APPENDIX A

Priority and Highest Priority Water Quality Condition Selection Methodology

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APPENDIX A – Methodology for Selecting Priority and Highest Priority Water Quality Conditions

The methodology to select the priority and highest priority water quality conditions follows four steps.

Step 1: Determine Receiving Water Conditions (Permit B.2.a). The goal of the receiving water assessment is to determine the receiving water conditions in the watershed. Some receiving water conditions may be selected as priority water quality conditions if there is sufficient data showing that the MS4 is causing and contributing to the receiving water condition or if it is suspected that the MS4 may be causing and contributing but there is a gap in the data.

a. Information and data to evaluate receiving waters conditions includes:
    i. TMDLs;
    ii. 303(d) listings to determine impaired beneficial uses;
    iii. Sources that are provided as part of the 303(d) listing. (This is important if the 303(d) listing has called out the MS4 as a source);
    iv. RW limits for appropriate segments;
    v. Historic and current data from the LTEA and WURMP. (Associate a NPDES monitoring location with each watershed when available. The priorities listed by these documents exceed water quality benchmarks.); and
    vi. 3rd party data submitted in response to public data call.
b. Determine a receiving water condition based on the following criteria:
    i. TMDLs in the watershed applied upstream where appropriate;
    ii. All 303(d) listings;
    iii. All additional receiving water conditions identified by reviewing historic and current monitoring data; and
    iv. 3rd party data submitted in response to public data call.

Step 2: Determine Potential Receiving Water Impacts from MS4 Discharges (Permit B.2.b). Review MS4 Monitoring Data to determine potential receiving water impacts associated with MS4 discharges by assessing the following:

a. Outfall monitoring data provided in the WURMP and LTEA. (It is important to note that often only one MS4 wet weather outfall location is associated with each NPDES monitoring location, meaning that the analysis is done at the subwatershed level and not in the receiving water);
b. WQBELs where appropriate;
c. The 303(d) listing identifies the MS4 as a source; and
d. 3rd party data.

Step 3: Determine Priority Water Quality Conditions (Permit B.2.c.(1)). The goal of this step is to select the priority water quality conditions by analyzing the receiving water conditions based on the potential for the MS4 to cause and contribute to the condition. Priority water quality conditions may be identified based on the following criteria:

a. MS4 subwatershed outfall data compared to the receiving water condition. If the subwatershed level outfall data shows that MS4 is causing and contributing to the receiving water condition then it may be considered a priority water quality condition;
b. If there is no outfall monitoring data associated with the receiving water condition, the 303(d) listing will be referenced to determine if the MS4 is included as a source. If the MS4 is listed as a source, this receiving water condition may be considered a priority water quality condition with a data gap; and
c. Consider 3rd party input submitted in response to public data call.

Step 4: Determine Highest Priority Water Quality Condition(s) (Permit B.2.c.(2)). The MS4 Permit requires the Copermittees to identify the highest priority water quality conditions to be addressed by the Water Quality Improvement Plan, and provide a rationale for selecting a subset of the priority water quality conditions identified in Step 3. Because the MS4 Permit requires the development and identification of numeric goals, strategies, and schedules for the highest priority water quality conditions, a scientifically-based screening analysis of priority water quality conditions was applied. Conditions already subject to an approved TMDL, ASBS or other water quality regulation will be elevated to highest priority water quality condition.

The Responsible Agencies will identify priority water quality conditions not subject to an approved water quality regulation as a highest priority based on the following factors:

a. The supporting data set is sufficient to adequately characterize the degree to which the priority water quality condition changes seasonally, and over geographic area, to support its consideration as a highest priority water quality condition.
b. Storm water/ non-storm water runoff is a predominant source for the priority water quality condition.
c. The priority water quality condition is controllable by the Responsible Agencies.
d. The priority water quality condition would not be addressed by strategies identified for other highest priority water quality conditions in this Water Quality Improvement Plan.

APPENDIX B

Los Peñasquitos WMA Maps

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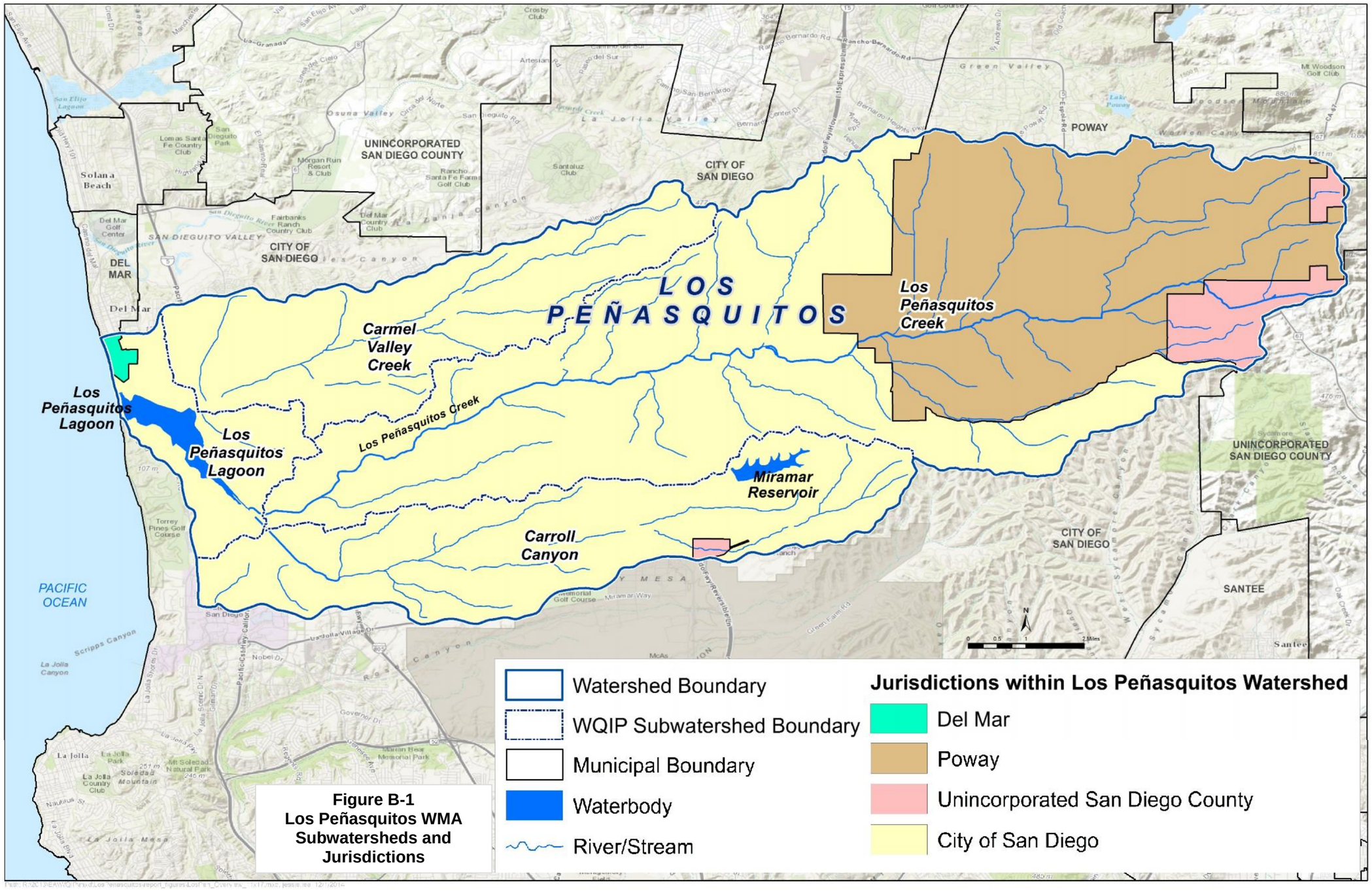

Figure B-1
Los Peñasquitos WMA Subwatersheds and Jurisdictions

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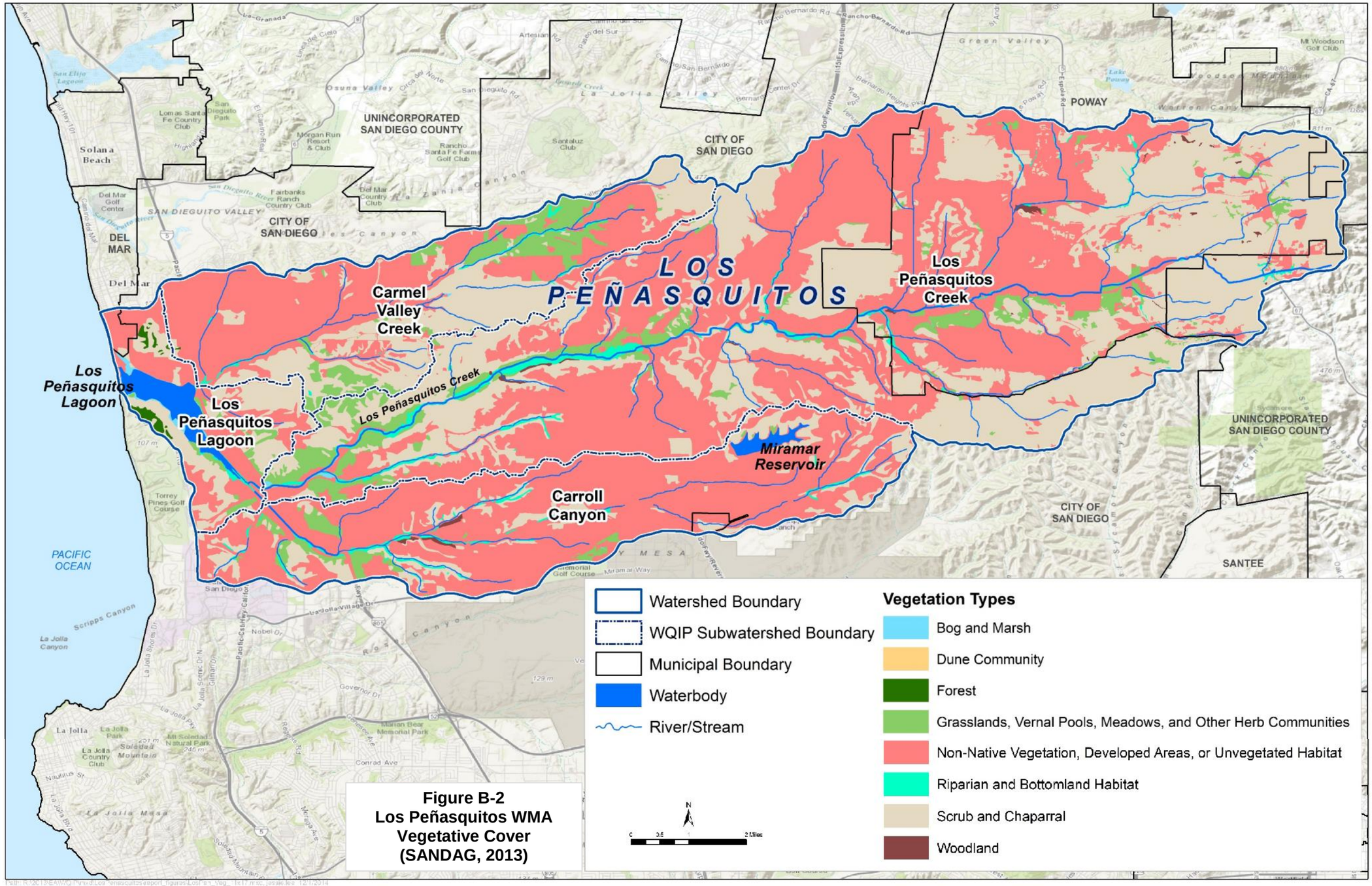

Figure B-2
Los Peñasquitos WMA
Vegetative Cover
(SANDAG, 2013)

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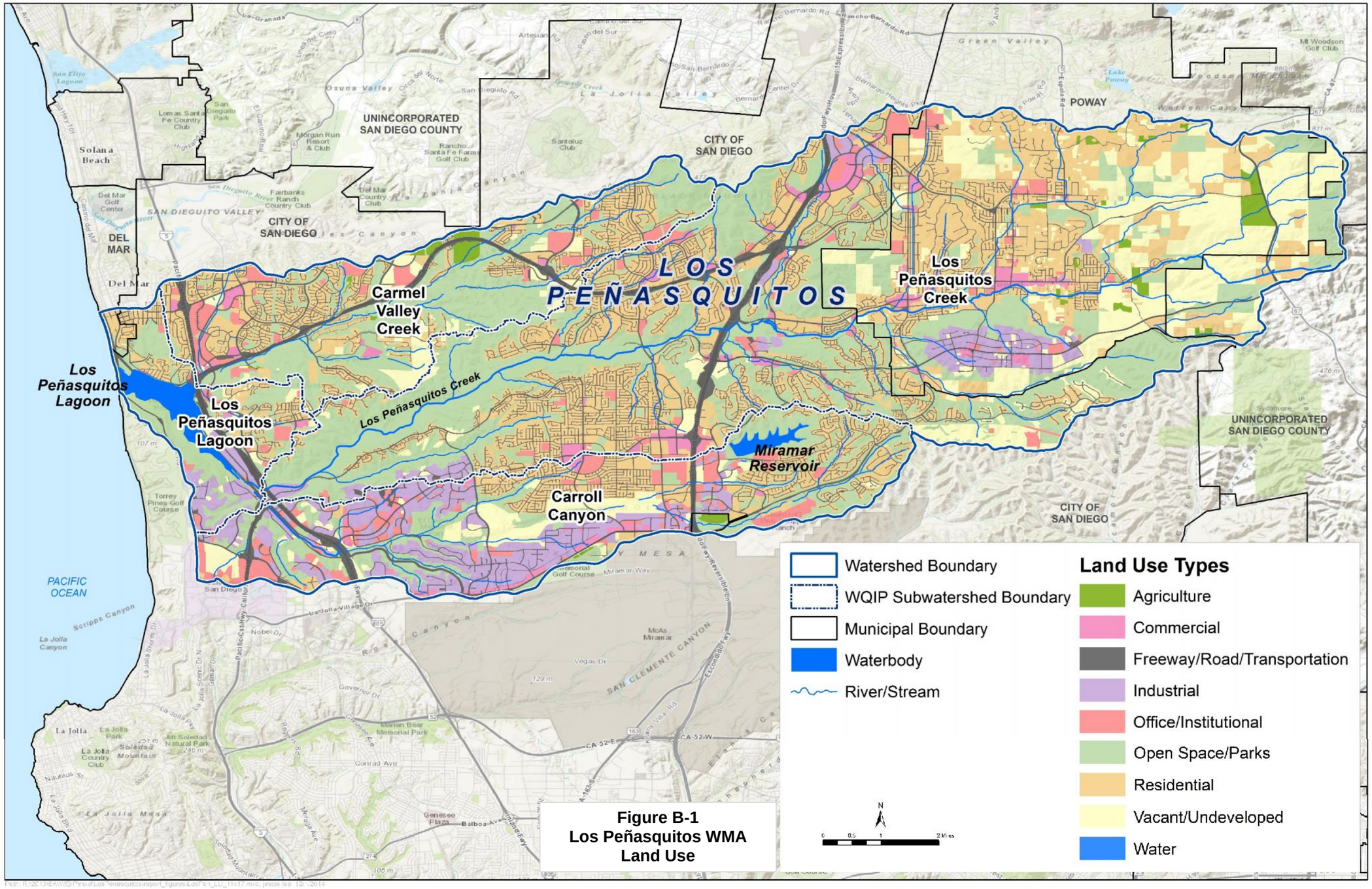

Figure B-1
Los Peñasquitos WMA
Land Use

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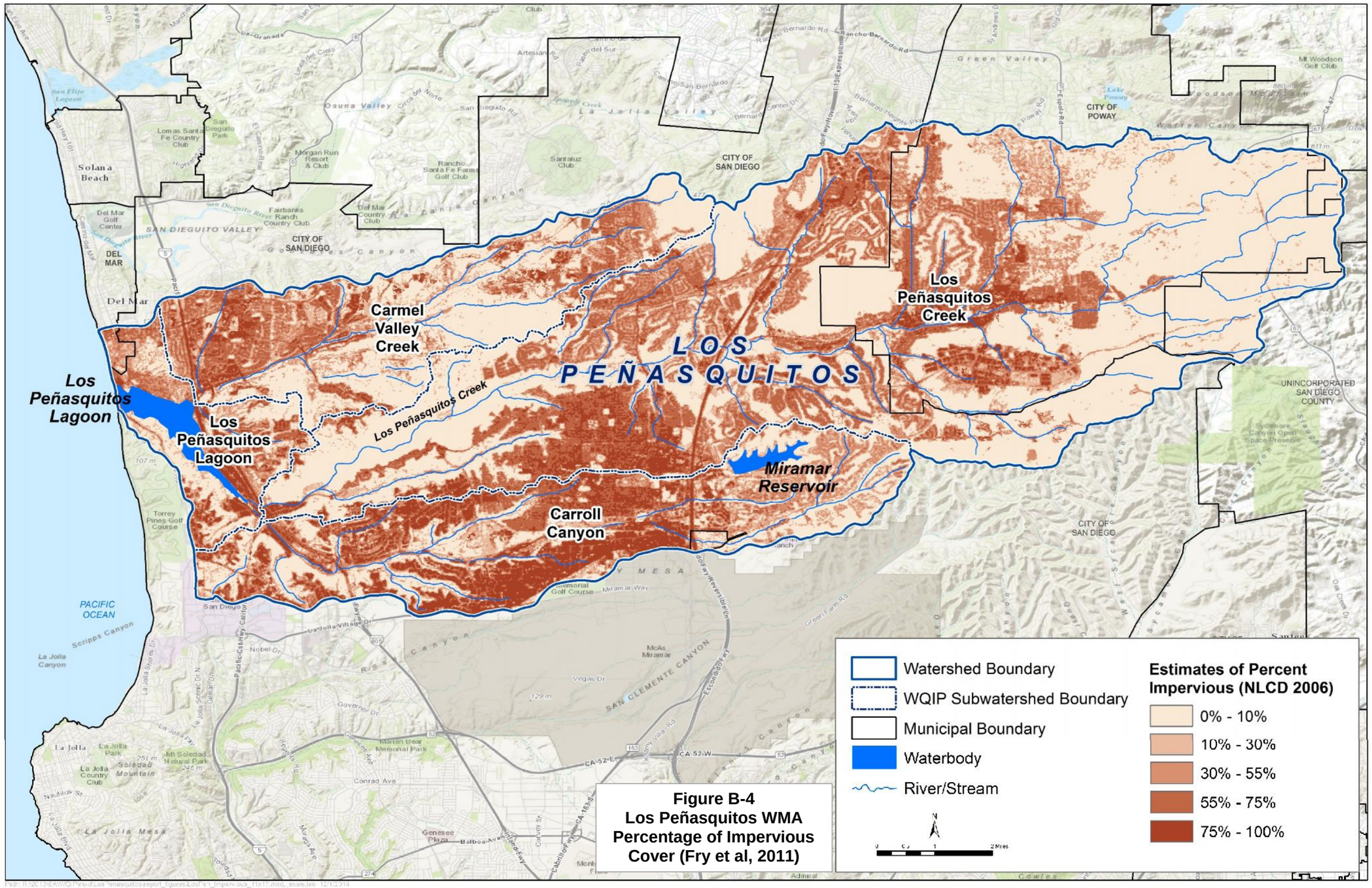

Figure B-4
Los Peñasquitos WMA
Percentage of Impervious Cover (Fry et al, 2011)

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APPENDIX C

Beneficial Uses of 303(d) Listed Waterbodies in the Los Peñasquitos WMA

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Table C-1 presents the beneficial use designations of the 303(d) listed waterbodies in the Los Peñasquitos WMA. Beneficial uses specifically identified as impaired by the 2010 303(d) list are shaded blue. This table does not present waterbodies that were not identified as impaired on the 303(d) list. Approximately 92% of the waterbodies in the Los Peñasquitos WMA are not impaired or have not been assessed. Of those waterbodies that are listed as having impairments, most beneficial uses are attained.

Table C-1
Beneficial Uses of the 2010 303(d) Listed Waterbodies
in the Los Peñasquitos WMA

303(d) Listed Waterbody Name	Beneficial Use																		
	MUN	AGR	IND	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN	NAV	COMM	EST	MAR	AQUA	MIGR	SHELL
Miramar Reservoir (in Los Peñasquitos Creek Subwatershed) (906.10)	●		●	●	●	●		●		●									
Soledad Canyon (Carroll Canyon Creek) (906.10)	+	●	●		○	●		●		●	●								
Poway Creek (906.20)	+	●	○		●	●		●		●									
Los Peñasquitos Creek (906.20 and 906.10)	+	●	●		●	●	●	●	●	●									
Los Peñasquitos Lagoon (906.10)					●	●	●			●	●	●			●	●		●	●
Pacific Ocean Shoreline (906.10)			●		●	●	●			●	●	●	●	●		●	●	●	●

Beneficial use is impaired based on the 2010 303(d) list

○ Potential beneficial use

● Existing beneficial use

+ Excepted from Municipal and Domestic Supply (MUN)

The definitions of beneficial uses that are impaired based on the 303(d) list in the Los Peñasquitos WMA are defined in the Basin Plan as follows:

- **Agricultural Supply (AGR)** includes uses of water for farming, horticulture, or ranching, including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.
- **Preservation of Biological Habitats of Special Significance (BIOL)** includes uses of water that support designated areas or habitats, such as established refuges, parks, sanctuaries, ecological reserves, or Areas of Special Biological Significance (ASBS), where the preservation or enhancement of natural resources requires special protection.

- **Estuarine Habitat (EST)** includes uses of water that support estuarine ecosystems, including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds).

- **Shellfish Harvesting (SHELL)** includes uses of water that support habitats suitable for the collection of filter-feeding shellfish (e.g., clams, oysters, and mussels) for human consumption, commercial, or sport purposes.

- **Warm Freshwater Habitat (WARM)** includes uses of water that support warm water ecosystems, including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

The beneficial uses in the Los Peñasquitos WMA which are not listed as impaired are defined in the Basin Plan as follows:

- **Aquaculture (AQUA)** includes the uses of water for aquaculture or mariculture operations including, but not limited to, propagation, cultivation, maintenance, or harvesting of aquatic plants and animals for human consumption or bait purposes.

- **Cold Freshwater Habitat (COLD)** includes uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish or wildlife, including invertebrates.

- **Commercial and Sport Fishing (COMM)** includes the uses of water for commercial or recreational collection of fish, shellfish, or other organisms including, but not limited to, uses involving organisms intended for human consumption or bait purposes.

- **Industrial Service Supply (IND)** includes uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well re-pressurization.

- **Marine Habitat (MAR)** includes uses of water that support marine ecosystems including, but not limited to, preservation or enhancement or marine habitats, vegetation such as kelp, fish, shellfish, or wildlife (e.g., marine mammals, shorebirds).

- **Migration of Aquatic Organisms (MIGR)** includes uses of water that support habitats necessary for migration, acclimatization between fresh and salt water, or other temporary activities by aquatic organisms, such as anadromous fish.

- **Municipal and Domestic Supply (MUN)** includes uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.

- **Navigation (NAV)** includes uses of water for shipping, travel, or other transportation by private, military, or commercial vessels.

- **Hydropower Generation (POW)** includes uses of water for hydropower generation.
- **Rare, Threatened, or Endangered Species (RARE)** includes uses of water that support habitats necessary, at least in part, for the survival and successful maintenance or plant or animal species established under state or federal law as rare, threatened, or endangered.
- **Contact Water Recreation (REC-1)** includes uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and SCUBA diving, surfing, white water activities, fishing, or use of natural hot springs.
- **Non-contact Water Recreation (REC-2)** includes the uses of water for recreational activities involving proximity to water but not normally involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.
- **Shellfish Harvesting (SHELL)** includes uses of water that support habitats suitable for the collection of filter-feeding shellfish (e.g., clams, oysters and mussels) for human consumption, commercial, or sport purposes.
- **Spawning, Reproduction, and/or Early Development (SPWN)** includes uses of water that support high quality habitats suitable for reproduction, early development and sustenance of marine fish and/or cold freshwater fish.
- **Wildlife Habitat (WILD)** includes uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

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APPENDIX D

Additional Data Sources

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APPENDIX D.1

Primary and Secondary Data Sources

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Primary and Secondary Data Sources

Primary References

2011 Long-Term Effectiveness Assessment. San Diego County Municipal Copermittees Urban Runoff Management Programs. Final Report
2011-2012 San Diego County Copermittee Receiving Waters and Urban Runoff Monitoring Report
2010-2011 San Diego County Copermittee Receiving Waters and Urban Runoff Monitoring Report
2008 City of Del Mar Jurisdictional Urban Runoff Management Plan (JURMP) (Including FY10 Annual Report)
2008 City of Poway JURMP (Including FY12 Annual Report)
2008 City of San Diego JURMP (Including FY11 and FY12 Annual Report)
2008 County of San Diego JURMP (Including FY11 and FY12 Annual Report)
Los Peñasquitos WURMP (Including FY11 and FY12 Annual Report)
Los Peñasquitos Watershed Comprehensive Load Reduction Plan (CLRP) Phase I

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APPENDIX D.2

Third Party Data Sources Summary

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Document:
San Diego Coastkeeper Data for Los Peñasquitos Watershed

Locations within watershed:
LPQ-020, LPQ -030, LPQ -040 (Los Peñasquitos Creek just upstream of the lagoon)

Conditions:
• Healthy levels of dissolved oxygen, pH, and temperature (basic water indicators of health). Most sites had elevated levels of electrical conductivity, especially during the dry season.
• Very low concentrations of dissolved metals. Only one sample slightly exceeded basin plan standards (cadmium in Carmel Creek). 99.2% of samples were below Basin Plan standards.
• Slightly elevated ammonia and phosphorus concentrations. Almost every sample showed ammonia and phosphorus levels at or slightly above Basin Plan thresholds.
• Generally low *E. coli* concentrations. 100% of samples met regulatory thresholds during the dry season. Compared to most of the region, the wet season had few samples that exceeded the threshold.
• Moderate levels of *Enterococcus*. Unlike E. coli, these results are not heavily tied to the wet or dry season; exceedances are spread through the whole year.

Sources:
No Data

Strategies:
No Data

Document:
Interstate 5/State Route 56 Interchange Project Water Quality Report, 2010

Locations within watershed:
Project drains to Carmel Valley Creek, Los Peñasquitos Creek, Los Peñasquitos Lagoon

Conditions:
• Los Peñasquitos Creek was 303(d) listed for phosphate and TDS, Los Peñasquitos Lagoon was listed for sedimentation/siltation
• Pollutants potentially added due to construction and/or operation = sediment, vehicle fluids, various chemical compounds, rubble/litter, nutrients from tree leaves, nitrite from exhaust, pesticides, metals, etc
• Hydromodification due to impervious surface addition

Sources:
Document identified construction activities as having short term impact on storm water runoff

Strategies:
• Temporary impacts will be avoided or minimized by the use of construction site best management practices (BMPs) such as fiber rolls, hydraulic mulch, drainage inlet protection, check dams, concrete washouts, construction entrances, and street sweeping.
• Phosphate and sediment will be targeted for treatment.

Document:
Public Input Form – Paula Roberts

Locations within watershed:
No data

Conditions:
No data

Sources:
No data

Strategies:
• Potential to use historical data from (illegible name) Creek Watershed District.
• Suggests leveraging satellite photos for longitudinal studies of water quality as well as data collected by local classrooms as part of global project.

Document:
Email from Jeff Carr of Poway to TSW Think Blue

Locations within watershed:
No Data

Conditions:
No Data

Sources:
• Residential runoff
• Swimming pools
• Parking lots and roads

Strategies:
• Swimming pool draining: suggests draining swimming pools into sewer, since pool water can be source of chemicals, algae, and debris as well as deteriorating streets and picking up additional debris when flowing into storm drains. Mr. Carr also suggests that this would not increase sewer charges for homeowners/cities because of how residential sewer charges are calculated: the homeowner with the pool is paying sewer fees for that water whether it's put in the sewer or not.
• Property drainage: suggests replacement of concrete gutter drains with swale or bioswale to reduce year round flows into storm drains. Mr. Carr also suggests updates to building codes to promote alternatives to standard concrete gutter drains.
• Parking lots and roads: suggests that in addition to contaminants from cars, road material can deteriorate due to surface damage and end up in storm drains via runoff. Mr. Carr suggests requiring municipalities/private property owners to properly maintain roads and parking lots to prevent deterioration that will end up in storm drains. Additionally, Mr. Carr notes there are many private and/or gated communities with access to city storm drains that do not receive City street sweeping (though residents pay for it via taxes). Mr. Carr suggests that HOAs should be required to perform similar maintenance activities or allow City street sweeping services to be extended into these private communities in an effort to maintain clean storm drains.

Document:
City of San Diego Strategic Plan for Watershed Activity Implementation, input from Consultation Committee

Locations within watershed:
Not specified

Conditions:
The following priority conditions were identified:
• Bacteria
• Nutrients
• Sediments
• Total Dissolved Solids
• Benthic Alterations

Sources:
Potential Sources include:
• Eating and Drinking Establishments
• Residential Areas and Activities
• Commercial Landscaping
• Animal Related Facilities
• Golf Courses, Parks, and Recreational Activities
• Municipal Facilities and Activities
• Auto Related Facilities
• Roads, Streets, Highways, and Parking Facilities
• Construction Activities

Strategies:
No data (Strategies identified through 2011 only)

Document:
Download SWAMP data from CEDEN website using the following search parameters – San Diego County and SWAMP RWB 9 Monitoring

http://ceden.waterboards.ca.gov/AdvancedQueryTool

Locations within watershed:
See red highlighted waterbodies in the table on Page C-9.

Conditions:
SWAMP monitoring data available from CEDEN for Region 9 was reviewed to determine if the data provide additional priority water quality conditions. Many of the programs included 1 -4 sampling events and measured a range of parameters. A majority of the monitoring occurred before the 2005 and 2011 LTEAs that incorporated the most recent regional monitoring data for the region. No additional conditions were selected based on a review of the data.

Sources:
No Data

Strategies:
No Data

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Project Name from CEDEN	Years	Station Name(s)	Temporal	No. of Sampling Events	Matrix	Summary of General Analyses
Statewide Project Urban Pyrethroid Status Monitoring		Peñasquitos Creek @ Springbrook	dry weather	1	sediment	TOC, % fines, moisture, and pyrethroids
RWB9 Status Sampling 2008	2008	Campo Creek 1, Ironside Creek, Los Peñasquitos Creek 6, Rose Canyon Creek 4	dry weather	1	water, benthic	field measurements, comments noted, velocity, algae, and conventional chemistry
RWB9 Rotational BA Monitoring 2005	2005	Santa Ysabel Creek ~2mi E Hwy 79	dry weather	1	physical	field measurements, velocity, and slope profile
RWB9 Rotational Monitoring 2002	2002	Los Peñasquitos Creek 6, Poway Creek 2, Rose Canyon Creek 4, Soledad Canyon Creek 2, and Soledad Canyon Creek 4	dry weather	1-4	water, sediment	field measurements, conventional chemistry, metals, herbicides, pesticides, and velocity. % fines
RWB9 Rotational Monitoring 2003	2003	Green Valley Creek 2, San Dieguito River 9, Santa Ysabel Creek 1	dry weather	2-4	water, sediment	Field measurements, conventional chemistry, metals, herbicides, pesticides, and velocity. % fines
San Diego Regional Board Fire Study	2005, 2007, 2008, 2009	Black Mountain Creek Upstream of Santa Ysabel Creek, Boden Canyon Creek (BOD), Boden Canyon Creek ~0.5 mile upstream of Santa Ysabel Creek , Chicarita Creek downstream of Evening Creek Road, Green Valley Creek 2, Kit Carson Creek Sunset Drive crossing	dry weather	1-3	water	field measurements and velocity
Statewide Perennial Streams Assessment 2008	2008	Encinitas Creek, Arroyo Trabuco 57, Santa Ysabel Creek	dry weather	1	water, benthic	field measurements, comments noted, velocity, algae, and conventional chemistry
CMAP Wadeable Streams 2004	2004	Santa Ysabel Creek below Witch Creek	dry weather	2	water	field measurements and velocity

continued on next page

Project Name from CEDEN	Years	Station Name(s)	Temporal	No. of Sampling Events	Matrix	Summary of General Analyses
Statewide Ref Condition Management Plan 2009	2009	Noble Canyon Creek ~0.8mi above Pine Valley Cr.	dry weather	1	water, benthic	field measurements, conventional chemistry, algae and velocity
Statewide Ref Condition Management Plan 2010	2010	Cedar Creek 2, Japacha Creek above Hwy 79, Spring Canyon Creek ~2.3mi above Hwy 74	dry weather	1	water, benthic	field measurements, conventional chemistry, algae and velocity
Statewide Ref Condition Management Plan 2008	2008	Arroyo Trabuco	dry weather	1	water, benthic	field measurements, conventional chemistry, algae and velocity
Statewide Ref Condition Management Plan 2011	2011	Cold Spring Canyon above Devil Cyn Creek, Devils Canyon Creek above San Mateo Cyn. Creek, Juaquapin Creek above Sweetwater River, Kitchen Creek at Kitchen Creek Road, Troy Canyon Creek (TCC2), Wilson Creek 3	dry weather	1	water, benthic	field measurements, conventional chemistry, algae and velocity
Statewide Ref Condition Mgmt Plan Index Study 2009	2009	Noble Canyon Creek ~0.8mi above Pine Valley Cr.	dry weather	2	water, benthic	field measurements, conventional chemistry, algae and velocity
Statewide Ref Condition Mgmt Plan Index Study 2010	2010	Cedar Creek 2	dry weather	4	water, benthic	field measurements, conventional chemistry, algae and velocity
Statewide Stream Pollution Trends Study 2008	2008, 2009, 2010	Agua Hedionda Creek 6, Escondido Creek at Camino del Norte, Forrester Creek 2, Los Peñasquitos Creek 6, San Diego River at Ward Road, San Dieguito River 9, San Juan Creek 9, Santa Margarita at Basilone Rd, Soledad Canyon Creek 4, Tijuana River at Hollister Rd	dry weather	1	sediment	Organics, PCBs, Pyrethroids, Pesticides, Semi-volatile Organic Carbons, metals

APPENDIX D.3

Persistent Flow Outfall Summary

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Potential Persistent Flow Outfalls[1]

Jurisdiction[2]	Subwatershed	Site ID	Latitude	Longitude	Land Use
City of San Diego[3]	Carmel Valley Creek	DW0017	32.96954	-117.13830	Residential
		DW0034	32.94366	-117.24016	Commercial
		DW0036	32.94300	-117.21310	Residential
		DW0037	32.94293	-117.21227	Residential/Commercial
		DW0281	32.94786	-117.20860	Residential
		DW0402	32.95021	-117.19780	Residential
		DW0422	32.93138	-117.20519	Residential
	Carroll Canyon	DW0027	32.90409	-117.15680	Residential
		DW0030	32.89081	-117.19461	Commercial/Industrial
		DW0031	32.89174	-117.18453	Industrial
		DW0064	32.88284	-117.17248	Industrial
		DW0266	32.90228	-117.16409	Residential
		DW0353	32.91149	-117.10614	Residential
		DW0429	32.89021	-117.15368	Industrial/Open Space
		DW0478	32.90555	-117.10285	Residential
		DW0481	32.90559	-117.09524	Residential/Open Space
		DW0643	32.88952	-117.16110	Industrial
		DW0692	32.88822	-117.22084	Industrial/Open Space
		DW0839	32.89915	-117.11371	Industrial
	Los Peñasquitos Creek	DW0024	32.92319	-117.14947	Residential
		DW0025	32.92164	-117.14905	Residential
		DW0247	32.96909	-117.09382	Residential
		DW0290	32.94188	-117.11442	Residential
		DW0302	32.91386	-117.17438	Industrial
		DW0308	32.91070	-117.18990	Industrial
		DW0375	32.92349	-117.21081	Residential
		DW0435	32.91739	-117.15250	Residential/Commercial
		DW0638	32.90833	-117.18039	Industrial
City of Del Mar	Los Peñasquitos Lagoon	S-12	32.94241	-117.26268	Open Space & Residential
City of Poway	Los Peñasquitos Creek	282-1749, 1	32.94269	-117.065	Residential
		282-1749, 3 (DW Site 2)	32.94177	-117.059	Open Space/Parks & Recreation
		282-1749, 2	32.9486	-117.062	Vacant/Undeveloped
		298-1749, 4 (123)	32.99228	-117.058	Road
		298-1749, 5	32.99311	-117.058	Freeway

1. This list of persistent flow outfalls is current based on 2014 dry weather monitoring data.
2. No outfalls with persistent dry weather flow have been identified in Caltrans or County of San Diego jurisdictions.
3. Identified land uses for the City of San Diego include all land uses comprising more than 30% of upstream drainage area.

