An Investigation of the Sources of Fecal Contamination to Four San Diego Beaches

Prepared by the
County of San Diego
Department of Environmental Health

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Executive Summary

Background

Each year more than 26 million people visit San Diego area beaches. Numerous concerns about the safety of swimming at these beaches have been raised. In addition to routine monitoring already conducted, several focused studies have begun to address issues surrounding these concerns. Following on the results of these and other investigations, the County of San Diego Department of Environmental Health (DEH) and the City of San Diego cooperatively initiated this study in Spring 1999 to determine the sources of fecal contamination at four beaches considered to be representative of coastal areas throughout San Diego County. The study addressed three primary objectives:

(1) Identify the sources contributing to elevated fecal coliform bacteria levels at local beaches,

(2) Identify management actions needed to control these sources, and

(3) Identify additional information needed to further characterize the problem.

Study Area

Four beaches located entirely within the City of San Diego in the central coastal portion of San Diego County were investigated.

- Avenida de la Playa (La Jolla Drainage Basin),
- Windansea Beach (Windansea Drainage Basin),
- Tourmaline Surf Park (Tourmaline Drainage Basin), and
- Dog Beach (San Diego River Watershed).

Representative sampling points for each of these areas were established. Each of these sites was chosen because it is used for a variety of recreational water contact activities and has a history of beach closures due to elevated bacteria levels. Three of the four sites convey runoff exclusively from basins of less than 1,100 acres located entirely within coastal communities, and the fourth (Dog Beach) drains a larger portion of the San Diego River watershed.

Study Design and Methods

This study was designed to identify the potential sources of *Eschericia coli* (*E.coli*). These bacteria make up approximately 80% of the coliform bacteria in normal intestinal flora. *E. coli* is easily modified and adaptive to various host environments leading to changes in genetic material that are thought to be specific to these host environments. As such, their genetic variability can be used to identify their host organisms.

275 water samples were collected at four sample sites for laboratory analysis, 105 during dry weather and 170 during wet weather conditions. Fecal specimens were also collected from fifty-six animals suspected to be fecal coliform contributors. The County of San Diego Public Health Laboratory processed the water samples for analysis of fecal coliform bacteria. Plated colonies and fecal specimens were shipped to the University of Washington, School of Public Health where they were further processed for ribosomal analysis of *E. coli* using polymerase chain reaction (PCR) and agarose gel electrophoresis. Sample results were then compared to a library of DNA fingerprints from known sources at the University of Washington.

Results

Of 550 possible *E. coli* colonies, 489 colonies were produced and positively verified as *E. coli*. Three hundred and fifty-three (353) were matched to 12 source groups; 179 isolates were reported as unknown. Human isolates were responsible for the highest percentage of matches during dry weather conditions, but were absent in all wet weather samples. In contrast, dog and bird isolates were generally the most abundant groups in wet weather samples. Matches for dogs were particularly abundant, accounting for more than 30% of wet weather matches at all sites, while birds accounted for more than 24% of isolates at all but the Dog Beach site.

Results were generally similar at the Avenida de la Playa, Windansea, and Tourmaline sites**.** Humans were responsible for the highest percentage of matches during dry weather conditions (31.6 to 44.7%), followed by dogs (2.6 to 20.0%), cats (0 to 17.5%), and indigenous mammals (2.5 to 13.2%). Conversely, humans were not represented during wet weather, but dogs accounted for the highest percentage of matches (31.4 to 36.4%), followed closely by birds (24.3 to 39.0%) which were unrepresented during dry weather. Results at the Dog Beach site were very different. Unlike the other three sites, only 1 dry weather isolate was matched to a human source. Avian matches were also relatively predominant during dry weather (40.7%) in contrast to the complete absence of birds in dry weather results at the other sites.

It is useful to consider the degree to which specific sources are controllable, as well as the types of controls which may be appropriate and feasible for each. As a rule it should be noted that a variety of non-structural best management practice (BMPs) can appropriately be applied to all of the source groups identified in this study but indigenous animals (birds and small mammals). Dogs and cats were the most consistently represented domestic animals throughout the study, and therefore should be a primary focus of management efforts. Humans are also important, but more information is needed on the specific sources of these inputs. In most cases, public education appears to be the most broadly applicable BMP since many people are still unaware of their role in preventing water quality contamination. It is therefore likely that effective public awareness campaigns can measurably change the attitudes and behaviors of many citizens.

Recommendations

As a whole, the results of this study support the continued use of conventional stormwater and urban runoff management practices and the collection of additional data to further characterize risks to human users. With this in mind, the following are recommended.

<u>Source Management Recommendations</u>

1. **Continue the use of non-structural BMPs as a general control measure**.
2. **Continue the use of diversion/interceptor systems for dry weather control where appropriate and feasible**.
3. **Develop performance measures for best management practices (BMPs)**.

<u>Monitoring / Research Recommendations</u>

4. **Conduct sanitary surveys to further characterize specific sources of human fecal matter during dry weather conditions**.
5. **Identify specific pathogens and risks to human recreational users**.
6. **Periodically re-evaluate study results against updated DNA Library**.
7. **Develop standard protocols with measures of statistical significance for DNA source studies**.

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Table of Contents

Introduction

Each year more than 26 million people visit San Diego area beaches. Numerous concerns about the safety of swimming at these beaches have been raised. Over the past few years, several focused studies in San Diego and other areas have begun to address issues surrounding these concerns. The County of San Diego has monitored coastal water quality for more than 25 years. The City of San Diego similarly conducts monitoring at a number of shoreline sites, and initiated a weekly coastal storm drain monitoring program in 1996 to augment these efforts. Although these activities provide valuable information for assessing the general water quality of local beaches, they are limited in that they do not directly measure the probability of adverse health effects. To effectively understand and manage these risks, a more comprehensive approach to understanding these issues has become necessary.

In 1995, an epidemiological study conducted by the Santa Monica Bay Restoration Project (SMBRP) provided an important step in this direction by demonstrating an increased risk of illness associated with swimming in proximity to flowing storm drain outlets during dry weather. Similarly, as part of a Southern California Bight 1998 Regional Monitoring Program, the Southern California Coastal Water Research Project (SCCWRP) identified the presence of human enteric virus material in 73% of water samples which exceeded state recreational water standards for fecal coliform. Results of these studies have clearly demonstrated that contaminated urban runoff has the potential to increase health risks to recreational users but have lacked specific information on the possible sources of this contamination. In response to this need, DNA fingerprinting has recently been utilized to identify specific sources of fecal contamination at several locations in San Diego County and elsewhere. In 1998, DNA source investigations were conducted to determine strategies for reducing fecal contamination at Coronado beaches, and to identify the source of elevated levels at the Children's Pool in La Jolla. Following on these results, a 1998 study was initiated by the San Diego area municipal stormwater co-permittees to identify sources of fecal coliform bacteria to the Agua Hedionda watershed. A similar study was completed in October 1999 to characterize sources in the Lower Rincon Creek watershed in Santa Barbara County.

Following on the results of these and other investigations, the County of San Diego Department of Environmental Health (DEH) and the City of San Diego cooperatively initiated this study in Spring 1999 to determine the sources of fecal contamination at four beaches considered to be representative of coastal areas throughout San Diego County. The study addressed three primary objectives:

(4) Identify the sources contributing to elevated fecal coliform bacteria levels at local beaches,

(5) Identify management actions needed to control these sources, and

(6) Identify additional information needed to further characterize the problem.

Through the identification of specific sources, the County and other responsible agencies will be better able to interpret the meaning of existing water quality data and to adapt appropriate strategies for health risk management.

Study Area

The four beaches investigated in this study are located entirely within the City of San Diego in the central coastal portion of San Diego County (Figure 1). The County's 1997 population was estimated at 2.7 million residents, approximately 1.2 million (43%) of which is within the City. As in other parts of the County, much of this population is concentrated in the west, reflecting a historical emphasis on development along the coastline prior to other inland areas. Land uses in the region are highly varied. As a whole, the County is still dominated by undeveloped uses. However, most of the total drainage area included in this study is predominantly residential.

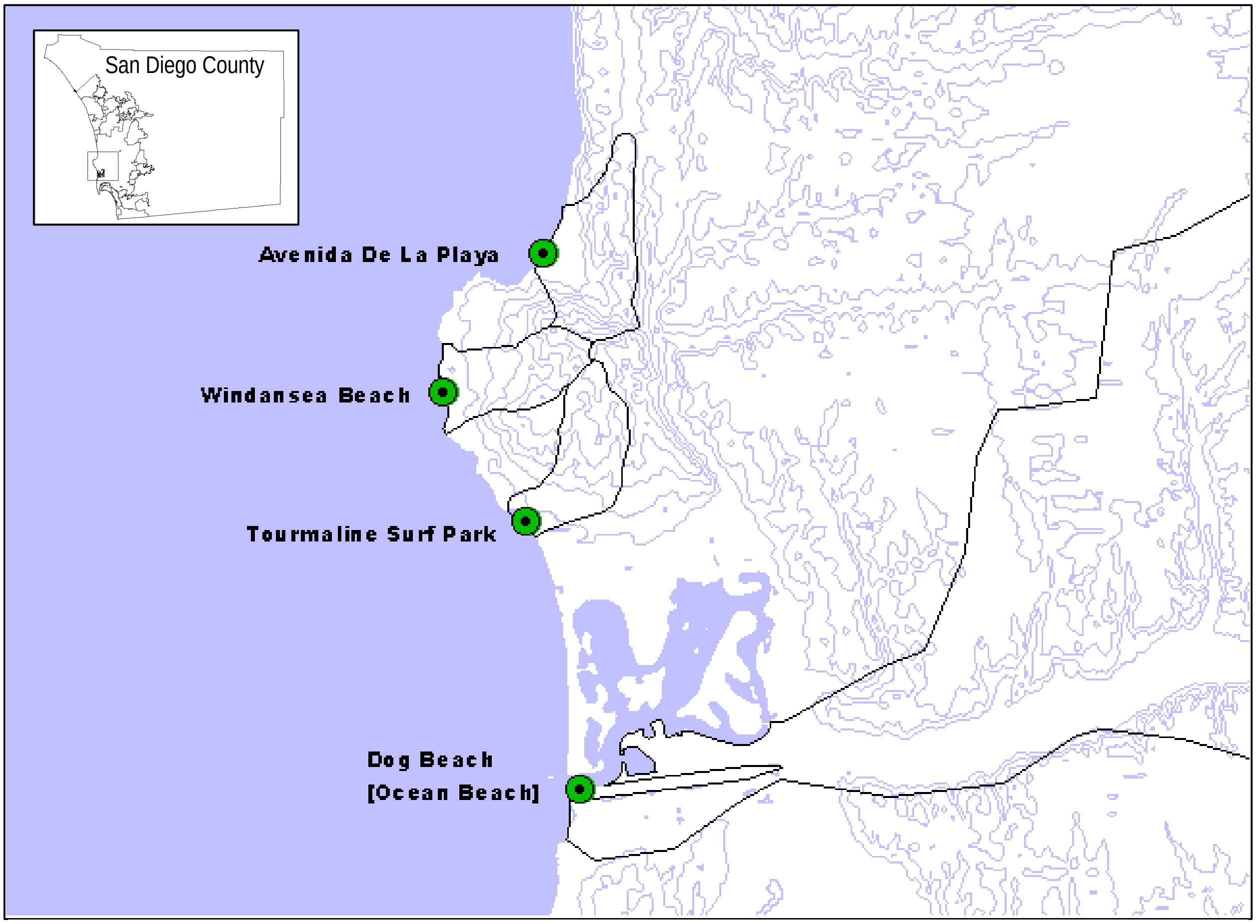

Figure 1: Locations of Sampling Sites and Drainage Areas

Climate in coastal San Diego County is generally mild with annual temperatures averaging around 65^{o} F. Annual rainfall usually ranges from less than 9" in the southwest to 11" in the north. There are two distinctive climatic periods, a dry period from late April to mid-October and a wet period from mid-October through late April. The wet period generally provides 85-90% of the annual rainfall.

Four distinct drainage areas were investigated. Representative sampling points for each of these areas were established. These points and their respective drainage areas are listed in Table 1. Each of these sites was chosen because it is used for a variety of recreational water contact activities and has a history of beach closures due to elevated bacteria levels. Three of the four sites convey runoff exclusively from basins of less than 1,100 acres located entirely within coastal communities and the fourth (Dog Beach) drains a larger portion of the San Diego River watershed. The Dog Beach site also differs from the others in that it is located along the mouth of the San Diego River rather than at a storm drain outlet. Locations of sampling points and their respective drainage areas are shown in Figure 1. Each of these drainage areas is described further below. Relative percentages of land uses for each are also summarized in Table 2[1].

