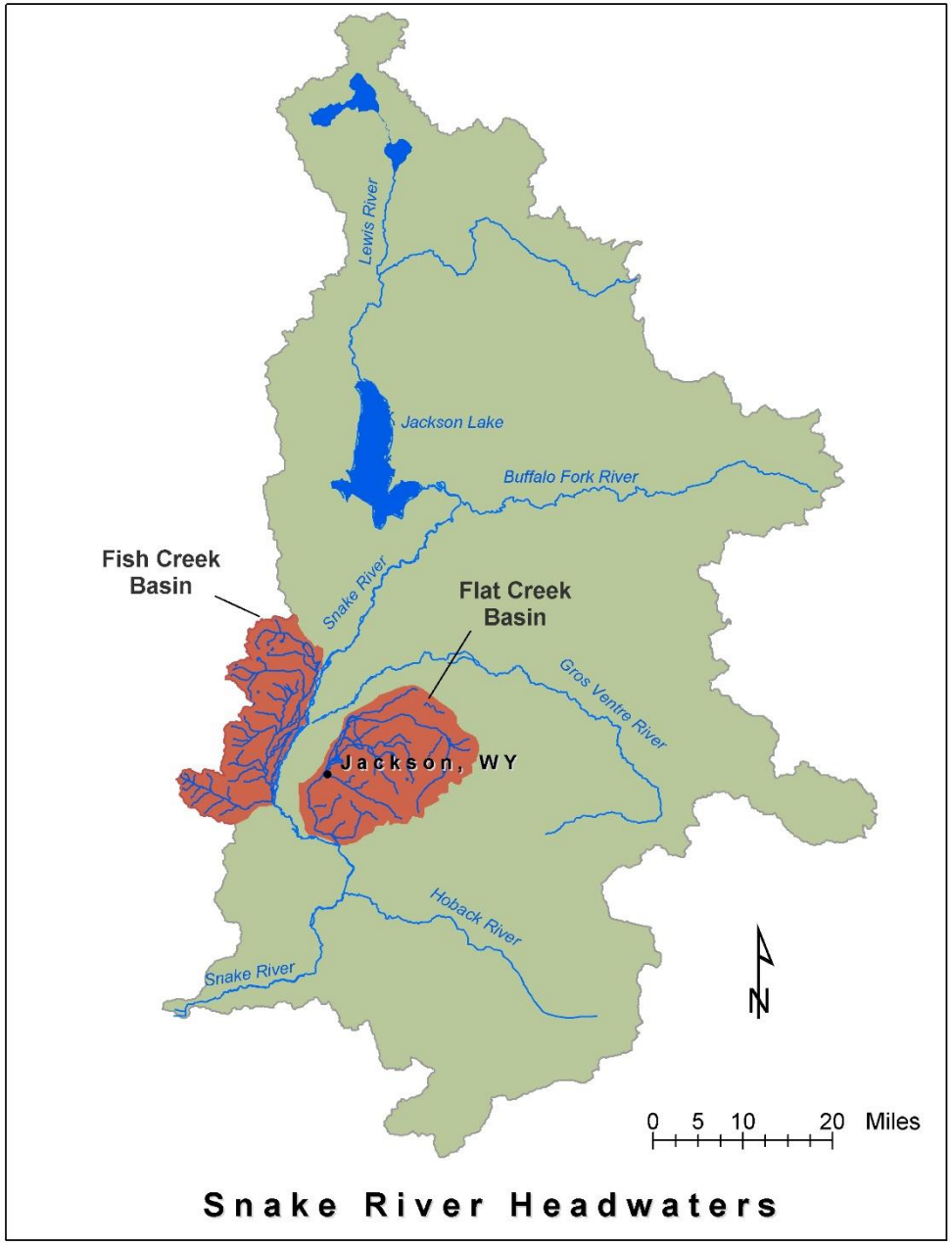
Microbial Source Tracking for *Escherichia coli* in Two Upper Snake River Basins

Fish Creek and Flat Creek Basins
Teton County, Wyoming
March-November 2003

Teton Conservation District
Est. 1946

By Brian E. Remlinger
Water Resources Specialist



Watershed Assessment

1996-2005

1) Develop an understanding of baseline water quality

2) Identify potential sources contributing to the degradation of water quality

3) Provide technical support to decision makers and private landowners to improve water quality and prevent further degradation.

Water Quality Problem

1996-1997 Cascade Creek and Garnet Creek

GTNP and USGS Study

Fecal coliform concentrations exceeded WDEQ Standards

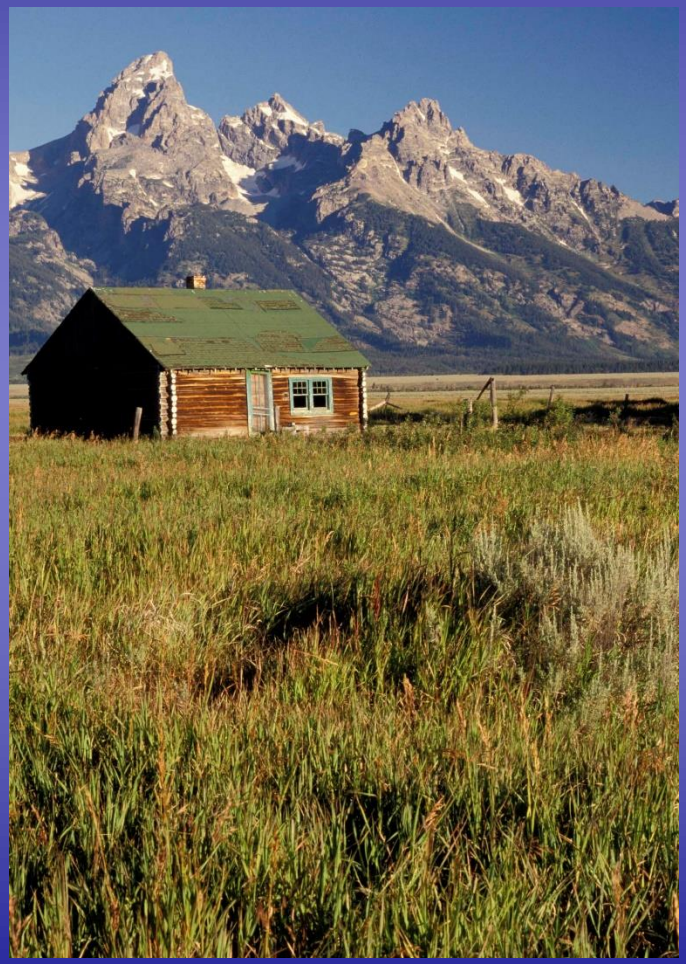
Avian, elk, deer, canine, rodent and human

2000 Fish Creek and Flat Creek

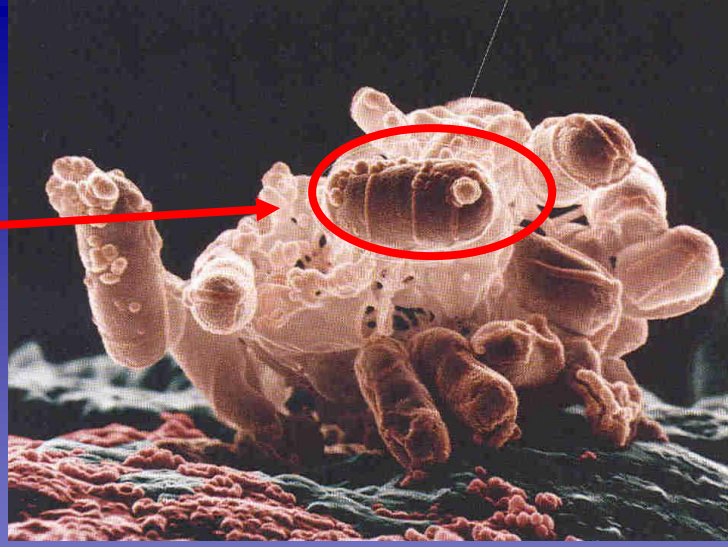
TCD Study

E. coli concentrations exceeded WDEQ Standards

multiple samples	>400 col/ml
single sample	> 3000 col/mL



Escherichia coli
Fecal-Indictor Bacteria



Coliform bacteria group

Part of the normal flora of the human intestinal tract

Non-Pathogenic: Plays a crucial role in food digestion by producing vitamin K from undigested material in the large intestine.

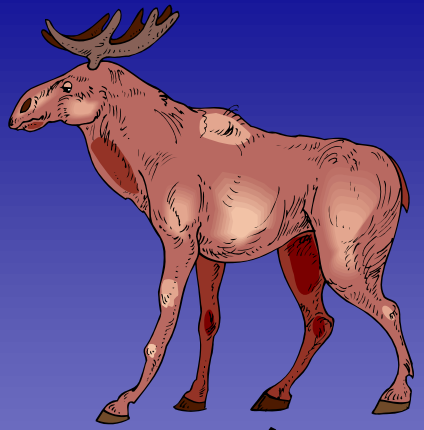
Pathogenic: Pneumonia, meningitis, and traveler's diarrhea are among the many illnesses. *E. coli* O157:H7 causes severe cases of diarrhea in all age groups by producing a powerful endotoxins.

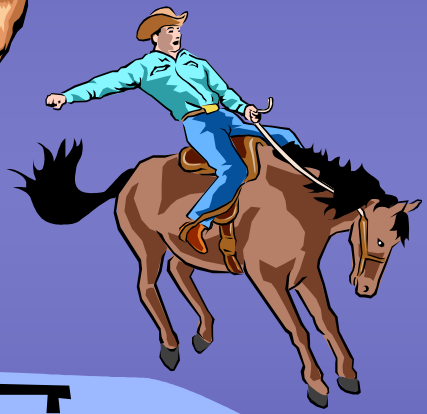
Fecal indicator bacteria: Presence in water indicates fecal contamination exists and potential pathogenic organisms may exist.

