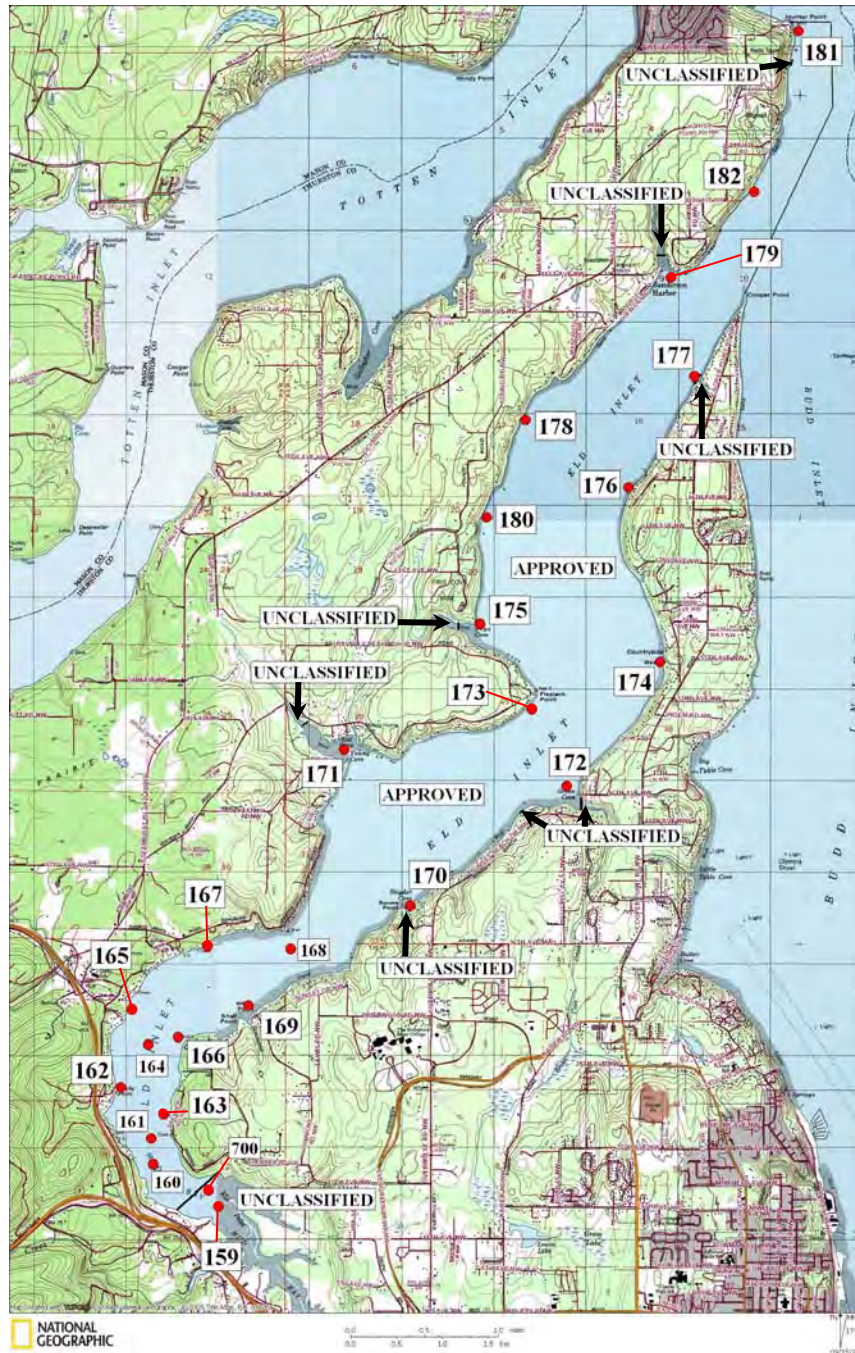


## Status and Trends Summary

# Fecal Coliform Pollution in Eld Inlet: Year 2009

October 2010



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## Remedial Action Summary in Eld Inlet

In the early 1990s, the Washington State Department of Health (DOH) reclassified part of Eld Inlet from Approved to Conditionally Approved. Thurston County Health Department surveyors found major fecal sources to be onsite sewage systems along marine shorelines and waste from farm animals. County Health staff carried out an intensive onsite sewage program in 1991-1992. Health workers conducted intensive education and outreach. They located failed systems by rigorous inspections, dye tracing, and water sampling. They provided technical help to residents. Enforcement was sometimes necessary. As a result, many failed onsite sewage systems were located and repaired. In 1998, the Department upgraded most of Eld Inlet from Conditionally Approved to Approved. There have been no extraordinary remedial efforts since that time. Although classified Approved, shellfish harvest is controlled by a special flood-related classification. Harvest must stop for 5 days whenever daily rainfall exceeds 3.0 inches.