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APPENDIX D.4

Public Input from Water Quality Improvement Plan Workshop

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Public Input

Priority Water Quality Conditions

- Erosion
- Velocity
- Sedimentation/Siltration
- Freshwater input – dry weather flows
- Nutrients
- Bacteria

Sources

- Industrial activities (sand and gravel) cause sediment issues
- Primarily non-point sources located along the watershed lagoon boundaries
- Deteriorating road materials

Potential Water Quality Strategies

- Curb cuts – retrofits
- Fungus (mycelium) that removes contaminants in soil and slow moving waterways as researched by Paul Stamets
- Targeted street sweeping
- Traffic slowing – no braking – such as roundabouts
- Stopping sediment closer to the source by improving maintenance to access roads and trails
- Man-made wetlands
- Return concrete channels back to natural state
- Day-lighting underground channels
- Build detention basins in recreational facilities
- Continue coordination with the Los Peñasquitos Lagoon Foundation and California State Parks with regard to planning efforts and activities within the Los Peñasquitos Watershed and Lagoon

- Address existing TMDL constituents of concern for Los Peñasquitos Lagoon (i.e. sediment/siltation and bacteria) and its tributaries (e.g. phosphorus, TDS).
- Consider approaches for reducing loading of other 303(d) constituents of concern (e.g. nutrients) and/or conditions (e.g. habitat conversion) to avoid additional TMDLs for Los Peñasquitos Lagoon and tributaries in the future
- Consider approaches for managing water input into the watershed and Lagoon from storm events and dry weather flows that can contribute to pollutant loading, habitat conversion and breeding habitat for *Culex tasalis* (freshwater species of mosquito known to transmit West Nile virus)
- Review swimming pool draining policies – fast moving water can contaminate storm water even if it is de-chlorinated
- Adjust building codes to promote alternatives to concrete gutter drains such as bioswales or swales.
- Require municipalities and private land owners to properly maintain roads and parking lots to prevent deterioration
- Require communities such as HOAs in Poway to sweep their streets on a regular basis

Data

- SMARTS database from the Regional Board
- Construction permits
- Locational data
- Historical data
- 1st water data from 1914 USGS
- Caltrans data
- Hydro geo morphological – erosion – Prescott 1975 and 1982
- CVREP Sediment transport study
- Developers studies – check with DSD
- Review Minnehaha Creek Watershed District in Minneapolis/St. Paul – they have longitudinal studies of satellite photos for water quality data

APPENDIX E

Receiving Water Condition and Urban Runoff Assessment

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Appendix E –Receiving Water Condition and Urban Runoff Assessment

Appendices E.1 and E.2 present an assessment of receiving water conditions and the impact of urban discharges in Los Peñasquitos WMA during wet and dry weather, respectively. The list of receiving water conditions was developed on the basis of the 2010 303(d) list, applicable TMDLs, waterbodies with special biological significance, public input, and the priority pollutants or stressors identified from current and historical receiving water monitoring data. MS4 monitoring data compiled from the LTEA and WURMP Annual Reports, as well as any applicable TMDL WQBELs, are also evaluated in relation to the receiving water conditions to determine if a priority water quality condition existed.

The tables in Appendices E.1 and E.2 are presented by WQIP Subwatershed and 303(d) listed waterbody. In order to mirror the process used by the Responsible Agencies to assess the potential receiving water conditions for each waterbody, the data are presented in the order they were evaluated. The following is an illustration of how the reader might follow the process used to assess receiving water conditions in an example waterbody (Example Waterbody A):

- **303(d) Listings (Page E-5, reading left to right)** identifies the WQIP subwatershed, applicable TMDLs, and 303(d) listed waterbody (Example Waterbody A), and then presents the associated pollutants, impaired beneficial uses, and potential sources of impairment for Example Waterbody A as identified under the 2010 303(d) list.
- **Receiving Water Assessment and Conditions (Page E-6, reading left to right)**
  - **Receiving Water Assessment** identifies the WQIP subwatershed, applicable TMDLs, and 303(d) listed waterbody (Example Waterbody A), and then presents public input submitted in response to the public data call and NPDES receiving water monitoring station data for Example Waterbody A. The receiving water priorities identified were noted as exceeding water quality benchmarks in the 2005-2010 LTEA, the FY 11 & 12 WURMP, or both.
  - **Receiving Water Conditions** summarizes the receiving water conditions identified through the 303(d) listings and receiving water assessment, and states the applicable lines of evidence.
- **Urban Runoff Monitoring Assessment (Page E-7, reading left to right)** identifies the WQIP subwatershed and 303(d) listed waterbody (Example Waterbody A), and then presents the priority pollutants at the MS4 outfall, based on the Urban Runoff Monitoring Program and identified in the 2005-2010 LTEA and FY 11&12 WURMP Annual Reports, for Example Waterbody A. as well as the applicable WQBELs where appropriate.

Page E-8 then restarts the assessment with an evaluation of 303(d) listings for the next waterbody.

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APPENDIX E.1

Wet Weather Receiving Water Condition Assessment

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WQIP Subwatershed	TMDL	303(d) Listed Waterbody	303(d) Listing(s)		
			Pollutant(s)	Impaired Beneficial Use(s)	Potential Source(s)
Carroll Canyon Creek	Draft Sediment TMDL and Bacteria TMDL	Soledad Canyon	Selenium	Warm Freshwater Habitat	Source Unknown, Unknown Non-point Source, Urban Runoff/Storm Sewers
			Sediment Toxicity	Warm Freshwater Habitat	Unknown Point Source, Unknown Non-point Source
		Miramar Reservoir	Total Nitrogen as N	Warm Freshwater Habitat	Source Unknown

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	Receiving Water Assessment				Receiving Water Conditions	
			Public Input	NPDES Receiving Water			Receiving Water Condition(s)	Line(s) of Evidence
				Applicable Receiving Water Station(s)	2005-2010 LTEA	FY 11 & 12 WURMP		
Carroll Canyon Creek	Draft Sediment TMDL and Bacteria TMDL	Soledad Canyon	Erosion, velocity, sedimentation/siltation, freshwater input, nutrients, bacteria	LPC-TWAS-1	Turbidity, TSS, Bifenthrin, Fecal Coliform, TDS	TSS, Turbidity, Bifenthrin, pH, Very Poor IBI ***Based on one sample in analysis***, Fecal Coliform, TDS	Impairment of WARM from selenium in Soledad Canyon during wet weather.	303(d)
							Impairment of WARM due to sediment toxicity in Soledad Canyon during wet weather.	303(d)
							Elevated fecal coliform near NPDES monitoring locations during wet weather.	RW monitoring data (historic & current)
							TDS not included because impact to WARM during wet weather is unknown. TDS will be listed as contributing to impairment of WARM during dry weather.	
							Elevated bifenthrin near NPDES monitoring locations during wet weather.	RW monitoring data (historic & current)
							Elevated TSS and turbidity near NPDES monitoring locations during wet weather.	RW monitoring data (historic & current)
		Miramar Reservoir		NA	NA	NA	Eutrophic conditions (total nitrogen) not included because impact to WARM during wet weather is unknown. Eutrophic conditions (total nitrogren) will be listed as contributing to impairment of WARM during dry weather.	

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	Urban Runoff Monitoring Assessment		
			MS4 Outfall and Dry Weather Monitoring Program		TMDL(s)
			2005-2010 LTEA	FY 11 & 12 WURMP	WQBELs
Carroll Canyon Creek	Draft Sediment TMDL and Bacteria TMDL	Soledad Canyon	Fecal Coliform	Fecal Coliform	Sediment Load, Lagoon Restoration (Order No. R9-2012-0033), *Enterococcus* , Fecal Coliform (Order No. R9-2013-0001; Attachment E.6)
		Miramar Reservoir	NA	NA	

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	303(d) Listing(s)		
			Pollutant(s)	Impaired Beneficial Use(s)	Potential Source(s)
Los Peñasquitos Creek	Draft Sediment TMDL and Bacteria TMDL	Los Peñasquitos Creek	*Enterococcus*	Warm Freshwater Habitat	Source Unknown
			Fecal Coliform	Warm Freshwater Habitat	Source Unknown
			Selenium	Warm Freshwater Habitat	Source Unknown
			Total Nitrogen as N	Warm Freshwater Habitat	Source Unknown
			TDS	Agricultural Supply	Source Unknown
			Toxicity	Warm Freshwater Habitat	Unknown Non-point Source, Unknown Point Source, Urban Runoff/Storm Sewers
		Poway Creek	Selenium	Warm Freshwater Habitat	Unknown Non-point Source, Unknown Point Source, Urban Runoff/Storm Sewers
			Toxicity	Warm Freshwater Habitat	Unknown Non-point Source, Unknown Point Source, Urban Runoff/Storm Sewers

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	Receiving Water Assessment				Receiving Water Conditions	
			Public Input	NPDES Receiving Water			Receiving Water Condition(s)	Line(s) of Evidence
				Applicable Receiving Water Station(s)	2005-2010 LTEA	FY 11 & 12 WURMP		
Los Peñasquitos Creek	Draft Sediment TMDL and Bacteria TMDL	Los Peñasquitos Creek	Same as above	LPC-MLS, LPC-TWAS-2	TDS, TSS, Turbidity, Bifenthrin, Diazinon, Toxicity (*H. azteca* acute survival), Fecal Coliform	Toxicity (*H. azteca* acute), Very Poor IBI ***Based on one sample in analysis***, Fecal Coliform, TDS, TSS, Turbidity, Bifenthrin	Impairment of WARM due to *Enterococcus* in Los Peñasquitos Creek during wet weather.	303(d)
							Impairment of WARM due to fecal coliform in Los Peñasquitos Creek during wet weather	303(d) and RW monitoring data
							Impairment of WARM due to selenium in Los Peñasquitos Creek during wet weather.	303(d)
							Eutrophic conditions (total nitrogen) not included because impact to WARM during wet weather is unknown. Eutrophic conditions (total nitrogren) will be listed as contributing to impairment of WARM during dry weather.	
							Impairment of AGR due to TDS in Los Peñasquitos Creek during wet weather	303(d) and RW monitoring data
							Impairment of WARM due to toxicity in Los Peñasquitos Creek during wet weather.	303(d) and RW monitoring data
							Elevated bifenthrin near NPDES monitoring locations in Los Peñasquitos Creek during wet weather.	RW monitoring data (historic & current)
							Elevated TSS and turbidity near NPDES monitoring locations in in Los Peñasquitos Creek during wet weather.	RW monitoring data (historic & current)
		Poway Creek					Impairment of WARM due to selenium in Poway Creek during wet weather.	303(d)
							Impairment of WARM due to toxicity in Poway Creek during wet weather.	303(d) and RW monitoring data

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	Urban Runoff Monitoring Assessment		
			MS4 Outfall and Dry Weather Monitoring Program		TMDL(s)
			2005-2010 LTEA	FY 11 & 12 WURMP	WQBELs
Los Peñasquitos Creek	Draft Sediment TMDL and Bacteria TMDL	Los Peñasquitos Creek	Fecal Coliform, TDS	Fecal Coliform	Sediment Load, Lagoon Restoration (Order No. R9-2012-0033), *Enterococcus* , Fecal Coliform (Order No. R9-2013-0001; Attachment E.6)
		Poway Creek			

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	303(d) Listing(s)		
			Pollutant(s)	Impaired Beneficial Use(s)	Potential Source(s)
Carmel Valley Creek	Draft Sediment TMDL and Bacteria TMDL	N/A	NA	NA	NA
Los Peñasquitos Lagoon	Draft Sediment TMDL and Bacteria TMDL	Los Peñasquitos Lagoon	Sedimentation/ Siltation	Estuarine Habitat	Non-point Source, Point Source
	Bacteria TMDL	Pacific Ocean Shoreline, at Torrey Pines State Beach at Del Mar	Indicator Bacteria	Water Contact Recreation	Unknown Non-point Source, Unknown Point Source, Urban Runoff/Storm Sewers
		Pacific Ocean Shoreline, at Los Peñasquitos River Mouth	Total Coliform	Shellfish Harvesting	Unknown Non-point Source, Unknown Point Source, Urban Runoff/Storm Sewers

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	Receiving Water Assessment				Receiving Water Conditions	
			Public Input	NPDES Receiving Water			Receiving Water Condition(s)	Line(s) of Evidence
				Applicable Receiving Water Station(s)	2005-2010 LTEA	FY 11 & 12 WURMP		
Carmel Valley Creek	Draft Sediment TMDL and Bacteria TMDL	N/A	Same as above	NA	NA	NA	NA	NA
Los Peñasquitos Lagoon	Draft Sediment TMDL and Bacteria TMDL	Los Peñasquitos Lagoon	Same as above	LPC-TWAS-1, LPC-MLS	Turbidity, TSS, Bifenthrin, Fecal Coliform, TDS	TSS, Turbidity, Bifenthrin, pH, Very Poor IBI ***Based on one sample in analysis***, Fecal Coliform, TDS	Impairment of BIOL and EST due to sedimentation in Los Peñasquitos Lagoon during wet weather.	303(d), Draft Sediment TMDL, RW monitoring data (historic & current; Turbidity and TSS)
							Elevated bacteria near NPDES monitoring locations in Los Peñasquitos Lagoon during wet weather.	RW monitoring data (historic & current)
							Elevated bifenthrin near NPDES monitoring locations in Los Peñasquitos Lagoon during wet weather.	RW monitoring data (historic & current)
							Elevated TDS near NPDES monitoring locations in Los Peñasquitos Lagoon during wet weather.	RW monitoring data (historic & current)
	Bacteria TMDL	Pacific Ocean Shoreline, at Torrey Pines State Beach at Del Mar					Impairment of REC-1 due to indicator bacteria of the Pacific Ocean Shoreline at Torrey Pines State Beach at Del Mar during wet weather.	Bacteria TMDL
		Pacific Ocean Shoreline, at Los Peñasquitos River Mouth					Impairment of REC-1 due to total coliform of the Pacific Ocean Shoreline at Los Peñasquitos River Mouth during wet weather.	303(d)

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	Urban Runoff Monitoring Assessment		
			MS4 Outfall and Dry Weather Monitoring Program		TMDL(s)
			2005-2010 LTEA	FY 11 & 12 WURMP	WQBELs
Carmel Valley Creek	Draft Sediment TMDL and Bacteria TMDL	N/A	NA	NA	Sediment Load, Lagoon Restoration (Order No. R9-2012-0033), *Enterococcus* , Fecal Coliform (Order No. R9-2013-0001; Attachment E.6)
Los Peñasquitos Lagoon	Draft Sediment TMDL and Bacteria TMDL	Los Peñasquitos Lagoon	Fecal Coliform, TDS	Fecal Coliform	Sediment Load, Lagoon Restoration (Order No. R9-2012-0033), *Enterococcus* , Fecal Coliform (Order No. R9-2013-0001; Attachment E.6)
	Bacteria TMDL	Pacific Ocean Shoreline, at Torrey Pines State Beach at Del Mar	No coastal outfall data	No coastal outfall data	*Enterococcus* , Fecal Coliform, Total Coliform (Order No. R9-2013-0001; Attachment E.6)
		Pacific Ocean Shoreline, at Los Peñasquitos River Mouth	No coastal outfall data	No coastal outfall data	NA

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APPENDIX E.2

Dry Weather Receiving Water Condition Assessment

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WQIP Subwatershed	TMDL	303(d) Listed Waterbody	303(d) Listings		
			Pollutant(s)	Impaired Beneficial Use(s)	Potential Source(s)
Carroll Canyon Creek	Draft Sediment TMDL and Bacteria TMDL	Soledad Canyon	Selenium	Warm Freshwater Habitat	Source Unknown, Unknown Non-point Source, Urban Runoff/Storm Sewers
			Sediment Toxicity	Warm Freshwater Habitat	Unknown Point Source, Unknown Non-point Source
		Miramar Reservoir	Total Nitrogen as N	Warm Freshwater Habitat	Source Unknown

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	Receiving Water Assessment					Receiving Water Conditions	
			NPDES Receiving Water			SMC Program		Receiving Water Conditions	Line(s) of Evidence
			Applicable Receiving Water Station(s)	2005-2010 LTEA	FY 11 & 12 WURMP	2005-2010 LTEA	FY 11 & 12 WURMP		
Carroll Canyon Creek	Draft Sediment TMDL and Bacteria TMDL	Soledad Canyon	LPC-TWAS-1	Toxicity (*C. dubia* reproduction, *S. capricornutum* acute), Poor IBI, O/E, *Enterococcus* , TDS	Toxicity (*S. capricornutum* acute), Very Poor IBI ***Based on one sample in analysis***, TDS, *Enterococcus* (Coastkeeper)	NA	NA	Impairment of WARM from selenium in Soledad Canyon during dry weather.	303(d)
								Impairment of WARM due to sediment toxicity in Soledad Canyon during dry weather.	303(d)
								Elevated *Enterococcus* near NPDES monitoring locations during dry weather.	RW monitoring data (historic & current)
								Elevated TDS near NPDES monitoring locations during dry weather.	RW monitoring data (historic & current)
								Poor -Very Poor IBI scores near NPDES monitoring locations during dry weather.	RW monitoring data (historic & current)
		Miramar Reservoir	NA	NA	NA	NA	NA	Impairment of WARM due to eutrophic conditions (total nitrogen) in Miramar Reservoir during dry weather.	303(d)

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	Urban Runoff Monitoring Assessment		
			MS4 Outfall and Dry Weather Monitoring Program		TMDL
			FY 11 & 12 WURMP	2005-2010 LTEA	WQBELs
Carroll Canyon Creek	Draft Sediment TMDL and Bacteria TMDL	Soledad Canyon	*Enterococcus* , Fecal Coliform, Total N, Total P, TDS	Dissolved Copper, *Enterococcus* , TDS, Total N, Total P	Lagoon Restoration (Order No. R9-2012-0033), *Enterococcus* , Fecal Coliform (Order No. R9-2013-0001; Attachment E.6)
		Miramar Reservoir			

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	303(d) Listings		
			Pollutant(s)	Impaired Beneficial Use(s)	Potential Source(s)
Los Peñasquitos Creek	Draft Sediment TMDL and Bacteria TMDL	Los Peñasquitos Creek	*Enterococcus*	Warm Freshwater Habitat	Source Unknown
			Fecal Coliform	Warm Freshwater Habitat	Source Unknown
			Selenium	Warm Freshwater Habitat	Source Unknown
			Total Nitrogen as N	Warm Freshwater Habitat	Source Unknown
			TDS	Agricultural Supply	Source Unknown
			Toxicity	Warm Freshwater Habitat	Unknown Non-point Source, Unknown Point Source, Urban Runoff/Storm Sewers
		Poway Creek	Selenium	Warm Freshwater Habitat	Unknown Non-point Source, Unknown Point Source, Urban Runoff/Storm Sewers
			Toxicity	Warm Freshwater Habitat	Unknown Non-point Source, Unknown Point Source, Urban Runoff/Storm Sewers

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	Receiving Water Assessment					Receiving Water Conditions	
			NPDES Receiving Water			SMC Program		Receiving Water Conditions	Line(s) of Evidence
			Applicable Receiving Water Station(s)	2005-2010 LTEA	FY 11 & 12 WURMP	2005-2010 LTEA	FY 11 & 12 WURMP		
Los Peñasquitos Creek	Draft Sediment TMDL and Bacteria TMDL	Los Peñasquitos Creek	LPC-MLS, LPC-TWAS-2	Toxicity (*C. dubia* reproduction), Poor IBI, O/E, *Enterococcus* , Benthic Algae, Total N, Total P, TDS	Toxicity (*S. capricornutum* acute), Very Poor IBI ***Based on one sample in analysis*** *Enterococcus* , Total P, Dissolved P, TDS	Chloride, Sulfates, Very Poor IBI, O/E, Total P, TDS	DO, Chloride, Sulfates, Poor IBI, Total N, Total P, TDS	Impairment of WARM due to *Enterococcus* in Los Peñasquitos Creek during dry weather.	303(d)
								Impairment of WARM due to fecal coliform in Los Peñasquitos Creek during dry weather.	303(d) and RW monitoring data
								Impairment of WARM due to selenium in Los Peñasquitos Creek during dry weather.	303(d)
								Impairment of WARM due to eutrophication (total nitrogen) in Los Peñasquitos Creek during dry weather.	303(d) and RW monitoring data
								Impairment of AGR due to TDS in Los Peñasquitos Creek during dry weather.	303(d) and RW monitoring data
								Impairment of WARM due to toxicity in Los Peñasquitos Creek during dry weather.	303(d) and RW monitoring data
								Poor -Very Poor IBI scores near NPDES monitoring locations in Los Peñasquitos Creek during dry weather.	RW monitoring data (historic & current)
								Elevated chloride near the SMC monitoring location in Los Peñasquitos Creek during dry weather.	SMC RW monitoring data
								Elevated sulfates near the SMC monitoring location in Los Peñasquitos Creek during dry weather.	SMC RW monitoring data
		Poway Creek						Impairment of WARM due to selenium in Poway Creek during dry weather.	303(d)
								Impairment of WARM due to toxicity in Poway Creek during dry weather.	303(d) and RW monitoring data

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	Urban Runoff Monitoring Assessment		
			MS4 Outfall and Dry Weather Monitoring Program		TMDL
			FY 11 & 12 WURMP	2005-2010 LTEA	WQBELs
Los Peñasquitos Creek	Draft Sediment TMDL and Bacteria TMDL	Los Peñasquitos Creek	*Enterococcus* , Fecal Coliform, Total N, Total P, TDS	*Enterococcus* , Fecal Coliform, Total N, Total P, TDS	Lagoon Restoration (Order No. R9-2012-0033), *Enterococcus* , Fecal Coliform (Order No. R9-2013-0001; Attachment E.6)
		Poway Creek			

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	303(d) Listings		
			Pollutant(s)	Impaired Beneficial Use(s)	Potential Source(s)
Carmel Valley Creek	Draft Sediment TMDL and Bacteria TMDL	N/A	NA	NA	NA
Los Peñasquitos Lagoon	Draft Sediment TMDL and Bacteria TMDL	Los Peñasquitos Lagoon	Sedimentation/ Siltation	Estuarine Habitat	Non-point Source, Point Source
			Freshwater Input		
	Bacteria TMDL	Pacific Ocean Shoreline, at Torrey Pines State Beach at Del Mar	Indicator Bacteria	Contact Water Recreation	Unknown Non-point Source, Unknown Point Source, Urban Runoff/Storm Sewers
		Pacific Ocean Shoreline, at Los Peñasquitos River Mouth	Total Coliform	Shellfish Harvesting	Unknown Non-point Source, Unknown Point Source, Urban Runoff/Storm Sewers

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	Receiving Water Assessment					Receiving Water Conditions	
			NPDES Receiving Water			SMC Program		Receiving Water Conditions	Line(s) of Evidence
			Applicable Receiving Water Station(s)	2005-2010 LTEA	FY 11 & 12 WURMP	2005-2010 LTEA	FY 11 & 12 WURMP		
Carmel Valley Creek	Draft Sediment TMDL and Bacteria TMDL	N/A	NA	NA	NA	NA	NA	NA	NA
Los Peñasquitos Lagoon	Draft Sediment TMDL and Bacteria TMDL	Los Peñasquitos Lagoon	LPC-TWAS-1, LPC-MLS	Toxicity (*C. dubia* reproduction, *S. capricornutum* acute), Poor IBI, O/E, *Enterococcus* , Benthic Algae, Total N, TDS	Toxicity (*S. capricornutum* acute, Very Poor IBI ***Based on one sample in analysis***, *Enterococcus* , Total P, Dissolved P, TDS,	NA	NA	Impairment of EST and BIOL due to freshwater intrusion in Los Peñasquitos Lagoon during dry weather.	303(d) and Draft Sediment TMDL
								Elevated bacteria near NPDES monitoring locations in Los Peñasquitos Lagoon during dry weather.	RW monitoring data (current)
								Poor -Very Poor IBI scores near NPDES monitoring locations in Los Peñasquitos Lagoon during dry weather.	RW monitoring data (historic & current)
								Impairment of WARM from eutrophic conditions (total phosphorus, dissolved phosphorus, benthic algae, and total nitrogen) in Los Peñasquitos Lagoon during dry weather.	RW monitoring data
	Bacteria TMDL	Pacific Ocean Shoreline, at Torrey Pines State Beach at Del Mar						Impairment of REC-1 due to indicator bacteria of the Pacific Ocean Shoreline at Torrey Pines State Beach at Del Mar during dry weather.	Bacteria TMDL
		Pacific Ocean Shoreline, at Los Peñasquitos River Mouth						Impairment of REC-1 due to total coliform of the Pacific Ocean Shoreline at Los Peñasquitos River Mouth during dry weather.	303(d)

WQIP Subwatershed	TMDL	303(d) Listed Waterbody	Urban Runoff Monitoring Assessment		
			MS4 Outfall and Dry Weather Monitoring Program		TMDL
			FY 11 & 12 WURMP	2005-2010 LTEA	WQBELs
Carmel Valley Creek	Draft Sediment TMDL and Bacteria TMDL	N/A	NA	NA	Lagoon Restoration (Order No. R9-2012-0033), *Enterococcus* , Fecal Coliform (Order No. R9-2013-0001; Attachment E.6)
Los Peñasquitos Lagoon	Draft Sediment TMDL and Bacteria TMDL	Los Peñasquitos Lagoon	*Enterococcus* , Fecal Coliform, Total N, Total P, TDS	Dissolved Copper, *Enterococcus* , Fecal Coliform, Total N, Total P, TDS	Lagoon Restoration (Order No. R9-2012-0033), *Enterococcus* , Fecal Coliform (Order No. R9-2013-0001; Attachment E.6)
	Bacteria TMDL	Pacific Ocean Shoreline, at Torrey Pines State Beach at Del Mar	No coastal outfall data	No coastal outfall data	*Enterococcus* , Fecal Coliform, Total Coliform (Order No. R9-2013-0001; Attachment E.6)
		Pacific Ocean Shoreline, at Los Peñasquitos River Mouth	No coastal outfall data	No coastal outfall data	NA

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APPENDIX F

Receiving Water Conditions, Potential Impacts of MS4 Discharges, and Priority Water Quality Conditions in the Los Peñasquitos WMA

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This appendix contains details of the analysis of receiving water conditions (Section 2.1), impacts from MS4 discharges (Section 2.2), and the factors that were evaluated to develop the final list of priority water quality conditions and high priority water quality conditions. The information is presented in three tables, which are described below.

Table F-1: Receiving Water Conditions and Potential Impacts of MS4 Discharges in the Los Peñasquitos WMA

Table F-1 presents all identified receiving water conditions in the Los Peñasquitos WMA and the potential impacts of the MS4 discharges. These conditions were identified as described in Sections 2.1 and 2.2 based on the considerations detailed in the table. These include:

- Available receiving water data (current or historic) or regulatory drivers that support the condition. A check mark in the table indicates that samples have exceeded water quality objectives or the 2010 303(d) list or a TMDL identifies the waterbody as impaired. Where possible, the data were divided by temporal extent (wet- or dry-weather).
- Available current or historic MS4 monitoring data indicating that the MS4 potentially causes or contributes to the condition. A check mark indicates that samples collected from the MS4 during wet- or dry-weather have exceeded water quality objectives. MS4 data from the subwatershed was typically used for this consideration; data for MS4 discharges directly to the receiving water body in question are rarely available.
- Identification of the MS4 as a source of the condition in the 2010 303(d) list or a TMDL.
- The factors that led to the determination that the condition exists and was therefore included in the table.

Table F-2: Priority Water Quality Conditions in the Los Peñasquitos WMA Subwatersheds

Table F-2 presents the following information for each priority water quality condition per the MS4 Permit (Provision B.2.b):

- The beneficial use impairment(s) associated with the priority water quality condition;
- The pollutant or stressor causing the beneficial use impairment, if known;
- The temporal extent of the priority water quality condition (dry and/or wet weather);
- The geographical extent of the priority water quality condition within the WMA, if known (based on the extent of the associated 303(d) listing or the location of the associated NPDES monitoring location);

- Lines of evidence leading to identification as a priority water quality condition, including evidence of MS4 discharges that may cause or contribute to the condition; and
- An assessment of the adequacy of the monitoring data to characterize the factors causing or contributing to the priority water quality condition, including consideration of spatial and temporal variation.

The table also lists the Responsible Agencies that potentially contribute to the condition. The contents of this table were determined by the assessment of the receiving water conditions and the MS4 impacts (presented in Table F-1).

Table F-3: Evaluation of Priority Water Quality Conditions in the Los Peñasquitos WMA

As described in Section 2.3, priority water quality conditions that were identified based on the methodology presented in Appendix A. The remaining priority water quality conditions were evaluated based on several factors to determine if they warranted elevation to high priority water quality conditions for this iteration of the Water Quality Improvement Plan. Table F-3 summarizes this evaluation. The priority water quality condition must meet all of the following criteria to be considered a high priority water quality condition:

- Supporting data are sufficient to characterize the receiving water condition. To be sufficient, multiple samples collected under quality controlled monitoring must have exceeded water quality objectives.
- Storm water or non-stormwater runoff is a predominant source. Samples or observations collected under quality controlled monitoring programs must indicate that MS4 discharges are a predominant source of the receiving water condition.
- Controllable by Responsible Agencies. The pollutant or stressor must be within the authority of the Responsible Agency to control. To be considered controllable, there must be a clear link between the MS4 contribution and the receiving water condition, and the potential strategies to address the condition must be applicable to the geographic extent of the condition.
- Cannot be addressed by strategies identified for other high priority water quality condition s. The condition was not elevated to a high priority water quality condition if strategies identified for other high priority water quality conditions are expected to address the condition

Table F-1
Receiving Water Conditions and Potential Impacts of MS4 Discharges in the Los Peñasquitos WMA

Subwatershed	Waterbody	Condition	Receiving Water Data or Regulatory Drivers Support Consideration as a Receiving Water Condition		Determining Factor(s) For Receiving Water Data	MS4 Monitoring Data Indicates Potential MS4 Impact		MS4 Listed As Source on 303(d) or TMDL	Elevated to Priority Water Quality Condition?
			Wet	Dry		Wet	Dry		
Carroll Canyon	Miramar Reservoir	Impairment of WARM due to eutrophic[1] conditions (total nitrogen as N)	–	✓	2010 303(d)	–	✓	–	Yes
	Soledad Canyon Creek	Impairment of WARM due to sediment toxicity	✓	✓	2010 303(d)	–	–	–	No; Toxicity cannot be identified as a priority water quality condition because the full impact of all environmental contributions including the MS4 have not been characterized.
		Impairment of WARM due to selenium	✓	✓	2010 303(d)	–	–	Wet, Dry	Yes
		Elevated *Enterococcus* near NPDES monitoring locations	–	✓	Current and historical receiving water monitoring data	–	✓	–	Yes
		Elevated fecal coliform near NPDES monitoring locations	✓	–	Current and historical receiving water monitoring data, public input	✓	–	–	Yes
		Elevated TDS near NPDES monitoring locations	–	✓	Current and historical receiving water monitoring data, public input	–	✓	–	Yes
		Elevated bifenthrin near NPDES monitoring locations	✓	–	Current and historical receiving water monitoring data	–	–	–	No; no MS4 data to justify designation as priority water quality condition.
		Elevated TSS and turbidity near NPDES monitoring locations	✓	–	Current and historical receiving water monitoring data	–	–	–	No; no MS4 data to justify designation as priority water quality condition.
		Poor to very poor IBI scores near NPDES monitoring locations	–	✓	Current and historical receiving water monitoring data	–	–	–	No; Poor to very poor IBI scores cannot be identified as a priority water quality condition because the full impact of all environmental contributions including the MS4 have not been characterized.
Los Peñasquitos Creek	Poway Creek	Impairment of WARM due to selenium and toxicity	✓	✓	2010 303(d) and receiving water monitoring data (toxicity only)	–	–	Wet, Dry	Yes
	Los Peñasquitos Creek	Impairment of WARM due to *Enterococcus*	✓	✓	2010 303(d) and current and historical outfall and receiving water monitoring data, public input	–	✓	–	Yes
		Impairment of WARM due to fecal coliform	✓	✓	2010 303(d) and current and historical outfall and receiving water monitoring data, public input	✓	–	–	Yes
		Impairment of WARM due to selenium	✓	✓	2010 303(d)	–	–	–	No; no MS4 data to justify designation as priority water quality condition.
		Impairment of WARM due to toxicity	✓	✓	2010 303(d) and receiving water monitoring data	–	–	Wet, Dry	Yes
		Impairment of WARM due to eutrophication[1] (total nitrogen)	–	✓	2010 303(d) and receiving water monitoring data, public input	–	✓	–	Yes
		Elevated total phosphorus and dissolved phosphorus near NPDES monitoring locations	–	✓	Current and historical receiving water monitoring data, public input	–	✓	–	Yes

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Subwatershed	Waterbody	Condition	Receiving Water Data or Regulatory Drivers Support Consideration as a Receiving Water Condition		Determining Factor(s) For Receiving Water Data	MS4 Monitoring Data Indicates Potential MS4 Impact		MS4 Listed As Source on 303(d) or TMDL	Elevated to Priority Water Quality Condition?
			Wet	Dry		Wet	Dry		
		Benthic algae growth near NPDES monitoring locations	–	✓	Historical receiving water monitoring data	–	–	–	No; no MS4 data to justify designation as priority water quality condition.
		Impairment of AGR due to TDS	✓	✓	2010 303(d) and receiving water monitoring data	✓	✓	–	Yes
Los Peñasquitos Creek	Los Peñasquitos Creek	Elevated bifenthrin near NPDES monitoring locations	✓	–	Current and historical receiving water monitoring data	–	–	–	No; no MS4 data to justify designation as priority water quality condition.
		Elevated TSS and turbidity near NPDES monitoring locations	✓	–	Current and historical receiving water monitoring data	–	–	–	No; no MS4 data to justify designation as priority water quality condition.
		Poor to very poor IBI scores near NPDES monitoring locations	–	✓	Current and historical receiving water monitoring data	–	–	–	No; Poor to very poor IBI scores cannot be identified as a priority water quality condition because the full impact of all environmental contributions including the MS4 have not been characterized.
		Elevated chloride near the Southern California Stormwater Monitoring Coalition (SMC) monitoring location in Los Peñasquitos Creek	–	✓	SMC receiving water data	–	–	–	No; no MS4 data to justify designation as priority water quality condition.
		Elevated sulfate near the SMC monitoring location in Los Peñasquitos Creek	–	✓	SMC receiving water data	–	–	–	No; no MS4 data to justify designation as priority water quality condition.
Carmel Valley Creek	Carmel Valley Creek	No receiving water conditions were found	–	–	N/A	–	–	–	No; no receiving water conditions found
Los Peñasquitos Lagoon	Los Peñasquitos Lagoon	Impairment of EST and BIOL due to hydromodification, siltation, and sedimentation	✓	–	2010 303(d), Draft Sediment TMDL, and current and historical receiving water monitoring data, public input	✓	–	Wet	Yes
		Impairment of EST and BIOL due to freshwater discharges	–	✓	2010 303(d) and Draft Sediment TMDL, public input	–	✓	Dry	Yes
		Elevated *Enterococcus* near NPDES monitoring locations	–	✓	Current and historical receiving water monitoring data, public input	–	✓	–	Yes
		Elevated fecal coliform near NPDES monitoring locations	✓	–	Current and historical receiving water monitoring data, public input	✓	–	–	Yes
		Elevated bifenthrin near NPDES monitoring locations	✓	–	Current and historical receiving water monitoring data, public input	–	–	–	No; no MS4 data to justify designation as priority water quality condition.
		Elevated TDS near NPDES monitoring locations	✓	–	Current and historical receiving water monitoring data, public input	✓	–	–	Yes
		Poor to very poor IBI scores near NPDES monitoring locations	–	✓	Current and historical receiving water monitoring data, public input	–	–	–	No; Poor to very poor IBI scores cannot be identified as a priority water quality condition because the full impact of all environmental contributions including the MS4 have not been characterized.