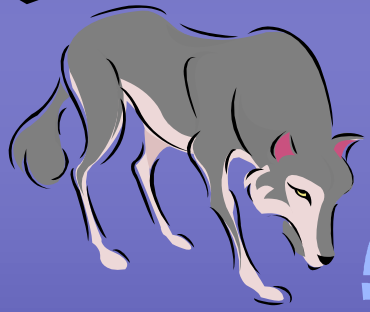
- **1914 U.S. Public Health Service**
- **1986 U.S. EPA bacteriological water quality criteria**

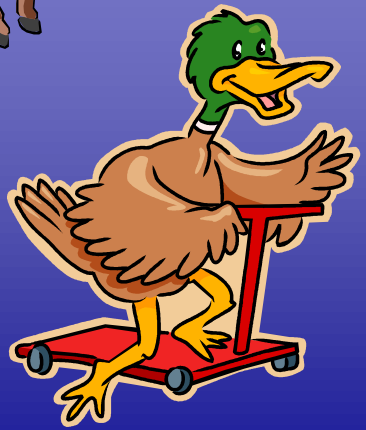
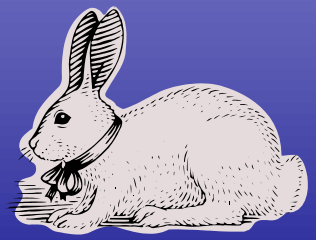
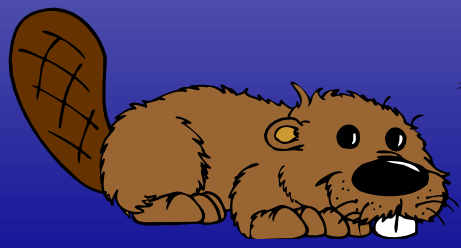
Fecal Bacteria?







NUMBERS OF VIABLE BACTERIA FOUND IN THE FECES OF ADULT ANIMALS

Animal	Fecal Bacteria (density per gram)
Duck	33,000,000
Dogs	23,000,000
Sheep	16,000,000
Humans	13,000,000
Chickens	13,000,000
Cats	7,900,000
Mice	330,000
Cattle	230,000
Horses	12,600
Rabbits	20

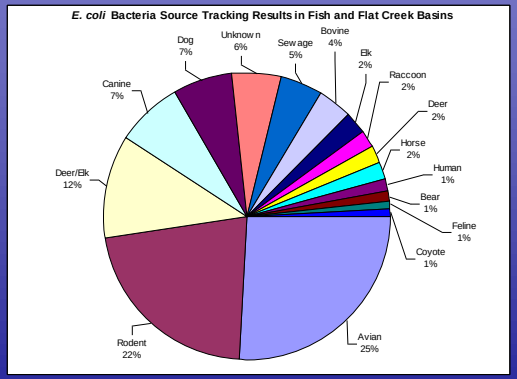
Modified from Rosebury, T. : Microorganisms Indigenous to Man. McGraw-Hill. New York. 1962.

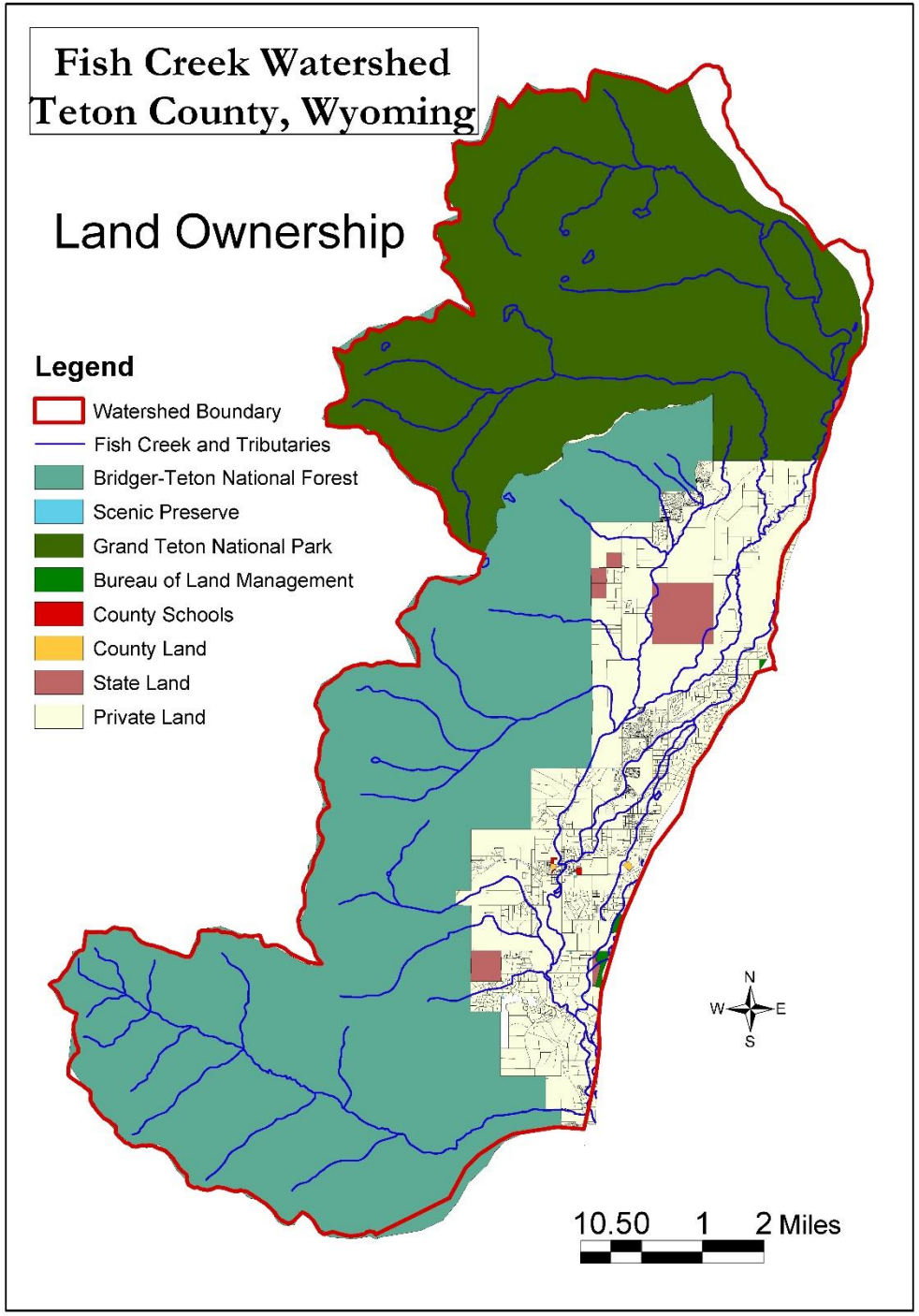
Potential Paths to Creek

Direct Human	Indirect Human	Direct Non-Human	Indirect Non-Human
Sewage infrastructure	RVs and tankers	Domestic pets/Livestock	Stormwater runoff
Recreation/Homeless	Stormwater runoff	Wildlife (Beaver, water fowl, etc.)	Irrigation runoff
Point-source discharge	Failing septic system		
	Portable toilets		