## Monitoring Fecal Pollution in Shellfish Growing Areas

DOH protects consumers from eating shellfish contaminated by pollution. The Department continually monitors marine water for fecal pollution in shellfish growing areas and searches for pollution sources on shorelines and adjacent uplands.

**Systematic Random Sampling (SRS).** The Department uses a systematic random sampling (SRS) method mandated by the National Shellfish Sanitation Program (NSSP) to monitor shellfish growing areas. DOH measures levels of fecal bacteria in water samples collected at sampling stations in each area. Under SRS, samples are collected at relatively even intervals over time. SRS purposely avoids targeting specific environmental factors, such as season, weather, tide, etc. SRS also requires substantial data (30 results) to calculate statistics used to classify growing areas. Thus, DOH data represents a wide range of environmental conditions encountered in the growing area. SRS ensures that unbiased, high-quality data are available for DOH tasks.

**NSSP Growing Area Criteria.** DOH uses the data gathered under SRS to classify shellfish beds according to level of fecal pollution. DOH applies the following NSSP criteria exclusively to areas potentially affected by nonpoint fecal pollution sources:

- The concentration of fecal coliform bacteria cannot exceed a geometric mean of 14 organisms per 100 milliliters (ml) in water (applied in all cases).
- The estimated 90<sup>th</sup> percentile cannot exceed 43 organisms per 100 ml of water

The Department uses a minimum of 30 results to calculate the criteria. Appendix A (page 9) explains how DOH uses NSSP criteria to classify shellfish growing areas.

DOH has reported status and trends for the Puget Sound Assessment and Monitoring Program (PSAMP) since 1998. The Department also uses the information to report progress on local remedial action programs.

## Status and Trends Analysis for Eld Inlet

To analyze status and trends in Dyes Inlet, DOH selected stations with the longest, most complete record of fecal coliform data. DOH calculated NSSP statistics (geometric means and 90<sup>th</sup> percentiles) for these stations from the earliest date possible (i.e., those stations with the minimum required 30 results: see paragraph above) and for all subsequent sampling dates through the end of calendar year 2009.

DOH takes the same initial analytical step for long-term status and trends analysis as it takes to classify a growing area. However, data analysis for classification may require additional sorting and editing of the data to evaluate the effect of short-term pollution factors. For example, it is sometimes necessary to evaluate the impact of environmental effects, such as rainfall, on the classification of a growing area (see Appendix A, “Classifying Shellfish Growing Areas”, page 9).

DOH uses 90<sup>th</sup> percentiles to make inferences about status and trends because 90<sup>th</sup> percentiles are more sensitive to changes in pollution conditions than geometric means. Note that the time-series graphs in Figure 2 (pages 5, 6) show both geometric means and 90<sup>th</sup> percentiles.

### Status of fecal pollution at each station in Eld Inlet in 2009.

DOH developed a “Fecal Pollution Index” (FPI) to provide a single value to describe the annual status of fecal pollution. Appendix B (page 11) shows the how the FPI is derived. The FPI can be applied at several geographic levels (sampling station, growing areas, regions within Puget Sound, or Puget-Sound wide). Figure 1 shows the status of fecal pollution at each station in Eld Inlet for calendar year 2009 according to its annual FPI.

### Trend of fecal pollution at each station in Eld Inlet 2004-2009.

Figure 1 also shows the trend in fecal pollution at each station for the most recent 5-year period (2005-2009). A green arrow pointing down means fecal pollution decreased. A red arrow pointing up means fecal pollution increased. A yellow diamond means no significant change occurred. The abbreviation “nd” means that trend was not determined because either the 90<sup>th</sup> percentiles were too low (less than 10 MPN per 100ml), or the record of 90<sup>th</sup> percentiles was too short (less than 3 years long). “Spearman’s Rho” (a “nonparametric” test based on ranked data) statistically tested the significance of the 5-year trends (significant at  $p < 0.05$ ).