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Subwatershed	Waterbody	Condition	Receiving Water Data or Regulatory Drivers Support Consideration as a Receiving Water Condition		Determining Factor(s) For Receiving Water Data	MS4 Monitoring Data Indicates Potential MS4 Impact		MS4 Listed As Source on 303(d) or TMDL	Elevated to Priority Water Quality Condition?
			Wet	Dry		Wet	Dry		
Los Peñasquitos Lagoon	Los Peñasquitos Lagoon	Elevated total phosphorus, dissolved phosphorus, benthic algae, and total nitrogen near NPDES monitoring locations	–	✓	Receiving water monitoring data, public input	–	✓	–	Yes
	Pacific Ocean Shoreline at Torrey Pines State Beach at Del Mar	Impairment of REC-1 due to indicator bacteria (total coliform, fecal coliform, *Enterococcus*)	✓	✓	Bacteria TMDL	–	–	Wet, Dry	Yes
	Pacific Ocean Shoreline at Los Peñasquitos River Mouth	Impairment of SHELL due to total coliform	✓	✓	2010 303(d)	–	–	Wet, Dry	Yes

1. Only listed as a dry weather condition based on best professional judgment that wet weather impacts are not quantifiable.
✓= Criterion applies to temporal extent. – = Criterion does not apply to temporal extent. N/A = Not Applicable

Table F-2
Priority Water Quality Conditions in the Los Peñasquitos WMA Subwatersheds

Priority Water Quality Condition (1)	Potential Stressor(s) (2)	Temporal Extent (3)	Geographical Extent (4)	Determining Factors (5)	Data Gaps (6)		Potentially Responsible Agencies				
					RW[1]	MS4[2]	CT	DM	P	SD	CO
Carroll Canyon Subwatershed											
Impairment of WARM in Miramar Reservoir	Eutrophic conditions (total nitrogen)	Dry	Miramar Reservoir 2010 303(d) listed segment	Current and historical subwatershed level outfall monitoring data	Y	Y	—	—	—	✓	—
Potential impairment of REC-1 in Soledad Canyon Creek	*Enterococcus*	Dry	Soledad Canyon Creek near NPDES monitoring location	Current and historical receiving water; current and historical subwatershed level outfall monitoring data	N	Y	—	—	—	✓	—
Potential impairment of REC-1 in Soledad Canyon Creek	Fecal coliform	Wet	Soledad Canyon Creek near NPDES monitoring location	Current and historical receiving water; current and historical subwatershed level outfall monitoring data	N	Y	—	—	—	✓	—
Impairment of WARM in Soledad Canyon Creek	Selenium	Wet, Dry	Soledad Canyon Creek 2010 303(d) listed segment	Urban runoff and storm sewers 2010 303(d) listed as source	Y	Y	—	—	—	✓	—
Potential Impairment of WARM in Soledad Canyon Creek	TDS	Dry	Soledad Canyon Creek near NPDES monitoring location	Current and historical receiving water; current and historical subwatershed level outfall monitoring data	N	Y	—	—	—	✓	—

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Priority Water Quality Condition (1)	Potential Stressor(s) (2)	Temporal Extent (3)	Geographical Extent (4)	Determining Factors (5)	Data Gaps (6)		Potentially Responsible Agencies				
					RW[1]	MS4[2]	CT	DM	P	SD	CO
Carroll Canyon Creek Subwatershed											
Potential Impairment of EST and BIOL in Los Peñasquitos Lagoon	Freshwater discharges	Dry	Soledad Canyon Creek near point of discharge to the Lagoon	Draft Sediment TMDL	N	N	—	—	—	✓	—
	Hydromodifi-cation, siltation, and sedimentation	Wet	Soledad Canyon Creek near point of discharge to the Lagoon	Current and historical receiving water monitoring data for TSS and turbidity; Draft Sediment TMDL	N	N	—	—	—	✓	—
Potential impairment of REC-1 in Pacific Ocean Shoreline at Torrey Pines State Beach at Del Mar	*Enterococcus*, fecal coliform, total coliform	Wet, Dry	Soledad Canyon Creek MS4 discharges	WQBELs assigned per Bacteria TMDL	N	N	—	—	—	✓	—
Los Peñasquitos Creek Subwatershed											
Impairment of WARM in Poway Creek	Selenium	Wet, Dry	Poway Creek 2010 303(d) listed segment	Urban runoff, storm sewers 2010 303(d) listed as source	Y	Y	—	—	✓	—	✓
	Toxicity		Poway Creek 2010 303(d) listed segment	Urban runoff, storm sewers 2010 303(d) listed as source; receiving water monitoring data	N	Y	—	—	✓	—	✓

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Priority Water Quality Condition (1)	Potential Stressor(s) (2)	Temporal Extent (3)	Geographical Extent (4)	Determining Factors (5)	Data Gaps (6)		Potentially Responsible Agencies				
					RW[1]	MS4[2]	CT	DM	P	SD	CO
Los Peñasquitos Creek Subwatershed											
Potential impairment of WARM in Los Peñasquitos Creek	Eutrophic conditions (total phosphorus and dissolved phosphorus)	Dry	Los Peñasquitos Creek near NPDES monitoring location	Current and historical receiving water; current and historical subwatershed level outfall monitoring data	N	Y[3]	—	—	—	✓	—
Impairment of WARM in Los Peñasquitos Creek	Eutrophic conditions (total nitrogen)	Dry	Los Peñasquitos Creek 2010 303(d) listed segment	Current and historical receiving water; current and historical subwatershed level outfall monitoring data	N	Y[3]	—	—	—	✓	—
	Enterococcus	Wet, Dry	Los Peñasquitos Creek 2010 303(d) listed segment	Current and historical receiving water; current and historical subwatershed level outfall monitoring data	N	Y	✓	—	—	✓	—
	Fecal coliform	Wet, Dry									
	Toxicity	Wet, Dry	Los Peñasquitos Creek 2010 303(d) listed segment	Storm sewers 2010 303(d) listed as source; current and historical receiving water	Y	Y[3]	✓	—	—	✓	—
Impairment of AGR in Los Peñasquitos Creek	TDS	Wet, Dry	Los Peñasquitos Creek 2010 303(d) listed segment	2010 303(d) listed; current and historical receiving water; current and historical subwatershed level outfall monitoring data	N	Y[3]	✓	—	—	✓	—
Potential Impairment of in Los Peñasquitos Creek[4]	*Enterococcus* and fecal coliform	Dry	Los Peñasquitos Creek 2010 303(d) listed segment	2010 303(d) listed; current and historical receiving water; current and historical subwatershed level outfall monitoring data	N	Y	—	—	—	✓	—

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Priority Water Quality Condition (1)	Potential Stressor(s) (2)	Temporal Extent (3)	Geographical Extent (4)	Determining Factors (5)	Data Gaps (6)		Potentially Responsible Agencies				
					RW[1]	MS4[2]	CT	DM	P	SD	CO
Los Peñasquitos Creek Subwatershed											
Potential Impairment of EST and BIOL in Los Peñasquitos Lagoon	Hydromodifi-cation, siltation, and sedimentation	Wet	Los Peñasquitos Creek near point of discharge to Lagoon	Current and historical receiving water monitoring data for TSS and turbidity; Draft Sediment TMDL	N	N	✓	—	✓	✓	✓
	Freshwater discharges	Dry	Los Peñasquitos Creek near point of discharge to Lagoon	Draft Sediment TMDL	N	Y	—	—	✓	✓	✓
Potential Impairment of REC-1 in Pacific Ocean Shoreline at Torrey Pines State Beach at Del Mar	*Enterococcus*, fecal coliform, total coliform	Wet, Dry	Los Peñasquitos Creek MS4 discharges	WQBELs assigned per Bacteria TMDL	N	Y	✓	—	✓	✓	✓
Carmel Valley Creek Subwatershed											
Potential Impairment of EST and BIOL in Los Peñasquitos Lagoon	Freshwater discharges	Dry	Carmel Valley Creek near point of discharge to the Lagoon	Draft Sediment TMDL	Y	Y	—	—	—	✓	—
	Hydromodifi-cation, siltation, and sedimentation	Wet			Y	Y	—	—	—	✓	—

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Priority Water Quality Condition (1)	Potential Stressor(s) (2)	Temporal Extent (3)	Geographical Extent (4)	Determining Factors (5)	Data Gaps (6)		Potentially Responsible Agencies				
					RW[1]	MS4[2]	CT	DM	P	SD	CO
Carmel Valley Creek Subwatershed											
Potential Impairment of REC-1 in Pacific Ocean Shoreline at Torrey Pines State Beach at Del Mar	*Enterococcus*, fecal coliform, and total coliform	Wet, Dry	Carmel Valley Creek MS4 discharges	WQBELs assigned per Bacteria TMDL	Y	Y	—	—	—	✓	—
Los Peñasquitos Lagoon Subwatershed											
Potential impairment of WARM or BIOL at NPDES monitoring locations upstream of Los Peñasquitos Lagoon	TDS	Wet	NPDES monitoring locations upstream of Lagoon	Current and historical receiving water monitoring data located upstream of the Lagoon; historical subwatershed level outfall monitoring data	Y	Y	✓	✓	✓	✓	✓
Impairment of EST and BIOL in Los Peñasquitos Lagoon	Hydromodifi-cation, sedimentation and siltation	Wet	Los Peñasquitos Lagoon	Current and historical receiving water monitoring data for TSS and turbidity; Draft Sediment TMDL	N	N	✓	✓	✓	✓	✓
	Freshwater discharges	Dry	Los Peñasquitos Lagoon	2010 303(d) listed; Draft Sediment TMDL	N	N	—	✓	✓	✓	✓

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Priority Water Quality Condition (1)	Potential Stressor(s) (2)	Temporal Extent (3)	Geographical Extent (4)	Determining Factors (5)	Data Gaps (6)		Potentially Responsible Agencies				
					RW[1]	MS4[2]	CT	DM	P	SD	CO
Los Peñasquitos Lagoon Subwatershed											
Potential impairment of WARM or BIOL in Los Peñasquitos Lagoon	Total phosphorus	Dry	NPDES monitoring locations upstream of Lagoon	Receiving water monitoring data; public input	Y	Y	✓	✓	✓	✓	✓
	Dissolved phosphorus										
	Benthic algae										
	Total nitrogen										
Potential Impairment of REC-1 in Los Peñasquitos Lagoon	*Enterococcus*	Dry	NPDES monitoring locations upstream of Lagoon	Current and historical receiving water monitoring data located upstream of the Lagoon; historical subwatershed level outfall monitoring data	Y	Y	✓	✓	✓	✓	✓
	Fecal coliform	Wet			Y	Y	✓	✓	✓	✓	✓
Potential Impairment of REC-1 in Pacific Ocean Shoreline at Torrey Pines State Beach at Del Mar	*Enterococcus* Fecal coliform, and total coliform	Wet, Dry	Los Peñasquitos Lagoon MS4 discharges	WQBELs assigned per Bacteria TMDL	N	N	✓	✓	✓	✓	✓

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Priority Water Quality Condition (1)	Potential Stressor(s) (2)	Temporal Extent (3)	Geographical Extent (4)	Determining Factors (5)	Data Gaps (6)		Potentially Responsible Agencies				
					RW[1]	MS4[2]	CT	DM	P	SD	CO
Los Peñasquitos Lagoon Subwatershed											
Impairment of REC-1 in Pacific Ocean Shoreline at Torrey Pines State Beach at Del Mar	*Enterococcus*, fecal coliform, and total coliform	Wet, Dry	Pacific Ocean Shoreline at Torrey Pines 2010 303(d) listed segment	Bacteria TMDL	N	N	✓	✓	✓	✓	✓
Impairment of SHELL in Pacific Ocean Shoreline at Los Peñasquitos River Mouth	Total coliform	Wet, Dry	Pacific Ocean Shoreline at Los Peñasquitos River Mouth	2010 303(d)	N	N	✓	✓	✓	✓	✓

1. Are there gaps in the RW data used to characterize the priority water quality condition? (Y = yes; N = no)
2. Are there gaps in the MS4 data used to characterize the geographical contribution of the MS4 to priority water quality condition? (Y = yes; N = no)
3. Data are available to indicate the MS4 may be contributing to the priority water quality condition, but the full impact is unknown because all environmental contributions have not been characterized.
4. Based on the Bacteria TMDL.

CO = County of San Diego; CT = California Department of Transportation (Caltrans); DM = City of Del Mar; P = City of Poway; RW= Receiving Water; SD = City of San Diego

Table F-3
Evaluation of Priority Water Quality Conditions in the Los Peñasquitos WMA

Sub-watershed	Priority Water Quality Condition	Potential Stressor(s)	(a) Supporting Data Are Sufficient to Characterize the Receiving Water Conditions	(b) Storm Water/ Non-Storm Water Runoff Predominant Source	(c) Controllable by Responsible Agencies[1]	(d) Cannot Be Addressed By Identified Strategies
Los Peñasquitos Creek	Impairment of WARM in Poway Creek	Selenium	—	—	—	✓
		Toxicity	✓	—	—	✓
	Potential impairment of WARM in Los Peñasquitos Creek	Eutrophic conditions (total phosphorus and dissolved phosphorus)	✓	—	—	—
	Impairment of WARM in Los Peñasquitos Creek	Eutrophic conditions (total nitrogen)	✓	—	—	—
		Enterococcus	✓	—	—	—
		Fecal coliform	✓	—	—	—
		Toxicity	✓	—	—	✓
	Impairment of AGR in Los Peñasquitos Creek	TDS	✓	—	—	✓
	Potential Impairment of REC-1 in Los Peñasquitos Creek	*Enterococcus* and fecal coliform	✓	—	—	—
Carroll Canyon	Impairment of WARM in Miramar Reservoir	Eutrophic conditions (total nitrogen)	✓	—	—	—
	Potential impairment of REC-1 in Soledad Canyon Creek	*Enterococcus*	✓	—	—	—

Continued on next page

Sub-watershed	Priority Water Quality Condition	Potential Stressor(s)	(a) Supporting Data Are Sufficient to Characterize the Receiving Water Conditions	(b) Storm Water/ Non-Storm Water Runoff Predominant Source	(c) Controllable by Responsible Agencies[1]	(d) Cannot Be Addressed By Identified Strategies
Carroll Canyon	Potential impairment of REC-1 in Soledad Canyon Creek	Fecal coliform	✓	—	—	—
	Impairment of WARM in Soledad Canyon Creek	Selenium	—	—	—	✓
	Potential Impairment of WARM in Soledad Canyon Creek	TDS	✓	—	—	✓
Carmel Valley Creek	All priority water quality conditions have been elevated to a highest priority water quality condition based on the review of the WMA regulatory drivers.					
Los Peñasquitos Lagoon	Potential impairment of WARM or BIOL at NPDES monitoring locations upstream of Los Peñasquitos Lagoon	TDS	—	—	—	✓
	Potential Impairment of REC-1 in Los Peñasquitos Lagoon	*Enterococcus*	—	—	—	—
	Potential Impairment of REC-1 in Los Peñasquitos Lagoon	Fecal coliform	—	—	—	—
	Impairment of SHELL in Pacific Ocean Shoreline at Los Peñasquitos River Mouth	Total coliform	—	—	—	—

"✓" – The criterion is met for the priority water quality condition.
"—" – The criterion is not met for the priority water quality condition.

1. The priority water quality condition is considered controllable if two criteria are met: (1) There is a clear link between the MS4 contribution and the receiving water conditions, and (2) The potential strategies that apply to the potential stressor are applicable for the drainage area of the receiving water condition.

APPENDIX G

Bacterial Conceptual Models and Literature Review

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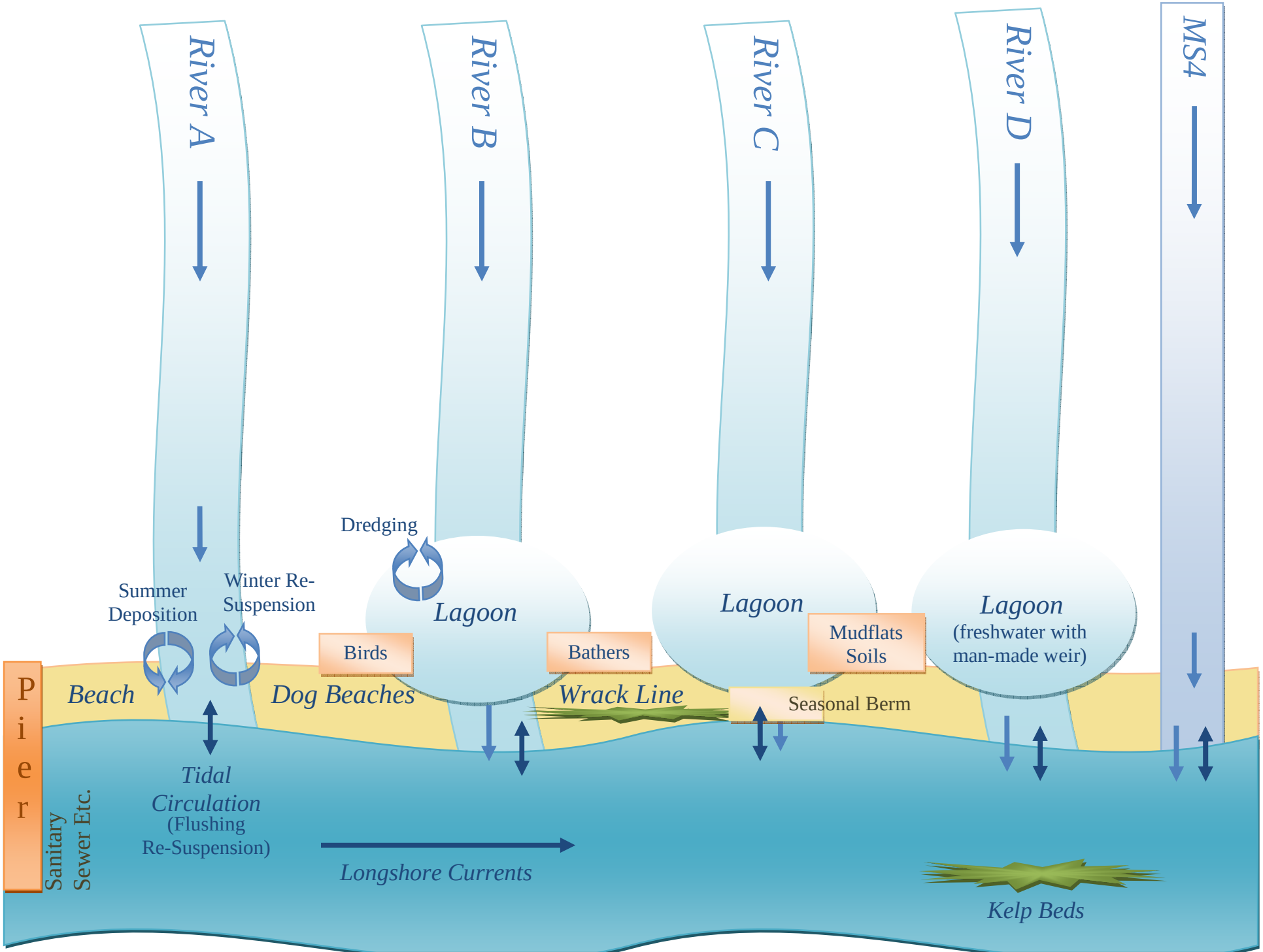
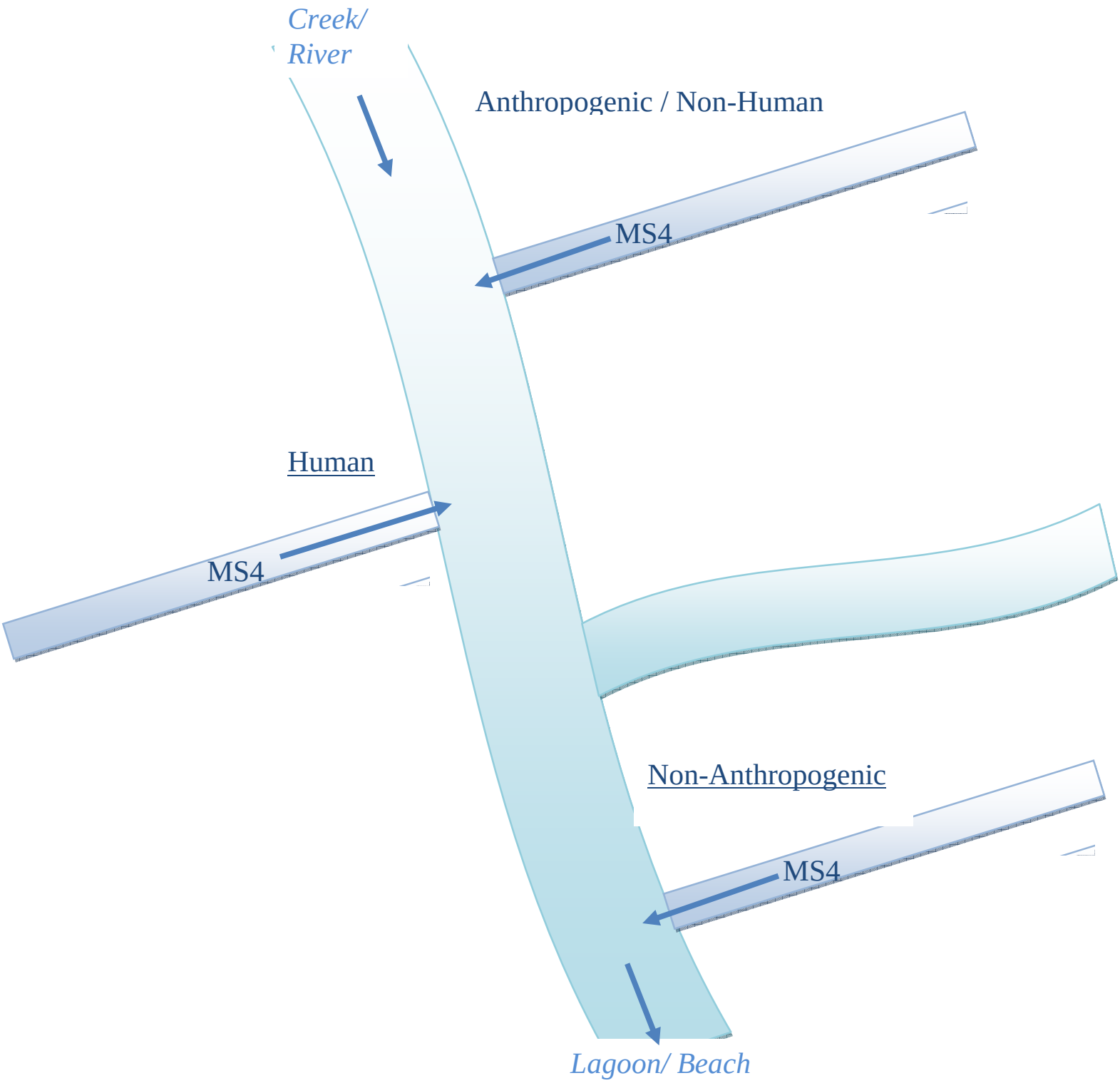
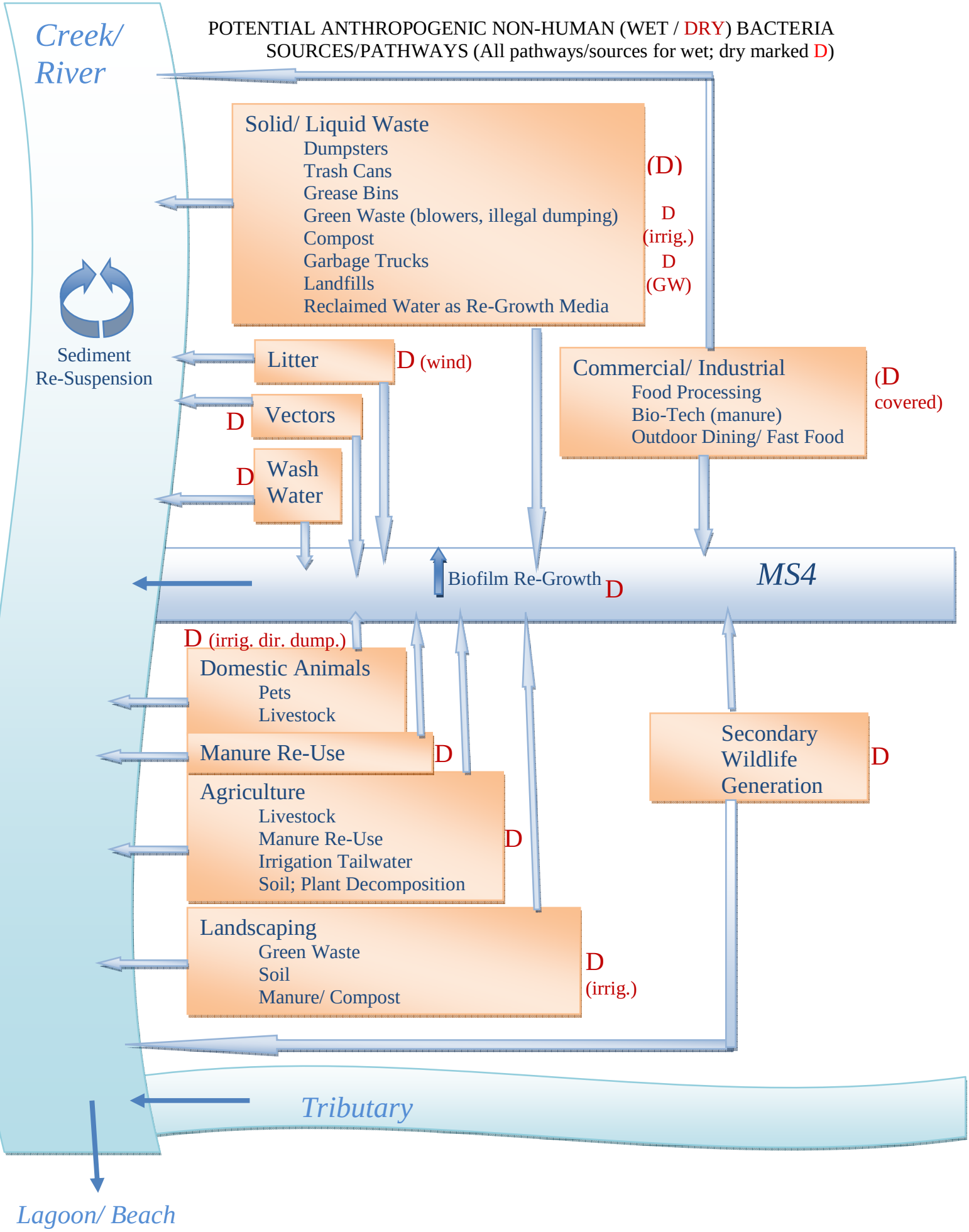

River A
River B
River C
River D
MS4
Dredging
Summer Deposition
Winter Re-Suspension
Lagoon
Lagoon
Lagoon
(freshwater with man-made weir)
Birds
Bathers
Mudflats
Soils
Seasonal Berm
Beach
Dog Beaches
Wrack Line
Pier
Sanitary Sewer Etc.
Tidal Circulation
(Flushing Re-Suspension)
Longshore Currents
Kelp Beds

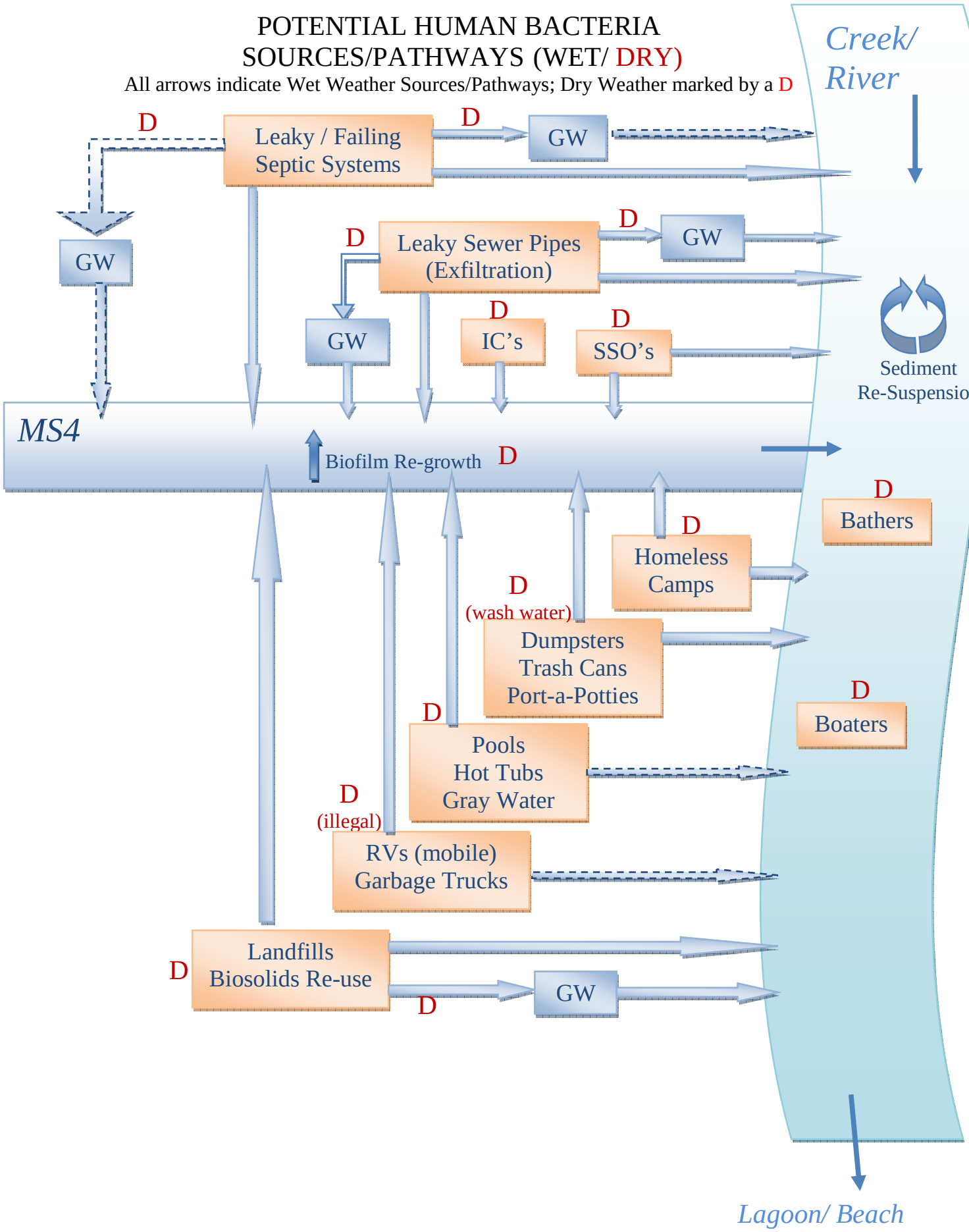
Conceptual Overview of Bacteria Sources



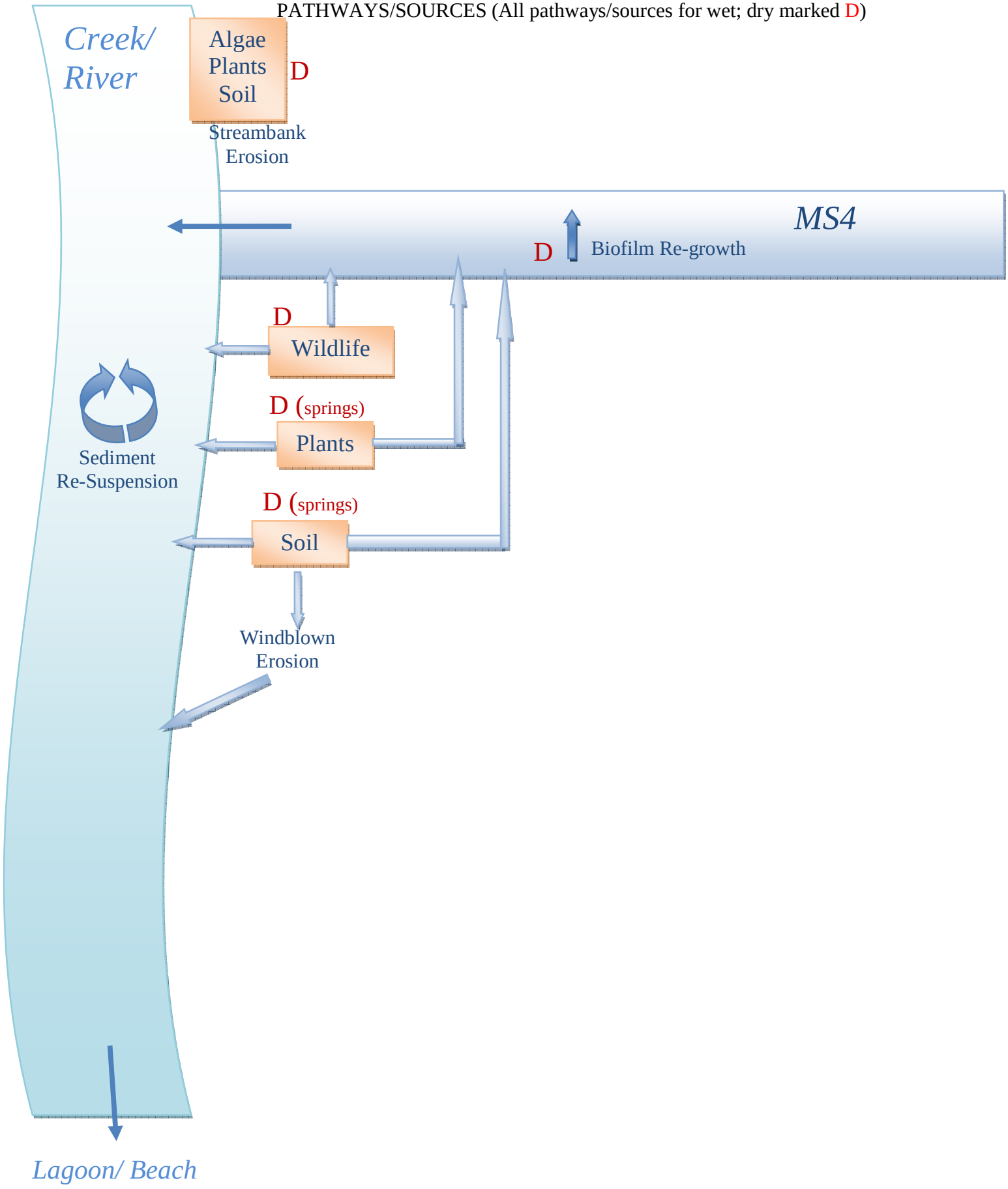

POTENTIAL ANTHROPOGENIC NON-HUMAN (WET / DRY) BACTERIA SOURCES/PATHWAYS (All pathways/sources for wet; dry marked D)
Creek/ River
Solid/ Liquid Waste
Dumpsters
Trash Cans
Grease Bins
Green Waste (blowers, illegal dumping)
Compost
Garbage Trucks
Landfills
Reclaimed Water as Re-Growth Media
(D)
D (irrig.)
D (GW)
Sediment Re-Suspension
Litter
D (wind)
D
Vectors
D
Wash Water
Commercial/ Industrial
Food Processing
Bio-Tech (manure)
Outdoor Dining/ Fast Food
(D covered)
Biofilm Re-Growth
D
MS4
D (irrig. dir. dump.)
Domestic Animals
Pets
Livestock
Manure Re-Use
D
Agriculture
Livestock
Manure Re-Use
Irrigation Tailwater
Soil; Plant Decomposition
D
Landscaping
Green Waste
Soil
Manure/ Compost
D (irrig.)
Secondary Wildlife Generation
D
Tributary
Lagoon/ Beach

POTENTIAL HUMAN BACTERIA SOURCES/PATHWAYS (WET/ DRY)

All arrows indicate Wet Weather Sources/Pathways; Dry Weather marked by a D



POTENTIAL NON-ANTHROPOGENIC WET/ DRY BACTERIA PATHWAYS/SOURCES (All pathways/sources for wet; dry marked D)



DRAFT TECHNICAL MEMORANDUM
Summary of Literature Review, Bacteria Source Identification
March 12, 2012
Prepared by: Armand Ruby Consulting in Association with AMEC

This Technical Memorandum summarizes work performed under Task 2, Literature Search and Data Review, for the County of San Diego Bacterial Indicators Source Identification Services Project. The work was overseen by a workgroup of San Diego County Stormwater Copermittee representatives, and included communication with scientists who have expertise in bacteria source tracking and identification. The literature review focused on identifying and summarizing studies that quantify sources and sinks for bacterial constituents in urban watersheds, and was international in scope.

