Wastewater and Nutrient Source Tracking – Results of Reconnaissance Chemical Mapping at Kualoa and Kahana, Oahu

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Partner / Program Linkages

• Hawaii Department of Health (HIDOH)
  – Clean Water Branch—Beach monitoring
  – TMDL tie-in?

• USEPA program links
  – Clean Water Act
  – Beach Act
  – TMDL program?
Problem

• Beach Monitoring of Recreational Waters
  – High fecal indicator bacteria at fixed sites
  – Sources uncertain, ambiguous
  – Although septic wastewater is suspected … … we lack a convincing “picture” to sway decision makers, stakeholders

• TMDL
  – Would like nutrient “source attribution”
Kualoa

High bacterial counts at DOH fixed monitoring sites
Kahana Bay

... and high bacteria counts near the beach?

<- what causes these slicks?
Beach Closure – Kualoa, Oahu

Photo: Jeff Widener, The Honolulu Advertiser
Malfunctioning beach-park septic systems may be a cause

Kualoa contamination nets city $300,000 fine

The release of sewage into the sea prompts the state's penalty

Honolulu Star-Bulletin
Feb 10, 2007
But There Are Non-Human Sources, Too

Pile of seaweed?

... or Labrador Retriever?

Photo: Jeff Widener, The Honolulu Advertiser
… the lighter side

Turtles key suspects in UFO* debate

* Unidentified Floating Object

Charles Memminger,
Honolulu Lite
Honolulu Star-Bulletin
Feb 19, 2006
Objectives and Approach

- Provide the “picture” or context via continuous mapping to aid interpretation of fixed-site data
- In-house DOH method for rapid reconnaissance
- Conduct proof-of-concept surveys, evaluate success, identify needed refinements
- Tiered approach - cheap mapping first, expensive lab analyses later
- Multi-tracer approach
Case-Study Surveys

Completed:

• Kualoa Beach, Oahu—Beach monitoring
  – Shoreline wading surveys (2)
  – Beach porewater transect (25 samples)

• Kahana Bay, Oahu—Beach monitoring
  – Beach porewater transect (25 samples)

Future:

• Hanalei, Kauai—Beach monitoring, TMDL
• Kaelepulu Pond, Oahu—TMDL
## Conclusions

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<th>Area</th>
<th>Observations</th>
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## Multiple Tracers

<table>
<thead>
<tr>
<th>Tracer</th>
<th>Possible Indicator of:</th>
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<tbody>
<tr>
<td>Salinity</td>
<td>Freshwater discharge (stream, GW)</td>
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<tr>
<td>NO$_3$, NH$_4$, PO$_4$</td>
<td>Animal / human waste, fertilizers</td>
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<tr>
<td>$^{15}$N, $^{18}$O of NO$_3$</td>
<td>Animal vs plant NO$_3$, denitrification</td>
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<tr>
<td>$^2$H, $^{18}$O of H$_2$O</td>
<td>Water origin, evaporation, mixing</td>
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<tr>
<td>$^{11}$B</td>
<td>Laundry detergents (low $^{11}$B)</td>
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<tr>
<td>Fluorescence</td>
<td>Fabric brighteners in detergents</td>
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<td>Pharmaceuticals</td>
<td>Household wastewater</td>
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<td>Household wastewater</td>
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Example Tracer - $^{15}$N of Nitrate Sources

Kendall and McDonnell (1998)
Mapping, Transecting Methods

• Wading instrument surveys (continuous)
  – GPS “trackline” fixes at 30-sec intervals
  – Multiparameter—Salinity, DO, chlorophyll, etc
  – Coming soon—fabric-brightener fluorescence
• Wading dip samples (fewer discrete points)
  – Fabric-brightener fluorescence, handheld meter
  – GPS “waypoint” fixes
• Beach porewater transects (discrete sites)
  – Lab analyses for various tracers
Wading survey, initializing instrument & GPS

Sensors extend about 4 inches below platform

Photo: Joshua Marvit, Hawaii Dept. of Health
Wading survey just off the beach

Photo: Joshua Marvit, Hawaii Dept. of Health
Beach Porewater Sampling

Retractable drivepoint & hammer drill

Photo: Gerald Higuchi, Hawaii Dept. of Health
Beach porewater sampling

Retractable drivepoint

Peristaltic pump

Photo: Gerald Higuchi, Hawaii Dept. of Health
Runoff and possible nonpoint pollution

Sand aquifer

USGS
science for a changing world
Stormwater swale

Photo: Joshua Marvit, Hawaii Dept. of Health
EXPLANATION

- Septic System

Salinity Along Wading Survey 1, in percent seawater:
- 87.6 - 90.3
- 90.4 - 93.0
- 93.1 - 97.9
- 98.0 - 99.2
- 99.3 - 100.0

Kualoa
EXPLANATION
Chlorophyll-a Along Wading Survey 1,
in micrograms per liter
- 0.18 - 0.45
- 0.45 - 0.88
- 0.88 - 1.74
- 1.74 - 2.90
- 2.90 - 5.93
- Septic System