Figure 2 shows graphs of NSSP statistics (geometric means and 90<sup>th</sup> percentiles) for four selected stations in Eld Inlet for the 10-year period from 2000 through 2009. The selected stations were among those most significantly affected by fecal pollution over the decade.



### **General Observations from Figure 1:**

- Twenty of 25 sampling stations showed negligible fecal pollution during 2009. Two stations located in Mud Bay (stations 159 and 700) had very high pollution. Two other nearby sites (stations 160 and 161) were moderate. Station 171 (Young Cove) was high.
- Over half of 22 sampling stations in Eld inlet showed increased fecal pollution over the last 5 years. Two stations showed decreased fecal pollution. Eight showed no significant change. One station was not evaluated for trend because the record of statistics was too short (less than 3 years).

### **Trends Analysis for Selected Individual Stations in Eld Inlet**

Figure 2 shows graphs of NSSP statistics (geometric means and 90<sup>th</sup> percentiles) for four stations in Eld Inlet for the 10-year period from 2000 through 2009. These stations showed the greatest affect of fecal pollution during the last 5 years. Three are located in Mud Bay, the southernmost end of Eld Inlet (stations 195-161). The sensitivity of these stations to pollution is undoubtedly due to a combination of the proximity of heavy pollutant loads and minimal tidal exchange. The fourth is Station 171 located in Young Cove. (See Figure 1 for locations of the stations).

Note that the 90<sup>th</sup> percentiles show a greater response to changing pollution conditions than the geometric means. Thus, DOH used 90<sup>th</sup> percentiles for analysis of trends.

**Figure 2. Trend in geometric means and ninetieth percentiles (NSSP statistics) from 2000 through 2009 at selected DOH stations in Eld Inlet.**