[1] For the La Jolla, Windansea, and Tourmaline Drainage Basins, areas and land use percentages were estimated by Department of Environmental Health staff using a Geographic Information System (GIS) to digitize drainage area boundaries from hard copy maps provided by the City of San Diego Stormwater Pollution Prevention Program. Data for the San Diego River watershed was obtained from the San Diego Association of Governments (SANDAG). All values are based on 1995 land uses.

Table 1: Study Sampling Locations and Drainage Areas

Sampling Location	Drainage Area	Drainage Area Size (Acres)
Avenida de la Playa	La Jolla Drainage Basin	974
Windansea Beach	Windansea Drainage Basin	736
Tourmaline Surf Park	Tourmaline Drainage Basin	1,090
Dog Beach (Ocean Beach)	San Diego River Watershed	277,543

Table 2: Land Uses Within the Study Area Drainage Basins (% of Total)

Land Use	La Jolla Shores Basin	Windansea Basin	Tourmaline Basin	San Diego River Watershed
Residential	74.1	91.0	81.4	14.9
Commercial/Industrial	1.1	3.2	2.1	4.2
Schools	4.7	0.5	3.4	0.7
Commercial Recreation	10.2	0.2	0.9	0.6
Freeways / Road Right-of-Ways	0.7	0.1	0.4	5.5
Parks / Open Space	3.3	4.6	8.7	13.2
Agricultural	---	---	---	2.5
Undeveloped / Vacant	5.9	0.4	3.1	58.4

Avenida de la Playa. The storm drain located at Avenida de la Playa lies in the La Jolla Shores drainage basin, an area of approximately 974 acres. The basin is surrounded by sloped hills on three sides. It includes the north-facing slope of Mount Soledad on the south and La Jolla Scenic Drive on the east and a wedge of canyon east of Torrey Pines Road, and south west of the intersection of Torrey Pines Road and La Jolla Village Drive. Land uses in the basin are primarily residential, but include a business district with shops and restaurants, three hotels, a gas station, a 9-hole golf course, open space, and the western portion of the University of California San Diego campus. The basin has neither agriculture nor heavy industry. Drainage is primarily from developed areas, but includes limited open space. Three other storm drains also convey runoff from within the basin to the La Jolla Shores area. Dry weather sample collection was conducted inside a below grade junction box, upstream of the interceptor, at the north side of the intersection of Avenida de la Playa and Paseo Grande. Hazardous conditions during wet weather precluded sampling at the same location as during dry weather. Wet weather sample collection was therefore conducted at the storm drain on the beach at the foot of Avenida de la Playa.

Windansea Beach. This storm drain is located at Bonair Street in La Jolla near its intersection with Neptune Place. The entire basin is 736 acres. Land uses are primarily residential, but also include open space, two high schools and a portion of a golf course. The area is bounded on the east by the western slope of Mount Soledad. The stormwater conveyance system receives runoff primarily from developed areas, but also from open, undeveloped areas. Two other storm drains also collect runoff within this drainage basin. Both dry weather and wet weather sample collection were conducted at the storm drain pipe protruding from the cliff on the beach at the foot of Bonair Street.

Tourmaline Surf Park. The storm drain at Tourmaline Surfing Park conveys runoff from southern La Jolla and northern Pacific Beach. The Tourmaline Drainage Basin is approximately 1,090 acres. It is primarily residential, but includes open space, and commercial districts with grocery stores, restaurants, automobile repair shops, and gas stations. The basin is fed by two canyon areas, both of which are undeveloped, but most of the drainage area is developed. A second storm drain also discharges from this basin approximately 0.5 miles north of Tourmaline Surf Park near the intersection of Searidge Drive and Linda Way. Sample collection for Tourmaline Surf Park was conducted at the storm drain channel slope, upstream of the interceptor, on the north side of the driveway in the Tourmaline Surf Park parking lot.

Dog Beach. Dog Beach in Ocean Beach lies at the western terminus of the San Diego River. This watershed drains an area of approximately 277,543 acres from the Cuyamaca Mountains in the east to the Pacific Ocean. In addition to the City of San Diego, the River drains portions of the unincorporated County, and the cities of Poway, Santee, El Cajon, and La Mesa. The San Diego River watershed includes a variety of land uses including residential, commercial/industrial, schools, commercial recreation, parks and open spaces, agriculture and vacant undeveloped land. The amount of total area characterized in this study is not known since flow is impounded in reservoirs (e.g., El Capitan Reservoir) at several points throughout the watershed. In view of this, it is likely that the sample site is more highly influenced by coastal land uses such as residential and commercial than the open space uses more characteristic of the eastern portions. The site is also heavily influenced by tidal flow. Sample collection for Dog Beach was conducted at the mouth of the San Diego River, north of the parking lot for Dog Beach.

Study Design and Methods

Overview. Coastal water quality monitoring activities are currently focused on determining concentrations of coliform bacteria in discharges and receiving waters rather than identifying the sources of these organisms. This study was designed to identify the potential sources of *Eschericia coli* (*E.coli*). These bacteria make up approximately 80% of the coliform bacteria in normal intestinal flora. *E. coli* is easily modified and adaptive to various host environments leading to changes in genetic material that are thought to be specific to these host environments. As such, the genetic variability of *E. coli* can be used to identify their host organisms by comparing their genetic fingerprint to a DNA library of *E. coli* obtained from known host sources. Sampling and analytical methods used in this study are described in detail below.

Water Sampling. In March 1999, 275 water samples were collected at four sample sites for laboratory analysis, 170 during wet weather and 105 during dry weather conditions (Table 3). Sampling was conducted in accordance with Standard Methods for the Examination of Water and Wastewater (APHA, 1997). Twenty dry weather samples were collected at each of the three storm drain locations, Avenida de la Playa, Windansea Beach, and Tourmaline Surf Park. Forty-five samples were collected at the Dog Beach site to better represent the larger volume of water flowing through the site. Two of the storm drain sites, Avenida de la Playa and Tourmaline, have interceptors to collect and divert the low flow runoff to the sewer system during dry weather. To ensure that bacteria contained in the runoff sampled did not result from accumulation in the diversion system, samples were collected upstream of the point where liquid flows into the diversion structures. Each of the three storm drain sites is above the tidal zone and therefore not influenced by ocean water. However, Dog Beach is tidally influenced. Dry weather samples at this site were taken early in a flood tide, and therefore probably include a mix of ocean water and river discharge.

Table 3: Summary of Water Sample Collection by Location

Location	Dry Weather	Wet Weather	Total
Avenida de la Playa	20	45	65
Windansea Beach	20	40	60
Tourmaline Surf Park	20	40	60
Dog Beach	45	45	90
Total	105	170	275

To ensure that samples were representative of dry weather conditions, a criterion of 72 hours without significant rainfall (equal to or greater than 0.1") was applied. In most cases, sampling was preceded by three days without rainfall. However, 0.05" of rain was recorded on March 7 at Sea World, approximately 0.75 miles east of the Dog Beach sampling site which was sampled on March 9. Other upstream sites at Santee and El Cajon also received 0.11" and 0.19", respectively, during that same period. The degree to which this rainfall affected the dry weather results at this site is unknown since the Sea World site received less than 0.1" and the other sites are both more than 10 miles away. The Avenida de la Playa site was also sampled on March 10, but the only coastal rain gauges exceeding the 0.1" criterion on March 7 were 6 miles north in the City of Del Mar (0.24") and 9 miles south at Lindbergh Field (0.11").

Due to the limited amount of rainfall in the San Diego area, all wet weather sampling was conducted during single events at each of the sites. To ensure that samples were representative of wet weather conditions, they were collected only during events of 0.1" of rain or greater. Forty to 45 samples were collected at each location. To better represent the greater flow at the Dog Beach site, samples taken in the river were collected by alternating between the nearshore and mid-river segment. Sewage spill report records were also checked to ensure that results were not influenced by sanitary sewer overflows in close proximity to the sites.

Source Sampling. Fifty-six local fecal specimens were collected for DNA analysis on June 9, 1999 (Table 4). These samples were used to augment the 32,000 samples already contained in the University of Washington's DNA library. Although many potential sources of fecal contamination were identified for investigation, sampling was confined to species that are abundant within the study areas and readily available for sample collection. Since a significant portion of the study area is comprised of urban residential land uses, domestic sources were emphasized. Specimens of dog and cat excrement were obtained at the San Diego County Animal Control Shelter on Gaines Street, San Diego. This facility receives animals from many San Diego communities. Fecal specimens from wild birds were collected in cooperation with Project Wildlife in San Diego. The birds were rescued from a variety of locations throughout the County and taken in for rehabilitation when injured or abandoned.

Laboratory Analysis. All water samples were delivered to the County of San Diego Public Health Laboratory within 2 hours of collection to quantify levels of fecal coliform bacteria. Representative fecal coliform colonies were isolated and shipped to Dr. Mansour Samadpour for DNA analysis at the University of Washington. These methods are described further below.

<u>Isolation and Quantification of Fecal Coliform Colonies</u>. At the Public Health Laboratory, three dilutions were plated for each sample to achieve the most accurate counting. The Membrane Filtration Method (APHA Standard Method 9222D) was coupled with m-FC Agar with Rosolic Acid to increase the specificity of recovering fecal coliforms without having to confirm the results. This is achieved within a completion time of 24 hours. Fecal coliform colonies were counted as per *Standard Methods* and plates

Table 4: Source Specimens Collected in the San Diego Region

Source Specimen	Number of Samples
Dog (Domestic)	25
Cat (Domestic)	25
Western Gull	1
Green Heron	1
Black-Crowned Night-Heron	2
Fulmar	1
Snowy Egret	1
Total	56

were selected at a dilution that had at least two fecal coliform colonies per plate. Fecal coliform results are presented in Appendix A.

Isolation and Selection of *E. coli* Colonies. Once the plates arrived at the University of Washington Laboratory, they were further processed to isolate, positively confirm, and purify their *E. coli* component. Two *E. coli* isolates from each water sample were selected, assigned an isolate number, and further cultured for storage until DNA Analysis could be conducted. Dr. Samadpour conducts DNA Testing based on 16S ribozomal RNA typing, a method that utilizes two restriction enzymes, or restriction endonucleases.

Restriction Endonucleases. Prior to the 1970's there was no method available for cutting DNA into discrete fragments. But with the advent of Nucleic Acid Hybridization Technology, molecular biologists were able to utilize natural DNA repair mechanisms to cut the connection between 2 specific locations (or base pairs) along the DNA molecule. Restriction systems allow bacterial cells to protect their own DNA by monitoring the origin of incoming DNA and destroying foreign DNA. Restriction endonucleases recognize specific sequences in the incoming DNA and cleave it into fragments at a specific site. The fragmentation products formed as a result are thought to be specific to the host source of *E.coli*.

Amplification. After they are cleaved, the fragmentation products can be replicated to increase their relative abundance through repeated cycles of denaturation, annealing, and primer extension. Denaturation involves heating the fragments at high temperatures to break their double-stranded DNA into single strands. Annealing is utilized to compose the complementary fragment to the now single-stranded DNA. Primer Extension recreates double-stranded target regions that are identical to the original target sequence. Repeating this cycle 25-45 times allows an exponential increase in DNA strands (e.g., 1 becomes 2, and 2 become 4, etc.) until a 10^6 increase is reached. Polymerase chain reaction, or PCR, allows a specific segment of DNA to be amplified very easily by a factor of 10^6 or more within hours. An enzyme called Taq DNA Polymerase, which is extremely stable at high temperatures, is used to increase the strength of the primer extension. By allowing the extension reactions to be performed at higher temperatures, non-specific annealing is eliminated, making this technology highly specific.

Agarose Gel Electrophoresis. After the PCR assay is complete, specific fragments must be separated to determine their DNA expression and compare it to those of known host sources. DNA molecules display elastic behavior by stretching in the direction of an applied electric field and then contracting into dense conglomerations. Electrophoresis is a widely used procedure in which an electric field is applied to an agarose gel forcing the DNA fragments, which are negatively charged, to run toward a positive electrode. Under the electric field, fragments with large molecular weights will migrate a shorter distance than those with smaller molecular weights, thereby resolving DNA fragments of different lengths. Dr. Samadpour uses Southern Blot Electrophoresis, in which the agarose gel is pre-treated by exposure to a short depurination treatment (0.25M HCl followed by alkali). This ensures that the DNA fragments are in a single-strand state and accessible for labeling by a radioactive nucleic acid probe (radioactive phosphorous) which is capable of specifically binding to the target region of the single-stranded DNA. Autoradiography is used to record the location of radiolabeled-DNA within the agarose gel by producing a picture of silver halide crystals suspended in the gel. This picture represents the distribution of DNA fragments within a host source with absolute clarity, and can be compared to known host sources in the DNA Library.