Source Investigation

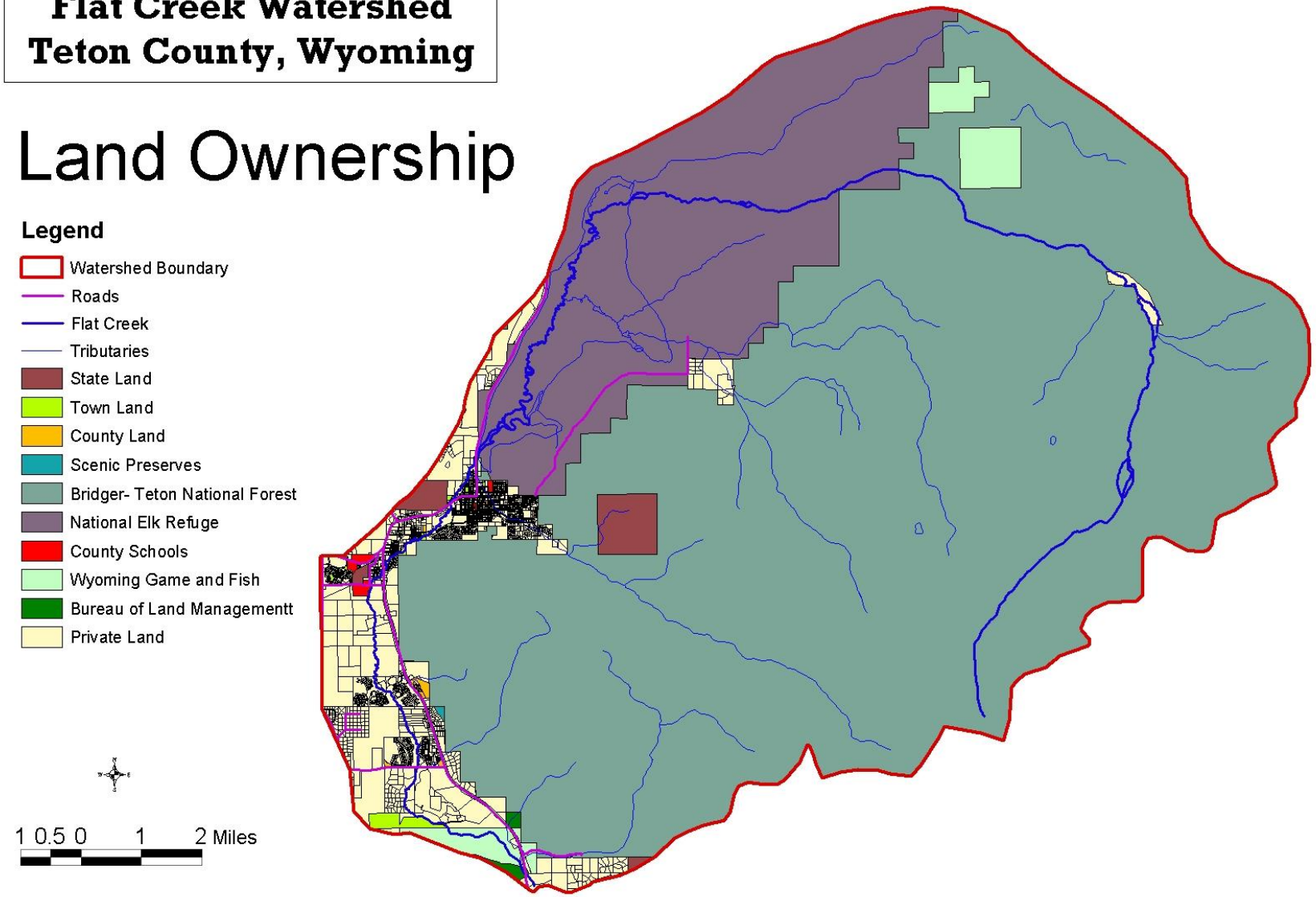
Original Source

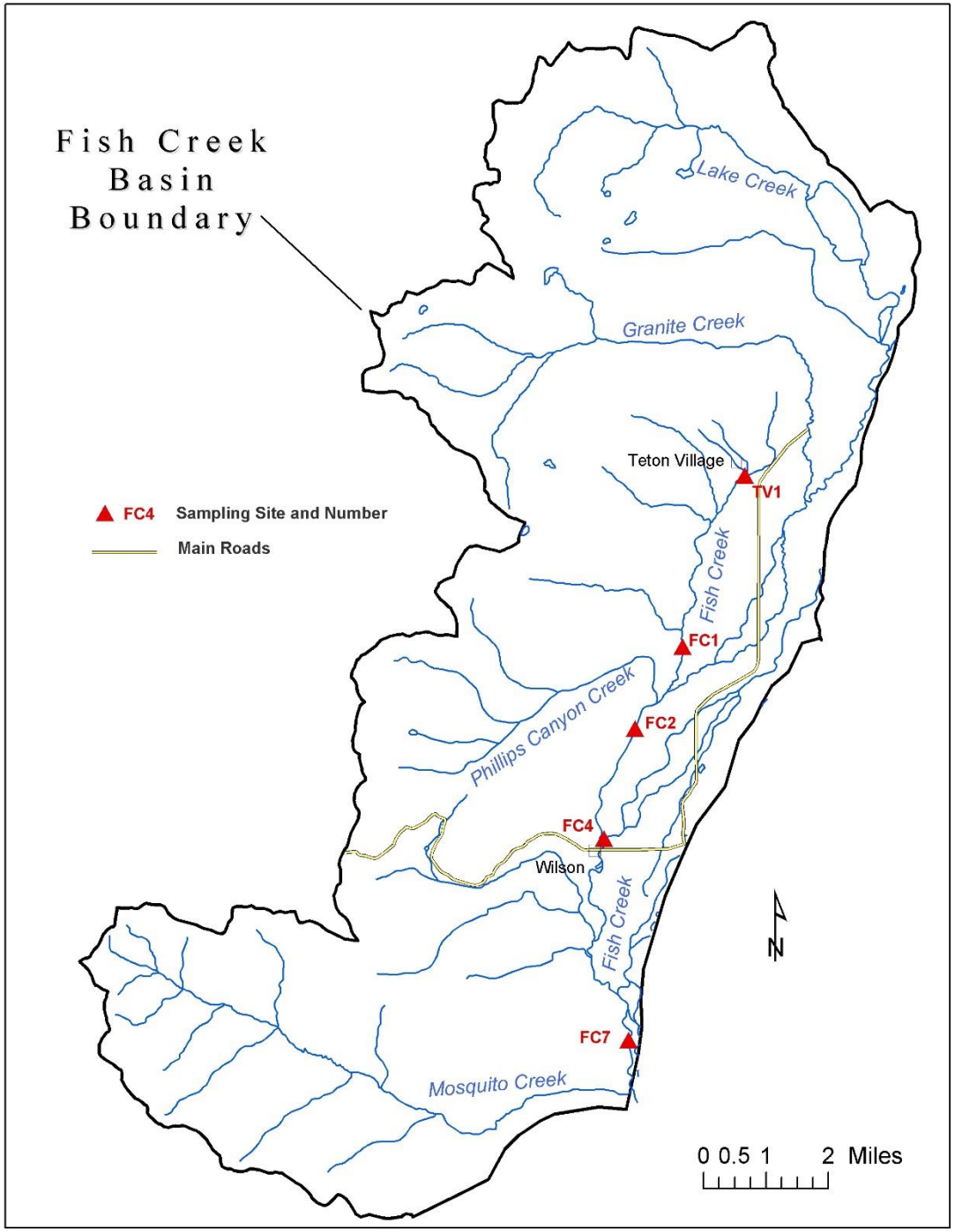


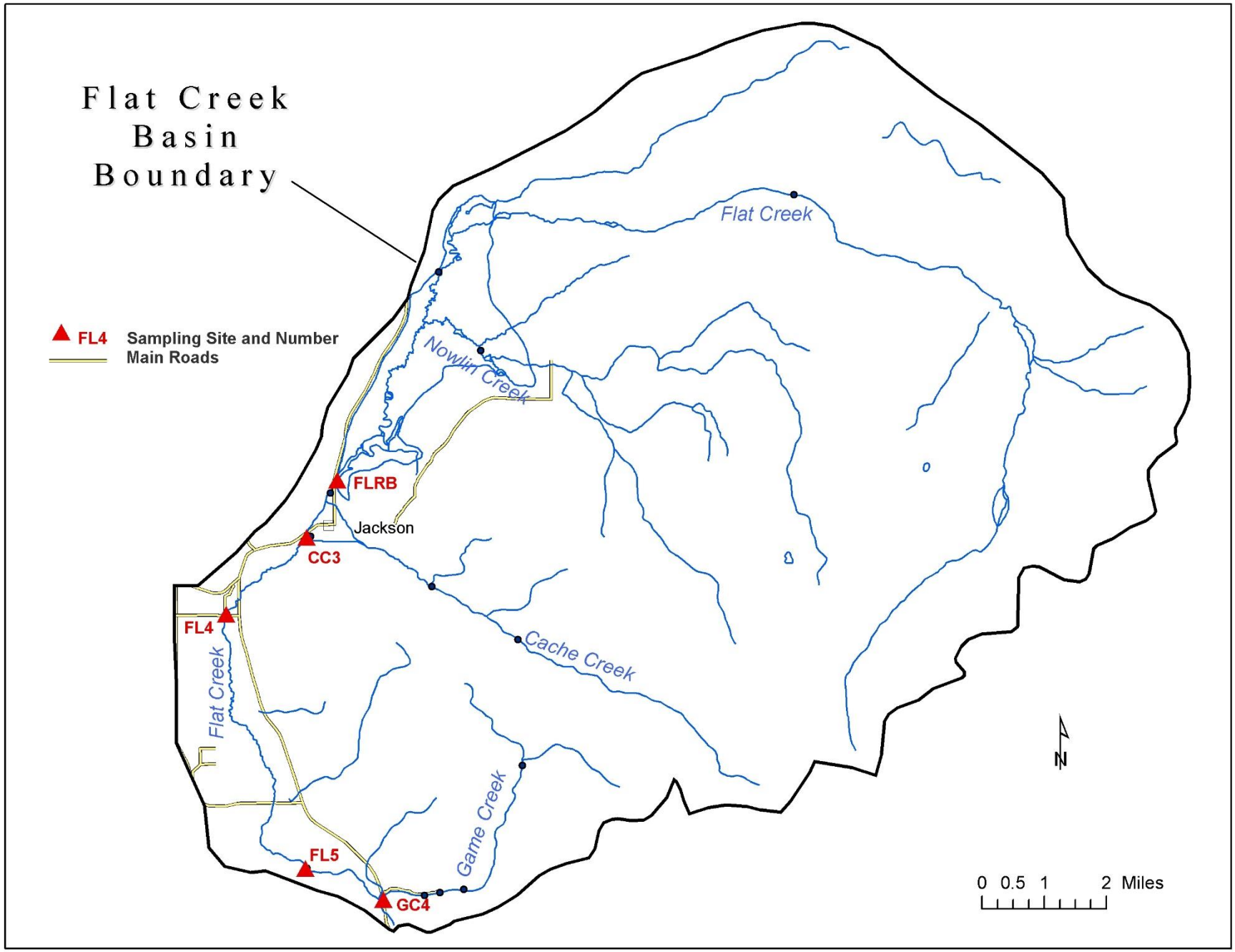

Fish Creek Watershed
Teton County, Wyoming
Land Ownership
Legend
Watershed Boundary
Fish Creek and Tributaries
Bridger-Teton National Forest
Scenic Preserve
Grand Teton National Park
Bureau of Land Management
County Schools
County Land
State Land
Private Land
N
W
E
S
1 0.5 0 1 2 Miles

Flat Creek Watershed
Teton County, Wyoming

Land Ownership

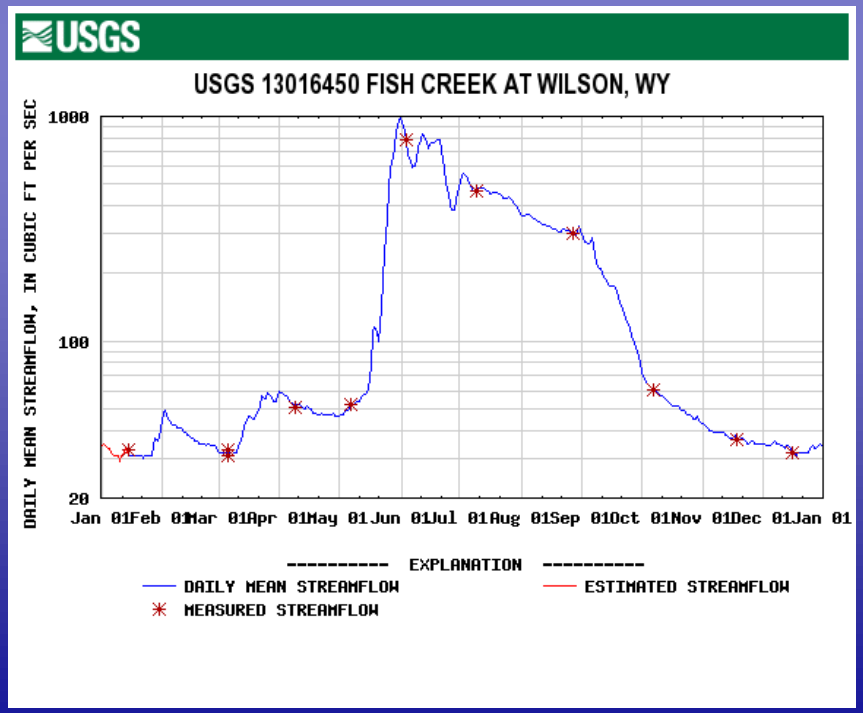


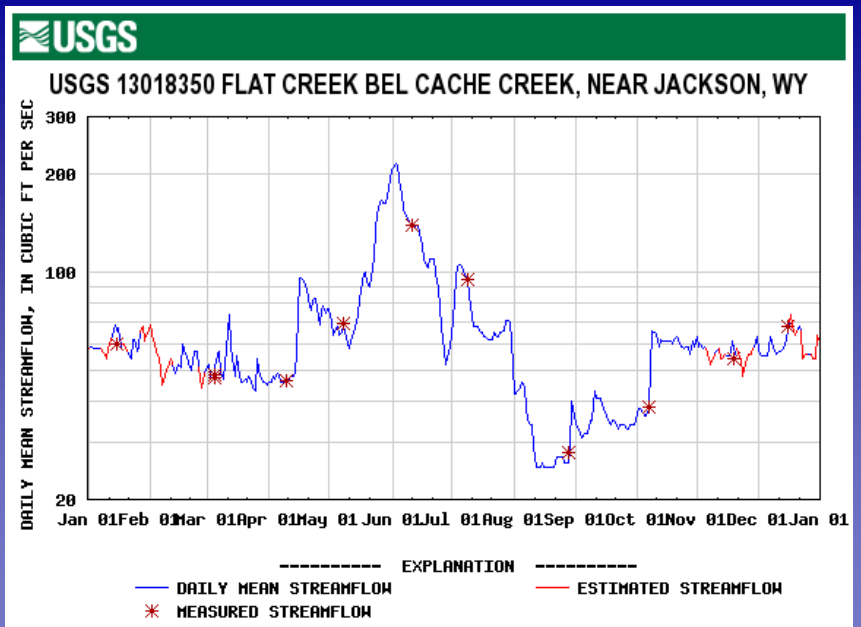

Fish Creek Basin Boundary
Lake Creek
Granite Creek
Teton Village
TV1
FC4 Sampling Site and Number
Main Roads
Fish Creek
FC1
Phillips Canyon Creek
FC2
FC4
Wilson
Fish Creek
N
FC7
Mosquito Creek
0 0.5 1 2 Miles