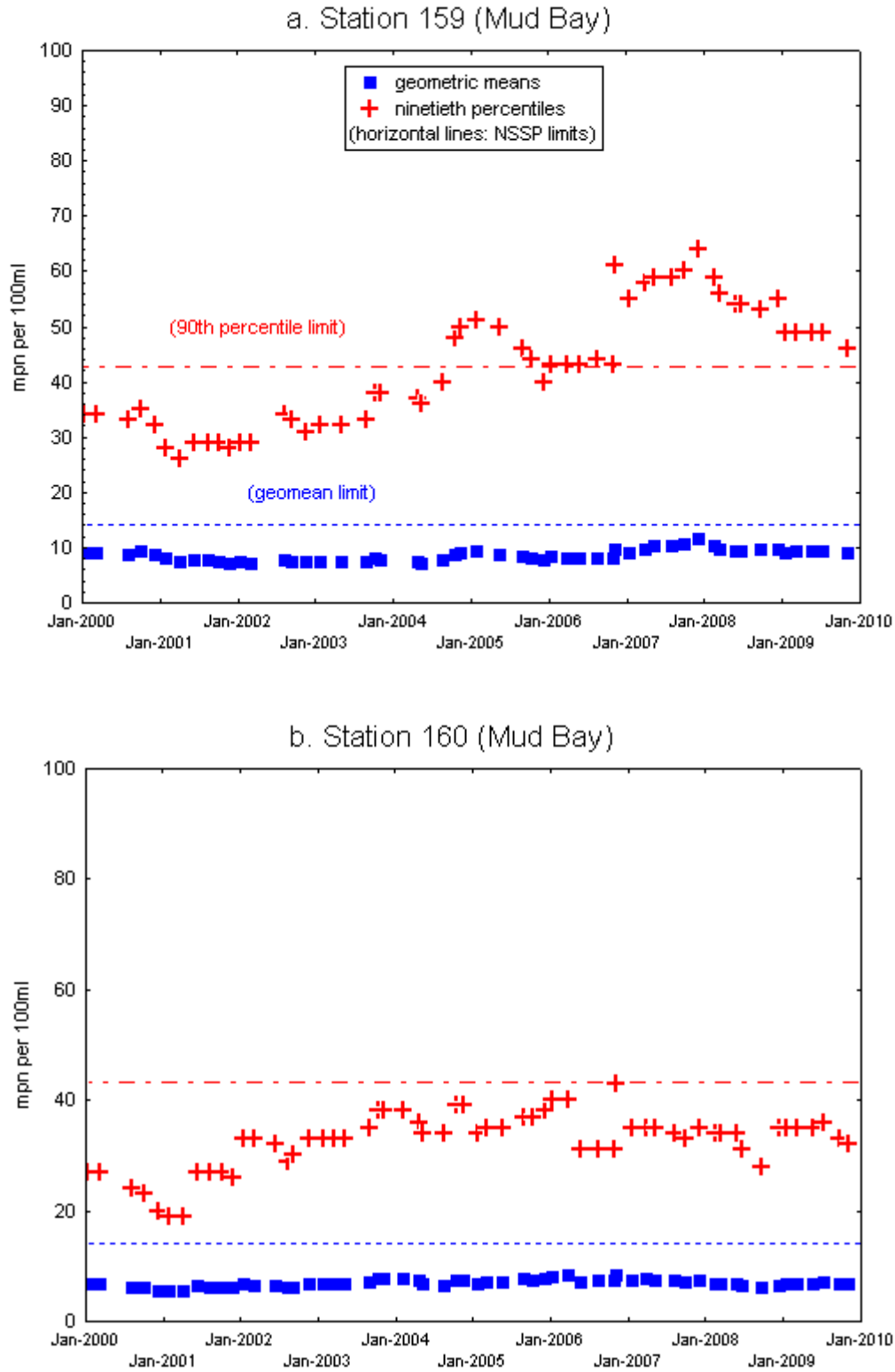
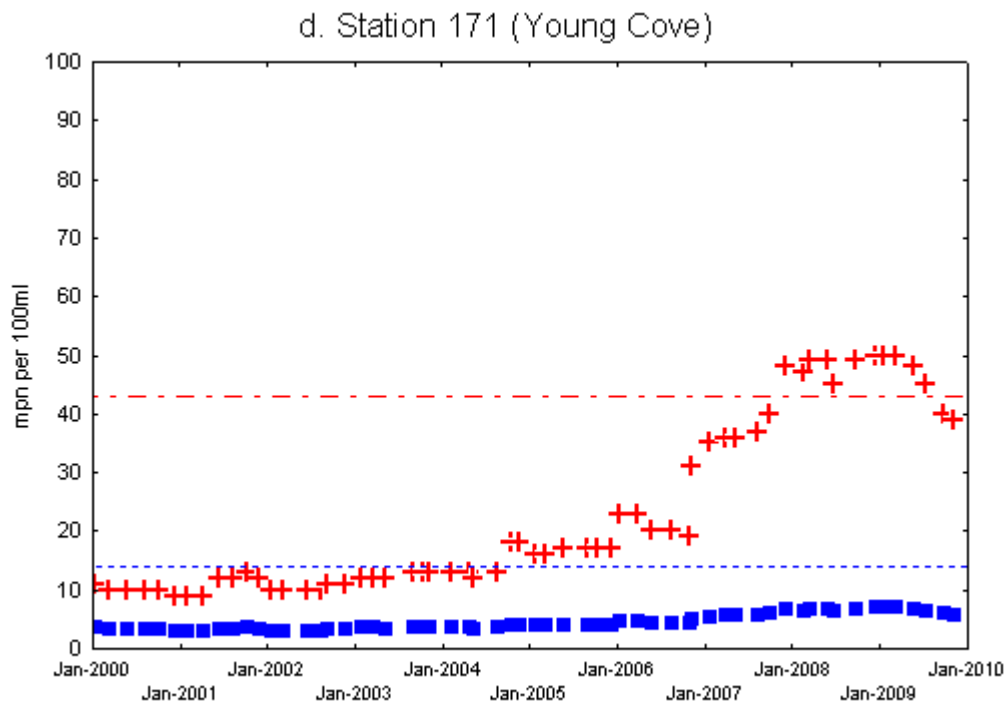
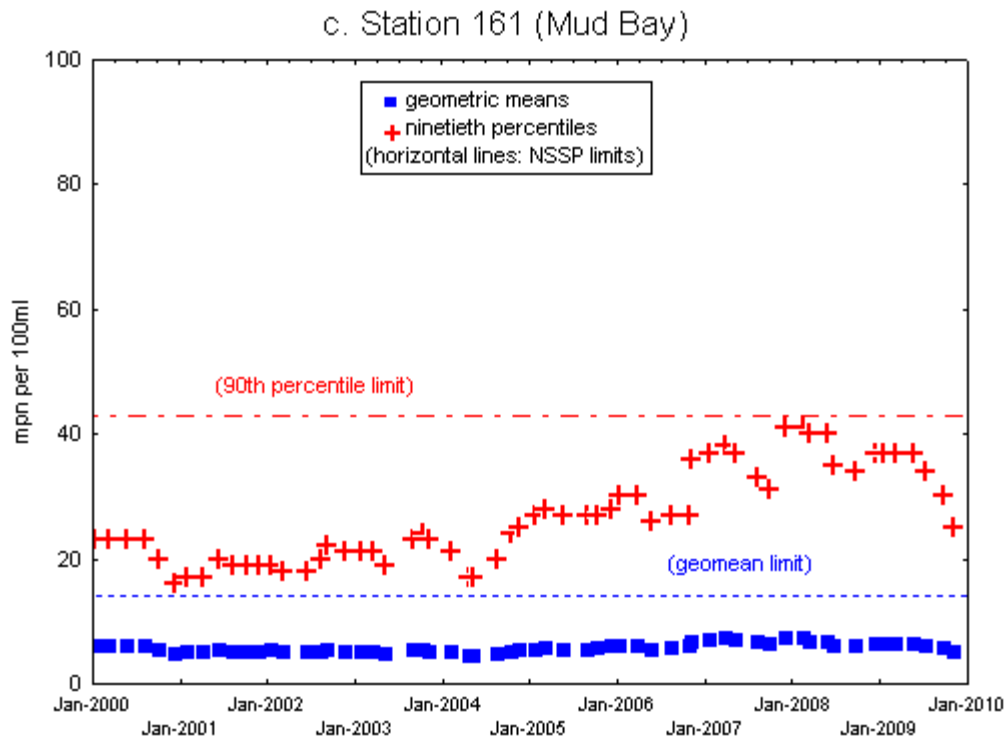