Analysis of Results. Sample results were assigned a match group and a ribotype number. If the pattern was a perfect match, it was assigned a group. If the pattern was very similar, but not a perfect match, the pattern number was entered into the database and assigned a letter suffix to the number, but not assigned a group. Many unknown strains have been entered into the database; at some point these may be identified, but currently do not match any known sources. Matched samples can be assigned to either of two types of groups. "Resident" matches are those which have only been observed within a particular host species or group, such as "dog" or "cat". "Transient" matches are those in which an *E. coli* match has been observed in more than one host group, e.g., both dog and cat. In this case it would be reported as "dog-cat." A "transient" match might have been observed within a group of similar species, such as "rodent", which would include mice, rats and voles. "Avian" is another example of a transient group, with matches limited to only birds. When there is a variation within a group, a ribotype number is assigned to each isolate that differentiates matches within the group. There are typically 3-4 ribotypes in a match group, but others may also be present.

Results

Two-hundred and seventy-five (275) samples were delivered to the University of Washington for DNA ribotyping. DNA match results are provided in Appendix B. As per the study methods described above, a maximum of 550 isolates, or two per sample, could theoretically have been produced. Because some samples did not produce either fecal coliform or *E. coli* colonies, a total of 489 isolates were produced. Of the 61 samples which did not produce *E. coli* isolates, 35 corresponded to wet weather samples at Dog Beach. Of the 489 total isolates produced, 353 (72.2%) were found to match known sources; 308 (63.0%) with the University of Washington's DNA Library and 45 (9.2%; 3 cat and 42 dog) with local source samples. 136 (27.8%) could not be matched. Each of the percentages presented was calculated using a total number (489) that includes unmatched isolates rather than as a percentage of known, or matched, isolates.

Results by Sampling Location. Tables 5 through 8 show the distribution of matches for each site during both wet and dry weather conditions. Figures 2 through 5 also illustrate the distribution of matches by wet and dry conditions, but combine specific avian and mammalian sources into larger groupings.

<u>Avenida de la Playa</u>**.** Of the 65 samples collected at the Avenida de la Playa site 126 isolates were produced; 40 (31.7%) of these corresponded to dry weather and 86 (68.3%) to wet weather. During dry weather, humans represented the highest percentage of total matches at 40.0%, followed by dogs and cats at 20.0% and 17.5%, respectively. Rodents accounted for a single match and birds were not detected. The unmatched component at this site was 20.0%. Wet weather results were significantly different. While the unmatched component and the combined contribution of dogs and cats varied only slightly, human matches were not found and 23 avian matches (26.7%) were observed, including seagulls, ducks, crows, and other unidentified birds. As previously mentioned, dry weather and wet weather samples were collected at different locations for this site because of safety concerns. For this reason, dry weather samples exclude a portion of the the conveyance that drains a primarily commercial area. The degree to which this difference has influenced these results is not known, although it does not appear that this area comprises a significant portion of the entire drainage area.

Windansea Beach**.** Of the 60 samples collected at the Windansea Beach site, 112 isolates were produced; 38 (33.9%) resulted from dry weather samples and 74 (66.1%) from wet weather samples. Of the four sites, Windansea had the highest percentage of human matches (44.7%) during dry weather and, as with the Avenida de la Playa site, no human matches during wet weather. Significantly higher match rates were also observed for dogs and cats during dry weather conditions. Birds were also detected only during wet weather conditions. Of these, the majority of matches were attributable to seagulls. Match rates for indigenous mammals were about the same during both dry (13.2%) and wet weather (10.8%). These included raccoons, opossums, and unspecified rodents.

Tourmaline Surf Park**.** Sixty samples were collected at Tourmaline Surf Park, producing 115 isolates; 38 (33.0%) corresponded to dry and 77 (67.0%) to wet weather. As with the Avenida de Playa and Windansea sites, humans were responsible for the highest percentage of matches (31.6%) during dry weather conditions and were not represented during wet weather. Similarly, birds were unrepresented during dry weather but represented a significant portion (39.0%) of wet weather matches. However, in this case, the majority of bird matches could not be assigned to a specific group. Dogs and cats collectively accounted for about twice the percentage of total matches in wet weather (41.6%) than in dry weather (18.4%). Three matches (7.9%) were attributed to raccoons during dry weather. There was otherwise no representation of indigenous mammals.

Dog Beach**.** From the 90 samples collected at Dog Beach (45 dry weather and 45 wet weather), only 136 of 180 possible isolates were produced; the fact that this site had a comparatively much higher number of samples not producing isolates suggests that dilution of fecal matter by greater volumes of river and/or ocean water may be significant. Unlike the other three sites, only 1 dry weather isolate was matched to a human source. This may be attributable to site-specific conditions. Since the Dog Beach samples were collected at the beginning of a flood tide, it is likely that the river discharge was significantly diluted by ocean water. Had the river discharge contained significant inputs of human fecal matter, these might have been diluted by the larger volume of ocean water in the sample. In this case, *E. coli* present in the ocean water would be more highly represented. This is also consistent with the relative predominance of avian samples at this site during dry weather. While birds were completely absent in dry weather results at the other sites, they comprised 40.7% of Dog Beach matches possibly suggesting an input of fecal matter from marine birds. A alternative explanation could be the possible influence of prior rainfall. As mentioned, some precipitation did occur within the San Diego River watershed two days prior to sampling. Had a significant amount of avian fecal matter been washed into the river, this might have been reflected in the discharge.

Seasonal Variation. Figure 6 below shows the relative contribution of each major source category during wet and dry weather conditions. In comparing the distribution of these matches, some trends are apparent, although it should be cautioned that these are not supported by statistical analysis. The most pronounced of these is the relative abundance of human isolates during dry weather conditions, and their complete absence in wet weather samples. In contrast, both dog and bird isolates were generally the most abundant groups in wet weather samples. Matches for dogs were particularly abundant, accounting for more than 30% of wet weather matches at all sites, while birds accounted for more than 24% of isolates at all but the Dog Beach site.

Matches by Source Category. Twelve categories of source matches were identified. For discussion, these are grouped into five broader categories.

Human Sources. During dry weather conditions, human sources were the most highly represented, ranging from 31.6 to 44.7% of total matches at three of four sites. In contrast, human matches were not identified during dry weather conditions at Dog Beach or at any site during wet weather. This total lack of human sources in wet weather samples suggests that human inputs may be masked by higher flows (dilution) and/or a greater relative presence of other sources during rainfall. Although there is still a likelihood that human sources are present, their statistical probability of detection decreases as other sources become comparatively more plentiful during rain, e.g. as dog and cat excrement is washed off of urban streets into the stormwater conveyance system.

Table 5: Source Matches at Avenida de la Playa

Match Category	Dry Weather # of Matches	Dry Weather % of Total	Wet Weather # of Matches	Wet Weather % of Total
Dog	8	20.0	27	31.4
Dog-Cat[2]	0	0.0	2	2.3
Cat	7	17.5	7	8.1
Human	16	40.0	0	0.0
Avian				
Unspecified[3]	0	0.0	8	9.3
Seagull	0	0.0	4	4.7
Duck	0	0.0	8	9.3
Crow	0	0.0	3	3.5
Duck-Goose[4]	0	0.0	0	0.0
Indigenous Mammals[5]				
Raccoon	0	0.0	3	3.5
Opossum	0	0.0	1	1.2
Rodent	1	2.5	0	0.0
Unmatched	8	20.0	23	26.7
Total	**40**	**100.0**	**86**	**100.0**

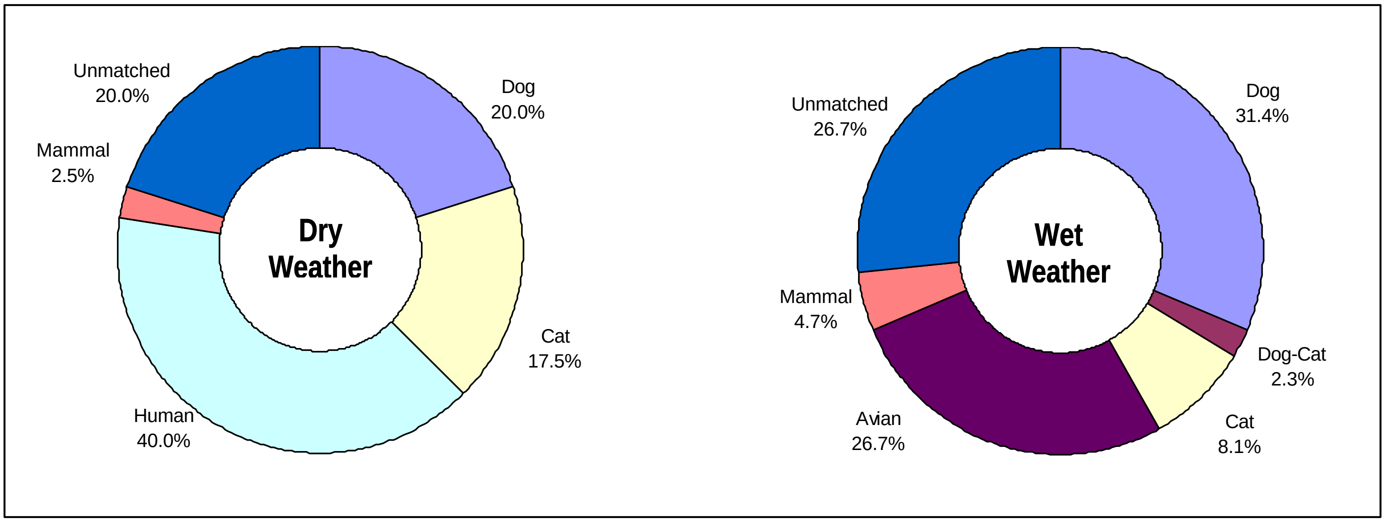

Figure 2: Percent Distribution of Source Match Categories at Avenida de la Playa

[2] Denotes a transient match that could be either dog or cat.
[3] Could not be assigned to a specific group of birds.
[4] Denotes a transient match that could be either duck or goose.
[5] Assumes that the contribution of domestic mammals, e.g., pet mice etc., is insignificant.

Table 6: Source Matches at Windansea Beach

Match Category	Dry Weather # of Matches	Dry Weather % of Total	Wet Weather # of Matches	Wet Weather % of Total
Dog	5	13.2	24	32.4
Dog-Cat[6]	0	0.0	3	4.1
Cat	0	0.0	5	6.8
Human	17	44.7	0	0.0
Avian				
Unspecified[7]	0	0.0	4	5.4
Seagull	0	0.0	13	17.6
Duck	0	0.0	0	0.0
Crow	0	0.0	0	0.0
Duck-Goose[8]	0	0.0	1	1.4
Indigenous Mammals[9]				
Raccoon	0	0.0	4	5.4
Opossum	3	7.9	2	2.7
Rodent	2	5.3	2	2.7
Unmatched	11	28.9	16	21.6
Total	38	**100**	74	**100**

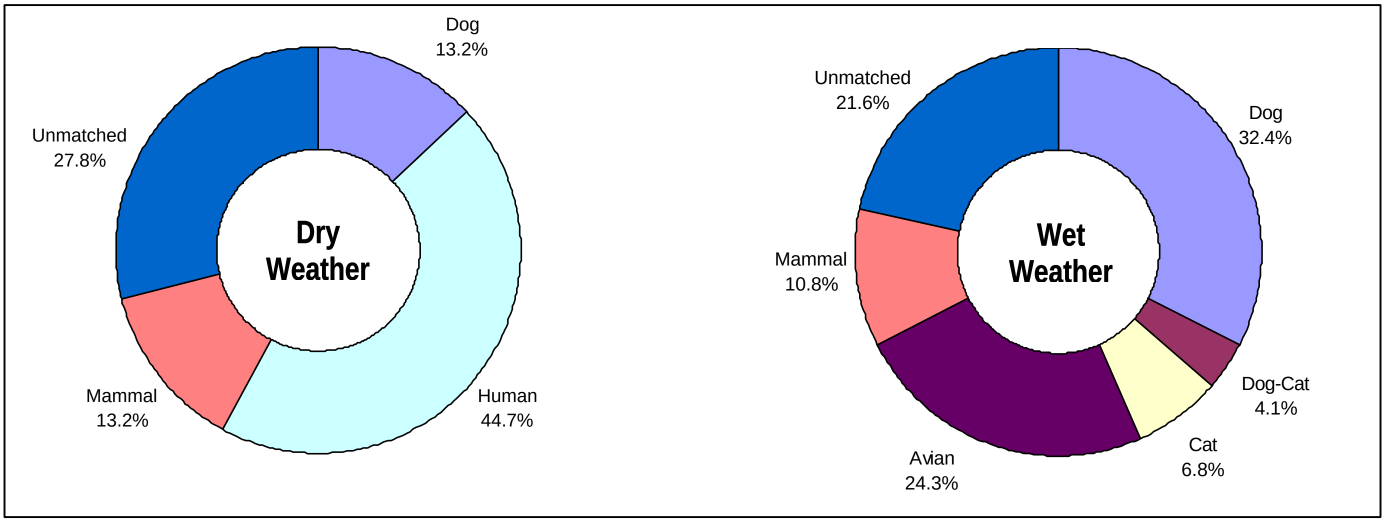

Figure 3: Percent Distribution of Source Match Categories at Windansea Beach

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[6] Denotes a transient match that could be either dog or cat.
[7] Could not be assigned to a specific group of birds.
[8] Denotes a transient match that could be either duck or goose.
[9] Assumes that the contribution of domestic mammals, e.g., pet mice etc., is insignificant.

