3. **Developing a Control Strategy**
4. **Source Control BMPs**
5. **Structural Control Practices**
6. Public Health Advisories
7. Regulatory Considerations / Site-Specific Standards
8. Conclusions
9. References

Report available for download at: udfcd.org/guidance-documents



Common Sources of FIB in Urban Stormwater ^ and Nutrients!

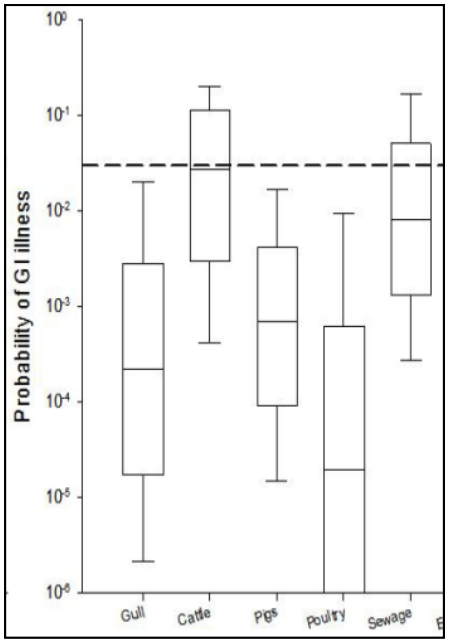
Primary below-ground targets for many IDDE programs



References: ASCE *Pathogens in Urban Stormwater Systems*, and *Colorado E. coli Toolbox*

Source Prioritization

- Most important factors are typically controllability and risk
- Therefore infrastructure-based sources of human waste should be top priorities of any control program



Source: Soller et al, 2010

Table 3. Factors Considered in a Source Prioritization Process
(Adapted from San Diego Co-permittees, as summarized by Armand Ruby Consulting 2011)

SOURCE CATEGORIES
TEMPORAL/FLOW CONDITION
Temporal Distribution of sources: wet weather vs. dry weather
PRIORITIZATION CRITERIA HUMAN HEALTH RISK
Potential for human pathogens to be present
Potential for human exposure
Dose
MAGNITUDE
Concentration and/or loading
Frequency of occurrence
Variability
GEOGRAPHICAL
Spatial distribution of sources; discrete locations (can map location) or spread out or distributed (e.g., pet waste, soil)
Proximity to Primary Contact Recreational Uses
Proximity to MS4 impermeable surfaces
Land uses, hydrology, soil types, population (design parameters)
Redevelopment opportunities
Ease of transport pathway to receiving waters
CONTROLLABILITY/IMPLEMENTABILITY
Cost, social impact, technological barriers, organizational barriers
Challenge of changing behavior/culturally
How many application sites for BMPs
Repetitive nature of behavioral changes
POTENTIAL BENEFITS
Ability to maximize human health improvement
Potential for multiple (secondary/additional) benefits
Other water quality issues
Other benefits (e.g., flood control)
Ability to target underlying water quality issues
Consideration of the benefits of source activities (e.g., flood control)
TECHNICAL/DESIGN
Structural: siting, costs, maintenance
Site-specific flow conditions
WWTP capacity for low-flow dry weather diversions
ORGANIZATIONAL
Regulatory imperative
Code barriers, conflicts w/state-federal regulations
Political opposition/pushback; public support/lack
Organizational ease of implementation
Benefit to public (per cost)

Non-Structural BMPs

- Select based on prioritized sources
- Lower cost than structural BMPs
- Little performance data available
- RWQCB expectations on what is "Maximum Extent Practicable" vary widely, best to confer with other MS4 agencies in your region
- Flow elimination is the only sure strategy for permit compliance with receiving water limits in dry weather

Table 8. Sources and Strategies for Bacteria Reduction

Bacteria Source	Stormwater Control/Management Strategy
Domestic Pets (dogs and cats)	Provide signage to pick up dog waste, providing pet waste bags and disposal containers. Adopt and enforce pet waste ordinances. Place dog parks away from environmentally sensitive areas. Protect riparian buffers and provide unmanicured vegetative buffers along streams to dissuade stream access.
Wildlife in Urban Areas (e.g., rats, bats, raccoons, beavers, deer, coyotes, foxes)	Reduce food sources accessible to urban wildlife (e.g., manage restaurant dumpsters/grease traps, residential garbage, feed pets indoors). Implement and enforce urban trash management practices. Consult with state wildlife offices (CPW) on strategies to reduce food, shelter and habitat for overpopulated urban wildlife.
Illicit Connections to MS4s	Implement an illicit discharge detection and elimination (IDDE) program to identify and remove illicit connections.
Leaking Sanitary Sewer Lines/Aging Sanitary Infrastructure	Conduct investigations to identify leaking sanitary sewer line sources and implement repairs.
Onsite Septic Systems and Package Plants	Implement a program to identify potentially failing septic systems. Enforce discharge permit requirements for small package plants.
Illegal Dumping	Implement a reporting hotline for illegal dumping and educate the public/industries that dumping to the storm drain system is illegal.
Storm Drain System and Stormwater Quality BMPs	Proper maintenance of the storm drain system and water quality BMPs is needed for proper functioning of the system. For example, sediment, organic deposits and biofilms in stormwater facilities can be sources of elevated FIB.
Storm Runoff from Urban Areas	Encourage site designs that minimize directly connected impervious areas (e.g., Green Infrastructure, Low Impact Development).
Dry Weather Urban Flows (irrigation, carwashing, powerwashing, etc.)	Implement public education programs to reduce dry weather flows from storm drains related to lawn/park irrigation practices, carwashing, powerwashing and other non-stormwater flows. Provide irrigation controller rebates. Implement and enforce ordinances related to outdoor water waste and/or collaborate with water utilities to promote water-wise landscapes and irrigation practices. Inspection of commercial trash areas, grease traps, washdown practices, along with enforcement of ordinances.
Birds (e.g., Canada geese, gulls, pigeons)	Identify areas with high bird populations and evaluate deterrents, population controls, habitat modifications and other measures that may reduce bird-associated FIB loading.
Homeless Populations	Support of city shelters and services to reduce homelessness. Periodic cleanup of homeless camps near streams. Police enforcement. Providing public restrooms. Fencing to prevent access to frequently used encampment areas. Partnering with non-governmental organizations to address homelessness.