Figure 2. (Cont.)



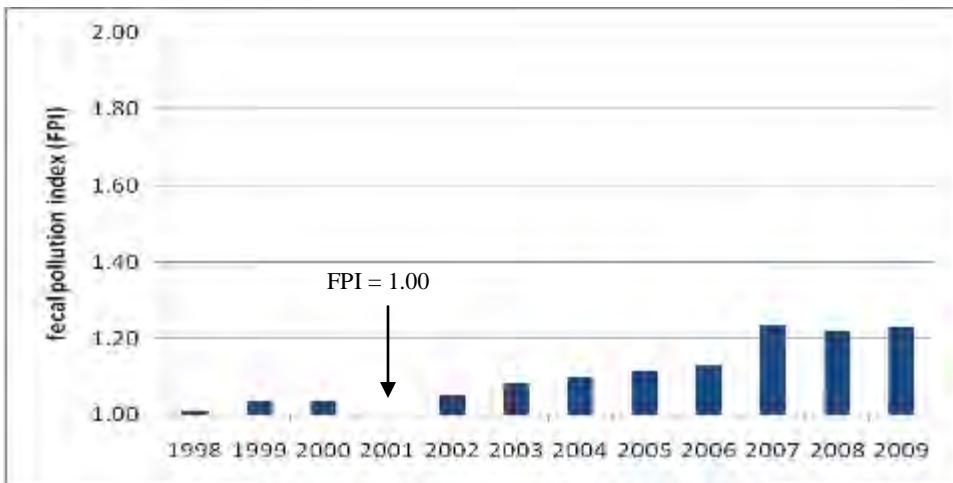
**General Observations from graphs in Figure 2:**

- All four stations show evidence of an overall increase in fecal pollution during the past decade.
- All four stations show evidence of a dramatic jump in 90<sup>th</sup> percentiles in late 2006. A likely cause was very lengthy and intense regional rainfall late in the year. The anomalous rainfall affected many growing areas in Puget Sound.
- Fecal pollution at Station 171 (Young’s Cove) began to increase significantly in early 2005. Pollution impact became very high by 2008.
- Fecal pollution at stations 159, 161, and 171 show limited evidence of a slight decline in recent years.