Table 7: Source Matches at Tourmaline Surf Park

Match Category	Weather Condition			
	Dry Weather		Wet Weather	
	# of Matches	% of Total	# of Matches	% of Total
Dog	1	2.6	28	36.4
Dog-Cat[10]	0	0.0	1	1.3
Cat	6	15.8	3	3.9
Human	12	31.6	0	0.0
Avian				
Unspecified[11]	0	0.0	25	32.5
Seagull	0	0.0	4	5.2
Duck	0	0.0	0	0.0
Crow	0	0.0	1	1.3
Duck-Goose[12]	0	0.0	0	0.0
Indigenous Mammals[13]				
Raccoon	3	7.9	0	0.0
Opossum	0	0.0	0	0.0
Rodent	0	0.0	0	0.0
Unmatched	16	42.1	15	19.5
Total	38	**100**	77	**100**

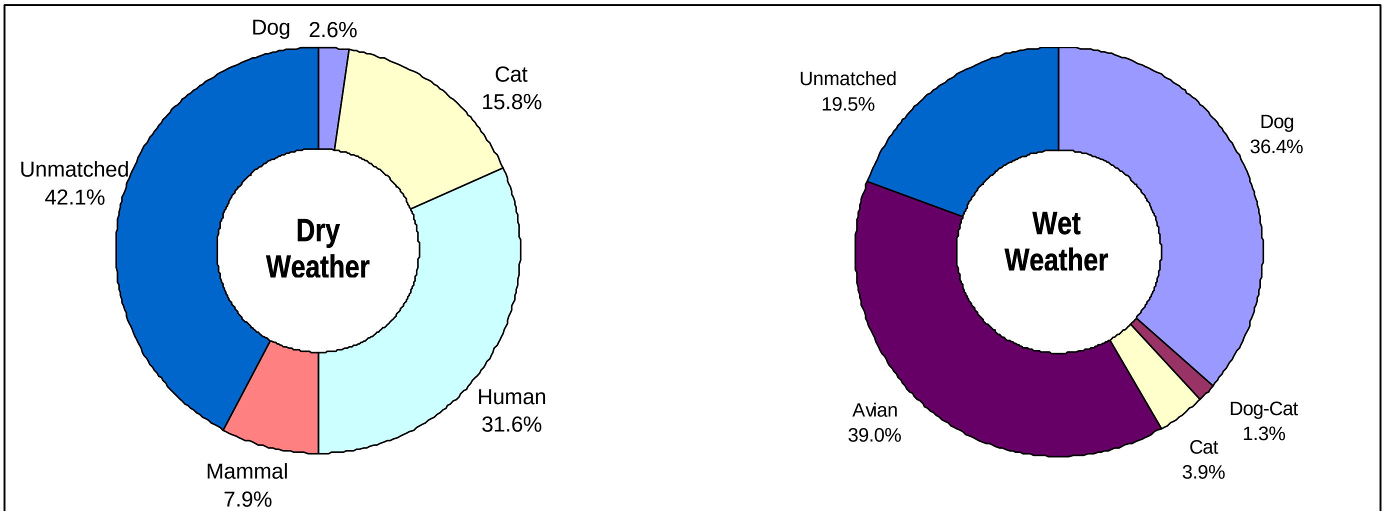

Figure 4: Percent Distribution of Source Match Categories at Tourmaline Surf Park

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[10] Denotes a transient match that could be either dog or cat.
[11] Could not be assigned to a specific group of birds.
[12] Denotes a transient match that could be either duck or goose.
[13] Assumes that the contribution of domestic mammals, e.g., pet mice etc., is insignificant.

Table 8: Source Matches at Dog Beach

Match Category	Weather Condition			
	Dry Weather		Wet Weather	
	# of Matches	% of Total	# of Matches	% of Total
Dog	14	17.3	23	41.8
Dog-Cat[14]	0	0.0	3	5.5
Cat	1	1.2	0	0.0
Human	1	1.2	0	0.0
Avian				
Unspecified[15]	29	35.8	4	7.3
Seagull	1	1.2	2	3.6
Duck	3	3.7	0	0.0
Crow	0	0.0	1	1.8
Duck-Goose[16]	0	0.0	1	1.8
Indigenous Mammals[17]				
Raccoon	3	3.7	0	0.0
Opossum	2	2.5	0	0.0
Rodent	1	1.2	0	0.0
Unmatched	26	32.1	21	38.2
Total	81	**100.0**	55	**100.0**

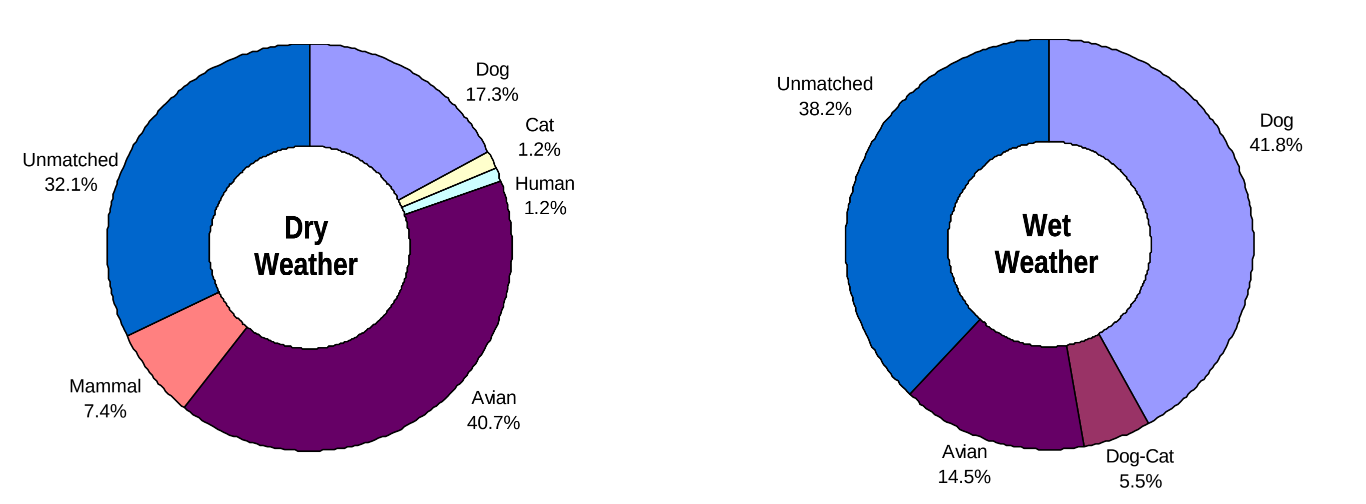

Figure 5: Percent Distribution of Source Match Categories at Dog Beach

[14] Denotes a transient match that could be either dog or cat.
[15] Could not be assigned to a specific group of birds.
[16] Denotes a transient match that could be either duck or goose.
[17] Assumes that the contribution of domestic mammals, e.g., pet mice etc., is insignificant.

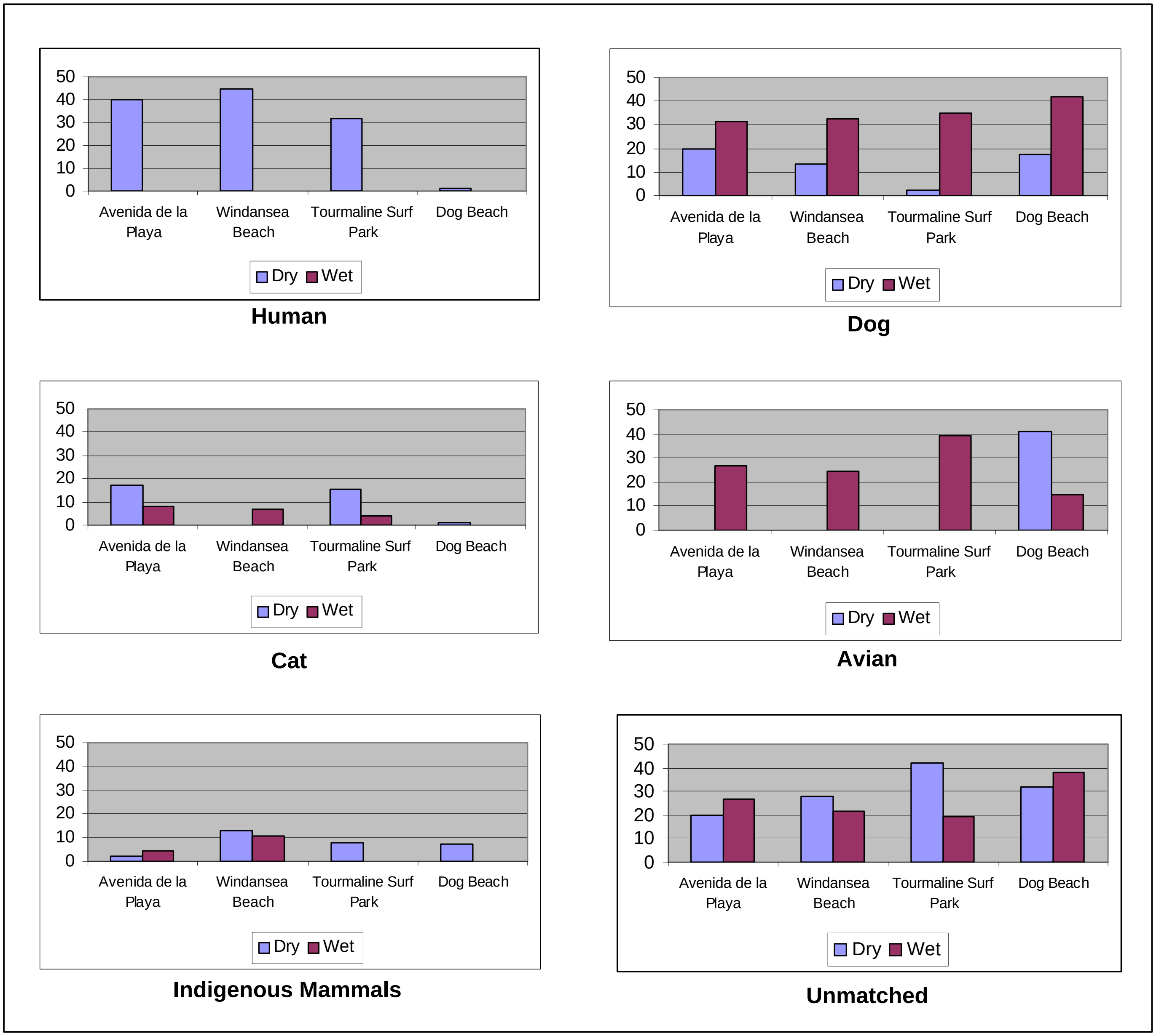

Figure 6: Comparison of Dry and Wet Weather Results by Source Category (% of Total)

The data obtained from this study do not allow a determination of the specific human sources that may be present. A number of such sources have been identified in these and other drainage areas, including losses from public or private sewage systems (sanitary sewer overflows, leaking lateral lines, and septic system failures), homeless encampments, recreational vehicles, and inconvenience of public restrooms. It should be noted that sewage release reporting records were reviewed to ensure that known releases had not occurred within three days of dry weather sampling or during wet weather events in the vicinity of any of the four sampling locations. Although it is possible that some events went unreported, sewer agencies typically report releases in a prompt manner. An alternate explanation might be overflows from private properties such as houses or apartment buildings which have a higher probability of going unreported.