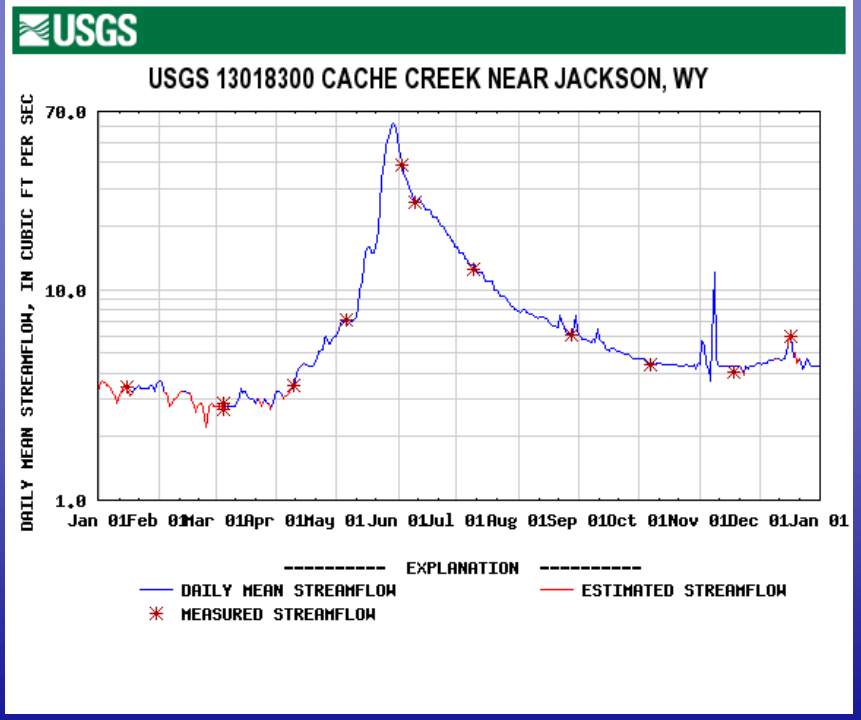

Flat Creek Basin Boundary
FL4 Sampling Site and Number
Main Roads
Flat Creek
Nowlin Creek
FLRB
Jackson
CC3
FL4
Flat Creek
Cache Creek
Game Creek
FL5
GC4
N
0 0.5 1 2 Miles

Stream Flow
During 2003 Study Period

March - November 2003, twice monthly
17 sampling events
10 sites

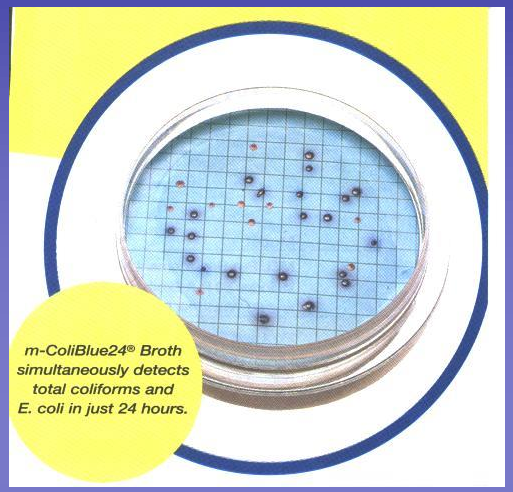




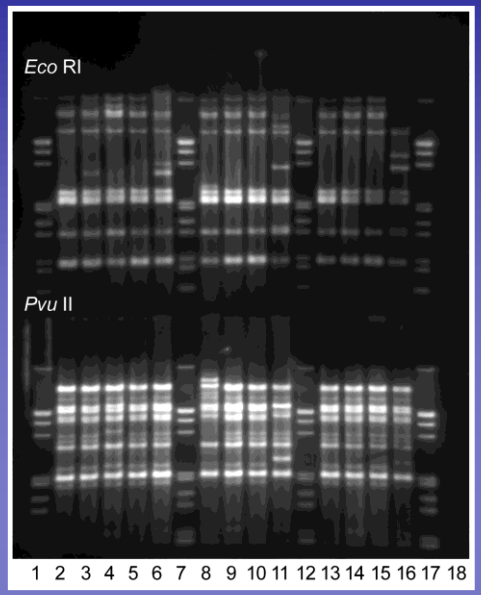


1 Water sample collection

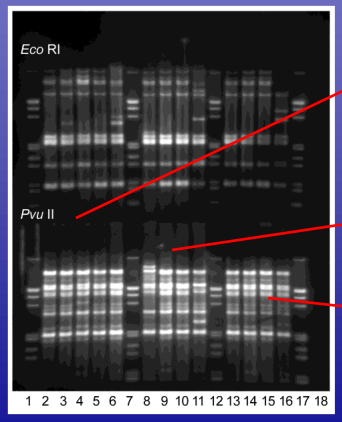
2 Sample dilution, filtering, incubation and enumeration