**Fecal Pollution Trend in Eld Inlet 1998-2009**

Figure 3 extends the concept of the Fecal Pollution Index (FPI) to all of Eld Inlet. An annual FPI was calculated from 90<sup>th</sup> percentiles pooled from all dates and stations in Eld Inlet for each year from 1998 through 2009 (see Appendix B, page 11). All 90<sup>th</sup> percentiles from Eld Inlet were included in the calculations regardless of the classification of the sub area in which it is located (Prohibited, Conditionally Approved, or Approved).

**Figure 3. Trend in fecal coliform pollution in Eld Inlet 1998-2009.**



**General Observations from Figure 3:**

- The year of least affect from fecal pollution in Eld Inlet in the past decade was 2001.
- There is strong evidence for an overall increase in fecal pollution in Eld Inlet from 2000-2009. However, fecal pollution may have leveled off slightly since 2007.

## Appendix A. Classifying Shellfish Growing Areas

DOH applies guidelines set by the National Shellfish Sanitation Program (NSSP). Each harvest area is classified into one or more of four categories:

- An area is classified **Approved** for unlimited harvest if water quality criteria are met and significant pollutant sources are absent.
- An area is classified **Conditionally Approved** if water quality criteria are met, except during pollution events that are *episodic* and *predictable*, such as rain-related runoff. Harvests from Conditionally Approved areas require a “Conditionally Approved Area Management Plan” (or CAAMP).
- An area is classified **Restricted** if it is subject to limited pollution. Shellfish from Restricted areas cannot be harvested directly. They may be “relayed” under strict supervision to clean waters for natural cleansing.
- If an area receives pollution that is *chronically excessive* and/or *unpredictable*, it is classified **Prohibited (P)**.

To classify a growing area, DOH evaluates two questions:

1. Does the area comply with the NSSP requirements for unlimited harvest of shellfish (Approved)?
2. If unlimited harvesting is not possible, are there conditions under which harvesting can be done (Conditionally Approved)?

**Question 1: Does an area comply with Approved classification?** DOH collects water samples in the growing area according to SRS (see **Introduction** on page 3). NSSP requires at least 30 samples be collected from each sampling station in a growing area. DOH calculates a geometric mean and a 90<sup>th</sup> percentile from the 30 results. These are compared to the NSSP criteria. Both the geometric mean and 90<sup>th</sup> percentile must meet the NSSP criteria.

1. The concentration of fecal coliform bacteria cannot exceed a geometric mean of 14 organisms per 100 milliliters (ml) in water (applied in all cases).
2. The estimated 90<sup>th</sup> percentile cannot exceed 43 organisms per 100 ml of water (applied to areas potentially affected by only nonpoint sources); OR not more than ten percent of the samples are to exceed 43 organisms per 100 ml of water (applied where point sources are present).

Besides the collection of fecal pollution data, DOH carries out a “shoreline survey” of the upland watershed and the marine shoreline to find and assess pollution sources. DOH cannot approve an area if the shoreline survey reveals pollution that presents a public health hazard, even if the water quality meets the NSSP criteria. If statistics from all stations meet the NSSP criteria and the shoreline survey does not reveal significant pollution that presents a public health hazard, DOH classifies the area Approved.

**Question 2. Can a growing area be classified Conditionally Approved?** If a shellfish growing area cannot be classified as Approved, DOH looks at the data to see if it can be classified Conditionally Approved. If conditions are found that would allow safe harvest, DOH prepares a “Conditionally Approved Area Management Plan” (CAAMP) for the area.

DOH examines the affect of various pollution factors in a growing area. Pollution factors include rainfall (daily or seasonal), flooding by major rivers, or seasonal boat activity. The most common Conditionally Approved classification is based on 24-hour rainfall. To set the rain-related condition, statistics are recalculated from edited data (i.e., fecal coliform results from the rainiest days are removed) to see if an upper limit on 24-hour rainfall exists below which harvest can be done. DOH puts the rainfall limit into a “Conditionally Approved Area Management Plan” (CAAMP) for the area. DOH removed the rainfall-based CAAMP in 1998 when Eld Inlet was reclassified from Conditionally Approved to Approved.

DOH reviews the classification of a growing area periodically. An objective review requires updated analysis of the water quality and the shoreline survey. For this reason DOH continues fecal pollution monitoring under SRS in ensure unbiased results are available when needed, even while the area does not meet the conditions specified in the CAAMP.