Dog. During wet weather conditions, dogs were the most highly represented group, ranging from 31.4 to 41.8% of total matches at all sites. In contrast, although dogs were also represented at all sites during dry weather, these percentages were generally less than one-half than their respective wet weather totals. This seasonal variation suggests that dog feces build up on streets and other surfaces during dry weather and are flushed into the conveyance system during rainfall.

Cat. Cat isolates generally represented a minor percentage of total matches. During dry weather cats accounted for approximately 15-18% of matches at the Avenida de la Playa and Tourmaline Beach sites, but were not detected at the two remaining sites. During wet weather cat isolates were produced at all sites, but accounted for a relatively small percentage (<8%) of matches at each. The degree to which feral and/or stray animals contributed to these totals is unknown. Since many domestic cats spend significant amounts of time wandering their neighborhoods, this distinction may not be significant.

Avian Sources. Although a high percentage of avian matches were not attributed to specific birds, it is assumed that all are wild or indigenous since people do not generally allow pet birds outside for significant periods. Birds were only detected during dry weather at the three storm drain sites and only during wet weather at Dog Beach. The relative abundance of bird isolates at the first three sites during wet weather is most likely attributable to a buildup of avian fecal matter within drainage basins during dry weather and subsequent transport of this matter into the conveyance system during rainfall. The opposite pattern observed at Dog Beach is less easily explained. However, since the dry weather samples at this site were taken at the beginning of a flood tide, a possible explanation is that the avian matches are attributable to shorebirds or other aquatic waterfowl defecating directly in the ocean or on the shoreline. Alternatively, rainfall in the San Diego River watershed two days prior to sampling could also have increased the loading of bird feces to the river discharge.

Indigenous Mammals. Opossums, raccoons and unspecified rodents were grouped together as indigenous mammals because, unlike humans and domestic pets, they live in the wild. As such, they are normally not considered manageable with non-structructural BMPs (education, etc.). Collectively, this group generally represented less than 10% percent of total dry weather matches at all sites, and was detected at only the Avenida de la Playa and Windansea Beach sites during wet weather. Unlike dogs and birds, dry weather totals were consistently higher than wet for indigenous mammals. Since the majority of these isolates were from raccoons and opossums, a possible explanation is that they are living in close proximity to receiving waters and therefore contribute a more consistent input of fecal matter during dry weather. These inputs may become proportionally smaller during wet weather as other animals (e.g., dogs and birds) contribute relatively higher amounts of fecal matter.

Comparison To Other Studies. The results of this study are similar to those found in other recent DNA source investigations. The overall match rate of 72% (353 of 489) was similar, but slightly higher, than that found in the Agua Hedionda (64%) and the Lower Rincon Creek (67%) studies. The types of matches observed were also consistent. The Agua Hedionda Study found that domestic pets (dogs and cats) were the most highly represented groups, followed by birds and humans. The Lower Rincon Creek Study similarly had the same top three groups but the percentages were slightly different. The wider variety of indigenous animals observed in the other studies (e.g., coyote, bobcat and fox) was not unexpected as these areas include a higher degree of open and undeveloped land.

Study Limitations. The methods employed in this study do not provide a quantitative measure or a complete accounting of all sources of fecal contamination represented by the discharges sampled. Rather they provide an indirect measurement of a subset of the fecal coliform sources contributing to a given water sample. While more abundant strains of *E. coli* have a higher statistical probability of being sampled, many strains present in the samples may not be accounted for. Because measurements of error and statistical uncertainty have not yet been determined for the sampling strategy employed in this study, the percentages reported should not be considered a highly accurate representation of the abundances of specific *E. coli* strains or their source organisms.

Of 489 total isolates produced, 136 (27.8%) could not be matched to specific sources, and of the 353 that could, only 45 (11.3%) were matched to local samples. The DNA source library used in this study is also more adequately supplied with domestic (e.g., human, cat, and dog) than indigenous sources (birds, etc.). The degree to which this has biased the results of this study is not known, but could be significant since a relatively high number of isolates were not matched. The library is also relatvely small (32,000) compared to the actual numbers of *E. coli* strains existing in the environment. As the library dataset increases, it is likely that the sources of many isolates which cannot presently be matched will be identified. However, it is also possible that some existing matches will become less certain since resident matches can become transient but transient matches cannot become resident. It is therefore possible that the limited number of existing source samples in the library makes some matches appear more specific than they actually are.

Although there are two distinctive climatic periods in the San Diego region (a late April to mid-October dry period and a mid-October through late April wet period), both dry weather and wet weather samples were collected during the month of March. While this period officially falls within the wet season, it was felt that by using a criteria of 72 hours without rainfall prior to collection, samples would be representative of dry weather conditions. Ideally, sampling would have occurred over a longer interval, but logistical considerations precluded this. Because of this, dry weather sampling at both the Dog Beach and Avenida de la Playa sites was preceded by some rainfall. Although this event was less than the 0.1” criterion, it is possible that sample results were affected.

Source Management. In interpreting the results of this study it is useful to consider the degree to which specific sources are controllable, as well as the types of controls which may be appropriate and feasible for each. Depending on the group, different management options may be considered. Table 9 shows potential best management practices (BMPs) for five broad groupings of source categories. As a rule it should be noted that a variety of non-structural BMPs can appropriately be applied to all source groups but indigenous animals. Dogs and cats were the most consistently represented domestic animals throughout the study, and therefore should be a primary focus of management efforts. While study results cannot make distinctions concerning individual animals, it is assumed that some portion of the dog and cat matches observed was attributable to stray and feral populations. While it is difficult to address the specific contribution of these populations, continued or increased emphasis on existing animal control and spay/neuter programs can play a significant role in management efforts by decreasing the numbers of these animals within watershed areas.

In most cases, public education appears to be the most viable BMP since many people are still unaware of their role in preventing water quality contamination. It is therefore likely that effective public awareness campaigns can measurably change the attitudes and behaviors of many citizens. Although education should always be emphasized first, it is important to remember that increased enforcement of stormwater and other applicable ordinances may be necessary in instances when voluntary compliance cannot be achieved. The best approach to controlling human inputs is less obvious. Although humans isolates were the most numerous at three of four sites during dry weather, more information is needed to clearly pinpoint their specific sources. As a general measure, it seems prudent to continue actively implementating existing control measures, e.g., public outreach, enforcement of existing ordinances, sanitary sewer overflow prevention, and sewer system preventive maintenance. However, the specific sources of these inputs should also continue to be better characterized.

Two groupings used in this study, birds and small mammals, were classified as indigenous since they live freely in most instances. Because these animals are not considered to be manageable with non-structructural controls such as education and enforcement, their contribution to potential human health risks should continue to be evaluated. Should this prove to be significant, structural controls (diverters, treatment, etc.) may be necessary in the future.

Table 9: Overview of Management Options

Source Category	Manageable w/ Nonstructural Controls?	Potential Best Management Practices (BMPs)
Dogs	Yes	▪ Public Outreach ▪ Enforcement ▪ Animal Control ▪ Spay / Neuter Programs
Cats	Yes	▪ Public Outreach ▪ Animal Control ▪ Spay / Neuter Programs
Humans	Yes	▪ Public Outreach ▪ Enforcement ▪ Sanitary Sewer Overflow (SSO) Prevention ▪ Sewer System Maintenance
Indigenous Animals	No	▪ None
Feral Animals	Yes	▪ Animal Control
Unknown	No	▪ None

Recommendations

As a whole, the results of this study support the continued use of conventional stormwater and urban runoff management practices and the collection of additional data to further characterize risks to human users. Most management programs have recognized the presence of, and begun to adapt management strategies to, a variety of fecal coliform sources. As such, typical best management practices (BMPs) already in use appear to be appropriate. With this in mind, the following are recommended.

Source Management Recommendations

1. **Continue the use of non-structural BMPs as a general control measure**.

Both dry and wet weather results showed that a variety of sources of fecal coliform bacteria are represented at each of the sites monitored. Effectively controlling these sources will necessarily involve strategies that consider their relative contributions, the risks they pose, and the degree to which each can be controlled. Of the management options available, public outreach is clearly the most important element since many people are still unaware of the nature of this problem and their role in preventing it. This is especially true for addressing the input of wastes from domestic animals such as dogs and cats. Since existing stormwater ordinances already prohibit the discharge of waste to the conveyance system, increased enforcement may also be necessary when compliance cannot be achieved through outreach alone. While it may be more difficult to address the contribution of stray and feral animal populations, continued or increased emphasis on existing animal control and spay/neuter programs can also play an important role by decreasing the numbers of these animals within watershed areas. Human inputs can also be addressed through non-structural controls, but the degree to which this is possible is less clear since spill prevention and infrastructure maintenance practices are already aggressively implemented by wastewater agencies. The development of strategies for more effectively controlling human fecal contamination will likely depend on obtaining a clearer understanding of the specific sources contributing to the problem.

2. **Continue the use of diversion/interceptor systems for dry weather control where appropriate and feasible**.

Dry weather results showed that a variety of fecal contamination sources were represented at each of the four sites. Because runoff at three of these sites is currently diverted or intercepted, it does not contribute to recreational water contamination during dry weather conditions. While increasing the use of non-structural BMPs (education, enforcement, etc.) shows promise for improving coastal water quality, these measures have not yet proven sufficient to completely prevent the contamination of runoff. Diversion/interceptor systems should therefore continue to be considered among the options for protecting the health of swimmers and other recreational users during dry weather conditions. The cost of constructing and operating additional systems understandably deters their placement at all beach storm drain outlets. However, their overall effectiveness should continue to be monitored to determine when and where they are most effectively used.

3. **Develop performance measures for best management practices (BMPs)**.

A variety of options currently exist for controlling fecal contamination of local receiving waters. Depending on site-specific and seasonal conditions, it may be necessary to consider a number of different strategies. Because of the potentially significant costs associated with structural (diversion, treatment, etc.) and non-structural (education, enforcement, etc.) controls, performance measures should be developed to measure their relative effectiveness and to determine whether, and in which instances, these expenditures are justified.

<u>Monitoring / Research Recommendations</u>

4. **Conduct sanitary surveys to further characterize specific sources of human fecal matter during dry weather conditions**.

Although dry weather results showed a significant human component at all but one sampling location, they do little to identify the specific causes of this input. Within any urban drainage area there are a multitude of human activities that can result in the release of fecal mater to the environment. Before these inputs can be eliminated, watershed-specific sanitary surveys are necessary to provide more detailed information on sources of human fecal contamination.

5. **Identify specific pathogens and risks to human recreational users**.

Because of their relative abundance in the intestinal tract of warm blooded animals, *E. coli* bacteria are extremely useful as a general indicator of fecal contamination, and more specifically as a tool for identifying potential source organisms. They do not, however, directly measure the presence of pathogenic microorganisms which may present risks to human recreational users. It is possible, for instance, that microrganisms present in bird feces are not pathogenic to humans, or conversely that risks are presented by pathogens associated with other sources of contamination not characterized in these study results. Investigators should continue to determine the presence of organisms which may be pathogenic to humans and to gather additional data necessary to fully characterize the risks they pose. This should include both a characterization of pathogens in the feces of organisms identified in this study, as well as further characterization of the presence of pathogens in stormwater and non-stormwater discharges. By determining the relative risks presented by identified sources, it will be possible to better allocate limited management resources.

6. **Periodically re-evaluate study results against updated DNA Library**.

Over time, the DNA source library against which ribotypes were compared will continue to be augmented. While the approximately 32,000 known sources already contained in the library are substantial, there are potentially millions of *E. coli* ribotypes in the natural environment. It is therefore critical that results be periodically re-evaluated for two reasons. First, a significant percentage of the total samples analyzed in this study were not matched to a known ribotype. Comparison to an augmented source library will enable further characterization of this unknown component. Second, some samples were assigned to "transient" groups, or ribotypes which could belong to more than one host group (e.g., dog and cat). While most matches were assigned to resident groups, the possibility exists that augmentation of the library will cause other samples to shift to transient groups. For example, a ribotype currently matched only to dogs may in the future also be matched to cats.