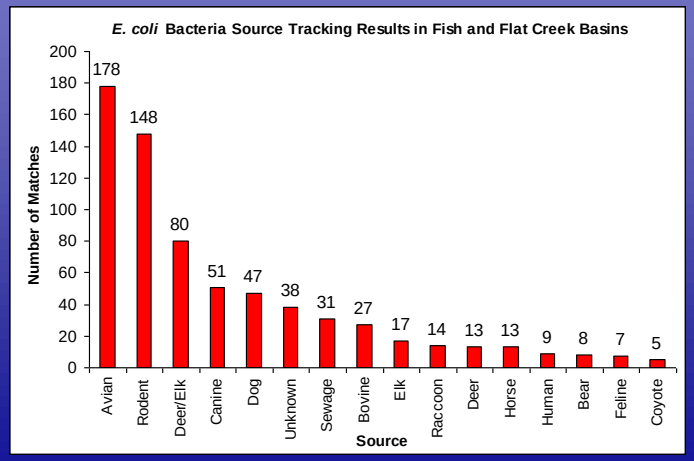
3 DNA Ribotyping



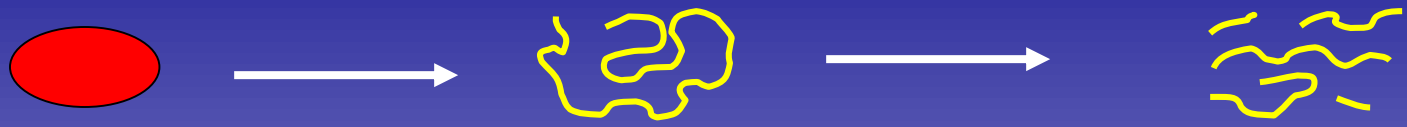
4 Source Matching



5 Interpretation



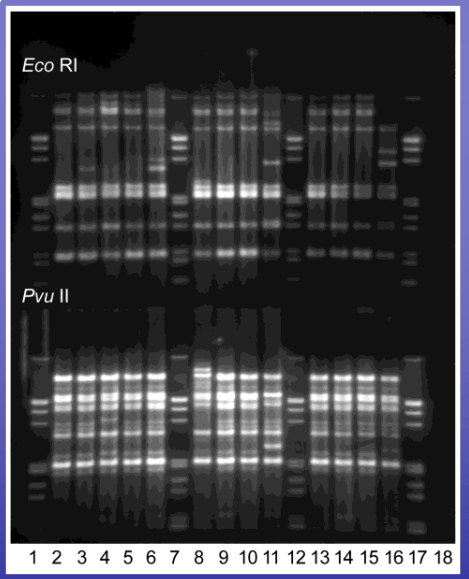
DNA Ribotyping

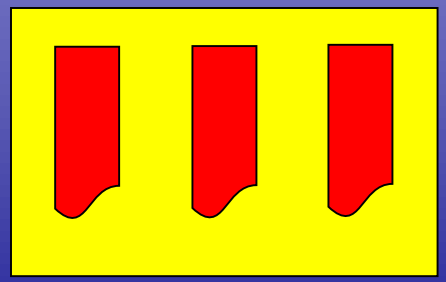


E. coli isolate

Isolate DNA

Cut DNA





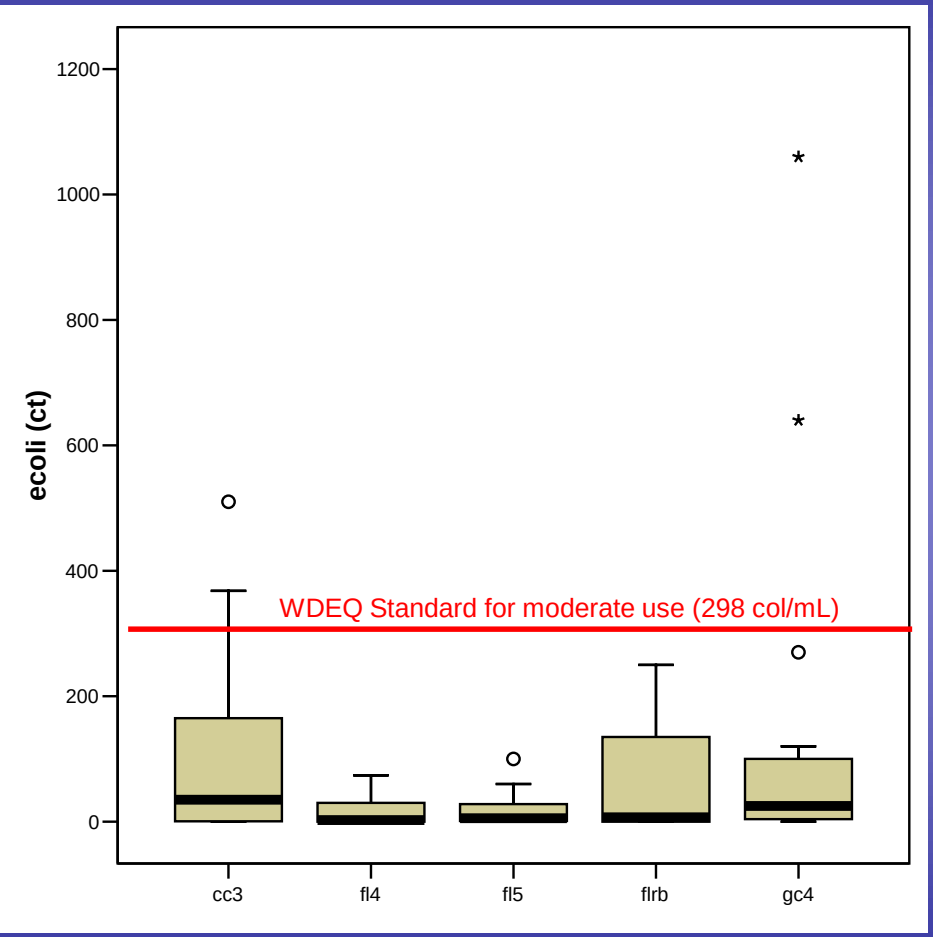
Run DNA on gel

Probe membrane with labeled DNA to give "fingerprint"

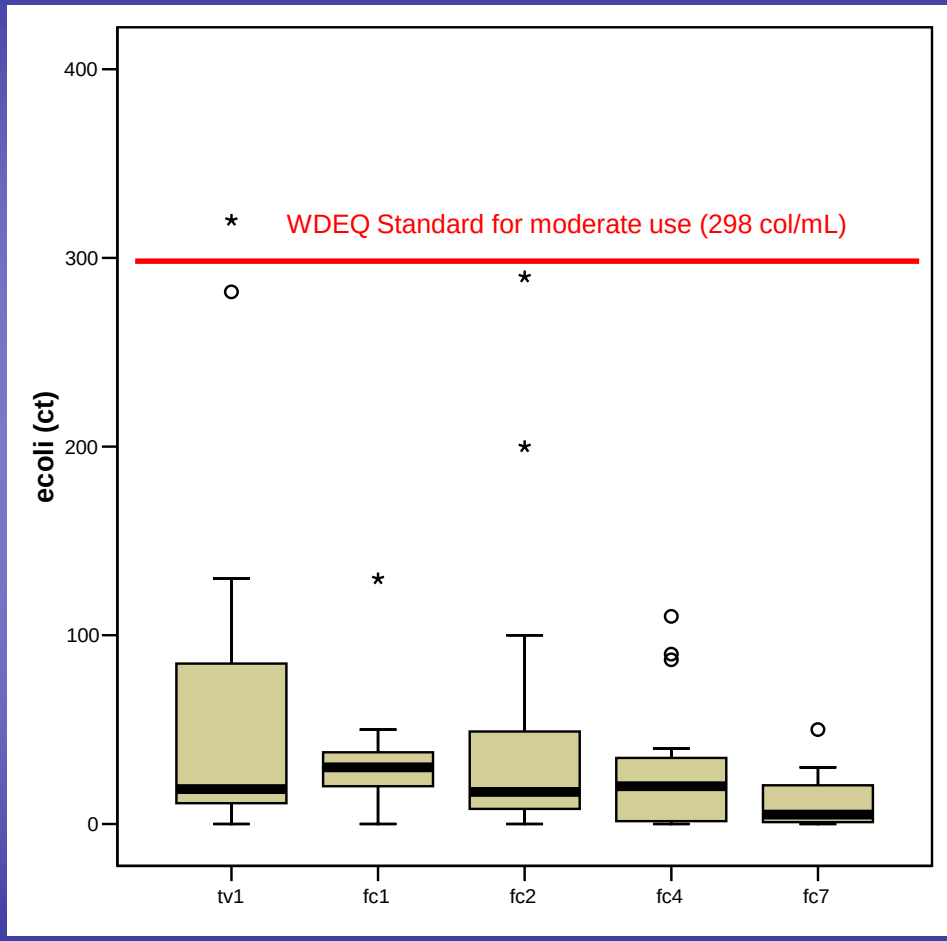
Sampling and Laboratory Analysis

- 162 water samples collected
- 686 *E. coli* isolate sources were identified
- 25 dog feces samples collected

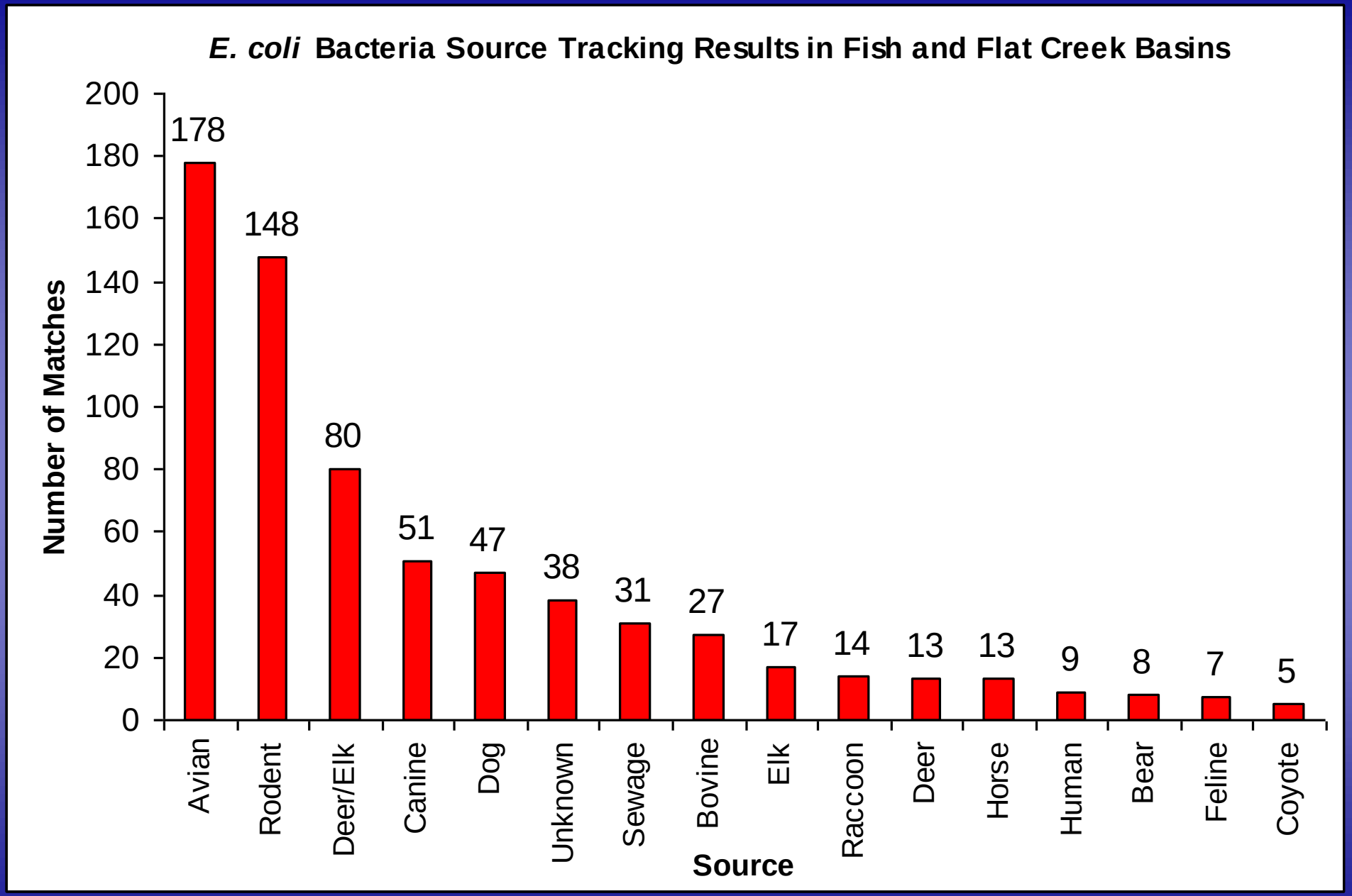
E. coli fecal-indicator bacteria results