The work products delivered for this task include this technical memorandum, a separate spreadsheet summary of each study/report reviewed, and a compilation of reviewed studies/reports on the AMEC ftp site:
ftp://ftp.mactec.com/Incoming/Copermittee%20Bact%20Lit%20Review/

The entries in this memorandum are ordered alphabetically by last name of primary author. Each entry begins with the study number (for cross-referencing back to the spreadsheet matrix), followed by the study title. Web links are provided when available.

A number of studies were found that contained information on indicator bacteria but did not include specific information related to source identification within urban watersheds. These studies are summarized as NSC (Not Source Characterization) studies, beginning on p. 53.

The "Bacteria Source ID Lit Review Matrix" Excel workbook contains the following worksheets:

- The "Source ID Studies Summary Table" worksheet contains summaries of all studies reviewed and found to have useful information on bacteria sources; for each of these studies, any identified sources are indicated as Probably, Potential, Low or Suspected (see "Legend" worksheet for definitions)
- The "# Citations by Source" worksheet contains a tally of the numbers of studies with identified information on each source type
- The "Sources Summary Table" worksheet contains condensed summaries of the studies that have information on each particular source type
- The "Data Summary Table" worksheet contains brief summaries of study data (this is a work in progress)
- The "NSC Studies" worksheet provides summaries of the NSC (Not Source Characterization) studies

56 - Human and bovine adenoviruses for the detection of source-specific fecal pollution in coastal waters in Australia
Warish Ahmed, A. Goonetilleke, and T. Gardner
http://eprints.qut.edu.au/37690/1/Human_and_bovine_adenoviruses_for_the_detection_of_source-specific_fecal_pollution_in_coastal_waters_in_Australia.pdf
Purpose - To enhance the scientific foundation for preemptive public health warnings, examine the relationship between rainfall and beach indicator bacteria concentrations using five years of fecal coliform data taken daily at 20 sites in southern California.

Results - There was a clear relationship between the incidence of rainfall and reduction in beach bacterial water quality in Los Angeles County. Bacterial concentrations remained elevated for five days following a storm, although they generally returned to levels below state water quality standards within three days. The length of the antecedent dry period had a minimal effect on this relationship, probably reflecting a quickly developing equilibrium between the decay of older fecal material and the introduction of new fecal material to the landscape.

Sources:
Probable –Septic (human waste), bovine (domestic animals), animal farms (agriculture),
Potential -
Possible -

31 - Evaluation of Multiple Sewage-Associated Bacteroides PCR Markers for Sewage Pollution Tracking
Warish Ahmed, A. Goonetilleke, D. Powell, and T. Gardner
http://eprints.qut.edu.au/29217/1/c29217.pdf
Purpose - The host specificity of the five published sewage-associated Bacteroides markers (i.e., HF183, BacHum, HuBac, BacH and Human-Bac) was evaluated in Southeast Queensland, Australia by testing fecal DNA samples (n = 186) from 11 animal species including human fecal samples collected via influent to a sewage treatment plant (STP).

Results - For the 5 sewage-associated markers tested in this study, the HF183 marker performed better than others. This marker showed 99% specificity to distinguish between the sources of human and animal fecal pollution. The performance of the five markers in terms of specificity was HF183 > BacHum > BacH > Human-Bac > HuBac.

78 - Detection and source identification of faecal pollution in non-sewered catchment by means of molecular markers host-specific
Warish Ahmed, D. Powell, A. Goonetilleke, and T. Gardner
http://s3.amazonaws.com/publicationslist.org/data/w.ahmed/ref-23/WST%20Article.pdf
Purpose - To validate the previously published host-specific PCR markers (i.e. HF183, HF134, CF128, BacCan and esp) for the detection of sources of faecal pollution by testing a large number of faecal samples from 13 host groups in Southeast Queensland, Australia.

Results - All 197 faecal samples (100%) from the 13 host groups were positive for general Bacteroides. Of the 42 (i.e. 30 sewage and 12 septic samples) sewage/septic samples tested, all were positive for the human-specific HF183 and HF134 Bacteroides markers. The HF183 marker could not be detected in any faecal samples from animal host groups suggesting that the suitability of this marker to detect human faecal pollution. In contrast, the HF134 marker was detected in 7 (35%) samples from dogs. The presence of this marker in dogs could be due to the transfer of faecal bacteria between human and their companion pets (Dick et al. 2005).

79 - Evaluation of Bacteroides markers for the detection of human faecal pollution
Warish Ahmed, J. Stewart, D. Powell, and T. Gardner
http://onlinelibrary.wiley.com/doi/10.1111/j.1472-765X.2007.02287.x/pdf
Purpose - Evaluating the specificity and sensitivity of human-specific HF183 and HF134 Bacteroides markers in various host groups and their utility to detect human faecal pollution in storm water samples collected from non-sewered catchments in Southeast Queensland, Australia.

Results - The specificity and sensitivity of the HF183 and HF134 Bacteroides markers was evaluated by testing 207 faecal samples from 13 host groups, including 52 samples from human sources (via sewage and septic tanks). Polymerase chain reaction analysis of these samples revealed the presence/absence of HF183 and HF134 across these host groups, demonstrating their suitability for distinguishing between human and animal faecal pollution. The HF183 marker was found to be more reliable than that of HF134, which was also found in dogs.

35 - Quantitative PCR assay of sewage-associated Bacteroides markers to assess sewage pollution in an urban lake in Dhaka, Bangladesh
Warish Ahmed, R. Yusuf, I. Hasan, A. Goonetilleke, and T. Gardner
http://eprints.qut.edu.au/37689/1/Quantitative_PCR_assay_of_sewage-associated_Bacteroides_markers_to_assess_sewage_pollution_in_an_urban_lake_in_Dhaka,_Bangladesh.pdf
Purpose - To assess the magnitude of sewage pollution in an urban lake in Dhaka, Bangladesh 34 by using Quantitative PCR (qPCR) of sewage-associated Bacteroides HF183 markers.

Results – From the 20 water samples tested, 14 (70%) and 7 (35%) were PCR positive for the HF183 and CF128 markers, respectively. The high numbers of enterococci and the HF183 markers indicate sewage pollution.

Sources:
Probable - Slum-like establishments (human waste), MS4 Infrastructure (human waste),
Potential -
Possible – Dogs and cows

139 - Coastal water quality impact of storm water runoff from an urban watershed in Southern California
Jong Ho Ahn, S.B. Grant, C.Q. Surbeck, P.M. DiGiacomo, N.P. Nezlin, and S. Jiang
ftp://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/528_B03_WQ_Appendix_I.pdf
Purpose - Assess the coastal water quality impact of storm water runoff from the Santa Ana River, which drains a large urban watershed located in southern California. This is the first wet weather study to examine the linkage between water quality in the surf zone -- where routine monitoring samples are collected and most human exposure occurs -- and water quality offshore of the surf zone.

Results - Storm water runoff from the Santa Ana River negatively impacts coastal water quality, both in the surf zone and offshore. However, the extent of this impact, and its human health significance, is influenced by numerous factors, including prevailing ocean currents, within-plume processing of particles and pathogens, and the timing, magnitude and nature of runoff discharged from river outlets over the course of a storm.

Sources:
Probable - Slum-like establishments (human waste), MS4 Infrastructure (human waste),
Potential -
Possible – Dogs and cows

17 - Lower San Luis Rey River Bacteria Source Identification Study
AMEC, UNC, City of Oceanside, SCCWRP, and USC
Purpose - The goal of the Project was to identify hot spots of fecal indicator bacteria; identify potential sources and prioritize those sources and locations for future bacteria reductions through management measures.

Results - There is evidence of the human-related bacterial sources throughout the river system. Sediment in the river mouth is a contributing source of fecal bacteria to the water column when the river mouth is closed to tidal exchange. The resident gull population was a probable source of fecal bacteria in the river mouth. Additional, monitoring is needed to identify human sources.

Sources:
Probable - Non-specific source (human waste),
Potential–Gulls (secondary wildlife), soil, sediment and sand (seasonal),
Possible - Sewage infrastructure, mobile sources (human waste), domestic animals

43 - Monitoring and Mitigation to Address Fecal Pathogen Pollution along California Coast
Applied Marine Sciences, Inc., University of California Davis, California Department of Fish and Game, and Marine Wildlife Veterinary Care and Research Center
Purpose - The goals of this research program were to use both laboratory and field approaches to investigate issues related to water quality monitoring and mitigation of fecal pathogen pollution along the central California coast.

Results - The universal Bacteroidales marker was detected in all water samples (100%). The human Bacteroidales marker was detected in 37% of samples, while the cow (8%) and dog (6%) bacteroidales markers were detected in less than 10% of samples. Overall, Bacteroidales concentrations ranged from 87-1.3 million gc/mL for universal markers, 45-17,268 gc/mL for human markers, 3-92 gc/mL for cow markers, and 12-575 gc/mL for dog markers.

Sources:
Probable – Non-specific source (human waste),
Potential - Dogs and livestock,
Possible –

68 - Little Sac River Watershed Bacterial Source Tracking Analysis
Dr. Claire Baffaut, Dr. C.A. Carson, and W. Rogers
https://mospace.umsystem.edu/xmlui/bitstream/handle/10355/3029/LittleSacBacterial.pdf?sequence=1
Purpose - To identify the sources of bacteria found in the Little Sac River using rep-PCR analyses of fecal material.

Results - The data show that the highest fecal coliform loads come from unknown sources, geese, and human. Data show that sources differ by season but the magnitude of the contamination is not significantly affected by season.

Sources:
Probable – Wastewater treatment plant, Geese (non-specific source)
Potential – Cattle and horses
Possible – Septic (sewage infrastructure)

117 - SOURCES OF POLLUTANTS IN WISCONSIN STORMWATER
R.T. Bannerman, D.W. Owens, R.B. Dodds, and N.J. Hornewer
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.176.2404&rep=rep1&type=pdf
Purpose - Identification of critical source areas (streets, roads, parking lots, etc.) could reduce the amount of area needing best-management practices in two areas of Madison, WI. Targeting best-management practices to 14% of the residential area and 40% of the industrial area could significantly reduce contaminant loads by up to 75%.

Results - Streets will probably be a critical source area in every land use. The majority of the runoff loads for many contaminants may be from streets in residential and commercial land uses. Parking lots are probably another critical source for commercial and industrial land uses. About 77% of the area in the commercial land use would have to be managed to control at least 75% of the loads for all contaminants except fecal coliform bacteria.

Sources:
Probable – Sewer outfall, Street runoff (residential, commercial and industrial)

Potential – Cattle and horses
Possible – Septic (sewage infrastructure)

82 - Tiered Approach for Identification of a Human Fecal Pollution Source at a Recreational Beach: Case Study at Avalon Bay, Catalina Island, California
Alexandria B. Boehm, J.A. Fuhrman, R.D. Morse, and S.B. Grant
http://dornsife.usc.edu/labs/fuhrman/Documents/Publications/Tiered%20Approach.pdf
Purpose - In this study, a three-tiered approach is used to identify human and nonhuman sources of FIB in Avalon Bay, a popular resort community on Catalina Island in southern California.

Results - Most of the FIB contamination along the shoreline of the City of Avalon is due to sources inside the bay and, in particular, from the land side of the beach. During the 24-h survey, the most contaminated shoreline sites exhibited a semi-diurnal FIB pattern in which the concentrations increased during ebbing tides. The multiple instances of positive HF and HV assay results at shoreline stations indicate that human fecal contamination exists in Avalon Bay. The nuisance runoff and bird feces had the highest levels of FIB with TC, EC, and ENT consistently near or above the upper limit of detection for water samples 24 192 MPN/100 mL. With the exception of sample R101, pipe discharges from underneath the pier and wharf and the cooling water boat discharge had relatively low levels of FIB. Sample R101 was take from a broken pipe carrying gray water underneath the wharf and had TC and EC levels above our detection limit of 24 192 MPN/100 mL and ENT levels of 10 462 MPN/100 mL, which is 100 times higher than the CDHS single-sample standard. City officials repaired this pipe in early October. Subsurface water collected from within the five trenches had sporadically high levels of FIB.

Sources:
Probable – Non-specific source (urban land use; human waste), MS4 Infrastructure (dry weather runoff; human waste), birds (secondary wildlife), reclaimed water (leaking graywater pipe)
Potential –
Possible – Commercial/Industrial (boat cooling water, pier, and wharf discharges from pipes)

153 - Cross-Shelf Transport at Huntington Beach Implications for the Fate of Sewage Discharged through an Offshore Ocean Outfall
Alexandria B. Boehm, B.F. Sanders, and C.D. Winant
http://www-ccs.ucsd.edu/~cdw/mypubs/109.pdf
Purpose - Evaluate the potential for internal tides to transport wastewater effluent from the Orange County Sanitation District (OCSD) ocean outfall toward Huntington Beach.

Results - On the basis of these analyses, it remains unclear whether OCSD effluent impairs surf-zone water quality. However, OCSD plume cannot be ruled out as a contributor to poor bathing-water quality at Huntington Beach.

131 - Source Tracking in Lake Darling Watershed
Janice Boekhoff
http://www.igsb.uiowa.edu/wqm/Publications/Reports/LakeDarlingFinalReport.pdf
Purpose - Determine the source of fecal contamination in Lake Darling and the surrounding watershed.

Results - E. coli bacteria from most of the water samples at Lake Darling have been identified by DNA ribotyping as coming from unknown sources of fecal contamination (75% of the water samples had bacteria from unknown sources using the WHU library). More unknown source classifications than known sources suggested the E. coli isolate library was either not large enough or was not representative of all of the sources in the watershed.

Sources:
Probable – Secondary wildlife (cattle and swine), Wildlife (unknown)
Potential –
Possible – Commercial/Industrial (boat cooling water, pier, and wharf discharges from pipes)

83 - Detection of Genetic Markers of Fecal Indicator Bacteria in Lake Michigan and Determination of Their Relationship to Escherichia coli Densities Using Standard Microbiological Methods
Patricia A. Bower, C.O. Scopel, E.T. Jensen, M.M. Depas, and S.L. McLellan
http://aem.asm.org/content/71/12/8305.full.pdf+html
Purpose - Lake Michigan surface waters impacted by fecal pollution were assessed to determine the occurrence of genetic markers for Bacteroides and Escherichia coli.

Results - Human-specific Bacteroides spp. were found at three of the nine beach sites tested. Human-specific Bacteroides genetic marker is a sensitive measure of sewage contamination. Sanitary sewage overflow samples taken in the suburban part of the watershed showed the presence of cow-specific genetic marker, since the cow-specific primers do not differentiate between types of ruminants, i.e., elk, deer, and cows.

Sources:
Probable – CSO and SSO (Sewage infrastructure; human waste)
Potential – Sanitary sewer infiltration into the storm drain (Sewage infrastructure; human waste), Ruminant (wildlife; non-anthropogenic)
Possible – Sanitary sewer infiltration into the storm drain (Sewage infrastructure; human waste)

27 – Antibiotic Resistance Analysis of Fecal Coliforms to Determine Fecal Pollution Sources in a Mixed-Use Watershed
Brian S. Burnes
http://www.springerlink.com/content/q3213338g1578x88/fulltext.pdf

Purpose - Antibiotic resistance analysis was performed on fecal coliform (FC) bacteria from a mixed-use watershed to determine the source, human or nonhuman, of fecal coliform contamination.

Results - Human sources contribute a majority (>50%) of the baseflow FC isolates found in the watershed in urbanized areas. Chicken and livestock sources are responsible for the majority of the baseflow FC isolates found in the rural reaches of the watershed. Stormwater introduces FC isolates from domestic (~16%) and wild (~21%) sources throughout the watershed and varying amounts (up to 60%) from chicken and livestock sources. These results suggest that antibiotic resistance patterns of FC may be used to determine sources of fecal contamination and aid in the direction of water quality improvement.

Sources:
Probable – Urbanized watershed (human waste), cows and chickens (rural watershed)
Potential –Stormwater runoff,
Possible –

13 - Results from a Microbial Source-Tracking Study at Villa Angela Beach, Cleveland, Ohio 2007

Rebecca N. Bushon, E.A. Stelzer, and D.M. Stoeckel
Purpose - The overall goal of the study was to provide NEORSD with source-tracking information to aid in their understanding of elevated bacterial concentrations at Villa Angela Beach in Cleveland Ohio. To understand these elevation concentrations, 13 source samples (influent/effluent to sewage treatment plant, waterfowl feces from beach area, combined sewer overflow, stormwater outfall) and 33 beach-area water and sand samples were analyzed for E coli and 3 Bacteroides DNA markers

Results - Therefore, Btheta does not appear to be a useful human-associated marker for this beach area. In the Lake, human source is not a likely contributor of fecal bacteria, however, the gulls are a probable source. In Euclid Creek, there were strong signals of human sources on two occasions and gulls were not present. The sand did not have human sources present and gull sources were present in low concentrations.

Sources:
Probable -
Potential - Combined sewer overflow, influent/effluent to sewage treatment plant, waterfowl feces from beach area,
Possible -

85 - Population structure, persistence, and seasonality of autochthonous Escherichia coli in temperate, coastal forest soil from a Great Lakes watershed

Muruleedhara N. Byappanahalli, R.L. Whitman, D.A. Shively, M.J. Sadowsky, and S. Ishii
http://www.glsc.usgs.gov/_files/publications/population.pdf

Purpose - In this study, undisturbed, forest soils within six randomly selected 0.5 m exclosure plots (covered by netting of 2.3 mm mesh size) were monitored from March to October 2003 for E. coli in order to describe its numerical and population characteristics.

Results - In this study, soil was found as a potential habitat for the persistent, perhaps resident, E. coli populations in temperate conditions. While our studies showed that E. coli can occur in temperate forest soils, albeit at low densities, it also had the ability to persist for extended periods in these habitats, suggesting that it is not a transient organism in soil but perhaps part of the natural microflora. Even if this is not the case, its population resiliency suggests that soil-borne E. coli should be treated as background concentration in source and impact evaluation investigations.

Sources:
Probable – Soil/Sediment/Sand (non-anthropogenic)
Potential –
Possible – Gull, deer, geese, terns (wrackline; non-anthropogenic)

84 - Ubiquity and Persistence of Escherichia coli in a Midwestern Coastal Stream
Muruleedhara Byappanahalli, M. Fowler, D. Shively, and R. Whitman.
http://aem.asm.org/content/69/8/4549.full.pdf+html
Purpose - Dunes Creek, a small Lake Michigan coastal stream that drains sandy aquifers and wetlands of Indiana Dunes, has chronically elevated Escherichia coli levels along the bathing beach near its outfall. This study sought to understand the sources of chronically elevated Escherichia coli levels along the bathing beach near its outfall in Dunes Creek's central branch.

Results - Water samples analyzed during the 1999 and 2000 monitoring seasons clearly demonstrated that E. coli concentrations in Dunes Creek were significantly correlated with the park's beach water. Dunes Creek empties directly onto the state park's only swimming beach, indicating that the creek directly impacts bathing water quality. E. coli is common within the stream basin, especially in submerged, margin, and wetted bank sediments, with numbers rapidly decreasing landward beyond the banks. The relationship between E. coli concentration and stream order suggests that excessive ditching and, consequently, non-point source input via sediment transport are responsible for elevated E. coli density in the watershed.

Sources:
Probable – Soil/Sediment/Sand (non-anthropogenic)
Potential –
Possible – Non-specific source (groundwater; non-anthropogenic)

3 - Pismo Beach Fecal Contamination Source Identification Study; Final Report. Aug. 12, 2010
CAL POLY and City of Pismo Beach
http://www.coastalrcd.org/images/cms/files/PismoFinalReport-v1_4%5B1%5D.pdf

Purpose - To identify biological sources of fecal contamination. Primary sources found were bird fecal contamination.

Results - The data collected in this study clearly shows the main source of fecal contamination on the beach is bird droppings near the pier. Nearly 40% of the E. coli strains collected in this study matched bird fecal sources, and E coli strains with a pigeon-specific fingerprint were collected. In addition, measuring the time since a tide last washed the part of the beach being sampled was an excellent predictor of FIB count, indicating that deposition of fecal matter on the beach itself was a predominate contamination mode.

Sources:
Probable - Bathers, dogs, pigeons (secondary wildlife)
Potential - Cows
Possible -

86 - Sourcing faecal pollution from onsite wastewater treatment systems in surface waters using antibiotic resistance analysis
S. Carroll, M. Hargreaves, and A. Goonetilleke
http://eprints.qut.edu.au/4018/1/4018.pdf
Purpose - To identify the sources of faecal contamination in investigated surface waters and to determine the significance of onsite wastewater treatment systems (OWTS) as a major contributor to faecal contamination.

Results - Antibiotic resistance patterns (ARP) were established for a library of 717 known Escherichia coli source isolates obtained from human, domesticated animals, livestock and wild sources. The resulting ARP DA indicated that a majority of the faecal contamination in more rural areas was nonhuman; however, the percentage of human isolates increased significantly in urbanized areas using OWTS for wastewater treatment.

Sources:
Probable – Sewage infrastructure (onsite wastewater treatment systems; human waste)
Potential –
Possible –

28 - Faecal pollution source identification in an urbanising catchment using antibiotic resistance profiling, discriminant analysis and partial least squares regression
Steven P. Carroll, L. Dawes, L., M. Hargreaves, and A. Goonetilleke
http://eprints.qut.edu.au/19108/1/c19108.pdf
Purpose - Antibiotic Resistance Patterns (ARP) were established for a library of 1005 known E. coli source isolates obtained from human and non-human (domesticated animals, livestock and wild) sources in an urbanising catchment in Queensland State, Australia. Discriminant Analysis (DA) was used to differentiate between the ARP of source isolates and to identify the sources of faecal contamination.

Results - The resulting ARP (Antibiotic Resistance Patterns) DA (Discriminant Analysis) indicated that a majority of the faecal contamination in the rural areas was non-human. However, the percentage of human isolates increased significantly in urbanised areas using onsite systems for wastewater treatment. The PLS regression was able to develop predictive models which indicated a high correlation of human source isolates from the urban area.

Sources:
Probable - Urbanized watershed (human waste), agriculture, other (land use)
Potential –
Possible -

47 - Middle Santa Ana River Bacterial Indicator TMDL Data Analysis Report
CDM and Risk Sciences
Purpose - The primary goal of this study was "to develop an investigative strategy at the highest priority sites, including site-specific or subwatershed-specific activities."

Results – Analysis showed significant differences in the frequency with which molecular markers for humans, dogs, and cattle were detected at the various source evaluation sites. The sites with highest frequency of detection of host-specific markers included the Human marker at Box Springs Channel and Chris Basin; Bovine marker at Anza Drain, Cypress Channel and San Antonio Channel; and Domestic canine marker at Chris Basin, County Line Channel and Day Creek. Where the universal marker was measured, it was a quantified at levels much higher than the other measured markers, indicating the presence of many other sources of bacteria, e.g. birds, rodents, small mammals and reptiles. Preliminary review of land use data indicates that bacterial concentrations are positively correlated with degree of urban development and negatively correlated with the proportion of agricultural acreage and open space in the area.

Sources:
Probable – Non-specific source (human waste; 1 of 13 sites), dogs(1 of 13 sites) and cows(3 of 13 sites), commercial/industrial (anthropogenic non-human source), residential, commercial, and industrial (land use)
Potential -
Possible – Agriculture (anthropogenic non-human source),natural land use (non-anthropogenic) natural and agricultural (land use)

127 - Densities of fecal indicator bacteria in tidal waters of the Ballona Wetlands, Los Angeles County, California
John. H. Dorsey
http://www.freepatentsonline.com/article/Bulletin-Southern-California-Academy-Sciences/151712972.html
Purpose - Densities of fecal indicator bacteria (FIB) represented by total coliforms, E. coil and enterococci were measured within tidal channels of the Ballona Wetlands (Los Angeles County) to see of the wetlands act as a sink or source for these bacteria and to measure increases in FIB densities during wet weather.

Results - Results suggest that the wetlands may act as a sink in that FIB densities tended to be greater during flood flows into the wetlands, but less in water draining out of the system during ebb flows. However, this condition was not consistently met, especially at stations farthest from the tide gates. These sites could be reflecting increased FIB densities through regrowth within sediments and other unidentified sources.

Sources:
Probable –Storm drains
Potential –
Possible -

181 - Reduction of fecal indicator bacteria (FIB) in the Ballona Wetlands saltwater marsh (Los Angeles County, California, USA) with implications for restoration actions
John H. Dorsey, P.M. Carter, S. Bergquist and R. Sagarin
http://www.sciencedirect.com/science/article/pii/S004313541000388X/
Purpose - Determine FIB tidal dynamics within the wetland

Results - The wetlands act as both a source and sink for FIB depending on tidal conditions and exposure to sunlight. Future restoration actions would result in a tradeoff – increased tidal channels offer a greater surface area for FIB inactivation, but also would result in a greater volume of FIB-contaminated re-suspended sediments carried out of the wetlands on stronger ebb flows. As levels of FIB in Ballona Creek and Estuary diminish through recently established regulatory actions, the wetlands could shift into a greater sink for FIB.

119 - FECAL COLIFORM AND STREPTOCOCCUS CONCENTRATIONS IN RUNOFF FROM GRAZED PASTURES IN NORTHWEST ARKANSAS
D. R. Edwards, M.S. Coyne, P.F. Vendrell, T.C. Daniel, P.A. Moore, Jr., and J.F. Murdoch
http://www.pcwp.tamu.edu/docs/lshs/end-notes/Fecal%20Coliform%20and%20Streptococcus%20Concen-0982758667/Fecal%20Coliform%20and%20Streptococcus%20Concentrations%20in%20Runoff%20from%20Grazed%20Pastures%20and%20Northwest%20Arkansas.pdf
Purpose - Assess the effects of grazing, time of year, and runoff amounts on FC and FS concentrations and to evaluate whether FCIFS concentration ratios are consistent with earlier values reported as characteristic of animal sources.

Results - In general, FC and FS concentrations were not directly related to either treatment with animal manure or presence of grazing cattle. Ratios of FC to FS concentrations varied widely ranging from almost zero to more than 100. These data confirm earlier findings that FC/FS ratios are not a reliable indicator of the source of FC and FS in the runoff.

147 - FECAL-INDICATOR BACTERIA IN STREAMS ALONG A GRADIENT OF RESIDENTIAL DEVELOPMENT
Steven A. Frenzel and C.S. Couvillion
http://lshs.tamu.edu/docs/lshs/end-notes/fecal%20indicator%20bacteria%20in%20streams%20along%20a%20gradient%20of%20resid-3692103194/fecal%20indicator%20bacteria%20in%20streams%20along%20a%20gradient%20of%20residential%20development.pdf
Purpose - In order to adopt EPA water-quality standards for concentrations of Escherichia coli (E. coli) or enterococci, and study to determine the effects of urbanization on water quality.

Results - Areas served by sewer systems had significantly higher fecal-indicator bacteria concentrations than did areas served by septic systems. The areas served by sewer systems also had storm drains that discharged directly to the streams, whereas storm sewers were not present in the areas served by septic systems. Fecal-indicator bacteria concentrations were highly variable over a two-day period of stable streamflow, which may have implications for testing of compliance to water-quality standards.

120 - Soil: the environmental source of Escherichia coli and Enterococci in Guam's streams
R. Fujioka, C. Sian-Denton, M. Borja, J. Castro, and K. Morphew
http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2672.1998.tb05286.x/pdf
Purpose - Test the hypothesis that faecal bacteria are able to establish themselves in the soil environments of tropical islands by conducting a study in Guam, a tropical pacific island with warmer temperatures and higher humidity than Hawaii (covered in a previous study).

Results - Results obtained in Guam were similar to the results obtained in Hawaii and provided convincing evidence that the faecal bacterial indicators selected by USEPA to establish recreational water quality standards are able to colonize the soil environments of warm, humid tropical islands, current hygienic water quality standards which are based on concentrations of faecal indicator bacteria may not be applicable in tropical islands and perhaps other subtropical and tropical countries in the world. In these countries, stream waters can be expected to contain elevated levels of faecal bacteria.

Sources:
Probable - Rainfall
Potential –
Possible -

91 - Use of composite data sets for source-tracking enterococci in the water column and shoreline interstitial waters on Pensacola Beach, Florida
Fred J. Genthner, J.B. James, D.F. Yates, and S.D. Friedman
http://64.9.200.77/lists/beachnet/2005-07/pdf00002.pdf

Purpose - Source identification was performed to better understand risk associated with higher densities of enterococci found in swash zone interstitial water (SZIW) as compared to adjacent bathing water on Pensacola Beach, FL.

Results - This study documents higher densities of enterococci in SZIW than in adjacent bathing waters on Pensacola Beach. Entrapment may partially account for increased bacteria densities, however, biological factors (nutrients, protection from predation) and physical factors (particulate matter, periodic wetting and drying, protection from solar irradiation) may not only allow the enhanced survival of bacteria but may actually provide a growth- promoting environmental niche on the beach.

Sources:
Probable – Seagull (secondary wildlife)
Potential –
Possible – **Non-specific source (human waste)**

46 - Laguna Watershed Study and Water Quality Improvement Feasibility Analysis
Geosyntec and UCSB
Purpose - To evaluate dry weather hydrology, microbiological indicators, bacterial sources and loads, and feasible water quality improvements for the Laguna Channel in Santa Barbara, CA.

Results – Based on the analysis of human-specific Bacteroides DNA, it appears that there is significant input of human fecal waste into some Laguna storm drains and into Laguna Channel. An obvious spatial correlation between measured FIB and Human specific Bacteroides Marker (HBM) concentrations could not be identified; similar trends between indicator species and HBM concentrations were also not observed.

Sources:
Probable – Non-specific source (human waste),
Potential -
Possible -

148 - Quantitative Detection of Hepatitis A Virus and Enteroviruses Near the United States-Mexico Border and Correlation with Levels of Fecal Indicator Bacteria
Richard M. Gersberg, M.A. Rose, R. Robles-Sikisaka, and A.K. Dhar
http://publichealth.sdsu.edu/publications/gersberg684.pdf
Purpose - To measure the levels of Hepatitis A virus (HAV) and enteroviruses in coastal waters, and compare to E. coli and enterococci.

Results - HAV and enterovirus were found in 93% of wet weather samples. Inadequate sewage infrastructure in Tijuana, Mexico, also contributes to the high levels found at some sites.

60 - Evaluation of Two Library-Independent Microbial Source Tracking Methods to Identify Sources of Fecal Contamination in French Estuaries
Michele Gourmelon, M.P. Caprais, R. Segura, C. Le Mennec, S. Lozach, J.Y. Piriou, and A. Rince
http://aem.asm.org/content/73/15/4857.full.pdf+html
Purpose - The aim of this study was to optimize and validate the two MST techniques (host-specific 16S rRNA gene markers from Bacteroidales and genotyping of F-specific RNA bacteriophages) on human and animal feces, sewage treatment plant (STP) sludge, wastewater samples, and pig liquid manure (PLM; pig slurry) collected in France. Both techniques were then applied to water samples collected at different times from three estuaries

Results - Humans and animals sources are detected as sources of E. coli and Enterococci contamination in the estuaries based on host-specific Bacteroidales and F-specific bacteriophages

Sources:
Probable – Septic (human waste), livestock (domestic animals), livestock (agriculture), birds (wildlife), birds (secondary wildlife)
Potential -
Possible -

23 - Generation of Enterococci Bacteria in Saltwater Marsh and its impact on the surf zone water quality
Steven B. Grant, B.F. Sanders, A.B. Boehm, A.J. Redman, J.H. Kim, R.D. Mrše, A.K. Chu, M. Gouldin, C.D. McGee, N.A. Gardiner, B.H. Jones, J. Svejkovsky, G.V. Leipzig, and A. Brown
https://www.crops.org/publications/jeq/pdfs/31/4/1300
Purpose - To characterize the sources and transport of Enterococcus in tidally influenced flood control channels and a saltwater marsh.

Results - We find that enterococci bacteria are present at high concentrations in urban runoff, bird feces, marsh sediments, and on marine vegetation. Surprisingly, urban runoff appears to have relatively little impact on surf zone water quality because of the long time required for this water to travel from its source to the ocean. On the other hand, enterococci bacteria generated in a tidal saltwater marsh located near the beach significantly impacts surf zone water quality.

Sources:
Probable – Marsh (non-anthropogenic; non-specific source), wildlife (marsh avian), marsh sediment, soil/sediment/sand
Potential –
Possible –

92 - Antibiotic Resistance Profiles to Determine Sources of Fecal Contamination in a Rural Virginia Watershed
Alexandria K. Graves, C. Hagedorn, A. Teetor, M. Mahal, A.M. Booth, and R.B. Reneau
https://www.crops.org/publications/jeq/pdfs/31/4/1300

Purpose - Antibiotic resistance analysis (ARA) was used to determine if enterococci of human origin were present in a stream (Spout Run) that passes through a rural non-sewered community (Millwood, VA)

Results - A human signature was found in Spout Run as it passed through upper and middle Millwood. No evidence of a human signature was found in Page Brook in an earlier report (Hagedorn et al., 1999), and no evidence of a human signature was found in any of the tributaries that form Spout Run in this study. There are 32 homes in upper Millwood, 21 homes in middle Millwood, and 13 homes in lower Millwood, all on individual septic systems. Repair or replacement of unsatisfactory systems (or installation of a community system) should result in removal of the human signature from Spout Run.

Sources:
Probable – Septic system (sewage infrastructure; human waste), Livestock (domestic animals; anthropogenic non-human sources), wildlife (non-anthropogenic)
Potential –
Possible –

2 - San Diego County Enterococcus Regrowth Study; Draft Final Report, June 11, 2011
John Griffith and D. Ferguson
Purpose - To investigate storm drains as a potential source of Enterococcus bacteria to San Diego's coastal waters during dry weather.