7. **Develop standard protocols with measures of statistical significance for DNA source studies**.

Several studies in the past few years have employed DNA ribotyping to identify potential sources of fecal contamination. Because this approach is still relatively new, standard protocols have not yet been developed to specifically address critical issues such as measures of error and statistical significance. The development of these measures is needed to ensure consistency and comparability of datasets, and to allow for optimal study design.

Appendix A

Public Health Laboratory Fecal Coliform Results

Key to Sampling Locations

I = Avenida de la Playa

II = Windansea

III = Tourmaline

V = Dog Beach

W represents wet weather sampling event

D represents dry weather sampling event

Fecal Coliform (cfu/100mL)								
Sample number	Locations							
	I-D	I-W	II-D	II-W	III-D	III-W	IV-D	IV-W
1	2400	9000	1800	21000	560	10000	20	300
2	2000	8000	1900	10000	610	50000	40	400
3	5800	12000	3100	11900	1100	8000	50	<100
4	2900	8000	2100	14000	400	15000	<10	100
5	2000	26000	2300	17000	600	30000	330	500
6	3400	8000	2700	160000	420	90000	30	500
7	2600	12000	2900	31000	350	11000	30	100
8	3300	8000	1900	20000	530	4000	70	300
9	3000	7000	8200	60000	350	10000	20	100
10	2800	13000	1800	16000	320	18000	70	600
11	12000	11000	1400	16000	100	41000	10	500
12	4200	8000	1700	100000	100	31000	100	100
13	4300	10000	2000	120000	350	180000	90	<100
14	5200	15000	4600	13100	240	40000	210	200
15	11000	11000	2000	60000	120	21000	250	300
16	4900	10000	3400	130000	30	>80000	60	800
17	4000	13000	12000	16000	100	3300	50	700
18	7500	12000	1800	11000	70	8200	130	500
19	2000	4000	2000	13000	150	150000	280	800
20	4800	13000	2200	16000	<10	10000	290	100
21		30000		25000		9000	100	500
22		18000		80000		80000	1100	100
23		18000		13000		5000	2500	2000
24		40000		50000		20000	80	100
25		60000		6000		20000	<10	700
26		40000		90000		3000	2900	300
27		60000		12000		11000	10	200
28		17000		15000		5000	580	<100
29		14000		20000		5000	830	<100
30		16000		9000		13000	700	<100
31		50000		11000		8500	ND	<100
32		20000		130000		6100	50	<100
33		7000		100000		40000	880	100
34		13000		12000		1300	800	<100
35		11000		ND		1100	1100	100
36		16000		15000		1500	2600	100
37		20000		12000		1300	2700	100
38		70000		ND		8700	650	100
39		11000		16000		310000	100	800
40		14000		20000		8400	650	300
41		10000					90	<100
42		9000					660	400
43		15000					80	<100
44		ND					430	1200
45		ND					390	200

Appendix B

DNA Match Results

Appendix B: DNA Match Results (Dry Weather)

Isolate	Provider Isolate	Source Type	Site	Date	Study Match	Database Match	Note
22928	Site #1D- 1	11	600	3/24/99		Cat	62
22931	Site #1D- 2	11	600	3/24/99		Cat	62
22933	Site #1D- 3	11	600	3/24/99		Cat	62
22938	Site #1D- 6	11	600	3/24/99		Cat	62
22940	Site #1D- 7	11	600	3/24/99		Cat	62
22941	Site #1D- 7	11	600	3/24/99		Cat	62
22942	Site #1D- 8	11	600	3/24/99		Cat	62
22391	Site #1D- 2	11	600	3/10/99		Dog	53
22392	Site #1D- 2	11	600	3/10/99		Dog	53
22401	Site #1D- 7	11	600	3/10/99	Dog	Dog	55
22402	Site #1D- 7	11	600	3/10/99	Dog	Dog	55
22406	Site #1D- 9	11	600	3/10/99	Dog	Dog	55
22407	Site #1D- 10	11	600	3/10/99	Dog	Dog	55
22408	Site #1D- 10	11	600	3/10/99	Dog	Dog	55
22945	Site #1D- 9	11	600	3/24/99	DOG	DOG	29
22389	Site #1D- 1	11	600	3/10/99		Human	210
22390	Site #1D- 1	11	600	3/10/99		Human	210
22393	Site #1D- 3	11	600	3/10/99		Human	54
22394	Site #1D- 3	11	600	3/10/99		Human	54
22395	Site #1D- 4	11	600	3/10/99		Human	54
22396	Site #1D- 4	11	600	3/10/99		Human	54
22397	Site #1D- 5	11	600	3/10/99		Human	54
22398	Site #1D- 5	11	600	3/10/99		Human	54
22399	Site #1D- 6	11	600	3/10/99		Human	54
22400	Site #1D- 6	11	600	3/10/99		Human	54
22403	Site #1D- 8	11	600	3/10/99		Human	37
22404	Site #1D- 8	11	600	3/10/99		Human	37
22405	Site #1D- 9	11	600	3/10/99		Human	37
22929	Site #1D- 1	11	600	3/24/99		Human	211
22935	Site #1D- 4	11	600	3/24/99		Human	211
22944	Site #1D- 9	11	600	3/24/99		Human	211
22946	Site #1D- 10	11	600	3/24/99		Rodent	149
22930	Site #1D- 2	11	600	3/24/99			209
22932	Site #1D- 3	11	600	3/24/99			12
22934	Site #1D- 4	11	600	3/24/99			188
22936	Site #1D- 5	11	600	3/24/99			189
22937	Site #1D- 5	11	600	3/24/99			190
22939	Site #1D- 6	11	600	3/24/99			191
22943	Site #1D- 8	11	600	3/24/99			192
22947	Site #1D- 10	11	600	3/24/99			12
23229	Site #3D-2	11	601	3/30/99		Cat	131
23230	Site #3D-2	11	601	3/30/99		Cat	131
23240	Site #3D-7	11	601	3/30/99		Cat	137
23242	Site #3D-8	11	601	3/30/99		Cat	137
23244	Site #3D-9	11	601	3/30/99		Cat	137
23239	Site #3D-7	11	601	3/30/99	CAT	CAT	90
22951	Site #3D- 2	11	601	3/22/99	DOG	DOG	29
22959	Site #3D- 7	11	601	3/22/99		Human	125
22960	Site #3D- 7	11	601	3/22/99		Human	126

Appendix B: DNA Match Results (Dry Weather)

Isolate	Provider Isolate	Source Type	Site	Date	Study Match	Database Match	Note
22961	Site #3D- 8	11	601	3/22/99		Human	125
22962	Site #3D- 8	11	601	3/22/99		Human	126
22964	Site #3D- 9	11	601	3/22/99		Human	125
22965	Site #3D- 10	11	601	3/22/99		Human	125
22966	Site #3D- 10	11	601	3/22/99		Human	126
23233	Site #3D-4	11	601	3/30/99		Human	136
23234	Site #3D-4	11	601	3/30/99		Human	136
23235	Site #3D-5	11	601	3/30/99		Human	107
23236	Site #3D-5	11	601	3/30/99		Human	107
23457	Site #3D-3	11	601	3/22/99		Human	107
23227	Site #3D-1	11	601	3/30/99		Raccoon	56
23228	Site #3D-1	11	601	3/30/99		Raccoon	56
23232	Site #3D-3	11	601	3/30/99		Raccoon	56
22948	Site #3D- 1	11	601	3/22/99			162
22949	Site #3D- 1	11	601	3/22/99			109
22950	Site #3D- 2	11	601	3/22/99			110
22952	Site #3D- 3	11	601	3/22/99			2
22953	Site #3D- 4	11	601	3/22/99			111
22954	Site #3D- 4	11	601	3/22/99			111
22955	Site #3D- 5	11	601	3/22/99			111
22956	Site #3D- 5	11	601	3/22/99			111
22957	Site #3D- 6	11	601	3/22/99			111
22958	Site #3D- 6	11	601	3/22/99			111
22963	Site #3D- 9	11	601	3/22/99			162
23231	Site #3D-3	11	601	3/30/99			81
23237	Site #3D-6	11	601	3/30/99			81
23238	Site #3D-6	11	601	3/30/99			130
23241	Site #3D-8	11	601	3/30/99			95
23243	Site #3D-9	11	601	3/30/99			163
22491	Site #4D- 5	11	602	3/9/99		Avian	65
22492	Site #4D- 5	11	602	3/9/99		Avian	65
22508	Site #4D- 14	11	602	3/9/99		Avian	65
22509	Site #4D- 14	11	602	3/9/99		Avian	65
22510	Site #4D- 15	11	602	3/9/99		Avian	65
22511	Site #4D- 15	11	602	3/9/99		Avian	65
22516	Site #4D- 18	11	602	3/9/99		Avian	140
22518	Site #4D- 19	11	602	3/9/99		Avian	65
22519	Site #4D- 19	11	602	3/9/99		Avian	65
22520	Site #4D- 20	11	602	3/9/99		Avian	65
22521	Site #4D- 20	11	602	3/9/99		Avian	65
22524	Site #4D- 22	11	602	3/9/99		Avian	65
22525	Site #4D- 22	11	602	3/9/99		Avian	65
22526	Site #4D- 23	11	602	3/9/99		Avian	65
22527	Site #4D- 23	11	602	3/9/99		Avian	65
22530	Site #4D- 26	11	602	3/9/99		Avian	65
22531	Site #4D- 26	11	602	3/9/99		Avian	65
22532	Site #4D- 27	11	602	3/9/99		Avian	19
22534	Site #4D- 28	11	602	3/9/99		Avian	65
22539	Site #4D- 32	11	602	3/9/99		Avian	100

Appendix B: DNA Match Results (Dry Weather)

Isolate	Provider Isolate	Source Type	Site	Date	Study Match	Database Match	Note
22541	Site #4D- 33	11	602	3/9/99		Avian	65
22542	Site #4D- 33	11	602	3/9/99		Avian	65
22543	Site #4D- 34	11	602	3/9/99		Avian	65
22545	Site #4D- 36	11	602	3/9/99		Avian	65
22546	Site #4D- 36	11	602	3/9/99		Avian	65
22547	Site #4D- 37	11	602	3/9/99		Avian	65
22549	Site #4D- 38	11	602	3/9/99		Avian	19
22550	Site #4D- 38	11	602	3/9/99		Avian	65
22551	Site #4D- 39	11	602	3/9/99		Avian	65
22498	Site #4D- 8	11	602	3/9/99		Cat	123
22485	Site #4D- 1	11	602	3/9/99	DOG	DOG	77
22486	Site #4D- 1	11	602	3/9/99	DOG	DOG	77
22487	Site #4D- 2	11	602	3/9/99	DOG	DOG	29
22494	Site #4D- 6	11	602	3/9/99		Dog	27
22497	Site #4D- 8	11	602	3/9/99	DOG	DOG	29
22502	Site #4D- 10	11	602	3/9/99		Dog	27
22504	Site #4D- 12	11	602	3/9/99	DOG	DOG	29
22506	Site #4D- 13	11	602	3/9/99	DOG	DOG	29
22507	Site #4D- 13	11	602	3/9/99	DOG	DOG	29
22512	Site #4D- 16	11	602	3/9/99	DOG	DOG	29
22513	Site #4D- 16	11	602	3/9/99	DOG	DOG	29
22515	Site #4D- 17	11	602	3/9/99	DOG	DOG	29
22522	Site #4D- 21	11	602	3/9/99	DOG	DOG	29
22523	Site #4D- 21	11	602	3/9/99		Dog	29
22500	Site #4D- 9	11	602	3/9/99		Duck	139
22505	Site #4D- 12	11	602	3/9/99		Duck	139
22540	Site #4D- 32	11	602	3/9/99		Duck	42
22529	Site #4D- 24	11	602	3/9/99		Human	176
22559	Site #4D- 43	11	602	3/9/99		Opossum	68
22562	Site #4D- 44	11	602	3/9/99		Opossum	68
22553	Site #4D- 40	11	602	3/9/99		Raccoon	48
22528	Site #4D- 24	11	602	3/9/99		Rodent	175
22556	Site #4D- 41	11	602	3/9/99		Sea Gull	103
22488	Site #4D- 2	11	602	3/9/99			64
22489	Site #4D- 3	11	602	3/9/99			130
22490	Site #4D- 3	11	602	3/9/99			130
22493	Site #4D-6	11	602	3/9/99			83
22495	Site #4D- 7	11	602	3/9/99			170
22496	Site #4D- 7	11	602	3/9/99			170
22499	Site #4D- 9	11	602	3/9/99			1
22501	Site #4D- 10	11	602	3/9/99			109
22503	Site #4D- 11	11	602	3/9/99			69
22514	Site #4D- 17	11	602	3/9/99			73
22517	Site #4D- 18	11	602	3/9/99			160
22533	Site #4D- 28	11	602	3/9/99			78
22535	Site #4D- 29	11	602	3/9/99			78
22536	Site #4D- 29	11	602	3/9/99			78
22537	Site #4D- 30	11	602	3/9/99			78
22538	Site #4D- 30	11	602	3/9/99			78