Non-Structural BMPs

- Little performance data available
- Lower cost th
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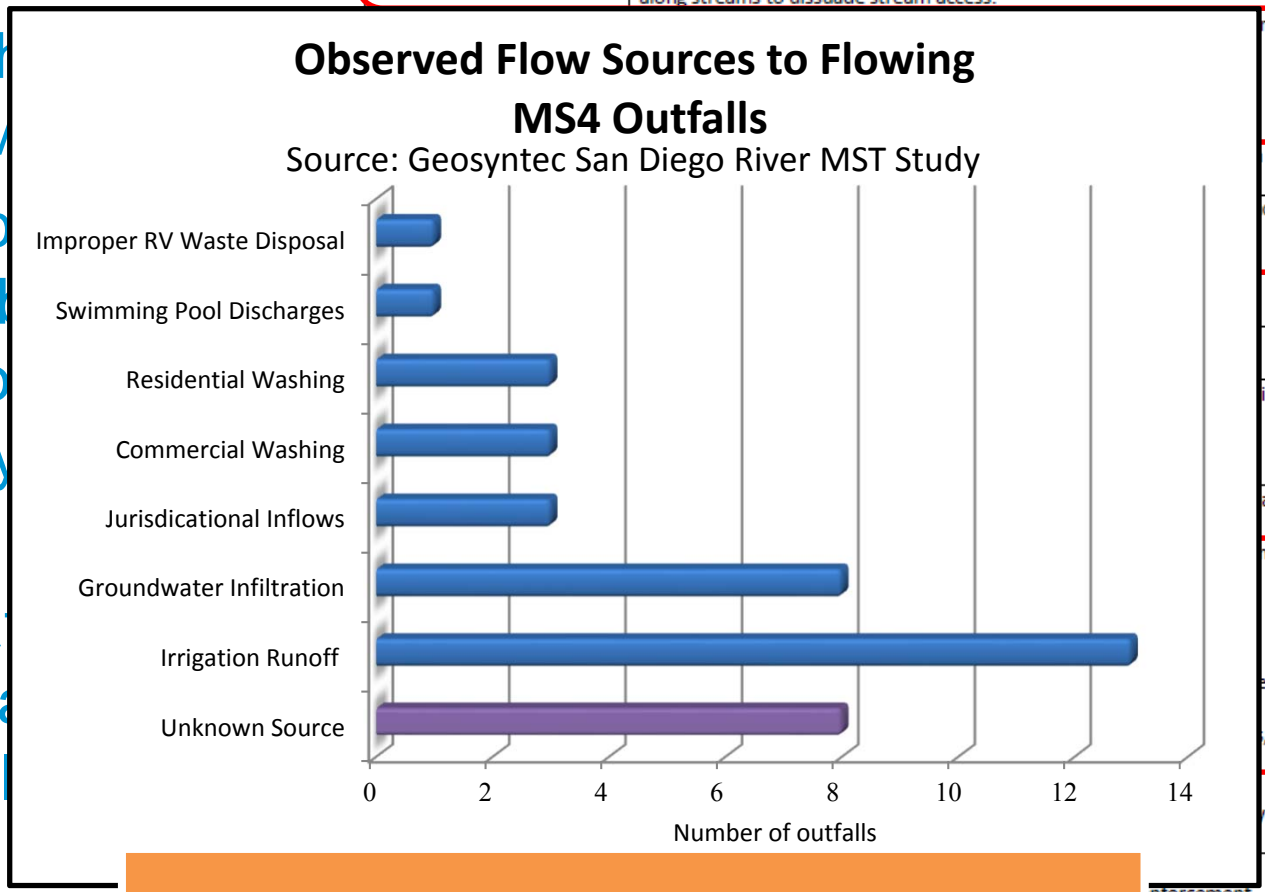


Identifying and documenting dry weather flow sources is the first step to eliminating them

Structural BMPs

- Retention is most effective (infiltration, capture-use)
- Of flow-through natural treatment options, biofilter/bioretention and subsurface flow wetlands are most effective
  - For bacteria-focused biofilter design advancements, refer to Monash University's Facility for Advancing Water Biofiltration (www.monash.edu.au/fawb)
- However no flow-through treatment options are capable of consistently meeting REC WQS except disinfection
- Carefully vet proprietary device vendor performance claims and toxicity export issues, and ensure DPR approval (required for "antimicrobial devices")

Figure 12. International Stormwater BMP Database Performance Data for *E. coli*

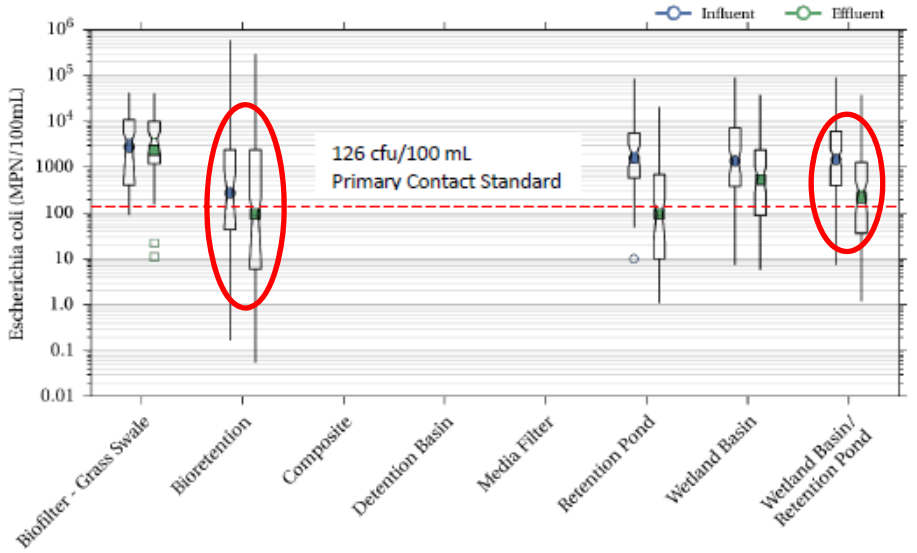
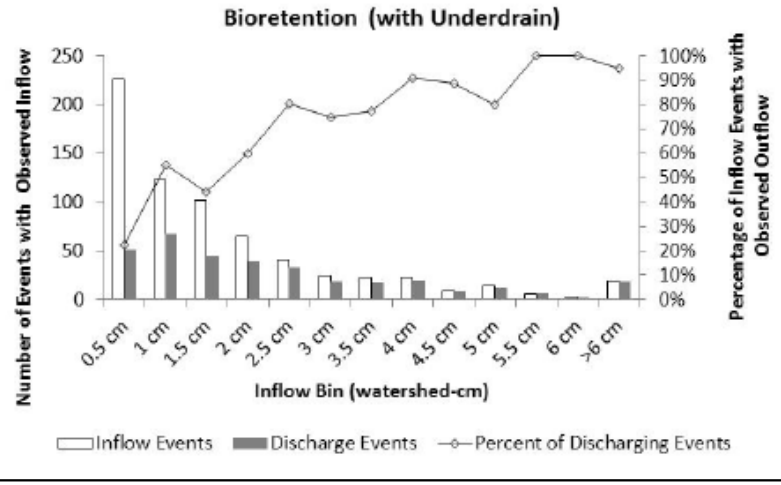