Results –The results of this study suggest that enterococci in these storm drain systems came from predominantly natural sources and include strains that are capable of growing on drain pipe surfaces. The results of the concrete coupon/growth study showed that enterococci were capable of attaching to and growing on concrete coupons. Testing of enterococci extracted from coupons in Cottonwood Creek revealed species and biotypes most closely related to freshwater plants and decomposed algae/vegetation. The majority (77%) of enterococci from the surfaces of coupons, pipe and cobble rock at a La Jolla storm drain were identified as an enterococcal species associated with plants.
A number of natural sources of enterococci were identified at Moonlight State Beach. In this study, up to 70% of creek water isolates were identified as a species commonly found on plants. Multivariate analysis of species and biotypes showed that enterococci in Cottonwood Creek were most similar enterococci found in decomposed algae and vegetation, freshwater plants and seawrack. At least 52% of enterococci in beach water were of a species found in plants, however 34% of isolates were either non-Enterococcus species or unidentifiable, suggesting the possibility of additional sources of enterococci that were not evaluated in this study. Some of the enterococci biotypes in beach water were the same ones found in decomposed algae and vegetation, freshwater plants and seawrack.
The low numbers of birds and predominance of E. faecalis in bird stools indicate that birds may not have been a major source of enterococci to creek and beach water, however the dissimilarity in enterococcal populations could also be related to different selection pressures.

All beach and storm drain/creek water samples tested for Bacteroidales indicated very low or non-detectable levels of the human marker, indicating that these samples had little or no evidence of human fecal material.

Sources:
Probable – MS4 Infrastructure (Human waste), avian (secondary wildlife), avian (non-anthropogenic)
Potential – Landscaping (irrigation and lawn clippings),
Possible – Wrackline, Plants (non-anthropogenic), seawrack, beach sand

121 - Escherichia coli and Enterococci at Beaches in the Grand Traverse Bay, Lake Michigan: Sources, Characteristics, and Environmental Pathways
Sheridan K. Haack, L.R. Fogarty, and C. Wright
http://www.glin.net/lists/beachnet/2007-07/pdf00000.pdf
Purpose - Overall objectives were to (i) quantify EC and ENT in dominant source materials and recreational waters; (ii) characterize selected source isolates using genomic (EC) or biochemical (ENT) profiling; (iii) identify associations between numbers of these two indicator bacteria groups and ambient conditions; (iv) identify processes that influence spatiotemporal variability of indicator bacteria at these beaches; and (v) evaluate standardized monitoring approaches in light of site-specific knowledge about sources and environmental processes

Results - Bird feces are likely one significant source of bacterial contamination to these beaches. Storm drains and the Boardman River contributed large numbers of EC and ENT to the bay, even during non-runoff conditions.
Sources:
Probable – Seawrack (vegetation and other detritus)
Potential –
Possible –

94 - Determining Sources of Fecal Pollution in a Rural Virginia Watershed with Antibiotic Resistance Patterns in Fecal Streptococci
C. Hagedorn, S.L. Robinson, J.R. Filtz, S.M. Grubbs, T.A. Angier, and R.B. Reneau Jr.
http://aem.asm.org/content/65/12/5522.full.pdf+html
Purpose - The objectives of this project were (i) to validate the method of using antibiotic resistance patterns in fecal streptococci and discriminant analysis (DA) to differentiate between human and animal sources and between certain types of animal sources with a larger database of known source isolates from a wider geographical region and (ii) to use this method in a watershed project to identify fecal pollution sources.

Results - The results presented affirm that antibiotic resistance patterns can be used with fecal streptococci to determine sources of fecal pollution in water. Results (detection of no human isolates) had a direct impact on water quality improvement in Page Brook, as local officials were able to focus restoration efforts on the actual sources (e.g., beef cattle) rather than on those that made no contribution to the water pollution.

Sources:
Probable – Cattle (domestic animals; anthropogenic non-human sources)
Potential – Waterfowl, deer unidentified (wildlife; non-anthropogenic)
Possible – Non-specific source (human waste)

69 - Influence of Freshwater Sediment Characteristics on Persistence of Fecal Indicator Bacteria
Laurence Haller, E. Amedegnato, J. Pote, and W. Wildi
http://www.springerlink.com/content/ju524662v67v4967/fulltext.pdf
Purpose - To investigate the effect of sediment characteristics such as particle grain size and nutrient and organic matter contents on the survival of fecal indicator bacteria including total coliforms, E. Coli, and Enterococcus.

Results - FIB survival in sediments and possible re-suspension are considerable significance for understanding permanent microbial pollution. Results revealed (1) FIB survived in sediments up to 50 days, (2) higher growth and lower decay rates of FIB in sediments with high levels of organic matter and nutrients and small grain size, (3) longer survival of Enterococcus compared to E. coli and total coliforms.

Sources:
Probable – Wastewater treatment plant (based on other studies), Soil/Sediment/Sand
Potential – Cattle and horses, storm runoff (MS4 Infrastructure; human waste), Agriculture
Possible – Septic (sewage infrastructure),Wastewater treatment plant, storm runoff (MS4 Infrastructure; human waste), Agriculture, Land use

193 - Soil: the environmental source of Escherichia coli and Enterococci in Hawaii's streams
C. M. Hardina, and R. Fukuda
http://md1.csa.com/partners/viewrecord.php?requester=gs&collection=ENV&recid=9200969&q=&uid=791338866&setcookie=yes
Purpose - To determine the concentrations and sources of Escherichia coli and enterococci in a typical stream (Manoa) in Hawaii.

Results - Soil is considered the most likely source for the high concentrations of indicator bacteria naturally present in the freshwater streams of Hawaii.

Sources:
Probable – Wastewater treatment plant (based on other studies), Soil/Sediment/Sand
Potential – Cattle and horses, storm runoff (MS4 Infrastructure; human waste), Agriculture, Land use
Possible – Septic (sewage infrastructure),Wastewater treatment plant, storm runoff (MS4 Infrastructure; human waste), Agriculture, Land use

61 - Combining targeted sampling and fluorometry to identify human fecal contamination in a freshwater creek
Peter G. Hartel, K. Rodgers, G.L. Moody, S.N.J. Hemmings, J.A. Fisher, and J.L. McDonald
http://www.iwaponline.com/jwh/006/0105/0060105.pdf
Purpose - The aim of this study was to conduct sampling at 2 reaches at Potato Creek, a freshwater creek in Georgia, and 1 tributary during baseflow and stormflow conditions and detect human sources of fecal contamination by using targeted sampling (finding hot spots of fecal contamination within the Creek and/or tributaries and re-sampling these spots) and fluorometry (detection of fluorescing compounds, optical brighteners, & laundry detergents)

Results - Humans, dogs, and cattle are the major suspected sources (not sampled) for fecal contamination in the Potato Creek reaches

Sources:
Probable -
Potential -
Possible – Broken home sewer line, dogs, cows, wildlife (non-anthropogenic),

63 - Drayton Harbor Watershed Microbial Source Tracking Pilot Study Phase 2: California Creek, Dakota Creek and Cain Creek Sub-watersheds
Hirsch Consulting Services
http://whatcomshellfish.whatcomcounty.org/Drayton/documents/DraytonHarborSanitarySurvey2010.pdf
Purpose - The objective of this study was to determine whether human or ruminant sources contribute to fecal contamination at selected sampling stations to inform follow-up investigations and corrective actions by Whatcom County and other agencies and to inform the Drayton Harbor Fecal Coliform TMDL Evaluation.

Results - Ruminant and human fecal sources threaten the shellfish harvest.

Sources:
Probable - Non-specific source (human waste), domestic animals,
Potential -
Possible -

67 - Sources and Mechanisms of Delivery of E. coli (bacteria) Pollution to the Lake Huron
Todd Howell
Purpose - To identify the potential sources of fecal pollution to the shoreline.

Results – The long-term fate of the potentially high E. coli loads delivered to the lake at these times is poorly understood. The association of E. coli with particulate material is thought to be a key mechanism by which survival and transport in the lake environment is enhanced.

Sources:
Probable – Agriculture,
Potential – Soil/Sediment/Sand
Possible - **Non-specific source (human waste), agriculture (listed under other with no degree of designation (probable, low, etc.)**

10 - Wrack promotes the persistence of fecal indicator bacteria in marine sands and seawater
Gregory J. Imamura, R.S. Thompson, A.B. Boehm, and J.A. Jay
http://onlinelibrary.wiley.com/doi/10.1111/j.1574-6941.2011.01082.x/full
Purpose - Study examined the relationship between beach wrack, FIB, and surrounding water and sediment at marine beaches along the California coast.

Results – FIB concentrations normalized to dry weight were the highest in stranded dry wrack, followed by stranded wet and suspended 'surf 'wrack. Laboratory microcosms were conducted to examine the effect of wrack on FIB persistence in seawater and sediment. Indigenous enterococci and Escherichia coli incubated in a seawater microcosm containing wrack showed increased persistence relative to those incubated in a microcosm without wrack. FIB concentrations in microcosms containing wrack-covered sand were significantly higher than those in uncovered sand after several days. These findings implicate beach wrack as an important FIB reservoir.

Sources:
Probable – Seawrack [1-Dry wrack (highest FIB), 2-wet wrack, 3-surf wrack]
Potential -
Possible -

57 - Presence and Growth of Naturalized Escherichia Coli in Temperate Soils from Lake Superior Watersheds
Satoshi Ishii, W.B. Ksoll, R.E. Hicks, and M.J. Sadowsky
http://aem.asm.org/content/72/1/612.full.pdf+html
Purpose - The goal of the study to was (i) examine the survival and persistence of E. coli populations in three soils in several coastal Lake Superior watersheds (extreme environmental conditions) and to determine if these E. coli strains have become naturalized to these soils, (ii) examine the genetic relatedness of soilborne E. coli strains from different locations, and (iii) determine if soilborne E. coli could actively multiply in the soils examined.

Results - E. Coli is able to survive and grow in soil, with growth occurring when temperature and nutrients are higher and able to survive in extreme environments (low temps). Animal feces of surrounding wildlife not shown to be likely source.
Sources:
Probable – Soil/Sediment/Sand
Potential -
Possible - Wildlife

156 - Sources and Persistence of Fecal Coliform Bacteria in a Rural Watershed
Rob C. Jamieson, R. J. Gordon, S. C. Tattrie, and G. W. Stratton
http://www.cawq.ca/journal/temp/journal/7.pdf#page=32
Purpose - Quantify the presence of fecal coliform bacteria in the surface waters of a rural watershed and to attempt to determine the primary sources of fecal pollution within rural watersheds.

Results - Fecal coliform levels frequently exceeded recreational water quality guidelines. At the watershed outlet, 94% of the collected samples exceeded the recreational water quality guideline during low flow conditions. Substantial bacterial loading was observed along stream reaches impacted by livestock operations. Bacterial loading was also observed along a stream reach that was not impacted by agricultural activities.

Sources:
Probable – Livestock
Potential -
Possible -

200 - The effect of cattle grazing on indicator bacteria in runoff from a Pacific Northwest watershed
M.D. Jawson, L.F. Elliott, K.E. Saxton, and D.H. Fortier
http://lshs.tamu.edu/docs/lshs/end-notes/the%20effect%20of%20cattle%20grazing%20on%20indica-1987218764/the%20effect%20of%20cattle%20grazing%20on%20indicator%20bacteria%20in%20runoff%20from%20a%20pacific%20northwest%20watershed.pdf
Purpose - Total coliform (TC), fecal coliform (FC), and fecal streptococcal (FS) numbers were monitored for 3 years to determine the effect of grazing on the presence of these organisms in runoff from a cattle grazed and a non-grazed watershed in the Pacific Northwest

Results - Sampling at several locations within the grazed watershed showed that sources of indicator bacteria were well distributed, and as a result were nonpoint after the initial runoff events. Thus, present FC recommendations developed for point-sources would not apply adequately to grazed land in the Pacific Northwest. Indicator bacteria as presently analyzed would not provide a basis for developing best management practices.

Sources:
Probable – Secondary Wildlife (Cows)
Potential -
Possible –

12 - 2009 Investigation of Spatial and Temporal Distribution of Human-specific Bacteroidales marker in Malibu Creek, Lagoon and Surfrider Beach

Jennifer Jay, R.F. Ambrose, V. Thulsiraj, and S. Estes
Purpose - The goal of the study is to understand the relationship between Fecal indicator bacteria (FIB) and human-specific Bacteroidales (HSB) in coastal wetland. The study examines the spatial & temporal relationship of human-specific Bacteroidales marker (HBM) & FIB in lower Malibu Creek, Lagoon, and Surfrider Beach during wet and dry weather to determine the presence of detectable concentrations of HBM in the lagoon and if concentrations of HBM correlate with FIB

Results - Of the 80 water samples analyzed within the Malibu watershed, five samples were positive for the human-specific HF183 Bacteroidales marker (HBM).The highest percent exceedance of FIB and HBM concentrations were measured during wet weather. During the study, 93.8% of the samples did not have detectable concentrations of HBM. These data do not rule out any particular potential sources of human fecal contamination.

Sources:
Probable -
Potential - storm drains
Possible - Septic systems, Tapia Wastewater Reclamation Facility disinfected discharge, wildlife and birds

98 - Microbial source tracking in a small southern California urban watershed indicates wild animals and growth as the source of fecal bacteria
Sunny C. Jiang, W. Chu B.H. Olson, J. He, S. Choi, J. Zhang, J.Y. Le, and P.B. Gedalanga
http://www.eng.uci.edu/files/07-1MST.pdf
Purpose - Apply three MST tools, namely, ARA, human viruses, and E. coli toxin biomarkers to aid in the cleanup of unknown pollution sources in Laguna Niguel. Laguna Niguel is a small urban watershed in southern California that experienced chronic fecal coliform and enterococci contamination, with concentrations on average of 2–4 orders of magnitude greater than State of California established type 2 recreational standards.

Results - Using three independent microbial source tracking methods, the results of this study indicate that human sewage was not a major contributor of fecal bacterial impairment in this small urban watershed. This study showed that rabbit feces contain one of the highest concentrations of Enterococcus spp. per unit weight.

Sources:
Probable – Urban land use (non-specific source), dogs (urban land use), cows and horses (rural open land use),
Potential –
Possible –

76 - Freshwater Beach Total Maximum Daily Load Microbial Source Tracking Study
Dr. Stephen H. Jones
http://des.state.nh.us/organization/divisions/water/wmb/tmdl/documents/sand_dam_appendix_b_beach.pdf
Purpose - The goal of this project was to investigate actual and potential bacterial sources at (3) public beaches. The approach reflects the latest concepts for efficient use of bacterial ribotyping for pollution source identification in New Hampshire, i.e., ribotyping of high priority samples and development of small local source species databases. This targeted approach was designed to optimize identification of the most significant contamination sources at the 3 beaches.

Results - Overall, birds were the most prevalent (37%) source species type, followed by livestock (24%), humans (5%), wild animals (4%) and pets (3%). The most commonly identified source species was geese (17 isolates), followed by cows and mixed avian (7) sheep (6), horses and ducks (3), septage, goat, wastewater effluent and dog (2), with single isolates identified as coming from deer, red foxes, wild turkeys and mixed wildlife.

Sources:
Probable – Livestock, birds (secondary wildlife)
Potential –
Possible – Non-specific source (human waste), pets, wildlife

99 - Tracking Bacterial Pollution Sources in Stormwater Pipes
Dr. Stephen H. Jones
http://www.unh.edu/users/unh/acad/colsa/marine-program/nhep/resources/pdf/trackingbacterialpollution-unh-03.pdf
Purpose - Determine the bacteria source species from two of the highest priority storm drain pipes that discharge to Hampton Harbor

Results - Many storm water/runoff studies have attributed fecal contamination to pet wastes. Of the four types of sources identified, pets were the least common, behind birds, humans and wildlife.

Sources:
Probable – Non-specific source (human waste), geese (secondary wildlife), cormorants (wildlife; non-anthropogenic)
Potential –
Possible – Cats and dogs (domestic animals; anthropogenic non-human sources), seagulls and pigeons (secondary wildlife), foxes, raccoons and coyotes (wildlife; non-anthropogenic)

32 - USING MULTIPLE ANTIBIOTIC RESISTANCE AND LAND USE CHARACTERISTICS TO DETERMINE SOURCES OF FECAL COLIFORM BACTERIAL POLLUTION
R. Heath Kelsey, G.I. Scott, D.E. Porter, B. Thompson, and L. Webster

http://www.springerlink.com/content/p5p4413ku0082707/fulltext.pdf
Purpose - Multiple Antibiotic Resistance (MAR) analysis and regression modeling techniques were used to identify surface water areas impacted by fecal pollution from human sources, and to determine the effects of land use on fecal pollution in Murrells Inlet, a small, urbanized, high-salinity estuary located between Myrtle Beach and Georgetown, South Carolina.

Results - MAR results suggest that the majority of the fecal pollution detected in the Murrells Inlet estuary may be from non-human sources, including fecal coliforms isolated from areas in close proximity to high densities of active septic tanks.

Sources:
Probable -
Potential -
Possible -

144 - Bacteria Attenuation Modeling and Source Identification in Kranji Catchment and Reservoir
Kathleen B. Kerigan, and J.M. Yeager
http://censam.mit.edu/publications/yeager.pdf
Purpose - Determine the bacterial loading of Kranji Catchment and Reservoir and how this will affect planned recreational use of the reservoir.

Results - Farm run-off near the reservoir was the bacterial source of greatest concern. The relatively high concentrations coupled with the short travel time, which diminishes opportunity for attenuation, resulted in high concentrations reaching the reservoir downstream levels.

73 - Draft Calleguas Creek Watershed Quantitative Microbial Source Tracking Study
Beverly Kildare, V. Rajal, S. Tiwari, D. Thompson, B. McSwain, S. Wuertz, D. Bambic, and G. Reide (Report Prepared by UC Davis in Collaboration with Larry Walker Associates)
Wuertz, S., Bambic, D., and Reide, G. (Report Prepared by UC Davis in Collaboration with Larry Walker Associates)
http://www.calleguas.com/ccwmp/DRAFT_CCW_MST_061406.pdf
Purpose - The goal of this microbial source tracking (MST) study was to provide quantitative, host-specific fecal source data and assist in the development of a bacteria TMDL for the Calleguas Creek Watershed(CCW).

Results - Urban areas were found to be sources of human and canine bacteria to Arroyo Simi and Conejo Creek. The Tapo Canyon site, which is upstream of urban influences, exhibited the lowest concentrations and ratios of the mixed-human marker, but the highest concentrations and ratios of the cow/horse marker. Analysis of tertiary-treated wastewater samples indicates that mixed-human Bacteroidales concentrations may be relatively high in discharged effluent. However, such cells are most likely non-viable and thus not associated with water quality objective exceedances.

Sources:
Probable – Non-specific source (human waste), dogs (canine urban land use), cows and horses (rural and open space)
Potential –
Possible –

100 - Non-point source pollution: Determination of replication versus persistence of Escherichia coli in surface water and sediments with correlation of levels to readily measurable environmental parameters
Julie Kinzelman, S.L. McLellan, A.D. Daniels, S. Cashin, A. Singh, S. Gradus, and R. Bagley
http://www.iwaponline.com/jwh/002/0103/0020103.pdf
Purpose - Racine, Wisconsin, located on Lake Michigan, experiences frequent recreational water quality advisories in the absence of any identifiable point source of pollution. This research examines the environmental distribution of Escherichia coli in conjunction with the assessment of additional parameters (rainfall, turbidity, wave height, wind direction, wind speed and algal presence) in order to determine the most probable factors that influence E. coli levels in surface waters.

Results - This study indicates that persistence, rather than environmental replication of E. coli, is responsible for the majority of microorganisms recovered from foreshore sands, submerged sands and surface waters at Racine, Wisconsin, beaches along Lake Michigan.

Sources:
Probable – Non-specific source (persistence in surface water; non-anthropogenic), Soil/Sediment/Sand (persistence)
Potential –
Possible –

135 - Source tracking faecal contamination in an urbanised and a rural waterway in the Nelson-Tasman region, New Zealand
M. Kirs, V.J. Harwood, A.E. Fidler, P.A. Gillespie, W.R. Fyfe, A.D. Blackwood, and C.D. Cornelisen
http://www.tandfonline.com/doi/pdf/10.1080/00288330.2010.535494
Purpose - Eight MST markers, including general, ruminant and human-associated Bacteroidales markers, a duck-associated E2 marker, a gull-associated Catellicoccus marimammalium marker and three additional human markers [Enterococcus faecium esp gene, Methanobrevibacter smithii nifH gene, and human polyoma viruses (HPyVs)] were tested for host specificity and sensitivity using an array of animal faecal samples of known origin and wastewater samples.

Results - The validation and application of a suite of end-point PCR assays for MST markers enabled us to identify the presence of faecal contamination from multiple sources, including humans, in a New Zealand urbanised waterway. Outcomes demonstrate that MST markers developed overseas can be utilised in New Zealand context.

150 - PISMO BEACH FECAL CONTAMINATION SOURCE IDENTIFICATION STUDY

Christopher L. Kitts, M.W. Black, M.Y. Moline, A.K. Hamrick, I.C. Robbins, A.A. Schaffner, and N.I. Boutet

http://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=1325&context=bio_fac

Purpose - Identify the biological sources of fecal contamination as well as the physical and environmental factors that influence the levels of bacteria in the ocean waters at Pismo Beach, California.

Results - The main source of fecal contamination on the beach is bird droppings near the pier. Both wave direction and current direction worked to push high concentrations of FIB away from the pier as the main source of fecal contamination.

Sources:
Probable – Sewage Infrastructure, Domestic animals (dogs, cats and horses), Secondary wildlife (cows, pigeons and gulls)
Potential –
Possible –

101 - Presence and Sources of Fecal Coliform Bacteria in Epilithic Periphyton Communities of Lake Superior

Winfried B. Ksoll, S. Ishii, M.J. Sadowsky, and R.E. Hicks

http://aem.asm.org/content/73/12/3771.full.pdf+html

Purpose - (i) determine if fecal coliforms and E. coli populations are present and persist in periphyton communities from a harbor and Lake Superior, (ii) identify the most probable sources of E. coli found in periphyton, (iii) use laboratory microcosms to examine colonization and survival of E. coli in natural periphyton communities, and (iv) estimate the contribution of periphyton borne E. coli to overlying waters.

Results - Although many E. coli strains isolated from periphyton may have originated from waterfowl and sewage effluent, other strains appeared to be unique to the periphyton studied and may have developed self-sustaining naturalized populations in these communities. E. coli cells attached to periphyton, whether they are unique to these periphyton communities or not, can detach and contribute to fecal coliform numbers measured in coastal waters. This confounds the use of fecal coliforms as a reliable indicator of recent fecal contamination of recreational waters.

Sources:
Probable –
Potential – Sewage effluent (wastewater treatment plant; human waste), waterfowl (wildlife; non-anthropogenic), algae (non-anthropogenic)
Possible –

65 - Microbial Source Tracking Study for South Cypress Creek
Thomas B. Lawrence, P.E. (City of Memphis, Division of Public Works)
Purpose - The objective of this project was to be able to determine possible sources of fecal coliform levels found in South Cypress Creek, as well as to be able to try to quantify the impacts. By identifying the sources of the impacts, the City will work to achieve the goal of the Clean Water Act by addressing the specific sources where possible.

Results – Data indicated that there may be both diffuse sources of Avian fecal coliform (such as deposited areas that are washed into the creek at a slow rate), as well as direct discharges into the creek, providing the high numbers. The total human impact was fairly low. Thus, pet contributions may be more related to storm water runoff, rather than would be seen with the other major source types which may be related to direct contact with the creek water. For sources attributed to Wild Animals, the number of isolates was higher than all of the other sources in all fecal result groups, except for the "TNTC" group, where it was second to Avian.

Sources:
Probable – avian (secondary wildlife), wildlife (including birds),
Potential -
Possible - Non-specific source (human waste), domestic animals,

39 - LINKING ON-FARM DAIRY MANAGEMENT PRACTICES TOSTORM-FLOWFECAL COLIFORM LOADING FOR CALIFORNIA COASTALWATERSHEDS
David J. Lewis, E.R. Atwill, M.S. Lennox, L. Hou, B. Karle, and K.W. Tate
http://waterquality.ucanr.org/documents/Dairy_Management_Resources7451.pdf
Purpose - We have conducted a systems approach study of 10 coastal dairies and ranches to document fecal coliform concentration and loading to surface waters at the management decision unit scale. Water quality samples were collected on a storm event basis from loading units that included: manure management systems; gutters; storm drains; pastures; and corrals and lots.

Results – Fecal coliform load from units of concentrated animals and manure are significantly more than units such as pastures while storm flow amounts were significantly less. Fecal coliform concentrations demonstrate high variability both within and between loading units. Fecal coliform concentrations for pastures range from 206 to 2,288,888 cfu/100 ml and for lots from 1,933 to 166,105,000 cfu/100 ml.

Sources:
Probable - Manure Management Systems, Stockpiles, and lots (agriculture),
Potential – MS4 Infrastructure (human waste), pasture (land use)
Possible -

15 - Evaluation of Chemical, Molecular, and Traditional Markers of Fecal Contamination in an Effluent Dominated Urban Stream
R.M. Litton, J.H. Ahn, B. Sercu, P.A. Holden, D.L. Sedlak, and S.B. Grant
http://pubs.acs.org/doi/abs/10.1021/es101092g

Purpose - To perform a quantitative sanitary survey of the Middle Santa Ana River, in southern California, utilizing a variety of source tracking tools, including traditional culture-dependent fecal markers, speciation of enterococci isolates, culture-independent fecal markers, and chemical markers of sewage and wastewater

Results - The results support the notion that regrowth of fecal indicator bacteria (FIB) in river sediments may lead to a decoupling between FIB and pathogen concentrations in the water column and thus limit the utility of FIB as an indicator of recreational waterborne illness in inland waters.

Sources:
Probable - in-situ growth in streambed sediments
Potential - effluent stream tributary to Santa Ana River, tributary to RW (Riverside WWTP plant stream tributary to Santa Ana River
Possible - Riverside WWTP & discharge pipe

128 - Snapshot investigation of likely contaminant sources in the Tilligerry Estuary catchment (Zones 5A and 5B)
S.A. Lucas, P.M. Geary, P.J. Coombes, and R.H. Dunstan
http://scholar.googleusercontent.com/scholar?q=cache:F75WyRF5YdUJ:scholar.google.com/&hl=en&num=100&as_sdt=0,5&as_vis=1
Purpose - a) To provide a "snapshot" of water quality in major surface waters draining to the estuary and within the estuary after a particularly wet period. The samples were analysed for nutrients (orthophosphate and nitrate), total coliforms, faecal coliforms, E.Coli, faecal streptococci and faecal sterols and; b) To interpret the most likely sources of faecal contamination from the data obtained as elevated faecal coliform concentrations had been recorded after significant rainfall in the past.

Results - However, the high microbial concentrations observed in major surface drains on the western and eastern side of the estuary also warrant further investigation, however it is clear that the majority of faecal contamination in the estuary is from agricultural land uses. A management program to control and mitigate runoff sources from agricultural lands in the catchment is therefore seen as an integral part of any plan to reduce faecal contamination in Tilligerry estuary.

Sources:
Probable –Human Waste (Non-specific source), Herbivores (Secondary Wildlife)
Potential -
Possible -

62 - Bacteriological methods for distinguishing between human and animal faecal pollution of water: results of fieldwork in Nigeria and Zimbabwe
D. Duncan Mara and J. Oragui
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2536379/pdf/bullwho00087-0144.pdf

Purpose - Recently, methods have been developed to distinguish between human and animal faecal pollution in temperate climates. The present study assessed the applicability and practicality of these methods in tropical countries.

Results - Ruminant and human fecal sources threaten the shellfish harvest.

Sources:
Probable –domestic animals,
Potential - Non-specific source (human waste), Non-specific source (anthropogenic non-human source),
Possible -

207 - Identifying sources of fecal contamination inexpensively with targeted sampling and bacterial source tracking
J.L. McDonald, P.G. Hartel, L.C. Gentit, C.N. Belcher, K.W. Gates, K. Rodgers, J.A. Fisher, K.A. Smith, and K.A. Payne
http://www.water.rutgers.edu/Source_Tracking/Enterococcus/IdentifyingSourcesofFecalContaminationInexpensivelywithTargetedSamplingandBacterialSource.pdf
Purpose - Our objective was to identify the sources of fecal contamination inexpensively at St. Andrews Park and Sea Island during calm and stormy weather conditions using targeted sampling and two or more BST methods: Enterococcus speciation, the detection of the esp gene, and fluorometry.

Results - Targeted sampling, when combined with two or more of three BST methods-enterococcal speciation, detection of the esp gene, and fluorometry--was able to identify sources of fecal contamination quickly, easily, and inexpensively.

Sources:
Probable – Wildlife (Birds)
Potential -
Possible –Human Waste (Non-specific source), Sewage infrastructure (leaking sewer lines), Unspecified wildlife

26 - Application of Bacteroides fragilis Phage as an Alternative Indicator of Sewage Pollution in Tampa Bay, Florida
Molly R. McLaughlin, and J.B. Rose
http://www.springerlink.com/content/922l116k3286u5p3/fulltext.pdf
Purpose - The use of bacteriophages were evaluated in the drainage basins of Tampa Bay

Results – In this study, the phages that infect B. fragilis host RYC2056 (RYC), including phage B56-3, and host ATCC 51477-HSP40 (HSP), including the human specific phage B40-8, were evaluated in the drainage basins of Tampa Bay, 7 samples (n=62), or 11%,
tested positive for the presence of phages infecting the host HSP, whereas 28 samples, or 45%, tested positive using the host RYC.

Sources:
Probable – Septic (sewage infrastructure),
Potential -
Possible -

4 - PB Point Bacterial Source Investigation Final Data Report
MEC- Weston and City of San Diego
Purpose - The goal of this study was to use molecular and standard bacterial indicator techniques to assess the host origin of the bacteria found in the receiving waters at PB point.

Results - The results of the PCR analysis are also presented in Table 2. Of the ten receiving water samples collected (not including duplicates), four (75-R on 8/15, 75R on 8/18, 75-L on 8/18 and 75-R on 8/20) were positive for the general PCR marker (GB), suggesting the presence of fecal material. Among the four samples that tested positive for the general marker, two were positive for at least one of the human-specific markers (75-L on 8/18 and 75-R on 8/20), which suggests the presence of bacteria from human origin.

Although the values for the bacterial indicators from all of the storm drain samples were high, only one (not including duplicates) of the five storm drain samples was positive for the general PCR marker (SD-0 on 8/15). None of the storm drain samples were positive for either of the two human markers.

Sources:
Probable –
Potential – Non-specific source (human waste)
Possible -

55 - MISSION BAY - Clean Beaches Initiative Bacterial Source Identification Study
MEC- Weston and City of San Diego
Purpose - The overall goal of this study was to identify the sources of bacterial contamination to Mission Bay.

Results -Results from both MST methods utilized in Phase II confirmed that the large majority of the enteric bacteria in Mission Bay originates from birds and contributions from human sources are insignificant

Sources:
Probable – Avian (secondary wildlife),
Potential –Dogs, over-irrigation, MS4 Infrastructure (delta sediment at storm drain outlet)
Possible - park restrooms and RV pump stations (human waste), boats and homeless(mobile sources), groundwater (non-anthropogenic), marine mammals, bay sediment

105 - Temporal and Spatial Variability of Fecal Indicator Bacteria: Implications for the Application of MST Methodologies to Differentiate Sources of Fecal Contamination
Marirosa Molina
http://www.environmental-center.com/Files%5C7698%5Carticles%5C5788%5CMolina20600.pdf
Purpose - Identify and compare the temporal and spatial variability of fecal indicator bacteria from a specific host in manure and water samples and evaluate the implications of such variability on microbial source tracking approaches and applications.

Results - Building an enterococci library is a time-consuming, expensive approach that has the potential to provide a great deal of information when the proper statistical analytical approach (in this case it was cluster analysis) is used to interpret the results. Application of a library-independent approach, such as the Bacteroides markers allows for a much faster and possibly less expensive results, but there remains a lack of thorough temporal, spatial and specificity analyses of the few genetic markers available so far.

Sources:
Probable – Cattle (domestic animals; anthropogenic non-human sources)
Potential –
Possible –

38 - Bacteria Monitoring and Source Tracking in Corpus Christi Bay at Cole and Ropes Parks
Joanna Mott, M. Lindsey, R. Sealy, and A. Smith
http://www.cbbep.org/publications/virtuallibrary/1010.pdf
Purpose - In this study water samples from the six Texas Beach Watch stations at Ropes and Cole Parks were analyzed to detect the esp marker as an indicator of human contamination at these locations. Additionally, data on three other human-specific markers--Bacteroidales, Human 2 Polyoma Viruses (HPyVs), and ethanobrevibacter.smithii—from another study, are included in this report for comparison with the esp analysis results.

Results - Human source contamination was detected at Ropes and Cole Park stations under ambient weather conditions as measured by several human-specific markers. The esp gene was detected when levels of enterococci at Ropes Park were higher following rainfall and suggest a human contribution at this location presumably either from storm drain outflow or non-point source run-off. For Ropes and Cole Parks, a broader bacteria source tracking project is recommended to examine not only human, but other sources of contamination.

Sources:
Probable – Non-specific source (human waste),
Potential -
Possible – MS4 Infrastructure (human waste),

72 - Bacteria Source Tracking on the Mission and Aransas Rivers
Joanna Mott, R. Lehman, Ph.D. and A. Smith
Purpose - In this study, bacteria source tracking (BST) was used to evaluate the sources of fecal contamination in the Mission and Aransas River segments and to provide additional data for assessment of sources of contamination into Copano Bay, the water body into which both segments empty.

Results - The majority of unknown source isolates collected from water samples at the five sampling stations along the Mission and Aransas tidal segments were classified as human source. Overall, 63.7-66.9% of unknown source isolate profiles from the composite (ARA+CSU) dataset were classified as treated human sources (originating from treated wastewater effluent). The remaining unknown source isolates were classified as livestock animals and wildlife, with cow, horse and duck contributions accounting for the majority of the animal sources in both the composite dataset and PFGE profiles.

Sources:
Probable – Wastewater treatment plant, cows, horses, ducks
Potential –
Possible – Gulls (secondary wildlife), hogs

41 - Multi-scale landscape factors influencing stream water quality in the state of Oregon
Maliha S. Nash, D.T. Heggem, D. Ebert, T.G. Wade, and R.K. Hall
http://www.springerlink.com/content/y17u3uh60155w313/fulltext.pdf
Purpose - This study used the State of Oregon surface water data to determine the likelihood of animal pathogen presence using enterococci and analyzed the spatial distribution and relationship of biotic (enterococci) and biotic (nitrogen and phosphorous) surface water constituents to landscape metrics and others (e.g. human use, percent riparian cover, natural covers, grazing, etc.).

Results – Landscape metrics related to amount of agriculture, wetlands and urban all contributed to increasing nutrients in surface water but at different scales. The probability of having sites with concentrations of enterococci above the threshold was much lower in areas of natural land cover and much higher in areas with higher urban land use within 60 m of stream. A 1% increase in natural land cover was associated with a 12% decrease in the predicted odds of having a site exceeding the threshold. Opposite to natural land cover, a one unit change in each of manmade barren and urban land use led to an increase of the likelihood of exceeding the threshold by 73%, and 11%, respectively. Change in urban land use had a higher influence on the likelihood of a site exceeding the threshold than that of natural land cover.