Appendix B: DNA Match Results (Dry Weather)

Isolate	Provider Isolate	Source Type	Site	Date	Study Match	Database Match	Note
22548	Site #4D- 37	11	602	3/9/99			78
22552	Site #4D- 39	11	602	3/9/99			182
22554	Site #4D- 40	11	602	3/9/99			211
22555	Site #4D- 41	11	602	3/9/99			150
22557	Site #4D- 42	11	602	3/9/99			81
22558	Site #4D- 42	11	602	3/9/99			72
22560	Site #4D- 43	11	602	3/9/99			168
22561	Site #4D- 44	11	602	3/9/99			73
22563	Site #4D- 45	11	602	3/9/99			82
22564	Site #4D- 45	11	602	3/9/99			78
22279	Site #2D-4	11	603	3/2/99		Dog	195
22280	Site #2D-5	11	603	3/2/99		Dog	195
22288	Site #2D-9	11	603	3/2/99	DOG	DOG	29
22295	Site #2D-12	11	603	3/2/99		Dog	122
22303	Site #2D-16	11	603	3/2/99		Dog	195
22276	Site #2D-3	11	603	3/2/99		Human	136
22277	Site #2D-3	11	603	3/2/99		Human	136
22282	Site #2D-6	11	603	3/2/99		Human	197
22284	Site #2D-7	11	603	3/2/99		Human	197
22287	Site #2D-8	11	603	3/2/99		Human	142
22289	Site #2D-9	11	603	3/2/99		Human	136
22290	Site #2D-10	11	603	3/2/99		Human	136
22291	Site #2D-10	11	603	3/2/99		Human	136
22292	Site #2D-11	11	603	3/2/99		Human	142
22293	Site #2D-11	11	603	3/2/99		Human	142
22294	Site #2D-12	11	603	3/2/99		Human	47
22298	Site #2D-14	11	603	3/2/99		Human	136
22300	Site #2D-15	11	603	3/2/99		Human	136
22302	Site #2D-16	11	603	3/2/99		Human	186
22304	Site #2D-17	11	603	3/2/99		Human	186
22305	Site #2D-17	11	603	3/2/99		Human	186
22307	Site #2D-19	11	603	3/2/99		Human	176
22272	Site #2D-1	11	603	3/2/99		Opossum	141
22273	Site #2D-1	11	603	3/2/99		Opossum	133
22278	Site #2D-4	11	603	3/2/99		Opossum	194
22283	Site #2D-6	11	603	3/2/99		Rodent	204
22306	Site #2D-19	11	603	3/2/99		Rodent	175
22274	Site #2D-2	11	603	3/2/99			134
22275	Site #2D-2	11	603	3/2/99			135
22281	Site #2D-5	11	603	3/2/99			63
22285	Site #2D-7	11	603	3/2/99			22
22286	Site #2D-8	11	603	3/2/99			206
22296	Site #2D-13	11	603	3/2/99			156
22297	Site #2D-13	11	603	3/2/99			205
22299	Site #2D-14	11	603	3/2/99			51
22301	Site #2D-15	11	603	3/2/99			108
22308	Site #2D-20	11	603	3/2/99			143
22309	Site #2D-20	11	603	3/2/99			127

Appendix B: DNA Match Results (Wet Weather)

Isolate	Provider Isolate	Source Type	Site	Date	Study Match	Database Match	Note
22729	Site #1W- 5	11	600	3/15/99		AVIAN	92
22734	Site #1W- 7	11	600	3/15/99		AVIAN	88
22735	Site #1W- 8	11	600	3/15/99		AVIAN	88
22767	Site #1W- 24	11	600	3/15/99		Avian	49
22785	Site #1W- 33	11	600	3/15/99		Avian	24
22786	Site #1W- 33	11	600	3/15/99		Avian	31
22799	Site #1W- 40	11	600	3/15/99		Avian	24
22800	Site #1W- 40	11	600	3/15/99		Avian	24
22721	Site #1W- 1	11	600	3/15/99		Cat	193
22722	Site #1W- 1	11	600	3/15/99		Cat	193
22724	Site #1W- 2	11	600	3/15/99		Cat	193
22727	Site #1W- 4	11	600	3/15/99		Cat	18
22789	Site #1W- 35	11	600	3/15/99		Cat	7
22790	Site #1W- 35	11	600	3/15/99		Cat	7
22805	Site #1W- 43	11	600	3/15/99	CAT	CAT	90
22723	Site #1W- 2	11	600	3/15/99		CROW	91
22751	Site #1W- 16	11	600	3/15/99		Crow	202
22756	Site #1W- 18	11	600	3/15/99		Crow	202
22732	Site #1W- 6	11	600	3/15/99		Dog	165
22733	Site #1W- 7	11	600	3/15/99	DOG	DOG	29
22739	Site #1W- 10	11	600	3/15/99		Dog	164
22740	Site #1W- 10	11	600	3/15/99		Dog	164
22745	Site #1W- 13	11	600	3/15/99		Dog	27
22746	Site #1W- 13	11	600	3/15/99	DOG	DOG	29
22754	Site #1W- 17	11	600	3/15/99		Dog	144
22757	Site #1W- 19	11	600	3/15/99		Dog	66
22758	Site #1W- 19	11	600	3/15/99		Dog	66
22759	Site #1W- 20	11	600	3/15/99		Dog	165
22760	Site #1W- 20	11	600	3/15/99		Dog	165
22765	Site #1W- 23	11	600	3/15/99		Dog	164
22766	Site #1W- 23	11	600	3/15/99		Dog	164
22771	Site #1W- 26	11	600	3/15/99	DOG	DOG	77
22772	Site #1W- 26	11	600	3/15/99	DOG	DOG	77
22773	Site #1W- 27	11	600	3/15/99		Dog	183
22774	Site #1W- 27	11	600	3/15/99		Dog	183
22776	Site #1W- 28	11	600	3/15/99		Dog	27
22778	Site #1W- 29	11	600	3/15/99	DOG	DOG	29
22780	Site #1W- 30	11	600	3/15/99	DOG	DOG	29
22787	Site #1W- 34	11	600	3/15/99		Dog	20
22788	Site #1W- 34	11	600	3/15/99	DOG	DOG	29
22792	Site #1W- 36	11	600	3/15/99	DOG	DOG	77
22793	Site #1W- 37	11	600	3/15/99	DOG	DOG	77
22794	Site #1W- 37	11	600	3/15/99	DOG	DOG	77
22801	Site #1W- 41	11	600	3/15/99		Dog	20
22806	Site #1W- 43	11	600	3/15/99	DOG	DOG	77
22791	Site #1W- 36	11	600	3/15/99		Dog-Cat	57
22798	Site #1W- 39	11	600	3/15/99		Dog-Cat	57
22731	Site #1W- 6	11	600	3/15/99		DUCK	87

Appendix B: DNA Match Results (Wet Weather)

Isolate	Provider Isolate	Source Type	Site	Date	Study Match	Database Match	Note
22737	Site #1W- 9	11	600	3/15/99		DUCK	89
22738	Site #1W- 9	11	600	3/15/99		DUCK	89
22744	Site #1W- 12	11	600	3/15/99		DUCK	89
22750	Site #1W- 15	11	600	3/15/99		DUCK	89
22752	Site #1W- 16	11	600	3/15/99		DUCK	89
22753	Site #1W- 17	11	600	3/15/99		DUCK	89
22779	Site #1W- 30	11	600	3/15/99		DUCK	89
22775	Site #1W- 28	11	600	3/15/99		Opossum	194
22741	Site #1W- 11	11	600	3/15/99		Raccoon	56
22742	Site #1W- 11	11	600	3/15/99		Raccoon	56
22755	Site #1W- 18	11	600	3/15/99		Raccoon	56
22768	Site #1W- 24	11	600	3/15/99		Sea Gull	50
22777	Site #1W- 29	11	600	3/15/99		Sea Gull	75
22782	Site #1W- 31	11	600	3/15/99		Sea Gull	75
22783	Site #1W- 32	11	600	3/15/99		Sea Gull	200
22725	Site #1W- 3	11	600	3/15/99			174
22726	Site #1W- 3	11	600	3/15/99			138
22728	Site #1W- 4	11	600	3/15/99			46
22730	Site #1W- 5	11	600	3/15/99			6
22736	Site #1W- 8	11	600	3/15/99			104
22743	Site #1W- 12	11	600	3/15/99			199
22747	Site #1W- 14	11	600	3/15/99			198
22748	Site #1W- 14	11	600	3/15/99			26
22749	Site #1W- 15	11	600	3/15/99			196
22761	Site #1W- 21	11	600	3/15/99			85
22762	Site #1W- 21	11	600	3/15/99			21
22763	Site #1W- 22	11	600	3/15/99			32
22764	Site #1W- 22	11	600	3/15/99			184
22769	Site #1W- 25	11	600	3/15/99			72
22770	Site #1W- 25	11	600	3/15/99			72
22781	Site #1W- 31	11	600	3/15/99			203
22784	Site #1W- 32	11	600	3/15/99			201
22795	Site #1W- 38	11	600	3/15/99			114
22796	Site #1W- 38	11	600	3/15/99			166
22797	Site #1W- 39	11	600	3/15/99			46
22802	Site #1W- 41	11	600	3/15/99			46
22803	Site #1W- 42	11	600	3/15/99			38
22804	Site #1W- 42	11	600	3/15/99			85
22427	Site #3W- 11	11	601	3/11/99		Avian	11
22428	Site #3W- 11	11	601	3/11/99		Avian	11
22429	Site #3W- 12	11	601	3/11/99		AVIAN	84
22430	Site #3W- 12	11	601	3/11/99		AVIAN	84
22431	Site #3W- 13	11	601	3/11/99		Avian	11
22433	Site #3W- 14	11	601	3/11/99		Avian	140
22435	Site #3W- 15	11	601	3/11/99		Avian	11
22436	Site #3W- 15	11	601	3/11/99		Avian	11
22437	Site #3W- 16	11	601	3/11/99		AVIAN	84
22446	Site #3W- 20	11	601	3/11/99		Avian	11
22447	Site #3W- 21	11	601	3/11/99		Avian	113

Appendix B: DNA Match Results (Wet Weather)