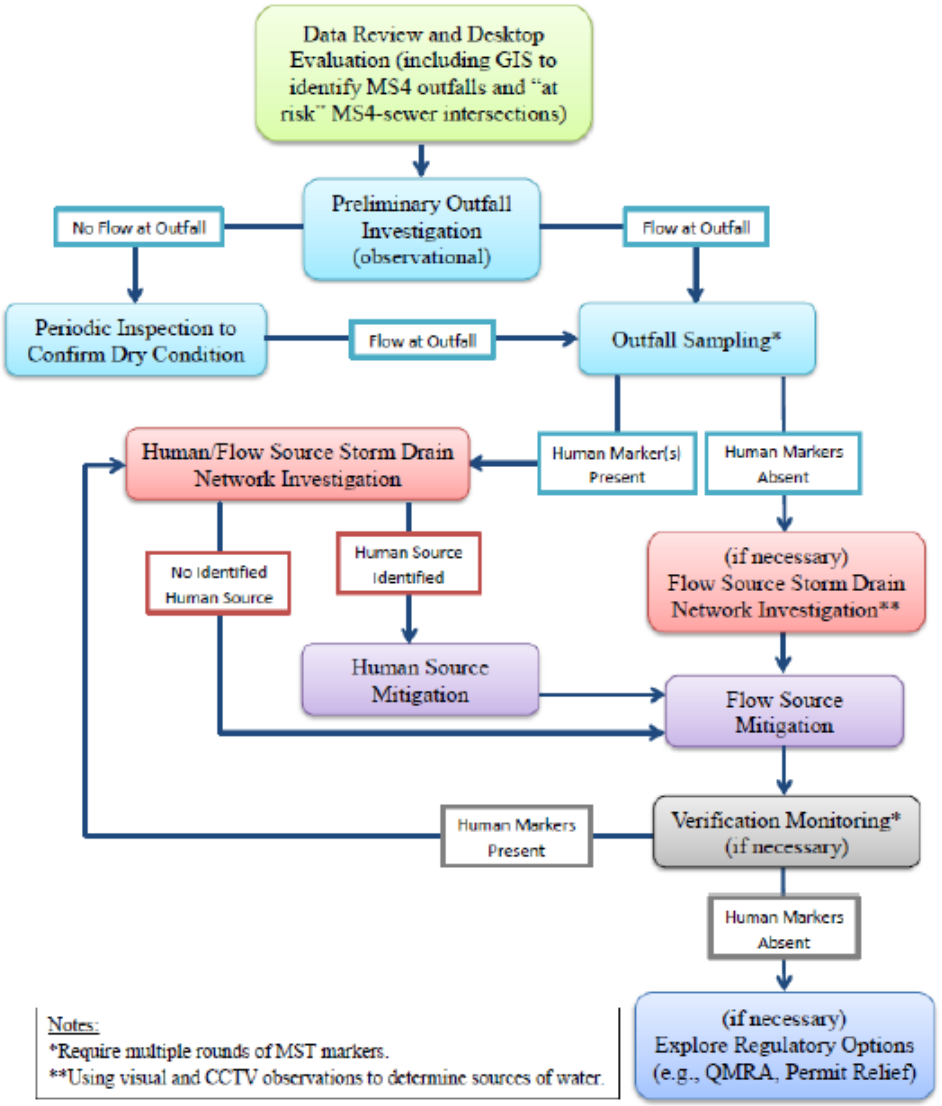
Figure 14. Presence/Absence of Discharge Plots for Bioretention Sites with Underdrains
(Source: Geosyntec and WWE 2011)



Locating Infrastructure Sources to MS4s

- Outfall prioritizations use sewage surrogates (FIB) or human markers
- Then network investigations can incorporate conventional tools (dye, GIS, CCTV, FIB)
- Human markers serve as the most accurate (sensitive and specific) measurement of IDDE program effectiveness and illicit discharge abatement verification currently available

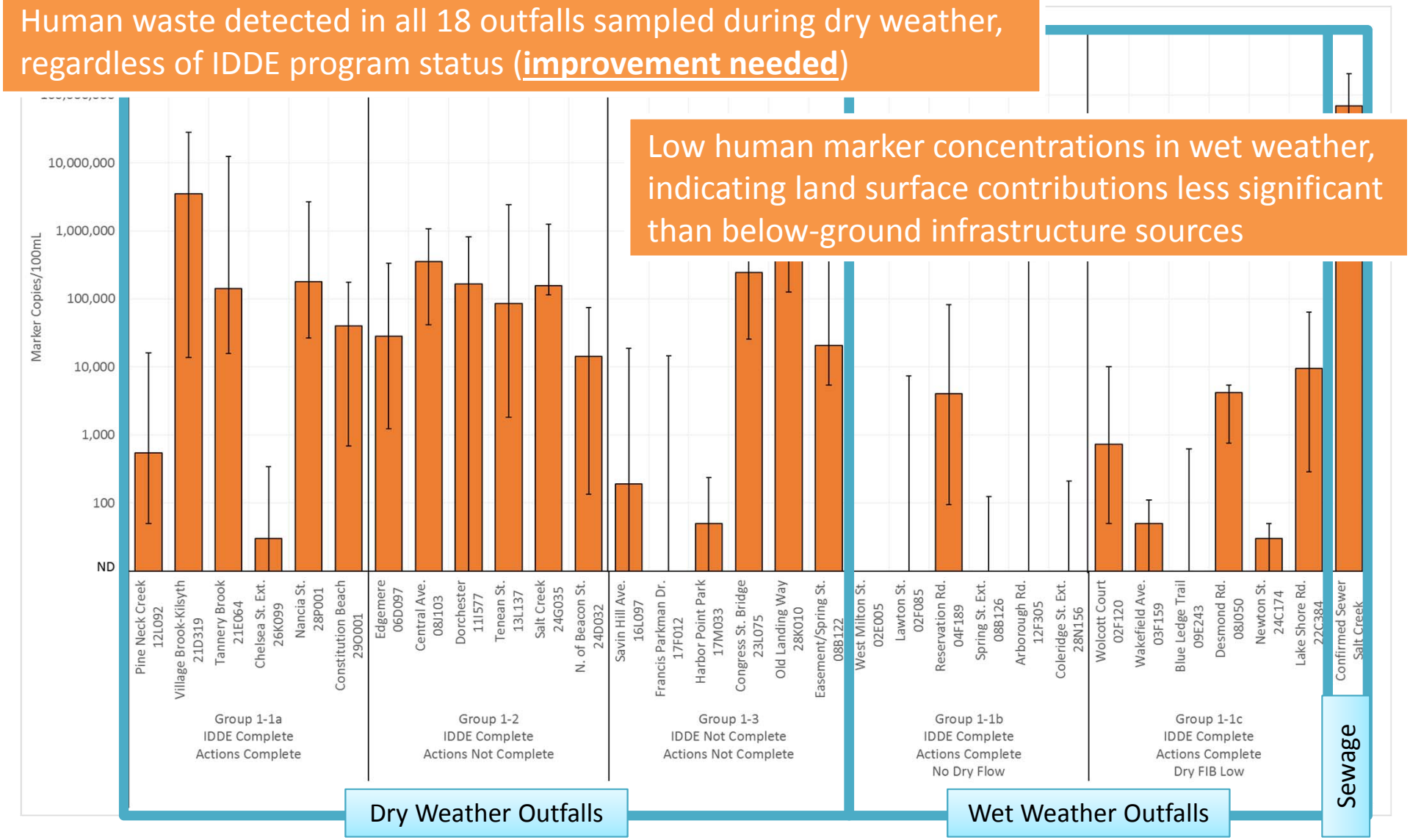
Figure 6. MS4 Microbial Source Identification Investigation Approach
(Source: Geosyntec Consultants, as presented in UWRRC [2014])