Flat Creek Basin

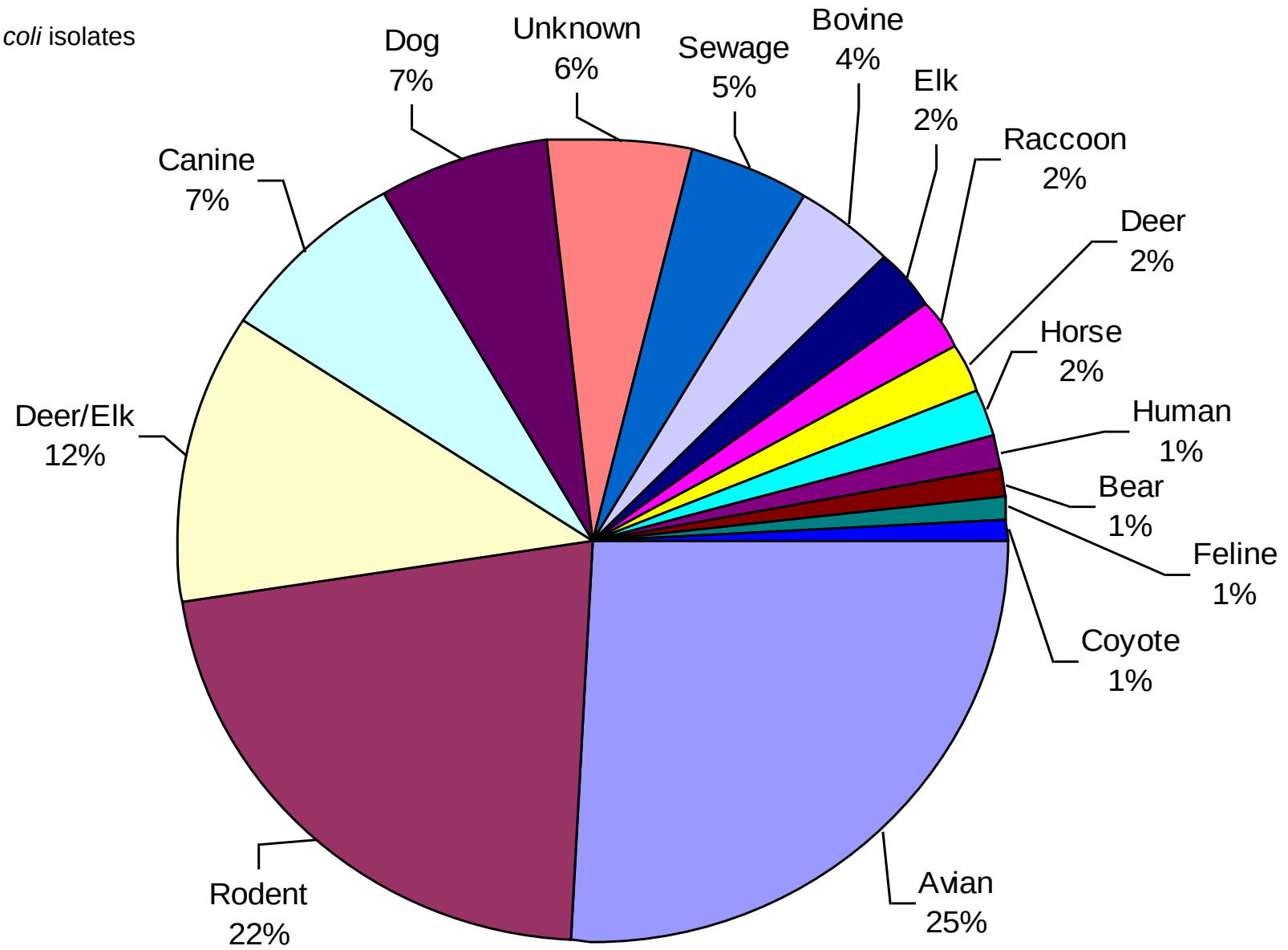


Fish Creek Basin


E. coli Bacteria Source Tracking Results in Fish and Flat Creek Basins
Number of Matches
200
180
160
140
120
100
80
60
40
20
0
178
148
80
51
47
38
31
27
17
14
13
13
9
8
7
5
Avian
Rodent
Deer/Elk
Canine
Dog
Unknown
Sewage
Bovine
Elk
Raccoon
Deer
Horse
Human
Bear
Feline
Coyote
Source

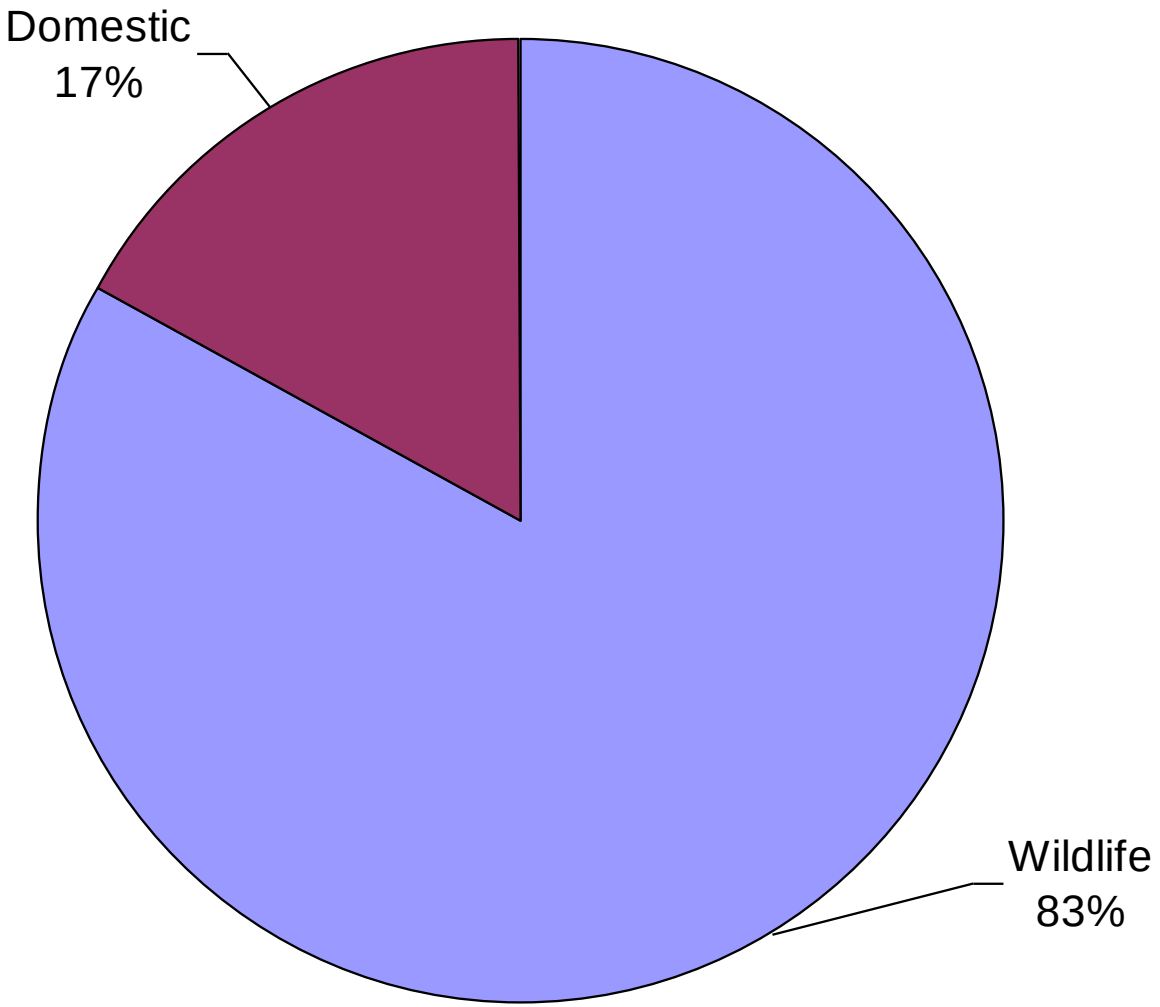
E. coli Bacteria Source Tracking Results in Fish and Flat Creek Basins

686 *E. coli* isolates



Wildlife and Domestic E. Coli DNA Matches

686 *E. coli* isolates



Domestic sources of *E. coli* for Fish and Flat Creek basins

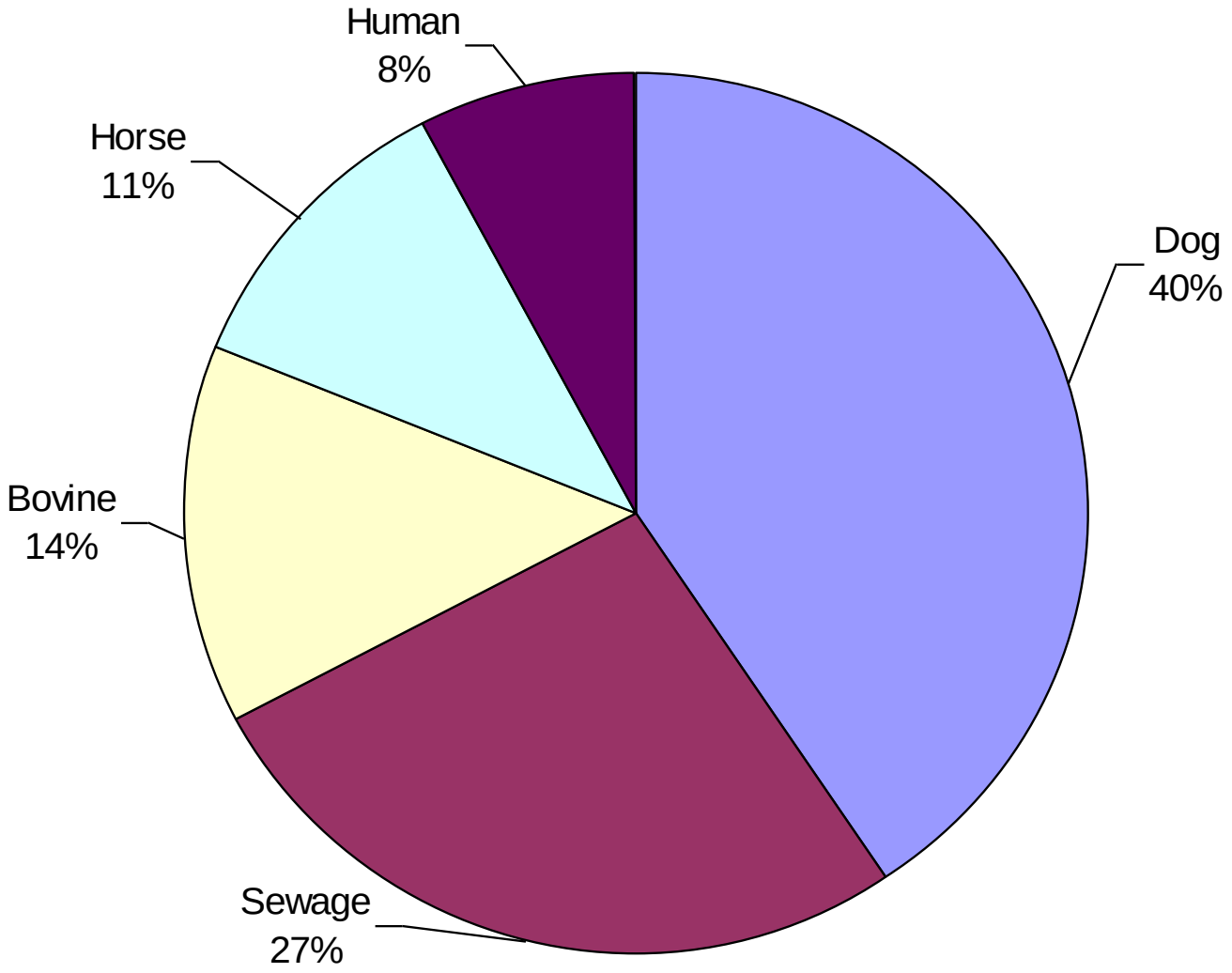
Species	# of Matches	% of Total Matches	Fish Creek Basin	Flat Creek Basin
Dog	47	7%	30	17
Sewage	31	5%	22	9
Bovine	16	2%	8	8
Horse	13	2%	5	8
Human	9	1%	7	2
TOTAL	**116**	**17%**	**72**	**44**