Isolate	Provider Isolate	Source Type	Site	Date	Study Match	Database Match	Note
22470	Site #3W- 32	11	601	3/11/99		Avian	11
22471	Site #3W- 33	11	601	3/11/99		Avian	11
22472	Site #3W- 33	11	601	3/11/99		Avian	11
22474	Site #3W- 34	11	601	3/11/99		Avian	11
22475	Site #3W- 36	11	601	3/11/99		Avian	11
22476	Site #3W- 36	11	601	3/11/99		Avian	11
22477	Site #3W- 37	11	601	3/11/99		Avian	11
22479	Site #3W- 38	11	601	3/11/99		Avian	11
22480	Site #3W- 38	11	601	3/11/99		Avian	11
22481	Site #3W- 39	11	601	3/11/99		Avian	11
22482	Site #3W- 39	11	601	3/11/99		Avian	11
22483	Site #3W- 40	11	601	3/11/99		Avian	11
22484	Site #3W- 40	11	601	3/11/99		Avian	11
23198	Site #3W- 6	11	601	3/11/99		Avian	11
22413	Site #3W- 3	11	601	3/11/99		CAT	97
22424	Site #3W- 9	11	601	3/11/99	CAT	CAT	98
22445	Site #3W- 20	11	601	3/11/99		Cat	7
22438	Site #3W- 16	11	601	3/11/99		Crow	59
22409	Site #3W- 1	11	601	3/11/99		Dog	27
22412	Site #3W- 3	11	601	3/11/99		Dog	5
22415	Site #3W- 4	11	601	3/11/99		Dog	5
22416	Site #3W- 5	11	601	3/11/99		Dog	5
22417	Site #3W- 5	11	601	3/11/99		Dog	5
22426	Site #3W- 10	11	601	3/11/99	Dog	Dog	39
22432	Site #3W- 13	11	601	3/11/99	Dog	Dog	39
22439	Site #3W- 17	11	601	3/11/99		DOG	99
22441	Site #3W- 18	11	601	3/11/99		DOG	99
22442	Site #3W- 18	11	601	3/11/99		Dog	164
22444	Site #3W- 19	11	601	3/11/99		Dog	164
22448	Site #3W- 21	11	601	3/11/99		Dog	159
22450	Site #3W- 22	11	601	3/11/99	Dog	Dog	39
22452	Site #3W- 23	11	601	3/11/99		Dog	165
22453	Site #3W- 24	11	601	3/11/99		Dog	5
22454	Site #3W- 24	11	601	3/11/99		Dog	5
22455	Site #3W- 25	11	601	3/11/99		Dog	5
22457	Site #3W- 26	11	601	3/11/99		Dog	5
22458	Site #3W- 26	11	601	3/11/99		Dog	5
22459	Site #3W- 27	11	601	3/11/99		Dog	5
22460	Site #3W- 27	11	601	3/11/99		Dog	5
22461	Site #3W- 28	11	601	3/11/99		Dog	5
22463	Site #3W- 29	11	601	3/11/99		Dog	5
22465	Site #3W- 30	11	601	3/11/99		Dog	14
22467	Site #3W- 31	11	601	3/11/99		Dog	159
22468	Site #3W- 31	11	601	3/11/99		Dog	5
22469	Site #3W- 32	11	601	3/11/99		Dog	27
22473	Site #3W- 34	11	601	3/11/99		Dog	27
22414	Site #3W- 4	11	601	3/11/99		Dog-Cat	57
22443	Site #3W- 19	11	601	3/11/99		Sea Gull	60
22451	Site #3W- 23	11	601	3/11/99		Sea Gull	75

Appendix B: DNA Match Results (Wet Weather)

Isolate	Provider Isolate	Source Type	Site	Date	Study Match	Database Match	Note
22456	Site #3W- 25	11	601	3/11/99		Sea Gull	50
22462	Site #3W- 28	11	601	3/11/99		Sea Gull	50
22410	Site #3W- 2	11	601	3/11/99			3
22411	Site #3W- 2	11	601	3/11/99			3
22418	Site #3W- 6	11	601	3/11/99			58
22419	Site #3W- 7	11	601	3/11/99			9
22420	Site #3W- 7	11	601	3/11/99			169
22421	Site #3W- 8	11	601	3/11/99			9
22422	Site #3W- 8	11	601	3/11/99			9
22423	Site #3W- 9	11	601	3/11/99			9
22425	Site #3W- 10	11	601	3/11/99			9
22434	Site #3W- 14	11	601	3/11/99			151
22440	Site #3W- 17	11	601	3/11/99			9
22449	Site #3W- 22	11	601	3/11/99			34
22464	Site #3W- 29	11	601	3/11/99			3
22466	Site #3W- 30	11	601	3/11/99			61
22478	Site #3W- 37	11	601	3/11/99			86
22890	Site #4W- 7	11	602	3/16/99		Avian	24
22892	Site #4W- 8	11	602	3/16/99		Avian	113
22899	Site #4W- 14	11	602	3/16/99		Avian	31
22926	Site #4W- 45	11	602	3/16/99		Avian	24
22881	Site #4W- 1	11	602	3/16/99	Dog	Dog	15
22883	Site #4W- 2	11	602	3/16/99		Dog	25
22884	Site #4W- 2	11	602	3/16/99	DOG	DOG	77
22885	Site #4W- 4	11	602	3/16/99		Dog	20
22888	Site #4W- 6	11	602	3/16/99		Dog	27
22895	Site #4W- 10	11	602	3/16/99		Dog	105
22896	Site #4W- 11	11	602	3/16/99		Dog	25
22897	Site #4W- 11	11	602	3/16/99		Dog	25
22898	Site #4W- 12	11	602	3/16/99		Dog	66
22900	Site #4W- 19	11	602	3/16/99		Dog	25
22905	Site #4W- 23	11	602	3/16/99		Dog	25
22906	Site #4W- 24	11	602	3/16/99		Dog	27
22907	Site #4W- 25	11	602	3/16/99		Dog	20
22909	Site #4W- 26	11	602	3/16/99		Dog	25
22911	Site #4W- 27	11	602	3/16/99		Dog	25
22914	Site #4W- 35	11	602	3/16/99		Dog	27
22915	Site #4W- 36	11	602	3/16/99		Dog	66
22919	Site #4W- 39	11	602	3/16/99		Dog	25
23221	Site #4W- 16	11	602	3/16/99		Dog	66
23222	Site #4W- 17	11	602	3/16/99		Dog	25
23223	Site #4W- 17	11	602	3/16/99		Dog	27
23224	Site #4W- 18	11	602	3/16/99		Dog	27
23226	Site #4W- 19	11	602	3/16/99	DOG	DOG	77
22904	Site #4W- 22	11	602	3/16/99		Dog-Cat	57
23218	Site #4W- 15	11	602	3/16/99		Dog-Cat	57
23219	Site #4W- 15	11	602	3/16/99		Dog-Cat	57
22893	Site #4W- 9	11	602	3/16/99		Duck-Goose	167
22910	Site #4W- 26	11	602	3/16/99		Raccoon	106

Appendix B: DNA Match Results (Wet Weather)

Isolate	Provider Isolate	Source Type	Site	Date	Study Match	Database Match	Note
22918	Site #4W- 39	11	602	3/16/99		Raccoon	146
23225	Site #4W- 18	11	602	3/16/99		Raccoon	56
22887	Site #4W- 5	11	602	3/16/99		Sea Gull	75
22889	Site #4W- 6	11	602	3/16/99		Sea Gull	75
22882	Site #4W- 1	11	602	3/16/99			101
22886	Site #4W- 5	11	602	3/16/99			177
22891	Site #4W- 8	11	602	3/16/99			177
22894	Site #4W- 10	11	602	3/16/99			23
22901	Site #4W- 20	11	602	3/16/99			26
22902	Site #4W- 21	11	602	3/16/99			67
22903	Site #4W- 21	11	602	3/16/99			145
22908	Site #4W- 25	11	602	3/16/99			178
22912	Site #4W- 27	11	602	3/16/99			8
22913	Site #4W- 33	11	602	3/16/99			52
22916	Site #4W- 37	11	602	3/16/99			8
22917	Site #4W- 38	11	602	3/16/99			70
22920	Site #4W- 40	11	602	3/16/99			28
22921	Site #4W- 40	11	602	3/16/99			147
22922	Site #4W- 42	11	602	3/16/99			74
22923	Site #4W- 42	11	602	3/16/99			13
22924	Site #4W- 44	11	602	3/16/99			67
22925	Site #4W- 44	11	602	3/16/99			112
22927	Site #4W- 45	11	602	3/16/99			63
23217	Site #4W- 14	11	602	3/16/99			185
23220	Site #4W- 16	11	602	3/16/99			208
22807	Site #2W- 1	11	603	3/15/99		Avian	115
22818	Site #2W- 6	11	603	3/15/99		Avian	140
22820	Site #2W- 7	11	603	3/15/99		Avian	140
22841	Site #2W- 19	11	603	3/15/99		Avian	155
22811	Site #2W- 3	11	603	3/15/99		Cat	172
22812	Site #2W- 3	11	603	3/15/99		Cat	172
22832	Site #2W- 13	11	603	3/15/99		Cat	17
22868	Site #2W- 32	11	603	3/15/99		Cat	131
22870	Site #2W- 33	11	603	3/15/99		Cat	131
22810	Site #2W- 2	11	603	3/15/99		DOG	96
22819	Site #2W- 7	11	603	3/15/99		Dog	27
22821	Site #2W- 8	11	603	3/15/99	DOG	DOG	29
22823	Site #2W- 9	11	603	3/15/99	DOG	DOG	29
22829	Site #2W- 12	11	603	3/15/99		Dog	27
22830	Site #2W- 12	11	603	3/15/99		Dog	27
22833	Site #2W- 15	11	603	3/15/99	DOG	DOG	29
22837	Site #2W- 17	11	603	3/15/99		DOG	96
22838	Site #2W- 17	11	603	3/15/99	DOG	DOG	29
22843	Site #2W- 20	11	603	3/15/99		DOG	96
22844	Site #2W- 20	11	603	3/15/99		Dog	27
22845	Site #2W- 21	11	603	3/15/99		DOG	96
22849	Site #2W- 23	11	603	3/15/99		Dog	171
22850	Site #2W- 23	11	603	3/15/99		Dog	171
22853	Site #2W- 25	11	603	3/15/99		Dog	171

Appendix B: DNA Match Results (Wet Weather)

Isolate	Provider Isolate	Source Type	Site	Date	Study Match	Database Match	Note
22854	Site #2W- 25	11	603	3/15/99	DOG	DOG	29
22855	Site #2W- 26	11	603	3/15/99		Dog	27
22862	Site #2W- 29	11	603	3/15/99		Dog	27
22863	Site #2W- 30	11	603	3/15/99		Dog	27
22867	Site #2W- 32	11	603	3/15/99		Dog	27
22871	Site #2W- 34	11	603	3/15/99		Dog	27
22873	Site #2W- 36	11	603	3/15/99		Dog	27
22876	Site #2W- 37	11	603	3/15/99	DOG	DOG	29
22877	Site #2W- 39	11	603	3/15/99		Dog	25
22836	Site #2W- 16	11	603	3/15/99		Dog-Cat	57
22842	Site #2W- 19	11	603	3/15/99		Dog-Cat	57
22875	Site #2W- 37	11	603	3/15/99		Dog-Cat	57
22878	Site #2W- 39	11	603	3/15/99		Duck-Goose	167
22865	Site #2W- 31	11	603	3/15/99		Opossum	68
22866	Site #2W- 31	11	603	3/15/99		Opossum	68
22835	Site #2W- 16	11	603	3/15/99		RACCOON	79
22846	Site #2W- 21	11	603	3/15/99		Raccoon	36
22848	Site #2W- 22	11	603	3/15/99		Raccoon	36
22851	Site #2W- 24	11	603	3/15/99		RACCOON	79
22856	Site #2W- 26	11	603	3/15/99		Rodent	10
22869	Site #2W- 33	11	603	3/15/99		Rodent	44
22808	Site #2W- 1	11	603	3/15/99		Sea Gull	75
22815	Site #2W- 5	11	603	3/15/99		Sea Gull	75
22816	Site #2W- 5	11	603	3/15/99		Sea Gull	75
22817	Site #2W- 6	11	603	3/15/99		Sea Gull	75
22822	Site #2W- 8	11	603	3/15/99		Sea Gull	75
22824	Site #2W- 9	11	603	3/15/99		Sea Gull	75
22825	Site #2W- 10	11	603	3/15/99		Sea Gull	75
22852	Site #2W- 24	11	603	3/15/99		Sea Gull	75
22857	Site #2W- 27	11	603	3/15/99		Sea Gull	75
22858	Site #2W- 27	11	603	3/15/99		Sea Gull	75
22874	Site #2W- 36	11	603	3/15/99		Sea Gull	75
22879	Site #2W- 40	11	603	3/15/99		Sea Gull	75
22880	Site #2W- 40	11	603	3/15/99		Sea Gull	75
22809	Site #2W- 2	11	603	3/15/99			33
22813	Site #2W- 4	11	603	3/15/99			132
22814	Site #2W- 4	11	603	3/15/99			132
22826	Site #2W- 10	11	603	3/15/99			181
22827	Site #2W- 11	11	603	3/15/99			158
22828	Site #2W- 11	11	603	3/15/99			157
22831	Site #2W- 13	11	603	3/15/99			33
22834	Site #2W- 15	11	603	3/15/99			152
22839	Site #2W- 18	11	603	3/15/99			45
22840	Site #2W- 18	11	603	3/15/99			45
22847	Site #2W- 22	11	603	3/15/99			179
22859	Site #2W- 28	11	603	3/15/99			129
22860	Site #2W- 28	11	603	3/15/99			173
22861	Site #2W- 29	11	603	3/15/99			173
22864	Site #2W- 30	11	603	3/15/99			162
22872	Site #2W- 34	11	603	3/15/99			128

Appendix B: DNA Match Results (Wet Weather)