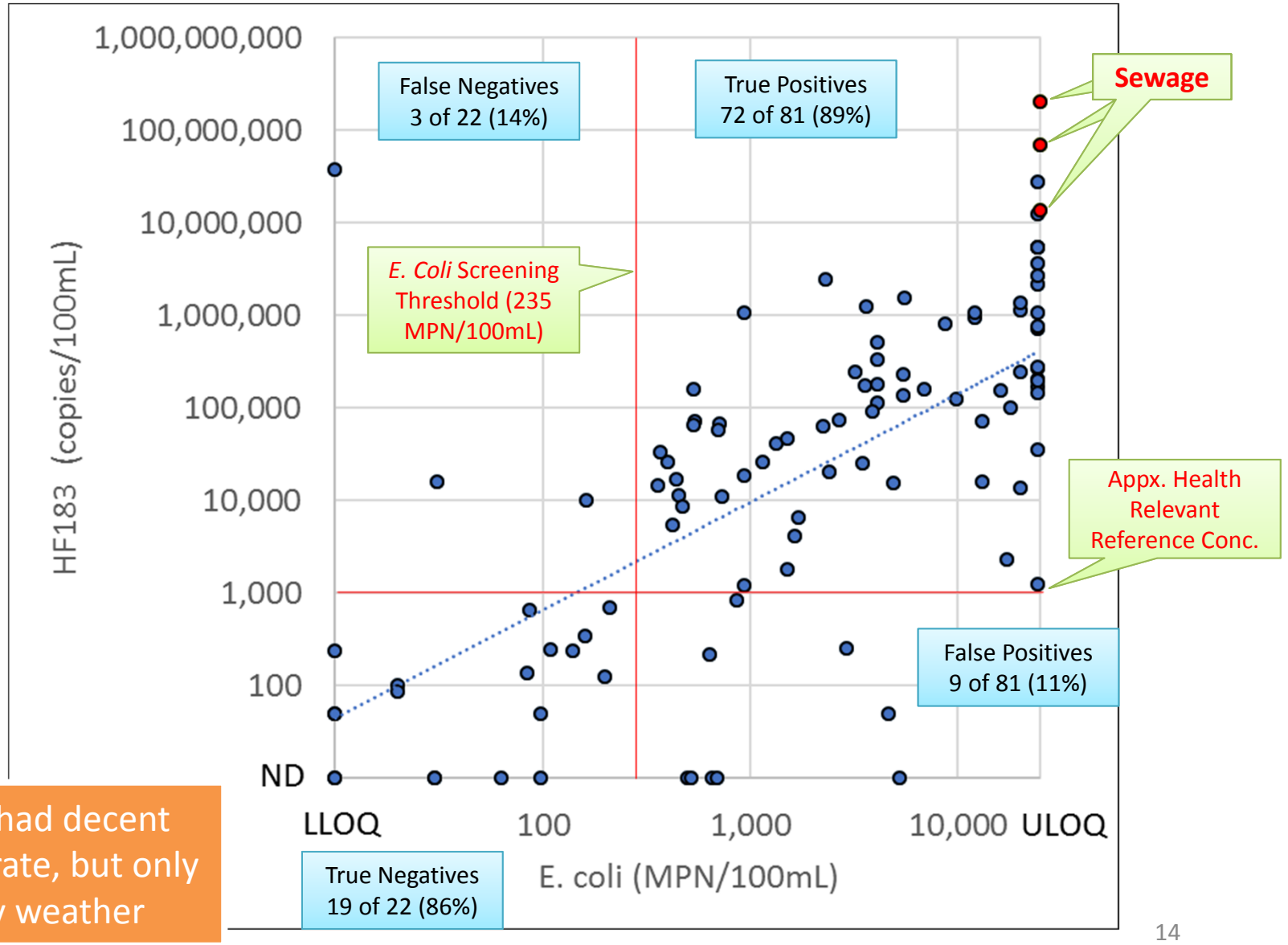
Case Study: Boston Water and Sewer Commission IDDE MST Project

Human waste detected in all 18 outfalls sampled during dry weather, regardless of IDDE program status (**improvement needed**)

Low human marker concentrations in wet weather, indicating land surface contributions less significant than below-ground infrastructure sources

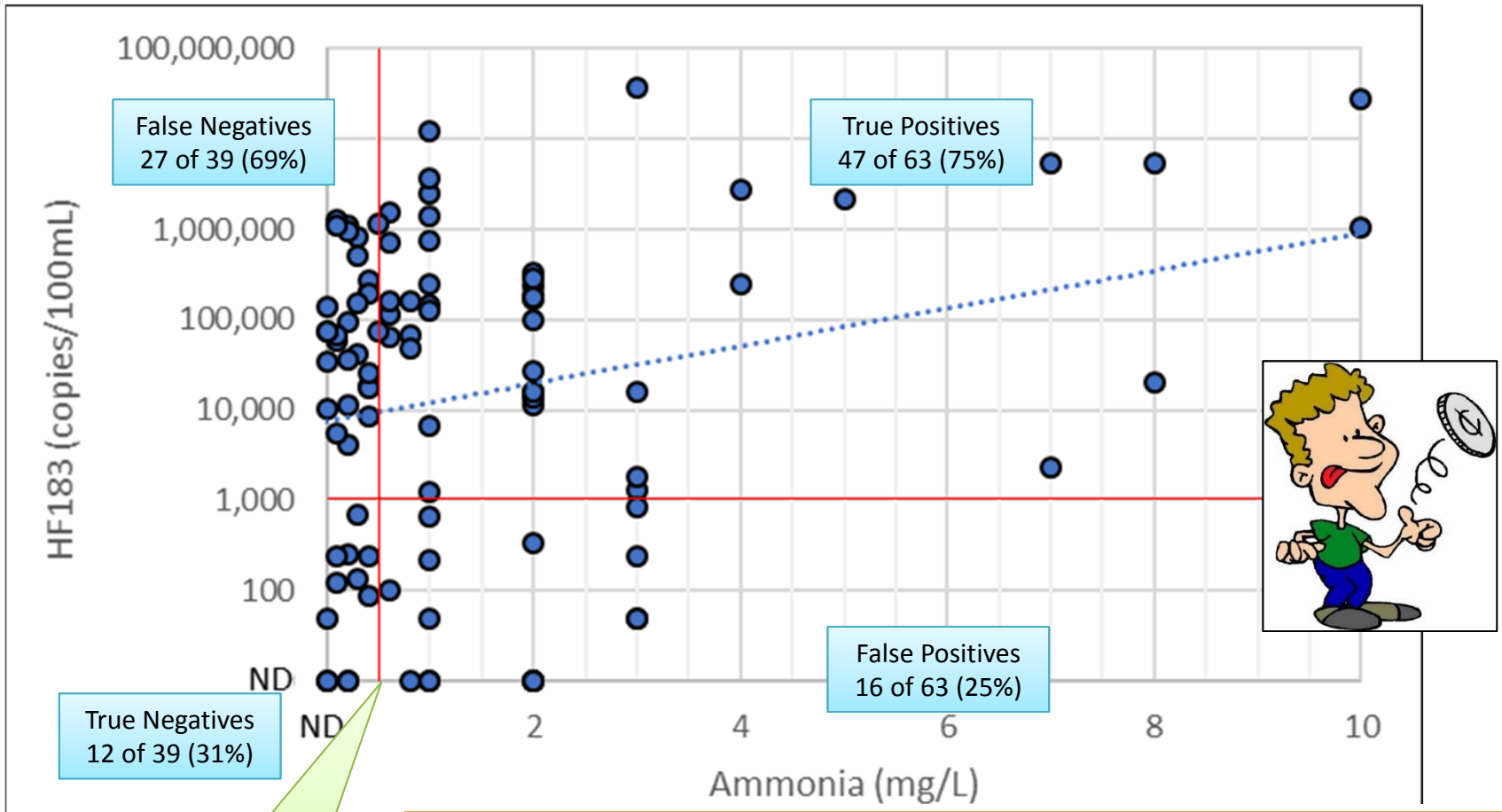


Outfall Prioritization is Working (Dry Weather)