Kualoa
EXPLANATION
- Septic System

Salinity Along Wading Survey 2, in percent seawater:
- 92.4 - 94.1
- 94.2 - 96.7
- 96.8 - 98.2
- 98.3 - 99.1
- 99.2 - 100.0

Kualoa
EXPLANATION
In percent
- 97.6 - 105.6
- 105.6 - 114.8
- 114.8 - 124.8
- 124.8 - 138.7
- 138.7 - 151.8
- Septic System
EXPLANATION

Beach Porewater Site and Number

- Ground Water
- Surface Water
- Septic System
EXPLANATION

Delta-15N of Dissolved Nitrate, in per mil

- Not analyzed (insufficient nitrate)
- 0.2 - 2.2
- 4.1 - 6.2
- 7.4 - 9.0
- 11.5 - 14.8

Septic System

Kualoa
EXPLANATION
Dissolved Ammonium, as N, in milligrams per liter

- Less than minimum reporting limit 0.02
- 0.05 - 0.08
- 0.09 - 0.11
- 0.13 - 0.15
- 0.18 - 0.19
- Septic System

Kualoa
EXPLANATION
Dissolved Nitrate, as N,
in milligrams per liter

- Less than minimum reporting limit 0.016
- 0.01 - 0.02
- 0.03 - 0.05
- 0.06 - 0.08
- 0.15 - 0.44
- Septic System

Kualoa
EXPLANATION
Dissolved Orthophosphorus, as P, in milligrams per liter
- 0.004 - 0.006
- 0.009 - 0.012
- 0.013 - 0.015
- 0.021 - 0.033
- 0.037 - 0.066
- Septic System

Kualoa
EXPLANATION
UV Fluorescence at 445 nm,
in nominal fluorescence units
- 0 - 1
- 2 - 4
- 5 - 8
- 12
- 21 - 22
- Septic System

Kualoa
EXPLANATION
Relative Salinity, in percent seawater

- 1
- 36 - 67
- 90
- 97 - 100
- 101
- Septic System

Kualoa
EXPLANATION
Dissolved Nitrate, as N,
in milligrams per liter
- Less than minimum reporting limit 0.016
- 0.01 - 0.04
- 0.09 - 0.14
- 0.16 - 0.25
- 0.52, 5.20
- Septic System
EXPLANATION
Dissolved Ammonium, as N,
in milligrams per liter
- Less than minimum reporting limit 0.02
- 0.01 - 0.05
- 0.06 - 0.16
- 0.19 - 0.31
- 1.10
- Septic System

Kahana
EXPLANATION
UV Fluorescence at 445 nm,
in nominal fluorescence units

- 1 - 2
- 3 - 4
- 5 - 7
- 10 - 18
- 28
- Septic System
Compare $^{15}$N at Kualoa & Kahana to Kihei

Denitrification trend
(slope = 0.5)

Kihei waters containing a wastewater component

Kihei waters unaffected by wastewater

Tap water
Wastewater effluent
Downgradient well
Cross-gradient well
Upgradient well
Kahana
Kualoa

KA-22 Stream backwater
KA-07 Dry streambed
KA-02 N end of park, pore & seawater
KA-20 Punaluu restroom N
KA-21 Punaluu restroom S
KA-08 Dry streambed, 10m inland

KU-19 Bayside of E pond
KU-16 Bayside of W pond
KU-14 House N of park
KU-12,13 Houses N of park
KU-05 Restroom 1 center
KU-06 Restroom 1 S
KU-02 N end breakwall
KU-01 N end of park
KU-24 Seawater at boat ramp
KU-22,23 House N end of park, pore & seawater
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Refinements & Further Work

- Retrospective bacteria vs rainfall time-series
  - wet or dry problem? (can do now with existing data)
- Begin to evaluate overland runoff sources
- Fluorescence sensor on multiparameter probe
- Conduct bacterial transects with wading surveys
- Denser beach porewater transects to make sure we’re not missing possible restroom “plumes”
- Targeted sampling for pharmaceuticals, wastewater indicator compounds, major ions
- Closer attention to redox conditions
- Ultimately – Bacterial source-tracking methods?
Wet or Dry Problem?

Friday Jan 12, 2007
(most recent beach closure)

Kualoa closed to swimmers because of bacteria count

Honolulu Advertiser
Jan 12, 2007
Monday Jan 8, 2007
Storm runoff, Waikane Stream

High bacT count = 945
(up from 2) caused beach closure
4 days later on Jan 12

Photo: F.L. Morris, Honolulu Star-Bulletin
Other Relevant USGS Studies

- Bacterial contamination, Huntington Beach
- Sources of microbial contamination at public beaches, Santa Barbara
- Enterococcus surface protein indicator of human fecal pollution, Russian River
- Pathogen Exposure through Recreational Water
  - Microbial Source Tracking page
  - Lots of Great Lakes work

http://health.usgs.gov/pathogens/
Future? - Hanalei Beach Park & River

Photos: HawaiiWeb, Inc.
Future? - Kaelepuulu Pond, Kailua (TMDL)