Sources:
Probable - Urbanized land use
Potential -
Possible – Agriculture

66 - Coastal Nonpoint Source Pollution Monitoring Program
New Jersey Department of Environmental Protection
Purpose - To identify the causes of the degrading water quality in the upper Navesink River. Perform stormwater monitoring to delineate major sources of fecal contamination. Utilize specialize tests, including coliphage and Multiple Antibiotic Resistance (MAR) analyses, to identify the sources of contamination (i.e., human, domestic animal, and wildlife). Once identified, actions can be recommended and taken to eliminate or reduce the impact.

Results – Results for Microbial Source Tracking indicators (F+RNA coliphage and Multiple Antibiotic Resistance) suggest a human source of fecal contamination at sites. Sites were identified as 'hot spots' for further source investigations.

Sources:
Probable - Non-specific source (human waste),wildlife
Potential – Domestic animals,
Possible -

1 - Multi-tiered Approach Using Quantitative Polymerase Chain Reaction for Tracking Source of Fecal Pollution to Santa Monica Bay, Ca, February 2005
Rachel T. Noble, J.F. Griffith, A.D. Blackwood, J.A. Fuhrman, J.B. Gregory, X. Hernandez, X. Liang, A.A. Bera, and K. Schiff
ftp://ftp.sccwrp.org/pub/download/DOCUMENTS/AnnualReports/2005_06AnnualReport/AR0506_181-194.pdf
Purpose - The objective of this study was to identify the contribution and quantify the loading of fecal contamination to the SMB using a multi-tiered approach. No discussion on what fecal source types (agriculture, birds, dogs) are impacting Santa Monica Bay

Results - Measurements of Bacteroides sp. and enterovirus indicated the presence of human fecal contamination throughout the system. Bacteroides sp. was present in 33% of mainstem samples. Enterovirus was present in 44% of mainstem samples. The concordance among these measurements was nearly complete; almost every location that detected Bacteroides sp. was also positive for enterovirus.

Sources:
Probable - Non-specific Source (human waste)
Potential -
Possible-

108 - Use of Fecal Steroids to Infer the Sources of Fecal Indicator Bacteria in the Lower Santa Ana River Watershed, California: Sewage Is Unlikely a Significant Source
James A. Noblet, D.L. Young, E.Y. Zeng and S. Ensari
ftp://ftp.sccwrp.org/pub/download/DOCUMENTS/JournalArticles/444_fecal_steroids.pdf
Purpose - Utilize a suite of fecal steroids, as chemical markers to examine whether sewage was a significant source of FIB within the lower Santa Ana River watershed.

Results - The results implied that sewage was not a significant source of fecal steroids, and therefore perhaps FIB to the study area. Instead, birds may be one possible source of the intermittently high levels of FIB observed in the lower Santa Ana River watershed and the nearby surf zone.

Sources:
Probable –
Potential – Gulls (secondary wildlife; anthropogenic non-human sources)
Possible – Sewage infrastructure (human waste), dogs (domestic animals; anthropogenic non-human sources)

109 - Fecal source tracking by antibiotic resistance analysis on a watershed exhibiting low resistance
Yolanda Olivas, and B.R. Faulkner
http://www.springerlink.com/content/k02q5v6748702773/fulltext.pdf
Purpose - To test the efficiency of the antibiotic resistance analysis (ARA) method under low resistance by tracking the fecal sources at Turkey Creek, Oklahoma exhibiting this condition.

Results - The original seasonal and annual DA of the stream sources showed no significant difference between human and livestock input rates in winter, spring and summer ($0.56 \leq P \leq 0.76$). Deer was consistently lower than the other two sources ($0.00 \leq P \leq 0.30$). In fall, the human source predominated over livestock and deer ($P < 0.0001$). Revision of the original DA using the rates of misclassification, decreased classification into the human and deer sources by 6–7% ($0.22 \leq P \leq 0.33$), and increased classification into livestock by 13–14% ($0.04 \leq P \leq 0.06$), showing the significance of the original DA misclassification. In conclusion, the major effect of low antibiotic resistance to this ARA work was a significant level of negative misclassification into the livestock source.

Sources:
Probable – Non-specific source (human waste), livestock (domestic animals; anthropogenic non-human sources)
Potential – Deer (wildlife; non-anthropogenic)
Possible –

143 - Investigation of Faecal Pollution and Occurrence of Antibiotic Resistant Bacteria in the Mooi River System as a Function of a Changed Environment
M.J. Pantshwa, A.M. van der Walt, S.S. Cilliers, and C.C. Bezuidenhout
http://www.ewisa.co.za/literature/files/2008_137.pdf
Purpose - Water quality monitoring and assessments are of paramount importance to identify the river confluence vulnerable to the pollution impacts of urbanization. Investigate some physico-chemical parameters, levels of faecal pollution and occurrence of antibiotic resistant bacteria in the Mooi River system as a function of a changed environment.

Results - Non-human sources contributed greater towards faecal pollution. Urban gradient was recognized in terms of faecal indicator species distribution. Higher levels of antibiotic resistant bacteria were detected in urban sites when compared to lower upstream and elevated downstream levels.

75 - Middle Rio Grande Microbial Source Tracking Assessment Report
Parsons Water & Infrastructure Inc.
Purpose - The objective of this project was to identify specific sources of fecal coliform causing high levels of bacteria in the Middle Rio Grande.

Results - Overall, ribotyping results show, the largest fraction of E. coli matched those found in avian sources, followed by canine, human/sewage, rodents, bovine, and equine. The source of approximately 9 percent of the E. coli could not be identified. With the exception of rodents, only a few species of wild mammals were identified as sources of fecal coliform found in water: deer or elk, raccoon, coyote, bear, and opossum. It should be noted that an unknown fraction of the canine isolates may be from coyotes and foxes, as many E. coli strains are resident both in domestic dogs and wild canines.

Sources:
Probable – Cats, dogs, birds (wildlife)
Potential – Non-specific source (human waste), livestock, rodents (secondary wildlife), Wildlife (deer or elk, raccoon, coyote, bear, and opossum)
Possible –

125 - Bacterial Contamination and Antibiotic Resistance in Fecal Coliforms from Glacial Water Runoff
S.P. Pathak, and K. Gopal
http://www.springerlink.com/content/fup31h3742514123/fulltext.pdf
Purpose - Assess the bacteriological contamination in glacial water runoff from the Gangotri glacier and Gangetic river system (Gaumukh to Rishikesh) by enumerating aerobic heterotrophs, coliforms, fecal coliforms and fecal streptococci. Antibiotic resistance among the fecal coliforms, identified as E. coli, was also studied.

Results - Contamination of coliform was observed in all samples, while fecal coliform and fecal streptococci were detected in 17 and 18 samples, respectively (Fig. 2). Thus, bacteriological analysis exhibited maximum contamination in most of the water samples from post-Gangotri and Gangetic stations. The observed increase in the proportion of coliforms and fecal coliforms was statistically significant ($p < 0.001$). The counts of fecal streptococci in all study stretches were too low for statistical comparison.

129 - Fecal BMAP Implementation: Identification of Probable Sources in the Butcher Pen Creek Watershed
PBS&J
http://publicfiles.dep.state.fl.us/dear/BMAP/LowerStJohns/Tributaries%20Fecal%20Coliform%20BMAPs/Technical_Reports/ButcherPen/Final%20Draft%20Butcher%20Pen%20WBID%202322%20Tech%20Report%20041008.pdf
Purpose - FDEP has verified 54 tributaries of the Lower St. Johns River—located throughout Duval County and in small portions of Clay and St. Johns Counties—as impaired for fecal coliform, and TMDLs must be developed for these waterbodies. Local stakeholders in the Lower St. Johns Basin, in conjunction with FDEP, are currently working to develop a Basin Management Action Plan (BMAP) to implement the TMDLs for fecal coliform.

Results - Elevated levels of fecal coliforms following rainfall may be an indication that unidentified pollution sources (e.g., leaking wastewater conveyance systems) are being transported by stormwater into Butcher Pen Creek. This evaluation indicates that the probable sources of fecal contamination in the Butcher Pen Creek WBID are human-related. Although Butcher Pen Creek does not have a designated septic tank phase-out area, some areas of the basin have likely had OSTDS failures, as indicated by the existence of septic tank repair permit applications, especially in the northeast corners of the watershed. Therefore, it is likely that there still remain isolated and problematic septic systems that are contaminating the neighboring surface waters.

Sources:
Probable – Sewage infrastructure (SSO events),
Potential – Wastewater discharge
Possible –

34 - Origin and spatial–temporal distribution of faecal bacteria in a bay of Lake Geneva, Switzerland
John Poté, N. Goldscheider, L. Haller, J. Zopfi, F. Khajehnouri, and W. Wildi
http://doc.rero.ch/lm.php?url=1000,43,4,20100511154847-XI/Pot_John_-_Origin_and_spatial-temporal_distribution_of_faecal_bacteria_20100511.pdf
Purpose - To quantify the input flux rates of faecal bacteria from the main contamination sources and to assess their spatial and temporal distribution in the bay, in order to estimate the human health risk related to recreational activities and drinking water use.

Results - The highest FIB concentrations in the near-surface water of the bay consequently occur during floods and mixed lake conditions. Although the thermocline protects the epilimnion from contamination in summer, effluent water may spread in the hypolimnion and reach the drinking-water pumping station 3.8 km further to the west.

Sources:
Probable – Wastewater Treatment Plant
Potential –
Possible –

110 - Classification Tree Method for Bacterial Source Tracking with Antibiotic Resistance Analysis Data
Bertram Price, E.A. Venso, M.F. Frana, J. Greenberg, A. Ware, and L. Currey
http://aem.asm.org/content/72/5/3468.full.pdf+html
Purpose - Apply the statistical method known as classification trees to build a model for BST for the Anacostia Watershed in Maryland.

Results - Applying the tree classification model to the 1,565 Anacostia River water isolates yielded the following distribution of sources: 468 (29.9%) pet, 222 (14.2%) human, 437 (27.9%) livestock, and 438 (28.0%) wildlife. These results were determined from analysis of all the water isolates, which represent six monitoring stations with samples collected monthly for 1 year. Therefore, the source distribution presented here does not account for the distribution of high-flow and low-flow periods, which may contribute different sources to the streams. Also, note that bacterial sources can be site specific in a watershed, given the non-conservative nature of bacterial transport. For the purpose of this analysis, all the water isolates from the six monitoring stations were used to estimate the overall watershed relative source contributions. The results based on this averaging method indicate that humans contribute the least bacterial contamination to the Anacostia River. The other sources of bacterial contamination are evenly distributed among pet animals, livestock, and wildlife.

Sources:
Probable – Pets and livestock (domestic animals; anthropogenic non-human sources), wildlife (non-anthropogenic)
Potential – Non-specific sources (human waste)
Possible –

113 - Quantitative microbial faecal source tracking with sampling guided by hydrological catchment dynamics
G. H. Reischer, J.M. Haider, R. Sommer, H. Stadler, K.M. Keiblinger, R. Hornek, W. Zerobin, R.L. Mach, and A.H. Farnleitner
http://onlinelibrary.wiley.com/doi/10.1111/j.1462-2920.2008.01682.x/pdf
Purpose - Apply modern quantitative microbial source tracking methods on a large and complex karstic spring catchment in context with hydrology and other water quality parameters over a prolonged period of time in order to comprehensively, qualitatively and quantitatively characterize the pollution sources.

Results - 1) Established and evaluated a new sampling concept with consideration for the whole seasonal hydrological catchment variability and special emphasis on strong pollution events.
2) Demonstrated the ability of quantitative microbial source tracking studies to quantitatively link source-specific marker levels to general faecal pollution indicators in order to estimate the contribution of one source group to total faecal pollution as measured in conventional faecal monitoring.

3) Showed that the thorough investigation of catchment hydrology and pollution dynamics is a prerequisite for successful quantitative microbial source tracking study design.

Sources:
Probable – Ruminant (wildlife; non-anthropogenic)
Potential – Non-specific sources (human waste)
Possible – Soil/Sediment/Sand

133 - Assessment of Sources of Bacterial Contamination At Santa Cruz County Beaches
John Ricker and S. Peters
ftp://ftpdpla.water.ca.gov/users/prop50/10045_SantaCruz/Work%20Plan%20CD%2004/reference%20plans%20and%20background%20information/Sources%20of%20Contamination%20at%20SCC%20Beaches%202005.pdf
Purpose - Determine the source and health threat of elevated bacteria levels at Santa Cruz County beaches

Results - The most significant source of beach contamination in Santa Cruz County is discharge from the creeks, with a high urban runoff component during both wet and dry weather. 22 point plan to be implemented to improve water quality

Sources:
Probable – Non-specific sources (human waste), Sewage infrastructure (storm drains), Domestic animals (dogs), Secondary wildlife (birds), Wildlife (rats)
Potential –
Possible –

42 - Bacterial Source Tracking Pilot Study DNA Fingerprinting, Human Bacteroidetes ID and Human Enterococci ID
Rogue Valley Council of Governments
Natural Resources Department
Purpose - The purpose of the pilot study was 1) to determine whether bacteria found in local streams is from human or animal sources and 2) to evaluate different BST methodology for future use within the Rogue Valley.

Results - DNA Fingerprinting results show that animal fecal matter is present, but were inconclusive in identifying whether human contamination was present. Many of the analyzed colonies could not be matched to animal or human sources. However, based on the isolates identified, animals are the primary contributor of bacteria to Ashland Creek, Baby Bear, and Griffin Creek (31 of 50).

Sources:
Probable - Domestic animals, wildlife,
Potential -
Possible – Non-specific source (human waste)

7 - Microbiological Water Quality at Reference Beaches in Southern California During Wet Weather
Kenneth Schiff, J. Griffith, and G. Lyon
http://www.sccwrp.org:8060/pub/download/DOCUMENTS/TechnicalReports/448_reference_beach.pdf
Purpose - The contribution of non-human sources of bacteria was quantified at coastal reference beaches in southern California. Provides an overview of sampling methods and analytical results for reference beaches are discussed. Bacteria sources were not identified

Results – Based on the results from this study, natural contributions of nonhuman fecal indicator bacteria were sufficient to generate exceedances of the State of California water quality thresholds during wet weather. Total coliform, E. coli, and enterococcus samples collected during wet weather exceeded water quality thresholds greater than 10 times more frequently during wet weather than during recent dry weather in summer or winter, although the frequency differed by beach. San Onofre State Beach had the greatest concentrations of bacteria and the greatest frequency of water quality threshold exceedances. This may have been the result of several factors that we cannot disentangle. First, San Onofre Creek was the largest watershed we sampled, which may have led to a greater number of nonhuman sources of fecal indicator bacteria upstream. Second, San Onofre Creek had the largest and most mature lagoon of any site sampled, which was located at the beach interface and may have attracted nonhuman fecal sources(i.e. birds). Third, San Onofre Creek was the only discharge where we found human enteric virus. The San Onofre Creek watershed had the greatest fraction of developed land use (3%) of any of the other watershed systems and human activities are known to occur in the lower part of this watershed.

Sources:
Probable – Non-specific source (anthropogenic)
Potential – Non-specific source (human waste)
Possible –

221 - Presence of Bacteroidales as a Predictor of Pathogens in Surface Waters of the Central California Coast
A. Schriewer, W.A. Miller, B.A. Byrne, M.A. Miller, S. Oates, P.A. Conrad,, D. Hardin, H.H. Yang, N. Chouicha, A. Melli, D. Jessup, C. Dominik, and S. Wuertz
http://ukpmc.ac.uk/articles/PMC2935056
Purpose - Evaluate the value of Bacteroidales genetic markers and fecal indicator bacteria (FIB) to predict the occurrence of waterborne pathogens in ambient waters along the central California coast.

Results - The ability to predict pathogen occurrence in relation to indicator threshold cutoff levels was evaluated using a weighted measure that showed the universal Bacteroidales genetic marker to have a comparable or higher mean predictive potential than standard FIB. This

predictive ability, in addition to the Bacteroidales assays providing information on contributing host fecal sources, supports using Bacteroidales assays in water quality monitoring programs.

77 - Tracking Sources of Fecal Pollution in a South Carolina Watershed by Ribotyping Escherichia coli: A Case Study
Troy M. Scott, J. Caren, G.R. Nelson, T.M. Jenkins, and J. Lukasik
http://sourcemolecular.com/pdfs/scott3.pdf
Purpose - To describe the effective use of the ribotyping microbial source tracking procedure to determine the source(s) of Escherichia coli within a South Carolina watershed.

Results - Prior to investigating potential fecal inputs into this watershed, a significant human source was suspected as the primary input; however, of the 515 E. coli isolated from water samples collected during the course of this study, 88% were typed as being of animal fecal origin. Thus, this study was integral in the realization that animals may be a significant source of contamination and that remediation efforts should be redirected to accommodate these findings. Of the 454 animal isolates analyzed, 51 RT profiles were directly matched from a specific animal source. Of these, 22 (43%) were classified as coming from deer feces and 9 (18%) directly matched those generated from dog feces.

Sources:
Probable – Wildlife (deer, raccoons, birds and pelicans),
Potential – Non-specific source (human waste), cats and dogs, gulls (secondary wildlife)
Possible –

19 - Sewage Exfiltration As a Source of Storm Drain Contamination during Dry Weather in Urban Watersheds
Bram Sercu
http://pubs.acs.org/doi/abs/10.1021/es200981k
Purpose - To determine whether transmission of sewage is occurring from leaking sanitary sewers directly to leaking separated storm drains, field experiments were performed in three watersheds in Santa Barbara, CA.

Results – Above-background RWT peaks were detected in storm drains in high-risk areas, and multiple locations of sewage contamination were found. Sewage contamination during the field studies was confirmed using the human-specific Bacteroidales HF183 and Methanobrevibacter smithii nifH DNA markers. This study is the first to provide direct evidence that leaking sanitary sewers can directly contaminate nearby leaking storm drains with untreated sewage during dry weather and suggests that chronic sanitary sewer leakage contributes to downstream fecal contamination of coastal beaches.

Sources:
Probable -
Potential -
Possible -

6 - Storm Drains are Sources of Human Fecal Pollution during Dry Weather in Three Urban Southern California Watersheds
Bram Sercu, L.C. Van de Werehorst, J. Murray, and P.A. Holden
http://www.santabarbaraca.gov/NR/rdonlyres/C3B1ADAE-37E8-4F89-8F2D-1A24FBAB8D6A/0/Sercuetal_ESnT_2009_v43p2938SI.pdf
Purpose - Dry weather bacteria monitoring in urbanized Santa Barbara, CA watersheds

Results - Of the 80 water samples analyzed within the Malibu watershed, five samples were positive for the human-specific HF183 Bacteroidales marker (HBM).The highest percent exceedance of FIB and HBM concentrations were measured during wet weather. During the study, 93.8% of the samples did not have detectable concentrations of HBM. These data do not rule out any particular potential sources of human fecal contamination.

Sources:
Probable -
Potential - Sewage infrastructure, non-stormwater discharges, MS4 infrastructure (less likely – human waste), MS4 infrastructure (anthropogenic non-human sources)
Possible -

116 - Identification of human fecal pollution sources in a coastal area: a case study at Oostende (Belgium)
Sylvie Seurinck, M. Verdievel, W. Verstraete, and S.D. Siciliano
http://www.iwaponline.com/jwh/004/0167/0040167.pdf
Purpose - Identify fecal pollution sources in the North Sea and produce a model required to predict fecal pollution

Results - The canal Gent-Oostende, the Dode Kreek and Gauwelozekreek, the Voorhaven, and the Montgommerydok contained high levels of the indicator bacteria. The European E. coli standard (5 £ 102/ 100 ml) suggested in the revised draft Bathing Water Directive (Council of the European Communities 2000) was exceeded most of the time at these sites. The human specific Bacteroides marker was detected in almost all water samples from these sites, which indicates that they are regularly contaminated with human fecal pollution. The river Noordede, the Visserijdok and the beach water at 2 sites were only lightly contaminated based on the European E. coli standard. At these sampling sites the human-specific Bacteroides marker was less frequently detected and in lower amounts, except at one locations where high concentrations of 107 human-specific Bacteroides marker per l were recorded at the beginning of the sampling survey and at the end. The detection of indicator organisms and the human specific Bacteroides marker was strongly related to rainfall for this coastal area.

Sources:
Probable – Non-specific sources (human waste)
Potential –Wildlife (non-anthropogenic)
Possible –

11 - Regrowth of Enterococci & Fecal Coliform in Biofilm. Printed in The Journal for Surface Water

John F. Skinner, J. Guzman, and J. Kappeler

Purpose - The goal of the study was to determine the sources of high numbers of enterococci and fecal coliform found in street gutter runoff flowing from residential areas to the Dover Drive storm drain in Newport Beach, Orange County

Results – Bacteria counts in runoff from washing the sidewalk using bacteria-free hose water were 220 enterococci/100 ml and 180 fecal coliform/100 ml. Washoff water from the driveway by manually flooding a residential front lawn was 160 enterococci/100 ml and 9 fecal coliform/100 ml. Runoff from flooding the grass contained 1,250 enterococci/100 ml and 2,000 fecal coliform/100 ml. Water draining directly into the gutter through a hole cut through the curb grew out 70 enterococci/100 ml and 100 fecal coliform/100 ml.

Bacteria-free hose water was introduced into a dry street gutter and tested for enterococci and fecal coliform at 10 meters, 45 meters, and 100 meters downstream when the flow from the hose water reached those locations. There was a progressive rise of both enterococci and fecal coliform bacteria with the increased distance of flow. The levels of fecal indicator bacteria were 26,000 enterococci/100 ml and 14,000 fecal coliform/100 ml when the water reached the 100-meter test site, the last testing station. The source of these high numbers of bacteria is suspected to be coming from regrowth in the street gutters.

The findings of these studies provide evidence that regrowth of both enterococci and fecal coliform bacteria are occurring in biofilm located in residential street gutters and storm drains in Newport Beach.

Sources:
Probable - Street gutter biofilm regrowth (MS4 infrastructure)
Potential – Dog excrement (not tested), lawn irrigation runoff, sidewalk and driveway runoff (Solid/liquid waste), residential washwater, residential lawn runoff
Possible - Residential backyard and side yard patios, roof gutter drains but not tested

49 - F+ RNA Coliphages as Source Tracking Viral Indicators of Fecal Contamination

Dr. Mark D. Sobsey, D.C. Love, and G.L. Lovelace

http://webmail.ciceet.unh.edu/news/releases/springReports07/pdf/sobsey.pdf

Purpose - To evaluate and apply novel, cost-effective technologies and methods for the detection, quantification and identification of sources of microbial contaminants and the characterization of those sources as human or nonhuman.

Results - Microbial indicator concentrations in water and shellfish were higher at sites with greater wastewater treatment plant discharges. Of the 9 estuaries in the study, 4 were impacted by point source discharges of waste water treatment plant (WWTP) effluent. Human point source pollution in this study was primarily from waste water treatment plant (WWTP) treated effluent

and possibly raw sewage leaks, while likely human non-point sources included urban runoff, seepage from septic tanks, and boat dumping. Sites with non-human non-point fecal waste contained populations of wildfowl (goose, duck, gull), wild horses, other feral animals, agricultural animals, a dog park and urban pet waste. At 4 estuaries the impacted sites included human point and non-point sources, while the non-impacted sites were pristine sites with wildlife refuges or were geographically separated from human populations. In the Tijuana River Reserve in Southern CA human impacts were documented at all study sites, so in the absence of a truly pristine or non-impacted site, a site with only non-point source runoff from human development was compared to a more contaminated site at the mouth of the Tijuana River containing untreated sewage from Mexico.

Sources:
Probable -
Potential – Sewage infrastructure, Urban runoff (MS4 infrastructure - human waste; suspected to potential)
Possible -

45 - Faecal sterols analysis for the identification of human faecal pollution in a non-sewered catchment.
D. Sullivan, P. Brooks, N. Tindale, S. Chapman, and Ahmed, W.
http://publicationslist.org/data/w.ahmed/ref-14/Daryle_s%20article_%20WST_revised%20version.pdf
Purpose - To identify human faecal pollution in a non-sewered catchment using faecal sterols.

Results - In this study, faecal sterol analysis was used to identify the presence of human sourced faecal pollution or others (non-point sources) in two adjacent creeks of North Maroochy Catchment. It appears that stanols concentrations generally increased with increased catchment runoff. After moderate rainfall, high coprostanols levels found in water samples indicated human faecal pollution and defective septic systems are the most likely sources of pollution. The human signal was traced on one occasion to a defective septic system. In contrast, it appears that during dry weather human faecal pollution is not occurring in the study catchment.

Sources:
Probable – Septic (sewage infrastructure),
Potential –
Possible -

124 - Ecological Control of Fecal Indicator Bacteria in an Urban Stream
Cristiane Q. Surbeck, S.C. Jiang, and S.B. Grant
http://lshs.tamu.edu/docs/lshs/end-notes/ecological%20control%20of%20fecal%20indicator%20bacteria%20in%20an%20urban%20stream-1429959691/ecological%20control%20of%20fecal%20indicator%20bacteria%20in%20an%20urban%20stream.pdf

Purpose - Determine the source(s) of elevated FIB concentrations in Cucamonga Creek, a concrete-lined urban stream in southern California. Flow in the creek consists primarily of treated and disinfected wastewater effluent, mixed with relatively smaller but variable flow of runoff from the surrounding urban landscape.

Results - Mass and volume balance calculations indicate that treated wastewater is not a significant source of FIB to Cucamonga Creek. Runoff from the urban landscape appears to be the primary source of FIB loading to Cucamonga Creek during both dry weather and wet weather periods. Observations from the study imply that DOC and FIB concentrations in runoff should co-vary, which is indeed the case both at Cucamonga Creek and in many agricultural and urban streams along the California coast. These results are not consistent with the hypothesis that FIB are static contaminants (like sediments or nutrients) with well-defined and land-use-specific export coefficients, as has been suggested for catchments in the United Kingdom. Rather, our data suggest that nonpoint source FIB impairments in southern California are best viewed as an ecological phenomenon, in which a dynamic balance between FIB sources, nutrient availability, competition with other heterotrophic bacteria, and predator prevalence determines the magnitude and extent of FIB pollution and its human health implications.

Sources:
Probable – Non-specific Source (Human Waste), Domestic animals (dogs), Secondary Wildlife (birds)
Potential –
Possible -

50 - B Street/Broadway Piers, Downtown Anchorage, and Switzer Creek Storm Drain Characterization Study
Tetra Tech, City of San Diego
Purpose - To further characterize the City's storm drain system discharges during both wet and dry weather. This monitoring program evaluated the potential sources of the pollutants-of-concern (POCs) throughout the MS4 system and collected data to calibrate and validate preliminary wet weather runoff modeling efforts for the San Diego Bay TMDLs.

Results - Bacteria concentrations from residential land use site DBR01 are higher than commercial land use site DBC02. The differences in bacteria concentrations across land use sampling sites were compared using t-test or Mann- Whitney Rank Sum test if data do not meet normality test. The results suggested significant difference in concentrations between the two sampling sites for both events and for all three microbiological parameters. Higher concentrations were found at the residential site (DBR01) than the commercial land use site (DBC02).

Sources:
Probable – Residential (Land use)
Potential – Commercial (Land use)
Possible -

53 - Chollas Storm Drain Characterization Study
Tetra Tech, City of San Diego
Purpose - To further characterize the City's storm drain system discharges during both wet and dry weather. This monitoring program evaluated the potential sources of the pollutants-of-concern (POCs) throughout the MS4 system and collected data to calibrate and validate preliminary wet weather runoff modeling efforts for the San Diego Bay TMDLs.

Results - The measured enterococcus and coliform concentrations generally showed large variations. The enterococcus concentrations showed a number of exceedances of the basin action level at a number of sites including several commercial and industrial sites and two residential sites. Fecal coliform concentrations were generally below action levels, with a few industrial and residential sites showing some exceedances. Total coliform concentrations showed a large number of exceedances at seven out of the ten sampling sites. The difference in bacteria concentrations across land use sampling sites was compared based on median concentrations and using the Mann-Whitney Rank Sum test (Table 7-4). The results suggested significant difference in concentrations among the sampling sites for both events and for all three microbiological parameters. Higher concentrations were found at two commercial (CHC07 and CHC12), industrial (CHI08) and two residential sites (CHR03 and CHR04).

Sources:
Probable – Commercial/Industrial (anthropogenic non-human sources; potential to probable), Commercial and industrial (land use)
Potential – Residential (land use)
Possible -

9 - Using Microbial Source Tracking to Support TMDL Development and Implementation
Tetra Tech, Inc. and Herrera Environmental Consultants
Purpose - Provides an overview of Microbial Source Tracking (MST) and how it can be used to support TMDL development and implementation. The document covers potential uses of MST, descriptions of common MST methods, factors for selecting an MST method and designing an MST study, and examples of MST studies used to support TMDL development or implementation.

Results – ID Study: The Bacteroides PCR results generally supported the PFGE results that wildlife was the predominant source of fecal bacteria in the sampled streams. The genetic fingerprinting showed that greater than 10 percent of the total E. coli colonies isolated were from dogs, and cats were almost 20 percent. In addition, there were two days on lower Hauser Creek when Idaho's primary contact water quality criterion for E. coli was exceeded, during which dogs were the source of over 40 percent of the isolates. Horses and cattle each did not exceed 10 percent of the total E. coli isolates; however, horses were greater than 15 percent of the E. coli isolates. Although humans made up 11 percent of the total E. coli colonies isolated on Right Fork Hauser Creek, only one E. coli colony was isolated from water samples collected on days when the water quality criterion was exceeded.

OR: Results indicated widespread contamination from ruminants (non-elk) and, in certain river segments of the Trask, Miami, and Tillamook Rivers and Holden Creek, significant contamination from humans.

NM: Overall, ribotyping results show the largest fraction of E. coli matched those found in avian sources, followed by canine, human/sewage, rodents, bovine, and equine. The source of approximately 9 percent of the E. coli could not be identified.

VA: MST Results indicate majority of sources derive from wildlife and livestock, followed by humans, and then pets.

NH: Ribotyping identified source species for 76% (19/25) of the E. coli isolates in the water samples. The remaining isolates (24%) could not be matched with certainty to patterns in the ribopattern database. Of the identified isolates, geese constituted the largest portion (52%) followed by livestock [sheep (12%) and cows (4%) for a total of 16%] and dogs (8%).

MI: During dry conditions, the human biomarker was present at all sites, except one site. The results were always negative for the human biomarker, giving a strong indication that E. coli from human sources was not impacting this site during dry conditions. Positive results for the other sites suggest that there are dry-weather sources of E. coli of human origin. These human sources of E. coli could include cross-connections between the sanitary and storm sewer systems, illicit discharges to storm sewers, failed on-site sewage disposal systems, and leaking sanitary sewers.

SD: Among the isolates for which the source could be identified, 26% were equine (horse) and 30% were ovine (sheep). Other identified animal sources include porcine (pig), bovine (cow), canine (dog), feline (cat) and human. Based on review of available information and communication with state and local authorities, the primary nonpoint sources of fecal coliform within the Beaver Creek watershed include agricultural runoff, as well as wildlife and human sources. Septic systems are assumed to be the primary human source of bacteria loads to Beaver Creek. The HSPF model was used to determine the contribution of fecal coliform bacteria from identified sources in the Beaver Creek watershed and evaluate the implementation of BMPs to control these sources.

Sources:
Probable – Geese (NH), avian (NM)
Potential – Non-specific source (human waste – NM, OR), sewage infrastructure (MI), illegal connections, domestic animals (NH, ID, NM), agriculture (OR), secondary wildlife (ID)
Possible -

37 - Monitoring Report for Bacterial Source Tracking Segments 0806, 0841, and 0805 of the Trinity River Bacteria TMDL
Texas Institute for Applied Environmental Research (TIAER)
http://repositories1.lib.utexas.edu/bitstream/handle/2152/7038/crwr_onlinereport08-08.pdf?sequence=2

Purpose - This report includes information on study area, characteristics, materials and methods of bacterial source tracking, and results and findings of the source tracking study.

Results – Overall, each of the source contributors showed a definite trend, whether positive or negative, as one moves downstream from Segment 0806, through Segment 0841, and into Segment 0805. The categories did show consistencies in source species. The avian category was consistently dominated by non waterfowl species, while the livestock category's contribution was shared by bovine and horses. Mammalian wildlife was found to be high in rodent species and raccoons, while the pet category was found to be consistently led by dogs.

Sources:
Probable – Non-specific source (human waste – potential to probable)
Potential - Pets and livestock, avian and mammals (wildlife)
Possible -

149 - Assessment of the Origins of Microbiological Contamination of Groundwater at a Rural Watershed in Chile
Mariela Valenzuela, M.A. Mondaca, M. Claret, C. Perez, B. Lagos, and O. Parra
http://www.scielo.org.mx/pdf/agro/v43n4/v43n4a10.pdf
Purpose - To improve the state of knowledge on the microbiological quality of groundwater at a rural watershed. Characterize the microbiological quality of the groundwater and to identify sources of contamination.

Results - The main source of fecal contamination is of animal origin, a diffuse one. Concentrations of bacterial indicators have a temporal basis showing variable levels among seasons, with a higher concentration in the rainy one. All 42 wells analyzed contained opportunistic pathogens.

167 - Bacterial pathogens in Hawaiian coastal streams-Associations with fecal indicators, land cover, and water quality
E.J. Viau, K.D. Goodwin, K.M. Yamahara, B.A. Layton, L.M. Sassoubre, S.L. Burns, H.I. Tong, S.H. Wong, and A.B. Boehm
http://www.sciencedirect.com/science/article/pii/S0043135411001448
Purpose - To understand the distribution of five bacterial pathogens in O'ahu coastal streams and relate their presence to microbial indicator concentrations, land cover of the surrounding watersheds, and physical-chemical measures of stream water quality.

Results - Results implicate streams as a source of pathogens to coastal waters. Future work is recommended to determine infectious risks of recreational waterborne illness related to O'ahu stream exposures and to mitigate these risks through control of land-based runoff sources.

146 - EFFECTS OF RUNOFF CONTROLS ON THE QUANTITY AND QUALITY OF URBAN RUNOFF AT TWO LOCATIONS IN AUSTIN, TEXAS

Clarence T. Welborn, and J.E. Veenhuis
http://pubs.usgs.gov/wri/1987/4004/report.pdf
Purpose - Determine if the rapid urban development in the Austin metropolitan area is causing an increase in the peak discharges from storm runoff and the degradation of the quality in receiving waters.

Results - Loads of most constituents and total densities of bacteria at the mall site were substantially larger in the inflow than in the outflow. The total densities of bacteria at the outflow were less by about 80 percent. Discharge weighted concentration data for Alta Vista indicate that the grass-covered swales and the grass-covered detention area had little or no effects on reducing concentrations or densities of most water-quality constituents.

Sources:
Probable – Residential, Industrial and Commercial Land Use(street, lawn and parking lot runoff)
Potential -
Possible -

14 - Tecolote Creek Microbial Source Tracking Summary Phases I, II, and III
Weston Solutions
Purpose - To investigate the bacterial sources, origins, and loads in the Tecolote Creek watershed and to assess and characterize specific priority activity contributions.

Results – Wet weather bacteria loads from individual land uses indicated that there were no significant differences between different land uses with flows merging and combining throughout drainage areas. There was some indication that higher loads were attributable to transportation corridors, commercial areas, and industrial land uses. Dry weather loads were higher in residential and commercial areas with specific activities identified as including poorly maintained dumpsters leaking high concentrations of indicator bacteria. A key transport mechanism found especially in commercial and industrial areas was over-irrigation. Residential areas were found to be abiding by water conservation recommendations, but this was not seen in commercial and industrial areas.

During dry weather, five positive Bacteroides samples were obtained. Each follow-up investigation failed to locate a point source; however, in every instance there was evidence of transient human activity. During wet weather, only 1 sample from a total of 37 samples collected over 9 storms was found to be positive for Bacteroides. This sample was collected during the early phase of the storm flows in an area known to be a transient area.