E. Coli had decent success rate, but only in dry weather

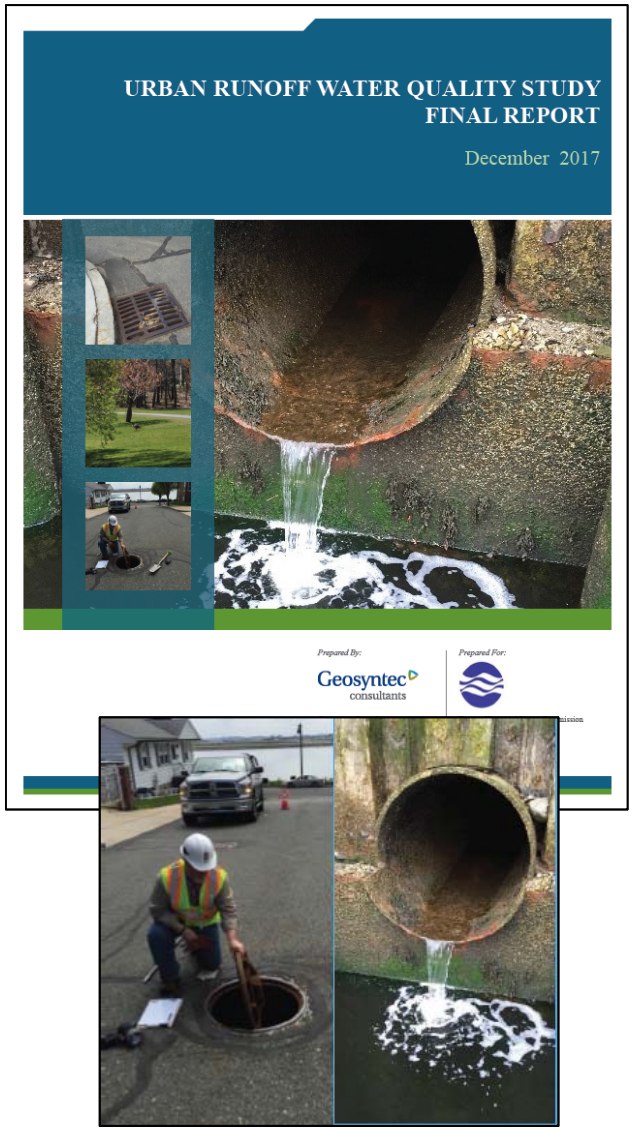
Network Investigation is Where Improvement is Needed



Test kit parameters (ammonia, surfactants, and chlorine) not correlated with human marker and prone to false negative and false positive results at outfalls… this comes at a cost

Boston Project Summary

- Evaluated effectiveness of existing IDDE program
- Won NACWA award
- Recommended refinements to network investigation procedures
  - Disregard wet weather FIB results for outfall prioritization
  - Add FIB for network investigation (dry)
  - Greater use of CCTV + GIS
  - Compliment dye testing with fluorimeter
  - Use HF183 to measure program effectiveness (EPAR1-recommended PPCPs but these are less accurate and similar cost)
- Anticipated Outcome: greater bacteria and nutrient load reduction (TMDLs!) through IDDE, therefore less need for Green Infrastructure – **cost savings**!



Example: GIS to Support Network Investigation, After Outfall Prioritization Using DNA Markers

Identify areas where sewers above and near stormdrains, visually determine if these are flowing sections, and then focus on these areas using CCTV

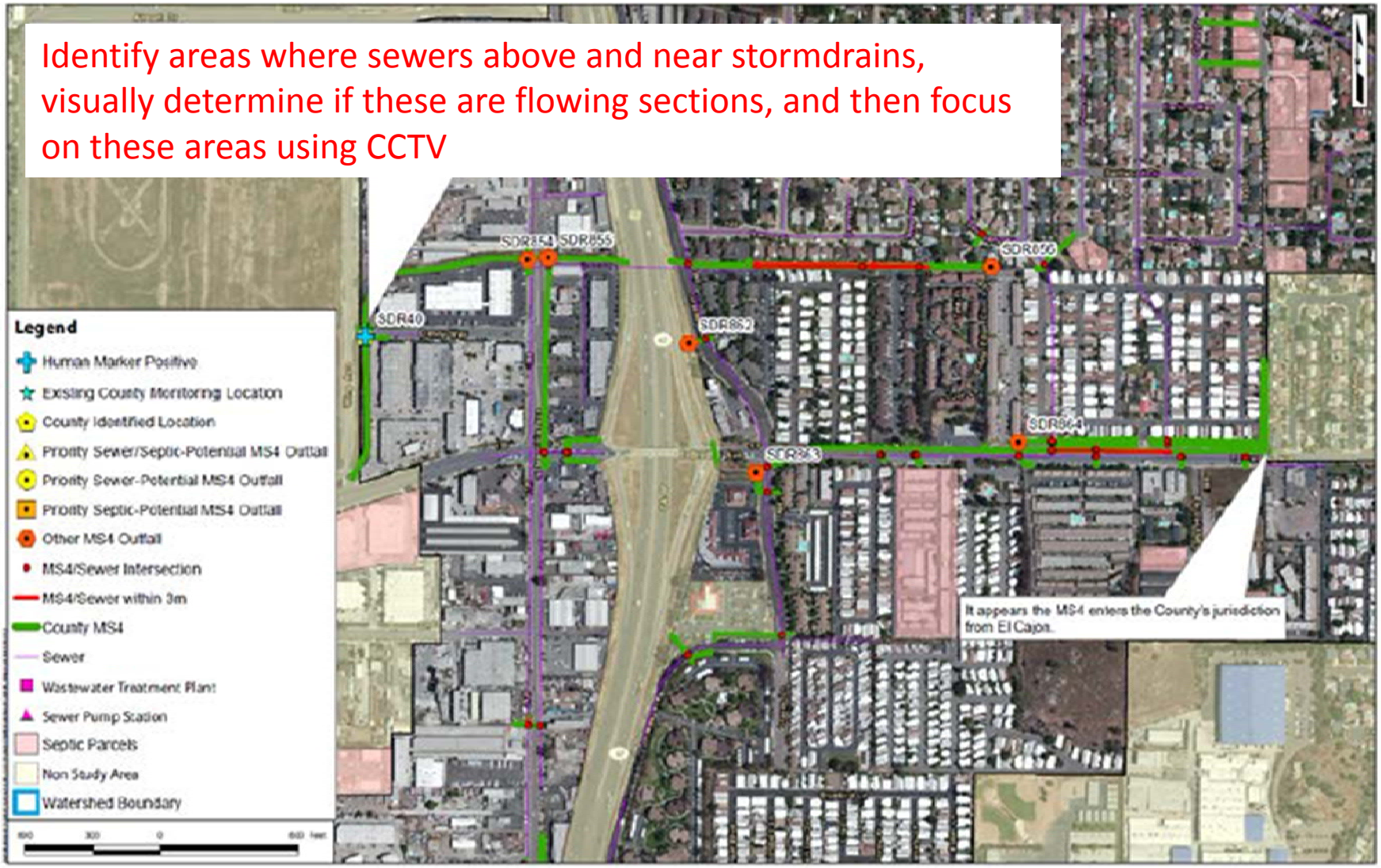


Figure 7. Example Use of GIS in Microbial Source Tracking Studies (Source: Weber et al. 2013)

Case Study: Santa Barbara Beaches MST Study (for SWRCB CBI Grant, with UCSB)

- Builds off prior investigations, which were first ever to document and publish on sewer exfiltration into stormdrains, shedding new light on this important source for agencies nationwide
- Local infrastructure sources thoroughly investigated and largely ruled out
- Homeless and bather sources continue to be evaluated
- DNA markers have been an essential complement to conventional tools (dye + fluorimeter, CCTV, GIS, etc.)
- Management actions being developed based on study results, to improve public health protection at high use beaches