## Appendix B. Derivation of the Annual Fecal Pollution Index (FPI)

The fecal pollution index (FPI) is a single number that describes the annual status of fecal pollution. FPIs can be applied to any level of resolution: sampling station, growing area, region, or all of Puget Sound.

We will use Dungeness Bay in 2008 as an example to show how to derive the FPI, and show how the FPI can be used to show annual impact at an individual sampling station, at the level of the growing area, or trend on the growing area. To begin, we calculate the estimated 90th percentiles for each station and sampling date in 2008.

After the 90<sup>th</sup> percentiles are calculated, we follow the steps described below (cross-referenced with color-coded text in Table B-1 (next page)).

**Step 1. NUMBERS.** Sort the estimated 90th percentiles from each station into categories:

- “GOOD” (90<sup>th</sup> percentiles  $\leq$  30 mpn/100ml)
- “FAIR” (30 mpn/100ml < 90<sup>th</sup> percentiles  $\leq$  43 mpn/100ml)
- “BAD” (90<sup>th</sup> percentiles > 43 mpn/100ml)

Table D-1 shows that Station 113 had **four** GOOD 90<sup>th</sup> percentiles, **four** FAIR 90<sup>th</sup> percentiles, and **4** BAD 90<sup>th</sup> percentiles during 2008 (in columns b-d in Table D-1).

**Step 2. FRACTIONS.** For each station, divide the number of estimated 90<sup>th</sup> percentiles in each category by the total 90<sup>th</sup> percentiles in all categories. For Station 113, **four** GOOD 90<sup>th</sup> percentiles (column b)  $\div$  **12** total 90<sup>th</sup> percentiles (column e) = **0.33** (in column f).

**Step 3. WEIGHTED FRACTIONS.** Now, “weight” each fraction by multiplying it by a weighting factor:

- “GOOD” fractions  $\times$  1.00
- “FAIR” fractions  $\times$  2.00
- “BAD fractions”  $\times$  3.00

For example, for Station 113: the weighted FAIR fraction (**0.33** in column g)  $\times$  2.00 = **0.67** (in column j).

**Step 4. FPI.** Finally, add the weighted fractions. The sum is the fecal pollution index for each station. The FPI will range from 1.00 (100% of estimated 90th percentiles are GOOD) to 3.00 (100% of 90th percentiles are BAD). For example, the FPI for Station 113 (column l): (**0.33** + **0.67** + **1.00**) = **2.00**.

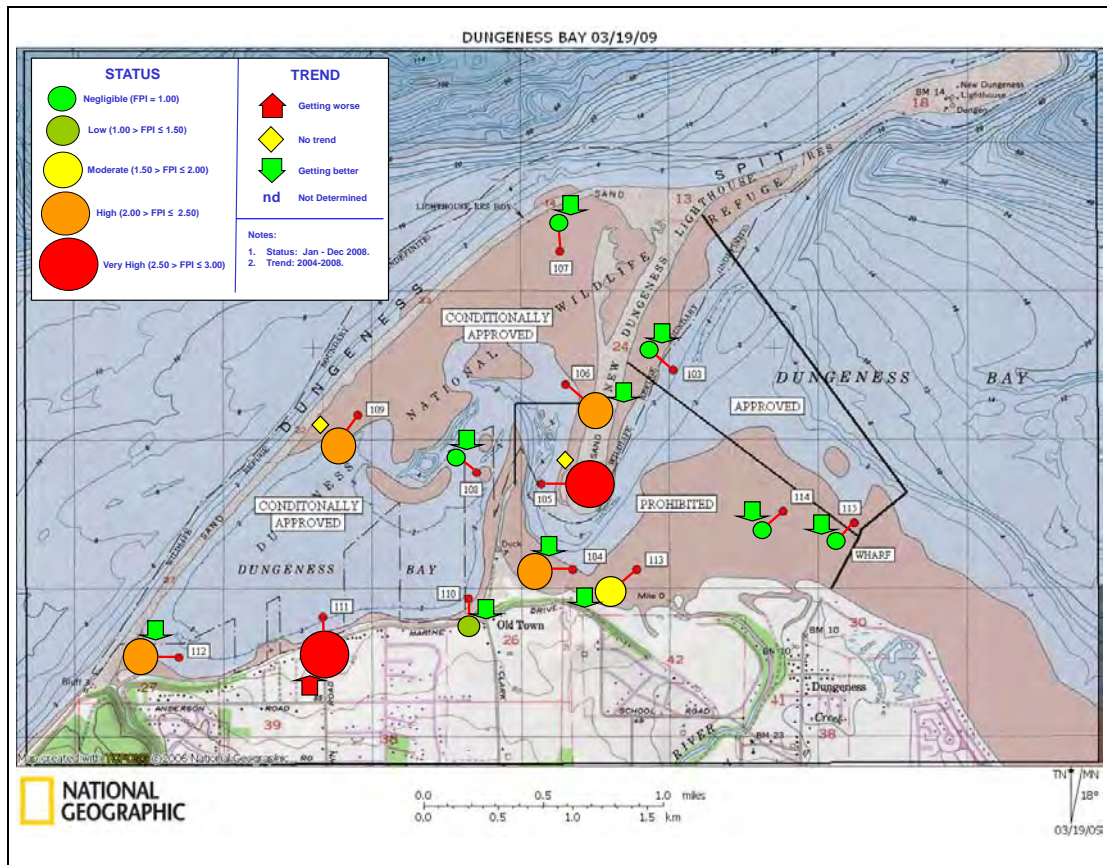
Figure B-1 uses the fecal pollution index at sampling stations in Dungeness Bay to characterize how fecal pollution was distributed in 2008.