Note: Bovine at FLRB, CC3 and GC3 were not included in domestic sources

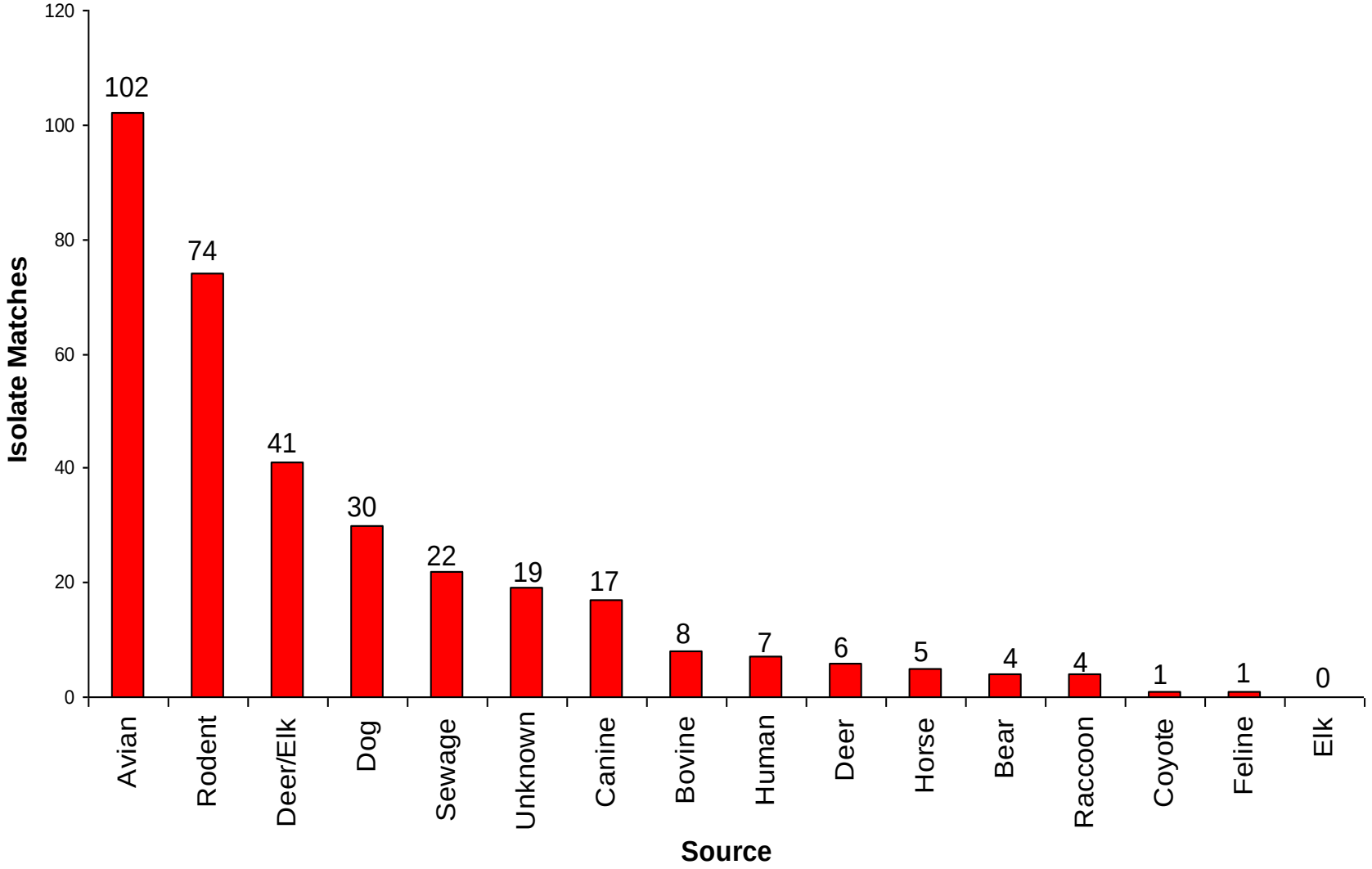
Species	# of Matches	% of Total Matches	Fish Creek Basin	Flat Creek Basin
Wildlife	570	83%	273	297
Domestic	116	17%	72	44
TOTAL	**686**	**100%**	**345**	**341**