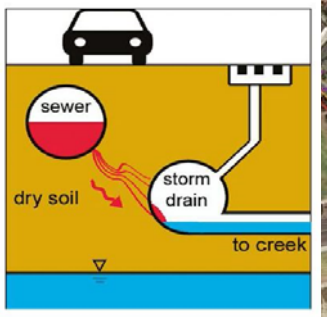
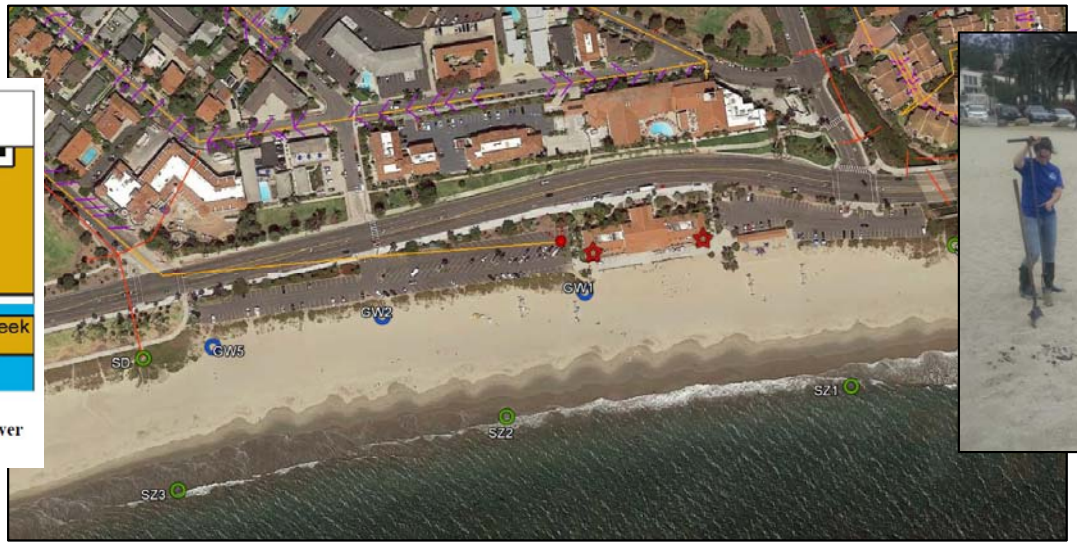
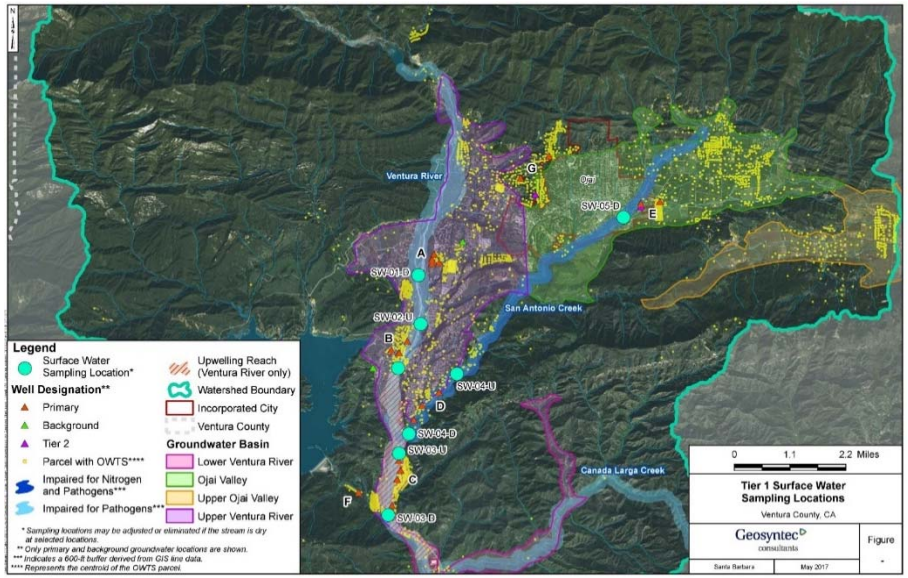


Figure 3-1. Leaking Sanitary Sewer Exfiltrating to Storm Sewer (Source: Sercu et al. 2011[4])



Case Study: Ventura River Septic Nutrient Study (for Ventura County EHD, under SWRCB Grant)

- Algae TMDL and statewide septic policy required watershed-wide upgrades to costly OWTS (nightmare for electeds)
- Objective is to geographically define septics that are contributing to elevated nutrients in surface water (first ever to use nutrient source tracking to map contributing septics, to our knowledge)
- Approach:
  - GW/SW sampling of nitrate, nitrate isotopes and chemical sewage markers
  - Representative sampling locations selected based on travel time and geology (bedrock vs alluvium)
- Related project is modeling GW-SW interactions to quantify nitrogen fate and transport from land application sources (ag, ranching/equestrian, and septics)
- Management actions (e.g., sewer connections, OWTS) are TBD based on study results



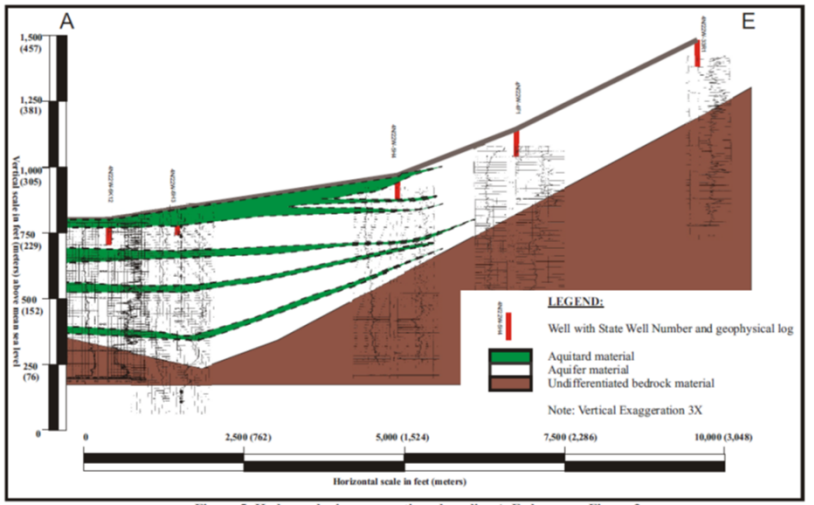
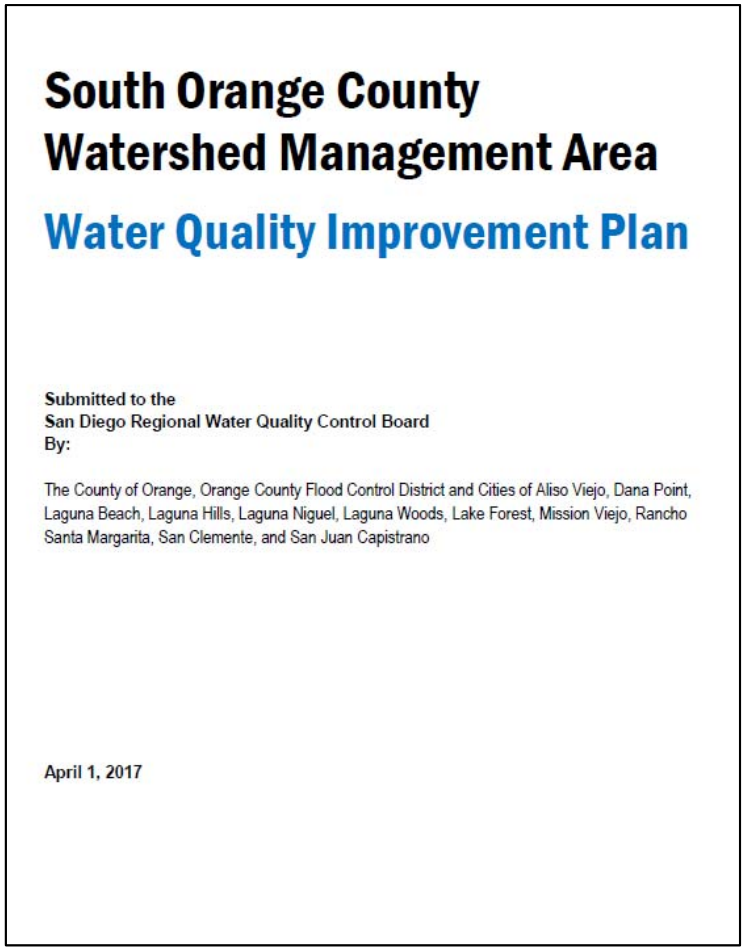