Biofilms on the walls of the MS4 system in particular were found to grow rapidly and contain high numbers of enterococci. Speciation of these enterococci determined that the origins were most likely environmental rather than fecal. Further investigation determined that the storm water, with high numbers of enterococci of fecal origin, was the primary inoculation mechanism but that biofilms matured rapidly into complex communities with a variety of species present. The high flows generated during wet weather were found to cause significant biofilm sloughing. The impact of biofilms on wet weather loads of indicator bacteria into receiving waters would

appear to be significant. Sediments and biofilms within the creek and MS4 system were found to be significant reservoirs.

Sources:
Probable - Biofilm (MS4 Infrastructure), Sediment and biofilms in Tecolote Creek, Sediment and biofilms in MS4 Infrastructure
Potential - MS4 Infrastructure (anthropogenic non-human sources) Land use (residential, commercial, schools, restaurants, nurseries, golf course, livestock & domestic animal, industrial, Open space/Parks/Recreation, transportation corridors)
Possible -

52 - Dry Weather Bacterial Source Identification Study in the Mouth of Chollas Creek
Weston Solutions and the City of San Diego
Purpose - 1. What are the sources and magnitudes of dry weather urban runoff and associated indicator bacteria that influence water quality at the mouth of Chollas Creek?
2. What BMPs may be put in place to reduce or eliminate the influence of dry weather urban runoff at the mouth of Chollas Creek?

Results - During dry weather, there is no hydrologic connection between the mouth of Chollas Creek (the area influenced by tidal action) and the upstream drainage. Thus, bacteria found in the receiving waters of the creek mouth originate from sources that discharge directly to the mouth (i.e., storm drains). The highest bacterial concentrations were associated with the two storm drains near the National Avenue Bridge. Concentrations of indicator bacteria associated with the other identified storm drains were lower, but still contributed to elevated concentrations in the receiving water in the south fork and main stem, respectively. Two sources of flow that contributed to the high bacterial concentrations were identified as (1) over-irrigation of landscaping at the strip mall located at National Avenue and 35th Street and (2) a freshwater slough adjacent to a freeway off ramp that periodically discharges to a storm drain in the south fork of the creek.

Sources:
Probable - Storm drains and scour ponds at storm drain outlet; MS4 infrastructure; human waste), over-irrigation (landscaping)
Potential – Non-specific source (Freshwater slough; non-anthropogenic)
Possible -

54 - Regional Harbor Monitoring Program Pilot Project 2005-08 Summary Final Report
Weston Solutions and the City of San Diego
Purpose - The core monitoring program assesses the conditions found in the harbors based on comparisons to historical reference values for the four harbors and comparisons of contaminant concentrations to known surface water and sediment thresholds using chemistry, bacterial, toxicology, and benthic infaunal community indicators.
Results - Based on the results of the Pilot Project, the following statements can be made: 1) All bacterial concentrations were well below AB 411 levels, 2) The majorities of the marina and

freshwater-influenced strata contained sediments that were not toxic, 3) Benthic infaunal communities in both strata occurred at intermediate levels of disturbance, 4) Toxicity levels in the marina sediments generally were better than harbor-wide historical conditions, 5) Toxicity levels and benthic infaunal communities did not differ between the two strata, and 6) From 2005-2007, no negative short-term trends were evident for any indicator that would be indicative of a degrading condition.

70 - 2009-2010 Coastal Storm Drain Monitoring Annual Report
Weston Solutions, Inc. and County of San Diego Copermittees
Purpose - To determine the impacts that storm drains have on coastal receiving waters.

Results - There were a total of 28 exceedances of the total coliform storm drain action level. Twelve sites had at least one exceedance for total coliform, of which 3 had a total coliform exceedance on multiple dates.

Sources:
Probable – Cats
Potential –Cows, horses, fox, cormorants,
Possible – Non-specific source (human waste), gulls (secondary wildlife), Wildlife (muskrats, raccoons, coyotes, rabbits, turkeys and geese)

74 - MICROBIAL SOURCE TRACKING IN TWO SOUTHERN MAINE WATERSHEDS Report Number: MSG-TR-04-03March 2004Merriland River, Branch Brook and Little River (MBLR) Watershed Report
Kristen Whiting-Grant, F. Dillon, C. Dalton, Dr. M. Dionne, and Dr. S. Jones
Purpose - This study focuses on the Merriland River, Branch Brook and Little River (MBLR) watershed in Wells, Kennebunk and Sanford Maine, where chronic and persistent bacterial contamination from unidentified sources has restricted shellfish harvesting.

Results - Cats were the most frequently identified single source of bacterial contamination (21%); followed by cow (11%); fox (7%); cormorant (5%); human, rabbit, muskrat, horse and gull (all at3%); turkey (2%); and goose, raccoon, coyote and dog (all at 1%). Also note that ribotypes for 35% of the bacteria samples analyzed by JEL could not be identified, which is to say that no clear matches could be established between ribotypes of known source species and ribotypes from unknown water samples.

Sources:
Probable – Cats
Potential –Cows, horses, fox, cormorants,
Possible – Non-specific source (human waste), gulls (secondary wildlife), Wildlife (muskrats, raccoons, coyotes, rabbits, turkeys and geese)

64 - Microbial Source Tracking in the Dungeness Watershed, Washington
D.L. Woodruff, N.K. Sather, V.I. Cullinan, and S.L. Sargeant
Purpose - To determine the sources of fecal coliform pollution that have been impacting the water quality and shellfish harvesting activities for more than a decade.

Results – The predominant sources of fecal coliform contamination in the Dungeness from all matrix types (e.g. water, sediment, wrack) in the freshwater and marine environments were, in rank order, avian (19.6%), gull (12.5%), waterfowl (9.7%), raccoon (9.2%), unknown (7.3%), human-derived (7.1%), rodent (6.3%) and dog (4.3%). When bird groups were combined, they represented in total about 42% of samples collected and analyzed throughout the study.

Sources:
Probable – Wildlife,
Potential - Non-specific source (human waste), domestic animals,
Possible -

44 - Quantitative Pathogen Detection and MST Combined with modeling of fate and transport of Bacteroidales in San Pablo Bay.
Stefan Wuertz, F. Bombardelli, K. Sirikanchana, A. Schriewer, and Z. Kaveh
Purpose - To develop a decision-making took in the form of a 3-D model to benefit coastal managers both in terms of pinpointing major sources of fecal pollution and maximizing the usefulness of any monitoring activity.

Results – Monitoring results indicated low-level general and human-derived fecal contamination in the bay, while cow- and dog-derived contamination was not detected, except for one sample which contained dog-specific genetic marker. Human viruses were also below the sample detection limit. The pollution was more likely to come from surrounding urban areas or wastewater treatment facilities than from agricultural farm land or wildlife areas.

Sources:
Probable – Non-specific source (human waste),
Potential -
Possible – Dogs and cows

232 - Indicator organism sources and coastal water quality: a catchment study on the island of Jersey
M.D. Wyer, D. Kay, G.F. Jackson, H.M. Dawson, J. Yeo, and L. Tanguy
http://www.ncbi.nlm.nih.gov/pubmed/7730205
Purpose - Compliance monitoring of bathing waters at La Grève de Lecq on the North coast of Jersey revealed a significant deterioration in water quality between 1992 and 1993, as indexed by presumptive coliform, presumptive Escherichia coli and streptococci concentrations. During the 1993 bathing season the beach failed to attain the compliance with the EC Guideline criteria for presumptive E. coli and streptococci.

Results - A bacteriological survey of the stream catchment draining to the beach revealed that: (i) concentrations of faecal indicator organisms were enhanced at high discharge after rainfall; and (ii) a captive water fowl population, which expanded between 1990 and 1993, was a potential source of faecal pollution.

233 - Beach sands along the California coast are diffuse sources of fecal bacteria to coastal waters
K.M. Yamahara, B.A. Layton, A.E. Santoro, and A.B. Boehm
http://pubs.acs.org/doi/abs/10.1021/es062822n
Purpose - The potential for FIB to be transported from the sand to sea was investigated at a single wave-sheltered beach with high densities of ENT in beach sand

Results - We collected samples of exposed and submerged sands as well as water over a 24 h period in order to compare the disappearance or appearance of ENT in sand and the water column. Exposed sands had significantly higher densities of ENT than submerged sands with the highest densities located near the high tide line. Water column ENT densities began low, increased sharply during the first flood tide and slowly decreased over the remainder of the study. During the first flood tide, the number of ENT that entered the water column was nearly equivalent to the number of ENT lost from exposed sands when they were submerged by seawater. The decrease in nearshore ENT concentrations after the initial influx can be explained by ENT die-off and dilution with clean ocean water. While some ENT in the water and sand at LP might be of human origin because they were positive for the esp gene, others lacked the esp gene and were therefore equivocal with respect to their origin.

58 - High-Throughput and Quantitative Procedure for Determining Sources of Escherichia coli in Waterways by Using Host-Specific DNA Marker Genes
Tao Yan, M.J. Hamilton, and M.J. Sadowsky
http://aem.asm.org/content/73/3/890.full.pdf+html
Purpose - The objective of the study was to evaluate a high-throughput, semi-automated, quantitative procedure for determining sources of *E. coli* in waterways by using host-specific DNA marker genes of geese and ducks and robot-assisted high-throughput technology. Although the objective was to evaluate the method, the seasonal goose/duck population as a bacteria source was evaluated at 2 lakes frequented with migratory goose/duck populations and an additional lake that is not frequented by migratory goose

Results - The relative contributions of fecal *E.coli* from the geese/ducks were estimated to be 34% and 51% in Lake Superior and Lake Calhoun, respectively and 0.28% at Lake Hartwell (which has no migratory goose population)

Sources:
Probable – Wildlife (Lake Calhoun, Lake Superior),
Potential -
Possible–Wildlife (Lake Hartwell which has no migratory goose populations)

NSC (Not Source Characterization) Studies

137 - Relationship between rainfall and beach bacterial concentrations on Santa Monica Bay beaches
Drew Ackerman and S. B. Weisberg
http://www.sccwrp.org:8060/pub/download/DOCUMENTS/AnnualReports/2001_02AnnualReport/18_ar37-drew.pdf
Purpose - To enhance the scientific foundation for preemptive public health warnings, examine the relationship between rainfall and beach indicator bacteria concentrations using five years of fecal coliform data taken daily at 20 sites in southern California.

Results - There was a clear relationship between the incidence of rainfall and reduction in beach bacterial water quality in Los Angeles County. Bacterial concentrations remained elevated for five days following a storm, although they generally returned to levels below state water quality standards within three days. The length of the antecedent dry period had a minimal effect on this relationship, probably reflecting a quickly developing equilibrium between the decay of older fecal material and the introduction of new fecal material to the landscape.

175 - Persistence and potential growth of the fecal indicator bacteria, Escherichia coli in shoreline sand at Lake Huron
E.W. Alm, J. Burke, and E. Hagan
http://www.bioone.org/doi/abs/10.3394/0380-1330%282006%2932%5B401:PAPGOT%5D2.0.CO;2
Purpose - This study was initiated to test the hypothesis that high abundances of the fecal indicator Escherichia coli in shoreline sand at freshwater beaches can be explained, at least in part, by the ability of E. coli to persist and grow in beach sand.

Results - In controlled laboratory microcosm studies using autoclaved beach sand inoculated with E. coli strains previously isolated from ambient beach sand, E. coli densities increased from 2 CFU/g to more than 2 × 105 CFU/g sand after 2 days of incubation at 19°C, and remained above 2 × 105 CFU/g for at least 35 days. In field studies utilizing similarly inoculated beach sand in diffusion chambers incubated at a Lake Huron beach, E. coli also grew rapidly, reaching high densities (approximately 7.5 × 105 CFU/g), and persisting in a cultivable state at high density for at least 48 days. In comparison, E. coli levels in ambient beach sand adjacent to the chambers always had densities <100 CFU/g. Lake Huron beach sand clearly provides nutrients, temperatures, and other conditions needed to support growth of E. coli. The growth of E. coli in sterile sand diffusion chambers to higher levels than occurs in ambient beach sand may indicate the presence in ambient sand of biological controls on bacterial growth, such as predation or competition.

59 - Host Species-Specific Metabolic Fingerprint Database for Enterococci and Escherichia coli and Its Application to Identify Sources of Fecal Contamination in Surface Waters
Warish Ahmed, R. Neller, and M. Katoulli
http://aem.asm.org/content/71/8/4461.full.pdf+html

Purpose - To characterize two fecal indicator bacteria, enterococci and E. coli, from different host groups (i.e., animal species) to develop a metabolic fingerprint database to identify the source(s) of fecal contamination in a creek in Australia.

Results - Out of 27 water samples:10% of the biochemical phenotypes (BPT) found for enterococci belonged to human origin, 61% belonged to animals tested. 13% of the BPTs found for E. coli belonged to human origin and 54% belonged to animals tested. The remaining BPT found for Enterococci and E. coli belonged to BPTs shared between humans and animals or did not match database

Sources:
Probable –Septic (human waste), animal farms (domestic animals), animal farms (agriculture),
Potential -
Possible -

80 - Persistence and Differential Survival of Fecal Indicator Bacteria in Subtropical Waters and Sediments

K.L. Anderson, J.E. Whitlock, and V.J. Harwood
http://aem.asm.org/content/71/6/3041.full.pdf+html
Purpose - Fecal coliforms and enterococci are indicator organisms used worldwide to monitor water quality. These bacteria are used in microbial source tracking (MST) studies, which attempt to assess the contribution of various host species to fecal pollution in water. Ideally, all strains of a given indicator organism (IO) would experience equal persistence (maintenance of culturable populations) in water; however, some strains may have comparatively extended persistence outside the host, while others may persist very poorly in environmental waters. Assessment of the relative contribution of host species to fecal pollution would be confounded by differential persistence of strains.

Results - IO persistence according to mesocosm treatment followed the trend: contaminated soil > wastewater > dog feces. E. coli ribotyping demonstrated that certain strains were more persistent than others in freshwater mesocosms, and the distribution of ribotypes sampled from mesocosm waters was dissimilar from the distribution in fecal material. These results have implications for the accuracy of MST methods, modeling of microbial populations in water, and efficacy of regulatory standards for protection of water quality. Saltwater had a negative effect on FC persistence, as the decay rates of FC (all inoculum sources combined) in saltwater sediments and water column were greater than those in freshwater. Saltwater also significantly increased enterococcal decay rates compared to freshwater. IO persistence tended to be greater in sediments than in the water column. The average decay rate of FC in sediments of freshwater mesocosms was significantly less than those in the water column, and the difference was nearly significantly at the $\alpha = 0.05$ level in saltwater ($P = 0.083$). Although decay rates of enterococci tended to be greater in the water column than in sediments, the difference was not significant in freshwater or saltwater mesocosms.

176 - Persistence and differential survival of fecal indicator bacteria in subtropical waters and sediments

K.L. Anderson, J.E. Whitlock, and V.J. Harwood

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1151827/

Purpose - This study utilized mesocosms designed to simulate natural conditions, which were inoculated with fecal material, to test the hypothesis that certain *E. coli* phylotypes exhibit greater persistence than others in aquatic environments.

Results - This study demonstrated a high degree of variability in the response of fecal indicator organisms to stresses in aquatic environments on all levels investigated. Responses to water type (saline versus fresh), location (sediment versus water column), and inoculum type all varied within and between indicator bacterial groups (FC and ENT). The discrepant results emphasize the difficulties encountered in attempting to regulate diverse types of water bodies by one regulatory standard. Also cautionary is the persistence of indicator organisms in sediments, which leads to elevation of their densities and a false indication of recent pollution in the water column after events such as rain storms, construction, or recreational use.

130 - LEVELS OF FECAL INDICATOR BACTERIA AT DOG BEACH AND NEARBY COASTAL BEACHES OF THE CITY OF SAN DIEGO, CA

Amir Baum

http://www.sandiegoriver.org/documents/baum_final_thesis.pdf

Purpose - An analysis of historical County of San Diego microbial marine water quality was conducted to quantitatively compare the levels of fecal indicator bacteria (FIB) levels at Dog Beach, located at the San Diego River Outlet, and nearby coastal beaches. Additionally, this study aimed to determine if relationships existed between daily average river flow/daily precipitation and FIB densities at Dog Beach and nearby coastal beach stations and if significant associations existed between daily precipitation and FIB single sample exceedances.

Results - The study found the strongest association between river flow, precipitation, and TC levels to be at river discharge points during wet months, but no significant association was found during dry weather. The study demonstrated that using a stratified-random sampling design, urban runoff outlets are a primary source of contaminated runoff with 90% of sites near urban runoff outlets failing water quality standards.

81 - Integrated Analysis of Established and Novel Microbial and Chemical Methods for Microbial Source Tracking

Anicet R. Blanch, L. Belanche-Muñoz, X. Bonjoch, J. Ebdon, C. Gantzer, F. Lucena, J. Ottoson, C. Kourtis, A. Iversen, I. Kühn, L. Mocé, M. Muniesa, J. Schwartzbrod, S. Skraber, G.T. Papageorgiou, H. Taylor, J. Wallis, and J. Jofre

http://aem.asm.org/content/72/9/5915.full.pdf+html

Purpose - The objectives of the present study were (i) to determine the most discriminant tracers showing wide and consistent geographical stability between all locations, (ii) to identify subsets of variables derived from tracers with the highest discriminant capacity, and (iii) to evaluate and

compare statistical or machine learning methods to develop predictive models for source tracking using the minimum number of these variables. In this multilaboratory study, different microbial and chemical indicators were analyzed in order to distinguish human fecal sources from nonhuman fecal sources using wastewaters and slurries from diverse geographical areas within Europe.

Results - Fecal coliforms, enterococci, clostridia, somatic coliphages, and total bifidobacteria were detected in almost all samples (other than a single sample in the case of total bifidobacteria) of both human and animal origin. They were more abundant in the animal samples than in the human samples, but this seems to be due to the higher fecal load of these samples, since relative densities were similar in both groups of samples.

21 - Enterococci Concentrations in Diverse Coastal Environments Exhibit Extreme Variability
A.R. Boehm
http://pubs.acs.org/doi/abs/10.1021/es071807v
Purpose - The study examines extreme temporal variations (periods between 1 min andZ4 h) in FIB concentrations in diverse marine coastal environments ranging from wave-sheltered to wave-exposed open ocean beaches.

Results - The high frequency variability indicates that regardless of sampling time, a single sample of water tells one little about the true water quality, so multiple samples need to be collected. If it is not feasible to collect multiple samples, then a spatially or temporally composited sample will improve the estimate of the true water quality.

157 - Methicillin-resistant Staphylococcus aureus (MRSA) in municipal wastewater: an uncharted threat?
S. Börjesson, A. Matussek, S. Melin, S. Löfgren, and P.E. Lindgren
http://www.mendeley.com/research/methicillinresistant-staphylococcus-aureus-mrsa-in-municipal-wastewater-an-uncharted-threat/#page-1
Purpose - (i) To cultivate methicillin-resistant Staphylococcus aureus (MRSA) from a full-scale wastewater treatment plant (WWTP), (ii) To characterize the indigenous MRSA-flora, (iii) To investigate how the treatment process affects clonal distribution and (iv) to examine the genetic relation between MRSA from wastewater and clinical MRSA.

Results - MRSA could be isolated on all sampling occasions, but only from inlet and activated sludge. The number of isolates and diversity of MRSA were reduced by the treatment process, but there are indications that the process was selected for strains with more extensive antibiotic resistance and PVL+ strains. The wastewater MRSA-flora had a close genetic relationship to clinical isolates, most likely reflecting carriage in the community.

158 - A seasonal study of the mecA gene and Staphylococcus aureus including methicillin-resistant S. aureus in a municipal wastewater treatment plant
S. Börjesson, S. Melin, A. Matussek, and P.E. Lindgren
http://www.loudounnats.org/pdf/09WRAseasonalstudyofmecASaureusandMRSAinafull-scaleWWTP.pdf
Purpose - Determine the effect of wastewater treatment processes on mecA gene concentrations, and the prevalence of S. aureus and MRSA over time. To achieve this a municipal wastewater treatment plant was investigated for the mecA gene, S. aureus and MRSA, using real-time PCR assays

Results - Using molecular methods and cultivation, MRSA was for the first time detected in a municipal activated sludge and trickling filter WWTP, but mainly in the early treatment steps, IN, PS and AS. The mecA gene and S. aureus could be detected throughout the year at all sampling sites. The wastewater treatment process reduces mecA gene concentrations, which can partly be explained by removal of biomass.

140 - Particle Associated Microorganisms in Stormwater Runoff
Michael Borst, and A. Selvakumar
http://www.epa.gov/ORD/NRMRL/pubs/600j03262/600j03262.pdf
Purpose - Investigate the effects of blending and chemical addition before analysis of the concentration of microorganisms in stormwater runoff play a significant role.

Results - Particle-associated microorganisms play an important, if often unmeasured, portion of the total organism count in stormwater. All organisms, except for E. coli, showed an increase in the measured concentration after blending samples at 22,000 rpm with or without the chemical mixture. Other than fecal streptococci, the organism concentrations decreased with the addition of the Camper's solution in both blended and unblended samples before analyses. There was a statistically significant interaction between the effects of Camper's solution and the effects of blending for all the organisms tested, except for total coliform. Blending did not alter the mean particle size significantly. The results show no correlation between increased total coliform, fecal coliform, and fecal streptococcus concentrations and the mean particle size.

87 - Direct comparison of four bacterial source tracking methods and use of composite data sets
E.A. Casarez, S.D. Pillai, J.B. Mott, M. Vargas, K.E. Dean and G.D. Di Giovanni
http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2672.2006.03246.x/pdf
Purpose - (i) To compare the identification ability of the four BST methods individually and in combination through the use of composite data sets and (ii) to evaluate the use of the developed data sets for the identification of faecal contamination sources in two Central Texas lakes suspected of being impacted by agricultural operations and dairy cattle.

Results - Best matching identification using the composite data set correctly identified 100% of the replicate QC cultures (precision), and had 100% accuracy for E. coli strain and source class

identification of the isolates. Therefore, the four-method composite performed better than any single method.

154 - Removal of bacterial indicators of fecal contamination in urban stormwater using a natural riparian buffer
M.J. Casteel, G. Bartow, S.R. Taylor, and P. Sweetland
http://www.lmtf.org/FoLM/Plans/Water/VistaGrande/Casteeletal_10icud_paper.PDF
Purpose - Determine if riparian buffers are able to remove bacterial indicators of fecal contamination and other microbial contaminants from intermittent, high-volume flows such as those encountered during storm events in heavily urbanized areas.

Results - Analysis of lake water showed that levels of Escherichia coli and total coliforms increased significantly during storm events, indicating the presence of nonpoint sources of fecal contamination in the area surrounding the lake.

134 - Population structure and persistence of Escherichia coli in ditch sediments and water in the Seven Mile Creek Watershed
Ramyavardhanee Chandrasekaran
http://conservancy.umn.edu/bitstream/108879/1/Chandrasekaran_Ramyavardhanee_May2011.pdf
Purpose - Examined the population structure of E. coli and determined whether ditch sediments can serve as reservoirs of environmental E. coli in the Seven Mile Creek (SMC) watershed, a minor watershed located in south central Minnesota

Results - Further analysis of the count data revealed a strong correlation between E. coli concentrations and temperature profile at the SMC. E. coli densities in SMC water samples exceeded the permissible Minnesota standard (126 CFU/100 ml) predominantly during summer and fall seasons. In addition to temperature, rainfall also drastically influenced the dynamics and distribution of E. coli populations at the SMC. Results suggest that the seasonal variation in E. coli counts observed in water and sediments are most likely related to temperature, rainfall, and the patchy distribution of E. coli within sampling locations

88 - Relative Decay of Bacteroidales Microbial Source Tracking Markers and Cultivated Escherichia coli in Freshwater Microcosms
Linda K. Dick, Erin A. Stelzer, Erin E. Bertke, Denise L. Fong, and Donald M. Stoeckel
http://aem.asm.org/content/76/10/3255.full.pdf+html
Purpose - Fecal indicator bacteria (FIB), commonly used to regulate sanitary water quality, cannot discriminate among sources of contamination. The use of alternative quantitative PCR (qPCR) methods for monitoring fecal contamination or microbial source tracking requires an understanding of relationships with cultivate FIB, as contamination ages under various conditions in the environment. In this study, the decay rates of three Bacteroidales 16S rRNA gene markers (AllBac for general contamination and qHF183 and BacHum for human-associated contamination) were compared with the decay rate of cultivated Escherichia coli in river water microcosms spiked with human wastewater.

Results - A major finding of this study was that HF marker decay was consistent with, or significantly faster than, that of E. coli under all treatments. This indicates that the HF markers might be useful as conservative estimators of human origin E. coli even as fecal contamination ages in the environment.

118 - Bacteriological Quality of Runoff Water from Pastureland
J.W. Doran, and D.M. Linn
http://aem.asm.org/content/37/5/985.abstract
Purpose - Determine the bacteriological characteristics of pasture runoff and to compare them with runoff from an ungrazed area.

Results - We found no relationship between FC and FS counts in rainfall runoff and either rainfall or total runoff for most events. Bacteriological quality of snowmelt runoff. During the 3-year study, there were 10 snowmelt runoff events-two in 1976 and 8 in 1978. The levels of TC in snowmelt runoff from both grazed and ungrazed pasture areas exceeded recommended water quality standards . FC counts, often considered a better index of fecal contamination, were within recommended standards.

89 - Microbial source tracking using host specific FAME profiles of fecal coliforms
Metin Duran, Berat Z. Haznedaroglu, and Daniel H. Zitomer
http://www.prairieswine.com/pdf/3397.pdf
Purpose - The objective of this study was to investigate the host-specific differences in fatty acid methyl ester (FAME) profiles of fecal coliforms (FC).

Results - The results presented here provide further evidence that FAME profiles of indicator organisms have statistically significant host specificity and suggest that these differences may be useful in predicting sources of microbial pollution in water environments. However, more research is needed to determine the mechanisms causing the host specificity and to assess the possible temporal and spatial variations in FAME profiles before FAME can be applied in the field.

183 - Quantitative evaluation of enterococci and Bacteroidales released by adults and toddlers in marine water
S.M. Elmir, T. Shibata, H.M. Solo-Gabriele, C.D. Sinigalliano, M.L. Gidley, G. Miller, L.R.W. Plano, J. Kish, K. Withum, and L.E. Fleming
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2761526/
Purpose - The main objectives of the this study were to measure shedding of enterococci and Bacteroidales using traditional and emerging laboratory methods, and to evaluate shedding from toddlers and adults. The added value of the current study was the evaluation of shedding from toddlers (all prior studies used adult volunteers), and the use of additional methods of fecal indicator bacteria analyses (i.e. enterococci by CS and qPCR, and Bacteroidales by qPCR) as no data are available which directly measure fecal indicator bacteria shedding using these alternate methods.

Results - Human bathers have the potential to release significant amounts of fecal indicator bacteria into the water column via direct shedding off their body and via sand transported by their skin. Direct shedding from the body can include releases from fecally contaminated body areas and skin, and releases from fecally contaminated diapers. In this study, the quantity of enterococci released was a function of bathing cycle, sand exposure, beach sand contamination levels, and microbial flora variations between swimmers.

182 - Quantitative evaluation of bacteria released by bathers in a marine water
S.M Elmir, M.E. Wright, A. Abdelzaher, H.M. Solo-Gabriele, L.E. Fleming, G. Miller, M. Rybolowik, M.T. Peter Shih, S.P. Pillai, J.A. Cooper and E.A. Quaye
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2633726/
Purpose - This study focused on estimating the amounts of enterococci and S. aureus shed by bathers directly off their skin and indirectly via sand adhered to skin.

Results - This study demonstrated that bathers shed significant concentrations of enterococci and S. aureus into the water column and that S. aureus was shed at concentrations at least one order of magnitude greater than enterococci. This study also showed that total enterococci and S. aureus released by bathers decreased significantly between bathing episodes, in particular after the first wash cycle. This conclusion agrees with the long standing universal requirement that bathers should shower before entering recreational waters to reduce the microbial load in particular at swimming pools since the water volume is limited. It is concluded from this study that the enterococci contribution from sand adhered to skin, was small relative to the amount shed directly from the skin and represented less than 5% of the total enterococci shed by bathers.

159 - Staphylococcus aureus and fecal indicators in Egyptian coastal waters of Aqaba Gulf, Suez Gulf, and Red Sea
M.A. El-Shenawy
http://www.nodc-egypt.org/contacts_files/vol-31-2/Volume%2031%20%282%29%202005.PDF/9/Text.pdf
Purpose - Study the hygienic status of Egyptian coastal waters of Aqaba Gulf, Suez Gulf and Red Sea. The possibility of using *S.aureus* as supplementary indicator to the conventional bacterial indicators was another goal.

Results - 107 samples (53.5 %) of the 200 total examined samples were found to harbour S aureus exceeding the aforementioned guide standards. The present results concluded that addition of S. aureus as supplementary indicator to the conventional fecal indications may be useful for judging the marine water quality in Red Sea region.

138 - Sediment Bacterial Indicators in an Urban Shellfishing Subestuary of the Lower Chesapeake Bay
Carl W. Erkenbrecher Jr.
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC244041/pdf/aem00190-0106.pdf

Purpose - Historically, the Lynnhaven, an urban shellfishing estuary of the lower Chesapeake Bay region, has been opened and closed periodically to shellfishing during the past 40 years due to high fecal coliform counts. Document the spatial and temporal distributions and compositions of bacteria in the sediments and overlying waters of an important urban shellfishing area in the lower Chesapeake Bay region, the Lynnhaven Estuary.

Results - Densities of all indicator bacteria were always significantly higher in the sediments than in the overlying subsurface waters. The major problems inherent in this system are nonpoint in their origin. The primary sources of the Lynnhaven's bacterial pollution appeared to be typical of urban and agricultural runoff, although failure of septic tank systems was suspected as a problem in the Lynnhaven's western branch. These results illustrated that sediments in shellfishing areas could serve as a reservoir for high densities of indicator bacteria and that, potentially, pathogens could pose a health hazard.

184 - Enumeration and speciation of enterococci found in marine and intertidal sediments and coastal water in southern California
D.M. Ferguson, D.F. Moore, M.A. Getrich, and M.H. Zhowandai
http://www.ochealthinfo.com/docs/public/h2o/Enumeration-speciation.pdf
Purpose - To determine the levels and species distribution of enterococci in intertidal and marine sediments and coastal waters at two beaches frequently in violation of bacterial water standards.

Results - High levels of Enterococcus in intertidal sediments indicate retention and possible regrowth in this environment. Significance and Impact of the Study: Re-suspension of enterococci that are persistent in sediments may cause beach water quality failures and calls into question the specificity of this indicator for determining recent faecal contamination.

90 - Comparison of Bacteroides-Prevotella 16S rRNA Genetic Markers for Fecal Samples from Different Animal Species
Lisa R. Fogarty and Mary A. Voytek
http://aem.asm.org/content/71/10/5999.full.pdf+html
Purpose - The goals of this study were to compare Bacteroides-Prevotella populations from nine host species collected at multiple geographical locations and to determine if unique populations could be identified for each host species that could be used to develop markers for fecal source tracking.

Results - Results support the use of molecular techniques to characterize Bacteroides-Prevotella populations as a means to improve the ability to track sources of fecal contamination, but also show the need for more development of these methods.

186 - Abundance and characteristics of the recreational water quality indicator bacteria Escherichia coli and enterococci in gull faeces
L.R. Fogarty, S.K. Haack, M.J. Wolcott, and R.L. Whitman
http://cws.msu.edu/documents/FogartyetalJAM2003.pdf

Purpose - To evaluate the numbers and selected phenotypic and genotypic characteristics of the faecal indicator bacteria Escherichia coli and enterococci in gull faeces at representative Great Lakes swimming beaches in the United States.

Results - Gull faeces could be a major contributor of E. coli (105–109 CFU g)1) and enterococci (104– 108 CFU g)1) to Great Lakes recreational waters. E. coli and enterococci in gull faeces are highly variable with respect to their genotypic and phenotypic characteristics and may exhibit temporal or geographic trends in these features.

162 - A preliminary investigation of fecal indicator bacteria, human pathogens, and source tracking markers in beach water and sand
K.D. Goodwin, L. Matragrano, D. Wanless, C. Sinigalliano, and M.J. LaGier
http://yyy.rsmas.miami.edu/groups/ohh/projects/microbesresearch/GoodwinERK2_4.pdf
Purpose - Data suggesting that fecal indicating bacteria may persist and/or regrow in sand has raised concerns that fecal indicators may become uncoupled from sources of human fecal pollution. To investigate this possibility, wet and dry beach sand, beach water, riverine water, canal water, and raw sewage samples were screened by PCR for certain pathogenic microbes and molecular markers of human fecal pollution.

Results - Overall, this analysis pointed to the need to find better methods of extracting nucleic acids from environmental samples in order to reduce the possibility of false negative results. High quality nucleic acids need to be consistently and efficiently delivered to the detector system if the relationship between fecal indicators and human pathogens and human source tracking markers is to be elucidated.

93 - Comparing Wastewater Chemicals, Indicator Bacteria Concentrations, and Bacterial Pathogen Genes as Fecal Pollution Indicators
Sheridan K. Haack, Joseph W. Duris, Lisa R. Fogarty, Dana W. Kolpin, Michael J. Focazio, Edward T. Furlong, and Michael T. Meyer
https://www.crops.org/publications/jeq/pdfs/38/1/248
Purpose - Compare fecal indicator bacteria (FIB) (fecal coliforms, Escherichia coli [EC], and enterococci [ENT]) concentrations with a wide array of typical organic wastewater chemicals and selected bacterial genes as indicators of fecal pollution in water samples collected at or near 18 surface water drinking water intakes.

Results - In our study, which examined ambient waters in various land use environments with a wide range of FIB concentrations, fecal pollution was indicated by gene-based and/or chemical-based markers for 14 of the 18 tested samples, with little relation to FIB standards.

95 - Development of Goose- and Duck-Specific DNA Markers To Determine Sources of Escherichia coli in Waterways
Matthew J. Hamilton, Tao Yan, and Michael J. Sadowsky
http://aem.asm.org/content/72/6/4012.full.pdf+html

Purpose - The development and validation of host source-specific genetic markers for E. coli strains originating from Canada geese (*Branta canadensis*).

Results - SSH was successfully used to identify seven DNA markers with high levels of hybridization specificity for E. coli strains originating from geese. Combined, the marker DNAs were capable of identifying about 76% of the goose E. coli strains examined and 73% of the duck E. coli strains examined.

192 - Waterfowl Abundance Does Not Predict the Dominant Avian Source of Beach Escherichia coli
D.L. Hansen, S. Ishii, M.J. Sadowsky, and R.E. Hicks
https://www.soils.org/publications/jeq/abstracts/40/6/1924?access=0&view=pdf
Purpose - The horizontal, fluorophore enhanced, rep-PCR (HFERP) DNA fingerprinting technique was used to identify potential sources of Escherichia coli in water, nearshore sand, and sediment at two beaches in the Duluth-Superior Harbor, near Duluth, MN, and Superior, WI, during May, July, and September 2006.

Results - Waterfowl, including Canada geese, ring-billed gulls, and mallard ducks, were the largest source of E. coli that could be identified in water (55–100%), sand (59–100%), and sediment (92–100%) at both beaches. Although ring-billed gulls were more abundant in this harbor, Canada geese were usually the dominant source of waterfowl E. coli found at these beaches.

96 - Validation and field testing of library-independent microbial source tracking methods in the Gulf of Mexico
Valerie J. Harwood, Miriam Brownell, Shiao Wang, Joe Lepo, R.D. Ellender, Abidemi Ajidahun, Kristen N. Hellein, Elizabeth Kennedy, Xunyan Ye, and Christopher Flood
http://www.usm.edu/bst/pdf/Water%20Res%202009.pdf
Purpose - Standardize and validate MST methods across laboratories in coastal Gulf of Mexico states.