**Growing Area and Puget Sound FPI.** To calculate the annual FPI for Dungeness Bay in 2008, we sum the numbers within each category for *all* stations (TOTAL DB line in Table B-1) and repeat the steps described above. The annual FPI for Dungeness Bay in 2008 was **1.57**. By extending the method to all stations in all Puget growing areas, the annual FPI for Puget Sound in 2008 was **1.16**.

Table B-1 summarizes FPI calculations for Dungeness Bay and Puget Sound in 2008.

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)
STATION	NUMBERS			TOTAL	FRACTIONS			WEIGHTED FRACTIONS			FPI
	GOOD	FAIR	BAD		GOOD	FAIR	BAD	GOOD	FAIR	BAD	
103	11	0	0	11	1.00	0.00	0.00	1.00	0.00	0.00	1.00
104	0	0	12	12	0.00	0.00	1.00	0.00	0.00	3.00	3.00
105	6	6	0	12	0.50	0.50	0.00	0.50	1.00	0.00	1.50
106	0	12	0	12	0.00	1.00	0.00	0.00	2.00	0.00	2.00
107	11	1	0	12	0.92	0.08	0.00	0.92	0.17	0.00	1.08
108	8	4	0	12	0.67	0.33	0.00	0.67	0.67	0.00	1.33
109	11	1	0	12	0.92	0.08	0.00	0.92	0.17	0.00	1.08
110	7	6	0	13	0.54	0.46	0.00	0.54	0.92	0.00	1.46
111	0	8	4	12	0.00	0.67	0.33	0.00	1.33	1.00	2.33
112	11	0	0	11	1.00	0.00	0.00	1.00	0.00	0.00	1.00
113	4	4	4	12	0.33	0.33	0.33	0.33	0.67	1.00	2.00
114	12	0	0	12	1.00	0.00	0.00	1.00	0.00	0.00	1.00
115	12	0	0	12	1.00	0.00	0.00	1.00	0.00	0.00	1.00
TOTAL DB	81	42	20	143	0.57	0.29	0.14	0.57	0.59	0.42	1.57
TOTAL PS	7962	436	506	8897	0.89	0.05	0.06	0.89	0.10	0.17	1.16

Figure B-1 shows fecal pollution impact at each sampling station in Dungeness Bay in 2008.



**Temporal Trend Using FPI.** The method is modified slightly to calculate annual “historical” FPIs for tracking change over time. “Historical” means that we use only 90<sup>th</sup> percentiles from stations with a continuous sampling history. We eliminate 90<sup>th</sup> percentiles from stations that were either dropped or added over time. Following the initial edit, we calculate an annual FPI for each year (1998 through 2008). Figure B-2 (below) shows the trend in “historical” FPIs in Dungeness Bay from 1998 through 2008.

*Figure B-2. Fecal Pollution impact in Dungeness Bay 1998-2008.*