Figure 5. Hydrogeologic cross section along line A-E shown on Figure 3 (view looking north along central portion of Ojai Valley)

Case Study: South Orange County WQIP

- Objective: to attain bacteria water quality standards (TMDL WLAs)
- First WQIP or EWMP to implement a human waste control strategy
- Significant (>>$100M) cost savings compared to wet weather structural controls, which were kept as backstop



South Orange County Watershed Management Area

Water Quality Improvement Plan

Submitted to the
San Diego Regional Water Quality Control Board
By:

The County of Orange, Orange County Flood Control District and Cities of Aliso Viejo, Dana Point, Laguna Beach, Laguna Hills, Laguna Niguel, Laguna Woods, Lake Forest, Mission Viejo, Rancho Santa Margarita, San Clemente, and San Juan Capistrano

April 1, 2017

Bacteria TMDL Implementation Approaches

Traditional Implementation Approach

Focuses on *FIB* reduction,

with

structural stormwater controls

as the primary implementation strategy (perhaps incorporating MST as an ancillary "special study")

New Implementation Approach

Focuses on *health risk* reduction,

with

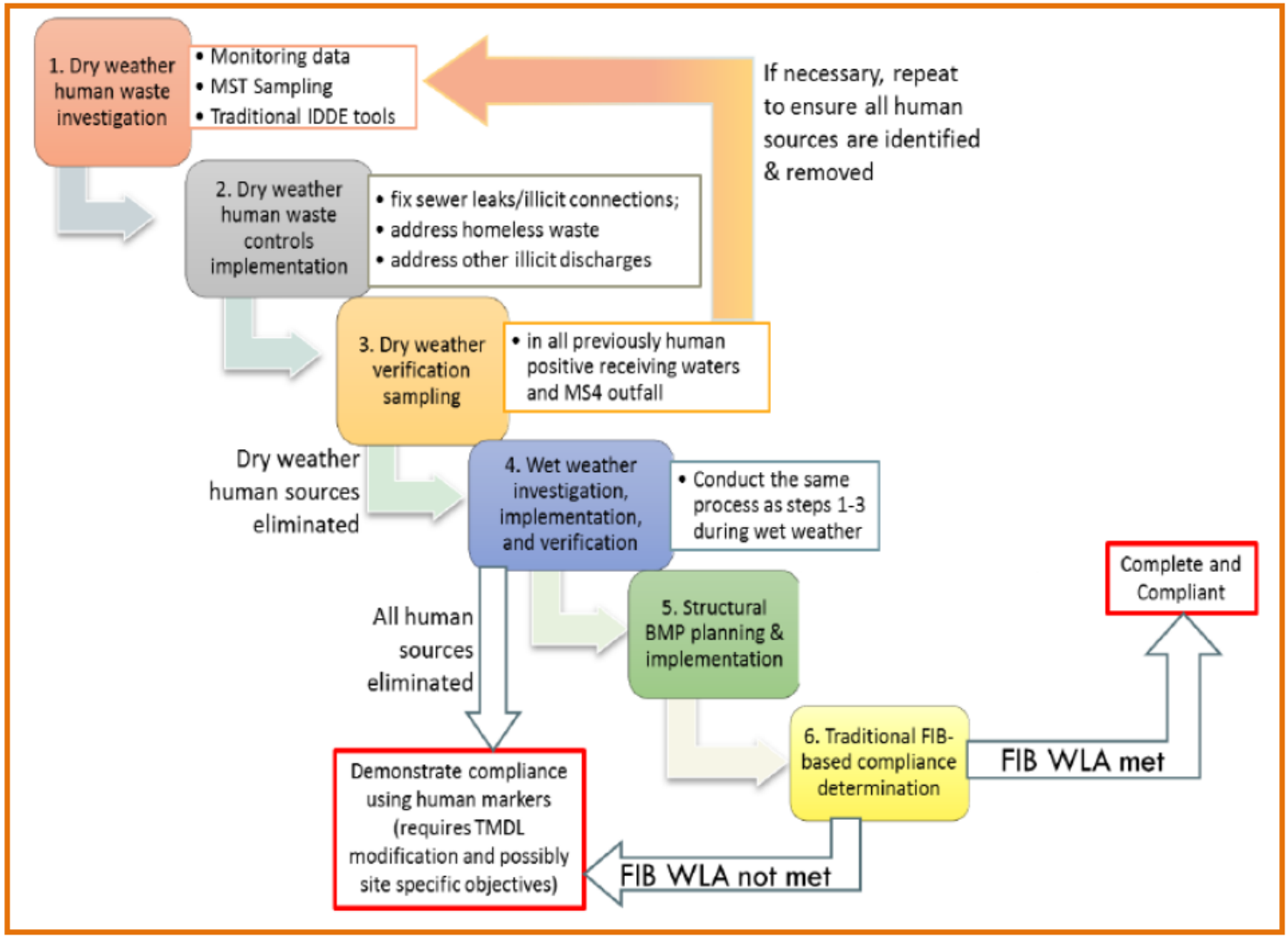
human waste control

as the primary implementation strategy (using MST as an implementation tool to comprehensively identify/locate human waste sources)

New Implementation Approach Process

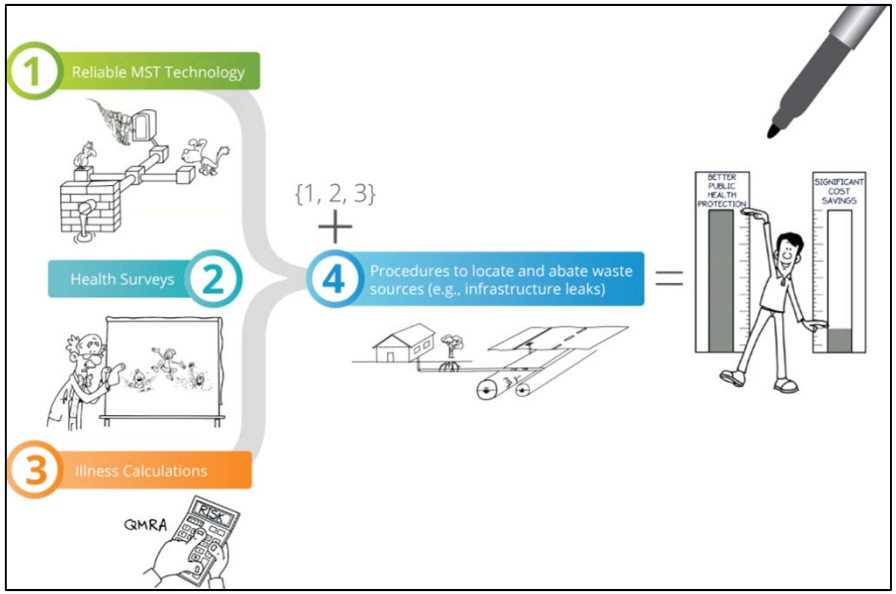
Features:

- Leverages MST to rigorously pursue sources
- Multi-year process
- Verification sampling is included to conclusively demonstrate abatement

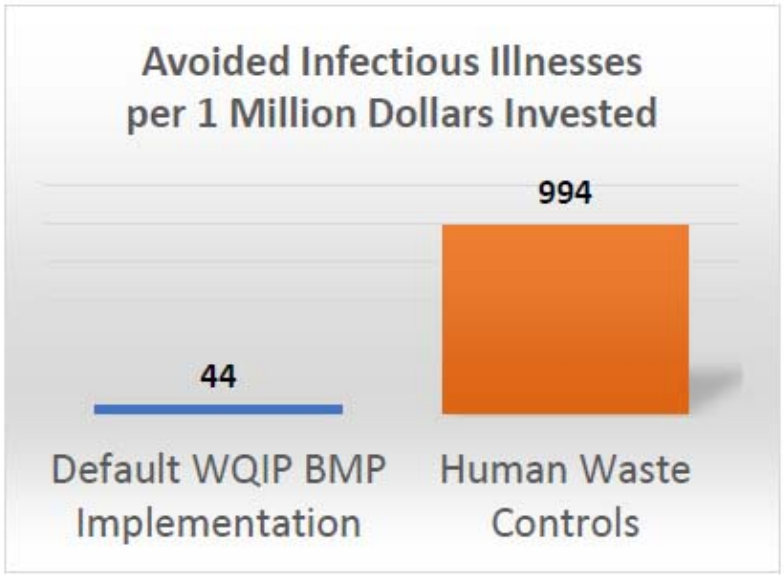


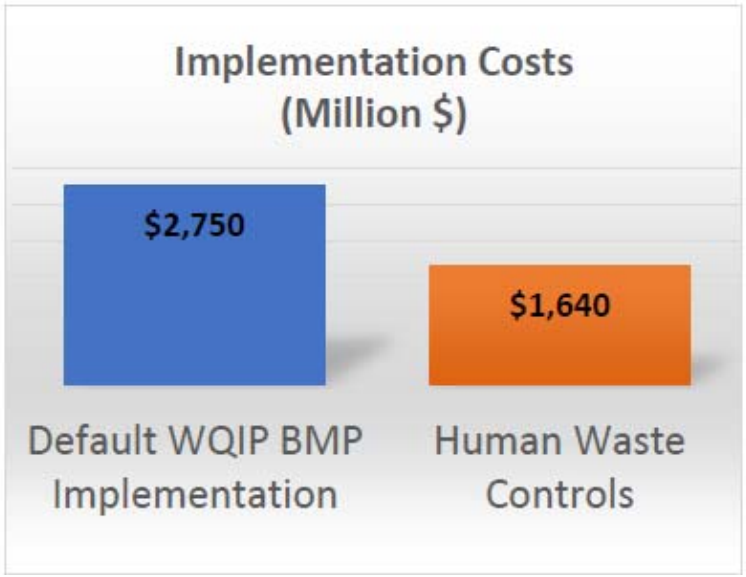
Advantages

- Greater Health Risk Reduction
  - Targets human waste sources that are both higher risk and more controllable than non-human sources of fecal indicator bacteria
- Lower Implementation Cost
  - Requires less public funding by de-emphasizing structural BMPs that were not selected to reduce illness risk
- In-line with USEPA's movement towards health-based criteria and consistent with ongoing efforts across the region
  - E.g., Surfer Health Study, QMRAs, and Cost Benefit Analysis
- Structural stormwater BMPs can remain as a backup plan



Subsequent Cost Benefit Analysis Confirmed Benefits of WQIP Strategy





- Analysis is one of several inputs into San Diego Bacteria TMDL Reopener
- After monetizing broad array of benefits including illnesses avoided, sum of benefits was far exceeded by default stormwater BMP-based implementation cost, therefore the alternative human waste control-based implementation strategy is favorable

Takeaways & Recommendations

- First focus on:
  - Dry weather (fewer variables to control)
  - Highest risk, most controllable sources (human waste from infrastructure)
- Use MST markers to guide implementation:
  - Expect human waste and infrastructure sources -- it's the norm
  - Involve infrastructure owners/operators early in investigation process (mine local knowledge)
  - Human marker may have higher analytical cost, but consider the labor cost of cheaper methods that are low sensitivity and low specificity (inefficient/ineffective IDDE)
  - When designing sampling plan, remember it's harder to prove a negative than it is to prove a positive, so more samples needed for Natural Source Exclusion demonstration and fewer samples needed for source investigations
  - Non-human markers typically aren't a useful line of evidence until human absence shown
  - Use experienced personnel to support study design, guidance on sample collection procedures, and interpretation of results

Takeaways & Recommendations (cont'd)

- BMP planning:
  - Follow available guidance
  - Where possible for dry weather, pursue discharge elimination to ensure permit compliance
  - Exhaust lower cost non-structural before moving on to structural wet weather controls
- What to do about FIB?
  - FIB may never meet REC WQS 100% of the time (especially in wet weather), even after human sources abated, because human marker and FIB sources are often different
  - Site specific objective pathways are available, though process is lengthy, costly, and uncertain… first test cases are still moving through pipeline

THANK YOU!! -- Q&A

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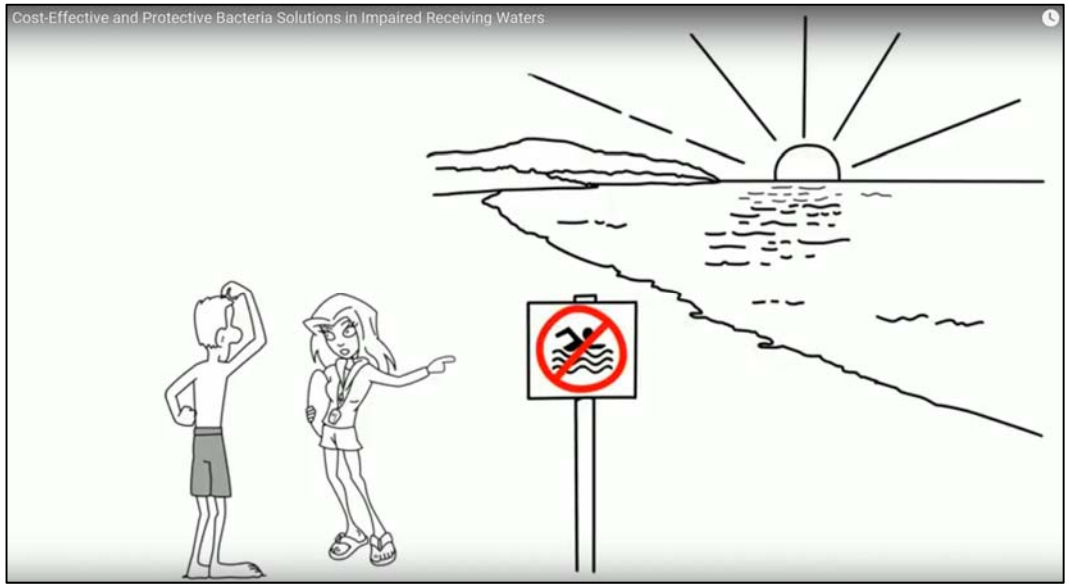

For a Youtube whiteboard video on the human waste control approach, visit: youtu.be/psXkqTc9eeE