Domestic E. Coli DNA Matches

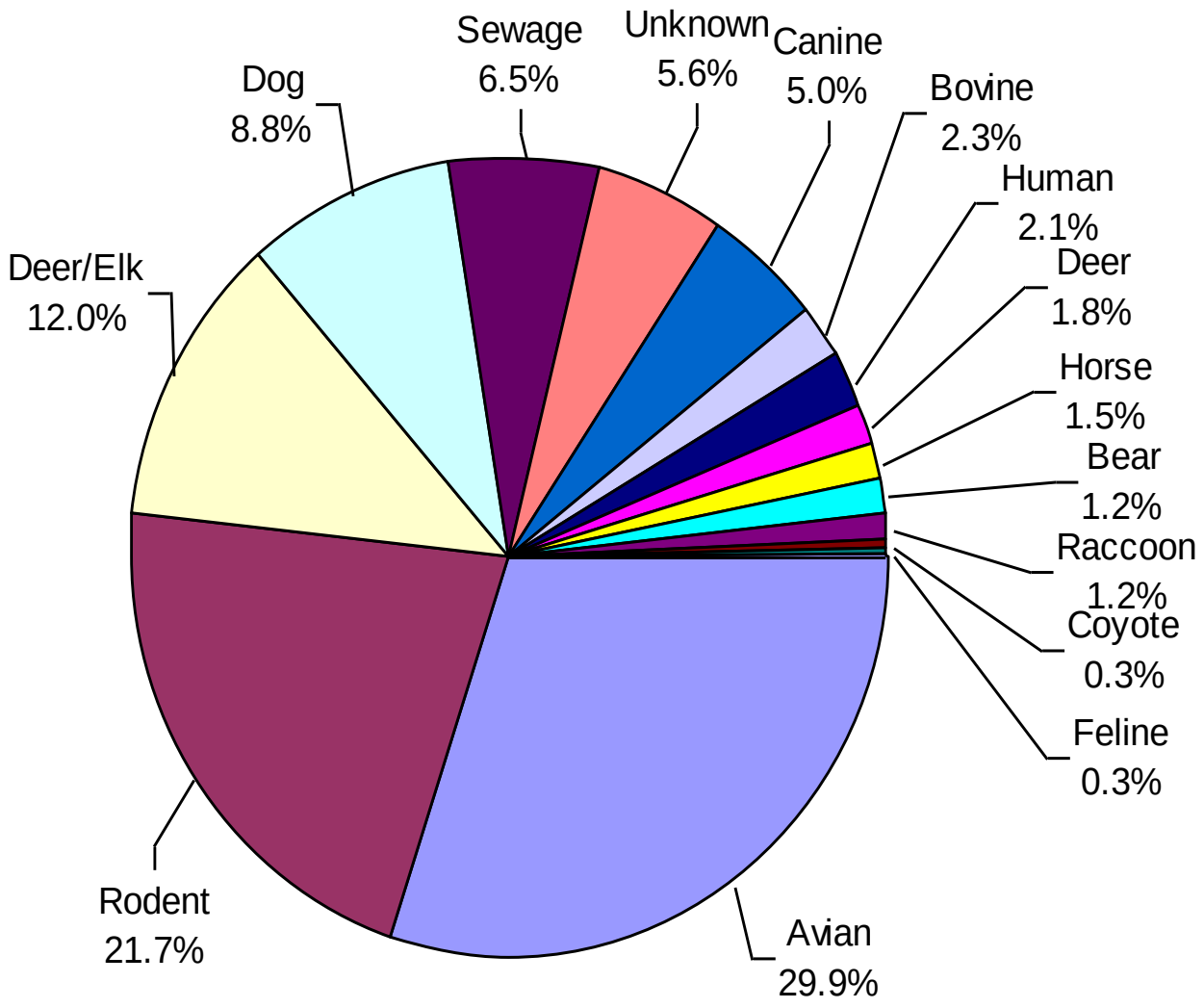
116 *E. coli* isolates

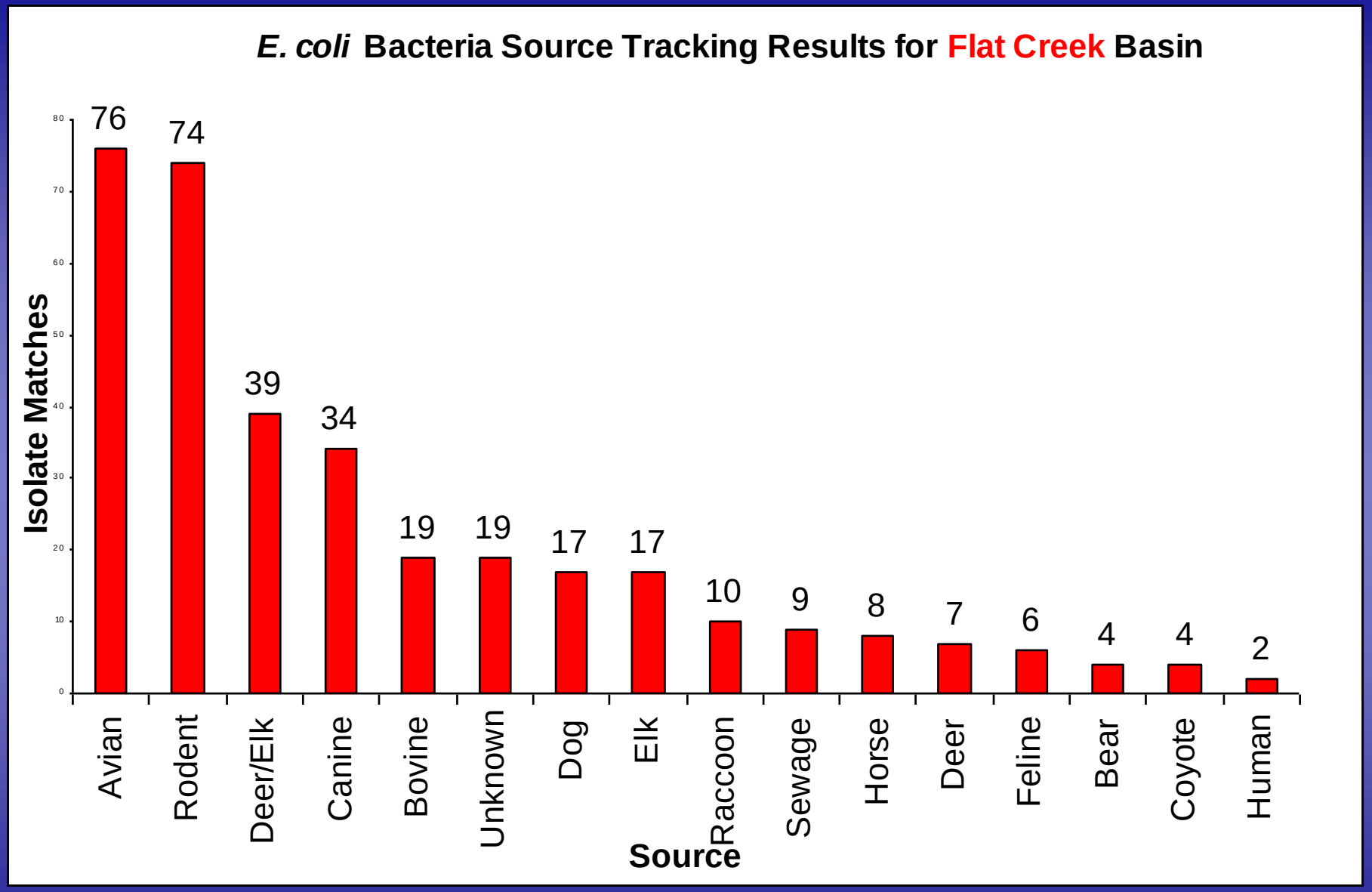


E. coli Bacteria Source Tracking Results for Fish Creek Basin

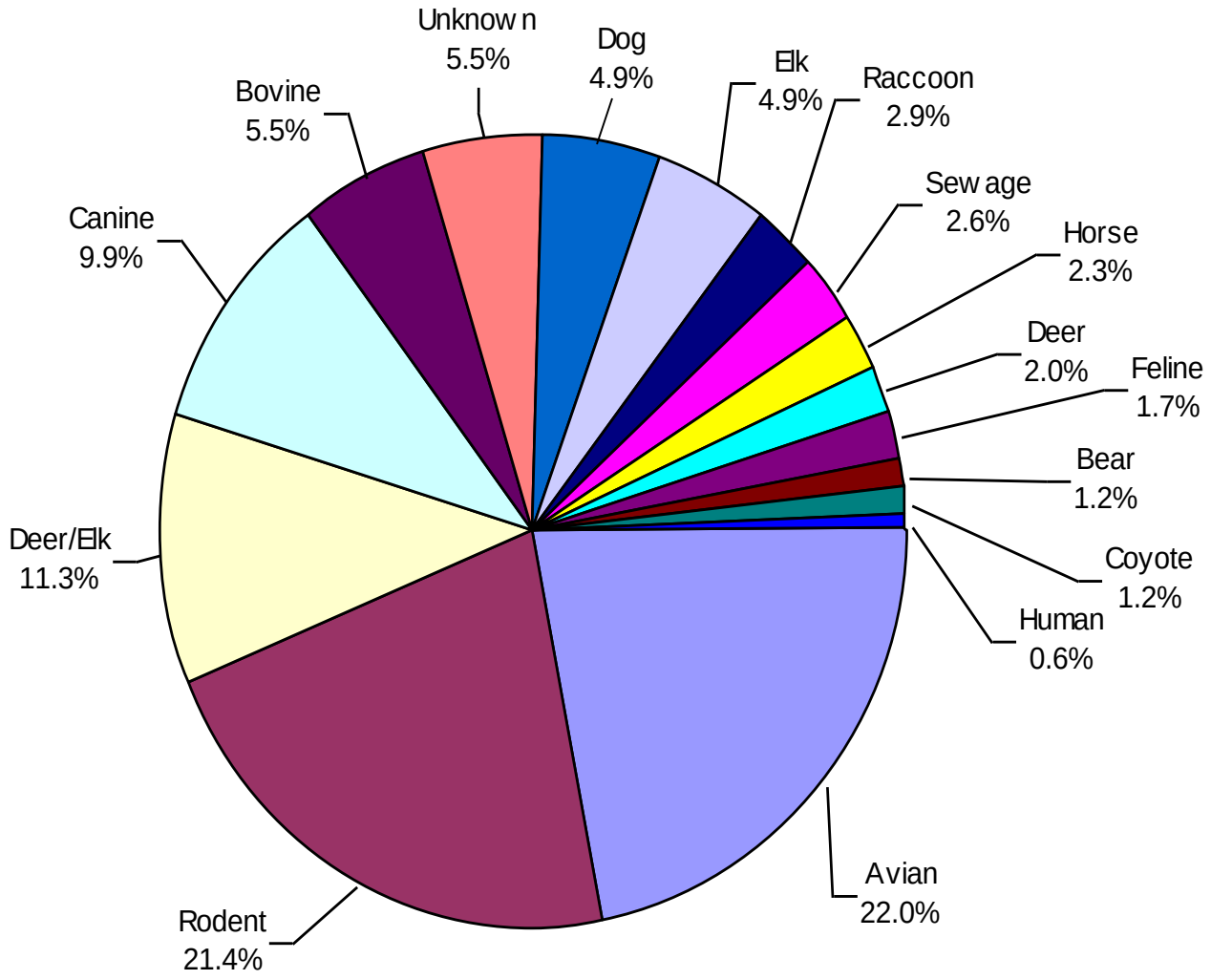


E. coli Bacteria Source Tracking Results for the Fish Creek Basin

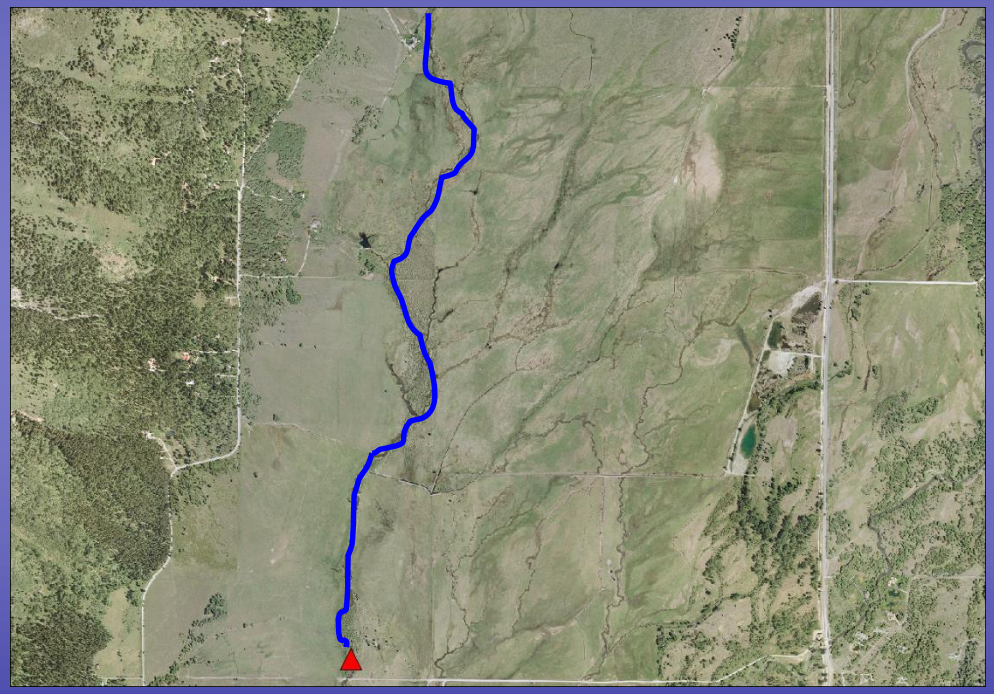



E. coli Bacteria Source Tracking Results for Flat Creek Basin
Isolate Matches
0
10
20
30
40
50
60
70
80
76
74
39
34
19
19
17
17
10
9
8
7
6
4
4
2
Avian
Rodent
Deer/Elk
Canine
Bovine
Unknown
Dog
Elk
Raccoon
Sewage
Horse
Deer
Feline
Bear
Coyote
Human
Source

E. coli Bacteria Source Tracking Results for Flat Creek Basin



Number of cattle on pastures upstream of site FC1 during sampling event periods



	# Head	Date	Bovine E. Coli
	1219	06/20/05	
	1219	06/21/05	
	1219	06/22/05	
FC1 - Test Date	**1219**	**06/23/03**	**0**
	403	07/22/03	
	400	07/23/03	
	400	07/24/03	
FC1 - Test Date	**400**	**07/25/03**	**1**
	400	08/02/03	
	335	08/03/03	
	335	08/04/03	
FC1 - Test Date	**335**	**08/05/03**	**1**
	335	08/15/03	
	335	08/16/03	
	335	08/17/03	
FC1 - Test Date	**335**	**08/18/03**	**1**
	883	09/01/03	
	1282	09/02/03	
	1282	09/03/03	
FC1 - Test Date	**1282**	**09/04/03**	**0**
	0	09/20/03	
	0	09/21/03	
	0	09/22/03	
FC1 - Test Date	**0**	**09/23/03**	**0**

Note: No steers in FC1 area drainage after 09/08/03

Drainage area consists of 9 pastures totaling approximately 1,229 acres

Wyoming DEQ proposed *E. coli* bacteria standards

Chapter 1 Water Quality Rules and Regulations, Section 27 (c)

During the recreation season, on all waters designated for primary contact recreation, the following single-sample maximum concentrations of *e.coli* bacteria shall apply:

(i) High use swimming areas - 235 organisms per 100 milliliters
(ii) Moderate full body contact - 298 organisms per 100 milliliters
(iii) Lightly used full body contact - 410 organisms per 100 milliliters
(iv) Infrequently used full body contact - 576 organisms per 100 milliliters

The appropriate recreational use category (i through iv above) shall be determined by the administrator as needed, on a case by case basis.

Water samples exceeding WDEQ moderate full body contact criteria (298 col/100 mL)

Site map number	Date sampled	*E. coli* col/100 mL	Avian	Bovine	Canine	Coyote	Deer/ Elk	Dog	Rodent	Unknown
TV1	10-07-03	320	3					1	1	
CC3	06-09-03	510	3			2		1	1	
CC3	07-25-03	368	1				2		1	2
GC4	07-25-03	640		1	6					
GC4	09-23-03	1060	1		3		1			1