Results - An SOP was developed that allowed simultaneous purification of DNA for viral and bacterial markers, and gave comparable results among three laboratories. The method performance was generally similar whether it was conducted in buffer, fresh water or salt water; however, the human Bacteroidales method had a lower limit of detection in buffer and in salt water compared to fresh water.

97 - Fidelity of bacterial source tracking: Escherichia coli vs. Enterococcus spp. and minimizing assignment of isolates from non-library sources
W.M. Hassan, R.D. Ellender and S.Y. Wang
http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2672.2006.03077.x/pdf
Purpose - Improve the fidelity of library-dependent bacterial source tracking efforts in determining sources of faecal pollution.

Results - The use of enterococci provides higher rates of correct source assignment compared with E. coli. The use of similarity thresholds to decide whether to accept source assignments made by computer programmes reduces the rate of mis-assignment of non-library isolates.

197 - Contact with beach sand among beachgoers and risk of illness
C. D. Heaney, E. Sams, S. Wing, S. Marshall, K. Brenner, A.P. Dufour, and T.J. Wade
http://aje.oxfordjournals.org/content/170/2/164.full.pdf
Purpose - The purpose of this study is to better understand the illness risk associated with beach sand that can harbor high concentrations of fecal indicator organisms, as well as fecal pathogens.

Results - The results of our study suggest that, among beachgoers participating in a large prospective cohort study at beaches nearby sewage treatment discharges, reported contact with beach sand (defined as either digging in the sand or having one's body buried in the sand) was associated with an elevated risk of enteric illnesses (gastrointestinal illness and diarrhea). Being buried in the sand was more strongly associated with enteric illness than was digging in the sand. We also observed a higher proportion of people who got sand in their mouth among those buried in the sand (40%) compared with those who dug in the sand (20%).

155 - The Impact of Rainfall on Fecal Coliform Bacteria in Bayou Dorcheat (North Louisiana)
Dagne D. Hill, W.E. Owens, and P.B. Tchounwou
www.mdpi.com/1660-4601/3/1/114/pdf
Purpose - Assess the effect of surface runoff amounts and rainfall amount parameters on fecal coliform bacterial densities in Bayou Dorcheat in Louisiana.

Results - Nonpoint source pollution that is carried by surface runoff has a significant effect on bacterial levels in water resources.

199 - Beach sand and sediments are temporal sinks and sources of Escherichia coli in Lake Superior
Satoshi Ishii, D.L. Hansen, R.E. Hicks, and M.J. Sadowsky
http://pubs.acs.org/doi/pdf/10.1021/es0623156
Purpose - Report on a 2-year investigation of the seasonal variation of E. coli concentrations in water, sand, and sediment at the DBC Beach in the Duluth-Superior Harbor of Lake Superior.

Results - Waterfowl in addition to humans can be a significant source of fecal indicator bacteria like E. coli at Great Lakes beaches. Although waterfowl have been reported to carry a limited number of pathogenic E. coli (36), which was also found our study, they may harbor other potential pathogens such as Salmonella and Campylobacter (37). The potential health risks associated with waterfowl-borne bacteria found at beaches needs to be investigated in the future.

122 - Fecal bacteria and sex hormones in soil and runoff from cropped watersheds amended with poultry litter
Michael B. Jenkins, D.M. Endale, H.H. Schomberg, and R.R. Sharpe
http://phoenix.nal.usda.gov/bitstream/10113/15527/1/IND44044786.pdf
Purpose - Determine if applications of poultry litter to small watersheds would contribute to the load of fecal bacteria and sex hormones to soil and runoff

Results - Under the conditions of drought and conservation tillage, the rates at which we applied poultry litter to the four cropped watersheds appeared to have little or no significant effect on (a) soil community of fecal indicator bacteria, (b) concentrations of estradiol and testosterone in surface soil, and (c) quantities of estradiol and testosterone coming off the watersheds with runoff.

202 - Bacteroidales Diversity in Ring-Billed Gulls (*Laurus delawarensis*) Residing at Lake Michigan Beaches
S.N. Jeter, C.M. McDermott, P.A. Bower, J.L. Kinzelman, M. J. Bootsma, G.W. Goetz, and S.L. McLellan
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2655448/pdf/2261-08.pdf
Purpose - This study investigated the occurrence and diversity of Bacteroidales fecal bacteria in gulls residing in the Great Lakes region.

Results - A total of 467 gull fecal samples from five coastal beaches spanning Lake Michigan's western shore and one inland beach on Lake Winnebago were screened for the presence of Bacteroidales by PCR. There was a low but consistent occurrence of Bacteroidales in the gull populations at these beaches.

151 - The Impact of Annual Average Daily Traffic on Highway Runoff Pollutant Concentrations
Masoud Kayhanian, A. Singh, C. Suverkropp, and S. Borroum
http://escholarship.org/uc/item/86f8c8n8
Purpose - Evaluate correlations between annual average daily traffic and storm water runoff pollutant concentrations generated from California Department of Transportation highway sites.

Results - No direct linear correlation was found between highway runoff pollutant mean concentrations and AADT. However, through multiple regression analyses, it was shown that AADT has an influence on most highway runoff constituent concentrations, in conjunction with factors associated with watershed characteristics and pollutant build-up and wash off.

102 - Development of Bacteroides 16S rRNA Gene TaqMan-Based Real-Time PCR Assays for Estimation of Total, Human, and Bovine Fecal Pollution in Water
Alice Layton, Larry McKay, Dan Williams, Victoria Garrett, Randall Gentry, and Gary Sayler
http://aem.asm.org/content/72/6/4214.full.pdf+html

Purpose - Design real-time PC assay to target Bacteroides species (AllBac) present in human, cattle, and equine feces.

Results - This assay was shown empirically to be proportional to the concentration of human, bovine, and equine feces in water and thus can be used to estimate fecal concentrations without calculating the number of Bacteroides cells in the sample. The simplicity of performing these assays by direct PCR of water samples suggests that these assays may be field deployable and thus would aid data collection in watersheds with inherently high spatial and temporal variabilities.

203 - Persistence of fecal indicator bacteria in Santa Monica Bay beach sediments
C.M. Lee, T.Y. Lin, C.C. Lin, G.A. Kohbodi, A. Bhatt, R. Lee, and J.A. Jay
http://www.sciencedirect.com/science/article/pii/S004313540600220X
Purpose - This study involved monitoring the fecal indicator bacteria (FIB) levels in water and sediment at three ocean beaches (two exposed and one enclosed) during a storm event, conducting laboratory microcosm experiments with sediment from these beaches, and surveying sediment FIB levels at 13 beaches (some exposed and some enclosed).

Results - Results from microcosm experiments showing similar, dramatic growth of FIB in both overlying water and sediment from all beaches, as well as results from the beach survey, support the hypothesis that the quiescent environment rather than sediment characteristics can explain the elevated sediment FIB levels observed at enclosed beaches. This work has implications for the predictive value of FIB measurements, and points to the importance of the sediment reservoir.

205 - Phylogenetic Diversity and Molecular Detection of Bacteria in Gull Feces
J. Lu, J.W. Santo Domingo, R. Lamendella, T. Edge, and S. Hill
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2446513/
Purpose - To determine the occurrence of *C. marimammalium* in waterfowl, species-specific 16S rRNA gene PCR and real-time assays were developed and used to test fecal DNA extracts from different bird (n = 13) and mammal (n = 26) species.

Results - To determine the occurrence of *C. marimammalium* in waterfowl, species-specific 16S rRNA gene PCR and real-time assays were developed and used to test fecal DNA extracts from different bird (n = 13) and mammal (n = 26) species.

103 - Genetic Diversity of Escherichia coli Isolated from Urban Rivers and Beach Water
Sandra L. McLellan
http://aem.asm.org/content/70/8/4658.full.pdf+html
Purpose - Evaluate the genetic profiles of E. coli strains found in stormwater, where fecal pollution is derived from multiple uncharacterized host sources, and compare these profiles to known host sources of pollution.

Results - There does not appear to be a proportional relationship between fecal indicator bacteria from a host and what is actually detected in the environment, which will be an important consideration when developing methods for fecal pollution source tracking. Matching of isolates to the entire data set demonstrated that strains from a type of sample (e.g., gull, sewage, stormwater, river water, beach water) were most similar to other strains from the same host or environmental source. These findings may be a function of geographic distribution rather than host source specificity.

126 - Identification and Quantification of Bacterial Pollution At Milwaukee County Beaches

Sandra L. McLellan, and E.T. Jensen

http://www.glwi.freshwater.uwm.edu/research/genomics/ecoli/media/Technical%20document%209-12-05.pdf

Purpose - Assess the bacterial contaminant load in the waters and sand at beaches within Milwaukee County.

Results - Bacterial water data collected during the summer 2005 beach surveys suggests a positive relationship between rainfall and increased E. coli levels at these particular beach sites. Sewage contamination could potentially reach the beach during combined sewage overflows, or from nearby sewer infrastructure failures.

104 - Evaluation of Repetitive Extragenic Palindromic-PCR for Discrimination of Fecal Escherichia coli from Humans, and Different Domestic and Wild Animals

Bidyut Mohapatra, Klaas Broersma, Rick Nordin and Asit Mazumder

http://web.uvic.ca/~h2o/publications/Mohapatra%20et%20al.%20MI07pdf.pdf

Purpose - Investigate the potential of rep-PCR in differentiating e. coli isolates of human, domestic and wild animal origin that might be used as a molecular tool to identify the possible source(s) of fecal pollution of source water.

Results - Rep-PCR DNA fingerprinting results provide evidence about the robustness of this method, and it's simple and cost-effective screening tool to isolate and track non-point sources of fecal contamination.

106 - Evaluation of antibiotic resistance analysis and ribotyping for identification of faecal pollution sources in an urban watershed

D.F. Moore, V.J. Harwood, D.M. Ferguson, J. Lukasik, P. Hannah1, M. Getrich and M. Brownell

http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2672.2005.02612.x/pdf

Purpose - The accuracy of ribotyping and antibiotic resistance analysis (ARA) for prediction of sources of faecal bacterial pollution in an urban Southern California watershed was determined using blinded proficiency samples. Low rates of correct classification for E. coli proficiency isolates compared with the ARCCs of the libraries indicate that testing of bacteria from samples that are not represented in the library, such as blinded proficiency samples, is necessary to

accurately measure predictive ability. The library-based MST methods used in this study may not be suited for determination of the source(s) of faecal pollution in large, urban watersheds.

Results - None of the methods performed well enough on the proficiency panel to be judged ready for application to environmental samples.

210 - Species distribution and antimicrobial resistance of enterococci isolated from surface and ocean water
D.F. Moore, J.A. Guzman, and C. McGee
http://www.glin.net/lists/beachnet/2008-05/pdf00000.pdf
Purpose - The species identification and antimicrobial resistance profiles were determined for enterococci isolated from Southern California surface and ocean waters.

Results - *Enterococcus faecalis, E. faecium, E. casseliflavus and E. mundti* are the most commonly isolated Enterococcus species from urban runoff and receiving waters in Southern California.

107 - A review of technologies for rapid detection of bacteria in recreational waters
Rachel T. Noble and Stephen B. Weisberg
http://www.environmental-expert.com/Files%5C19961%5Carticles%5C6674%5C479_rapid_detection_recreational_waters.pdf
Purpose - Review new methods that have the potential to reduce measurement period for fecal indicator bacteria from more than a day to less than an hour to reduce risk of swimmers to fecal bacteria.

Results - Enzyme substrate methods are most likely to be the first rapid methods adopted for recreational water quality. Enzymatic substrate methods are based on the same capture technology as currently-approved EPA methods, with greater speed attained through enhanced detection technology. As such, the relationship to health risk can be established by demonstrating that the new detection capability produces equivalent results to existing procedures.

214 - Comparison of total coliform, fecal coliform, and enterococcus bacterial indicator response for ocean recreational water quality testing
Rachel T. Noble, D.F. Moore M.K. Leecaster, C.D. McGee, and S.B. Weisberg
http://www.ochealthinfo.com/docs/public/epi/h2o/Water-Research-Publication-2003.pdf
Purpose - To compare the relationship between the bacterial indicators, and the effect that changing the standards would have on recreational water regulatory actions, three regional studies were conducted along the southern California shoreline from Santa Barbara to San Diego, California.

Results - Cumulatively, our results suggest that replacement of a TC standard with an EC standard will lead to a five-fold increase in failures during dry weather and a doubling of failures

during wet weather. Replacing a TC standard with one based on all three indicators will lead to an eight-fold increase in failures. Changes in the requirements for water quality testing have strong implications for increases in beach closures and restrictions.

217 - Relationships between sand and water quality at recreational beaches
M.C. Phillips, H.M. Solo-Gabriele, A.M. Piggot, J.S. Klaus and Y. Zhang
http://www.sciencedirect.com/science/article/pii/S0043135411006269
Purpose - Enterococci are used to assess the risk of negative human health impacts from recreational waters. Studies have shown sustained populations of enterococci within sediments of beaches but comprehensive surveys of multiple tidal zones on beaches in a regional area and their relationship to beach management decisions are limited.

Results - We sampled three tidal zones on eight South Florida beaches in Miami-Dade and Broward counties and found that enterococci were ubiquitous within South Florida beach sands although their levels varied greatly both among the beaches and between the supratidal, intertidal and subtidal zones.

218 - Shedding of Staphylococcus aureus and methicillin-resistant Staphylococcus aureus from adult and pediatric bathers in marine waters
L.R.W. Plano, A.C. Garza, T. Shibata, S.M. Elmier, J. Kish, C.D. Sinigalliano,M.L. Gidley, G. Miller, K. Withum, L.E. Fleming, and H.M. Solo-Gabriele
http://www.biomedsearch.com/attachments/00/21/21/10/21211014/1471-2180-11-5.pdf
Purpose - The primary aim of this study was to evaluate the amount and characteristics of the shedding of methicillin sensitive S. aureus, MSSA and MRSA by human bathers in marine waters.

Results - Twelve of 15 MRSA isolates collected from the water had identical genetic characteristics as the organisms isolated from the participants exposed to that water while the remaining 3 MRSA were without matching nasal isolates from participants. The amount of S. aureus shed per person corresponded to 105 to 106 CFU per person per 15-minute bathing period, with 15 to 20% of this quantity testing positive for MRSA. These findings clearly demonstrate that adults and toddlers shed their colonizing organisms into marine waters and therefore can be sources of potentially pathogenic S. aureus and MRSA in recreational marine waters. Additional research is needed to evaluate recreational beaches and marine waters as potential exposure and transmission pathways for MRSA.

111 - A comparison of ARA and DNA data for microbial source tracking based on source-classification models developed using classification trees
Bertram Price, Elichia Venso, Mark Frana, Joshua Greenberg, and Adam Ware
http://faculty.salisbury.edu/~mffrana/Cell%20Biol%20Spring%2008/Frana%20paper,%20after.pdf

Purpose - Determine whether increased reliability, if any, of library-based MST developed with DNA data is sufficient to justify its higher cost, where source predictions are used in TMDL surface water management programs.

Results - While the overall rates of correct classification are higher for the DNA data than for the ARA data, the resulting source predictions for both data indicate similar TMDL surface water bacterial contamination reduction strategies. Questioning the value of DNA data relative to ARA data for MST intended for application in a TMDL program is justified, and the answer may favor ARA data for this application.

112 - Quantitative PCR Method for Sensitive Detection of Ruminant Fecal Pollution in Freshwater and Evaluation of This Method in Alpine Karstic Regions
Georg H. Reischer, David C. Kasper, Ralf Steinborn, Robert L. Mach, and Andreas H. Farnleitner
http://aem.asm.org/content/72/8/5610.full.pdf+html
Purpose - Establish a method for the sensitive quantification of ruminant fecal pollution in spring water and groundwater from alpine karstic regions important for public water supplies. Identify a ruminant-specific genetic marker in fecal members of the phylum Bacteroidetes.

Results - The marker could be found at concentrations ranging from not detectable in 4.5 liters (KPAS) to 106 marker equivalents per liter (LKAS2 flood). Strong differences in occurrence were obvious and in accordance with the expected different levels of ruminant fecal.

Preliminary experiments testing the stability of the marker in highly diluted fecal suspensions in spring water at ambient temperatures (4°C) found no strong reduction of detectable marker levels during an incubation period of 2 months.

After additional evaluation, the assay might allow the specific allocation of fecal pollution in alpine water sources, enabling target oriented measures in the catchment area and thus facilitating watershed management. Furthermore, it could also provide additional information for quantitative microbial risk assessment studies as part of water safety plans recommended by the WHO (35), allowing the relative estimation of ruminant fecal input compared to other sources.

164 - Pathogenic fungi: an unacknowledged risk at coastal resorts? New insights on microbiological sand quality in Portugal
R. Sabino, C. Verissimo, M.A. Cunha, B. Wergikoski, F.C. Ferreira, R. Rodrigues, H. Parada, L. Falcão, L. Rosado, C. Pinheiro, E. Paixão, and J. Brandão
http://www.sciencedirect.com/science/article/pii/S0025326X11001962
Purpose - Determine the presence of yeasts, pathogenic fungi, dermatophytes, total coliforms, Escherichia coli and intestinal enterococci in sand at thirty-three beaches across Portugal.

Results - Results showed that 60.4% of the samples were positive for fungi and that 25.2% were positive for the bacterial parameters. The most frequent fungal species found were Candida sp. and Aspergillus sp., whereas intestinal enterococci were the most frequently isolated bacteria.

Positive associations were detected among analyzed parameters and country-regions but none among those parameters and sampling period. Regarding threshold values, we propose 15 cfu/g for yeasts, 17 cfu/g for potential pathogenic fungi, 8 cfu/g for dermatophytes. Eighty four cfu/g for coliforms, 250 cfu/g for E. coli, and 100 cfu/g for intestinal enterococci.

114 - The use of ribotyping and antibiotic resistance patterns for identification of host sources of Escherichia coli strains

M. Samadpour, M.C. Roberts, C. Kitts, W. Mulugeta and D. Alfi

http://onlinelibrary.wiley.com/doi/10.1111/j.1472-765X.2004.01630.x/pdf

Purpose - To compare antibiotic resistance and ribotyping patterns ability to identify triplicate isolates sent from a group of 40 Escherichia coli taken from seven host sources.

Results - Of the 120 isolates, 22 isolates were resistant to ampicillin, streptomycin, tetracycline and trimethoprim and 98 isolates were susceptible. Antibiotic patterns identified 33 of the triplicates and three of the six groups had isolates from multiple hosts. Ribotyping divided the isolates into 27 ribotype groups with all triplicates grouped into the same ribotype group with one host per group.

219 - The effects of rainfall on Escherichia coli and total coliform levels at 15 Lake Superior recreational beaches

R. Sampson, S. Swiatnicki, C. McDermott, and G. Kleinheinz

http://www.environmental-expert.com/Files%5C6063%5Carticles%5C9235%5C11-12-6.pdf

Purpose - Fifteen beaches along Lake Superior were monitored over the course of the 2003 and 2004 summer swimming seasons from mid-May through mid-September. Water samples were collected at these 15 beaches less than 24-h after a rainfall event of at least 6 mm. The effect of rainfall on bacterial concentrations along the Wisconsin shores of Lake Superior was investigated.

Results - No relationship between rainfall amount and bacterial concentrations at any of the 15 beaches tested was found. Although other researchers have observed a direct positive relationship between rainfall and E. coli levels in beach water, we found no significant relationship for Lake Superior beaches. This is an important finding given the fact that beach closures are often based upon rainfall alone rather than on actual E. coli concentration measurements. This study reinforces the fact that the data obtained at one location should not necessarily be extrapolated to beach closure decisions at other locations.

141 - Modeling the dry-weather tidal cycling of fecal indicator bacteria in surface waters of an intertidal wetland

Brett F. Sanders, F. Arega, and M. Sutula

ftp://www.sccwrp.org/pub/download/DOCUMENTS/AnnualReports/2005_06AnnualReport/AR0506_051-66.pdf

Purpose - Utilize a developed model and apply it to predict the dry-weather tidal cycling of FIB in Talbert Marsh, in response to loads from urban runoff, bird feces and resuspended sediments.

Results - Model predictions show that surface water concentrations of TC, EC, and ENT in the wetland are driven by loads from urban runoff and resuspended wetland sediments. The model more accurately predicts TC than EC or ENT. The crucial role that sediments play in the cycling of FIB is highlighted by this study. Sediments function as a reservoir of FIB that may accumulate FIB due to regrowth or settling, or shed FIB when tidal currents or storm flows scour away or even just disturb surficial particles.

115 - Patterns of Antimicrobial Resistance Observed in Escherichia coli Isolates Obtained from Domestic- and Wild-Animal Fecal Samples, Human Septage, and Surface Water
Raida S. Sayah, J.B. Kaneene, Y. Johnson, and R. Miller
http://aem.asm.org/content/71/3/1394.full.pdf+html
Purpose - (i) To identify patterns of antimicrobial agent resistance of E. coli strains obtained from human septage, domestic animals, and wildlife living in the Red Cedar watershed in Michigan, and (ii) to compare these antimicrobial agent resistance patterns with those of E. coli strains obtained from surface water in the same watershed.

Results - Antimicrobial agent resistance was detected in all types of samples collected (Table 4). The most frequently encountered form of resistance in all samples was resistance to tetracycline (27.3%), followed by resistance to cephalothin (22.7%), resistance to sulfisoxazole (13.3%), and resistance to streptomycin (13.1%). Animal fecal samples exhibited resistance to all agents tested, while human septage and river water samples showed resistance to three agents and one agent, respectively.
Resistance to cephalothin was present in all types of samples, while tetracycline resistance and streptomycin resistance were found in all types of samples except river water. Resistance to tetracycline was present in both fecal and farm environment samples from all livestock species, while resistance to trimethoprim-sulfamethoxazole was present in both types of samples from only dairy cattle and equids.

142 - Tracking sources of bacterial contamination in stormwater discharges from Mission Bay, California
Kenneth C. Schiff, and P. Kinney
ftp://www.sccwrp.org/pub/download/DOCUMENTS/AnnualReports/1999AnnualReport/07_ar06.pdf
Purpose - Identify whether wet-weather discharges were the predominant source of bacterial contamination to receiving waters.

Results - Seasonal cycles were evident, with the highest levels of total coliform, fecal coliform and enterococcus occurring during the wettest months.

220 - Microbiological Water Quality at Reference Beaches in Southern California During Wet Weather. Technical Report #448
Kenneth C. Schiff, J. Griffith, and G. Lyon

http://www.sccwrp.org:8060/pub/download/DOCUMENTS/TechnicalReports/448_reference_beach.pdf
Purpose - Assess the microbial water quality at reference beaches following wet weather events in southern California.

Results - Based on the results from this study, natural contributions of nonhuman fecal indicator bacteria were sufficient to generate exceedances of the State of California water quality thresholds during wet weather.

145 - Water Quality Indicators and the Risk of Illness in Non-Point Source Impacted Recreational Waters
Kenneth C. Schiff, S.B. Weisberg and J.M. Colford Jr.
ftp://swrcb2a.waterboards.ca.gov/pub/rwqcb2/TMDL-WEF/5d.pdf
Purpose - Determine if: 1) water contact increased the risk of illness in the two weeks following exposure to water in Mission Bay? and 2) did the risk of illness increase with increasing levels of microbial indicators of water quality?

Results - Outside of skin rash and diarrhea, there was no statistically increased risk of 12 other symptoms, including highly credible gastrointestinal illness (HCGI). These results contrast with most other recreational bathing studies, most likely because of the lack of human sources of fecal pollution.

165 - Variation of microorganism concentrations in urban stormwater runoff with land use and seasons
A. Selvakumar, and M. Borst
http://www.iwaponline.com/jwh/004/0109/0040109.pdf
Purpose - This study investigates if variations in concentrations of microorganisms by at least 1/3-log at the 95% level of confidence are potentially attributable to land use and seasons. Differences less than 1/3-log have little practical importance even if there is statistical significance as the sensitivity of the analyses procedure is less than these.

Results - Statistically significant differences were found between land uses for all microorganisms studied except for E. coli. Other than E. coli, the microbial concentrations in stormwater runoff consistently vary within and between land uses. Generally, the concentrations in runoff from high-density residential areas are higher than the concentrations in other tested land uses.

222 - Indicator microbes correlate with pathogenic bacteria, yeasts and helminthes in sand at a subtropical recreational beach site
A.H. Shah, A.M. Abdelzaher, M. Phillips, R. Hernandez, H.M. Solo-Gabriele, J. Kish, G. Scorzetti, J.W. Fell, M.R. Diaz, T.M. Scott, J. Lukasik, V.J. Harwood,, S. McQuaig, C.D. Sinigalliano, M.L. Gidley, D. Wanless, A. Ager, J. Lui, J.R. Stewart, L.R. Plano, and L.E. Fleming
http://www.ncbi.nlm.nih.gov/pubmed/21447014

Purpose - The objectives of this study were to evaluate the presence and distribution of pathogens in various zones of beach sand (subtidal, intertidal and supratidal) and to assess their relationship with environmental parameters and indicator microbes at a non-point source subtropical marine beach.

Results - Results indicate that indicator microbes may predict the presence of some of the pathogens, in particular helminthes, yeasts and the bacterial pathogen Staphylococcus aureus including methicillin-resistant forms. Indicator microbes may thus be useful for monitoring beach sand and water quality at non-point source beaches.

132 - Evaluation of conventional and alternative monitoring methods for a recreational marine beach with non-point source of fecal contamination
Tomoyuki Shibata, H.M. Solo-Gabriele, C.D. Sinigalliano, M.L. Gidley, L.R.W. Plano, J.M. Fleisher, J.D. Wang, S.M. Elmir, G. He, M.E. Wright, A.M. Abdelzaher, C. Ortega, D. Wanless, A.C. Garza, J. Kish, T. Scott, J. Hollenbeck, L.C. Backer, and L.E. Fleming
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2966524/
Purpose - Compare enterococci (ENT) measurements based on the membrane filter, ENT(MF) with alternatives that can provide faster results including alternative enterococci methods (e.g. chromogenic substrate (CS), and quantitative polymerase chain reaction (qPCR)), and results from regression models based upon environmental parameters that can be measured in real-time.

Results - In addition to physico-chemical and hydrometeorological parameters, results also suggested that bacterial indicator levels were affected by the numbers of animals on the beach which may also have seasonal patterns associated with their numbers and fecal inputs. Thus, levels of enterococci at non-point source beaches are affected by a myriad of environmental factors and input loadings which are very difficult to capture within simple regression models.

223 - Adhesion of Enterococcus faecalis in the nonculturable state to plankton is the main mechanisms responsible for persistence of this bacterium in both lake and seawater
C. Signoretto, G. Burlacchini, M. del Mar Lleò, C. Pruzzo, M. Zampini, L. Pane, G. Franzini, and P. Canepari
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC525140/
Purpose - In this study we describe the results of the monitoring of the microbiological quality of both freshwater and marine water by applying an approach consisting of detecting both culturable and nonculturable enterococci which are present in water and adherent to the plankton in order to evaluate to what extent the adhesion to plankton and the VBNC state may represent survival strategies and contribute to the formation of environmental reservoirs of these microorganisms.

Results - We show that molecular methods for the detection of enterococci resulted in a higher number of positive samples than the culture method. The most interesting result of this study was the observation that in Lake Garda E. faecalis is almost exclusively found either adhering to plankton or in water, and not both. This result was also confirmed by the results in seawater, although not to such an evident extent.

123 - TRANSPORT OF FECAL BACTERIA FROM POULTRY LITTER AND CATTLE MANURES APPLIED TO PASTURELAND
M.L. Soupir, S. Mostaghimi, E.R. Yagow, C. Hagedorn, and D.H. Vaughan
http://www.environmental-center.com/Files%5C0%5Carticles%5C9338%5CTransportOfFecalBacteria.pdf
Purpose - An understanding of the overland transport mechanisms from land applied waste is needed to improve design of best management practices (BMPs) and modeling of nonpoint source (NPS) pollution.

Results - Results of this comparative study clearly indicate that cowpies have a greater potential to contribute high fecal bacteria concentrations into streams than the land application of liquid dairy manure or turkey litter, although bacteria concentrations in runoff from all treatments exceeded Federal standards for primary contact in the United States. The relationship between runoff rates and concentrations of the indicator species was dependent upon the animal waste application, the indicator species and antecedent soil moisture conditions.

152 - Variability of Indicator Bacteria at Different Time Scales in the Upper Hoosic River Watershed
Elena Traister, and S.C. Anisfeld
http://www.forestry.yale.edu/uploads/publications/Anisfeld-pub03.pdf
Purpose - Evaluate whether the Upper Hoosic River Basin is meeting water quality criteria for indicator bacteria.

Results - Bacterial levels were higher in more developed watersheds; in summer rather than winter; in storms rather than baseflow; and in the early morning rather than afternoon.

227- Prevalence of yeasts in beach sand at three bathing beaches in South Florida
C. Vogel, A. Rogerson, S. Schatz, H. Laubach, A. Tallman, and J. Fell
http://www.sciencedirect.com/science/article/pii/S004313540700108X
Purpose - Determine the abundance and types of yeasts in the wet and dry sand of three recreational beaches in South Florida.

Results - While definitive statements cannot be made, high levels of yeasts may have a deleterious bearing on human health and the presence of such a diverse aggregation of species suggests that yeasts could have a role as indicators of beach health.

224 - Effect of waterfowl (Anas platyrhynchos) on indicator bacteria populations in a recreational lake in Madison, Wisconsin
J.H. Standridge, J.J. Delfino, L.B. Kleppe, and R. Butler
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC243530/pdf/aem00202-0205.pdf

Purpose - Determine the level of effect that waterfowl has on the water quality of a Madison, WI lake.

Results - The most common human health hazard associated with ducks is swimmer's itch, or echinostoma revolutum (12). The duck tapeworm can also occasionally infect humans (4). Ducks have often been implicated as carriers and disseminators of Salmonella (1, 3, 11, 12, 16, 17). The occurrence of these zoonoses indicates that fecal contamination from ducks is a human health hazard and that beach closings based on the presence of high counts of fecal coliform indicator bacteria are warranted. Future surveys aimed at detecting the possible presence of Salmonella in the Vilas Park beach area are indicated.

228 - Estimation of enterococci input from bathers and animals on a recreational beach using camera images
J.D. Wang, H.M. Solo-Gabriele, Am. M. Abdelzher, and L.E. Fleming
http://www.sciencedirect.com/science/article/pii/S0025326X10001062
Purpose - Develop a counting methodology to better understand non-point source load impacts. Enterococci inputs to the study beach site (located in Miami, FL) are dominated by non-point sources (including humans and animals).

Results - Enterococci source functions were computed from the observed number of unique individuals for average days of each month of the year, and from average load contributions for humans and for animals. Results indicate that dogs represent the larger source of enterococci relative to humans and birds.

229 - Hand-mouth transfer and potential for exposure to E. coli and F+ coliphage in beach sand, Chicago, Illinois
R.L. Whitman, K. Przybyla-Kelly, D.A. Shively, M.B. Nevers, and M.N. Byappanahalli
http://www.ncbi.nlm.nih.gov/pubmed/19590129
Purpose - Examine the transferability of Escherichia coli and F+ coliphage (MS2) from beach sand to hands in order to estimate the potential subsequent health risk.

Results - Using dose-response estimates developed for swimming water, it was determined that the number of individuals per thousand that would develop gastrointestinal symptoms would be 11 if all E. coli on the fingertip were ingested or 33 if all E. coli on the hand were ingested. These results suggest that beach sand may be an important medium for microbial exposure; bacteria transfer is related to initial concentration in the sand; and rinsing may be effective in limiting oral exposure to sand-borne microbes of human concern.

169 - Microbial load from animal feces at a recreational beach
M.E. Wright, H.M. Solo-Gabriele, S. Elmir, and L.E. Fleming
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2771205/pdf/nihms138348.pdf
Purpose - The goal of this study was to quantify the microbial load (enterococci) contributed by the different animals that frequent a beach site.

Results - The highest enterococci concentrations were observed in dog feces with average levels of 3.9 x 10(7) CFU/g; the next highest enterococci levels were observed in birds averaging 3.3 x 10(5)CFU/g. The lowest measured levels of enterococci were observed in material collected from shrimp fecal mounds (2.0 CFU/g). A comparison of the microbial loads showed that 1 dog fecal event was equivalent to 6940 bird fecal events or 3.2 x 10(8) shrimp fecal mounds. Comparing animal contributions to previously published numbers for human bather shedding indicates that one adult human swimmer contributes approximately the same microbial load as one bird fecal event. Given the abundance of animals observed on the beach, this study suggests that dogs are the largest contributing animal source of enterococci to the beach site.

231 - Microbial load from animal feces at a recreational beach
M.E. Wright, H.M. Solo-Gabriele, S. Elmir, and L.E. Fleming
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2771205/
Purpose - Quantify the microbial load (enterococci) contributed by the different animals that frequent a beach site.

Results - Results from this study provide evidence that dog feces represent the largest animal source to the study site. Improved management of dog feces at the beach could potentially reduce enterococci inputs to the beach, thereby decreasing the number of advisories for beach sites which are frequented by significant numbers of dogs.

8 - Are microbial indicators and pathogens correlated? A statistical analysis of 40 years of research
J. Wu, S. C. Long, D. Das and S. M. Dorner
http://www.iwaponline.com/jwh/up/wh2011117.htm
Purpose - The data were analyzed to assess factors affecting correlations using a logistic regression model considering indicator classes, pathogen classes, water types, pathogen sources, sample size, the number of samples with pathogens, the detection method, year of publication and statistical methods.

136 - Monitoring and Modeling Non-Point Source Contributions of Host-Specific Fecal Contamination in San Pablo Bay
Stefan Wuertz, F.A. Bombardelli, K. Sirikanchana, and D. Wang
http://escholarship.org/uc/item/8tk0z6p0.pdf
Purpose - This study employed mathematical and numerical transport models in concert with new molecular techniques to (i) characterize the sources of fecal contamination of water bodies and (ii) quantify the loads and distributions of *Bacteroidales* marker DNA sequences originating from different animal hosts in San Pablo Bay.

Results - Microbial source tracking using fecal *Bacteroidales* is an effective way to monitor fecal pollution of coastal waters. Low levels of the universal genetic marker are ubiquitous throughout

San Pablo Bay. The human marker BacHum-UCD was found in 75% of all samples but no cow- and almost no dog-specific marker was detected.

234 - Growth of enterococci in unaltered, unseeded beach sands subjected to tidal wetting
K.M. Yamahara, S.P. Walters, and A.B. Boehm
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2655449/
Purpose - To establish if naturally occurring enterococci can replicate in beach sands under environmentally relevant conditions.

Results - The results provide evidence that enterococci may not be an appropriate indicator of enteric disease risk at recreational beaches subject to nonpoint sources of pollution.

170 - A water quality modeling study of non-point sources at recreational marine beaches
X. Zhu, J.D. Wang, H.M. Solo-Gabriele, L.E. Fleming
http://www.sciencedirect.com/science/article/pii/S0043135411001266
Purpose - A model study was conducted to understand the influence of non-point sources including bather shedding, animal fecal sources, and near shore sand, as well as the impact of the environmental conditions, on the fate and transport of the indicator microbe, enterococci, at a subtropical recreational marine beach in South Florida.

Results - Enterococci released from beach sand during high tide caused mildly elevated concentration for a short period of time (ten to twenty of CFU/100 ml initially, reduced to 2 CFU/100 ml within 4 h during sunny weather) similar to the average baseline numbers observed at the beach. Bather shedding resulted in minimal impacts (less than 1 CFU/100 ml), even during crowded holiday weekends. In addition, weak current velocity near the beach shoreline was found to cause longer dwelling times for the elevated concentrations of enterococci, while solar deactivation was found to be a strong factor in reducing these microbial concentrations.